FINAL FOCUSED FEASIBILITY STUDY
PART II – GROUNDWATER

CTS Printex Superfund Site
Mountain View, Californnia

Prepared for:

United States Environmental Protection Agency

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
%D	percent difference
%R	percent recovery
µg	micrograms
ARAR	applicable or relevant and appropriate requirement
AS	air sparging
ATT	Aqua Terra Technologies, Inc.
bgs	below ground surface
BHRA	Baseline health risk assessment
bio-PRB	biological permeable reactive barrier
BZ	benzene
CAH	chlorinated aliphatic hydrocarbon
CAO	Cleanup and abatement order
CalEPA	California Environmental Protection Agency
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHL	chloroform
COC	chemical of concern
COPC	chemical of potential concern \
CSIA	compound specific isotope analysis
CSM	conceptual site model
CSS	CSS Environmental Services, Inc.
DCA	dichloroethane
DCE	dichloroethene
DHS	Department of Health Services
DO	dissolved oxygen
DPE	dual-phase extraction
DPT	direct push technology
DQO	data quality objective
DTSC	California Department of Toxic Substances Control
EC	exposure concentration
EPA	United States Environmental Protection Agency
ESL	Environmental Screening Levels
FFS	Focused Feasibility Study
FS	Feasibility Study
ft	foot (or feet)
ft/ft	foot/feet
ft^2	square feet

HI	hazard index
IC(s)	institutional control(s)
IRIS	Integrated Risk Information System
ISCO	in-situ chemical oxidation
ISCR	in-situ chemical reduction
ITRC	Interstate Technology and Regulatory Council
ITSI	Innovative Technical Solutions, Inc.
IUR	inhalation unit risk
kg	kilograms
L	liter
m^3	cubic meter
MCL	Maximum Contaminant Level
MeCl	methylene chloride
mg/kg	milligrams per kilogram or parts per million
mg/L	milligrams per liter
MIP	membrane interface probe
msl	mean sea level
mV	millivolts
NAPL	non-aqueous phase liquids
NPL	National Priorities List
NTU	nephelometric turbidity units
O&M	operation and maintenance
OEHHA	Office of Environmental Health Hazard Assessment
OMM	operation, maintenance, and monitoring
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Organization
PCDF	pozzolanic controlled density fill
PCE	tetrachloroethene
ppm	parts per million
PRB	permeable reactive barrier
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QC	quality control
RAC	Remedial Action Contract II
RAO	remedial action objective
RD	Remedial Design
RfC	reference concentration
RL	reporting limit
RME	reasonable maximum exposure

RMP	Risk Management Plan
ROD	Record of Decision
ROI	radius of influence
RPD	relative percent difference
RWQCB	California Regional Water Quality Control Board (San Francisco Bay Region)
SAP	Sampling and Analysis Plan
SC	soil conductivity
SCR	Site Cleanup Requirements
Site	CTS Printex Superfund Site
SMP	self-monitoring program
SOP	standard operating procedures
SSD	sub-slab depressurization
SVE	soil vapor extraction
TBC	to-be-considered criteria
TCA	trichloroethane
TCE	trichloroethene
TI	technical impracticability
TO	Task Order
UCL	upper confidence limit
USCS	Unified Soil Classification System
VI	vapor intrusion
VOCs	volatile organic compounds
ZVI	zero-valent iron

1.0 INTRODUCTION

The United States Environmental Protection Agency (EPA), under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. §§ 9601-9675 (CERCLA), has conducted a focused feasibility study (FFS) to address contamination at the CTS Printex Superfund Site, Mountain View, California (the “Site”). The FFS is being developed in two parts: Part 1 assesses alternatives for addressing vapor intrusion (VI) of volatile organic compounds (VOCs) from the subsurface into overlying buildings at the Site (ITSI, 2011b); and Part 2, as presented herein, assesses alternatives for cleaning up groundwater to achieve remediation goals (RGs) established in the Site’s Record of Decision (ROD) that was issued in 1991 (EPA, 1991). This two-part FFS will support a future planned amendment to the ROD.

1.1 PURPOSE AND ORGANIZATION OF REPORT

This FFS identifies, evaluates, and compares alternatives for addressing the remaining groundwater contamination at the Site.

The purpose and associated objectives of this FFS are the following:

- Update the conceptual site model (CSM) to incorporate recent data on the nature and extent of contamination in groundwater at the Site and associated potential exposure pathways.
- Establish groundwater cleanup criteria that will be protective of human health and the environment and that will satisfy applicable or relevant and appropriate requirements (ARARs).
- Develop and evaluate appropriate alternatives for groundwater that will achieve the cleanup criteria.

The FFS report is organized as described below:

- **Section 1.2 - Background Information.** This subsection presents summaries of previous RI reports, the ROD, and the current supplemental RI (ITSI, 2011a), addressing topics including site description; updated list of chemicals of concern (COCs); nature and extent of contamination, contaminant fate and transport, and baseline health risk assessment (BHRA).
- **Section 2 – Remedial Action Objectives.** This section describes the development of remedial action objectives (RAOs) for groundwater, identifies ARARs; and presents site-specific RGs.
- **Section 3 – Identification and Screening of Technologies and Institutional Controls:** This section presents remedial technologies and institutional controls (ICs)

that address the COCs and ARARs for groundwater, and evaluates the technologies and ICs against site-specific parameters.

- **Section 4 – Development and Screening of Alternatives:** This section assembles the technologies and ICs into alternatives, and evaluates the alternatives against qualitative screening criteria including effectiveness, implementability, and cost.
- **Section 5 – Detailed Analysis of Alternatives.** This section presents the detailed analysis of alternatives against the evaluation criteria defined by EPA in the *Guidance for Conducting Remedial Investigation and Feasibility Studies under CERCLA* (EPA, 1988). This section also includes a comparative analysis of alternatives.
- **Section 6 – References:** Reference documents referred to in this FFS are listed.

1.2 BACKGROUND INFORMATION

This section provides brief descriptions of the Site and of cleanup activities implemented at the Site. Information on the hydrogeology, the nature and extent of contamination, contaminant fate and transport, risks associated with the contaminants in the groundwater, and the CSM are also discussed in this section.

1.2.1 Site Description

The CTS Printex Superfund Site is located in the northern part of Mountain View, California; San Francisco Bay is approximately 2.5 miles to the north of the Site (Figure 1-1). The former CTS Printex manufacturing facility occupied approximately 5.3 acres on property bounded on the north by Plymouth Street; on the northeast by the Bayshore Freeway (U.S. Highway 101); on the east by Permanente Creek (an enclosed culvert); on the south by Colony Street; and on the west by Sierra Vista Avenue.

Buildings associated with the former CTS Printex facility were located at 1904, 1940, and 1950 Colony Street, and 1905, 1911, 1921, and 1931 Plymouth Street. The ROD contains detailed descriptions of the buildings and their use at the facility (EPA, 1991). The neighborhood of the former facility is currently developed, consisting of commercial, light industrial, and residential buildings.

1.2.2 Site History

Printex manufactured circuit boards at the Plymouth Street/Colony Street facility from 1970 to 1981, leasing the property from ADN Corporation, the titled property owner. In 1981, Printex was acquired by CTS Corporation, forming a new company called CTS Printex, Inc. (CTS Printex). CTS Printex continued manufacturing operations at the facility. Prior to 1970, the property was reportedly open undeveloped land (EPA, 1991).

In the mid-1980s, CTS Printex voluntarily initiated site closure activities, including demolition of buildings and other structures related to manufacturing and waste processing; removal of sludges and process debris; removal of contaminated soil; and construction, operation, and maintenance (O&M) of a groundwater extraction system that extracted shallow groundwater and directly discharged the water to the local sanitary sewer. The State of California Department of Health Services (DHS) certified closure of the former CTS Printex manufacturing facility in 1986. The State of California Regional Water Quality Control Board, San Francisco Bay Region (RWQCB) subsequently issued cleanup and abatement orders (CAOs) to CTS Printex to assess the extent of contaminated groundwater and to implement cleanup actions.

EPA placed the CTS Printex facility on the National Priorities List (NPL) in February 1990. RWQCB issued CAO No. 90-14 in November 1990 that stipulated continued O&M of the groundwater extraction system. RWQCB subsequently issued Final Site Cleanup Requirements (SCRs) Order No. 91-081 that included groundwater monitoring and establishing a deed restriction on the property to prevent use of groundwater for drinking water. The ROD issued by EPA in June 1991 reinforced CAO 90-14 by selecting continued operation of seven active extraction wells, with direct discharge to the sanitary sewer, until cleanup levels were achieved.

Groundwater extraction occurred from 1986 to 1996, and was reportedly effective in removing COC mass and reducing concentrations of dissolved-phase COCs (CSS and Geosyntec, 2007). Groundwater extraction ceased in 1996, with acceptance from RWQCB, due to contaminant concentrations reaching asymptotic levels (EPA, 1999b).

In 2005, EPA commented on the second 5-year review, recommending that a ROD amendment be prepared to include ICs prohibiting the use of groundwater and to evaluate potential VI risk (EPA, 2005). In 2006, EPA assumed lead regulatory status from RWQCB.

1.2.3 Hydrogeology and Nature and Extent of Contaminants

1.2.3.1 Hydrogeology

Two major water-yielding units underlying the Site include a shallow aquifer (75 feet thick) and a deep aquifer, separated by an aquitard which is approximately 50 feet thick. Three shallow aquifer zones have been identified, designated as the A, B, and intermediate zones. The A zone has its upper boundary at approximately 10 feet below ground surface (bgs) with the lower boundary at approximately 20 feet bgs. The B zone lies between approximately 30 and 40 feet bgs, and the intermediate zone between 60 and 75 feet bgs (EPA, 1991). The A and B zones are hydraulically connected - no continuous aquitard separating the A and B zones was observed either during the previous investigations (ATT, 1991) and recent supplemental RI (ITSI, 2011a).

COCs at the Site were found only in the A and B zones (ATT, 1991). Groundwater monitoring of wells screened in the intermediate zone was discontinued after 2000 (RWQCB, 2005) because the COCs were either not detected or the few detected concentrations were significantly below the groundwater cleanup criteria. The RI investigations in 2010 did not include sample collection from the intermediate zone.

Groundwater flow within the shallow A and B zones is generally to the northwest, consistent with the regional flow direction towards San Francisco Bay (EPA, 1991). A similar flow direction was observed during the recent investigations (CSS 2011 and ITSI, 2011a).

1.2.3.2 Nature and Extent of Contamination

The COCs identified in the ROD (EPA, 1991) consisted of the following chemicals: 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethane (1,2-DCA); trans-1,2-dichloroethene (t-DCE), tetrachloroethene (PCE); toluene; 1,1,1-trichloroethane (1,1,1-TCA), trichloroethene (TCE); methylene chloride (MeCl); chloroform (CHL); and benzene (BZ).

Cleanup levels for groundwater established in the ROD were the federal maximum contaminant level goal (MCLG), unless the MCLG was equal to zero; the federal maximum contaminant level (federal MCL); or the California MCL, whichever was most stringent. The cleanup goals for the COCs are listed in Table 2-1.

Based on groundwater monitoring data from 2009 and 2010, COCs present at concentrations above federal or state MCLs are listed in Table 2-2, along with the basis for the chemical being identified as a COC. While cis-1,2-dichloroethene (cis-1,2-DCE) was mentioned in the ROD, cis-1,2-DCE was not specifically listed as a COC.

Pre-Remediation Conditions: Prior to initiation of groundwater extraction in 1986, the VOC plume extended in the shallow groundwater to the east side of the Bayshore Freeway and vertically into both the A and B zones (Figures 1-2 and 1-3, respectively). Due to the estimated extent of TCE-impacted groundwater within the A zone prior to groundwater extraction, wells 23W, 33W, and 34W were installed in 1987. The highest historical concentration of TCE in the A zone was detected in groundwater from monitoring well 12W, located approximately 200 feet directly downgradient of the former CTS Printex facility, and with a TCE concentration of 1,500 micrograms per liter (µg/L) (CSS, 2011).

TCE in groundwater within the B zone extended north an estimated 500 feet from the former CTS Printex facility, to just beyond the eastern side of Highway 101, as shown on Figure 1-3 (pre-groundwater extraction period 1985/1986). The highest reported concentration of TCE within the B zone was detected in monitoring well 8W at 7,500 µg/L (CSS, 2011).

Impact of Groundwater Extraction from 1987 to 1996: Groundwater extraction removed about 99 pounds of TCE and reduced the areal extent of the TCE plume in the A and B zones (CSS and Geosyntec, 2007). By 1996, TCE concentrations had generally stabilized and reached asymptotic levels, leading the RWQCB in 1996 to permit the extraction system to be shut down (EPA, 1999b).

In the A zone, TCE remained above the cleanup level in monitoring wells 7W, 12W, 17W, 20W, 23W, 33W, 34W, and 38W as shown in Figure 1-2 (groundwater extraction 1996 final period), with a maximum of 77 µg/L in monitoring well 12W. In the B zone, TCE remained above the cleanup level in monitoring wells 8W, 14W, and 15W as shown in Figure 1-3 (groundwater extraction 1996 final period), with a maximum of 35 µg/L in 14W. Other chlorinated aliphatic hydrocarbon (CAHs) were also significantly reduced, with cis- and trans-1,2-DCE, 1,1-DCE, and 1,1-DCA concentrations decreasing below their respective cleanup levels in many of the monitoring wells in both the A and B zones. Exceedances of the groundwater cleanup level for more than one of the CAHs included monitoring wells 7W, 12W, 17W, 20W, 23W, and 33W.

Post-Remediation Conditions: The trend in TCE concentrations based on monitoring events at the Site indicates that, following an initial increase after pumping ended, a general decline in concentrations occurred in most wells, with a slight increasing trend in monitoring well 22W located at the downgradient edge of the B zone plume. TCE plume extents based on data gathered during years 2000, 2005, and 2010 are shown on Figures 1-4 and 1-5 for the A and B zones, respectively.

The initial “rebound” suggests that residual CAHs remained sorbed to the saturated zone soil. The subsequent declining trend suggests that natural attenuation is affecting the concentration and distribution of TCE in the groundwater. These natural attenuation processes may include volatilization and biotic transformation. Figures 1-6 and 1-7 illustrate the 2010 TCE plumes for the A and B zones, respectively. Trend graphs showing TCE and 1,2-DCE concentrations over time since shut down of the groundwater extraction system are presented in Appendix G.

TCE in samples collected from well 17W have declined since shut down of the extraction system (see Figure G-1 in Appendix G); however, elevated concentrations remain, indicating possible residual COC mass in the saturated soils near the well. This was reinforced by the results of the membrane interface probe (MIP) survey in the area of 17W, which identified a mass of residual VOC contamination and potential hydraulic connection between the A and B zones just north of 17W (ITSI, 2011a). The presence of this residual contaminant mass could also account for the trend in TCE concentrations in monitoring well 22W (see Figure G-2 of Appendix G), screened in the B zone and located downgradient of this residual mass. The results from the MIP survey suggest that the downgradient portion of this residual CAH mass may extend under an existing building at 935 Sierra Vista Avenue located approximately 60 feet northwest of well 17W.

Table 1-1 provides a summary of the COCs in groundwater during a comprehensive sampling of available monitoring wells and of temporary wells installed in 2010 as part of the supplemental groundwater investigation. Vinyl chloride was added to the analytical list because this chemical is a daughter product of the biological transformation of TCE and 1,2-DCE under anaerobic conditions. A total of 16 existing monitoring wells and 23 temporary wells were sampled, and two grab samples were collected during the MIP investigation.

TCE has been the primary CAH reported to exceed its remedial action objective (RAO), as established in the ROD (EPA, 1991). Eight of the VOCs listed in Table 1-1 were detected in groundwater samples from existing monitoring wells and/or temporary wells. Based on the 2010 groundwater data shown in Table 1-1, five VOCs in shallow groundwater at the Site are present at levels above their individual, cleanup level or current MCL: TCE, cis-1,2-DCE (mentioned in the ROD but not specifically identified as a COC), trans-1,2-DCE, 1,1-DCE, and 1,1-DCA. The VOCs that exceeded their individual, cleanup level in the most monitoring wells at the Site were TCE and 1,2-DCE. Vinyl chloride, when detected in shallow groundwater, has been at concentrations below its MCL (0.5 μg/L). Recent monitoring data indicate that the plume extent is generally stable, with COC concentrations showing a declining concentration trend in most wells.

Two wells, 15W and 16W, were destroyed in 2007 due to re-development of the former CTS Printex property. These wells were replaced in 2010 at locations approximately 80 feet south of their former locations as shown on Figures 1-6 and 1-7 for wells 16WR and 15WR, respectively. The replacement Well 16WR is screened in the A zone, while replacement well 15WR is screened in the B zone.

Private Wells: Privately owned wells have been identified near the Site. EPA obtained the names of the owners of these private wells from the Santa Clara Valley Water District (SCVWD). Information obtained by EPA from contacting the well owners is that none of these wells are currently used for drinking water supply. While last used as an irrigation water supply source, information obtained to date by EPA indicates that most, if not all, of these privately owned wells are inactive. The private wells are located outside the extent of the impacted groundwater associated with the Site, but some wells are not far downgradient from the extent of the plume. To date, these wells have not been monitored for the chemicals of concern associated with the Site.

1.2.4 Contaminant Fate and Transport

As described in the Supplemental RI (ITSI, 2011a), the COCs at the Site that currently exceed their respective cleanup levels are all in the class of compounds known as chlorinated aliphatic hydrocarbons (CAHs). A detailed description of how these CAHs behave when released to groundwater is also found in the Supplemental RI (ITSI, 2011a). Properties of the CAHs associated with the Site are listed in Appendix E, Table E-1.

The nature and extent of contaminants in groundwater at the Site indicate that the CAHs are presently sorbed to the saturated zone soils, in soil gas, and dissolved in groundwater. Of these, the dissolved-phase CAHs would account for the greatest mobility of the contaminants through the environment. Based on the dissolved concentrations observed at the Site since the discontinuation of groundwater extraction, groundwater concentrations do not indicate the presence of non-aqueous phase liquids (NAPL). These fate and transport factors contribute to the generally declining trends in TCE (see Appendix G). The declining concentration trends for TCE are also indicators that natural attenuation is occurring in shallow groundwater at the Site.

1.2.4.1 Biological (Biotic) and Chemical (Abiotic) Transformations

The CAHs are subject to both biotic and abiotic transformations, with the resulting formation of other chlorinated and non-chlorinated products commonly referred to as “daughter products”. Figure 1-8 shows the abiotic and biotic transformations of CAHs associated with the Site. Due to the slow rate of groundwater flow, abiotic or chemical transformations of some CAHs can occur (McCarty, 1996).

Biotic Transformations: Biotic transformation under anaerobic conditions is the expected dominant transformation mechanism for the CAHs at the Site. As shown on Figure 1-8, CAHs in groundwater are subject to reductive dechlorination under anaerobic conditions. Table 1-2 identifies the oxidation-reduction potential (ORP) or redox conditions associated with reductive dechlorination. Optimum conditions for reductive dechlorination are associated with the redox conditions for sulfate and carbon dioxide reduction.

During the groundwater sampling and site investigations conducted in 2010 (ITSI, 2011a), the ORPs measured in the groundwater monitoring wells ranged from 235 millivolts (mV) for well 23W to 8.5 mV for well 17W. The measured ORPs in the temporary wells installed for a one-time sampling were consistently negative, with -430 mV as the lowest reading in temporary well TW2-D1. These data demonstrate that although groundwater in dedicated wells may not show highly reducing conditions, micro-environments in the saturated zone can be suitable for reductive, biotic transformations.

The biotic transformation by reductive dechlorination of chlorinated ethenes, as shown on Figure 1-8 for tetrachloroethene (PCE) and TCE, is likely responsible for the formation of cis-1,2-DCE and trans-1,2-DCE from TCE at the Site. An example where reductive dechlorination may be occurring at the Site can be seen in the historic data for monitoring well 39W. From 1992 to 1997, TCE concentrations were slowly decreasing while 1,2-DCE concentrations were slowly increasing. The decreasing TCE/1,2-DCE ratio suggests the occurrence of biotic transformation. Other examples are indicated by the trend plots for the A and B zones, shown in Appendix G.

Reductive dechlorination of the more chlorinated compounds (PCE and TCE) occurs more readily than the less chlorinated compounds (DCE and vinyl chloride), thus, DCE and vinyl chloride may accumulate in anaerobic environments (EPA, 2000). This appears consistent with recent conditions at the Site where 1,2-DCE was reported in some groundwater samples in 2010 at concentrations greater than TCE, and only very low levels of vinyl chloride were detected.

To achieve significant reductive, biotic transformation of the CAHs, the following conditions are needed in groundwater: (1) an anaerobic environment with the low oxidation-reduction potential associated with sulfate reduction and methane fermentation, and (2) the presence of sufficient organic material in the groundwater for production of dissolved hydrogen.

Abiotic Transformations: Among the Site COCs, 1,1,1-TCA is the only COC considered subject to abiotic transformation (see Figure 1-8). This abiotic transformation is associated with the formation of 1,1-DCE from 1,1,1-TCA (Vogel et. al., 1987).

1.2.5 Baseline Risk Assessment

A baseline public health evaluation was conducted by ATT (1991), and a baseline health risk assessment (BHRA) was conducted in 2006 (Geosyntec, 2006). Chlorinated ethenes, notably TCE and 1,2-DCE, are the primary COCs currently detected in groundwater at concentrations above their respective MCL. The potential risk to human health associated with these COCs in groundwater results from ingestion or vapor intrusion. The evaluation of the potential vapor intrusion risk and appropriate mitigation measures were previously identified in the supplemental RI (ITSI, 2011a) and Part 1 of this FFS (ITSI, 2011b). Consistent with the 1991 ROD, cleanup criteria based on achieving CAH concentrations at or below the applicable federal or state MCL (whichever is lower) will address the potential risk from vapor intrusion and ingestion of groundwater. As shallow groundwater at the Site is not being used as drinking water, there is no current risk to human health associated with groundwater ingestion.

1.2.5.1 Time Frame to Achieve Groundwater Cleanup Criteria

Modeling was performed to estimate the time required for TCE in shallow groundwater at the Site to reach its MCL through natural attenuation. Being the primary COC, the modeling was based on TCE concentration distribution at the Site. In addition, the modeling of TCE migration and decay were modeled separately for the A and B zones. Details of the modeling are presented in Appendix A and are summarized below. Groundwater data from the first quarter 2010 groundwater sampling event (ITSI, 2011a) were the inputs to the model.

The BIOCHLOR version 2.2 spreadsheet model (USEPA, 2000, 2002) was used to estimate the time frame. BIOCHLOR is a screening model that predicts the natural attenuation of chlorinated solvents through sequential decay. The model allows for three-dimensional dispersion, one-dimensional advection, linear adsorption, and biotransformation by means of reductive dechlorination modeled by a sequential first-order decay process. The modeling used groundwater concentration data from the groundwater monitoring performed during the first quarter of 2010 as part of the Supplement RI investigations (ITSI, 2011a). Specifics of source input to the model are identified in Appendix A. Based on the TCE concentration data input and using the BIOCHLOR calibration tool for this site-specific data, the first order decay coefficient for TCE was 0.053 $year^{-1}$. BIOCHLOR, like other groundwater models, does not fully account for site-specific heterogeneity in soil properties, diffusion and mass transfer variability, extent of sorption, and other factors contributing to CAH fate and transport in the shallow groundwater at the Site.

As a check on the BIOCHLOR modeling predictions, the REMChlor model (EPA, 2007) was used. REMChlor results were similar to the BIOCHLOR time frame predictions for natural attenuation, so the BIOCHLOR results were used as the basis for the estimated time frame to achieve groundwater cleanup criteria based solely on natural attenuation processes.

Based on the model predictions, TCE is anticipated to persist at the Site at a concentration above its MCL of 5 µg/L for over 100 years in the A zone and almost 70 years in the B zone. The model indicates that the residual CAH mass in the vicinity of well 17W is a key factor in the estimated time frames required to achieve groundwater cleanup criteria for TCE and other CAHs in the shallow groundwater through natural attenuation.

1.2.6 Conceptual Site Model (CSM)

A description of the updated conceptual site model (CSM) is included in the Supplemental RI (ITSI, 2011a). Specific to the groundwater portion of the Site and at the request of EPA, groundwater samples from selected wells that historically had the highest TCA concentrations were analyzed in 2010 for 1,4-dioxane, a stabilizer compound present in 1,1,1-TCA that was used as a chlorinated solvent. 1,4-dioxane was not detected above the reporting limit of 0.8 µg/L (CSS, 2011). Prior to 2010, groundwater monitoring had not included analysis for 1,4-dioxane.

The following are the key results from the risk assessment and updated CSM:

- While shallow groundwater (A and B zones) has low CAH concentrations, several chemicals have concentrations above their applicable MCL.
- The shallow groundwater plume is stable.
- The primary CAH contaminants in the shallow groundwater are TCE and 1,2-DCE.
- An area of residual contaminant mass is located near well 17W and at depths of 15 to 30 feet bgs. This residual mass is the main reason for the projected time frames reported in Section 1.2.5.1, and therefore a key driver for evaluating shallow groundwater remediation at the Site.

- Natural attenuation processes are occurring, with biotic transformations of TCE to 1,2-DCE and vinyl chloride.

2.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

This section presents applicable or relevant and appropriate requirements (ARARs), remedial action objectives (RAOs), and remedial goals (RGs) for groundwater at the Site. The RAOs were developed based on action-, location-, and chemical-specific federal and state ARARs, as well as on appropriate federal, state, and local criteria, community and other advisories, guidance, and proposed standards (i.e., To Be Considered [TBC] criteria). RAOs are also based on site-specific human health and environmental concerns identified in the baseline BHRA previously discussed (Section 1.2.5).

2.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

Section 121(d) of CERCLA states that remedial actions at Superfund sites must attain (or the decision document must justify the waiver of) any federal or more stringent state environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate. This section identifies the potentially applicable or relevant and appropriate requirements (ARARs) with regard to this Site's vapor intrusion evaluation.

"Applicable requirements" are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address the circumstance at a CERCLA Site. An applicable federal requirement is an ARAR. An applicable state requirement is an ARAR only if it is more stringent than federal ARARs.

If the requirement is not legally applicable, then the requirement is evaluated to determine whether it is relevant and appropriate. "Relevant and appropriate requirements" are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable, address situations or problems similar to the circumstances of the proposed response action and are well suited to the conditions of the site. A requirement must be determined to be both relevant and appropriate in order to be considered an ARAR.

An ARAR may be either "applicable" or "relevant and appropriate," but not both. Identification of ARARs must be done on a site-specific basis and involve a two-part analysis: first, a determination whether a given requirement is applicable; then, if it is not applicable, a determination whether it is nevertheless both relevant and appropriate. When the determination is that a requirement is both relevant and appropriate, such a requirement must be complied with to the same degree as if it were applicable.

Non-promulgated advisories or guidance issued by federal or state governments are not legally binding and do not have the status of ARARs. Such guidelines may, however, be useful, and are "to be considered" (TBC), pursuant to 40 CFR §300.400(g)(3). These requirements complement ARARs but do not override them. They are useful for guiding decisions regarding cleanup levels or methodologies when regulatory standards are not available. However, if incorporated into a ROD, then TBCs become legally binding.

ARARs are generally divided into three categories: chemical-specific, location-specific, and action-specific requirements. Chemical-specific ARARs are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. Location-specific ARARs set restrictions on certain types of activities based on characteristics of the site locale. Action-specific ARARs are technology- or activity-based requirements or limitations for remedial activities. These requirements are triggered by the particular remedial activities conducted at the site.

The potential ARARs and TBCs identified for groundwater remediation at the Site are discussed below. The discussion of the potential ARARs is relative to the development of remedial alternatives. The final ARAR determination will be made when a remedy for the Site is selected in the planned ROD amendment.

2.1.1 Chemical-specific ARARs

Safe Drinking Water Act: The Safe Drinking Water Act (SDWA) establishes national primary drinking water standards, referred to as maximum contaminant levels (MCLs), to project the quality of water in public water systems. MCLs are enforceable standards and represent the maximum contaminant concentrations permissible in drinking water delivered to the public. SDWA also requires monitoring to determine compliance with the MCLs.

California drinking water standards, under the SDWA, establish primary MCLs for contaminants that cannot be exceeded in public water systems. If a California drinking water MCL is more stringent than a federal MCL for a specific COC, then the more stringent of the state or federal MCLs was chosen as the potential ARAR. The MCLs for COCs at the Site are listed in Table 2-4. The MCLs are potentially relevant and appropriate to this remedy.

State Water Resources Control Board (SWRCB) Resolution 68-16 (Anti-degradation Policy): This resolution requires the continued maintenance of high-quality for waters of the State. Water may not be allowed to be degraded below what is necessary to protect the "beneficial uses" of the water source. Beneficial uses of groundwater at the Site are identified in the RWQCB's Basin Plan. SWRCB Resolution 68-16 is potentially applicable.

SWRCB Resolution No. 92-49, III-G: This resolution requires clean-up that abates the effects of discharges so that receiving waters attain either background water quality or the best water quality, whichever is reasonable. Similar to SWRCB Resolution 68-16, this resolution has the objective of maintaining high-quality waters of the State. SWRCB Resolution No. 92-49, III-G is potentially relevant and appropriate.

RWQCB's Basin Plan: The State of California established water quality objectives for the protection of groundwater (and surface water) under the Porter-Cologne Water Quality Control Act. For the Site, these water quality objectives were established by the San Francisco Bay RWQCB. The Basin Plan, latest amendments dated December 31, 2010, established drinking water source as a beneficial use for groundwater at the Site. The Basin Plan states that:

- "All groundwater shall be maintained free of organic and inorganic chemical constituents in concentrations that adversely affect beneficial uses".
- "At a minimum, groundwater designated for use as a domestic or municipal supply shall not contain concentrations in excess of the maximum (MCLs) or secondary maximum contaminant levels."

The substantive provisions of the RWQCB's Basin Plan, Chapters II and III are potentially applicable.

2.1.2 Location-specific ARARs

None identified.

2.1.3 Action-specific ARARs

National Pollution Discharge Elimination System (NPDES) Permit Program: The remedy included in the 1991 ROD had discharge of extracted groundwater to the sanitary sewer. Some of the considered groundwater cleanup alternatives will include discharge of the extracted groundwater to the sanitary sewer for treatment at the City of Mountain View's municipal wastewater treatment facility. This treatment facility has a NPDES permit in accordance with 40 CFR Part 122 to cover the discharge of treated water. The NPDES Permit Program is potentially relevant and appropriate.

Hazardous Waste Management: EPA has authorized California to implement its own hazardous waste program which includes the provisions of RCRA and California-specific hazardous waste management requirements. If hazardous wastes are generated as part of remedial actions for shallow groundwater, the relevant provisions of the state statutes and regulations (California Hazardous Waste Control Act and Title 22, California Code of Regulations §§66261.1 to 66262.127, §66261.24 Table III, §§66264 et seq. and 66265 et seq.) are treated as the hazardous waste management requirements and compliance with California requirements would mean compliance with RCRA. In addition, California Health and Safety Code §§25100-25395 establish standards for handling hazardous waste. While a possibility, hazardous wastes are not expected to be generated for the shallow groundwater cleanup remedy. The substantive provisions of the States Hazardous Waste Control Act are potentially relevant and appropriate.

Clean Water Act 402(p): This portion of the Clean Water Act (CWA) establishes requirements for storm water management. Storm water discharges will need to comply with requirements during the period of groundwater remediation. CDA 402(p) is potentially relevant and appropriate.

California Well Standards: Bulletin 74-90 and 74-81, adopted pursuant to California Water Code Section 13800 establish minimum standards for extraction and monitoring well construction. The Santa Clara Valley Water District enforces the California Well Standard for the Site. California Well Standards are potentially applicable.

Waste Discharge Requirements: Injection of chemicals as part of a remedial action to cleanup groundwater is regulated by California Water Code, Section 13260. To ensure that the injected chemical(s) or by-products of the injection do not have an adverse impact on groundwater, waste discharge requirements are established to control the injection. For in-situ groundwater remediation, the RWQCB will prescribe general waste discharge requirements (WDRs) for discharges associated with chemical injection for the cleanup of groundwater. To implement remedial alternatives that include in-situ biological, chemical, and physical treatments to cleanup contaminants in groundwater, the RWQCB will need to approve WDRs specific for the method of in-situ groundwater remediation. Pursuit to Section 13263(a) of the California Water Code, WDRs must implement the Basin Plan and are applied for in-situ groundwater remediation in order to achieve water quality for the designated beneficial use(s) of the groundwater. Section 13263(a) of the California Water Code is potentially relevant and appropriate.

Environmental Restriction Covenants: Land use covenants under California Civil Code § 1471(a) include environmental restriction covenants. This statutory provision sets the requirements for an environmental restriction covenant in California and is potentially relevant and appropriate.

Other action-specific ARARs (e.g., excavation, treatment, and disposal of soil; discharge to surface water; and chemical storage of potentially dangerous chemicals) are not anticipated for groundwater cleanup.

2.2 REMEDIAL ACTION OBJECTIVES FOR GROUNDWATER

As defined in EPA guidance (EPA, 1988), RAOs are goals for protecting human health and the environment, and should specify the following elements:

- COCs,
- Exposure routes/receptors, and
- An acceptable contaminant level or range of levels for each exposure route

Based on the site characterization information, the COCs, exposure routes, and receptors described in earlier sections, the proposed RAOs for groundwater at the Site are described below.

- Achieve drinking water standards (i.e., MCLs), as the RWQCB's Basin Plan has designated drinking water as a potential beneficial use for groundwater at the Site.
- Accelerate the reduction of vapor intrusion (i.e., Site COCs in shallow groundwater and soil gas) to levels that are protective of current and future building occupants, such that the need for a vapor intrusion remedy would be minimized or no longer necessary.

2.3 SITE-SPECIFIC REMEDIAL GOALS

Site-specific RGs for the COCs and COPCs at the Site were developed by selecting the most stringent of the following:

- Federal MCLs for drinking water,
- California MCLs for drinking water,
- Federal MCLGs (if not equal to zero).

The groundwater RGs are listed in Table 2-3, along with their basis. As previously discussed, the 1991 ROD did not list, cis-1,2-DCE or vinyl chloride among the chemicals to be monitored in groundwater; however, these substances were included here because they are recognized daughter products of TCE and have been detected in groundwater samples collected at the Site (ITSI, 2011a).

The COC list for the Site should be amended to include cis-1,2-DCE and vinyl chloride for the following reasons:

- Reductive dechlorination of TCE is occurring, and cis-1,2-DCE is the primary product formed.
- The MCL for cis-1,2-DCE (6 µg/L) is different than the MCL for trans-1,2-DCE (10 µg/L). Monitoring for 1,2-DCE needs to quantify the concentrations of cis-1,2-DCE and trans-1,2-DCE to enable determination of compliance with the drinking water cleanup levels.
- Vinyl chloride is a reductive dechlorination product of both TCE and 1,2-DCE (cis or trans). With the low MCL for vinyl chloride, 0.5 µg/L, groundwater monitoring needs to confirm that vinyl chloride concentrations remain below its MCL.

Table 2-3 presents the recommended list of COCs for the Site. Identified in Table 2-3 are COCs that are at concentrations below the groundwater cleanup level.

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3.0 SCREENING OF REMEDIAL TECHNOLOGIES AND ICS FOR GROUNDWATER

In this section, general response actions and potential technologies and process options are discussed. ICs that are appropriate for protection of human health and/or the environment, or necessary to conduct groundwater remediation are also described and screened. The ICs and technologies were screened with regard to feasibility, implementability, and cost.

3.1 GENERAL RESPONSE ACTIONS FOR GROUNDWATER

General response actions are broad categories of media-specific remedial actions that are intended to satisfy the RAOs. For this analysis, the general response actions were evaluated on their ability to reduce, eliminate, and/or limit the toxicity, mobility, or volume of the Site-specific COCs in groundwater.

3.1.1 General Response Actions Applicable to Groundwater at the Site

No Action: No action means no further remedial activities.

Institutional Controls: These actions include administrative actions that protect human health and the environment. EPA recognizes the following general types of ICs: (1) government controls, (2) proprietary controls, (3) enforcement and permit tools, and (4) information devices. ICs examples include recorded land use restrictions, permitting requirements, and/or zoning requirements restricting groundwater use within the boundaries of the groundwater plume.

Monitoring: This action involves monitoring of groundwater to assess changes in concentrations and/or extent (lateral and vertical) of the COCs. Although there are different methods of groundwater monitoring, this general response action is commonly included with any groundwater remediation alternative.

Containment: This action involves technologies that reduce the mobility of COCs, eliminate the exposure pathways, or limit the migration of COCs in impacted groundwater to areas of non-impacted groundwater. For groundwater, the aim would be to prevent further lateral or vertical migration of the plume.

Active In-Situ Treatment: These actions include technologies applied directly to the saturated zone to destroy COCs in-place, and do not involve removal of impacted groundwater for aboveground treatment. Active in-situ treatment can include a variety of thermal, biological, and/or chemical technologies capable of destroying or removing the COCs in groundwater.

Passive In-Situ Treatment: These actions involve technologies that result in biological degradation or chemical destruction of COCs in groundwater using options that rely on groundwater flow direction or velocity. The controlling factor on the time frame for groundwater remediation by passive in-situ treatment is the rate of groundwater movement through the established treatment zone.

Hydraulic Control: Hydraulic control captures groundwater and prevents further off-site migration. The action includes technologies that physically remove groundwater from the subsurface; treat the water by physical, chemical, and/or biological processes; and discharge the water in accordance with local laws and regulations.

3.1.2 Response Actions Not Considered Applicable for Groundwater

General response actions for soil gas are being considered separately in Part 1 of this FFS (ITSI, 2011b). Source removal was previously implemented as part of site closure activities that were accepted by California DHS.

3.2 SCREENING PROCESS

ICs and remedial technologies, including treatment process options, were identified and screened against the broad criteria of effectiveness, administrative implementability, and cost, as described below.

3.2.1 Effectiveness

In assessing effectiveness, the following factors were considered:

- Potential effectiveness of each process option in remediating groundwater at the Site to standards that are consistent with the RAOs for protection of human health and the environment.
- Potential effects on human health and the environment during the construction and implementation phase.
- Reliability and proven history of the technologies or process options in addressing Site-specific contaminants and conditions.

Effectiveness of each IC and technology (and/or process option) was rated qualitatively as low, moderate, or high.

3.2.2 Implementability

Implementability encompasses both the technical and administrative feasibility of implementing an IC, a technology, or a process option. Technologies and options that are clearly ineffective or technically not applicable to the Site-specific conditions are eliminated in the primary screening. In the secondary screening, the emphasis is on the institutional or administrative aspects of implementability. Screening may consider the availability of services; capacity for treatment, storage, and disposal; and the availability of necessary equipment and skilled workers to implement the technology. Implementability of each IC and technology (and/or process option) was rated as low (relatively difficult), moderate, or high (relatively easy).

3.2.3 Cost

Cost plays a qualitative role in the screening of technologies and process options. Relative estimates of costs for capital improvements and O&M rather than detailed estimates were used for comparing the technologies/process options. Relative cost comparisons were based on professional experience and judgment. Costs for ICs and technologies, including process options, were rated as low, moderate, or high.

3.3 SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

In this section, remedial technologies (including treatment process options) for the general response actions discussed in Section 3.1 are evaluated with respect to the Site-specific conditions and screened against the criteria defined in Section 3.2. Screening of ICs is presented in Section 3.4.

No Action. In accordance with EPA guidance, a no-action option was carried through the FFS process as a baseline for comparison. No action is retained as a default option in accordance with FS guidance, and is not discussed explicitly in the screening process.

The no-action option assumes that no remedial activities will be conducted at the Site to improve groundwater quality or to achieve RAOs. The no-action option also assumes that the future Site conditions will be consistent with current conditions.

Slurry Wall/Sheet Piles. A slurry wall and/or sheet piles would be placed around selected areas and/or at the boundaries of the plume to prevent and contain migration of CAH-contaminated groundwater. One process option is to only apply this technology to areas with residual CAH mass within the A and/or B Zones. Due to desorption from these areas with residual CAH mass, currently detected COCs are continuously being released into the dissolved phase. This results in the lateral movement of the plume and/or increases of COC concentrations at down-gradient locations. To achieve contaminant containment, this technology has to extend sufficiently deep so that the base of the containment system ties into a low permeability layer in the saturated zone. In addition, groundwater extraction within the containment boundaries will be needed to maintain a hydraulic balance between the interior and exterior of the contained area.

Effectiveness: To be effective the containment system, whether a slurry wall or sheet piles, would have to be anchored in a continuous soil formation with low-permeability properties. This technology would not reduce the residual mass of CAH contamination in groundwater associated with the A and B Zones. This technology would have to be combined with groundwater extraction. **Rating: Low to Moderate**

Implementability: Installation would require anchoring of the slurry wall/sheet piles at depths below the B Zone. Due to the existing development at the Site, it would be relatively difficult to implement sufficient excavation and installation of slurry wall/sheet piles so that the containment system is properly anchored to a low permeability soil layer deeper than the B Zone depths of 40 feet bgs. **Rating: Low (relatively difficult).**

Cost: Construction of slurry wall/sheet pile under the Site-specific conditions would be high. **Rating: High.**

Screening Summary: Not retained. This technology would not be feasible to implement, considering the soil properties, current land occupancy (business and residential buildings), and nearby Highway 101. Groundwater extraction would also be required to maintain hydraulic balance, and previous experience has demonstrated that groundwater extraction is not effective in removing the residual mass of CAHs in groundwater within the containment zone.

Dual-Phase Extraction. Dual-phase extraction (DPE) involves the removal of soil vapor and groundwater by applying vacuum to a well that is screened across the vadose zone and the groundwater table. Soil vapor and groundwater would be simultaneously extracted within a screened well by using a blower to apply vacuum. An alternative approach would be to use a pump to extract the groundwater, using the applied vacuum to only remove soil vapor. The removal of groundwater would cause a drawdown in the water table creating a cone of depression around the extraction well. The void volume previously occupied by groundwater then would be available for vapor extraction. The applied vacuum would induce removal of VOCs dissolved in extracted groundwater, in the exposed soil vapor from the vadose zone, and in the void pore space created by the groundwater extraction. Extracted soil vapor and groundwater would be separated in a knockout tank. The extracted soil vapor and groundwater would be treated in an above-ground facility and discharged to the environment or to a permitted treatment facility.

Effectiveness: The overall effectiveness is limited by the extent that the water table can be lowered so that groundwater can be extracted. Subsurface heterogeneity and the density of the CAHs being heavier than water are influencing factors. Groundwater extraction to dewater and achieve depths associated with the residual mass of CAHs would be difficult at the Site, thereby minimizing the ability to induce vapor flow and remove adsorbed-phase COCs in hard-to-reach pore spaces (deeper depths and/or finer grained soils). **Rating: Low to Moderate.**

Implementability: Installation of the extraction system does not require a large area of support for small zones of treatment. Applying this technology to the entire groundwater plume would be difficult. For small treatment areas, the DPE system can be mobile and operated from a system mounted on a truck or trailer. **Rating: Low (relatively difficult for entire plume to Moderate for localized areas.**

<u>Cost</u>: Costs associated with the installation of additional vapor extraction wells and management of relatively high volume of extracted water would contribute to the overall cost of this option, especially with respect to cost per unit of contaminant mass removed. **Rating: High.**

<u>Screening Summary</u>: **Not retained.** The subsurface of the Site is highly heterogeneous. The residual VOC mass is sorbed in fine grained layers (i.e. silts and clays) and at depths sufficiently below the water table. Thus, this technology is not cost-effective for the removal of the residual CAH contamination in groundwater.

In-Situ Thermal Remediation with Vapor Extraction. In-situ thermal remediation (ISTR) involves heating the shallow, saturated zone to high temperatures (around 100 °C for CAHs) to induce volatilization of the contaminants. Volatilized contaminants would be captured by a vapor extraction system, and the vapors treated above- ground prior to discharge to the environment in accordance with local laws and air quality regulations. The combined application of ISTR with soil vapor extraction would reduce the expected duration of treatment (anticipated to be less than a year) compared to other in-situ technologies. Several case studies have shown that the application of ISTR with vapor extraction results in more than 99% removal of VOC mass. ISTR is equally applicable for mass removal from both soil and groundwater.

<u>Effectiveness</u>: ISTR is an aggressive and effective method because it would provide maximum mass removal over the short-term compared to other in-situ technologies. Implementation of this technology requires that access is available so that the thermal probes can be distributed in the necessary grid layout for the treatment area. ISTR would facilitate rapid volatilization of dissolved mass and of adsorbed-phase mass trapped in hard-to-reach pore spaces. If existing buildings and/or subsurface utilities limit the ability to create the desired grid layout, inconsistent subsurface temperatures will occur and the effectiveness will be reduced. **Rating: Moderate.** The highly developed nature of the Site and associated buried utilities are limiting factors on the effectiveness of this technology.

<u>Implementability</u>: Due to the current physical conditions at the Site, access approval and temporary relocation of adjacent residences and businesses would be required during the operational phase. The ability to get agreement from residences and businesses to implement this technology is questionable. While the technology is potentially more effective for areas with residual CAH mass, the likely presence of subsurface utilities, as well as potential impacts from the residual heat in the soils beneath existing business buildings and/or the Highway 101, would have to be evaluated on a site-specific basis. **Rating: Low (relatively difficult).**

Cost: Costs associated with this technology are high with respect to both the capital cost and operation and maintenance (O&M) costs. This is a high energy technology, and implementation would likely involve costs to restore utilities and other building infrastructure. While the period of operation is short (up to 1 year), the energy costs are high, especially with respect to the O&M costs per mass of contaminant removed. **Rating: Very High.**

Screening Summary: Not retained. This technology is cost-effective for removal of NAPL-like concentrations, which do not exist at the Site. Implementation is difficult because the area overlying the plume, as well as the area with residual contaminant mass to be treated, is fully developed and occupied by businesses, residences, and Highway 101. Temporary relocation is considered non-practicable.

Air Sparging with Soil Vapor Extraction. Air sparging (AS) in conjunction with soil vapor extraction (SVE) consists of a system that relies on air injection wells, vapor extraction wells, an air compressor, a vacuum pump, a vapor treatment unit, piping and connections. AS involves injection of air into contaminated groundwater to enhance contaminant volatilization into the overlying vadose zone. SVE is commonly implemented with AS to remove the generated vapor-phase contamination from the vadose zone. The system is most effective when localized contamination exists in aquifers with relatively permeable soils and little heterogeneity of fine-grained soil layers; the aquifer is underlain by a low permeable geologic unit; and residual contaminant mass is not under structures.

Effectiveness: AS with SVE operations create complex transient air and vacuum conditions within the subsurface. The heterogeneous nature of the subsurface at the Site will likely cause injected air to not move equally through the entire zone of contamination, thus, impairing the effectiveness of this technology. Dissolution of contaminants into the groundwater and transport to areas beyond the zone influenced by AS may also occur. Overlying buildings could be subject to possible vapor intrusion concerns, and subsurface utilities could provide fortuitous pathways for air movement, thus, reducing the ability to capture by vapor extraction the CAHs removed from groundwater by AS. **Rating: Moderate.**

Implementability: Due to the presence of existing buildings and residences across the Site, the implementation of this technology for the entire plume would be difficult. Implementation is more favorable for treatment of residual contaminant mass that is not underlying a building or is not associated with layers of fine-grained soils. **Rating: Low (relatively difficult).** Implementing AS/SVE to treat smaller areas containing residual CAH mass is less complex. **Rating: High (relatively easy) to Moderate,** contingent on whether the residual CAH mass underlies structures.

Cost: The overall cost associated with both the capital cost and O&M is moderate. The energy requirements are moderate for this technology, and implementation would likely involve costs to install the system around utilities and to provide vapor capture beneath existing buildings. While the period of operation is typically short (up to 1 year), the time frame will depend upon the ability to remove residual contaminant mass at areas with fine-grained soils. Overall costs are relatively high with respect to the costs per mass of contaminant removed. **Rating: Moderate to High.**

Screening Summary: Not retained. Potentially high costs due to the highly developed conditions at the Site, and achieving effectiveness would be difficult in a heterogeneous subsurface. Implementation is difficult because the area to be treated is fully developed and consists of businesses, residences, and Highway 101.

Enhanced Anaerobic Bioremediation. Enhanced anaerobic bioremediation (EAB) consists of delivering organic carbon substrate (serving as an electron donor) and nutrients to the saturated zone to promote growth of indigenous microbes that break down CAHs to innocuous end products. The performance of EAB is influenced by the type of organic substrate (soluble to slow release), subsurface hydrogeology, method of substrate delivery (recirculation, direct push injection, fixed barrier), and presence or absence of naturally-occurring VOC-degrading microbes. Examples of substrates used for EAB applications include ethanol, sodium lactate, molasses, cheese whey, HRC®, glycerin, and emulsified vegetable oil.

The challenge in achieving a high level of performance of the EAB technology would be to provide sufficient contact between injected amendments and the targeted contaminants in subsurface zones with heterogeneous conditions. Based on the absence of extensive reductive biotransformation in the shallow groundwater, as well as the observed oxidation-reduction potential of groundwater, a suitable population of naturally-occurring CAH-degrading microbes is not anticipated at the Site. Therefore, known CAH-degrading microbes would have to be injected (bioaugmentation) with the organic substrate to achieve complete reductive dechlorination of the CAHs.

Effectiveness: Treatability study testing may be required to evaluate the site-specific requirements for this technology. At a minimum, testing to quantify the extent of CAH-degrading microorganisms will be needed. This technology has been used successfully at similar sites with positive results, and the treatability test results would establish the requirements to effectively implement this technology under Site-specific conditions. **Rating: Moderate to High.**

Implementability: Implementation of EAB to treat residual CAH mass contaminants in a relatively small scale is usually practicable and relatively easy. With areas of finer-grain soils, flushing to achieve uniform organic substrate (electron donor) distribution will be difficult. Through a combination of advection, dispersion, and diffusion, the necessary reducing conditions can be established in subsurface areas within the general zone of EAB treatment. **Rating: Moderate to High (relatively easy).**

While building structures and roads are obstructions that could limit uniform injection and distribution of amendments (organic substrate, nutrients, and/or microbial bioaugmentation), hydraulic flushing (extraction and re-injection of groundwater to distribute the amendments in the saturated zone) could achieve EAB coverage over the entire COC plume area, including under buildings. **Rating: Moderate.**

Cost: Multiple injections of amendments are not anticipated, although flushing may be required for a period of time to promote microbial activity and contaminant degradation in the zone being remediated. **Rating: Moderate.**

Screening Summary: Retained. Application of this technology has a residual life that would enable treatment of both the dissolved and the sorbed, residual, COC mass contamination within the heterogeneous layers of the saturated zones associated with the shallow groundwater at the Site.

In-Situ Chemical Oxidation. In-situ chemical oxidation (ISCO) consists of the application of chemical oxidants, such as hydrogen peroxide, permanganate, persulfate, ozone, and/or Fenton's reagent, to achieve destruction by oxidation of contaminants in-place. The oxidizing reactions convert the contaminants to carbon dioxide, inorganic ions (such as chloride), and water. The oxidants would be injected into the subsurface by the direct-push drilling method. An advantage of ISCO is the direct conversion of contaminants to carbon dioxide, inorganic ions, and water without formation of intermediate chemicals. Application of ISCO may result in a temporary increase in dissolved-phase concentrations as the sorbed-phase mass undergoes dissolution and redistribution in groundwater. However, continuous application of ISCO would eventually treat the dissolved phase contaminants in groundwater. A potential disadvantage of ISCO is that the application of the oxidants into the saturated zone may result in the formation of harmful by-products, such as hexavalent chromium, in groundwater.

Effectiveness: This success of this technology depends on the ability to effectively and uniformly distribute the injected oxidant in the saturated zone, thus, enabling contact of the oxidant with the CAH contamination. To achieve sufficient oxidant distribution throughout the impacted zone, spacing of injection points is a key design parameter with regard to ISCO meeting the RAOs with a single injection. With heterogeneous layers of soil types in the saturated zone, the effectiveness of this technology is impacted by the difficulty in achieving uniform distribution of the oxidants. In addition, injection points would be limited by the extensive development (buildings) across the lateral footprint of the groundwater plume. The time frame that the oxidants remain active in the saturated zone depends on which oxidant is used, but typically the oxidants have a relatively short life. In consideration of the CAH concentrations in shallow groundwater, the need for multiple treatments is not anticipated to achieve sufficient oxidation of all CAHs in the area being treated. Treatability study tests would be required to evaluate the site-specific oxidant demand and the potential for formation of less toxic by-products of TCE, such as dichloroacetaldehyde and dichloroacetic acid, compounds with lower toxicity. **Rating: Moderate.**

Implementability: Injection of ISCO reagents using low-pressure injection techniques requires a tight, regular pattern of injection points. If the CAH contamination being treated is present within a building footprint, access within the building would be required. While access would only be needed on a temporary basis, injection of ISCO reagents to address CAH contamination under a building may not be technically feasible, and would need to be addressed on a building-by-building basis. While not as effective as pressure injection techniques, oxidant materials could be delivered through dedicated trench lines installed in the floor slab. Multiple injection events are typically required to achieve the desired contaminant removal with ISCO. For treating CAH contamination below buildings, specialized injection equipment would be mobilized to the site. Chemical storage and other equipment associated with the pressure injection technique could be located out-of-doors to reduce impacts to business operations during each event. Considering the heterogeneity of the saturated zone at the Site, the implementability of ISCO in treating a relatively small area of residual mass of VOC contaminant that is accessible is **Moderate to High (relatively easy).** The implementability for full coverage of the entire plume would be difficult to achieve due to the areas occupied by existing buildings, roads, and residences. Thus the rating to treat the entire plume is **Low (relatively difficult).**

Cost: If ISCO is used to treat a small area, the cost rating is **Moderate.** To treat a broader area such as the entire lateral and vertical extent of the TCE plume, the rating is **High.**

Screening Summary: Retained. ISCO could be used to treat areas of residual contaminant mass. With suitable access, ISCO can be used to locally treat the sorbed, residual VOC mass contaminants within the heterogeneous subsurface soils present in shallow groundwater.

In-Situ Chemical Reduction. CAHs can also be reduced chemically. A field-proven method for in-situ chemical reduction (ISCR) is the application of zero-valent iron (ZVI) for the abiotic, reductive, destruction of CAHs. ZVI, in the size of granules to nano-particles, is injected into the subsurface by direct-push drilling/injection methods. When the CAHs contact the surface of the ZVI, reduction occurs resulting in the destruction of the contaminants without creating undesired or harmful by-products. Thus, ISCR primarily treats the CAH contaminants in the dissolved phase. Unlike chemical oxidants, ZVI remains active for a suitable length of time. This stability with time enables treatment of the CAHs present in the sorbed phase. With time, the desorption of CAHs transfers the contaminants into the dissolved phase, and reduction of the CAHs occur. Like EAB and ISCO, the challenge in ISCR is achieving uniform and effective distribution of the ZVI mixture throughout the desired treatment zone (lateral and vertical profile).

Effectiveness: ISCR using ZVI is highly effective in dechlorinating dissolved-phase COCs at the Site. The key to this effectiveness is achieving adequate subsurface distribution of the ZVI throughout the treatment zone. Distribution may be more challenging and less consistent within zones or layers of fine-grained soils that are less permeable. However, ZVI has a longevity of months to years. This longevity enables effective treatment over time, even within low permeability zones. As with ISCO, low-pressure injection methods are anticipated to be the most suitable delivery method. **Rating: High.**

Implementability: Injection of in-situ reduction reagents requires a suitably spaced, regular pattern of injection points. Implementability of ISCR in treating CAH contamination has similar issues and considerations as ISCO. Therefore, available access is a key consideration for the technical feasibility of this technology. While access would be required on a temporary basis only, business operations could still be affected for a relatively short period of time (e.g., weekend or non-working hours). ZVI is suitable for low-pressure injection. Because ZVI has some longevity when injected, multiple events will likely not be required unless site access is limited for each injection event. Temporary equipment would be mobilized to the site and could be located outside to reduce impacts to local business operations during the injection event.

Suitable particle size of materials containing ZVI have been developed, and injection techniques have been field tested to enable efficient injection of nano-scale, powdered, or granular ZVI materials. Achieving a suitable distribution of ZVI to treatment zones under the footprint of buildings is the main challenge for implementation. **Rating: Overall Moderate,** primarily due to the extensive development at the Site. **Moderate to High (relatively easy)** for treatment of areas with residual contaminant mass, with the level of accessibility being location-specific.

Cost: ZVI materials and injection techniques are established. The major cost is the capital cost for performing the injection, with little to no O&M costs. **Rating: Moderate.**

Screening Summary: Retained. ISCR using ZVI would be a cost-effective technology to treat areas with residual CAH mass. ISCR would not be suitable for treating the entire groundwater plume at the Site.

Permeable Reactive Barrier with Zero Valent Iron. This technology consists of a ZVI-filled permeable reactive barrier (PRB) constructed downgradient of the contaminant source area and oriented perpendicular to the direction of groundwater flow. The wall would be constructed in the form of a trench filled with a mixture of ZVI and sand across the depth of the shallow groundwater. When groundwater moves through the PRB, the dissolved-phase contaminants are destroyed by reaction with ZVI. Since this is a passive treatment that relies on the advective movement of groundwater to convey contaminants to the treatment location, the PRB would be implemented at the downgradient edge of the plume and/or downgradient of the area with the residual CAH mass.

Effectiveness: ZVI with PRB is as effective as ISCR in destroying CAH contaminants in groundwater. The limitation on the effectiveness is the rate of groundwater flow, as well as the extent that the CAH residual mass is in the sorbed state rather than dissolved in groundwater. **Rating: Moderate.**

Implementability: PRB implementation at the Site would be challenging due to existing buildings and underground utility lines associated with the developed area overlying the groundwater plume at the Site. These factors would likely limit locations where this technology could be applied. This technology has been implemented successfully at similar locations for plume containment, so installation techniques for a PRB are available without impacting subsurface utilities. Maintenance of a PRB trench installation may also be an issue if treatment of the entire plume is anticipated to take a long time. If accumulated mineralization occurs on the iron particle surfaces, reactivity locations on the ZVI surface is reduced and the permeability of the PRB is potentially decreased. If mineralization occurs, then O&M is required to "shake" the materials comprising the PRB in order to re-establish a suitable exposed surface area on the ZVI particles. **Rating: Moderate.**

Cost: Established techniques for ZVI with PRB construction have been developed and employed in field applications. The highly developed nature of the Site will increase the installation cost for this technology. In consideration of the rate of shallow groundwater movement at the Site, more than one PRB is anticipated to reduce the overall time frame for achieving compliance with the RAOs in a reasonable time frame. **Rating: Moderate to High**

Screening Summary: Not Retained. ZVI with PRB is a field proven technology that cost-effectively controls the migration of groundwater contaminated with CAHs. However, as the plume is stable, migration control is not necessary. In addition, this technology would not address the area with residual contaminant mass without installation of several ZVI-PRBs, resulting in very high costs.

Biological Permeable Reactive Barrier. A biological PRB (bio-PRB) combines the characteristics of a PRB as described above (ZVI-PRB) with an active, anaerobic treatment zone suitable for the reductive dechlorination of CAHs, as previously described for in-situ EAB. Creation of the active reductive dechlorination zone at the PRB requires the injection and distribution of a suitable electron donor (organic substrate and/or hydrogen release compound) throughout the PRB, nutrients, and microorganisms that completely reduce CAHs (bioaugmentation). While injection and flushing techniques have been used to establish and maintain the active EAB zone in the PRB, wood chips and other organic substrates, microbial beads consisting of suitable microorganisms immobilized in beads of calcium alginate, polyethylene glycol, and polyethylene imide have recently been developed that create a Bio-PRB when placed with sand. Similar to the PRB with ZVI, the bio-PRB reactive zone is created perpendicular to the direction of groundwater flow. COCs in groundwater passing through the reactive zone are destroyed under the enhanced anaerobic conditions and microbial activity. Like ZVI-PRB, bio-PRB is considered to be a passive treatment that would be implemented downgradient of the source area.

Effectiveness: If appropriately installed and maintained, a Bio-PRB is as effective as the ZVI-PRB for treatment of CAHs in groundwater. **Rating: Moderate to High.**

Implementability: The initial installation of bio-PRB has the same implementation issues as the ZVI-PRB technology. To sustain the activity of bio-PRB, its construction includes piping and distribution ports to enable the addition of a suitable organic substrate throughout the length and depth of the barrier, and to sustain the desired anaerobic conditions and microbial activity for the CAH degraders. Thus, more O&M requirements can be expected for a bio-PRB relative to the ZVI-PRB. **Rating: Moderate.**

Cost: Factors influencing costs for the ZVI-PRB are also applicable to the bio-PRB. O&M costs can be expected to be higher for the bio-PRB relative to the ZVI-PRB. In consideration of the rate of shallow groundwater movement at the Site, more than one PRB is anticipated to reduce the overall time frame for this technology to achieve compliance with the RAOs in a reasonable time frame. **Rating: Moderate to High.**

Screening Summary: Not Retained. Similar to ZVI-PRB, a BIO-PRB could be a cost-effective approach to controlling plume migration that is not necessary for this Site. In addition, this technology would not address the area with residual contaminant mass.

Phytoremediation. Phytoremediation involves planting of appropriate trees for the in-situ treatment of contaminants in soil and groundwater. Treating organic contaminants by phytoremediation typically occurs at the roots of the plants. The chemicals secreted from tree roots enhance the subsurface geochemical and microbial environment, thus, facilitating in-situ treatment of contaminants. In addition to in-situ treatment, trees also provide hydraulic control by extending roots into the water table, resulting in the uptake of groundwater. Trees would be planted in the heart of the plume or along the plume boundary to control migration of contaminants in groundwater to off-site locations. Phytoremediation is a passive in-situ treatment applicable to dissolved-phase CAHs, petroleum hydrocarbons, semi-volatile organics, and metals.

Effectiveness: This technology would not be effective for treating either the shallow groundwater or saturated zone areas with residual CAH mass. Phytoremediation is limited by the depths of the plant roots, which would only extend into the upper portion of the A Zone (i.e., depths of 15 feet or less; Interstate Technology and Regulatory Council [ITRC], 2009). Thus, impacted groundwater at lower depths of the A Zone, as well as the entire B Zone, would not be subject to treatment by phytoremediation. **Rating: Low.**

Implementability: In consideration of existing structures (i.e. buildings, roads, parking, freeway, etc.) and limited available space for growing plants, Site conditions would impede and restrict the applicability of this technology. **Rating: Low (relatively difficult).**

Cost: Cost for operations associated with planting trees do not require complicated and complex engineering equipment and methods. **Rating: Low.**

Screening Summary: Not retained. Technology is only effective in shallow soils and groundwater. As the Site is a fully developed area, this technology is not suitable for application to the entire plume. In addition, this technology would not be effective in treating the residual contaminant mass due to the depth of the residual contaminant mass near well 17W.

Monitored Natural Attenuation. Monitored natural attenuation (MNA) is a combination of naturally-occurring processes such as advection, dilution, dispersion, adsorption, volatilization, and biodegradation that reduce the concentrations of contaminants in groundwater. Biodegradation transforms contaminants into non-toxic end-products. As discussed in Section 1, advection, dilution, dispersion, sorption, and volatilization are physical processes that can reduce concentrations, but do not reduce the total mass of contamination. While biodegradation is the most common MNA process associated with contaminant degradation, chemical or abiotic transformations can also occur. These combined natural processes can result in a reduction of the mass, toxicity, or volume of contaminants. Sorption also retards the movement of CAHs in groundwater.

MNA consists of a groundwater sampling program that includes long-term monitoring of the natural attenuation processes. In addition to concentrations of CAHs, groundwater geochemical parameters would be monitored to evaluate the potential for natural attenuation processes associated with biological or chemical transformations. Geochemical parameters would include dissolved oxygen, oxidation-reduction potential, temperature, pH, conductivity, nitrate, ferrous iron, manganese, sulfate, sulfide, methane, carbon dioxide, alkalinity, and total organic carbon. To assess the extent and rate of biodegradation, a monitoring program using compound specific isotope analysis (CSIA) is also recommended. Implementation of the CSIA monitoring program would follow EPA guidance (EPA, 2008).

<u>Effectiveness</u>: Reductive dechlorination of TCE has been well documented and the biochemical pathway and microorganisms responsible have been identified (Wiedemeier et. al., 1999). With the appropriate reducing conditions and activity of microorganisms, TCE can be reductively biodegraded to carbon dioxide, water, and chloride (Gossett and Zinder, 1996). Based on the long-term groundwater monitoring results for the Site and the modeling results, MNA would require a potentially long time frame before the RAOs for groundwater at the Site can be achieved. MNA could also be included as a follow-up technology to active groundwater remediation. This is expected to be more effective because active remediation could sufficiently reduce CAH mass so that natural attenuation processes could effective reduce the low levels of remaining CAHs. **Rating: Moderate** as a stand-alone technology. **High** when combined with an appropriate active remediation technology for the area with residual contaminant mass.

<u>Implementability</u>: An MNA program can be easily implemented and added to the existing groundwater monitoring and sampling program. Commercial laboratories are available to perform CSIA to enable use of this tool. **Rating: High (relatively easy).**

<u>Cost</u>: Additional laboratory costs associated with data required for MNA evaluation. **Rating: Low to Moderate.** As a stand-alone technology, costs would be **moderate** considering the monitoring (i.e., CSIA, geochemical, and CAH concentrations). As a follow-up technology with an active remedial technology, costs would be **low.**

<u>Screening Summary</u>: Retained. Natural attenuation may be used as a stand-alone, or as a follow-up to other (active) remedial measures.

Groundwater Extraction, Treatment, and Discharge

Groundwater extraction is the pumping of groundwater from wells screened within the A and B zones at the Site. The general strategy for this technology consists of extracting (pumping) contaminated groundwater from wells distributed across the Site, treating the extracted groundwater, and discharging the groundwater in compliance with an NPDES permit. Options for treatment include discharge of the groundwater to the sanitary sewer as approved in the 1991 ROD (EPA, 1991) or on-site treatment and discharge under a new NPDES permit issued by the RWQCB. Because the ROD approved discharging the groundwater to the City of Mountain View's sanitary sewer for treatment and subsequent discharge under a NPDES permit, this is the treatment method assumed for this technology. The extent of the groundwater extraction would be sufficient to capture groundwater within the lateral and vertical extent (A and B zones) of CAH-impacted groundwater at the Site.

Effectiveness: Groundwater extraction and treatment would be applied for the removal of all dissolved-phase COCs, and serves to control the source area from migrating downgradient. Based on previous use of this technology at the Site, groundwater extraction has the ability to contain the plume. Extraction well locations, screen intervals, and operational parameters would need to be selected to enable the removal of the residual COC mass. Due to the presence of sorbed residual contaminant mass, groundwater extraction may require a longer time than other technologies in achieving compliance with the cleanup criteria for groundwater. This technology would not result in treatment of the area with residual contaminant mass as aggressively as other technologies evaluated herein. **Rating: Moderate.**

Implementability: Successful installation and operation of extraction wells clustered within the foot print of the TCE plume area was implemented previously. Agreements establishing utility corridors for the wells and the conveyance system would be required. Obtaining suitable agreements and space to install the wells and conveyance piping would take time and may require regulatory agency involvement because the Site is fully developed and the responsible party does not own any land. **Rating: Moderate.**

Cost: The capital costs, the annual O&M costs, and the anticipated extended time frame for operating this technology (potentially 20 years or more) to achieve RAOs would be high. **Rating: High.**

This technology screening assumes extracted groundwater would be discharged to the sanitary sewer for treatment by the municipal wastewater treatment system. Considerations for this method of treating extracted groundwater are described below.

Discharge to the Sanitary Sewer

Effectiveness: Treatment of extracted groundwater by the local municipal wastewater treatment system has a demonstrated record of being effective at this Site. Using a municipal wastewater treatment plant provides trained and experienced personnel to operate and maintain the treatment system. Rating: High.

Implementability: Successful installation and operation of a system for discharge and subsequent treatment of the groundwater have previously been conducted at the Site. Even with the recent redevelopment of some areas of the Site, a conveyance system and sanitary sewer connections from extraction wells can be installed. Agreements establishing utility corridors for the conveyance system would be required. Obtaining suitable agreements and space to install the conveyance piping and electrical service connections would be required. **Rating: Moderate.**

Cost: While the capital costs would be moderate, the annual O&M costs would be relatively high due to the anticipated time frame for operation (potentially 20 years or more). **Rating: High.**

Screening Summary: Retained. Groundwater extraction with discharge to the sanitary sewer of the City of Mountain has been previously used at the Site. This is the current shallow groundwater remedy established for the Site in the 1991 ROD (EPA, 1991).

3.4 INSTITUTIONAL CONTROLS

Institutional controls (ICs) provide protection from exposure through the use of non-engineered or legal controls that limit land or resource use, such as access controls and property restrictions. Although ICs provide no reduction of toxicity, volume or mobility of contaminants, they can reduce or eliminate direct exposure pathways and resultant risk. Proprietary controls could include restrictions recorded with the County Recorder's Office limiting the use of groundwater for properties overlying the Site's plume. Government controls could include state and local government restrictions on installing groundwater wells in the shallow aquifer within the existing footprint of the TCE plume. Enforcement and permit tools include unilateral administrative orders and administrative order on consent to compel a land owner to limit certain site activities, which may prohibit land use in certain ways or restrict the conducting of certain activities at a property. ICs provide information or notification with regard to a remedy or residual contamination at a site. Examples include state registries of contaminated properties, public notices, deed notices, fact sheets, and advisories.

The objective of any IC is to ensure that the remedial alternatives are implemented and operated properly to minimize the potential for human exposure to contamination. Possible ICs for the Site include:

- Zoning and zoning overlays
- Municipal ordinances
- Local permits/State codes
- Covenants
- Administrative orders
- Consent decrees

Currently, the area associated with the TCE plume attributable to the former CTS Printex operation is zoned for light industrial, commercial, and residential uses. Use of zoning overlay as part of groundwater remediation could include requirements that new buildings are designed and built so as not to interfere with the installation, operation, maintenance, and/or monitoring of the implemented groundwater remedy for the Site. Land use permits, building permits, and state codes set forth specific requirements or provide for imposition of specific conditions, before an activity or construction is authorized on a property. EPA may use enforcement mechanisms (orders and agreements) to bind property owners to any affirmative duties regarding a remedy. In addition, SCVWD Ordinance 90-1 establishes requirements for new well installations, reconstruction of existing wells, and destruction of wells, including water wells, monitoring wells, cathodic protection wells, and deep excavations. SCVWD Ordinance 90-1 requires that well are not screened in the first 50 feet bgs. The existing wells associated with the Site are in compliance with SCVWD Ordinance 90-1.

Proprietary Control – Land Use Covenant to Restrict Groundwater Use
A proprietary control in the form of a land use restriction covenant was recorded in April 2010 by the current owners of the former CTS Printex facility property (Geosyntec, 2010). This IC prevents use of groundwater from this portion of the Site for drinking water, thereby preventing exposure to contaminated groundwater. For other portions of the Site, groundwater use restrictions in the form of a deed restriction or land use restriction covenant have not been established. SCVWD Ordinance 90-1 does apply to the other portions of the Site for which a land use restriction covenant has not been established.

Effectiveness: Groundwater monitoring within the affected permeable A and B zones at the Site will continue in order to assess if COC concentrations are changing with time. However, the covenant eliminates an exposure pathway by restricting use. **Rating: Moderate to High.** Adherence to the groundwater use restriction will prevent human exposure by ingestion.

Implementability: Groundwater use restrictions are currently in place as part of a covenant recorded on property associated with the former CTS Printex facility. However, there are no land use convents in place on properties overlying the down gradient (north of Plymouth Street) portion of the contaminant plume. In addition, SCVWD, which has authority, will not issue a permit for sites with impacted groundwater such as at this Site. **Rating: Moderate to High.** While use restrictions are not recorded for the portion of the plume north of Plymouth Street, the SCVWD's ability to withhold a permit for new well installation is established and already being implemented.

Cost: Costs associated with this IC are zero, as the SCVWD's permitting policy is established. **Rating: Low.**

Screening Summary: Retained. Maintaining groundwater use restrictions reduces the potential for ingestion of the contaminated groundwater. This IC should be included with other remedial alternatives until RAOs are achieved in groundwater at the Site.

Municipal Ordinances
A proprietary control in the form of a municipal ordinance is in place for the existing monitoring wells at the Site. SCVWD Ordinance 90-1 establishes requirements for new well installations, reconstruction of existing wells, and destruction of wells, including water wells, monitoring

wells, cathodic protection wells, and deep excavations. According to SCVWD Ordinance 90-1 and SCVWD's 1989 standards for well construction, water wells may not be screened at depths shallower than 50 feet bgs. The existing monitoring wells associated with the Site are in compliance with SCVWD Ordinance 90-1. Current policy of the SCVWD does not allow permits for drinking water wells in the shallow groundwater aquifer.

Effectiveness: The SCVWD ordinance establishes appropriate controls on shallow groundwater use. Adherence to SCVWD Ordinance 90-1 will also assist in preventing potential human exposure associated with use of the shallow groundwater as a drinking water source. As the City of Mountain View has an available drinking water supply for properties at the Site, groundwater from the Site is not needed as a drinking water source. **Rating: High.**

Implementability: The SCVWD Ordinance is established and enforced, meaning that a new well will not be screened within the depths of impacted shallow groundwater. In addition, SCVWD will not approve the permit for a new well installation for sites with impacted groundwater such as at this Site. **Rating: High (relatively easy).**

Cost: Costs associated with this institutional control are minimal. **Rating: Low.**

Screening Summary: Retained. Eliminating the groundwater exposure pathway will prevent human exposure to contaminated groundwater. This IC should be included with other remedial alternatives until RAOs are achieved in groundwater at the Site.

3.5 SUMMARY OF RETAINED TECHNOLOGIES

The ICs and remedial technologies retained for development of alternatives for CTS Printex include the following:

ICs Retained

- Proprietary ICs to restrict groundwater use; and
- Municipal Ordinances to restrict groundwater use.

Technologies and Process Options Retained

- No Action
- MNA (Site-wide or in combination with other retained, active remediation technologies)
- EAB
- ISCO
- ISCR
- Groundwater Extraction

For the above technologies (excluding No Action), groundwater monitoring would be conducted to monitor attenuation of contaminant concentrations within the shallow groundwater plume at the Site. In addition, ICs would be implemented restricting the use of contaminated groundwater within the plume in the shallow aquifer. Especially for site-wide application of MNA for shallow groundwater remediation, and also as an evaluation tool for MNA combined with an active remedial technology, groundwater monitoring would also include appropriate sampling and analysis consistent with recommendations in MNA guidance (EPA, 1998, EPA, 1999a, and EPA, 2008).

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4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES FOR GROUNDWATER

This section presents the development of alternatives from the ICs and technologies retained in Section 3. The alternatives were evaluated against screening-level criteria – effectiveness, implementability, and cost.

4.1 ALTERNATIVES FOR GROUNDWATER

The objective of this process is to develop a range of alternatives for groundwater that ensure protection of human health and the environment, satisfy RAOs, and meet the cleanup goals identified in Table 2-3. In developing the alternatives, a number of elements were identified that were common to each alternative. These common elements included: ICs, groundwater monitoring; and MNA. These common elements are further discussed in Section 4.1.1. The development of alternatives also considered the following range of general approaches for groundwater remediation at the Site:

- No action (default alternative under EPA guidance [EPA, 1988]);
- Remediation of the area(s) with residual contaminant mass;
- MNA; and
- Remediation of the entire plume.

The screened remedial alternatives are identified in Table 4-1, and described in Section 4.1.2.

4.1.1 Common Elements

In assembling the alternatives, several ICs or technologies/process options are necessary components of any comprehensive alternative for groundwater remediation. These common elements include:

- ICs, including, but not necessarily limited to, groundwater use restrictions and municipal ordinance, including SCVWD Ordinance 90-1;
- MNA for areas of the plume without active remediation as well as following discontinuation of active remedial treatment; and
- Groundwater monitoring to quantify the concentration of all COCs in Table 2-3.

4.1.2 Description of Alternatives for Groundwater

Alternatives developed for groundwater at the Site are described below. For each of the alternatives, an estimate was made of the time frame to achieve groundwater cleanup. Existing models accepted by EPA were used to estimate the time frames. The models used were BIOCHLOR and REMChlor. These models have limitations as discussed in Appendix A (BIOCHLOR) and Appendix F (REMChlor). Soil properties in the A and B zones vary, resulting in permeability variations and associated diffusion and mass transfer considerations that are not completely addressed by the models. The time frames projected by the models are estimates only. The actual time to achieve groundwater cleanup for each alternative will likely vary from the model's estimated time frame. The modeling projections and resulting estimated times to achieve groundwater cleanup are only intended to provide an appropriate basis for alternative comparison.

The alternative descriptions below are conceptual designs developed for alternative comparison and cost estimating purposes only. The actual design of the selected groundwater remedy will occur during remedial design.

4.1.2.1 Alternative 1 - No Action

EPA guidance (EPA, 1988) requires that a no-action alternative be considered and compared to the alternatives developed for remediation of the shallow groundwater. The no-action alternative does not include active remediation or monitoring. No incremental increased costs are associated with this alternative.

4.1.2.2 Alternative 2A – Groundwater Extraction, Monitoring, and ICs

Groundwater would be extracted from new wells screened in the A or the B Zones, with extraction wells located at multiple locations in the plume to extract shallow groundwater throughout the plume as well as achieve contaminant mass removal. New extraction wells will be needed because the former extraction wells have been abandoned. The extracted groundwater would be discharged to the sanitary sewer for subsequent treatment at the municipal wastewater treatment plant. Discharge of the groundwater would be in accordance with the NPDES permit for the municipal wastewater treatment plant. This alternative is consistent with the groundwater remedy in the 1991 ROD (EPA, 1991). The locations of the new extraction wells and points of discharge to the sanitary sewer are shown on Figure 4-1.

Estimated time to achieve groundwater cleanup: 22 years (based on REMChlor modeling results with details presented in Appendix F).

4.1.2.3 Alternative 2B – Groundwater Extraction, MNA, and ICs

This alternative would establish a groundwater extraction network for the areas with residual CAH mass based on groundwater monitoring concentration trends, such as the area around well 17W with residual contaminant mass. Extracted groundwater would be discharged directly to the sanitary sewer without treatment. The locations of the new extraction wells and points of discharge to the sanitary sewer are shown on Figure 4-2. For the rest of the plume not influenced by groundwater extraction, MNA would be used for groundwater remediation.

Groundwater would be extracted at locations and from wells screened as follows (see Figure 4-2 for locations):

- Three wells in vicinity of monitoring well 17W
  - One well in the A Zone (10 to 20 feet bgs);
  - One well from 20 to 30 feet bgs, referred to herein as the A/B Zone; and
  - One well in the B Zone (30 to 40 feet bgs).
- Two wells at Plymouth Street in the vicinity of 11W and 14W
  - One well in the A Zone (10 to 20 feet bgs); and
  - One well in the B Zone (30 to 40 feet bgs).
- Two wells near the corner of Leghorn Street and Sierra Vista Avenue in the vicinity of downgradient monitoring wells 22W and 23W
  - One well in the A Zone (10 to 20 feet bgs); and
  - One well in the B Zone (30 to 40 feet bgs).

New extraction wells will be needed because the former extraction wells have been abandoned in accordance with the requirements of SCVWD Ordinance 90-1. The extracted groundwater would be discharged to the City of Mountain View's sanitary sewer for subsequent treatment at the municipal wastewater treatment plant. Discharge of the treated groundwater would be in accordance with the NPDES permit for the municipal wastewater treatment plant.

Estimated time to achieve groundwater cleanup: 22 years (based on REMChlor modeling results with details presented in Appendix F).

4.1.2.4 Alternative 3A –In-situ Chemical Oxidation (ISCO), MNA, and ICs

This alternative would apply ISCO to the area around well 17W where a residual contaminant mass was characterized from the MIP investigation conducted in February 2010 (ITSI, 2010). For the rest of the plume, MNA would be used for groundwater remediation. If MNA is not effective in reducing COC concentrations in the other portions of the plume, ISCO will be applied to those areas as well. EPA would determine the need to invoke this contingency during its evaluation of remedy effectiveness as part of the five-year reviews starting with the second review following completion of the ISCO treatment.

A treatability study would be needed to identify the Site's natural oxidant demand in the A and B zones of shallow groundwater. The treatability study would also select the oxidant and injection concentration of the oxidant based on the natural oxidant demand and the requirements to treat the dissolved and sorbed mass of CAHs. For purposes of developing and screening this alternative, the assumed oxidant for the ISCO treatment would be permanganate or activated persulfate. These oxidants were selected because they are effective in oxidizing CAHs, especially chlorinated ethenes, and permanganate and activated persulfate persist for a time in the saturated zone after injection. The stoichiometric reactions of potassium permanganate and persulfate with TCE are shown below in equations (1) and (2), respectively (ITRC, 2005).

$$2KMnO_4 + CCl_2{=}CHCl \rightarrow 2CO_2 + 2MnO_2(s) + 3Cl^- + 2K^+ + H^+ \quad (1)$$

$$3Na_2S_2O_8 + CCl_2{=}CHCl + 4H_2O \rightarrow 2CO_2 + 9H^+ + 3Cl^- + 6Na^+ + 6SO_4^{2-} \quad (2)$$

To effectively degrade the CAHs, the oxidant must come into contact with the contaminant molecules. To achieve a uniform delivery of the oxidant, an injection grid layout will be established across the lateral footprint of the treatment area. Prior to full-scale application of ISCO, a pilot study would be performed to establish the appropriate spacing and layout of the injection grid. The layout of the injection grid would be a little less than the determined radius of influence for the injections. Therefore, the radius of influence (ROI) of the oxidant distribution would overlap between adjacent injection points. The assumed injection point grid for Alternative 3A is shown on Figure 4-3.

Using direct-push drilling equipment, the oxidant would be injected under pressure at each injection point. The pressure of the injection would allow lateral delivery of the oxidant solution as the injection process moves vertically through the treatment zone. Pneumatic fracturing is not considered necessary to achieve sufficient oxidant delivery at the Site.

Estimated time to achieve groundwater cleanup: 15 years (based on modeling results presented in Appendix B).

4.1.2.5 Alternative 3B – Enhanced Anaerobic Bioremediation (EAB), MNA, and ICs

This alternative would use EAB in-situ to address the plume near well 17W that contains residual COC mass. For the remaining portions of the plume, MNA would be used for groundwater remediation. If MNA is not effective in reducing COC concentrations in the other portions of the plume, EAB will be applied to those areas as well. EPA would determine the need to invoke this contingency during its evaluation of remedy effectiveness as part of the five-year reviews starting with the second review following completion of the active EAB treatment.

Implementing EAB would involve multiple steps. Initially, a suitable organic substrate (e.g., lactate, emulsified oils, molasses, ethanol, etc.) would be injected into the subsurface at selected locations using techniques similar to that described in Alternative 3A for oxidant injection.

Because monitoring data from the Site indicate that reductive dechlorination has generally reduced TCE to DCE only (so-called "stall out"), bioaugmentation using *Dehalococcoides ethenogenes* would be included with the injection solution of organic substrate. In combination with the reduced environment created with the organic substrate addition, the presence of *Dehalococcoides ethenogenes* will allow the reduction of the chlorinated VOCs (TCE, DCE, and vinyl chloride) to ethene (Gossett and Zinder, 1996).

Instead of the extensive injection grid for Alternative 3A, a groundwater recirculation system with fewer injection points would be used. This recirculation system would consist of extraction and injection wells. Figure 4-4 shows the conceptual location of the injection points, extraction wells, and injection wells. The flushing action of the recirculation system would be used to distribute the organic substrate and bacteria throughout the lateral and vertical extents of the treatment zone, and will allow for additional injections of substrate and bacteria if necessary. A conceptualization of the flushing action of the recirculation system in the A zone is presented on Figure 4-5.

Testing to confirm the presence of specific CAH-degrading microorganisms would be performed as part of the treatability study and design of this alternative to confirm the requirements for bioaugmentation.

Estimated Time Frame to Groundwater Cleanup: 15 years (based on BIOCHLOR modeling results shown in Appendix B).

4.1.2.6 Alternative 3C – In-situ Chemical Reduction (ISCR), MNA, and ICs

This alternative would be very similar to Alternative 3A, with the exception that ZVI solutions would be applied to the area around well 17W with residual contaminant mass. For the rest of the plume, MNA would be used for groundwater remediation. If MNA is not effective in reducing COC concentrations in the other portions of the plume, ISCR will be applied to those areas as well. EPA would determine the need to invoke this contingency during its evaluation of remedy effectiveness as part of the five-year reviews starting with the second review following completion of the ISCR treatment.

A treatability study would be needed to identify the appropriate injection concentration, type of ZVI particle to use, and ZVI delivery approach that would effectively treat the dissolved and sorbed mass of CAHs. ZVI is effective in reducing CAHs, especially chlorinated ethenes, and will persist for a significant time in the saturated zone after injection. The primary reactions associated with ZVI reduction of TCE involve the reactions shown in equations (3) and (4) (Tratnyek and Johnson, 2010).

Direct Reduction at ZVI surface:

$$3Fe^0 \text{ (ZVI surface)} + CCl_2{=}CHCl + 3H^+ \rightarrow CH_2{=}CH_2 + 3Cl^- + 3Fe^{2+} \quad (3)$$

Reduction by ferrous iron:

$$6Fe^{2+} + CCl_2{=}CHCl + 3H^+ \rightarrow CH_2{=}CH_2 + 3Cl^- + 6Fe^{3+} \quad (4)$$

To effectively degrade the CAHs, the ZVI must come into contact with the contaminant. To achieve a uniform delivery of ZVI, an injection grid layout will be established across the lateral footprint of the treatment area. Prior to full-scale application of ISCR, a pilot study would be performed to establish the method of ZVI injection and the appropriate spacing and layout of the injection grid. This alternative assumes that a water solution containing ZVI particles is injected by a direct push injection method. The layout of the injection grid would be a little less than the determined radius of influent for the injections so that the radius of influence of the ZVI distribution would overlap between adjacent injection points. The assumed injection point grid for Alternative 3A is shown on Figure 4-6.

ZVI would be injected under pressure at each injection point using an approach similar to that described above for Alternative 3A. The pressure injection would enable lateral and vertical delivery of the ZVI solution across the treatment zone. Pneumatic fracturing with gel/ZVI injection is an alternative deliver method, but is not considered necessary to achieve ZVI delivery across the treatment zone.

Estimated Time Frame to Groundwater Cleanup: 15 years (based on modeling results presented in Appendix B).

4.1.2.7 Alternative 4 - Monitored Natural Attenuation (MNA) and ICs

This alternative would continue groundwater monitoring and track concentrations in the groundwater for the A and B Zones. While annual monitoring data have indicated that natural attenuation may be occurring at the Site, there is a high degree of uncertainty with the extent of natural attenuation. As biodegradation is the only natural attenuation process that achieves reduction of contaminant mass, the current groundwater monitoring program would be expanded under this alternative to assess if biodegradation is occurring. For the purpose of this FFS, the expanded groundwater monitoring program is assumed to include a combination of the following:

- Sampling the existing monitoring well network for evaluating the effectiveness of MNA.
- Monitoring the 18 existing and available wells in the A and B Zones for the baseline year through year 10. These wells are shown on Figure 1-6 for the A zone and Figure 1-7 for the B zone and consist of the following:
  - A-Zone – 7W, 12W, 13W, 16WR, 17W, 20W, 23W, 25W, 33W, 34W, and 38W; and
  - B-Zone – 8W, 11W, 14W, 15WR, 19W, 21W, and 22W
- Monitoring the 6 wells in the A Zone and 4 wells in the B Zone. This is based on the assumption that wells reaching MCLs by year 10 are not subject to further groundwater monitoring.
- Semi-annual groundwater monitoring for 3 years to establish baseline conditions so that the effectiveness of MNA could be evaluated. Thereafter, perform annual groundwater monitoring.

- Each monitoring event for the first 3 years will include characterization of the geochemical conditions in the A and B Zones consistent with EPA guidance for MNA (EPA, 1998 and EPA, 1999a).
- Compound-specific isotope analysis (CSIA) for groundwater samples from selected wells for the first two monitoring events consistent with EPA recommendations (EPA, 2008). Trend evaluation of the CSIA results in conjunction with the other monitoring results following EPA guidance would establish a basis to determine if the chlorinated volatile organic chemicals are being biodegraded.

Estimated time to achieve groundwater cleanup: As stated in Section 1.2.5.1, the BIOCHOR modeling projected time frames on the order of 100 years in the A zone and 70 years in the B zone (see Appendix A for details of the modeling). For purposes of alternative screening, a time frame of over 30 years was used.

4.2 SCREENING OF REMEDIAL ALTERNATIVES

This section screens the alternatives against the short- and long-term aspects of effectiveness, implementability, and cost. The objective of this effort is to identify remedial alternatives that will be retained for detailed analysis.

Effectiveness Evaluation

This evaluation focuses on short- and long-term effectiveness of each alternative in protecting human health and the environment, compliance with RAOs, and reduction in toxicity, mobility, or volume of contaminants. Short-term effectiveness relates to protection of human health and the environment during construction and implementation of remedial action (i.e., time to construct) versus long-term operation (i.e., time to achieve groundwater cleanup) for the remedial action alternative. Reduction in toxicity, mobility, or volume relates to the elimination of COCs in the impacted groundwater with respect to eliminating the risk associated with exposure to COCs in the impacted groundwater.

The effectiveness of an alternative is rated as:

High – effective in protection of human health and the environment over both the short- and long-term;

Moderate – may protect human health and the environment, but with limited effect over both the short- and long-term; or

Low – ineffective in protection of human health and the environment.

Implementability Evaluation

This evaluation considers both the technical and administrative implementability of constructing, operating, and maintaining each remedial alternative. Site-specific conditions, such as geology and hydrogeological properties of the shallow groundwater; surface restriction; and access for remedial system installation, operation, maintenance, and monitoring are expected to influence the design and construction of each remedial alternative. Technical feasibility refers to the ability to construct, operate, and maintain a remediation system that is suitable for site-specific conditions.

Administrative feasibility refers to the acceptance of a remedial alternative by the community and local and State regulatory agencies; ability to obtain permits for construction of a remediation system; and availability of local services for materials, equipment, and labor for construction and operation of the various components of a remediation system. Implementability of an alternative is rated as:

High – readily implementable under Site conditions, and/or remedial technology has a proven record of performance including application at similar sites;

Moderate – implementable with additional efforts to ensure technical and administrative feasibility for the Site; or

Low – difficult to implement due to the Site-specific conditions.

Cost Evaluation

This evaluation focuses on capital and O&M costs for constructing and operating each remedial alternative using engineering experience and judgment. A detailed cost estimate is not necessary at the screening-level stage of the evaluation. [Note: A detailed cost estimate is prepared for retained remedial alternatives as part of the detailed analysis in Section 5.]

Cost of an alternative is rated relative to other alternatives as:

High – high probable present worth cost for the alternative;

Moderate – moderate probable present worth cost for the alternative; or

Low – Low probable present worth cost for the alternative.

4.2.1 No Action

As discussed in Section 4.1.2.1, a No Action Alternative is included, and will be retained throughout the development and detailed analysis/comparison (Section 5) of alternatives for remediation of the shallow groundwater.

4.2.2 Alternative 2A - Groundwater Extraction, Monitoring, and ICs

Groundwater extraction and subsequent treatment have been used extensively for containment and remediation of COC-impacted groundwater.

Effectiveness: Groundwater extraction is effective in containing further migration of CAH-impacted groundwater. Because of the fate and transport properties of CAH and the low levels of concentrations in shallow groundwater for many portions of the Site, groundwater extraction can be expected to take longer than in-situ technologies that destroy CAHs in the dissolved and sorbed phase. To be effective in achieving groundwater cleanup throughout the plume, the following must be addressed:

- Well locations selected to achieve shrinkage of the plume with time.
- Screen intervals of extraction wells established so that flushing of the entire depth of impacted groundwater occurs. To achieve this, each of the multiple wells will have a discrete screen interval based on the residual COC mass remaining from the previous groundwater extraction. This approach enables establishment of a screen interval at depths of residual COC mass, thus, improving groundwater movement through the depth zone of residual COC mass. Flushing will improve removal of the sorbed, residual COC mass.
- Pulsing or other modes of extraction well operation to enhance mass removal should be considered, especially for the areas with low contaminant concentrations.

Rating: Low to Moderate. Groundwater extraction that achieves more flushing through zones of residual CAH mass is the key to improving effectiveness. While this alternative previously reduced the plume extent and reduced contaminant concentrations, groundwater extraction did not remove the residual contaminant mass that is the primary basis for further groundwater remediation. In addition, low concentrations of contaminants remained in many portions of the Site after groundwater extraction was discontinued.

Implementability: Having previously applied this remedy at the Site, groundwater extraction can be implemented. Due to new development at the southern portion of the Site since the discontinuance of the former groundwater extraction system, both administrative and technical implementation issues will need to be addressed. The extent of new development may limit the available locations and result in specific implementation requirements for extraction wells. **Rating: Moderate.** As CTS Printex does not own property within the Site, administrative issues for implementation will need to be addressed.

Cost: Capital costs would be moderate for installing the extraction wells and piping to convey the extracted groundwater to the sanitary sewer. The major cost consideration is operation and maintenance for this alternative due to the anticipated 22-year time frame for groundwater extraction to meet the groundwater cleanup goals across the plume. **Rating: High.** Based on previous experience with this remediation approach at the Site, the main contributor to cost rating is the high annual O&M costs and time frame to achieve cleanup goals.

4.2.3 Alternative 2B – Groundwater Extraction, MNA, and ICs

Groundwater extraction and subsequent treatment have been used extensively for containment and remediation of CAH-impacted groundwater.

Effectiveness: Groundwater extraction is effective in containing further migration of CAH-impacted groundwater. For sorbed CAH mass in finer grain soils, groundwater extraction is not as effective in removing CAH mass. Because of the fate and transport properties of CAHs, groundwater extraction can be expected to take longer than in-situ technologies that destroy CAHs in dissolved and sorbed phase.

To be effective in achieving groundwater cleanup, the following must be addressed:

- Extraction wells located and screened to achieve residual contaminant mass removal.
- Extraction wells operated to remove CAH residual mass and reduce dissolved concentrations with time. Pulsing operation can be used to enhance the overall effectiveness of CAH mass removal.
- Screen intervals of extraction wells established so that flushing of the entire depth of impacted groundwater occurs. To achieve this, multiple wells will be installed at locations of groundwater extraction. Each of the multiple wells will have a discrete screen interval based on the vertical profile of the residual CAH mass remaining. This approach enables establishment of a screen interval at depths of residual CAH mass, with the objective of improving groundwater movement through the depth zone of residual CAH mass. If pore space flushing is enhanced, this will improve removal of the residual CAH mass.

Rating: Moderate. Groundwater extraction that achieves more flushing through zones of residual CAH mass is the key to improving effectiveness. While this alternative previously reduced the plume extent and reduced contaminant concentrations, groundwater extraction did not remove the residual contaminant mass that is the primary basis for further groundwater remediation.

Implementability: Having previously applied this remedy at the Site, groundwater extraction can be implemented. Both administrative and technical implementation issues will need to be addressed. The extraction wells for this alternative are planned for available locations. This also applies to the location for piping from the wells in the area of 17W to the sanitary sewer. **Rating: Moderate to High.** Groundwater extraction wells can be located at the selected locations.

Cost: Capital costs would be moderate for installing the extraction wells and piping to convey the extracted groundwater to the sanitary sewer. A major cost consideration for this alternative to meet the groundwater cleanup goals across the plume is operation and maintenance due to the anticipated 22-year time frame for groundwater extraction and associated sewer discharge charges. **Rating: Moderate to High.** Based on previous experience with this remediation approach at the Site, time frame to achieve cleanup goals is a main contributor to cost rating.

4.2.4 Alternative 3A – In-situ Chemical Oxidation (ISCO), MNA, and ICs

ISCO treatment for chlorinated ethenes such as TCE is an established remedial approach for shallow groundwater.

Effectiveness: ISCO can chemically destroy TCE and other CAHs, resulting in the formation of carbon dioxide, chloride salts, and water as end products. To be effective, this reaction needs the oxidant to contact the CAH. For this reason, rebound effects may occur due to incomplete oxidation of the CAHs attributable to 1) the sorption of the CAHs to finer-grained soil particles and 2) injection of the oxidant not achieving a uniform distribution throughout the treatment zone (lateral and vertical). Consequently, while multiple doses of oxidant are commonly required to achieve the cleanup criteria for groundwater with elevated CAH concentrations, the CAH concentrations in the area of well17W with residual contaminant mass are relatively low. A single injection with an appropriate injection grid is assumed sufficient to achieve the desired destruction of TCE and other CAHs.

The effectiveness of this alternative is dependent on how well the oxidants will be delivered within the heterogeneous soil media present beneath the area around well 17W. Even considering the limited duration of the oxidant activity in the saturated zone, and the heterogeneity of the soil properties in the shallow groundwater of the treatment zone, a single injection event using appropriate oxidant dosage and injection grid spacing should achieve cleanup criteria in the area with residual CAH mass. **Rating: Moderate.** The possible need for multiple injections resulting from the heterogeneous geological conditions in the treatment zone and the relatively short duration of oxidant activity impact the possible effectiveness of this alternative relative to the other alternatives for treating the area with residual contaminant mass. Monitoring would be required to confirm that rebound does not occur after completing the necessary treatment(s).

Implementability: The known lateral extent of the area with residual contaminant mass may extend under a building as well as land owned by Caltrans (areas that are not accessible), although MIP investigations (ITSI, 2011a) indicate that the extent under the building is uncertain and estimated to be limited. Established field techniques exist to implement ISCO at accessible locations of the Site. **Rating: Moderate.** Implementability is influenced by the lateral footprint and associated accessibility of the locations with subsurface CAH contamination, and the current land use and development (buildings) extent of the area. For some areas, implementation is relatively easy, while other areas overlying the footprint of residual mass are not as easily accessed, or are not accessible.

Cost: While ISCO is a destructive process, this alternative only addresses the area of the Site identified with residual CAH mass. Relative to Alternative 3B and 3C, capital costs may be a little higher if multiple injections are needed. Like all three alternatives for treating the area with residual CAH mass, groundwater monitoring would still be required to confirm that concentrations do not rebound, and that natural attenuation reduces the CAHs to levels below the cleanup criteria across the Site in a reasonable time frame. **Rating: Moderate to High.**

4.2.5 Alternative 3B – Enhanced Anaerobic Bioremediation (EAB), MNA, and ICs

EAB treatment for CAHs is an established and field proven remedial alternative.

Effectiveness: If complete reductive dechlorination of the CAHs is achieved, EAB will convert TCE and other CAHs to end products with no human health or environmental impact. The resulting end products, ethene/ethane, carbon dioxide, chloride ions, and water, would not impact the beneficial uses of the shallow groundwater. To be effective, this reaction will require the creation of anaerobic conditions throughout the treatment zone, as well as establishing an active microbial (*Dehalococcoides ethenogenes*) population. With these conditions established through the proposed bioaugmentation (i.e., organic substrate injection, the recirculation system), EAB will biologically complete the transformation of dissolved and sorbed CAHs in the treatment zone. With recirculation, accessible areas can be used for the injections with the flushing enabling possible coverage of areas not accessible. In addition, EAB needs an established anaerobic zone for the area of residual CAH mass. While advective movement of the flushing action will be somewhat limited in areas of finer grain soils, dispersion and diffusion will effectively distribute the organic substrate to enable degradation of the CAHs through the achievement of anaerobic conditions throughout the treatment zone. Compared to Alternatives 3A and 3C, the effectiveness of this alternative is not anticipated to be as affected by the lateral footprint of the residual CAH mass, including possibly extending under a building and the heterogeneous soil media present beneath the area around well 17W. Once the anaerobic conditions are established, consistent operation of the recirculation system would not be required to sustain the anaerobic conditions for EAB to meet the cleanup criteria in the treatment zone with residual CAH mass. **Rating: Moderate to High.** The effectiveness is associated with achieving anaerobic conditions and microbial activity for CAH-degrading microorganisms throughout the lateral and vertical extent of the area with residual CAH mass. Alternative 3B may possibly be more effective than Alternatives 3A and 3C if the flushing distributes the organic substrate to areas that are not accessible for injections. Monitoring would be required to confirm that rebound does not occur.

Implementability: By using focused injection locations with the recirculation system, EAB can be implemented throughout the area with residual contaminant mass. Established field techniques exist to implement EAB at the Site. **Rating: Moderate to High.** The locations for the injections and installation of the recirculation system are reasonably accessible, and hydraulic flushing can be used to distribute the soluble electron donor substrate, such as lactate. Once suitable anaerobic conditions are established at the zone being treated, EAB will remediate the sorbed CAH mass in the finer grain soil with time.

Cost: Like Alternatives 3A and 3C, EAB results in the transformation of the CAHs to innocuous end products and is focused on active remediation. Similar to Alternatives 3A and 3C, this alternative only addresses the area of the Site identified with residual CAH mass. Relative to Alternatives 3A and 3C, capital costs would be the same or slightly less, with a little higher O&M costs to achieve/maintain the anaerobic conditions in the treatment zone. Like all three alternatives for treating the area with residual CAH mass, long-term groundwater monitoring would still be required to confirm that concentrations do not rebound and that natural attenuation reduces the CAHs to levels below the cleanup criteria across the Site in a reasonable time frame. The longer life of the anaerobic conditions in the shallow groundwater enhances the ability to address residual CAH mass in finer-grain soils, and may also contribute to biological transformations of the CAHs downgradient of this area due to the electron donor substrate being conveyed through advection, dispersion, and diffusion through the treatment zone. **Rating: Moderate.**

4.2.6 Alternative 3C – In-situ Chemical Reduction (ISCR), MNA, and ICs

ISCR of chlorinated ethenes using ZVI is an established remedial approach if the ZVI contacts the CAHs.

Effectiveness: ISCR can chemically destroy TCE and other CAHs to form innocuous end products consisting of carbon dioxide, chloride ions, ferrous iron, and water. To be effective, this reaction needs the ZVI to contact the CAH. The extent of contact duration increases as the number of chlorine atoms present in the CAH decreases (Muegge, 2008). As an example, Muegge reported the half-life of cis-1,2-DCE and vinyl chloride in contact with ZVI as 3.1 hours and 4.7 hours, respectively, while the half-life for TCE was 0.6 hours. For this reason, rebound effects may occur due to incomplete reduction of the CAHs if the CAHs are sorbed to the soil mass and/or if the ZVI injection is not suitably distributed in a uniform manner throughout the treatment zone.

Due to existing conditions at the area to be treated, a direct push injection application approach similar to that described for Alternative 3A is assumed for Alternative 3C. The method of injection reduces the potential need for multiple injection treatments of ZVI to achieve the cleanup criteria at the Site. With the direct push injection method, ZVI is effective for areas that are accessible. The access influence on effectiveness for ISCR has similar considerations to that for ISCO (Alternative 3A). Unlike ISCO, ISCR with ZVI has a long activity life in the saturated zone. **Rating: Moderate to High.** The effectiveness is influenced by the ability to deliver the ZVI through the zone with residual contaminant mass. Monitoring would be required to confirm that rebound does not occur after completing the necessary treatment(s).

Implementability: The known lateral extent of the area with high residual contaminant mass could pose access issues for this alternative similar to those described for Alternative 3A. The lateral extent of the area with residual contaminant mass is suspected to extend under a building and also property owned by Caltrans (Highway 101), and these areas are not accessible. Established field techniques exist to implement ISCR for the accessible area with residual contaminant mass, but areas near or under the building and the area adjacent to Highway 101 have access limitations. **Rating: Moderate.** Implementability is influenced by access due to the space required for the injections to implement ISCR. For some areas, implementation is relatively easy, whereas the lateral extent of the residual contaminant mass is not easily accessed in other areas that are near and under building, or near the freeway. Except for the possible need for multiple injections using ISCO, implementability and rating of direct pressure injection for ISCR would be similar to that described for ISCO.

Cost: Like ISCO and EAB, ISCR with ZVI is a destructive process for the CAHs. Like Alternatives 3A and 3B, this alternative only addresses the area of the Site identified with residual CAH mass near Well 17W. Relative to Alternative 3A, capital costs would be a similar assuming that only a single injection is needed to achieve the desired CAH destruction. Costs are anticipated to be similar to Alternative 3A and are primarily controlled by the costs for the injection solution and to mobilize and implement the treatment using the injection equipment. Like all three alternatives to treat the area with residual CAH mass, long-term groundwater monitoring would still be required to confirm that concentrations do not rebound and that natural attenuation reduces the CAHs to levels below the cleanup criteria across the Site in a reasonable time frame. **Rating: Moderate.**

4.2.7 Alternative 4 – Monitored Natural Attenuation (MNA) and ICs

Monitoring of contaminant concentrations in groundwater is the approach currently being applied to the entire, shallow groundwater plume at the Site. The current monitoring program only partially meets EPA's guidance for monitoring associated with MNA for remediation of groundwater with CAH contamination (EPA, 1998, EPA, 1999a, and EPA, 2008). An expanded monitoring program would be implemented to comply with EPA's guidance for MNA.

Effectiveness: Under suitable and maintained reducing conditions, reductive dechlorination of TCE has been well documented and the biochemical pathway and microorganisms responsible have been identified (Wiedemeier et al., 1999). While monitoring alone is the current approach at the Site, to date monitoring has not included geochemical analyses and other analyses to verify that suitable reducing conditions and complete biodegradation of TCE to ethene. Based on the long-term groundwater monitoring results for the Site and the MNA modeling results (Appendix A), MNA will require an estimated time frame greater than 30 years to satisfy the RAOs for groundwater at the Site. Additional geochemical and chemical analyses would be needed to ascertain and monitor the effectiveness of MNA as the groundwater remedial approach. **Rating: Moderate.** The monitoring results over the last 10 years only show moderate effectiveness. Locations with stable CAH concentrations need additional analyses/evaluations completed to establish if conditions are suitable for achieving appropriate reducing conditions and activity for CAH-degrading microorganisms.

Implementability: MNA program can be easily implemented and added to the existing groundwater monitoring and sampling program. Commercial laboratories are available to perform CSIA and microbial characterization to enable use of these monitoring tools to validate if MNA is active. **Rating: High (relatively easy).**

Cost: Additional laboratory costs to obtain suitable data for MNA evaluation would be required. Based on the estimated time frame to achieve all remediation criteria as modeled using BIOCHLOR, over 30 years is assumed for this alternative. **Rating: Low to Moderate.** O&M costs associated with long-term monitoring of geochemical and CAH concentrations, along with special analyses (i.e., CSIA and microbial), are the primary cost input.

4.3 RETAINED ALTERNATIVES

Based on the screening of alternatives presented in Section 4.2, all alternatives were retained as the alternatives provide protection of human health and the environment, satisfy RAOs, and satisfy the groundwater RGs in a reasonable time frame. These alternatives are identified in Table 4-2 and discussed below.

4.3.1 Alternative 1 - No Action

The No Action alternative was described in Section 4.1.2.1.

4.3.2 Alternative 2A – Groundwater Extraction, Monitoring, and ICs

The description of Alternative 2A was presented in Section 4.1.2.2. Figure 4-1 is a plan view showing the assumed locations of the extraction wells (A and B zones) and discharge points to the sanitary sewer. Details and estimated quantities for Alternative 2A are listed in Table 4-3.

4.3.3 Alternative 2B – Groundwater Extraction, MNA, and ICs

The description of Alternative 2B was presented in Section 4.1.2.3. Figure 4-2 is a plan view showing the assumed locations of the extraction wells (A and B zones), routing of conveyance piping, and the location of the discharge to the sanitary sewer. Details and estimated quantities for Alternative 2B are listed in Table 4-4.

4.3.4 Alternative 3A – In-situ Chemical Oxidation (ISCO), MNA, and ICs

The description of Alternative 3A was presented in Section 4.1.2.4. Figure 4-3 is a plan view showing the assumed locations of the injection points, and also well 17W. Details and estimated quantities for Alternative 3A are listed in Table 4-5.

4.3.5 Alternative 3B – Enhanced Anaerobic Bioremediation (EAB), MNA, and ICs

The description of Alternative 3B was presented in Section 4.1.2.5. Figure 4-4 is a plan view showing the assumed locations of the extraction well, injection wells (A and B zones), injection points, and well 17W. A conceptualization of this Alternative is presented in Figure 4-5. Details and estimated quantities for Alternative 3B are listed in Table 4-6.

4.3.6 Alternative 3C – In-situ Chemical Reduction (ISCR), MNA, and ICs

The description of Alternative 3C was presented in Section 4.1.2.6. Figure 4-6 is a plan view showing the assumed locations of the injection points, and also well 17W. Details and estimated quantities for Alternative 3C are listed in Table 4-7.

4.3.7 Alternative 4 – Monitored Natural Attenuation (MNA) and ICs

The description of Alternative 4 was presented in Section 4.1.2.7. With the exception of monitoring well 21W located on the east side of the Bayshore Freeway over 200 feet northeast of monitoring well 22W, Figure 4-9 shows the locations of the existing A- and B-zone groundwater monitoring wells. Details and estimated quantities for Alternative 4 are listed in Table 4-10.

5.0 DETAILED ANALYSIS OF GROUNDWATER ALTERNATIVES

This section presents a detailed analysis of the alternatives developed and retained in Section 4. This section concludes with a comparative analysis of the remedial alternatives. The alternatives for groundwater include:

- **Alternative 1** - No action;
- **Alternative 2A** – Groundwater Extraction, Monitoring, and ICs;
- **Alternative 2B** – Groundwater Extraction, MNA, and ICs;
- **Alternative 3A** – In-situ Chemical Oxidation (ISCO), MNA, and ICs;
- **Alternative 3B** – Enhanced Anaerobic Bioremediation (EAB), MNA, and ICs;
- **Alternative 3C** – In-situ Chemical Reduction (ISCR), MNA, and ICs; and
- **Alternative 4** – Monitored Natural Attenuation (MNA) and ICs

As discussed in Section 4, there are a number of elements that are common to Alternatives 2A through 4. These common elements are discussed as part of the detailed alternative evaluations, including the cost estimates. These common elements include:

- ICs consisting of groundwater use restrictions and SCVWD Ordinance 90-1;
- MNA in conjunction with or following active treatment (Alternatives 2B through 3C only); and
- Groundwater monitoring.

5.1 EVALUATION CRITERIA

The purpose of the detailed analysis is to evaluate the alternatives with respect to established criteria (EPA, 1988), allow comparison of the alternatives, and facilitate the selection of an appropriate remedy for a site. The evaluation criteria are grouped into three categories: threshold criteria, primary balancing criteria, and modifying criteria.

5.1.1 Threshold Criteria

Threshold criteria are:

Overall Protection of Human Health and the Environment: The alternative must be able to achieve and maintain protection of human health and the environment. For this FFS, the site-specific application of this criterion relates to elimination of risk from exposure to groundwater impacted with COCs above concentration levels that are protective of human health and/or the environment. As volatilization results in COCs in the soil gas, the groundwater remediation objectives have been established so that satisfying this criterion for groundwater is sufficient to protect human health with respect to potential VI.

Compliance with ARARs: The alternative must comply with the ARARs that were identified in Section 2. The detailed analyses also address other information from advisories, criteria, and guidance that were identified as “to be considered”. If an alternative does not comply with the

ARARs, the evaluation will identify if a waiver is required, and how the waiver is justified. The applicability of ARARs to each alternative is presented in Table 5-1.

5.1.2 Primary Balancing Criteria

The five primary balancing criteria are used to evaluate the technical and economic aspects of an alternative. The primary balancing criteria include: (1) long-term effectiveness and permanence; (2) reduction of toxicity, mobility, or volume through treatment; (3) short-term effectiveness; (4) implementability; and (5) cost.

Long-Term Effectiveness and Permanence: The focus of long-term effectiveness of an alternative is maintaining the protection of human health and the environment after completing the RA. The two components of this assessment are:

- The magnitude of residual risks remaining after conclusion of the remedial activity; and
- The adequacy and reliability of controls or mitigation measures necessary to manage the residuals or untreated COCs associated with these risks.

Reduction of Toxicity, Mobility, or Volume (TMV) through Treatment: This criterion considers the anticipated performance of an alternative to permanently and significantly reduce the toxicity, mobility, or volume of COCs in groundwater. Factors considered include:

- Treatment processes used and materials to be treated;
- The amount of hazardous substances to be treated;
- Estimated degree of expected reduction in toxicity, mobility, or volume;
- The degree to which the treatment is irreversible; and
- Type and quantity of residuals from the treatment.

Short-Term Effectiveness: This criterion is used to assess the impact of an alternative on human health (construction workers and the community) and the environment during the construction and implementation of the remedial alternative. Components included in the evaluation for this criterion include:

- Protection of community health during the mitigation action;
- Protection of workers' health during the mitigation action;
- The time duration to achieve the response objectives; and
- Any environmental impacts resulting from the activities associated with implementing the alternative.

Implementability: This criterion addresses the technical and administrative feasibility of implementing an alternative. This criterion involves analysis of the following factors:

- Technical feasibility - pertains to the ability of constructing and operating the alternative, the reliability of the alternative, the ease of undertaking additional actions, and the ability to monitor the effectiveness of the alternative.

- Administrative feasibility - refers to the likelihood of permitting, regulatory agency approval, and access to install, operate, maintain, and monitor the remedial system.
- Availability of materials and services - includes the availability of personnel and technology, off-site treatment, storage, and disposal capacity; and the availability of necessary services, equipment, materials, and specialists.

Cost: This criterion considers the capital costs, the operational and maintenance (O&M), and the monitoring costs associated with implementing an alternative. Capital costs include the costs for construction and installation of the components of a remedial alternative; and consist of labor, equipment, materials, waste disposal, permitting, engineering design, and start up. Treatability studies and/or pilot tests performed to establish the design basis for a remedial alternative are part of the design cost portion of capital costs.

O&M costs include the costs to operate and maintain the systems; and consist of power source(s) (e.g., electricity), materials for maintenance, analytical services, labor, and compliance with regulatory reporting requirements (e.g., performance monitoring and periodic site reviews). While the time frame associated with capital costs is fairly short, and commonly occurring at the beginning of the remedial alternative implementation. Operation maintenance monitoring (OMM) costs occur with time until the cleanup criteria are met. The costs (capital and OMM) are estimates, and their accuracy may be within -30 percent to +50 percent of the final cost for a remedy.

Periodic costs include efforts to comply with regulatory reporting requirements, project activities that are performed during specific years, and preparation of a site closure report. Additionally, well abandonment and treatment system demolition costs were included in the periodic costs for the estimated final year of the time frame to achieve compliance with the cleanup criteria. The lump sum periodic costs were estimated based on engineering judgment and experience.

To account for the time value of money, the present worth cost of each alternative normalizes variations in the cost of capital, OMM, and periodic costs during the multi-year remediation period for each alternative and facilitates a comparison of the alternatives. As the estimated time frame for achieving compliance with the cleanup criteria can vary for the remedial alternatives, the present worth costs are determined for each alternative based on the estimated time frame to achieve RAOs and associated cleanup criteria. The present worth costs were calculated for a 30-year life (or less depending upon the alternative) using a 2% rate of escalation and a 7% interest rate. These rates were used based on engineering judgment and experience, and the rates are within the range established under EPA guidance (EPA, 1988.

5.1.3 Modifying Criteria

The two modifying criteria (state acceptance and community acceptance) are not addressed in this FFS. These criteria will be addressed in the ROD amendment after comments on the Proposed Plan are received. A description of each criterion is presented below.

State Acceptance: This criterion is intended to identify the issues and concerns that the State regulatory agency (DTSC and/or RWQCB) may have with respect to each alternative. Assessment of this criterion will be completed after comments from DTSC and/or the RWQCB on this FFS Report are received.

Community Acceptance: This criterion considers the issues and concerns that the public may have with respect to each alternative. Assessment of this criterion will be completed after the EPA receives public comments on the Proposed Plan. While a previous groundwater remedy has already been implemented at the Site in accordance with the 1991 Record of Decision (EPA, 1991), limited community input has been received with regard to groundwater remediation. The public will have an opportunity to provide input on this FFS and the resulting Proposed Plan.

5.2 DETAILED ANALYSIS OF ALTERNATIVES

The detailed analyses are presented below for each alternative. The detailed capital cost analysis for each alternative is presented in Appendix C. For each alternative, a table is identified in Appendix D presenting the capital costs, annual operational and maintenance costs, time frame for the annual costs, periodic costs and associated time frame for the periodic costs, and the net present worth. A summary of the present worth cost estimates is presented in Table 5-2.

5.2.1 Alternative 1 – No Action

For this alternative, no action would be taken to address the shallow groundwater at the Site that is impacted with CAHs. The no action alternative must be included in the detailed analysis to satisfy applicable regulatory guidance (EPA, 1988). Inherent in the no action alternative is natural attenuation that will occur due to processes described in Section 1.2.4. With no action, including no monitoring, zero costs are assumed to be incurred for this alternative.

<u>Overall Protection of Human Health and the Environment</u>: This alternative is considered as a baseline for comparison to the other alternatives. As groundwater concentrations exceed the groundwater cleanup goals listed in Table 2-3, this alternative would not be protective of human health. Due to established ICs restrict groundwater use at the Site, no evidence exists that ingestion of the impacted, shallow groundwater is currently occurring. Besides the potential ingestion exposure pathway, the shallow groundwater is a source for CAH vapors in soil gas, and therefore the possible exposure by vapor intrusion.

Compliance with ARARs: The applicability of ARARs to Alternative 1 is identified in Table 5-1. This alternative would not comply with the ARARs and RAOs for the Site as identified in Tables 5-1 and 2-4, respectively. The beneficial uses of groundwater would be restricted, the required groundwater monitoring would not be performed, and the impacted shallow groundwater could be a potential source for exposure via soil gas.

Long-Term Effectiveness and Permanence: SCVWD Ordinance 90-1 would be the IC protecting human health. This ordinance does not provide long-term effectiveness with regard to remediation of CAH concentrations in the shallow groundwater. The CAHs currently present in the shallow groundwater would persist. In addition, the CAH-impacted, shallow groundwater also provides a potential source via volatilization for CAHs to be present in the soil gas. This alternative does not provide long-term effectiveness or permanence.

Reduction of Toxicity, Mobility, or Volume through Treatment: The no-action alternative does not reduce the toxicity, mobility, or volume of CAHs through treatment associated with shallow groundwater at the Site. As discussed in Section 1.2.4, some reduction of groundwater concentration may occur due to volatilization of CAHs at the water table. This reduction only transfers the CAHs from groundwater to soil gas, another potential exposure pathway. The transformation of TCE to 1,2-DCE under reducing conditions also does not achieve reduction of toxicity, mobility, or volume. The modeling projections (see Section 1.2.5) indicate a very long time frame for contaminant reduction and achievement of groundwater cleanup criteria from only natural attenuation.

Short-term Effectiveness: This criterion does not apply because no action is taken.

Implementability: This alternative, while technically feasible, is not administratively feasible. The EPA would not approve of this alternative because leaving contamination in place would have CAH concentrations in the shallow groundwater continuing to exceed the cleanup criteria.

Cost: Costs for no action are zero, resulting in the present worth cost of $0 (see Table 5-2).

5.2.2 Alternative 2A – Groundwater Extraction, Monitoring, and ICs

Groundwater extraction would contain the CAH-impacted groundwater plume, and wells would be installed to extract groundwater from the primary, remaining source of residual CAH mass in the shallow groundwater (area around 17W). When groundwater concentrations are below the cleanup criteria (Table 2-3), monitoring would be performed to verify concentrations remain below the cleanup criteria. If concentrations rebound, groundwater extraction would continue and the monitoring process repeated until compliance with the groundwater cleanup criteria is verified. The estimated time frame to achieve the groundwater cleanup criteria is 22 years.

Overall Protection of Human Health and the Environment: This alternative would be protective of human health and the environment. This alternative would contain the plume and with time remove the residual mass of CAHs in the area around Well 17W. To remove sorbed CAH mass, groundwater extraction would need to achieve sufficient flushing of the soil pore zones with this residual mass to transfer the CAHs mass from a sorbed to a dissolved state. Previous groundwater extraction did not effectively address this residual CAH mass, which is the primary source contributing to downgradient CAH concentrations in the shallow groundwater. With extraction wells in the vicinity of well 17W, this alternative may require groundwater extraction for an extended period of time. Thus, in time this alternative would be protective of human health and the environment. Groundwater extraction would contain and reduce the extent of the impacted, shallow groundwater. With time, Alternative 2A would achieve the cleanup criteria in groundwater and protect human health and the environment. During the time frame to achieve the cleanup criteria, established ICs would continue to restrict groundwater use at the Site.

Compliance with ARARs: The applicability of ARARs to Alternative 2A is identified in Table 5-1. This alternative would satisfy the ARARs and RAOs for the Site by containing the plume and reducing residual CAH mass in the impacted, shallow groundwater. With sufficient time and optimization operation of the extraction wells, groundwater extraction would comply with the cleanup criteria and restore the beneficial uses of shallow groundwater at the Site. Groundwater extraction and CAH mass removal would also eventually eliminate the shallow groundwater as a source for potential vapor intrusion exposure via soil gas. Monitoring would be conducted during the estimated time frame of 22 years based on groundwater modeling projections for compliance with the ARARs.

Long-term Effectiveness and Permanence: This alternative would provide long-term effectiveness and permanence by shrinking and containing the plume, removing the COCs in the area of residual CAH mass, and eventually achieving the groundwater cleanup criteria. As this residual CAH mass is the primary source of continuing CAH concentrations in the shallow groundwater, previous groundwater extraction was not that effective in removing this residual mass so groundwater extraction would need to continue for a sufficient period of time. In addition, previous use of groundwater extraction was not successful in achieving long-term effectiveness and permanence as low concentrations of contaminants remain in the shallow groundwater. Groundwater extraction has not been found to be cost-effective when contaminant concentrations are low, and a significant portion of the Site has low contaminant concentrations in shallow groundwater. Following discontinuation of groundwater extraction, monitoring would be required to verify no rebound in CAH concentrations above the cleanup criteria. This alternative would remediate the CAH-impacted, shallow groundwater with time. Groundwater extraction is a proven remediation approach for plume containment, but previous application of this remedy for the Site has demonstrated that zones of CAH residual mass may not be effectively flushed, necessitating a long period of groundwater extraction to sufficiently remove the residual CAH mass.

Reduction of Toxicity, Mobility, or Volume through Treatment: Groundwater extraction will contain the plume (mobility reduction), and reduce the volume of CAH-impacted groundwater. In consideration of previous experience with groundwater extraction at the Site, extraction for a sufficient period of time is anticipated to reduce the concentration in groundwater and the volume of groundwater impacted with CAHs in the area of residual contaminant mass. Being primarily effective in reducing dissolved concentrations, groundwater extraction will require sufficient flushings of the pore spaces throughout the lateral and vertical extent of the CAH residual mass.

Groundwater extraction is only effective in removing dissolved CAHs. In consideration of the rebound observed previously when groundwater extraction was discontinued, pulsing and/or other optimization operational approaches for the extraction process has been assumed for the extraction wells to sufficiently remove the sorbed mass of CAHs and achieve COC concentrations below the cleanup criteria. Aboveground treatment, required to remove the CAHs from the extracted groundwater, will be performed at Mountain View's treatment facility. Based on previous studies on the fate of CAH compounds in water discharged to the sanitary sewer, volatilization and/or leaks in the sewer line may allow some release of the COCs prior to the extracted groundwater reaching the municipal treatment plant. The reduction in the CAH concentrations in shallow groundwater at the Site would also reduce the potential toxicity of CAHs in soil gas.

Short-term Effectiveness: Having been previously used at the Site, groundwater extraction would have minimal risk to workers implementing the remediation system. These risks would be readily addressed through standard health and safety practices and engineering controls during the installation and operation of the groundwater extraction system. For the local community, no known potential exposure routes would be completed, resulting in no risk to the community associated with groundwater extraction. Estimated time to construct the components of this alternative is no more than one year, which includes installation of the new extraction wells and conveyance piping and connecting the conveyance piping to the sanitary sewer. The estimated time frame for groundwater extraction to achieve compliance with the ARARs and cleanup criteria is 22 years based on groundwater modeling projections. Minimal residual wastes would be generated by this alternative, consisting of soil cuttings from well installation and construction debris (soil, asphalt pavement, etc.) from installation of the piping for the conveyance of the extracted groundwater to the sanitary sewer.

Implementability: This alternative is technically and administratively feasible for implementation at the Site. Technically, this alternative uses field-applied technology and implementation methods. The locations for the extraction wells (see Figure 4-1) were selected based on achieving accessible locations while enabling the installation and operation of a suitable and easily operated groundwater extraction system. Monitoring the performance of this alternative is readily available through sampling of existing monitoring wells. Administratively, this alternative uses systems that have previously been permitted by local, state, and federal agencies. Access agreements will be required to install, operate, and monitor the system. With the potential exception of the A-zone well at the location of the former CTS Printex facility, the groundwater extraction wells and conveyance piping routes are located in accessible areas, consisting primarily of sidewalks, roadways, and vehicle parking lots. Thus, obtaining access approval is feasible. Due to the recent development at the site of the former CTS Printex facility, obtaining access approval is uncertain for installing a new extraction well and conveyance piping. Materials and services to install, operate, and monitor the components of this alternative are locally available.

Cost: Estimates of capital costs and present worth costs for Alternative 2A are presented in Table 5-2. The cost estimates for capital and annual O&M costs are presented in Appendix C-1. Table D-1 (Appendix D) summarizes the costs, including: (1) capital cost of $855,000; (2) total O&M costs of $5,641,000 (current dollars) resulting in an average annual O&M cost of $256,400; and (3) total periodic costs of $185,000 (current dollars). The total estimated present worth for this alternative is $4,482,000. A time frame of 22 years is estimated for Alternative 2A to achieve compliance with the groundwater cleanup criteria.

5.2.3 Alternative 2B – Groundwater Extraction, MNA, and ICs

Groundwater extraction would occur at selected locations to achieve the following: (1) contain the CAH-impacted groundwater plume, and (2) extract groundwater from the primary, remaining sources of residual CAH mass in the shallow groundwater, which includes the area around 17W. For other portions of the plume without active groundwater extraction, MNA would be implemented. When groundwater concentrations are below the cleanup criteria (Table 2-3), monitoring would be performed to verify concentrations remain below the cleanup criteria. If concentrations rebound at locations associated with extraction wells, groundwater extraction would continue and the monitoring process repeated until compliance with the groundwater cleanup criteria is verified.

Alternative 2B, like Alternative 2A, has extracted groundwater discharged directly to the sanitary sewer without treatment. The proposed locations for the discharge to the sanitary sewer are at existing manholes. Based on current land use at the proposed extraction well and conveyance piping locations, obtaining access to the land for implementing Alternative 2B should be feasible. The estimated time frame to achieve the groundwater cleanup criteria is 22 years.

<u>Overall Protection of Human Health and the Environment</u>: This alternative would be protective of human health and the environment. This alternative would contain the plume by groundwater extraction to remove the residual mass of CAHs, including the area around 17W; and use of MNA for other areas of the plume. The time for achievement of groundwater cleanup criteria is estimated to be controlled by the time frame to remove sorbed CAH mass, and this time frame is sufficient for MNA to achieve groundwater cleanup in the areas without active groundwater extraction. Previous groundwater extraction did not sufficiently address the residual CAH mass in the vicinity of Well 17W, which is the primary source contributing to downgradient CAH concentrations in the shallow groundwater. With extraction wells in the vicinity of well 17W, this alternative may require groundwater extraction for an extended period of time. Thus, in time this alternative would be protective of human health and the environment. Groundwater extraction would contain and reduce the extent of the impacted, shallow groundwater. With time, Alternative 2B would achieve the cleanup criteria in groundwater and protect human health and the environment. During the time frame to achieve the cleanup criteria, established ICs would continue to restrict groundwater use at the Site.

<u>Compliance with ARARs</u>: The applicability of ARARs to Alternative 2B is identified in Table 5-1. This alternative would satisfy the ARARs and RAOs for the Site by containing the plume and reducing residual CAH mass in the impacted, shallow groundwater. With sufficient time and optimizing the operation of the extraction wells, groundwater extraction would comply with the cleanup criteria and restore the beneficial uses of groundwater at the Site. Groundwater extraction for CAH mass removal combined with MNA would also eventually eliminate the shallow groundwater as a source for potential vapor intrusion exposure via soil gas. Monitoring would be conducted during the estimated time frame of 22 years based on groundwater modeling projections for compliance with the ARARs.

<u>Long-Term Effectiveness and Permanence</u>: This alternative would provide long-term effectiveness and permanence by containing the plume, removing the COCs in the area of residual CAH mass, and eventually achieving the groundwater cleanup criteria. As this residual CAH mass is the primary source of continuing CAH concentrations in the shallow groundwater, previous groundwater extraction was not that effective in removing this residual mass so groundwater extraction would need to continue for an extended period of time and operation of the extraction process optimized for CAH removal. Following discontinuation of groundwater extraction, monitoring would be required to verify no rebound in CAH concentrations above the cleanup criteria. This alternative would remediate the CAH-impacted, shallow groundwater with time. Groundwater extraction is a proven remediation approach for plume containment, but previous application of this remedy for the Site has demonstrated that zones of CAH residual mass may not be effectively flushed, necessitating a long period of groundwater extraction to sufficiently remove the residual CAH mass.

<u>Reduction of Toxicity, Mobility, or Volume through Treatment</u>: Groundwater extraction will contain the plume (mobility reduction), and reduce the volume of CAH-impacted groundwater. In consideration of previous experience with groundwater extraction at the Site, extraction for a sufficient period of time is anticipated to reduce the concentration in groundwater and volume of groundwater impacted with CAHs in the area with the residual contaminant mass. Being primarily effective in reducing dissolved concentrations, groundwater extraction will require sufficient flushings of the pore spaces throughout the lateral and vertical extent of the CAH residual mass. Groundwater extraction is only effective in removing dissolved CAHs. In consideration of the rebound observed previously when groundwater extraction was discontinued, pulsing or other optimization approaches for the extraction process has been assumed as the operational approach for the extraction wells to sufficiently remove the sorbed mass of CAHs and achieve COC concentrations below the cleanup criteria. Aboveground treatment, required to remove the CAHs from the extracted groundwater, will be performed at Mountain View's treatment facility. Based on previous studies on the fate of CAH compounds in water discharged to the sanitary sewer, volatilization and/or leaks in the sewer line may allow some release of the COCs prior to the extracted groundwater reaching the municipal treatment plant. The reduction in the CAH concentrations in shallow groundwater would also reduce the potential toxicity of CAHs in soil gas.

<u>Short-Term Effectiveness</u>: Groundwater extraction would have minimal risk to workers implementing the remediation system. These risks would be readily addressed through standard health and safety practices and engineering controls during the installation and operation of the groundwater extraction and on-site treatment system. For the local community, no known potential exposure routes would be completed, resulting in no risk to the community associated with groundwater extraction. Estimated time to construct the components of this alternative is no more than one year, which includes installation of the new extraction wells and conveyance piping and connecting to the sanitary sewer. The estimated time frame for groundwater extraction to achieve compliance with the ARARs and cleanup criteria is 22 years based on groundwater modeling projections. Minimal residual wastes would be generated by this alternative, consisting of soil cuttings from well installation and construction debris (soil, asphalt pavement, etc.) from installation of the piping for the conveyance of the extracted groundwater to the sanitary sewer.

<u>Implementability</u>: This alternative is technically and administratively feasible for implementation at the Site. Technically, this alternative uses field-applied technology and implementation methods. The locations for the extraction wells and sanitary sewer discharge points (see Figure 4-2) were selected based on achieving accessible locations while enabling the installation and operation of a suitable and accessible groundwater extraction system. Monitoring the performance of this alternative is readily available through sampling of existing monitoring wells. Administratively, this alternative uses systems that have previously been permitted by local, state, and federal agencies. Access agreements will be required to install, operate, and monitor the system. The groundwater extraction wells and conveyance piping routes are located in accessible areas, consisting primarily of sidewalks, roadways, and vehicle parking lots). Thus, obtaining access approval is feasible. Materials and services to install, operate, and monitor the components of this alternative are locally available.

Cost: The estimated capital and present worth costs for Alternative 2B are presented in Table 5-2. The cost estimates for capital and annual O&M costs are presented in Appendix C-2. Table D-2 (Appendix D) summarizes the costs, including: (1) capital cost of $695,000; (2) total O&M costs of $5,022,000 (current dollars) resulting in an average annual O&M cost of $228,300; and (3) total periodic costs of $158,000 (current dollars). The total estimated present worth for this alternative is $3,976,000. A time frame of 22 years is estimated for Alternative 2B to achieve compliance with the groundwater cleanup criteria.

5.2.4 Alternative 3A – In-situ Chemical Oxidation (ISCO), MNA, and ICs

The primary, remaining source of residual CAH mass in the shallow groundwater (area around 17W) would be treated by ISCO for this alternative. Following this active remediation, MNA would be used to achieve compliance with the cleanup criteria. The estimated time frame to achieve the groundwater cleanup criteria is 15 years.

Overall Protection of Human Health and the Environment: This alternative would be protective of human health and the environment. This alternative focuses on removing the residual mass of CAHs in the area around 17W. As this residual mass is the primary source contributing to downgradient CAH concentrations in the shallow groundwater, ISCO would remove this residual mass of CAHs and in conjunction with MNA, groundwater concentrations in time would comply with the groundwater cleanup criteria. Thus, this alternative would be protective of human health and the environment. For upgradient and downgradient areas of the plume, MNA would be the primary mechanism for CAH concentration reduction. During the time frame to achieve the cleanup criteria, established ICs would continue to restrict groundwater use at the Site. Remediating the area with residual CAH mass also removes the area of shallow groundwater that may be a potential contributing source for CAH vapors in soil gas.

Compliance with ARARs: The applicability of ARARs to Alternative 3A is identified in Table 5-1. This alternative would satisfy the ARARs and RAOs for the Site by applying ISCO to remove the residual CAH mass in the current, primary source area for the plume. In a reasonable time frame, MNA would enable compliance with the cleanup criteria and restore the beneficial uses of groundwater at the Site. ISCO followed by MNA would also remove the shallow groundwater as a source for potential vapor intrusion exposure via soil gas. Monitoring would be conducted during the estimated time frame for compliance with the ARARs of 15 years.

Long-Term Effectiveness and Permanence: This alternative would provide long-term effectiveness and permanence by removing the COCs in the area of residual CAH mass. As this residual CAH mass is the primary source of continuing concentrations in the shallow groundwater, removal of this residual mass by ISCO would remove the magnitude of potential risk associated with shallow groundwater. Following ISCO treatment, MNA would reduce the CAH concentrations in the shallow groundwater below the cleanup criteria. In time, this alternative would remove shallow groundwater as a potential source for vapor intrusion. ISCO is a field-proven, in-situ, remediation approach for transforming CAHs to innocuous end-products, and adequate and reliable implementation measures are established to treat the CAHs without any resulting risk to human health.

Reduction of Toxicity, Mobility, or Volume through Treatment: ISCO will reduce the toxicity and volume of CAHs in the area of residual contaminant mass. ISCO results in the chemical oxidation of CAHs to innocuous end-products, thus eliminating the toxicity associated with the CAHs. Following ISCO, MNA in time would reduce the toxicity and volume of impacted shallow groundwater and result in COC concentrations being below the cleanup criteria. The ISCO and MNA treatment end products are not reversible. This reduction in the CAH concentrations in shallow groundwater would also reduce the potential toxicity of CAHs in soil gas.

Short-Term Effectiveness: Being an in-situ remediation technology that is implemented through field-proven methods, ISCO would have minimal risk to workers implementing the remediation system. The primary risk to workers is the safe handling of the chemical oxidant and injection solutions. These risks would be readily addressed through established health and safety practices and engineering controls during the performance of the ISCO injections. For the community, no potential exposure routes would be completed, resulting in no risk to the community associated with ISCO. The estimated time for completing the performance of the ISCO treatment is no more than one year which includes time for a treatability study and field time for performing the ISCO injections. The estimated time for MNA to achieve groundwater cleanup in the other portions of the Site is 15 years after performing the ISCO injections. The chemical oxidant injected to achieve oxidation of the CAHs will naturally dissipate and lose oxidizing potential within a short time. The water quality of the shallow groundwater within the area of ISCO treatment will return to natural conditions within the time frame of MNA. Minimal residual wastes would be generated by this alternative, consisting of process water, unused injection solution, and construction debris (primarily asphalt pavement) from exposing the ground surface at each injection point.

Implementability: This alternative is technically and administratively feasible for implementation at the Site. Technically, this alternative uses field-proven technology and implementation methods. The locations for the ISCO injections (see Figure 4-3) were selected based on injecting only at accessible locations and selecting an injection grid suitable to achieve the desired results with a single injection (i.e., some estimated overlap of injection radius between injection points). Post-injection monitoring the performance of this alternative is readily available through sampling of 17W. Administratively, this alternative uses systems that have previously been permitted by local, state, and federal agencies. An access agreement will be required to perform the injections and monitor the results. As an access agreement is in place for 17W and the ISCO injection points are located in accessible areas used for parking, obtaining access approval is feasible. Materials and services to perform and monitor the components of this alternative are locally available.

Cost: The estimated capital and present worth costs for Alternative 3A are presented in Table 5-2. The cost estimates for capital and annual O&M costs are presented in Appendix C-3. Table D-3 (Appendix D) summarizes the costs, including: (1) capital cost of $2,365,000; (2) total O&M costs of $1,027,000 (current dollars) resulting in an average annual O&M cost of $68,500; and (3) total periodic costs of $121,000 (current dollars). The total estimated present worth for this alternative is $3,197,000. A time frame of 15 years is estimated for Alternative 3A to achieve compliance with the groundwater cleanup criteria. If MNA is not successful in an area and as a contingency active remediation by ISCO is implemented, the estimated cost for this contingency treatment is $190,000 to $300,000 (current dollars) depending upon the extent of the area to be treated.

5.2.5 Alternative 3B – Enhanced Anaerobic Bioremediation (EAB), MNA, and ICs

The primary, remaining source of residual CAH mass in the shallow groundwater (area around 17W) would be treated by EAB for this alternative. Following this active remediation, MNA would be used to achieve compliance with the cleanup criteria. The estimated time frame to achieve the groundwater cleanup criteria is 15 years.

Overall Protection of Human Health and the Environment: This alternative would be protective of human health and the environment. This alternative focuses on removing the residual mass of CAHs in the area around 17W. As this residual mass is the primary source contributing to downgradient CAH concentrations in the shallow groundwater, EAB would remove this residual mass of CAHs and in conjunction with MNA, groundwater concentrations in time would comply with the groundwater cleanup criteria. Thus, this alternative would be protective of human health and the environment. The established EAB treatment zone would also remediate CAHs concentrations from upgradient areas as groundwater flow moves through this remediation zone. Downgradient, MNA would be the primary mechanism for CAH concentration reduction. During the time frame to achieve the cleanup criteria, established ICs would continue to restrict groundwater use at the Site. Remediating the area with residual CAH mass also removes the area of shallow groundwater that may be a potential contributing source for CAH vapors in soil gas.

Compliance with ARARs: The applicability of ARARs to Alternative 3 is identified in Table 5-1. This alternative would satisfy the ARARs and RAOs for the Site by applying EAB to remove the residual CAH mass in the current, primary source area for the plume. In a reasonable time frame, MNA would enable compliance with the cleanup criteria and restore the beneficial uses of groundwater at the Site. EAB followed by MNA would also remove the shallow groundwater as a source for potential vapor intrusion exposure via soil gas. Monitoring would be conducted during the estimated time frame for compliance with the ARARs of 15 years.

Long-Term Effectiveness and Permanence: This alternative would provide long-term effectiveness and permanence by removing the COCs in the area of residual CAH mass. As this residual CAH mass is the primary source of continuing concentrations in the shallow groundwater, removal of this residual mass by EAB would remove the magnitude of potential risk associated with shallow groundwater. Following EAB treatment, MNA would reduce the CAH concentrations in the shallow groundwater below the cleanup criteria. In time, this alternative would remove shallow groundwater as a potential source for vapor intrusion. EAB is a field-proven, in-situ, remediation approach for transforming CAHs to innocuous end-products, and adequate and reliable implementation measures are established to treat the CAHs without any resulting risk to human health.

Reduction of Toxicity, Mobility, or Volume through Treatment: EAB will reduce the toxicity and volume of CAHs in the area of residual mass. With suitable reducing conditions and microbial activity, EAB results in the biological transformation of CAHs to innocuous end-products, thus eliminating the toxicity associated with the CAHs. Maintaining suitable reducing conditions and microbial activity, including bioaugmentation if necessary, will minimize the potential of only partial TCE and 1,2-DCE reduction and the formation of vinyl chloride (see Figure 1-8). Following EAB, MNA in time would reduce the toxicity and volume of impacted shallow groundwater and result in COC concentrations being below the cleanup criteria. The EAB and MNA treatment end products are not reversible. This reduction in the CAH concentrations in shallow groundwater would also reduce the potential toxicity of CAHs in soil gas.

Short-Term Effectiveness: Being an in-situ remediation technology that is implemented through field-proven methods, EAB would have minimal risk to workers implementing the remediation system. These risks would be readily addressed through standard health and safety practices and engineering controls during the installation and operation of the EAB system. For the community, no potential exposure routes would be completed, resulting in no risk to the community associated with EAB. Estimated time to construct the components of this alternative is one year, which includes performing a treatability study. The estimated time frame for the EAB treatment is 2 years, followed by MNA through year 15 to achieve compliance with the ARARs and groundwater cleanup criteria. The residual organic substrate added to achieve reductive dechlorination of the CAHs would naturally biodegrade, with water quality conditions of the shallow groundwater would return to natural conditions within the time frame of MNA. Minimal residual wastes would be generated by this alternative, consisting of soil cuttings from well installation and construction debris (soil, asphalt pavement, etc.) from installation of the distribution piping for the EAB system.

Implementability: This alternative is technically and administratively feasible for implementation at the Site. Technically, this alternative uses field-proven technology and implementation methods. The locations for the EAB components (see Figure 4-4) were selected based on achieving a reliable and easily operated EAB system. Monitoring the performance of this alternative is readily available through sampling of 17W and the injection/extraction wells. Administratively, this alternative uses systems that have previously been permitted by local, state, and federal agencies. An access agreement will be required to install, operate, and monitor the system. As an access agreement is in place for 17W and the EAB system components are located in accessible areas used for parking, obtaining access approval is feasible. Materials and services to install, operate, and monitor the components of this alternative are locally available.

Cost: The estimated capital and present worth costs for Alternative 3B are presented in Table 5-2. The cost estimates for capital and annual O&M costs are presented in Appendix C-4. Table D-4 (Appendix D) summarizes the costs, including: (1) capital cost of $859,000; (2) total O&M costs of $1,093,000 (current dollars) resulting in an average annual O&M cost of $72,900; and (3) total periodic costs of $141,000 (current dollars). The total estimated present worth for this alternative is $1,766,000. A time frame of 15 years is estimated for Alternative 3B to achieve compliance with the groundwater cleanup criteria. If MNA is not successful in an area and as a contingency active remediation by EAB is implemented, the estimated cost for this contingency treatment is $80,000 to $150,000 (current dollars) depending upon the extent of the area to be treated.

5.2.6 Alternative 3C – In-situ Chemical Reduction (ISCR), MNA, and ICs

The primary, remaining source of residual CAH mass in the shallow groundwater (area around 17W) would be treated by ISCR for this alternative. Following this active remediation, monitored natural attenuation would be used to achieve compliance with the cleanup criteria. The estimated time frame to achieve the groundwater cleanup criteria is 15 years.

Overall Protection of Human Health and the Environment: This alternative would be protective of human health and the environment. This alternative focuses on removing the residual mass of CAHs in the area around 17W. As this residual mass is the primary source contributing to downgradient CAH concentrations in the shallow groundwater, ISCR (zero valent iron solution injection) would remove this residual mass of CAHs and in conjunction with MNA, groundwater concentrations in time would comply with the groundwater cleanup criteria. Thus, this alternative would be protective of human health and the environment. For upgradient and downgradient areas of the plume, MNA would be the primary mechanism for CAH concentration reduction. During the time frame to achieve the cleanup criteria, established ICs would continue to restrict groundwater use at the Site. Remediating the area with residual CAH mass also removes the area of shallow groundwater that may be a potential contributing source for CAH vapors in soil gas.

Compliance with ARARs: The applicability of ARARs to Alternative 3C is identified in Table 5-1. This alternative would satisfy the ARARs and RAOs for the Site by applying ISCR to remove the residual CAH mass in the current, primary source area for the plume. In a reasonable time frame, MNA would enable compliance with the cleanup criteria and restore the beneficial uses of groundwater at the Site. ISCR followed by MNA would also remove the shallow groundwater as a source for potential vapor intrusion. Monitoring would be conducted during the estimated time frame for compliance with the ARARs of 15 years.

Long-Term Effectiveness and Permanence: This alternative would provide long-term effectiveness and permanence by removing the COCs in the area of residual CAH mass. As this residual CAH mass is the primary source of continuing concentrations in the shallow groundwater, removal of this residual mass by ISCR would remove the magnitude of potential risk associated with shallow groundwater. Following ISCR treatment, MNA would reduce the CAH concentrations in the shallow groundwater below the cleanup criteria. In time, this alternative would remove shallow groundwater as a potential source for vapor intrusion. ISCR is a field-proven, in-situ, remediation approach for transforming CAHs to innocuous end-products, and adequate and reliable implementation measures are established to treat the CAHs without any resulting risk to human health.

Reduction of Toxicity, Mobility, or Volume through Treatment: ISCR will reduce the toxicity and volume of CAHs in the area of residual mass. ISCR results in the chemical reduction of CAHs to innocuous end-products, thus eliminating the toxicity associated with the CAHs. Following ISCR, MNA in time would reduce the toxicity and volume of impacted shallow groundwater and result in COC concentrations being below the cleanup criteria. The ISCR and MNA treatment end products are not reversible. This reduction in the CAH concentrations in shallow groundwater would also reduce the potential toxicity of CAHs in soil gas.

Short-Term Effectiveness: Being an in-situ remediation technology that is implemented through field-proven methods, ISCR would have minimal risk to workers implementing the remediation system. The primary risk to workers is the safe handling of the injection solutions containing the chemical reducing agent (ZVI). These risks would be readily addressed through established health and safety practices and engineering controls during the performance of the

ISCR injections. For the community, no potential exposure routes would be completed, resulting in no risk to the community associated with ISCR. The estimated time frame for completing the performance of the ISCR treatment is no more than one year which includes time for a treatability study and field time for performing the ISCR injections. The estimated time for MNA to achieve groundwater cleanup in the other portions of the Site is 15 years after performing the ISCR injections. The ZVI solution injected to achieve reduction of the CAHs will have some period of activity, and with time will naturally dissipate. The water quality of the shallow groundwater in the area of ISCR treatment will return to natural conditions within the time frame of MNA. Minimal residual wastes would be generated by this alternative, consisting of process water, unused injection solution, and construction debris (primarily asphalt pavement) from exposing the ground surface at each injection point.

Implementability: This alternative is technically and administratively feasible for implementation at the Site. Technically, this alternative uses field-proven technology and implementation methods. The locations for the ISCR injections (see Figure 4-6) were selected based on injecting only at accessible locations and selecting an injection grid suitable to achieve the desired results with a single injection (i.e., some estimated overlap of injection radius between injection points). Post-injection monitoring the performance of this alternative is readily available through sampling of 17W. Administratively, this alternative uses systems that have previously been permitted by local, state, and federal agencies. An access agreement will be required to perform the injections and monitor the results. As an access agreement is in place for 17W and the ISCR injection points are located in accessible areas used for parking, obtaining access approval is feasible. Materials and services to perform and monitor the components of this alternative are locally available.

Cost: The estimated capital and present worth costs for Alternative 3C are presented in Table 5-2. Estimates for capital costs and annual O&M costs are presented in Appendix C-5. Table D-5 (Appendix D) summarizes the costs, including: (1) capital cost of $1,542,000; (2) total O&M costs of $1,027,000 (current dollars) resulting in an average annual O&M cost of $68,500; and (3) total periodic costs of $121,000 (current dollars). The total estimated present worth for this alternative is $2,374,000. A time frame of 15 years is estimated for Alternative 3C to achieve compliance with the groundwater cleanup criteria. If MNA is not successful in an area and as a contingency active remediation by ISCR is implemented, the estimated cost for this contingency treatment is $120,000 to $180,000 (current dollars) depending upon the extent of the area to be treated.

5.2.7 Alternative 4 – Monitored Natural Attenuation (MNA) and ICs

This alternative relies on natural attenuation processes to achieve compliance with remediation criteria in the entire shallow groundwater plume. MNA has been the selected approach since groundwater extraction was discontinued in 1996. Previous groundwater monitoring has not established if the appropriate geochemical and other conditions (microbial, etc.) exist for the biodegradation of TCE to ethene. In addition, insufficient data are available to ascertain the rate and extent of reductive dechlorination of TCE and its daughter products. Therefore, an enhanced groundwater monitoring is included in this alternative to able a reasonable projection of the performance of natural attenuation processes and the time frame to achieve compliance with groundwater cleanup criteria. Based on the results from the modeling using BIOCHLOR, a time frame of more than 30 year is estimated for this alternative to comply with the cleanup criteria. For cost estimating purposes, a 30 year time frame was used in determining the present worth cost for this alternative even though a longer time frame likely would be needed.

Overall Protection of Human Health and the Environment: This alternative would be protective of human health and the environment. This alternative uses natural attenuation processes to remediate the CAHs in the A and B zones. While some transformation of TCE to cis-1,2-DCE has occurred, groundwater monitoring data indicate that the reductive dechlorination of TCE to ethene is not occurring, or is occurring at a slow rate. Data are not currently available to verify that groundwater concentrations are being reduced by natural attenuation processes sufficiently to achieve the groundwater cleanup criteria within 30 years or less. As discussed in Section 1.2.5.1, a time frame of 70 to 100 years is expected for MNA to achieve the groundwater cleanup criteria. With time, which is estimated at more than 30 years due to areas within the plume of contaminant residual mass such as in the vicinity of well 17W, this alternative would be protective of human health and the environment. Therefore during the time frame for MNA to achieve the groundwater cleanup criteria, established ICs would continue to restrict groundwater use at the Site.

Compliance with ARARs: The applicability of ARARs to Alternative 4 is identified in Table 5-1. This alternative would satisfy the ARARs and RAOs for the Site with sufficient time, estimated more than 30 years. The results from the enhanced groundwater monitoring program for this alternative would provide more appropriate data to estimate the rate of TCE and cis-1,2-DCE biodegradation for modeling the estimated time frame for MNA to achieve compliance with the ARARs.

Long-Term Effectiveness and Permanence: In consideration of monitoring results over the last fourteen years, as well as recent investigation results indicating areas with residual contaminant mass, this alternative would require more than 30 years to provide long-term effectiveness and permanence. Insufficient data are currently available to assess if CAH biodegradation to innocuous end-products is occurring in the shallow groundwater at the Site, thereby the permanence of this alternative is uncertain.

Reduction of Toxicity, Mobility, or Volume through Treatment: Natural attenuation does not include active treatment to reduce toxicity, mobility, or volume, but rather relies on natural processes for this reduction. Insufficient data are currently available to assess if CAH biodegradation to innocuous end-products is occurring by means of natural attenuation processes in the shallow groundwater at the Site. While some reduction of toxicity, mobility, or volume of contaminants in shallow groundwater is occurring, the extent and rate appears limited and insufficient to ensure transformation of TCE and other CAHs to innocuous end-products by reductive dechlorination.

Short-Term Effectiveness: As this alternative will continue groundwater monitoring using existing wells, this alternative has minimal impact to implement. For the community, no potential exposure routes would be completed, resulting in no risk to the community associated with MNA. No new construction is associated with this alternative, although possibly one or more monitoring wells may be needed between monitoring wells MW-17 and MW-22/MW-23. The additional monitoring wells would be used to assess if the residual contaminant mass in the vicinity of MW-17 is migrating downgradient. A long time frame of more than 30 years is estimated for MNA to achieve the groundwater cleanup criteria. Minimal residual wastes would be generated by this alternative, consisting of purge water from groundwater sampling.

Implementability: This alternative is technically and administratively feasible for implementation at the Site. Technically, this alternative uses the existing monitoring wells and implementation methods are established for collecting groundwater samples. The enhanced monitoring program for this alternative is readily available through sampling of existing monitoring wells and completing the analyses through commercially available laboratories. Administratively, access agreements are established to monitor groundwater from the existing monitoring wells. Materials and services to perform and monitor the components of this alternative are locally available.

Cost: The estimated present worth cost for Alternative 4 is presented in Table 5-2. No capital costs are associated with this alternative. The cost estimates for annual O&M associated with Alternative 4 are presented in Appendix C-6. Table D-6 (Appendix D) summarizes the estimated costs, including: (1) capital cost of $0; (2) total O&M costs of $1,012,000 (current dollars) resulting in an average annual O&M cost of $33,800; and (3) total periodic costs of $201,400 (current dollars). The total estimated present worth for this alternative is $661,000. A time frame of 30 years was assumed to calculate the present worth for Alternative 4, although a longer time frame is estimated to be required to achieve compliance with the groundwater cleanup criteria. A longer time frame than 30 years would increase the total costs for this alternative, although the longer time would not have a significant impact on the estimated present worth cost for this alternative.

5.3 EVALUATION AND COMPARATIVE ANALYSIS OF ALTERNATIVES

This section evaluates the performance of each groundwater alternative relative to each of the seven evaluation criteria. The purpose of this comparison is to focus on the advantages and disadvantages of each alternative relative to one another. Overall protection of human health and compliance with ARARs are threshold criteria and must be met by an alternative for it to be eligible for selection. A qualitative evaluation of the alternatives is presented in Table 5-3.

5.3.1 Overall Protection of Human Health and the Environment

Alternatives 2A, 2B, 3A, 3B, 3C, and 4 are protective of human health and the environment. Without any remedial action or monitoring, Alternative 1 may not be protective of human health and the environment.

5.3.2 Compliance with ARARs

Alternatives 2A, 2B, 3A, 3B, 3C, and 4 comply with the ARARs. Alternative 1 does not comply with the ARARs. Compliance with ARARs is better for Alternatives 3A, 3B, and 3C than for Alternatives 2A, 2B, and 4. Alternatives 2A and 2B are more likely to achieve compliance with the ARARs and groundwater cleanup criteria than Alternative 4. While modeling projections indicate a long time frame for Alternatives 2A and 2B, a longer time frame for Alternative 4 is projected in order to achieve compliance with the ARARs. Alternatives 3A, 3B, and 3C are expected to achieve the ARARs and cleanup criteria for groundwater in the shortest time frame. The estimated time frames for compliance with the ARARs is 15 years for Alternatives 3A, 3B, and 3C; 22 years for Alternatives 2A and 2B; and 30 years or more for Alternatives 1 and 4.

5.3.3 Long-Term Effectiveness and Permanence

Alternatives 3A, 3B, and 3C have similar and the highest rating relative to the criterion of long-term effectiveness and permanence for groundwater remediation as these alternatives remediate the area with residual CAH mass. Alternatives 2A and 2B have similar long-term effectiveness and permanence for groundwater remediation, but are rated lower than Alternatives 3A, 3B, and 3C. Alternatives 3A, 3B, and 3C would more effectively remediate the area with residual CAH mass to irreversibly remove the COCs. Alternatives 3A, 3B, and 3C also rely on MNA to achieve the cleanup criteria and thereby provide long-term effectiveness and permanence. According to modeling results, Alternative 4 is the least effective in comparison to Alternatives 2A, 2B, 3A, 3B, and 3C. Alternative 1 is not effective because without monitoring, the plume stability or concentration decreases cannot be evaluated. In consideration of the projected time frames for Alternatives 2A, 2B, 3A, 3B, 3C, and 4 to achieve groundwater cleanup criteria, data need to be evaluated every 5 years to show progress in reducing CAH concentrations, and the CAH residual mass in the vicinity of well 17W.

5.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 3A, 3B, and 3C apply active remediation to reduce the toxicity and volume of the CAHs at the area of CAH residual mass, and are the highest rated alternatives for this criterion. Alternatives 2A and 2B reduce the volume of the impacted shallow groundwater by plume containment and resulting shrinkage of the plume extent. Alternatives 3A, 3B, and 3C are expected to be more effective in reducing the toxicity, mobility, or volume of COCs than groundwater extraction (Alternatives 2A and 2B). Alternatives 2A and 2B rely on groundwater flushing to remove the residual CAH mass, and previous use of this remedial technology at the Site did not achieve sufficient reduction of the COC residual mass. Alternatives 3A, 3B, and 3C rely on MNA for further reduction in the toxicity, mobility, or volume of the CAH-impacted groundwater in the low concentration areas of the Site. Alternative 4 does not apply treatment and completely relies on MNA for further reduction in the toxicity, mobility, or volume of the CAH-impacted groundwater. Available data indicate that biodegradation to harmless end products is not occurring by the natural attenuation processes associated with Alternative 4. The concentration reductions observed in shallow groundwater appear more attributable to physical processes. Alternative 1 is the least effective in the reduction of toxicity, mobility, or volume of CAHs because no active remedial treatment would occur, only natural attenuation processes, and no monitoring is performed to assess if reduction is occurring.

5.3.5 Short-Term Effectiveness

Alternatives 3B and 3C have similar short-term effectiveness, and are better than Alternatives 2A, 2B, 3C, and 4. Due to potential worker's safety and health issues handling the chemical agent for ISCO, Alternative 3A is not rated as high as Alternatives 3B and 3C. Alternatives 2A and 2B have similar short-term effectiveness and are better than Alternative 4. The projected time duration to achieve the groundwater cleanup criteria is the primary factor in this short-term effectiveness rating. Protection of community and workers' health during the mitigation action is similar for Alternatives 2A, 2B, 3A, 3B, 3C, and 4. A land use restriction covenant is in place to prevent use of shallow groundwater for a portion of the Site until compliance with the cleanup criteria. An additional IC, SCVWD Ordinance 90-1, is proposed to prevent shallow groundwater use at the Site until groundwater cleanup criteria are met. Alternatives 2A and 2B have a larger footprint of construction activities, and each alternative will use construction techniques that are field-proven and readily controlled to prevent worker exposure to contaminated media. From previous studies at other locations in California, Alternatives 2A and 2B, which include discharge to the sanitary sewer, could result in CAH release to the environment along the sanitary sewer route. Alternative 4 does not have active remediation so worker health would only relate to groundwater monitoring which is also a common element in Alternatives 2A, 2B, 3A, 3B, and 3C. Because Alternative 1 does not include implementing any remedial activities, short-term effectiveness does not apply to this alternative.

5.3.6 Implementability

Alternative 4 would be simplest to implement as wells are already installed and monitoring is currently being performed. After Alternative 4, the order of implementability from easiest to most difficult is Alternatives 3A, 3B, and 3C; Alternative 2B; and Alternative 2A. The active remediation area for Alternatives 3A, 3B, and 3C is currently a paved parking area with an existing monitoring well and implementation is technically and administratively feasible. Similar in-situ remedial technology applications have been permitted by the relevant state and local regulators. Alternatives 2A and 2B include extraction wells and buried conveyance piping. For Alternative 2B, the extraction wells and buried piping are located in public right of ways or parking lots. While the extraction wells and buried piping are located primarily in public right of ways or parking lots for Alternative 2A, the extraction well at the upgradient portion of the plume may have technical and administrative feasibility issues due to the area of the proposed extraction well having been recently redeveloped. Alternative 1 is not administratively feasible.

5.3.7 Cost

Based on the estimated present worth (Table 5-2), Alternative 3B has the lowest cost of the alternatives with active remediation (Alternatives 2A, 2B, 3A, 3B, and 3C). Next to Alternative 1 (cost of $0), Alternative 4 has the lowest estimated present worth. For alternatives with active remediation, Alternative 3C has the second lowest estimated present worth cost, with Alternative 3A being third and Alternative 2B fourth. The present worth costs for the groundwater extraction alternative addressing the entire plume (Alternatives 2A) are the highest for active remediation. The present worth cost for Alternative 3A, 3B, and 3C assume achievement of the cleanup criteria at the end of 15 years.

5.4 SUMMARY OF EVALUATION OF ALTERNATIVES

In developing the alternatives (Section 4) and completing the detailed analysis of the retained alternatives in this section (Section 5), EPA evaluation guidance (EPA, 1988) was applied and evaluations incorporated current conditions and groundwater concentration data trends at the Site. Shallow groundwater is designated as a potential source of drinking water, and the cleanup goal is therefore compliance with the MCLs (Table 2.4). There are groundwater use restrictions already in place for the Site.

Groundwater modeling suggested that relying on natural attenuation processes (Alternative 4) would take more than 30 years. For Alternatives 3A, 3B, and 3C, natural attenuation processes would be used to comply with the MCLs for shallow groundwater in the other portions of the plume, as active remediation would only be applied at the area around well 17W where the residual CAH mass is present. The modeling results indicate that concentrations in wells 12W (A zone) and 14W (B zone) in this upgradient portion of the plume will likely control the time frame for shallow groundwater to meet the cleanup goals for Alternatives 3A, 3B, and 3C. Alternatives 2A and 2B have a longer estimated time frame to complete groundwater cleanup than Alternatives 3A, 3B, or 3C, and this estimated time frame is consistent with results from the previous use of groundwater extraction at the Site. Based on prior use at the Site and associated data, groundwater extraction did not sufficiently reduce sorbed CAH mass in the shallow groundwater, especially in the vicinity of well 17W.

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TABLES

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Table 1-1
Results for Selected VOCs during 2010 Groundwater Sampling
CTS Printex Superfund Site, Mountain View, California

COC	Number of Samples	Number of Detects	Frequency of Detection (%)	Maximum Value (µg/L)	Remedial Action Objective (RAO) (µg/L)	MCL[3] (Federal/ California) (µg/L)
PCE 44		0	0	–	5	5/5
TCE[2]	44	27	61	79	5	5/5
1,1,1-TCA 44		14	32	0.82	200	200/200
cis-1,2-DCE[1]	44	35	80	340	–	70/6
trans-1,2-DCE[2]	44	7	15	11	10	100/10
1,1-DCE[2]	44	13	30	33	6	7/6
1,1-DCA[2]	44	29	66	31	5	–/5
1,2-DCA 44		0	0	–	0.5	5/0.5
Vinyl Chloride[1]	44 18		41	0.25	–	2/0.5
Chloroform 44		0	0	–	100	80/80
Methylene Chloride	44 6		13	1	5	5/5
Benzene 44		1	2	0.12	1	5/1
Toluene 44		16	36	0.45	100	1,000/150

Notes: 1 Not specifically listed as a COC in the 1991 ROD.

2 Shading indicates 2010 concentrations above their respective RAO or current MCL.

3 MCLs as currently established (August 2010).

Table 1-2
Oxidation-Reduction Potentials for Various Biochemical Reactions
(pH =7 and Temperature = 25°C)
CTS Printex Superfund Site, Mountain View, California

Half Cell Reaction	Reduction Potential[1] (mV)	Reductive Dechlorination Range
O_2 to H_2O	800	
Fe^{3+} to Fe^{2+}	770	
NO_3^- to NO_2^-	740	
PCE to TCE	430	600 mV
TCE to DCE	420	↑
Vinyl Chloride to Ethene	380	Possible
DCE to Vinyl Chloride	310	Range[2] -100 mV
SO_4^{2-} to H_2S	-230	↓ Optimum Range[2] ↕
CO_2 to CH_4	-260	-240 mV -240 mV
H^+ to H_2	-430	

Notes: [1]Source: Wiedemeier, et. al., 1999

[2]Source: Bouwer, 1994

[3]mV = millivolts

Table 2-1
Cleanup Concentrations for Groundwater from the 1991 ROD
CTS Printex Superfund Site, Mountain View, California
(EPA, 1991)[1]

Chemical	Clean-up Levels for Groundwater (µg/L)[2]	Basis
PCE	5	State/Federal MCL
TCE	5	State/Federal MCL
1,1-DCE	6	State MCL
trans 1,2-DCE	10	State MCL
1,1,1-TCA	200	Federal MCLG
1,1-DCA	5	State MCL
1,2-DCA	0.5	State MCL
Chloroform 100		Federal MCL
Methylene Chloride	5	Federal MCL
Benzene 1		State MCL
Toluene	100	State DHS action level

Notes: [1] Clean-up levels established in Table 7 of the 1991 ROD.
[2] µg/L = micrograms per liter or parts per billion

Table 2-2
Chemicals of Concern in Groundwater and with Concentrations above MCLs
CTS Printex Superfund Site, Mountain View, California

Chemical	Basis for Identification as Chemical of Concern (COC)
TCE	Classified as a probable human carcinogen, and reported to cause reproductive, mutagenic, and teratogenic effects.
trans 1,2-DCE	Reported to cause mutagenic effects.
cis 1,2-DCE[1]	Not considered a human carcinogen, reported to have non-carcinogenic effects.
1,1-DCE	Classified as a possible human carcinogen, and reported to cause reproductive, teratogenic, and mutagenic effects.
1,1-DCA	Classified as a probable human carcinogen, and reported to cause teratogenic effects.

Note: [1] cis 1,2-DCE was not identified as a chemical of concern in the 1991 ROD (EPA, 1991).

Table 2-3
Remediation Goals for Chemicals of Concern in Shallow Groundwater
CTS Printex Superfund Site, Mountain View, California

Chemical	Concentration (µg/L)	Basis
PCE[1]	5	State/Federal MCL
TCE	5	State/Federal MCL
1,1-DCE	6	State MCL
trans 1,2-DCE	10	State MCL
cis 1,2-DCE[2]	6	State MCL
1,1,1-TCA[1]	200	Federal MCLG
1,1-DCA	5	State MCL
1,2-DCA[1]	0.5	State MCL
Vinyl Chloride[2]	0.5	State MCL
Chlorofom[1]	100	Federal MCL
Methylene Chloride[1]	5	Federal MCL
Benzene[1]	1	State MCL
Toluene[1]	100	State DHS action level

Notes:
1 Current concentrations for this chemical of concern listed in the 1991 ROD are now below its MCL.
2 Chemical not included in the 1991 ROD.

Table 4-1
Assembly of Groundwater Remedial Alternatives for Screening
CTS Printex Superfund Site, Mountain View, California

Number	Alternative Description	Components of the Alternative	
		Common Elements	Description of Remedial Approach
1	No Action	None	None
2A	Plume-wide Groundwater Extraction	Yes	Groundwater extraction throughout the entire plume with discharge to the sanitary sewer for treatment at the municipal wastewater treatment facility and discharge under the facility's NPDES permit.
2B	Groundwater Extraction at select areas plus site-wide MNA	Yes	Groundwater extraction at selected areas to enhance residual CAH mass removal; discharge of the groundwater to the sanitary sewer for treatment at the municipal wastewater treatment facility; treated water discharge under the facility's NPDES permit; and MNA for the other areas
3A	ISCO at Areas with Residual containment Mass MNA plus site-wide MNA	Yes	In-situ chemical oxidation at the Area with residual CAH mass and MNA for other areas
3B	EAB at Areas with Residual containment Mass plus site-wide MNA	Yes	Enhanced in-situ anaerobic bioremediation at the area with residual CAH mass and MNA for other areas
3C	ISCR at Areas with Residual containment Mass plus site-wide MNA	Yes	In-situ chemical reduction at the area with residual CAH mass and MNA for other areas
4	MNA	Yes	Monitored natural attenuation for all areas of the plume

Table 4-2
Groundwater Remedial Alternatives Retained for Detailed Analysis and Comparison
CTS Printex Superfund Site, Mountain View, California

Number	Alternative Description	Basis for Retaining Alternative for Analysis
1	No Action	None
2A	Groundwater Extraction, MNA, and ICs[1]	Remedy in the 1991 ROD (EPA, 1991)
2B	Groundwater Extraction, MNA, and ICs[1]	Selected locations with groundwater extraction and sanitary sewer discharge consistent with the original remedy in the ROD (EPA, 1991). MNA would be applied at other areas for groundwater clean-up
3A	In-situ Chemical Oxidation (ISCO), MNA, and ICs[1]	A proven and cost effective technology that can be implemented at accessible locations for remediating the area with CAH residual mass. MNA would achieve groundwater clean-up for the other portions of the plume.
3B	Enhanced Anaerobic Bioremediation (EAB), MNA, and ICs[1]	A cost-effective, proven, and implementable alternative for remediating the area with residual CAH mass. MNA would achieve groundwater clean-up for the other portions of the plume.
3C	In-situ Chemical Reduction (ISCRJ), MNA, and ICs[1]	A proven and cost effective technology that can be implemented at accessible locations for remediating the area with CAH residual mass. MNA would achieve groundwater clean-up for other the portions of the plume.
4	Monitored Natural Attenuation (MNA) and ICs	Currently being applied at the Site with some areas having shown the desired decline in CAH concentrations.

Note: [1]Alternative includes the common elements previously described in Section 4.

Table 4-3
Description of Alternative 2A – Plume-wide Groundwater Extraction
CTS Printex Superfund Site, Mountain View, California

Alternative Description:			
•	Groundwater Extraction System would be installed and operated to extract groundwater across the entire plume and from both the A- and B-Zones, and, locally in the area near well 17W with residual CAH mass from the depth between A- and B-Zones. A total of 9 extraction wells will be installed with five wells to capture A-Zone impacted groundwater, one well to capture groundwater between A- and B-Zones, and three wells to capture impacted B-Zone groundwater.		
•	Contaminated groundwater will be extracted at selected points distributed throughout the site as shown in Figure 4-1 to contain the plume and remove the CAH-impacted groundwater.		
•	The extracted groundwater from each extraction well will be conveyed in buried piping to the nearest point of discharge to the City of Mountain View's sanitary sewer system.		
Site Characteristics:			**Comments:**
•	Maximum TCE concentration	64 µg/L	Well 17W (2010 sampling event)
•	Maximum cis-1,2-DCE concentration	27 µg/L	Well 17W (2010 sampling event)
•	Maximum 1,1-DCA	27 µg/L	Well 17W (2010 sampling event)
•	Effective porosity	30 %	Assumed
•	Groundwater extraction area	170,000 square feet	See Figure 4-1
•	Impacted depth (A and B zones)	30 feet	From top of water table (10 ft. bgs) to 40 ft. bgs)
•	Average extraction rate per well	6.5 gpm	Based on the former extraction wells
Conceptual Design Components and Assumptions:			
Groundwater Extraction System			
•	Layout is based on the former extraction system, but improved to extract and flush areas and depths with residual CAH mass.		
•	Addition of extraction well A-5 to capture the lateral extension of the A-zone plume at northwest downgradient portion of plume (Figure 4-1).		
•	Three wells (A-3, A/B-3, and B-3) screened at 10-20, 20-30, and 30-40 feet, respectively, will be installed to capture the horizon affected by the high residual CAH mass identified in the vicinity of well 17W.		
•	The extraction wells in A-Zone and the one screened between the A/B zones will consist of 6-inch PVC casing with a total linear footage of 120 feet (50 feet of blank casing and 70 feet of screened casing). The extraction wells in the B-Zone will consist of 4-inch PVC casing with a total linear footage of 80 feet (60 feet of blank casing and 20 feet of screened casing).		

Table 4-4
Description of Alternative 2B - Groundwater Extraction at Select Locations
CTS Printex Superfund Site, Mountain View, California

Alternative Description:				
•	Groundwater Extraction System (GWS) would be installed and operated under this alternative to extract groundwater from areas with residual CAH contaminant mass and from both the A- and B-Zones, including the area near well 17W with residual CAH mass. A total of 7 extraction wells will be installed with 3 wells to capture A-Zone impacted groundwater, one well to capture groundwater between A- and B-Zones near 17W, and three wells to capture impacted B-Zone groundwater.			
•	Groundwater will be extracted at selected locations as shown on Figure 4-2.			
•	The extracted groundwater from each extraction well will be conveyed in buried piping to the nearest point of discharge to the City of Mountain View's sanitary sewer system.			
Site Characteristics:				**Comments:**
•	Maximum TCE concentration	64	µg/L	Well 17W (2010 sampling event)
•	Maximum cis-1,2-DCE concentration	27	µg/L	Well 17W (2010 sampling event)
•	Maximum 1,1-DCA	27	µg/L	Well 17W (2010 sampling event)
•	Effective porosity	30	%	Assumed
•	Groundwater extraction area	52,000	square feet	See Figure 4-2
•	Impacted depth (A and B zones)	30	feet	From top of water table (10 ft bgs) to 40 ft bgs
•	Total flow rate extraction	35	gpm	Based on the pulsing operation of the extraction wells
Conceptual Design Components and Assumptions:				
Groundwater Extraction System				
•	Layout of the groundwater extraction well system enables the capture of groundwater from the areas with residual CAH mass and from both the A- and B-zones.			
•	Location of the extraction wells are shown on Figure 4-2. Groundwater extraction will occur from wells located on Plymouth Street (near 11W and 12W), in the vicinity of well 17W, and near the corner of Leghorn Street and Sierra Vista Avenue near downgradient wells 22W and 23W.			
•	Three wells (A-2, A/B-2, and B-2) screened at 10-20, 20-30, and 30-40 feet bgs, respectively, will be installed to capture the horizon affected by the high residual CAH mass identified in the vicinity of well 17W. At the other two well locations, an extraction well will be screened in each of the A-zone and the B-zone.			
•	The extraction wells in A- and A/B- zone will consist of 6-inch PVC casing with a total linear footage of 80 feet (30 feet of blank casing and 50 feet of screened casing). The extraction wells in B- zone will consist of 4-inch PVC casing with a total linear			

Table 4-4
Description of Alternative 2B - Groundwater Extraction at Select Locations
CTS Printex Superfund Site, Mountain View, California

Alternative Description:
footage of 80 feet (60 feet of blank casing and 20 feet of screened casing). Extracted groundwater across the Site will be conveyed through underground piping to the nearest point of discharge to the City of Mountain View's sanitary sewer system as shown on Figure 4-2.

Table 4-5
Description of Alternative 3A – In-situ Chemical Oxidation (ISCO) Treatment with MNA
CTS Printex Superfund Site, Mountain View, California

Alternative Description:				
•	In-situ chemical oxidation (ISCO) would be performed under this alternative to treat the area in the vicinity of well 17W with residual CAH mass. Monitored natural attenuation (MNA) would be applied to achieve groundwater clean-up in the other portions of the plume. Components of ISCO are described below.			
•	Injection of an oxidant solution of sufficient mass to satisfy the natural oxidant demand of the saturated zone in the area to be treated and also chemically destroy the residual CAH mass.			
•	Injection points would be established on a grid laid throughout the treatment zone as shown on Figure 4-3. Injection of the chemical oxidant would occur throughout the A and B zones, from depths of 10 feet bgs and continuing to 40 feet bgs. Direct push equipment will be used for the oxidant solution injection. Sodium Permanganate at 40% dilution is assumed as the oxidant for costing purposes.			
•	A treatability study would be performed as part of the remedial system design to evaluate and select the actual oxidant chemical and concentration. A field pilot test would be performed to confirm the appropriate injection grid layout and other design criteria.			
Site Characteristics:				**Comments:**
•	Maximum TCE concentration	64	µg/L	Well 17W (2010 sampling event)
•	Maximum cis-1,2-DCE concentration	27	µg/L	Well 17W (2010 sampling event)
•	Maximum 1,1-DCA	27	µg/L	Well 17W (2010 sampling event)
•	Effective porosity	30	%	Assumed
•	ISCO treatment area	7,700	square feet	See Figure 4-3
•	ISCO treatment depth (A and B zones)	30	feet	From top of water table (10 ft bgs) to 40 ft bgs
•	ISCO injection points (A and B zones)	98	points	From top of water table (10 ft bgs) to 40 ft bgs
•	ISCO treatment volume (void volume)	1,950,000	liters	Calculated
•	Injection of 40% Sodium Permanganate diluted in water	641,373	liters	Calculated

Table 4-5
Description of Alternative 3A – In-situ Chemical Oxidation (ISCO) Treatment with MNA
CTS Printex Superfund Site, Mountain View, California

Conceptual Design Components and Assumptions:
In-situ Chemical Oxidation
• A laboratory bench-scale test treatability test would be performed to ascertain the most effective chemical oxidant and injection concentration.
• Estimated quantity for injection (direct push injection points) is 173,500 gallons of 40% Sodium Permanganate to treat the entire treatment zone for the area with high residual CAH mass. Cost of oxidant solution is $5.30 per gallon.
• Treatment spacing is based on intersection nodes of two 10x10-foot overlapping grids. A total of approximately 98 Injection points are located on accessible areas.
• Post-injection sampling and analysis would be performed to evaluate ISCO effectiveness for the area being treated. Ground sampling/analyses would be performed for 2 quarters to confirm no rebound and CAH concentrations in the treatment zone are below the clean-up criteria.

Table 4-6
Description of Alternative 3B – Enhanced Anaerobic Bioremediation (EAB) Treatment with MNA
CTS Printex Superfund Site, Mountain View, California

Alternative Description:			
•	Enhanced anaerobic bioremediation (EAB) would be performed under this alternative to treat the area of residual CAH mass in the vicinity of well 17W. Monitored natural attenuation (MNA) would be applied to achieve groundwater clean-up in the other portions of the plume. Components of the EAB are described below.		
•	Injection of an organic substrate of sufficient mass to achieve anaerobic conditions in the treatment zone will be performed at selected points distributed throughout the treatment zone as shown on Figure 4-3. Injection of the organic substrate would occur throughout the A and B zones, beginning at the water table (depth of 10 feet bgs) and continuing to 40 feet bgs. Direct push equipment will be used for the substrate injection. Sodium lactate assumed as the organic substrate for costing purposes.		
•	Besides the organic substrate, a microbial amendment(s) for bioaugmentation would also be included with the organic substrate injected into the A- and B-Zones. The organic substrate with bioaugmentation will result in the complete biological transformation of the CAHs to ethene.		
•	Shallow groundwater recirculation (i.e., flushing) systems would be established in each of the A- and B-Zones by installing injection and extraction wells appropriately screened for each zone. Each zone's recirculation system would include an extraction well, ability to augment the extracted groundwater with substrate or amendments, and reinjection by gravity flow at the injection wells. Organic substrate, bioaugmentation, and other amendments would be added to the water being re-injected, as needed. The flushing action of the recirculation system will enhance the distribution of the injected substrate and microbial amendments throughout the treatment zone.		
•	A treatability study would be performed as part of the remedial system design to evaluate and select the actual organic substrate, appropriate nutrients, bioaugmentation requirements, and other design criteria.		
Site Characteristics:			**Comments:**
•	Maximum TCE concentration	64 µg/L	Well 17W (2010 sampling event)
•	Maximum cis-1,2-DCE concentration	27 µg/L	Well 17W (2010 sampling event)
•	Maximum 1,1-DCA	27 µg/L	Well 17W (2010 sampling event)
•	Effective porosity	30 %	Assumed
•	EAB treatment area	7,700 square feet	See Figure 4-4
•	EAB treatment depth (A and B zones)	30 feet	From top of water table (10 ft bgs) to 40 ft bgs

Table 4-6
Description of Alternative 3B – Enhanced Anaerobic Bioremediation (EAB) Treatment with MNA
CTS Printex Superfund Site, Mountain View, California

Alternative Description:			
•	EAB treatment volume (void volume)	1,950,000 liters	Calculated
Conceptual Design Components and Assumptions			
Enhance Anaerobic Bioremediation			
•	Amendment, consisting of organic substrate, *Dehalococcoides* microbial cultures, and nutrients, will be delivered through 7 injection points, with injection zone targeted from depths between 10 and 40 feet bgs. Amendment would be injected by direct push drilling equipment method.		
•	Separate re-circulating (i.e., flushing) systems established within A-Zone and B-Zone. The injection and extraction wells will be screened to target a specific zone, either the A- or B-Zone. At each injection and extraction location, a pair of wells will be installed with one well for the A zone and the second well for the B zone. For the A-Zone, the extraction well will be screened between 10 and 25 feet bgs, with the B-Zone extraction well screened from 30 to 40 feet bgs. The injection wells for the A-Zone will be screened from 5 to 25 feet bgs, whereas the B-Zone injection wells will be screened between 25 and 40 feet bgs.		
•	The re-circulation system will consist of 3 pairs of injection wells (a pair being a well screened in the A-Zone and another well screened in the B-Zone) and 1 pair of extraction wells. A submersible pump (0.5 HP, 230 single phase VAC) will be installed in each of the extraction wells.		
•	Both the injection and extraction wells will consist of 4-inch PVC casing with a total linear footage of 260 feet (130 feet of blank casing and 130 feet of screened casing)		
•	A laboratory bench-scale test treatability test would be performed to ascertain the necessary amendment contents and dosage.		
•	Estimated quantity for injection (direct push injection points) is 1,910 Kg of 60% Sodium Lactate to treat the entire treatment zone for the area with high residual CAH mass. Volume of 60% sodium Lactate needed is 390 gallons. Cost of 60% Sodium Lactate - $4 per kilogram.		
• •	Injection (direct push injection) of amendments would be completed prior to installing wells (Injection and Extraction) for the re-circulating system. Each re-injection well will have a level sensor that will shut down the extraction pump if water level rises above 4 feet bgs. Wiring from each well will run to the PLC that controls the extraction well. The PLC will be located in a subsurface, utility vault located adjacent to the extraction well. The utility box will also contain a manifold on the pipe from the extraction well to enable the addition of substrate and/or amendments while operating the re-		

Table 4-6
Description of Alternative 3B – Enhanced Anaerobic Bioremediation (EAB) Treatment with MNA
CTS Printex Superfund Site, Mountain View, California

Alternative Description:	
	circulation system.
•	Additional sampling and analysis would be performed to evaluate EAB effectiveness for the area being treated. Frequency sampling/analyses would be monthly for the first 6 months, and quarterly thereafter until CAH concentrations in the treatment zone are below the clean-up criteria. Analyses to include CAHs, *Dehalococcoides* (DHC), and other parameters as established in the treatability study.
•	O&M frequency for the EAB system would be on a weekly basis from the first thru the third month after implementation; bi-weekly from the fourth thru the sixth month; monthly from the seventh thru the twelfth month; and quarterly after one year. Estimated labor and equipment cost for an O&M one day visit is $ 1,600.00 (cost includes vehicle).
Utilities Trench Excavation (12 inches wide by 3 feet deep)	
•	Utility trench excavation using a backhoe with cross section dimensions of 12 inches wide and 2 feet deep. Piping and control wiring would be installed in the trench.
•	Re-use excavated soil as fill material to backfill utility trenches.
•	Excess of the excavated soil and other materials (concrete or asphalt) estimated at 5 CY would be disposed as construction debris (non-hazardous waste).
•	Pipe connecting the extraction wells to the injection wells will be 2-inch diameter PVC. Total length of this pipe to connect 3 pairs of injection wells with 1 pair of extraction wells is 444 feet.

Table 4-7
Description of Alternative 3C – In-situ Chemical Reduction (ISCR) Treatment with MNA
CTS Printex Superfund Site, Mountain View, California

Alternative Description				
•	In-situ chemical reduction (ISCR) using a carbon plus zero valent iron solution (ZVI solution) would be performed under this alternative to treat the area in the vicinity of well 17W with residual CAH mass. Monitored natural attenuation (MNA) would be applied to achieve groundwater clean-up in the other portions of the plume. Components of ISCR are described below.			
•	Injection of the ZVI solution of sufficient mass to chemically reduce the residual CAH mass to ethene.			
•	Injection points would be established on a grid laid throughout the treatment zone as shown on Figure 4-6. Injection of the ZVI solution would occur throughout the A and B zones, from depths of 10 feet bgs and continuing to 40 feet bgs. Direct push equipment will be used for the ZVI solution injection. .			
•	A treatability study would be performed as part of the remedial system design to evaluate and select the actual ZVI chemical and concentration. A field pilot test would be performed to confirm the appropriate injection grid layout and other design criteria.			
Site Characteristics:				**Comments:**
•	Maximum TCE concentration	64	µg/L	Well 17W (2010 sampling event)
•	Maximum cis-1,2-DCE concentration	27	µg/L	Well 17W (2010 sampling event)
•	Maximum 1,1-DCA	27	µg/L	Well 17W (2010 sampling event)
•	Effective porosity	30	%	Assumed
•	ISCR treatment area	7,700	square feet	See Figure 4-6
•	:ISCR treatment depth (A and B zones)	30	feet	From top of water table (10 ft bgs) to 40 ft bgs
•	ISCR treatment volume (void volume)	1,950,000	liters	Calculated
•	Injection of EHC slurry based on 29% solids in slurry	125,000	liters	Calculated
Conceptual Design Components and Assumptions:				
In-situ Chemical Reduction				
•	A laboratory bench-scale test treatability test would be performed to ascertain the most effective form of ZVI and injection concentration.			
•	Estimated quantity for injection (direct push injection points) is 33,800 gallons of ZVI solution to treat the entire area with high residual CAH mass. Cost of EHC solution is $2.60 per gallon			
•	Treatment spacing is based on intersection nodes of two 10x10-foot overlapping grids. A total of approximately 98 Injection points are located in locations that are currently accessible.			
•	Post-injection sampling and analysis would be performed to evaluate ISCR effectiveness for the area being treated. Ground sampling/analyses would be performed for 2 quarters to confirm no rebound and CAH concentrations in the treatment zone are below the clean-up criteria.			

Table 4-8
Description of Alternative 4 – Monitored Natural Attenuation (MNA)
CTS Printex Superfund Site, Mountain View, California

Alternative Description:			
•	An enhanced groundwater monitoring program would be performed under this alternative to characterize the nature and extent of TCE and associated daughter products. This enhanced monitoring program would include characterization of geochemical properties of the A- and B-Zones, and compound specific isotope analysis (CSIA) to evaluate if biodegradation is occurring. Monitoring for characterization of VOC concentrations would occur semi-annually for three years in all existing wells. For the next seven years, annual monitoring would occur. Beginning after 10 years, groundwater monitoring would only occur for six wells in the A-Zone and four wells in the B-Zone on an annual frequency assuming that compliance with the groundwater remediation criteria have been met in wells eliminated from further monitoring.		
•	For the A-Zone, the CSIA would be performed on groundwater from 7W, 12W, 16WR, 17W, and 23W. For the B-Zone, the CSIA would be performed on groundwater from 8W, 11W, 15WR, 19W, and 22W. The CSIA analyses would be performed during the first two monitoring events.		
•	The geochemical characteristics of all monitoring wells (10 in the A-Zone and 6 in the B-Zone) would be quantified for 3 years.		
Site Characteristics:			**Comments:**
•	Maximum TCE concentration	64 µg/L	Well 17W (2010 sampling event)
•	Maximum cis-1,2-DCE concentration	27 µg/L	Well 17W (2010 sampling event)
•	Maximum 1,1-DCA	27 µg/L	Well 17W (2010 sampling event)

Table 5-1
Summary of ARARs for Remedial Alternatives
CTS Printex Superfund Site, Mountain View, California

Source/Citation		Description of Requirement	Applicable/ Relevant & Appropriate/ To Be Considered	Findings and Comments
Chemical-Specific: Federal				
Safe Drinking Water Act (42 U.S.C. §§ 300 *et seq.*)	National Primary Drinking Water Standards, 40 CFR §141.61	Establishes the Federal Maximum Contaminant Levels (MCLs) for organic contaminants in drinking water. MCLs may be used to establish water discharge standards and groundwater remediation standards.	Relevant and appropriate	The MCLs would be a relevant and appropriate requirement applicable for alternatives 1 through 4. The NCP, at 40 CFR §300.430(e)(2)(i)(B) and (C), requires that the remedy selected attain non-zero MCLGs or MCLs for each contaminant if the groundwater is a current or potential drinking water source.
Safe Drinking Water Act (42 U.S.C. §§ 300 *et seq.*)	National Primary Drinking Water Standards, 40 CFR §141.24	Requires monitoring to determine compliance with MCLs.	Relevant and appropriate	For Alternatives 2A through 4, substantive monitoring requirements are relevant and appropriate to ensure that treated effluent is meeting clean-up levels.
Chemical-Specific: State				
SWRCB Resolution No. 68-16		Requires that waste discharges to existing high quality waters are required to meet best practical treatment or control.	Applicable	For Alternatives 2A and 2B, the treatment (off-site) of extracted groundwater would have to meet the best practical treatment requirements established in the NPDES permit.
SWRCB Resolution No. 92-49, III-G		Requires clean-up and abatement of the effects of discharges in a manner that promotes attainment of either background water quality or the best water quality, which is reasonable.	Relevant and appropriate	Applicable to Alternatives 1 through 4 as water quality is associated with the groundwater being useable for drinking water.
San Francisco Bay Regional Water Quality Control Board (RWQCB) Basin Plan, Chapters II and III		Establishes beneficial uses and water quality objectives. Remediation of groundwater includes consideration of State and regional water quality objectives. Groundwater designated for use as domestic or municipal supply shall not contain concentrations of COCs at or above MCLs.	Applicable	As previously stated, compliance with the MCLs is a requirement applicable for all alternatives (1 through 4).
Location-Specific: Federal and State (None Identified)				

Table 5-1
Summary of ARARs for Remedial Alternatives
CTS Printex Superfund Site, Mountain View, California

Source/Citation	Description of Requirement	Applicable/ Relevant & Appropriate/ To Be Considered	Findings and Comments
Action-Specific: Federal			
Resource Conservation and Recovery Act (RCRA) as amended by Hazardous and Solid Waste Amendments (HWSA); 42 USC 7401-7642; 40 CFR Parts 260 to 280	Regulates treatment, storage and disposal of hazardous wastes. Residuals from groundwater treatment may be considered hazardous waste under RCRA.	Relevant and appropriate	Residuals, from off-site groundwater treatment (Alternatives 2A and 2B) are not anticipated to be classified as hazardous wastes.
National Pollutant Discharge Elimination System (NPDES); 40 CFR Part 122	Substantive requirements of NPDES permits. Treated groundwater may require permit for on-site or off-site disposal. The RWQCB may issue an actual NPDES permit for some off-site discharges.	Relevant and appropriate	Alternatives 2A and 2B would involve discharge in accordance with the NPDES permit for Mountain View's wastewater treatment facility and associated discharge of treated water to surface water. Alternatives 3A through 3C would involve compliance with Waste Discharge Requirements for injection of substrate to enhance in-situ treatment.
Storm Water Discharge Requirements; CWA 402(p)	Establishes requirements for storm water discharge. Groundwater remedial action should ensure storm water discharge at the Site is in compliance with requirements.	Relevant and appropriate	All alternatives, except 1, would have to prevent solids or groundwater from being discharged with storm water.
Action-Specific: State			
Hazardous Waste Control Act (HWCA) (California Health and Safety Code §§25100 – 25395) 22 CCR Division 4.5: Environmental Health Standards for Management of Hazardous Wastes	Site groundwater with COCs, or residuals from the treatment of groundwater, may be considered hazardous waste which would require compliance with regulations for accumulation, transportation, treatment, or disposal.	Applicable	Applicable to Alternatives 2A through 4 with regard to evaluation of residual solids (soil and/or cuttings from well installation) or purge water from groundwater monitoring.
Hazardous Waste Accumulation, 22 CCR §66262.34	On-site hazardous waste accumulation is allowed for up to 90 days as long as the waste is stored in containers or in tanks, on drip pads, inside buildings, is labeled and dated, etc.	Applicable	Applicable to Alternatives 2A through 4 with regard to evaluation if residual solids (soil and/or cuttings from well installation) or purge water are hazardous wastes; and if yes, complying with the accumulation limitations and storage standards.
Land Use Covenants	The property may be restricted from certain future development, if COCs identified on-site, are not addressed to unrestricted standards.	Relevant and appropriate	Applies to all alternatives with regard to groundwater use until the entire plume

Table 5-1
Summary of ARARs for Remedial Alternatives
CTS Printex Superfund Site, Mountain View, California

Source/Citation	Description of Requirement	Applicable/ Relevant & Appropriate/ To Be Considered	Findings and Comments
			has concentrations below the MCLs.
California Water Well Standards for water wells, monitoring wells, and cathodic protection wells, Bulletin 74-90 and 74-81, adopted pursuant to California Water Code Section 13800	Provides minimum construction and abandonment criteria for water wells, monitoring wells, and cathodic protection wells. Also includes criteria for borehole abandonment.	Applicable	Applicable to Alternatives 1 through 4.
California Water Code, Section 13260 and 13263(a)	Injection of materials (e.g., potassium permanganate) into the groundwater is considered a discharge of waste. To provide full and complete containment of any injected chemical or resulting by-product, waste discharge requirements established specific to the proposed in-situ remediation plan and associated considerations to minimize any adverse impacts caused by the injection.	Relevant and appropriate	Applicable to Alternatives 3A, 3B, and 3C.

Table 5-2
Summary of Present Worth Costs
CTS Printex Superfund Site, Mountain View, California

Alternative	**Present Worth (U.S. 2010 $)**			
	Capital	**Annual O&M**	**Periodic**	**Total**
Alternative 1 – No Action	$0	$0	$0	$0
Alternative 2A – Groundwater Extraction for the Entire Plume	$855,000	$3,539,000	$88,000	$4,482,000
Alternative 2B – Groundwater Extraction for Selected Areas plus Site-wide MNA	$695,000	$3,024,000	$77,000	$3,976,000
Alternative 3A – ISCO at Areas with Residual Contaminant Mass plus Site-Wide MNA	$2,365,000	$763,000	$69,000	$3,197,000
Alternative 3B – EAB at Areas with Residual Contaminant Mass plus Site-Wide MNA	$859,000	$824,000	$83,000	$1,766,000
Alternative 3C – ISCR at Areas with Residual Contaminant Mass plus Site-Wide MNA	$1,542,000	$763,000	$69,000	$2,374,000
Alternative 4 – Monitored Natural Attenuation (MNA)	$0	$585,000	$76,000	$661,000

Table 5-3
Qualitative Evaluation[1] of Alternatives for Groundwater
CTS Printex Superfund Site, Mountain View, California

Evaluation Criteria	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost (Present Worth)
Alternative 1 – No Action	Low[2]	Low[2]	Not Retained	Not Retained	Not Retained	Not Retained	$0
Alternative 2A - Groundwater Extraction, Monitoring, and ICs (remedy in 1991 ROD, not currently operating)	Moderate (longer time frame)	Moderate (long time frame for compliance with MCLs)	Moderate (long time frame to achieve MCLs)	Moderate (long time frame)	Moderate (long time frame)	Moderate (may have access issues for a portion of the plume)	$4,482,000
Alternative 2B – Groundwater Extraction, MNA, and ICs	Moderate (longer time frame)	Moderate (long time frame for compliance with MCLs)	Moderate (long time frame to achieve MCLs)	Moderate (long time frame)	Moderate (long time frame)	High	$3.976,000
Alternative 3A – In-situ Chemical Oxidation (ISCO), MNA, and ICs	Moderate	Moderate	High	High	Moderate (chemical handling potential issue for workers)	High	$3,197,000
Alternative 3B – Enhanced Anaerobic Bioremediation (EAB)J, MNA, and ICs	Moderate	Moderate	High	High	High	High	$1,766,000
Alternative 3C – In-situ Chemical Reduction (ISCR), MNA, and ICs	Moderate	Moderate	High	High	High	High	$2,374,000
Alternative 4 – Monitored Natural Attenuation (MNA)	Moderate (longest time frame with uncertainty)	Moderate (longest time frame with uncertainty)	Moderate (longest time frame with uncertainty)	Low (No treatment)	Moderate	High	$661,000

Note: [1] Basis of Qualitative Evaluation: **Low** – does not satisfy the criterion; **Moderate** – satisfies the criterion; **High** – satisfies the criterion and has a higher rating with respect to the criterion.
[2] By not satisfying a threshold criterion, alternative is not retained for further comparison.

FIGURES

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Note:
Background aerial photograph from TerraServer® and Bing™ (2009).

CTS Printex Superfund Site
Mountain View, California

FIGURE 1-1
Site Location Maps

CTS Printex Superfund Site
Mountain View, California

FIGURE 1-2
TCE Concentrations in
A-Zone Groundwater Monitoring Wells
(1985/86, 1989, 1996)

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CTS Printex Superfund Site
Mountain View, California

FIGURE 1-3
TCE Concentrations in
B-Zone Groundwater Monitoring Wells
(1985/86, 1989, 1996)

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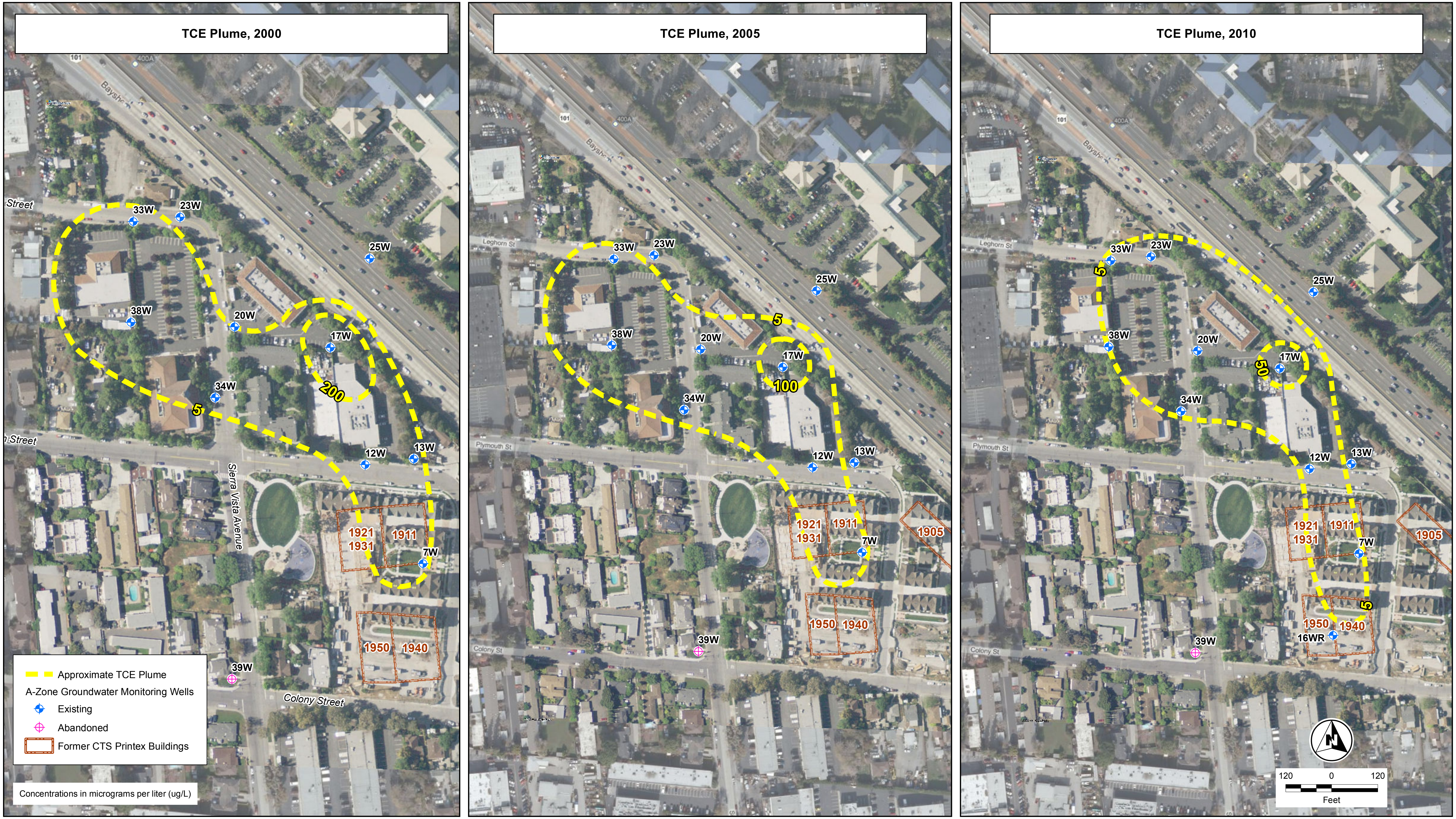

CTS Printex Superfund Site
Mountain View, California

FIGURE 1-4
TCE in A-Zone, Years 2000, 2005, and 2010

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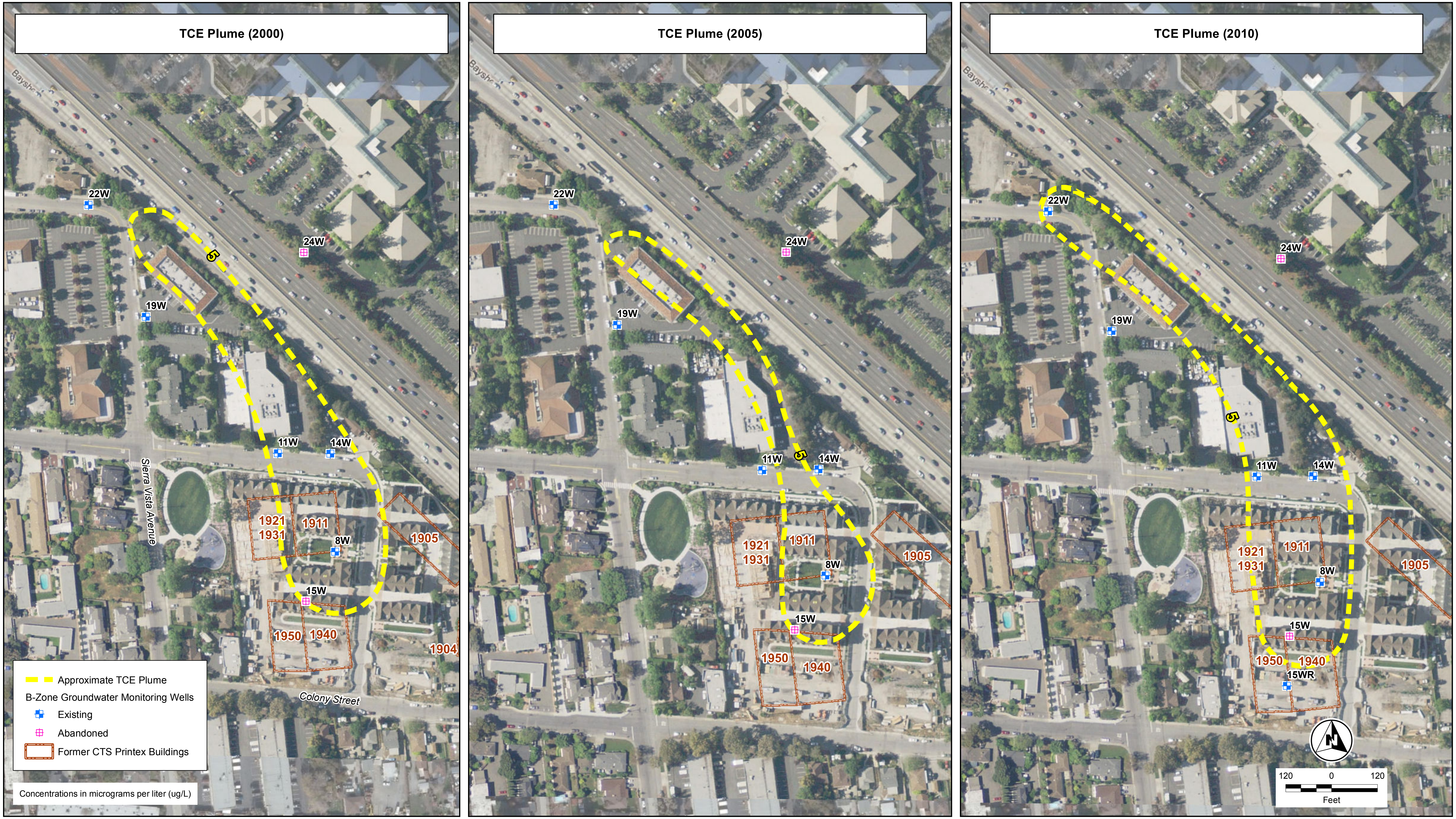

CTS Printex Superfund Site
Mountain View, California

FIGURE 1-5
TCE in B-Zone, Years 2000, 2005, and 2010

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Mountain View, California

FIGURE 1-6
TCE Plume 2010
A-Zone (10-20 ft bgs) Monitoring Wells

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Mountain View, California

FIGURE 1-7
TCE Plume 2010
B-Zone (30-40 ft bgs) Monitoring Wells

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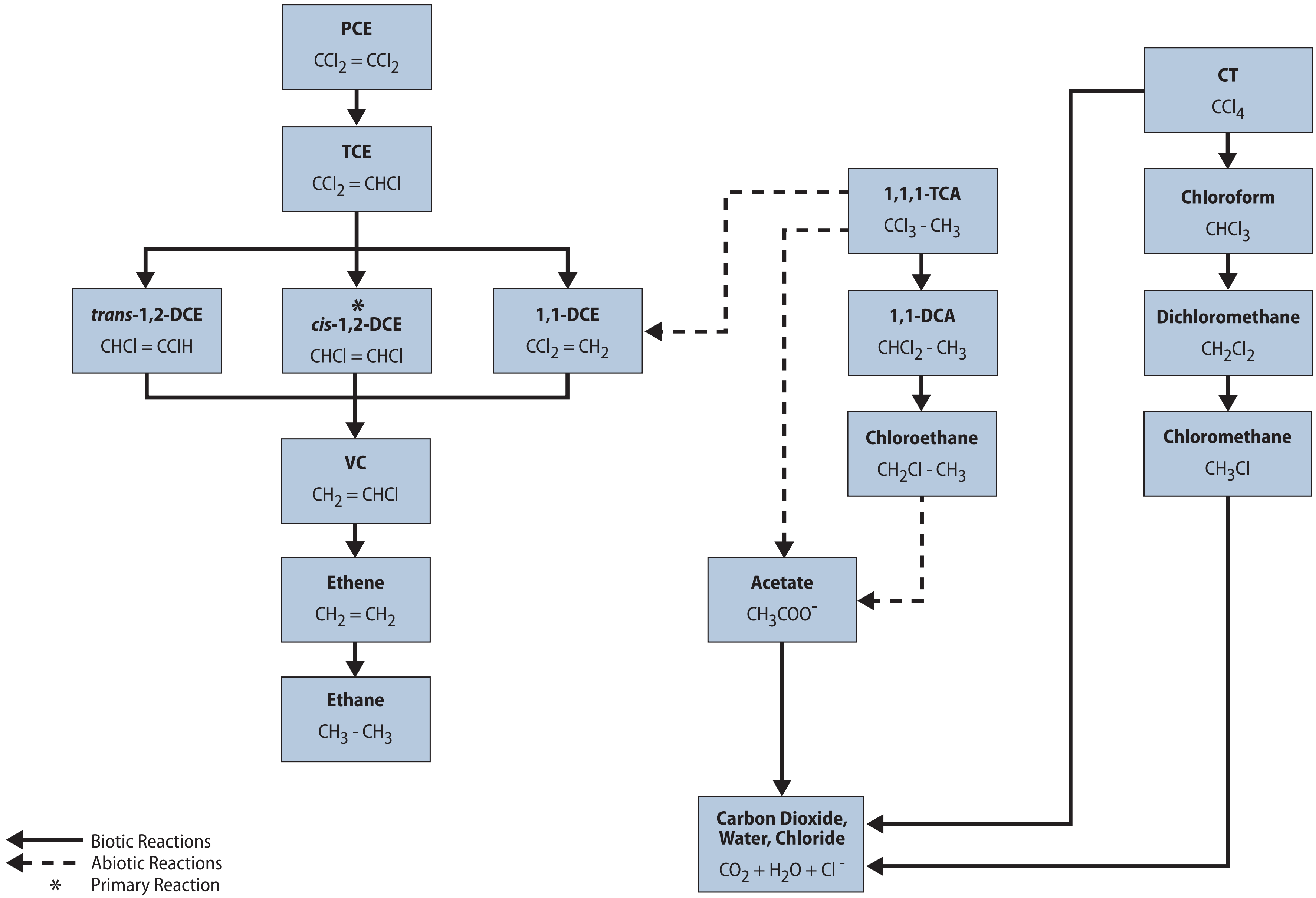

Adapted from McCarty 1996; McCarty and Semprini 1994; and Vogel et al. 1987

CTS PRINTEX SUPERFUND SITE
Mountain View, California

FIGURE 1-8
Transformation Pathways for Select CAHs

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CTS Printex Superfund Site
Mountain View, California

FIGURE 1-9
Cross-Section Line A-A'

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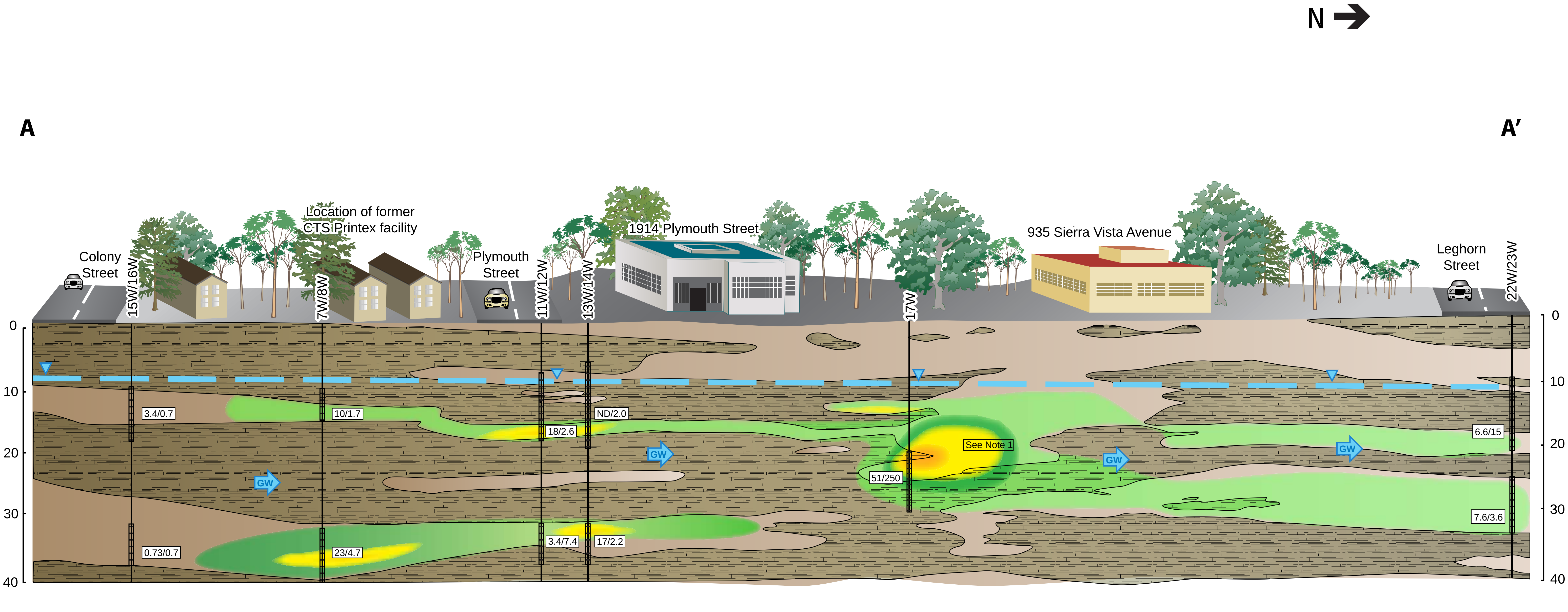

Sands and Gravel Predominant

Silts and Clay Predominant

Groundwater

0.73/0.7 — TCE - Trichloroethene (TCE MCL is 5 µg/L); cis 1,2 DCE - Dichloroethene (cis 1,2-DCE MCL is 6 µg/L)

TCE >50

TCE 20-50

TCE 10-20

TCE 5-10

A-Zone Wells: 7W, 12W, 13W, 17W, 23W

B-Zone Wells: 8W, 11W, 22W

TCE and DCE concentrations (µg/L) detected in groundwater samples collected December 2010

NOT TO SCALE

Note 1. Interconnectivity between A and B-Zone identified in 2010 Supplemental RI (ITSI, 2011a)

CTS PRINTEX SUPERFUND SITE
Mountain View, California

FIGURE 1-10
Current Conceptual Site Model

CTS Printex Superfund Site
Mountain View, California

FIGURE 4-1
Conceptual Layout for Alternative 2A
Plume-wide Groundwater Extraction

CTS Printex Superfund Site
Mountain View, California

FIGURE 4-2
Conceptual Layout for Alternative 2B
Groundwater Extraction at Select Locations

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CTS Printex Superfund Site
Mountain View, California

FIGURE 4-3
Conceptual Layout for Alternative 3A
Injection Grid for ISCO Treatment

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Mountain View, California

FIGURE 4-4
Conceptual Layout for Alternative 3B: EAB Treatment
Re-circulating System and Injection Points

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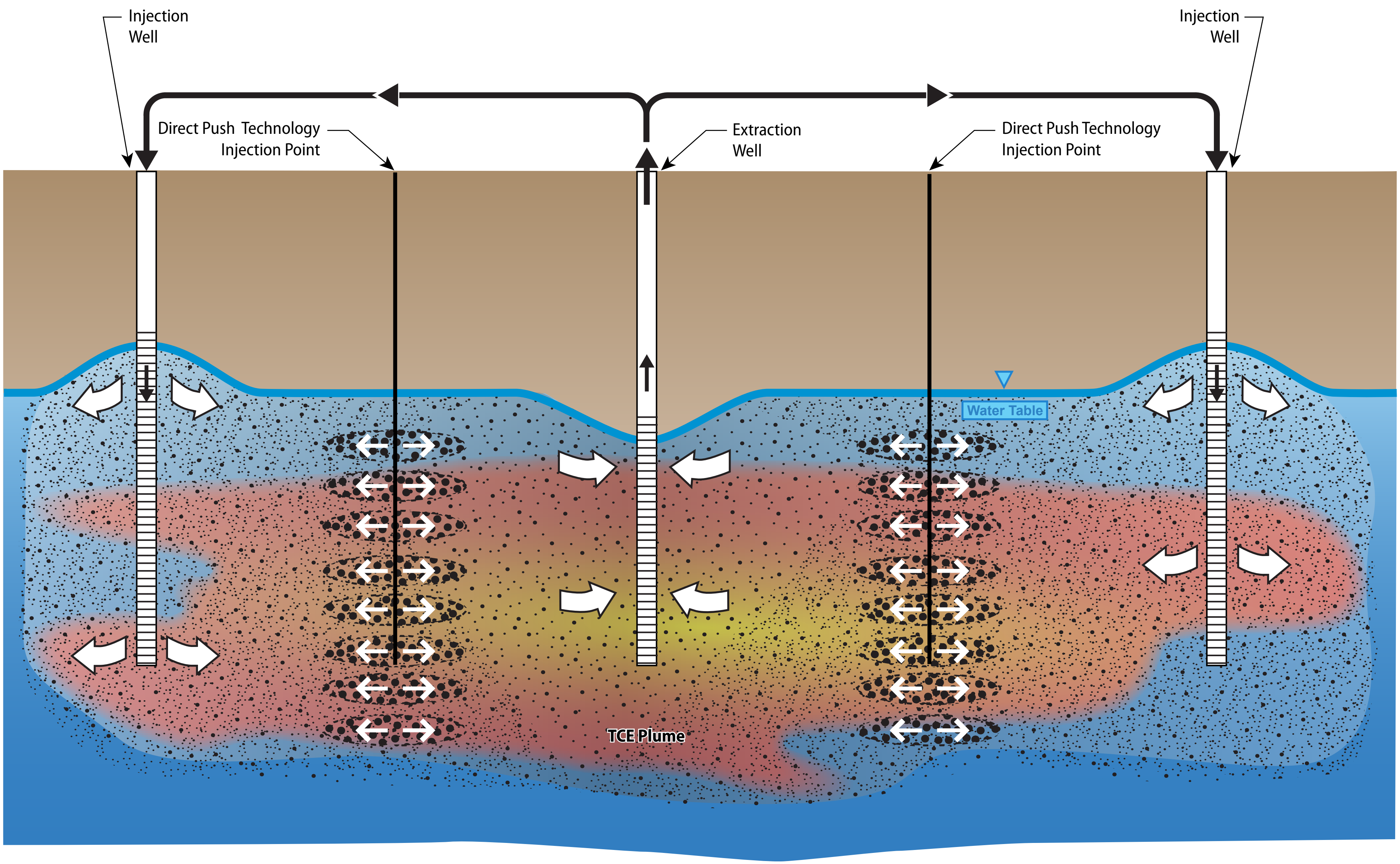

1. Initially inject large mass of organic substrate and amendments by direct push technology.
2. Extraction with re-injection distributes the amendments throughout the treatment zone.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

CTS PRINTEX SUPERFUND SITE
Mountain View, California

FIGURE 4-5
Typical Groundwater Re-circulating System

CTS Printex Superfund Site
Mountain View, California

FIGURE 4-6
Conceptual Layout for Alternative 3C
Injection Grid for ISCR Treatment

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APPENDIX A

BIOCHLOR Modeling

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BIOCHLOR ANALYSIS

1. Introduction

Trichloroethene (TCE) migration was modeled in groundwater at the CTS Printex Superfund Site (Site) located in Mountain View, California, using groundwater quality data obtained from the January 2010 groundwater sampling event. This evaluation has been conducted to estimate the potential time required for TCE to reach its Maximum Contaminant Level (MCL) of 5 µg/L (0.005 mg/L) at the Site due to natural attenuation alone.

The BIOCHLOR version 2.2 spreadsheet model was utilized for this assessment (USEPA, 2000, 2002). BIOCHLOR is a screening model that predicts the natural attenuation of chlorinated solvents through sequential decay. This model was used to calculate the concentration of TCE in groundwater throughout the Site. The model allows for three-dimensional dispersion, one-dimensional advection, linear adsorption and biotransformation by means of reductive dechlorination.

The BIOCHLOR model allows calculation of concentrations along the centerline of the plume and in a three-dimensional array. The output of the model is regenerated each time any element of the input data is changed, which allows the user to see almost immediately the effects of changes in the input data. The BIOCHLOR model is intended for use with chlorinated solvents that may react with organic carbon in soil and/or may be subject to biotransformation that can be described by a sequential first-order decay process. BIOCHLOR is used to evaluate natural attenuation via reductive dechlorination.

The shallow groundwater at the Site is divided into two zones: A zone - depths between 10 and 20 feet below ground surface (bgs) and B zone – depths between 30 and 40 feet bgs.

The sources of the model input parameters are as follows:

- Source Concentration (mg/L): The concentration of TCE detected in the plume in January 2010. A zone - Highest TCE concentration of 0.079 mg/L was detected in 17W. B zone - Highest TCE concentration of 0.019 mg/L was detected in 14W.
- Seepage Velocity (feet/year): 25 feet/year in A zone A and 30 feet/year in B zone which are values within the range of site-specific conditions.

- Longitudinal Dispersivity (alpha x): 40 feet for the A zone and 104 feet for the B zone, which are values derived using the BIOCHLOR calibration tool.
- Transverse Dispersivity (alpha y) / Longitudinal Dispersivity (alpha x): 0.1 for the A and B zones, which is the value recommended by USEPA.
- Vertical Dispersivity (alpha z) / Longitudinal Dispersivity (alpha x): 1×10^{-99}, the value recommended by USEPA for a conservative estimate of vertical dispersion.
- Soil Bulk Density (kilogram /Liter): 1.55 kilogram /Liter for both the A and B zones based on site-specific data.
- Fraction of Organic Carbon (foc) (unitless): 0.0002 for both the A and B zones, which is a value in the recommended range by USEPA for the site-specific soil type.
- Partition Coefficient (Koc) (Liter/kilogram): 130 Liter/kilogram for TCE which is a USEPA default value.
- First Order Decay Coefficient (1/year): 0.053 for TCE which is derived using the BIOCHLOR calibration tool from site-specific data.
- Source Width (feet): 425 feet for the A zone and 280 feet for the B zone, estimated source width perpendicular to groundwater flow direction.
- Source Thickness: 10 feet, the estimated thickness of the source in both zones.

These parameters are shown in the Attachment.

2. Limitations

BIOCHLOR is a Domenico-based model which approximates the analytical solutions of the advective-dispersive solute transport equation. Therefore, an error could be generated for a set of input parameters when compared to the exact values. The error is largely sensitive to high values of longitudinal dispersivity. When the longitudinal dispersivity value is low, this error is insignificant. Since longitudinal dispersivity is a calibration parameter and not a site-specific value, BIOCHLOR is appropriate for use as a screening tool.

A major limitation of any analytical groundwater transport model is that steady, uniform groundwater flow is assumed. BIOCHLOR is primarily intended for use in unconsolidated (soil) aquifers with reasonably uniform physical and hydrogeologic properties, whereas the Site's soil in the saturated zone associated with the A and B zones has some degree of heterogeneities. These heterogeneities may create preferential constituent migration pathways, which could not be predicted by the model.

3. Results

The results of the BIOCHLOR model runs are shown in the Attachment. According to the model, TCE is anticipated to persist at the Site at a concentration above its MCL of 0.005 mg/L for over 100 years in the A zone and almost 70 years in the B zone.

4. Calibration

In order to calibrate the BIOCHLOR model, groundwater analytical results were plotted against model results using the BIOCHLOR calibration tool. Monitoring wells 17W and 14W were considered to be the source of contamination in the A and B zones, respectively. Monitoring wells 20W, 23W, and 33W are located approximately 240 feet, 600 feet, and 680 feet, respectively, downgradient of 17W in the A zone. Monitoring well 22W is located approximately 1,040 feet downgradient of 14W in the B zone. TCE concentrations at the various monitoring wells from groundwater analytical results were plotted for each zone and then values for dispersivity were adjusted until the model results were comparable to the plotted analytical results.

5. BIOCHLOR Modeling to Estimate Groundwater Cleanup Times

Separate from the above modeling, BIOCHLOR was also used to estimate the groundwater cleanup time for Alternatives 3A, 3B, and 3C. The results assumed removal of TCE and daughter products at well 17W, and BIOCHLOR model runs were performed to estimate the time to achieve groundwater cleanup at the other monitoring wells. The results of these BIOCHLOR model predictions are presented in Appendix B.

6. References

United States Environmental Protection Agency (USEPA). 2000. BIOCHLOR Natural Attenuation Decision Support System. User's Manual. Version 1.0. EPA/600/R-00/008. January.

United States Environmental Protection Agency (USEPA). 2002. BIOCHLOR Natural Attenuation Decision Support System. User's Manual Addendum. Version 2.2. March.

ATTACHMENT

To

APPENDIX A

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

CTS Printex Superfund
Zone A
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
or 2. Calculate by filling in gray
0.02 cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes (selected) / Ethanes

1. ADVECTION

Seepage Velocity*	Vs	25.0	(ft/yr)
or			
Hydraulic Conductivity	K	1.0E-03	(cm/sec)
Hydraulic Gradient	i	0.0053	(ft/ft)
Effective Porosity	n	0.4	(-)

2. DISPERSION

Alpha x*	40	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.545	(kg/L)
FractionOrganicCarbon, foc	2.0E-4	(-)

Partition Coefficient	Koc		R	
PCE	426	(L/kg)	1.33	(-)
TCE	130	(L/kg)	1.10	(-)
DCE	125	(L/kg)	1.10	(-)
VC	30	(L/kg)	1.02	(-)
ETH	302	(L/kg)	1.23	(-)

Common R (used in model)* = 1.10

4. BIOTRANSFORMATION -1st Order Decay Coefficient*

Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.000		0.79
TCE → DCE	0.053		0.74
DCE → VC	0.000		0.64
VC → ETH	0.000		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	430	(yr)
Modeled Area Width*	425	(ft)
Modeled Area Length*	700	(ft)
Zone 1 Length*	700	(ft)
Zone 2 Length*	0	(ft)

L, W
Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Decaying Single Planar

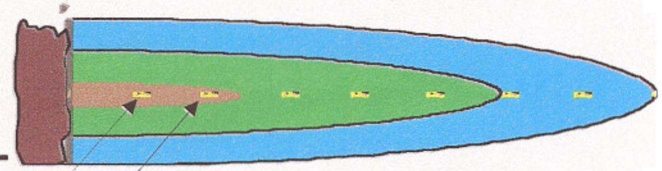
Source Options

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

Source Thickness in Sat. Zone* 10 (ft)

Y1
Width* (ft) 425

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE		0.006
TCE	.079	0.006
DCE		0.006
VC		0.006
ETH		0.006



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)	.079	.007	.007	.008							
DCE Conc. (mg/L)	.341										
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Distance from Source (ft)	0	240	600	680							
Date Data Collected	2010										

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

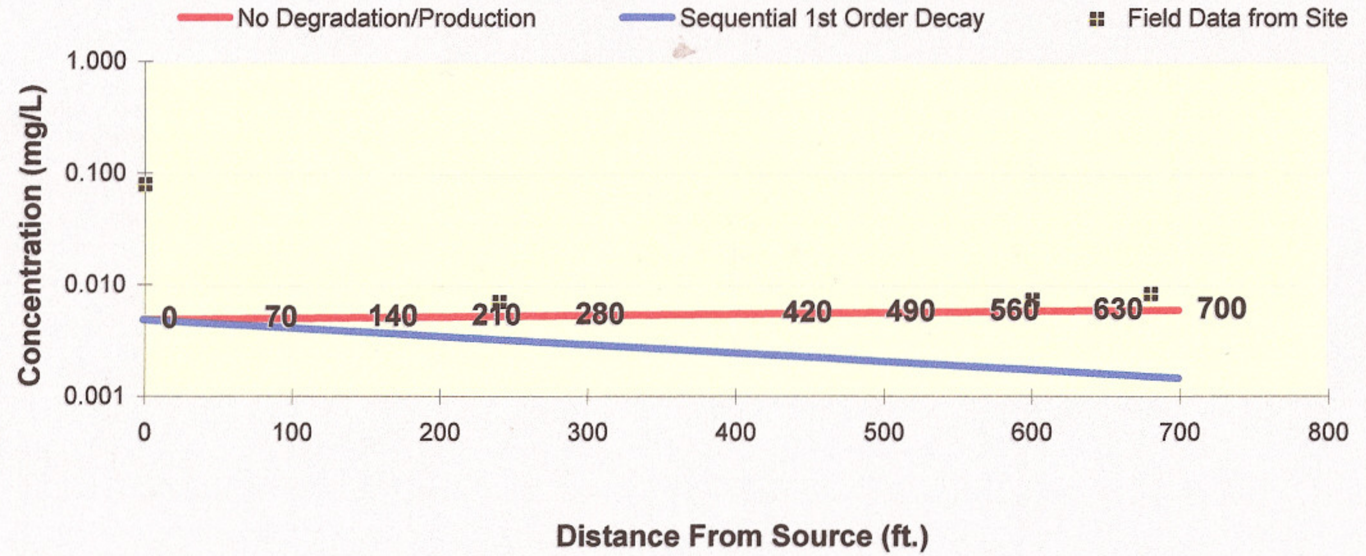
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

Distance from Source (ft)

TCE	0	70	140	210	280	350	420	490	560	630	700
No Degradation	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006
Biotransformation	0.0050	0.004	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002

Monitoring Well Locations (ft)

	0	240	600	680							
Field Data from Site	0.079	0.007	0.007	0.008							



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

430.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

CTS Printex Superfund
Zone A
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
↑ or 2. Calculate by filling in gray
0.02 cells. Press Enter, then (C)
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes (●) Ethanes (○)

1. ADVECTION

Seepage Velocity*	Vs	25.0	(ft/yr)
or			
Hydraulic Conductivity	K	1.0E-03	(cm/sec)
Hydraulic Gradient	i	0.0053	(ft/ft)
Effective Porosity	n	0.4	(-)

2. DISPERSION

Alpha x*	40	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.545	(kg/L)
FractionOrganicCarbon, foc	2.0E-4	(-)

Partition Coefficient	Koc		R	
PCE	426	(L/kg)	1.33	(-)
TCE	130	(L/kg)	1.10	(-)
DCE	125	(L/kg)	1.10	(-)
VC	30	(L/kg)	1.02	(-)
ETH	302	(L/kg)	1.23	(-)

Common R (used in model)* = 1.10

4. BIOTRANSFORMATION **-1st Order Decay Coefficient***

Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.000		0.79
TCE → DCE	0.053		0.74
DCE → VC	0.000		0.64
VC → ETH	0.000		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	20	(yr)
Modeled Area Width*	425	(ft)
Modeled Area Length*	700	(ft)
Zone 1 Length*	700	(ft)
Zone 2 Length*	0	(ft)

L W
Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Decaying Single Planar

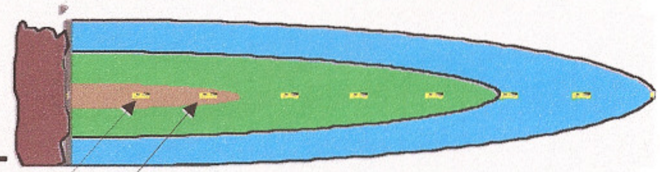
Source Options

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

Source Thickness in Sat. Zone* 10 (ft)

Y1
Width* (ft) 425

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE		0.006
TCE	.087	0.006
DCE		0.006
VC		0.006
ETH		0.006



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)	.079	.007	.007	.008							
DCE Conc. (mg/L)	.341										
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Distance from Source (ft)	0	240	600	680							
Date Data Collected	2010										

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

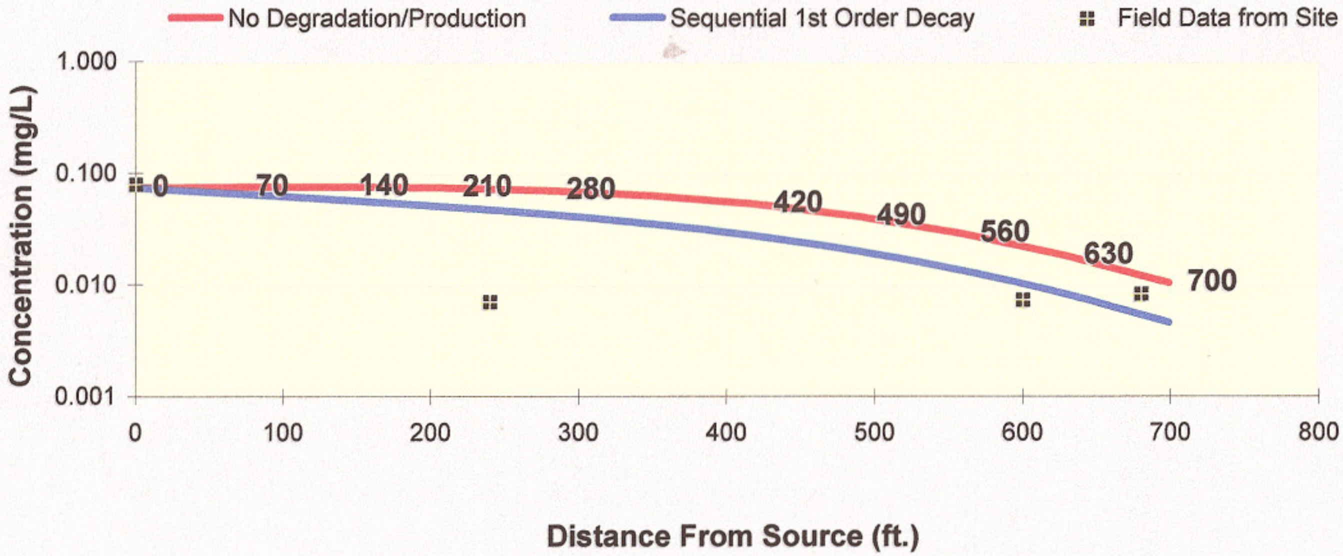
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

Distance from Source (ft)

TCE	0	70	140	210	280	350	420	490	560	630	700
No Degradation	0.077	0.078	0.078	0.076	0.072	0.065	0.055	0.042	0.030	0.019	0.011
Biotransformation	0.0765	0.068	0.060	0.052	0.044	0.036	0.028	0.021	0.014	0.009	0.005

Monitoring Well Locations (ft)

	0	240	600	680							
Field Data from Site	0.079	0.007	0.007	0.008							



See PCE | See TCE | See DCE | See VC | See ETH

Prepare Animation

Time: 20.0 Years

Log ⟺ Linear

Return to Input | To All | To Array

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

CTS Printex Superfund
Zone B
Run Name

Data Input Instructions:

115	1. Enter value directly....or
or	2. Calculate by filling in gray
0.02	cells. Press Enter, then C

(To restore formulas, hit "Restore Formulas" button)

Variable* Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	30.0	(ft/yr)
or			
Hydraulic Conductivity	K	1.0E-03	(cm/sec)
Hydraulic Gradient	i	0.0053	(ft/ft)
Effective Porosity	n	0.4	(-)

2. DISPERSION

Alpha x*	104	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* R

or

Soil Bulk Density, rho	1.545	(kg/L)
FractionOrganicCarbon, foc	2.0E-4	(-)

Partition Coefficient	Koc		R	
PCE	426	(L/kg)	1.33	(-)
TCE	130	(L/kg)	1.10	(-)
DCE	125	(L/kg)	1.10	(-)
VC	30	(L/kg)	1.02	(-)
ETH	302	(L/kg)	1.23	(-)

Common R (used in model)* = 1.10

4. BIOTRANSFORMATION -1st Order Decay Coefficient*

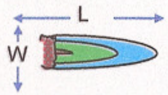
Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.000		0.79
TCE → DCE	0.053		0.74
DCE → VC	0.000		0.64
VC → ETH	0.000		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	67	(yr)
Modeled Area Width*	280	(ft)
Modeled Area Length*	1040	(ft)
Zone 1 Length*	1040	(ft)
Zone 2 Length*	0	(ft)



Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Decaying Single Planar

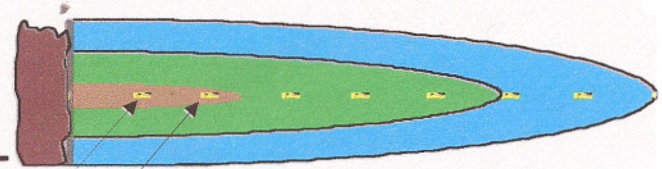
Source Options

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

Source Thickness in Sat. Zone* 10 (ft)

Y1
Width* (ft) 280

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE		0.02
TCE	.019	0.02
DCE		0.02
VC		0.02
ETH		0.02



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)	.019	.01	.008								
DCE Conc. (mg/L)											
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Distance from Source (ft)	0	120	1040								
Date Data Collected	2010										

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

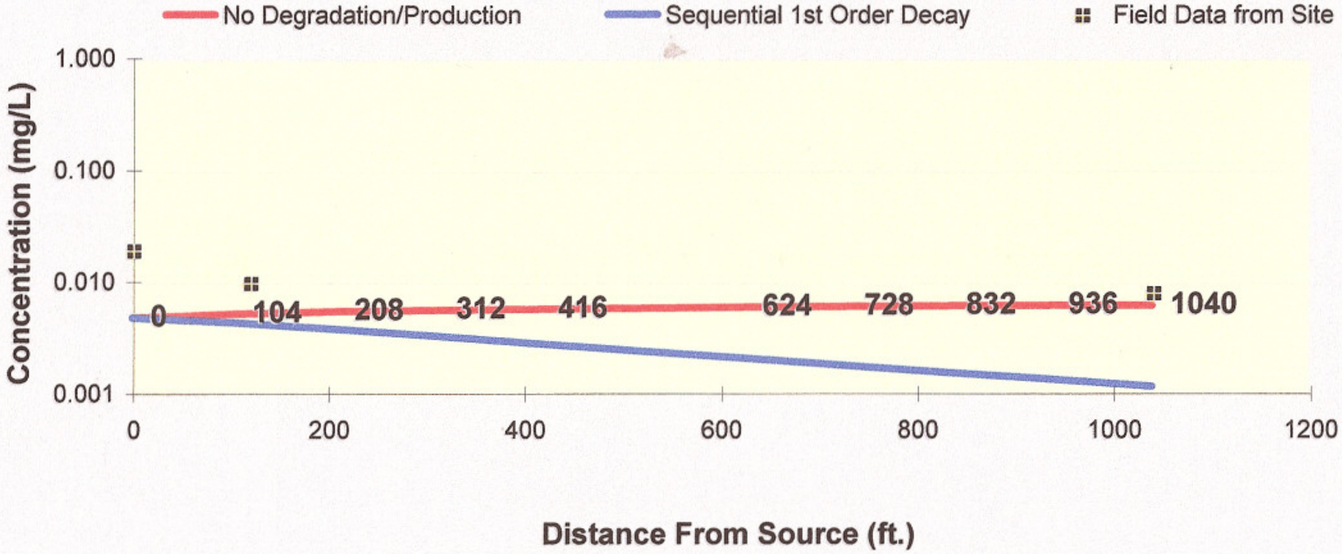
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

Distance from Source (ft)

TCE	0	104	208	312	416	520	624	728	832	936	1040
No Degradation	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
Biotransformation	0.0050	0.005	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.001	0.001

Monitoring Well Locations (ft)

	0	120	1040								
Field Data from Site	0.019	0.010	0.008								



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

67.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

CTS Printex Superfund
Zone B
Run Name

Data Input Instructions:

115 — 1. Enter value directly....or
or — 2. Calculate by filling in gray
0.02 — cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button)
Variable* — Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes (selected) / Ethanes

1. ADVECTION

Seepage Velocity*	Vs	30.0	(ft/yr)
or			
Hydraulic Conductivity	K	1.0E-03	(cm/sec)
Hydraulic Gradient	i	0.0053	(ft/ft)
Effective Porosity	n	0.4	(-)

2. DISPERSION

Alpha x*	104	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.545	(kg/L)
FractionOrganicCarbon, foc	2.0E-4	(-)

Partition Coefficient	Koc		R	
PCE	426	(L/kg)	1.33	(-)
TCE	130	(L/kg)	1.10	(-)
DCE	125	(L/kg)	1.10	(-)
VC	30	(L/kg)	1.02	(-)
ETH	302	(L/kg)	1.23	(-)

Common R (used in model)* = 1.10

4. BIOTRANSFORMATION

-1st Order Decay Coefficient*

Zone 1

	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.000		0.79
TCE → DCE	0.053		0.74
DCE → VC	0.000		0.64
VC → ETH	0.000		0.45

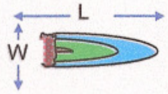
Zone 2

	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	20	(yr)
Modeled Area Width*	280	(ft)
Modeled Area Length*	1040	(ft)
Zone 1 Length*	1040	(ft)
Zone 2 Length*	0	(ft)



Zone 2= L - Zone 1

6. SOURCE DATA

TYPE: Decaying Single Planar

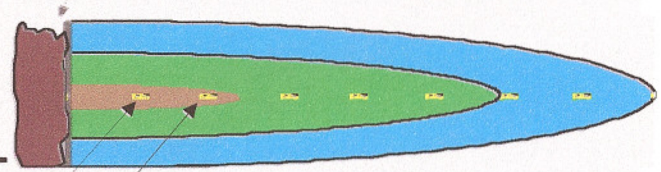
Source Options

Source Thickness in Sat. Zone* 10 (ft)

Y1
Width* (ft) 280

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE		0.02
TCE	.088	0.02
DCE		0.02
VC		0.02
ETH		0.02

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)	.019	.01	.008								
DCE Conc. (mg/L)											
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Distance from Source (ft)	0	120	1040								
Date Data Collected	2010										

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

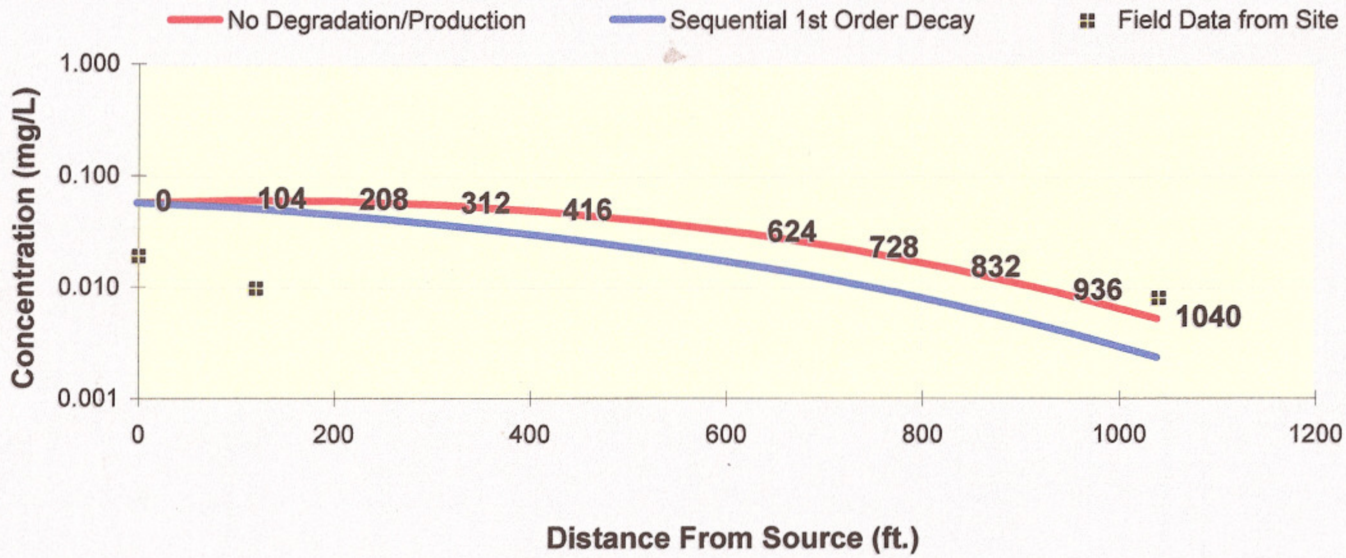
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

Distance from Source (ft)

TCE	0	104	208	312	416	520	624	728	832	936	1040
No Degradation	0.059	0.062	0.060	0.056	0.049	0.040	0.031	0.022	0.015	0.009	0.005
Biotransformation	0.0590	0.053	0.045	0.037	0.029	0.022	0.016	0.011	0.007	0.004	0.002

Monitoring Well Locations (ft)

	0	120	1040								
Field Data from Site	0.019	0.010	0.008								



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

20.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

APPENDIX B

BIOCHLOR Modeling of the Decay Constant to Estimate the Time Required for TCE to Reach the MCL for Alternatives 2B, 3A, 3B, 3C, and 4

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Former CTS Printex Superfund Site
Mountain View, California

First Order Source Decay Constant (ks)

Zone A Groundwater	
Well	**ks (1/years)**
12W	0.103
17W	0.0064
20W	0.0094
23W	0.0023
33W	0.0004
combined data	0.0313

Zone B Groundwater	
Well	**ks (1/years)**
8W	0.2334
14W	0.0187
11W	0.0036
22W	0.0009
combined data	0.0647

Zones A and B Groundwater	
Well	**ks (1/years)**
combined data	0.047

BIOCHLOR requires that ks be < 0.055 years^{-1} which is less than the ks calculated for some wells.

Former CTS Printex Superfund Site
Mountain View, California

Time Required for TCE in Groundwater to Reach the MCL

Zone A Groundwater		
Well	**TCE Concentration (mg/L)**	**Time to Reach MCL (years)**
12W	0.016	25
17W	0	0
20W	0.007	7
23W	0.007	7
33W	0.008	10

Zone B Groundwater		
Well	**TCE Concentration (mg/L)**	**Time to Reach MCL (years)**
8W	0.0037	0
14W	0.019	29
11W	0.01	15
22W	0.008	10

Note:
TCE MCL = 0.005 mg/L
Based on ks = 0.047 / yr for Zones A and B.

APPENDIX C

Cost Estimates

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APPENDIX C-1

Alternative 2A Direct Capital Cost Estimate

Labor Rate Table – 2010 RS Means Standard
Equipment Rate Table – 2010 RS Means Equipment

Alternative 2A O&M Cost Estimate

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Basis of Cost Estimates - Capital and Operation and Maintenance for Alternative 2A

Assumptions and the scope of work associated with building the Groundwater Extraction System included in the capital costs for Alternative 2A are described below. The rationale, site characteristics, and discussions of the remedial components and system functionality are presented in Table 4-3.

Extraction Wells (construction time frame estimated at 1 month)

- Prepare work plan for well installation.
- Perform utility survey to clear utility interferences from drilling locations.
- Drill and install 9 extraction wells (assumes concrete and asphalt coring). Five (5) extraction wells are to be installed within the A zone (screen interval 10 to 20 feet bgs), one well is to capture the horizon between A and B zone (screen interval 20 to 30 feet bgs), and 3 wells to capture the B-zone (screen interval 30 to 40 feet bgs).
- Develop all wells.
- Dispose of drilling and well development wastes. Assumes disposal of approximately 7.5 cubic yard of soil cuttings and 2,000 gallons of purged water.

Installation of Pumps (construction time frame estimated at 1 month)

- Install 9 submersible pumps (0.5 HP) and associated piping.
- Install well vault for each extraction well, electrical power supply to each well with service box, process control (water level and timer) to control pump operation, associated valves (shut-off, check, etc.), and inline flow meter and totalizer.

Electrical (construction time frame estimated at 2 weeks)

- Electrical service drop to well vault from PG&E's nearest available power source at each extraction well location.
- Complete electrical service connection in each well vault.
- Electrical contingency ($20,000) assumed due to uncertainty.

Trench (construction time frame estimated at 1 month)

- Obtain encroachment permits on trenching within Plymouth Street and Sierra Vista Avenue, City of Mountain View's right-of-way.
- Conduct utility clearance for proposed trench lines from each extraction location to the nearest sanitary sewer manhole assumed discharge point. Approximately 1,300 linear feet will be trenched across the site.
- Saw cut asphalts and/or concrete pavement, estimated concrete pavement is 300 linear feet and 1,000 linear feet with asphalt pavement.
- Excavate trenches to 3.5 feet deep, place piping bedding of sand, and install PVC piping connecting each extraction well location to the City's sanitary sewer discharge point. See Figure 4-1 for assumed utility trench routing.
- Backfill and compact soil in trenches at 6-inch incremental layers. Assumes use of excavated soil for backfill.
- Dispose of asphalt and concrete debris.
- Contingency for easements and applicable fees ($120,000).

Site Restoration (construction time frame estimated at one week)

- Restore asphalt, concrete curb and pavement in Plymouth Street and Sierra Vista Avenue.
- Restore asphalt within the parking lots in well 17W area and northeast of the Site.
- Restore grassy areas, patios, sidewalks within the Gables End Townhome area.

Fees and contingency estimated as a percent of the direct Capital Cost subtotal at the following rates:

- G&A at 20%
- Contingency at 20%

Design and management costs estimated as a percent of the total Capital Cost (direct capital costs plus fees and contingency) at the following rates:

- Remedial Design at 10%
- Project Management at 10%

The basis for the operation and maintenance costs for Alternative 2A are summarized below. A total O&M time frame of 22 years assumed based on modeling results. Details for costing and rationale are presented in Appendix C-1.

Assumptions for Year 1 thru 5

- Perform quarterly monitoring and sampling on 9 extraction wells.
- Perform semi-annual monitoring and sampling on all existing site wells (9 extraction and 14 monitoring wells).
- Conduct monthly inspection and maintenance on the 9 nine extraction wells.
- Issue monthly letter compliance report for discharging groundwater into the City's sanitary sewer system.
- Issue semi-annual groundwater monitoring and sampling report.

Assumptions for Year 6 and 7

- Shut down of two extraction wells within the Gables End Townhome area due to achievement of MCLs.
- Perform quarterly monitoring and sampling on 7 extraction wells.
- Perform semi-annual monitoring and sampling on all existing site wells (7 extraction and 14 monitoring wells).
- Conduct monthly inspection and maintenance on the 7 nine extraction wells.
- Prepare monthly letter compliance report for discharging groundwater into the City's sanitary sewer system.
- Prepare semi-annual groundwater monitoring and sampling report.

Assumptions for Year 8 thru 10

- No rebound is verified within the Gable End Townhome area. Reduce the sampling program from 14 to 9 groundwater monitoring wells.
- Perform quarterly monitoring and sampling on 7 extraction wells.
- Perform semi-annual monitoring and sampling on all existing site wells (7 extraction and 9 monitoring wells).
- Conduct monthly inspection and maintenance on the 7 nine extraction wells.

- Prepare monthly letter compliance report for discharging groundwater into the City's sanitary sewer system.
- Prepare semi-annual groundwater monitoring and sampling report.
- Abandon 7 wells (2 extraction and 5 monitoring wells).

Assumptions for Year11 thru 12

- Shut down two extraction wells treating the area of Plymouth Street achieve MCLs. Reduce the sampling program from 9 to 5 groundwater monitoring wells.
- Perform quarterly monitoring and sampling on 5 extraction wells.
- Perform semi-annual monitoring and sampling on all existing site wells (5 extraction and 5 monitoring wells).
- Conduct monthly inspection and maintenance on the 5 nine extraction wells.
- Prepare monthly letter compliance report for discharging groundwater into the City's sanitary sewer system.
- Prepare semi-annual groundwater monitoring and sampling report.

Assumptions for Year11 thru 12

- No rebound is verified within the Plymouth Street area.
- Perform quarterly monitoring and sampling on 5 extraction wells.
- Perform semi-annual monitoring and sampling on all existing site wells (5 extraction and 9 monitoring wells).
- Conduct monthly inspection and maintenance on the 5 nine extraction wells.
- Prepare monthly letter compliance report for discharging groundwater into the City's sanitary sewer system.
- Prepare semi-annual groundwater monitoring and sampling report.
- Abandon 7 wells (2 extraction and 5 monitoring wells) by Year 13.
- Abandon all remaining wells (5 extraction and 9 monitoring wells) by Year 23.

Contingency, management and technical support are applied to O&M Cost subtotal at the following rates:

- Contingency at 15%
- Project Management at 10%
- Technical Support at 15%

Appendix C-1
Capital Costs for Alternative 2A
CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit	Unit Cost	Total Cost	Notes
			ALTERNATIVE 2A			
1	**Capital Cost**					
1.1	Capital Cost Subtotal	1	LS	$494,000.00	$494,000.00	Breakdown details are included in Alternative 2A - Direct Cost Estimate in Appendix C-1
1.2	Direct Contractor G&A and Fee	$494,000	Percent	20.00%	$99,000.00	G&A at 12% and Fee at 8% applied to the subtotal
				Subtotal - Direct Capital Cost with G&A and Fee	**$593,000.00**	
	Contingency					
2	Contigency	$593,000	Percent	20.00%	$119,000.00	
				Subtotal - Capital with contingency	**$712,000.00**	
3	**Design and Management**					
3.1	Remedial Design		Percent	10.00%	$71,200.00	Based on EPA FS Cost Estimate guidance. Percent of capital cost with contingency subtotal
3.2	Project Management		Percent	10.00%	$71,200.00	Based on EPA FS Cost Estimate guidance. Percent of capital cost with contingency subtotal
Note:	Construction Management costs are included in direct Capital Cost					
				Subtotal - Project Management	**$143,000.00**	
				Total Cost for Alternative 2A	**$855,000.00**	

Project Name	CTS Printex Superfund Site Focused Fesibility Study Report - Alternate 2A
Labor Rate Table	2010 RS Means Standard with O&P
Equipment Rate Table	2010 RS Means Equipment with O&P
Alternate Activator Mode	Selectable
Active Alternates	Alternative 2A

CTS Printex Superfund Site Focused Fesibility Study Report - Alternate 2A

Innovative Technical Solutions, Inc.
A Gilbane Company

Estimated By:

Type of Contract:
Revision #:

Alternate Code	WBS2	Item Description	Takeoff Qty	Unit	Labor Total	Subs Total	Mat Total	Other Total	Grand Total
		(Unassigned)							
	*** General Conditions**	*** General Conditions**			**23,589.00**		**7,022**		**33,747.02**
		(Unassigned)			**23,589.00**		**7,022**		**33,747.02**
Alternative 2A	* General Conditions	Rent toilet portable chemical - Rent per month	4.0	mnth					686.95
Alternative 2A	* General Conditions	Rent truck dump rear trailer only 16.5 CY - Rent per week	2.0	week					799.47
Alternative 2A	* General Conditions	Storage Boxes and Tools	2.0	mnth			310		310.00
Alternative 2A	* General Conditions	Temporary Fencing, chain link, rented up to 12 months, 6' high, 11 ga, to 1000'	420.0	LF	861.00		2,092		2,952.60
Alternative 2A	* General Conditions	Labor Cleanup Crew	600.0	hour	22,728.00		1,020		25,398.00
Alternative 2A	* General Conditions	Dumpsters	6.0	mnth			3,600		3,600.00
	Drilling for Well Installation	**Drilling for Well Installation**			**22,104.56**	**30,732.00**	**4,340**		**59,576.56**
		(Unassigned)			**22,104.56**	**30,732.00**	**4,340**		**59,576.56**
Alternative 2A	Drilling for Well Installation	Installation of 9 each Extraction Wells	250.0	vlft		15,000.00			15,000.00
Alternative 2A	Drilling for Well Installation	Development of the Wells	1.0	lsum		4,000.00			4,000.00
Alternative 2A	Drilling for Well Installation	Geologist	120.0	hour	16,633.20				16,633.20
Alternative 2A	Drilling for Well Installation	Procurement	4.0	hour	508.96				508.96
Alternative 2A	Drilling for Well Installation	Rent truck - pick-up - Rent per month	2.0	mnth					2,400.00
Alternative 2A	Drilling for Well Installation	Fuel - Rent truck - pick-up - per gal	400.0	gal			1,200		1,200.00
Alternative 2A	Drilling for Well Installation	Traffic Signs, Barricades, Detour	2.0	EA			600		600.00
Alternative 2A	Drilling for Well Installation	PID	2.0	week			540		540.00
Alternative 2A	Drilling for Well Installation	Miscellaneous (gloves, towels, coolers etc)	1.0	lsum			500		500.00
Alternative 2A	Drilling for Well Installation	Enchroachment - City of Mountain View - 2 locations	2.0	lsum			1,500		1,500.00
Alternative 2A	Drilling for Well Installation	Jr. Scientist	40.0	hour	4,962.40				4,962.40
Alternative 2A	Drilling for Well Installation	Private Utility Locator	2.0	days		1,500.00			1,500.00
Alternative 2A	Drilling for Well Installation	Asphalt saw cutting, asphalt,	5.0	lsum		3,750.00			3,750.00
Alternative 2A	Drilling for Well Installation	Concrete core drilling,	5.0	EA		3,500.00			3,500.00
Alternative 2A	Drilling for Well Installation	Non-Hazardous disposal - soil cutting.	1,200.0	gal		1,992.00			1,992.00
Alternative 2A	Drilling for Well Installation	Non-Hazardous disposal - groundwater	1,500.0	gal		990.00			990.00
	Easement	**Easement**					**100,000**	**20,000.00**	**120,000.00**
		(Unassigned)					**100,000**	**20,000.00**	**120,000.00**
Alternative 2A	Easement	Permits and Access Fees	1.0	lsum			100,000		100,000.00
Alternative 2A	Easement	Easement Contingency	20,000.0	EA				20,000.00	20,000.00
	Electrical	**Electrical**			**17,301.58**		**13,309**	**20,000.00**	**50,910.18**
		(Unassigned)			**17,301.58**		**13,309**	**20,000.00**	**50,910.18**
Alternative 2A	Electrical	Temporary electrical power equipment (pro-rated per job), feeder, EMT and CU wire, 100 amp	1,200.0	LF	8,742.00		9,180		17,922.00
Alternative 2A	Electrical	Temporary electrical power equipment (pro-rated per job), spider box, 50 Amp, 3 uses	5.0	EA	364.25		780		1,144.25
Alternative 2A	Electrical	Temporary electrical power equipment (pro-rated per job), connections, compressor or pump, 30 Amp	5.0	EA	416.29		99		515.29
Alternative 2A	Electrical	Combination starter & nonfusible disconnect, 1-2 pole, 240 volt, .75 HP motor	5.0	EA	1,851.85		3,100		4,951.45
Alternative 2A	Electrical	Electrical Contingency	20,000.0	EA				20,000.00	20,000.00

Innovative Technical Solutions, Inc.
A Gilbane Company

Estimated By:

Type of Contract:
Revision #:

Alternate Code	WBS2	Item Description	Takeoff Qty	Unit	Labor Total	Subs Total	Mat Total	Other Total	Grand Total
Alternative 2A	Electrical	Project Field Superintendent	40.0	hour	5,927.20				5,927.20
Alternative 2A	Electrical	Rent truck - pick-up - Rent per month	0.3	mnth					300.00
Alternative 2A	Electrical	Fuel - Rent truck - pick-up - per gal	50.0	gal			150		150.00
	ITSI Plans & Report	**ITSI Plans & Report**			**21,595.60**				**21,595.60**
		(Unassigned)			**21,595.60**				**21,595.60**
Alternative 2A	ITSI Plans & Report	Geologist	80.0	hour	11,088.80				11,088.80
Alternative 2A	ITSI Plans & Report	JR Scientist	40.0	hour	4,962.40				4,962.40
Alternative 2A	ITSI Plans & Report	Chemist	40.0	hour	5,544.40				5,544.40
	Oversight	**Oversight**			**4,200.00**				**4,503.50**
		(Unassigned)			**4,200.00**				**4,503.50**
Alternative 2A	Oversight	Field Personnel, superintendent, maximum	2.0	week	4,200.00				4,200.00
Alternative 2A	Oversight	Rent truck flatbed 1axle 1-1/2 ton rating - Rent per month	0.5	mnth					303.50
	Piping	**Piping**			**56,631.85**	**30,000.00**	**6,126**		**92,757.68**
		(Unassigned)			**56,631.85**	**30,000.00**	**6,126**		**92,757.68**
Alternative 2A	Piping	Pipe, plastic, PVC, 2" diameter, schedule 40, includes couplings 10' OC, and hangers 3 per 10'	1,700.0	LF	44,352.45		5,573		49,925.63
Alternative 2A	Piping	Elbow, 90 Deg., plastic, PVC, white, socket joint, 2", schedule 40	44.0	EA	1,852.98		102		1,954.49
Alternative 2A	Piping	Tee, plastic, PVC, white, socket joint, 2-1/2", schedule 40	14.0	EA	1,207.93		131		1,339.35
Alternative 2A	Piping	Coupling, plastic, PVC, white, socket joint, 2", schedule 40	170.0	EA	7,159.25		235		7,394.25
Alternative 2A	Piping	Adapter, plastic, PVC, white, female, socket weld x female thread, 2", schedule 40	56.0	EA	2,059.24		85		2,143.97
Alternative 2A	Piping	Fab Chemical Hopper and Misc Pipe & fittings	5.0	EA		25,000.00			25,000.00
Alternative 2A	Piping	Misc Budget for Piping Repairs in Parking Lots	1.0	EA		5,000.00			5,000.00
	Pumps	**Pumps**			**35,162.65**		**17,175**		**56,119.01**
		(Unassigned)			**35,162.65**		**17,175**		**56,119.01**
Alternative 2A	Pumps	Pump, submersible sump, automatic, plastic, 1/2 H.P., 1-1/2" discharge	9.0	EA	1,923.03		2,001		3,923.66
Alternative 2A	Pumps	Pump Vaults	6.0	EA	9,530.82		14,574		26,686.54
Alternative 2A	Pumps	Project Field Superintendent	160.0	hour	23,708.80				23,708.80
Alternative 2A	Pumps	Rent truck - pick-up - Rent per month	1.0	mnth					1,200.00
Alternative 2A	Pumps	Fuel - Rent truck - pick-up - per gal	200.0	gal			600		600.00
	Site Restoration	**Site Restoration**			**7,501.51**		**9,557**		**18,135.12**
		(Unassigned)			**7,501.51**		**9,557**		**18,135.12**
Alternative 2A	Site Restoration	Asphaltic concrete, parking lots & driveways, 6" stone base, 2" binder course, 2" topping, no asphalt hauling included	2,668.0	SF	845.81		7,847		9,457.96
Alternative 2A	Site Restoration	Concrete admixture, integral colors, red/yellow/brown, 5 bag mix, 9.4 lb./bag, includes color only, add	2.8	CY			372		371.70

Innovative Technical Solutions, Inc.
A Gilbane Company

Estimated By:

Type of Contract:
Revision #:

Alternate Code	WBS2	Item Description	Takeoff Qty	Unit	Labor Total	Subs Total	Mat Total	Other Total	Grand Total
Alternative 2A	Site Restoration	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3000 psi, 6" thick, excludes base	150.0	SF	423.80		494		918.15
Alternative 2A	Site Restoration	Cast In-place curb and Gutter Patch Vaious Locations	22.0	LF	171.96		576		748.00
Alternative 2A	Site Restoration	Project Field Superintendent	40.0	hour	5,927.20				5,927.20
Alternative 2A	Site Restoration	Rent truck - pick-up - Rent per month	0.3	mnth					300.00
Alternative 2A	Site Restoration	Fuel - Rent truck - pick-up - per gal	50.0	gal			150		150.00
Alternative 2A	Site Restoration	Sodding, bluegrass sod, on sloped ground, 1 inch, 4 M.S.F.	0.3	Msf	132.75		118		262.10
	Travel	**Travel**						**360.00**	**360.00**
		(Unassigned)						**360.00**	**360.00**
Alternative 2A	Travel	Milege	800.0	Mile				360.00	360.00
	Trenching	**Trenching**			**27,589.53**		**5,852**		**36,250.93**
		(Unassigned)			**27,589.53**		**5,852**		**36,250.93**
Alternative 2A	Trenching	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	248.1	B.C.Y.	1,576.78				2,210.50
Alternative 2A	Trenching	Utility Line Signs, Markers, and Flags, underground tape, detectable, reinforced, aluminum foil core, 6", excludes excavation and backfill	10.0	Clf	30.08		94		123.90
Alternative 2A	Trenching	Backfill and compact, by hand, 6" layers, air rammer/tamper	3.0	E.C.Y.	33.52				38.12
Alternative 2A	Trenching	Selective demolition, saw cutting, asphalt, up to 3" deep	1,314.0	LF	1,146.57		702		2,519.79
Alternative 2A	Trenching	Asphalt Disposal	33.0	ton			3,225		3,224.92
Alternative 2A	Trenching	Concrete Disposal	6.0	ton			586		586.35
Alternative 2A	Trenching	Structural excavation for minor structures, bank measure, sandy soil, pits to 6' deep, hand	8.0	B.C.Y.	424.67				424.67
Alternative 2A	Trenching	Fill by borrow and utility bedding, for pipe and conduit, sand, dead or bank, excludes compaction	34.3	L.C.Y.	313.35		475		876.35
Alternative 2A	Trenching	Concrete sawing, concrete slabs, mesh reinforcing, up to 3" deep	300.0	LF	355.75		170		737.52
Alternative 2A	Trenching	Project Field Superintendent	160.0	hour	23,708.80				23,708.80
Alternative 2A	Trenching	Rent truck - pick-up - Rent per month	1.0	mnth					1,200.00
Alternative 2A	Trenching	Fuel - Rent truck - pick-up - per gal	200.0	gal			600		600.00
		(Unassigned) Total			**215,676.29**	**60,732.00**	**163,380**	**40,360.00**	**493,955.60**
		Grand Total			**215,676.29**	**60,732.00**	**163,380**	**40,360.00**	**493,955.60**

Total Estimate 493,956

Appendix C-1
Alternative 2A- Groundwater Extraction
Year 1 thru 5 Annual O&M Costs (see Note 1)
CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Sampling of Extraction wells**					
	Perform grab sampling at each port from nine extraction wells	4	$240	Quarterly	$960	Unit cost is based on one technician at a rate of $95.00/hr for 2 hours + $50.00 ODCs (cooler, containers, shipping, gas).
	Sample Analysis for 9 VOC samples and 1 duplicate sample	4	$1,200	Quarterly	$4,800	Unit cost for 10 VOC samples at $120,00
1.2	**Sampling of monitoring wells**					
	Semi -Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs).
	Discharge of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.3	**Extraction System**					
	Extraction system Inspection	12	$460	Monthly	$5,520	Tech visit at a daily rate cost includes 4 hours of Tech and trip (4x$95.00+$80.00= $460.00). Frequency of site inspection is once a month.
	Well and Pump Maintenance	9	$350	LS	$3,150	Estimated average annual cost of $350,00 for maintaining pumps, associated connections and parts.
	Power for pumps	17,520	$0.15	kW-HR	$2,628	Power for 9 submersible pumps 0.5-HP. Consumption of each pump is approximately 0.4 Kw/hr. Assumes that pumps will operate in cycle, therefore the daily power usage is estimated for 8 pumps operating 12 hours and 1 pump operating 24 hours. Calculation is 0.4 KW-hr x 8 pumps x 12 hours + 0.4 KW x 1 pump x 24 hours = 48 KW-hr per day X 365 days = 17,520 KW-hr per year.
	City of Mountain View Discharge fee	24,594	$5.73	100 Cu. Ft.	$140,921	Based on total extraction rate of 35 gpm flow from cycling operation of 9 wells.
1.4	**Reporting**					
	Discharge compliance letter report	12	$560	monthly	$6,720	Unit cost based on 4 hours for a Scientist at a rate of $140.00/hr to prepare and submit a letter of discharge report with the City of Mountain View.
	Semi-Annual Monitoring Report	2	$15,000	Ea	$30,000	
				O&M Subtotal Raw	**$216,099**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$32,415	
				O&M Subtotal	**$248,514**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$24,851	Based on EPA FS Cost Estimate guidance.
	Technical Support	15%	of O&M Subtotal		$37,277	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$62,128**	
				Annual O&M Cost	**$311,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 1 thru 5:
- Scope includes 9 active extraction wells consisting of 5 A-zone wells (near 7W, 12W, 17W, and 23W, and between 38W and 20W), 1 A/B-zone well (near 17W), and 3 B-zone wells (near 11W, 17W, and 22W).
- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.

Appendix C-1
Alternative 2A- Groundwater Extraction
Year 6 and 7 Annual O&M Costs (see Note 1)
CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Sampling of Extraction wells**					
	Perform grab sampling at each port from seven extraction wells	4	$240	Quarterly	$960	Unit cost is based on one technician at a rate of $95.00/hr for 2 hours + $50.00 ODCs (cooler, containers, shipping, gas).
	Sample Analysis for 7 VOC samples and 1 duplicate sample	4	$960	Quarterly	$3,840	Unit cost for 8 VOC samples at $120,00.
1.2	**Sampling of monitoring wells**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs)
	Discharge of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.3	**Extraction System**					
	Extraction system Inspection	12	$460	Monthly	$5,520	Tech visit at a daily rate cost includes 4 hours of Tech and trip (4x$95.00+$80.00= $460.00). Frequency of site inspection is once a month.
	Well and Pump Maintenance	7	$350	LS	$2,450	Estimated average annual cost of $350,00 for maintaining pumps, associated connections and parts.
	Power for pumps	14,016	$0.15	kW-HR	$2,102	Power for 7 submersible pumps 0.5-HP. Consumption of each pump is approximately 0.4 Kw/hr. Estimates pumps will operate in cycle, therefore the daily power usage is estimated for 5 pumps operating 12 hours and 1 pump operating 24 hours. Calculation is (0.4 KW-hr x 6 pumps x 12 hours + 0.4 KW x 1 pump x 24 hours) x 365 days
	City of Mountain View Discharge fee	21,080	$5.73	100 cu ft	$120,790	Based on total extraction rate of 30 gpm flow from cycling operation of 7 wells
1.4	**Reporting**					
	Discharge compliance letter report	12	$560	monthly	$6,720	unit cost based on 4 hours for a Scientist at a rate of $140.00/hr to prepare and submit a letter of discharge report with the City of Mountain View.
	Semi-Annual Monitoring Report	2	$15,000	ea	$30,000	
				O&M Subtotal Raw	**$193,782**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$29,067	
				O&M Subtotal	**$222,849**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$22,285	Based on EPA FS Cost Estimate guidance.
	Technical Support	15%	of O&M Subtotal		$33,427	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$55,712**	
				Annual O&M Cost	**$279,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 6 and 7:
- Scope includes 7 active extraction wells consisting of 3 A-zone wells (near 12W, 17W, and 23W), 1 A/B-zone well (near 17W), and 3 B-zone wells (near 11W, 17W, and 22W).
- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.
- Assumes 2 A-zone extraction wells (near 7W and between 20W and 38W) treating areas of lower CAH concentrations achieve MCL by Year 5, thus the 2 wells will remain inactive during Year 6 and 7 to verify no rebound.
- Achieve MCLs in 3 A-zone monitoring wells (7W, 34W, and 38W) and 1 B-zone monitoring well (8W) by Year 7.

Appendix C-1

Alternative 2A- Groundwater Extraction

Year 8 thru 10 Annual O&M Costs (see Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Sampling of Extraction wells**					
	Perform grab sampling at each port from seven extraction wells	4	$240	Quarterly	$960	Unit cost is based on one technician at a rate of $95.00/hr for 2 hours + $50.00 ODCs (cooler, containers, shipping, gas).
	Sample Analysis for 7 VOC samples and 1 duplicate sample	4	$960	Quarterly	$3,840	Unit cost for 8 VOC samples at $120,00.
1.2	**Sampling of monitoring wells**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$7,280	Event	$14,560	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs). Sampling program reduced to 70% of original cost of $10,400.00.
	Discharge of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.3	**Extraction System**					
	Extraction system Inspection	12	$460	Monthly	$5,520	Tech visit at a daily rate cost includes 4 hours of Tech and trip (4x$95.00+$80.00= $460.00). Frequency of site inspection is once a month.
	Well and Pump Maintenance	7	$350	LS	$2,450	Estimated average annual cost of $350,00 for maintaining pumps, associated connections and parts.
	Power for pumps	14,016	$0.15	kW-HR	$2,102	Power for 7 submersible pumps 0.5-HP. Consumption of each pump is approximately 0.4 Kw/hr. Estimates pumps will operate in cycle, therefore the daily power usage is estimated for 5 pumps operating 12 hours and 1 pump operating 24 hours. Calculation is (0.4 KW-hr x 6 pumps x 12 hours + 0.4 KW x 1 pump x 24 hours) x 365 days.
	City of Mountain View Discharge fee	21,080	$5.73	100 cu ft	$120,790	Based on total of 30 gpm flow discharge from cycling operation of 7 wells.
1.4	**Reporting**					
	Discharge compliance letter report	12	$560	monthly	$6,720	Unit cost based on 4 hours for a Scientist at a rate of $140.00/hr to prepare and submit a letter of discharge report with the City of Mountain View.
	Semi-Annual Monitoring Report	2	$15,000	ea	$30,000	
				O&M Subtotal Raw	**$187,542**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$28,131	
				O&M Subtotal	**$215,673**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$21,567	Based on EPA FS Cost Estimate guidance.
	Technical Support	15%	of O&M Subtotal		$32,351	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$53,918**	
				Annual O&M Cost	**$270,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 8 thru 10:
- Scope includes 7 active extraction wells consisting of 3 A-zone wells (near 12W, 17W, and 23W), 1 A/B-zone well (near 17W), and 3 B-zone wells (near 11W, 17W, and 22W).
- Assumes no rebound occurs and reduction on number of wells monitored and sampled from 14 to 9 wells.
- Wells monitored consist of 5 A-zone wells (12W, 13W, 17W, 20W, and 23W) and 4 B-zone wells (11W, 14W, 19W and 22W).
- Abandonment of 6 wells occurs in Year 8, and consists of 3 A-zone monitoring wells (7W, 34W, and 38W), 1 B-zone monitoring well (8W), and 2 A-zone extraction wells (near 7W and between 38W and 20W).
- Achieve MCLs by Year 10 in 2 A-zone monitoring wells (12W and 13W) and 2 B-zone monitoring wells (11W and 14W).

Appendix C-1
Alternative 2A- Groundwater Extraction
Year 11 and 12 Annual O&M Costs (see Note 1)
CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit Cost	Unit	Total Cost	Notes
1.1	**Sampling of Extraction wells**					
	Perform grab sampling at each port from five extraction wells	4	$240	Quarterly	$960	Unit cost is based on one technician at a rate of $95.00/hr for 2 hours + $50.00 ODCs (cooler, containers, shipping, gas).
	Sample Analysis for 5 VOC samples and 1 duplicate sample	4	$720	Quarterly	$2,880	Unit cost for 6 VOC samples at $120,00.
1.2	**Sampling of monitoring wells**					
	Semi -Annual Groundwater Monitoring and Sampling	2	$7,280	Event	$14,560	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs). Sampling program reduced to 70% of original cost of $10,400.00.
	Discharge of decontaminated water and purged groundwater	1	$300	Ea	$300	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.3	**Extraction System**					
	Extraction system Inspection	12	$270	Monthly	$3,240	Tech visit at a daily rate cost includes 2 hours of Tech and trip (2x$95.00+$80.00= $270.00). Frequency of site inspection is once a month.
	Well and Pump Maintenance	5	$350	LS	$1,750	Estimated average annual cost of $350,00 for maintaining pumps, associated connections and parts.
	Power for pumps	10,512	$0.15	kW-HR	$1,577	Power for 5 submersible pumps 0.5-HP. Consumption of each pump is approximately 0.4 Kw/hr. Estimates pumps will operate in cycle, therefore the daily power usage is estimated for 4 pumps operating 12 hours and 1 pump operating 24 hours. Calculation is (0.4 KW-hr x 4 pumps x 12 hours + 0.4 KW x 1 pump x 24 hours) x 365 days.
	City of Mountain View Discharge fee	17,567	$5.73	100 cu ft	$100,658	Based on total of 25 gpm flow discharge from cycling operation of 5 wells.
1.4	**Reporting**					
	Discharge compliance letter report	12	$560	monthly	$6,720	Unit cost based on 4 hours for a Scientist at a rate of $140.00/hr to prepare and submit a letter of discharge report with the City of Mountain View.
	Semi-Annual Monitoring Report	2	$15,000	ea	$30,000	
				O&M Subtotal Raw	**$162,645**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$24,397	
				O&M Subtotal	**$187,042**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$18,704	Based on EPA FS Cost Estimate guidance
	Technical Support	15%	of O&M Subtotal		$28,056	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$46,760**	
				Annual O&M Cost	**$234,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 11 thru 12:
- Scope includes 5 active extraction wells consisting of 2 A-zone wells (near 17W and 23W), 1 A/B-zone well (near 17W), and 2 B-zone wells (near 17W and 22W).
- Monitoring wells (total of 6) consist of 5 A-zone (17W, 20W, 23W, and 33W) and 2 B-zone (19W and 22W) wells.
- Assumes two extraction wells (1 A-zone near 12W and 1 B-zone near 11W) treating areas of lower CAH concentrations achieve MCL by Year 10, thus the two wells will remain inactive during Year 11 and 12 to verify no rebound.
- Achieve MCLs by Year 12 in 1 B-zone monitoring well (19W).

Appendix C-1
Alternative 2A- Groundwater Extraction
Year 13 and 22 Annual O&M Costs (see Note 1)
CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Sampling of Extraction wells**					
	Perform grab sampling at each port from five extraction wells	4	$240	Quarterly	$960	Unit cost is based on one technician at a rate of $95.00/hr for 2 hours + $50.00 ODCs (cooler, containers, shipping, gas).
	Sample Analysis for 5 VOC samples and 1 duplicate sample	4	$720	Quarterly	$2,880	Unit cost for 6 VOC samples at $120,00.
1.2	**Sampling of monitoring wells**					
	Semi -Annual Groundwater Monitoring and Sampling	2	$4,160	Event	$8,320	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs). Sampling program reduced to 40% of original cost of $10,400.00.
	Discharge of decontaminated water and purged groundwater	1	$300	Ea	$300	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.3	**Extraction System**					
	Extraction system Inspection	12	$270	Monthly	$3,240	Tech visit at a daily rate cost includes 2 hours of Tech and trip (2x$95.00+$80.00= $270.00). Frequency of site inspection is once a month.
	Well and Pump Maintenance	5	$350	LS	$1,750	Estimated average annual cost of $350,00 for maintaining pumps, associated connections and parts.
	Power for pumps	10,512	$0.15	kW-HR	$1,577	Power for 5 submersible pumps 0.5-HP. Consumption of each pump is approximately 0.4 Kw/hr. Estimates pumps will operate in cycle, therefore the daily power usage is estimated for 4 pumps operating 12 hours and 1 pump operating 24 hours. Calculation is (0.4 KW-hr x 4 pumps x 12 hours + 0.4 KW x 1 pump x 24 hours) x 365 days.
	City of Mountain View Discharge fee	17,567	$5.73	100 cu ft	$100,658	Based on total of 25 gpm flow discharge from 5 wells.
1.4	**Reporting**					
	Discharge compliance letter report	12	$560	monthly	$6,720	Unit cost based on 4 hours for a Scientist at a rate of $140.00/hr to prepare and submit a letter of discharge report with the City of Mountain View.
	Semi-Annual Monitoring Report	2	$15,000	ea	$30,000	
				O&M Subtotal Raw	**$156,405**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$23,461	
				O&M Subtotal	**$179,866**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$17,987	Based on EPA FS Cost Estimate guidance
	Technical Support	15%	of O&M Subtotal		$26,980	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$44,967**	
				Annual O&M Cost	**$225,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 13 thru 22:
- Scope includes 5 active extraction wells consisting of 2 A-zone wells (near 17W and 23W), 1 A/B-zone well (near 17W), and 2 B-zone wells (near 17W and 22W).
- Assumes no rebound occurs and reduction of wells monitored and sampled from 9 to 5 wells beginning in Year 13.
- Monitoring wells (total of 5) consist of 4 A-zone wells (17W, 20W, 23W, and 33W) and 1 B-zone (22W) well.
- Abandonment of 7 wells occurs in Year 13: 5 monitoring wells consisting of 2 A-zone wells (12W and 13W), 3 B-zone wells (11W, 14W and 19W) wells, and 2 extraction wells (near 12W in the A-zone and 11W in the B-zone.
-Abandonment of remaining extraction wells, consisting of 2 A-zone wells (near 17W and 23W), 1 A/B-zone well (near 17W), and 2 B-zone wells (near 17W and 22W), and 5 monitoring wells, consisting of 4 A-zone wells (17W, 20W, 23W, and 33W) and 1 B-zone (22W) well, in Year 23.

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APPENDIX C-2

Alternative 2B Direct Capital Cost Estimate

Labor Rate Table – 2010 RS Means Standard
Equipment Rate Table – 2010 RS Means Equipment

Alternative 2B O&M Cost Estimate

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Basis of Cost Estimates - Capital and Operation and Maintenance for Alternative 2B

Assumptions and the scope of work associated with building the Groundwater Extraction System included in the capital costs for Alternative 2B are described below. The rationale, site characteristics, and discussions of the remedial components and system functionality are presented in Table 4-4.

Extraction Wells (construction time frame estimated at 1 month)

- Prepare work plan for well installation.
- Perform utility survey to clear utility interferences from drilling locations.
- Drill and install 7 extraction wells (assumes concrete and asphalt coring). Three (3) extraction wells are to be installed within the A zone (screen interval 10 to 20 feet bgs), one well is to capture the horizon between A and B zone (screen interval 20 to 30 feet bgs), and 3 wells to capture the B-zone (screen interval 30 to 40 feet bgs).
- Develop all wells.
- Dispose of drilling and well development wastes. Assumes disposal of approximately 6.5 cubic yard of soil cuttings and 1,500 gallons of purged water.

Installation of Pumps (construction time frame estimated at 1 month)

- Install 7 submersible pumps (0.5 HP) and associated piping.
- Install well vault for each extraction well, electrical power supply to each well with service box, process control (water level and timer) to control pump operation, associated valves (shut-off, check, etc.), and inline flow meter and totalizer.

Electrical (construction time frame estimated at 1 week)

- Electrical service drop to well vault from PG&E's nearest available power source at each extraction well location.
- Complete electrical service connection in each well vault.

Trench (construction time frame estimated at3 weeks)

- Obtain encroachment permits on trenching within Plymouth Street and Sierra Vista Avenue, City of Mountain View's right-of-way.
- Conduct utility clearance for proposed trench lines from each extraction location to the nearest sanitary sewer manhole assumed discharge point. Approximately 900 linear feet will be trenched across the site.
- Saw cut asphalts and/or concrete pavement, estimated concrete pavement is 300 linear feet and 600 linear feet with asphalt pavement.
- Excavate trenches to 3.5 feet deep, place piping bedding of sand, and install PVC piping connecting each extraction well location to the City's sanitary sewer discharge point. See Figure 4-2 for assumed utility trench routing.
- Backfill and compact soil in trenches at 6-inch incremental layers. Assumes use of excavated soil for backfill.
- Dispose of asphalt and concrete debris.
- Contingency for easements and applicable fees ($100,000) assumed due to uncertainty

Site Restoration (construction time frame estimated at one week)

- Restore asphalt, concrete curb and pavement in Plymouth Street and Sierra Vista Avenue.

- Restore asphalt within the parking lots in well 17W area and northeast of the Site.

Fees and contingency estimated as a percent of the direct Capital Cost subtotal at the following rates:

- G&A at 20%
- Contingency at 20%

Design and management costs estimated as a percent of the total Capital Cost (direct capital costs plus fees and contingency) at the following rates:

- Remedial Design at 10%
- Project Management at 10%

The basis for the operation and maintenance costs for Alternative 2B are summarized below. A total O&M time frame of 22 years assumed based on modeling results. Details for costing and rationale are presented in Appendix C-2.

Assumptions for Year 1 thru 7

- Perform quarterly monitoring and sampling on 7 extraction wells.
- Perform semi-annual monitoring and sampling on all existing site wells (7 extraction and 14 monitoring wells).
- Conduct monthly inspection and maintenance on 7 nine extraction wells.
- Prepare monthly letter compliance report for discharging groundwater into the City's sanitary sewer system.
- Prepare semi-annual groundwater monitoring and sampling report.

Assumptions for Year 8 thru 10

- Perform quarterly monitoring and sampling on 7 extraction wells.
- Perform semi-annual monitoring and sampling on all existing site wells (7 extraction and 14 monitoring wells).
- Conduct monthly inspection and maintenance on 7 nine extraction wells.
- Prepare monthly letter compliance report for discharging groundwater into the City's sanitary sewer system.
- Prepare semi-annual groundwater monitoring and sampling report.
- Assumes that VOC concentrations in wells located at Gables End Townhome, Plymouth Street, and westernmost of the TCE plume are below MCL by Year 10.

Assumptions for Year11 thru 16

- Reduction of sampling from 14 to 6 wells due to achievement of MCLs.
- Perform quarterly monitoring and sampling on 5 extraction wells.
- Perform annual monitoring and sampling on all existing site wells (5 extraction and 6 monitoring wells).
- Conduct monthly inspection and maintenance on the 5 nine extraction wells.
- Prepare monthly letter compliance report for discharging groundwater into the City's sanitary sewer system.
- Prepare annual groundwater monitoring and sampling report.
- Abandon 8 monitoring wells and 2 extraction wells (Plymouth Street) in Year 11.
- Assumes two monitoring wells located on west side of VOC plume perimeter achieve MCL by Year 16.

Assumptions for Year 16 thru 22

- Reduction of sampling from 6 to 4 wells due to achievement of MCLs.
- Perform quarterly monitoring and sampling on 5 extraction wells.
- Perform annual monitoring and sampling on all existing site wells (5 extraction and 4 monitoring wells).
- Conduct monthly inspection and maintenance on the 5 nine extraction wells.
- Prepare monthly letter compliance report for discharging groundwater into the City's sanitary sewer system.
- Prepare semi-annual groundwater monitoring and sampling report.
- Abandon 2 monitoring wells by Year 17.
- Abandon all remaining wells (5 extraction and 4 monitoring wells) by Year 23.

Contingency, management and technical support are applied to O&M Cost subtotal at the following rates:

- Contingency at 15%
- Project Management at 10%
- Technical Support at 15%

Appendix C-2
Capital Costs for Alternative 2B
CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit	Unit Cost	Total Cost	Notes
					ALTERNATIVE 2B	
1	**Capital Cost**					
1.1	Capital Cost Subtotal	1	LS	$401,000.00	$401,000.00	Breakdown details are included in Alternative 2B - Direct Cost Estimate in Appendix C-2
1.2	Direct Contractor G&A and Fee	$401,000	Percent	20.00%	$81,000.00	G&A at 12% and Fee at 8% applied to the subtotal
				Subtotal - Direct Capital Cost with G&A and Fee	**$482,000.00**	
	Contingency					
2	Contigency	$482,000	Percent	20.00%	$97,000.00	
				Subtotal - Capital with contingency	**$579,000.00**	
3	**Design and Management**					
3.1	Remedial Design		Percent	10.00%	$57,900.00	Based on EPA FS Cost Estimate guidance. Percent of capital cost with contingency subtotal
3.2	Project Management		Percent	10.00%	$57,900.00	Based on EPA FS Cost Estimate guidance. Percent of capital cost with contingency subtotal
Note:	Construction Management costs are included in direct Capital Cost					
				Subtotal - Project Management	**$116,000.00**	
				Total Cost for Alternative 2B	**$695,000.00**	

Project Name	CTS Printex Superfund Site Focused Fesibility Study Report - Alternate 2B
Labor Rate Table	2010 RS Means Standard with O&P
Equipment Rate Table	2010 RS Means Equipment with O&P
Alternate Activator Mode	Selectable
Active Alternates	Alternative 2B

Innovative Technical Solutions, Inc.
A Gilbane Company

Estimated By:

Type of Contract:
Revision #:

Alternate Code	WBS2	Item Description	Takeoff Qty	Unit	Labor Total	Subs Total	Mat Total	Other Total	Grand Total
		(Unassigned)							
	*** General Conditions**	*** General Conditions**			**23,589.00**		**7,022**		**33,747.02**
		(Unassigned)			**23,589.00**		**7,022**		**33,747.02**
Alternative 2B	* General Conditions	Rent toilet portable chemical - Rent per month	4.0	mnth					686.95
Alternative 2B	* General Conditions	Rent truck dump rear trailer only 16.5 CY - Rent per week	2.0	week					799.47
Alternative 2B	* General Conditions	Storage Boxes and Tools	2.0	mnth			310		310.00
Alternative 2B	* General Conditions	Temporary Fencing, chain link, rented up to 12 months, 6' high, 11 ga, to 1000'	420.0	LF	861.00		2,092		2,952.60
Alternative 2B	* General Conditions	Labor Cleanup Crew	600.0	hour	22,728.00		1,020		25,398.00
Alternative 2B	* General Conditions	Dumpsters	6.0	mnth			3,600		3,600.00
	Drilling for Well Installation	**Drilling for Well Installation**			**18,639.31**	**24,080.22**	**3,590**		**48,709.53**
		(Unassigned)			**18,639.31**	**24,080.22**	**3,590**		**48,709.53**
Alternative 2B	Drilling for Well Installation	Installation of 7 Extraction Wells	210.0	vlft		12,600.00			12,600.00
Alternative 2B	Drilling for Well Installation	Development of the Wells	1.0	lsum		4,000.00			4,000.00
Alternative 2B	Drilling for Well Installation	Geologist	95.0	hour	13,167.95				13,167.95
Alternative 2B	Drilling for Well Installation	Procurement	4.0	hour	508.96				508.96
Alternative 2B	Drilling for Well Installation	Rent truck - pick-up - Rent per month	2.0	mnth					2,400.00
Alternative 2B	Drilling for Well Installation	Fuel - Rent truck - pick-up - per gal	400.0	gal			1,200		1,200.00
Alternative 2B	Drilling for Well Installation	Traffic Signs, Barricades, Detour	2.0	EA			600		600.00
Alternative 2B	Drilling for Well Installation	PID	2.0	week			540		540.00
Alternative 2B	Drilling for Well Installation	Miscellaneous (gloves, towels, coolers etc)	1.0	lsum			500		500.00
Alternative 2B	Drilling for Well Installation	Enchroachment - City of Mountain View - 1 location	1.0	lsum			750		750.00
Alternative 2B	Drilling for Well Installation	Jr. Scientist	40.0	hour	4,962.40				4,962.40
Alternative 2B	Drilling for Well Installation	Private Utility Locator	2.0	days		1,500.00			1,500.00
Alternative 2B	Drilling for Well Installation	Asphalt saw cutting, asphalt,	1.0	lsum		750.00			750.00
Alternative 2B	Drilling for Well Installation	Concrete core drilling,	4.0	EA		2,800.00			2,800.00
Alternative 2B	Drilling for Well Installation	Non-Hazardous disposal - soil cutting.	1,000.0	gal		1,660.00			1,660.00
Alternative 2B	Drilling for Well Installation	Non-Hazardous disposal - groundwater	1,167.0	gal		770.22			770.22
	Easement	**Easement**					**100,000**		**100,000.00**
		(Unassigned)					**100,000**		**100,000.00**
Alternative 2B	Easement	Permits and Access Fees	1.0	lsum			100,000		100,000.00
	Electrical	**Electrical**			**13,334.63**		**8,657**	**20,000.00**	**42,291.79**
		(Unassigned)			**13,334.63**		**8,657**	**20,000.00**	**42,291.79**
Alternative 2B	Electrical	Temporary electrical power equipment (pro-rated per job), feeder, EMT and CU wire, 100 amp	800.0	LF	5,828.00		6,120		11,948.00
Alternative 2B	Electrical	Temporary electrical power equipment (pro-rated per job), spider box, 50 Amp, 3 uses	3.0	EA	218.55		468		686.55
Alternative 2B	Electrical	Temporary electrical power equipment (pro-rated per job), connections, compressor or pump, 30 Amp	3.0	EA	249.77		59		309.17
Alternative 2B	Electrical	Combination starter & nonfusible disconnect, 1-2 pole, 240 volt, .75 HP motor	3.0	EA	1,111.11		1,860		2,970.87
Alternative 2B	Electrical	Electrical Contingency	20,000.0	EA				20,000.00	20,000.00
Alternative 2B	Electrical	Project Field Superintendent	40.0	hour	5,927.20				5,927.20
Alternative 2B	Electrical	Rent truck - pick-up - Rent per month	0.3	mnth					300.00

Innovative Technical Solutions, Inc.
A Gilbane Company

Estimated By:

Type of Contract:
Revision #:

Alternate Code	WBS2	Item Description	Takeoff Qty	Unit	Labor Total	Subs Total	Mat Total	Other Total	Grand Total
Alternative 2B	Electrical	Fuel - Rent truck - pick-up - per gal	50.0	gal			150		150.00
	ITSI Plans & Report	**ITSI Plans & Report**			**21,595.60**				**21,595.60**
		(Unassigned)			**21,595.60**				**21,595.60**
Alternative 2B	ITSI Plans & Report	Geologist	80.0	hour	11,088.80				11,088.80
Alternative 2B	ITSI Plans & Report	JR Scientist	40.0	hour	4,962.40				4,962.40
Alternative 2B	ITSI Plans & Report	Chemist	40.0	hour	5,544.40				5,544.40
	Oversight	**Oversight**			**4,200.00**				**4,503.50**
		(Unassigned)			**4,200.00**				**4,503.50**
Alternative 2B	Oversight	Field Personnel, superintendent, maximum	2.0	week	4,200.00				4,200.00
Alternative 2B	Oversight	Rent truck flatbed 1axle 1-1/2 ton rating - Rent per month	0.5	mnth					303.50
	Piping	**Piping**			**43,556.61**	**20,000.00**	**4,690**		**68,246.25**
		(Unassigned)			**43,556.61**	**20,000.00**	**4,690**		**68,246.25**
Alternative 2B	Piping	Pipe, plastic, PVC, 2" diameter, schedule 40, includes couplings 10' OC, and hangers 3 per 10'	1,300.0	LF	33,916.58		4,262		38,178.42
Alternative 2B	Piping	Elbow, 90 Deg., plastic, PVC, white, socket joint, 2", schedule 40	35.0	EA	1,473.96		81		1,554.71
Alternative 2B	Piping	Tee, plastic, PVC, white, socket joint, 2-1/2", schedule 40	10.0	EA	862.81		94		956.68
Alternative 2B	Piping	Coupling, plastic, PVC, white, socket joint, 2", schedule 40	135.0	EA	5,685.29		187		5,871.90
Alternative 2B	Piping	Adapter, plastic, PVC, white, female, socket weld x female thread, 2", schedule 40	44.0	EA	1,617.97		67		1,684.55
Alternative 2B	Piping	Fab Chemical Hopper and Misc Pipe & fittings	3.0	EA		15,000.00			15,000.00
Alternative 2B	Piping	Misc Budget for Piping Repairs in Parking Lots	1.0	EA		5,000.00			5,000.00
	Pumps	**Pumps**			**25,631.17**		**11,872**		**40,199.37**
		(Unassigned)			**25,631.17**		**11,872**		**40,199.37**
Alternative 2B	Pumps	Pump, submersible sump, automatic, plastic, 1/2 H.P., 1-1/2" discharge	7.0	EA	1,495.69		1,556		3,051.74
Alternative 2B	Pumps	Pump Vaults	4.0	EA	6,353.88		9,716		17,791.03
Alternative 2B	Pumps	Project Field Superintendent	120.0	hour	17,781.60				17,781.60
Alternative 2B	Pumps	Rent truck - pick-up - Rent per month	1.0	mnth					975.00
Alternative 2B	Pumps	Fuel - Rent truck - pick-up - per gal	200.0	gal			600		600.00
	Site Restoration	**Site Restoration**			**5,483.38**		**7,197**		**13,576.98**
		(Unassigned)			**5,483.38**		**7,197**		**13,576.98**
Alternative 2B	Site Restoration	Asphaltic concrete, parking lots & driveways, 6" stone base, 2" binder course, 2" topping, no asphalt hauling included	2,040.0	SF	646.72		6,000		7,231.73
Alternative 2B	Site Restoration	Concrete admixture, integral colors, red/yellow/brown, 5 bag mix, 9.4 lb./bag, includes color only, add	2.8	CY			372		371.70
Alternative 2B	Site Restoration	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3000 psi, 6" thick, excludes base	50.0	SF	141.27		165		306.05
Alternative 2B	Site Restoration	Cast In-place curb and Gutter Patch Vaious Locations	15.0	LF	117.24		393		510.00
Alternative 2B	Site Restoration	Project Field Superintendent	30.0	hour	4,445.40				4,445.40

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Estimated By:

Type of Contract:
Revision #:

Alternate Code	WBS2	Item Description	Takeoff Qty	Unit	Labor Total	Subs Total	Mat Total	Other Total	Grand Total
Alternative 2B	Site Restoration	Rent truck - pick-up - Rent per month	0.3	mnth					300.00
Alternative 2B	Site Restoration	Fuel - Rent truck - pick-up - per gal	50.0	gal			150		150.00
Alternative 2B	Site Restoration	Sodding, bluegrass sod, on sloped ground, 1 inch, 4 M.S.F.	0.3	Msf	132.75		118		262.10
	Trenching	**Trenching**			**20,541.58**		**4,491**		**27,328.94**
		(Unassigned)			**20,541.58**		**4,491**		**27,328.94**
Alternative 2B	Trenching	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	190.0	B.C.Y.	1,207.47				1,692.77
Alternative 2B	Trenching	Utility Line Signs, Markers, and Flags, underground tape, detectable, reinforced, aluminum foil core, 6", excludes excavation and backfill	8.0	Clf	24.07		75		99.12
Alternative 2B	Trenching	Backfill and compact, by hand, 6" layers, air rammer/tamper	1.0	E.C.Y.	11.17				12.71
Alternative 2B	Trenching	Selective demolition, saw cutting, asphalt, up to 3" deep	914.0	LF	797.54		488		1,752.73
Alternative 2B	Trenching	Asphalt Disposal	25.0	ton			2,443		2,443.12
Alternative 2B	Trenching	Concrete Disposal	4.5	ton			440		439.76
Alternative 2B	Trenching	Structural excavation for minor structures, bank measure, sandy soil, pits to 6' deep, hand	6.5	B.C.Y.	345.05				345.05
Alternative 2B	Trenching	Fill by borrow and utility bedding, for pipe and conduit, sand, dead or bank, excludes compaction	28.0	L.C.Y.	256.10		388		716.24
Alternative 2B	Trenching	Concrete sawing, concrete slabs, mesh reinforcing, up to 3" deep	100.0	LF	118.58		57		245.84
Alternative 2B	Trenching	Project Field Superintendent	120.0	hour	17,781.60				17,781.60
Alternative 2B	Trenching	Rent truck - pick-up - Rent per month	1.0	mnth					1,200.00
Alternative 2B	Trenching	Fuel - Rent truck - pick-up - per gal	200.0	gal			600		600.00
		(Unassigned) Total			**176,571.28**	**44,080.22**	**147,519**	**20,000.00**	**400,198.99**
		Grand Total			**176,571.28**	**44,080.22**	**147,519**	**20,000.00**	**400,198.99**

Total Estimate 400,199

Appendix C-2

Alternative 2B- Groundwater Extraction

Year 1 thru 7 Annual O&M Costs (see Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit Cost	Unit	Total Cost	Notes
1.1	**Sampling of Extraction wells**					
	Perform grab sampling at each port from seven extraction wells	4	$240	Quarterly	$960	Unit cost is based on one technician at a rate of $95.00/hr for 2 hours + $50.00 ODCs (cooler, containers, shipping, gas).
	Sample Analysis for 7 VOC samples and 1 duplicate sample	4	$960	Quarterly	$3,840	Unit cost for 8 VOC samples at $120,00.
1.2	**Sampling of monitoring wells**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs).
	Discharge of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water.
1.3	**Extraction System**					
	Extraction system Inspection	12	$460	Monthly	$5,520	Tech visit at a daily rate cost includes 4 hours of Tech and trip (4x$95.00+$80.00= $460.00). Frequency of site inspection is once a month.
	Well and Pump Maintenance	7	$350	LS	$2,450	Estimated average annual cost of $350,00 for maintaining pumps, associated connections and parts.
	Power for pumps	14,016	$0.15	kW-HR	$2,102	Power for 7 submersible pumps 0.5-HP. Consumption of each pump is approximately 0.4 Kw/hr. Estimates pumps will operate in cycle, therefore the daily power usage is estimated for 5 pumps operating 12 hours and 1 pump operating 24 hours. Calculation is (0.4 KW-hr x 6 pumps x 12 hours + 0.4 KW x 1 pump x 24 hours) x 365 days.
	City of Mountain View Discharge fee	21,080	$5.73	100 Cu. Ft	$120,790	Based on total extraction rate of 30 gpm flow from cycling the operation of 7 wells.
1.4	**Reporting**					
	City of Muntain View compliance letter report	12	$560	monthly	$6,720	Unit cost based on 4 hours for a Scientist at a rate of $140.00/hr to prepare and submit a letter of discharge report with the City of Mountain View.
	Semi-Annual Monitoring Report	2	$15,000	Ea	$30,000	
				O&M Subtotal Raw	**$193,783**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$29,067	
				O&M Subtotal	**$222,850**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$22,285	Based on EPA FS Cost Estimate guidance.
	Technical Support	15%	of O&M Subtotal		$33,428	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$55,713**	
				Annual O&M Cost	**$279,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Years 1 through 7:

- Scope includes 7 active extraction wells consisting of 3 A-zone wells (near 12W, 17W, and 23W), 1 A/B-zone well (near 17W), and 3 B-zone wells (near 11W, 17W, and 22W).

- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.

Appendix C-2
Alternative 2B- Groundwater Extraction
Year 8 thru 10 Annual O&M Costs (see Note 1)
CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit Cost	Unit	Total Cost	Notes
1.1	**Sampling of Extraction wells**					
	Perform grab sampling at each port from seven extraction wells	4	$240	Quarterly	$960	Unit cost is based on one technician at a rate of $95.00/hr for 2 hours + $50.00 ODCs (cooler, containers, shipping, gas).
	Sample Analysis for 7 VOC samples and 1 duplicate sample	4	$960	Quarterly	$3,840	Unit cost for 8 VOC samples at $120,00.
1.2	**Sampling of monitoring wells**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs).
	Discharge of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.3	**Extraction System**					
	Extraction system Inspection	12	$460	Monthly	$5,520	Tech visit at a daily rate cost includes 4 hours of Tech and trip (4x$95.00+$80.00= $460.00). Frequency of site inspection is once a week.
	Well and Pump Maintenance	7	$350	LS	$2,450	Estimated average annual cost of $350,00 for maintaining pumps, associated connections and parts.
	Power for pumps	14,016	$0.15	kW-HR	$2,102	Power for 7 submersible pumps 0.5-HP. Consumption of each pump is approximately 0.4 Kw/hr. Estimates pumps will operate in cycle, therefore the daily power usage is estimated for 5 pumps operating 12 hours and 1 pump operating 24 hours. Calculation is (0.4 KW-hr x 6 pumps x 12 hours + 0.4 KW x 1 pump x 24 hours) x 365 days.
	City of Mountain View Discharge fee	21,080	$5.73	100 Cu. Ft	$120,790	Based on total extraction rate of 30 gpm flow from cycling the operation of 7 wells.
1.4	**Reporting**					
	City's compliance letter report	12	$560	monthly	$6,720	Unit cost based on 4 hours for a Scientist at a rate of $140.00/hr to prepare and submit a letter of discharge report with the City of Mountain View.
	Semi-Annual Monitoring Report	2	$15,000	Ea	$30,000	
				O&M Subtotal Raw	**$193,782**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$29,067	
				O&M Subtotal	**$222,849**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$22,285	Based on EPA FS Cost Estimate guidance.
	Technical Support	15%	of O&M Subtotal		$33,427	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$55,712**	
				Annual O&M Cost	**$279,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 8 thru 10:

- Scope includes 7 active extraction wells consisting of 3 A-zone wells (near 12W, 17W, and 23W), 1 A/B-zone well (near 17W), and 3 B-zone wells (near 11W, 17W, and 22W).
- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.
- Assumes at Year 10 achievement of MCLs for monitoring wells 7W, 8W, 11W, 12W, 13W, and 14W (Plymouth Street), 34W, and 38W with no rebound. Beginning in Year 11, reduction of number of wells monitored and sampled from 14 to 6 wells.

Appendix C-2
Alternative 2B- Groundwater Extraction
Year 11 thru 16 Annual O&M Costs (see Note 1)
CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Sampling of Extraction wells**					
	Perform grab sampling at each port from five extraction wells	4	$145	Quarterly	$580	Unit cost is based on one technician at a rate of $95.00/hr for 1 hour + $50.00 ODCs (cooler, containers, shipping, gas).
	Sample Analysis for 5 VOC samples and 1 duplicate sample	4	$720	Quarterly	$2,880	Unit cost for 1 VOC sample at $120,00 each.
1.2	**Sampling of monitoring wells**					
	Annual Groundwater Monitoring and Sampling	1	$4,160	Event	$4,160	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs). Sampling program reduced to 40% of original cost of $10,400.00.
	Discharge of decontaminated water and purged groundwater	1	$300	Ea	$300	Purged water from low-flow sampling method and equipment decontamination water.
1.3	**Extraction System**					
	Extraction system Inspection	12	$460	Monthly	$5,520	Tech visit at a daily rate cost includes 4 hours of Tech and trip (4x$95.00+$80.00= $460.00). Frequency of site inspection is once a week.
	Well and Pump Maintenance	5	$350	LS	$1,750	Estimated average annual cost of $350,00 for maintaining pumps, associated connections and parts.
	Power for pumps	10,512	$0.15	kW-HR	$1,577	Power for 5 submersible pumps 0.5-HP. Consumption of each pump is approximately 0.4 Kw/hr. Estimates pumps will operate in cycle, therefore the daily power usage is estimated for 4 pumps operating 12 hours and 1 pump operating 24 hours. Calculation is (0.4 KW-hr x 4 pumps x 12 hours + 0.4 KW x 1 pump x 24 hours) x 365 days.
	City of Mountain View Discharge fee	17,567	$5.73	100 Cu. Ft	$100,658	Based on total extraction rate of 25 gpm flow from cycling the operation of 5 wells.
1.4	**Reporting**					
	compliance letter report	12	$560	monthly	$6,720	Unit cost based on 4 hours for a Scientist at a rate of $140.00/hr to prepare and submit a letter of discharge report with the City of Mountain View.
	Annual Monitoring Report	1	$15,000	Ea	$15,000	
				O&M Subtotal Raw	**$139,145**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$20,872	
				O&M Subtotal	**$160,017**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$16,002	Based on EPA FS Cost Estimate guidance.
	Technical Support	15%	of O&M Subtotal		$24,003	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$40,005**	
				Annual O&M Cost	**$201,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 11 thru 16:

- Scope includes 5 active extraction wells consisting of 2 A-zone wells (near 17W and 23W), 1 A/B-zone well (near 17W), and 2 B-zone wells (near 17W and 22W).
- Monitoring of 6 wells consisting of 4 A-zone (17W, 20W, 23W and 33W) and 2 B-zone (19W and 22W) wells.
- Abandonment of 8 monitoring wells, consisting of 5 A-zone (7W, 12W, 13W, 34W, and 38W) and 3 B-zone (8W, 11W, and 14W) wells, and 2 extraction wells (Plymouth Street, A-and B-zone wells) occurs in Year 11.
- Assumes at Year 16 achievement MCL criteria for 1 A-zone monitoring wells (20W), and 1 B-zone well (19W) with no rebound. Beginning in Year 16, reduction of number of wells monitored and sampled from 6 to 4 wells consisting of 3 A-zone wells (17W, 23W and 33W) and 1 B-zone well (22W).

Appendix C-2
Alternative 2B- Groundwater Extraction
Year 16 thru 22 Annual O&M Costs (see Note 1)
CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit Cost	Unit	Total Cost	Notes
1.1	**Sampling of Extraction wells**					
	Perform grab sampling at each port from five extraction wells	4	$145	Quarterly	$580	Unit cost is based on one technician at a rate of $95.00/hr for 1 hour + $50.00 ODCs (cooler, containers, shipping, gas).
	Sample Analysis for 5 VOC samples and 1 duplicate sample	4	$720	Quarterly	$2,880	Unit cost for 1 VOC sample at $120,00 each.
1.2	**Sampling of monitoring wells**					
	Annual Groundwater Monitoring and Sampling	1	$4,160	Event	$4,160	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs). Sampling program reduced to 40% of original cost of $10,400.00.
	Discharge of decontaminated water and purged groundwater	1	$300	Ea	$300	Purged water from low-flow sampling method and equipment decontamination water.
1.3	**Extraction System**					
	Extraction system Inspection	12	$460	Monthly	$5,520	Tech visit at a daily rate cost includes 4 hours of Tech and trip (4x$95.00+$80.00= $460.00). Frequency of site inspection is once a week.
	Well and Pump Maintenance	5	$350	LS	$1,750	Estimated average annual cost of $350,00 for maintaining pumps, associated connections and parts.
	Power for pumps	8,760	$0.15	kW-HR	$1,314	Power for 5 submersible pumps 0.5-HP. Consumption of each pump is approximately 0.4 Kw/hr. Estimates pumps will operate in cycle, therefore the daily power usage is estimated for 4 pumps operating 12 hours and 1 pump operating 24 hours. Calculation is (0.4 KW-hr x 3 pumps x 12 hours + 0.4 KW x 1 pump x 24 hours) x 365 days.
	City of Mountain View Discharge fee	14,053	$5.73	100 Cu. Ft	$80,526	Based on total extraction rate of 20 gpm flow from cycling the operation of 5 wells. Extraction by pulsing mode.
1.4	**Reporting**					
	compliance letter report	12	$560	monthly	$6,720	Unit cost based on 4 hours for a Scientist at a rate of $140.00/hr to prepare and submit a letter of discharge report with the City of Mountain View.
	Annual Monitoring Report	1	$15,000	Ea	$15,000	
				O&M Subtotal Raw	**$118,750**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$17,813	
				O&M Subtotal	**$136,563**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$13,656	Based on EPA FS Cost Estimate guidance.
	Technical Support	15%	of O&M Subtotal		$20,484	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$34,140**	
				Annual O&M Cost	**$171,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 16 thru 22:

- Scope includes 5 active extraction wells consisting of 2 A-zone wells (near 17W and 23W), 1 A/B-zone well (near 17W), and 2 B-zone wells (near 17W and 22W).
- Monitoring of 4 wells consisting of 3 A-zone (17W, 23W and 33W) and 1 B-zone (22W) wells.
- Abandonment of 2 monitoring wells (20W in A-zone and 19W in B-zone) in Year 17.
- Abandonment of all remaining of 4 monitoring wells, consisting of 3 A-zone (17W, 23W and 33W) and 1 B-zone (22W) wells, and 5 extraction wells occurs in Year 23.

APPENDIX C-3

Alternative 3A Direct Capital Cost Estimate

Labor Rate Table – 2010 RS Means Standard
Equipment Rate Table – 2010 RS Means Equipment

Alternative 3A O&M Cost Estimate

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<u>Basis of Cost Estimates - Capital and Operation and Maintenance for Alternative 3A</u>

Assumptions and the scope of work associated with In Situ Chemical Oxidation (ISCO) included in the capital costs for Alternative 3A are described below. The rationale, site characteristics, and discussions of the remedial components and design are presented in Table 4-5.

Bench-scale study (time frame estimated at 2 weeks)

- Prepare work plan for bench scale study.
- Conduct bench scale study to establish oxidant addition requirements and a field pilot study to establish injection spacing.

ISCO (time frame estimated at2 months)

- Prepare work plan for ISCO.
- Determine and mark injection points based on a grid pattern as shown on Figure 4-3.
- Conduct clearance of potential utility interferences from drilling and injection points.
- Perform injection in B-zone through 98 points using 40% sodium permanganate and flow rate at 5 gallons per minute to treat depths between 20 and 40 feet below grade surface. Assumes productivity of 8 locations injected simultaneously per day for a total of 16 days to inject an estimated amount of 228,000 pounds of 40% sodium permanganate solution.
- Perform injection in A-zone through 98 points using 40% sodium permanganate and flow rate at 5 gallons per minute to treat depths between 10 and 20 feet below grade surface. Assumes productivity of 8 locations injected simultaneously per day for a total of 10 days to inject an estimated amount of 77,000 pounds of 40% sodium permanganate solution.

Site Restoration (construction time frame estimated at one week)

- Restore asphalt within the parking lot in 17W area. Estimated area of restoration is approximately 2,000 square feet.

Fees and contingency estimated as a percent of the direct Capital Cost subtotal at the following rates:

- G&A at 20%
- Contingency at 20%

Design and management costs estimated as a percent of the total Capital Cost (direct capital costs plus fees and contingency) at the following rates:

- Treatability Study cost assumed at $150,000.00.
- Remedial Design at 15%
- Project Management at 10%

The basis for the operation and maintenance costs for Alternative 3A are summarized below. A total O&M time frame of 15 years assumed based on modeling results. Details for costing and rationale are presented in Appendix C-3.

Assumptions for Year 1

- Perform semi-annual monitoring and sampling on all existing site wells (14 monitoring wells).
- Perform quarterly sampling at well 17W area for ISCO rebound evaluation.

- Request analysis for MNA parameters and microbial degrader population to evaluate MNA conditions.
- Prepare semi-annual groundwater monitoring and sampling report.

Assumptions for Year 2

- Perform semi-annual monitoring and sampling on all existing site wells (14 monitoring wells).
- Request analysis for MNA parameters and microbial degrader population to evaluate MNA conditions.
- Prepare semi-annual groundwater monitoring and sampling report.

Assumptions for Year 3 thru 10

- Perform semi-annual monitoring and sampling on all existing site wells (14 monitoring wells).
- Request analysis for MNA parameters to evaluate MNA conditions.
- Prepare semi-annual groundwater monitoring and sampling report.
- Assumes 8 wells achieving MCL by Year 10.

Assumptions for Year 10 thru 15

- Reduction of sampling from 14 to 6 wells due to achievement of MCLs.
- Perform annual monitoring and sampling on 4 monitoring wells.
- Abandon 8 wells by Year 11.
- Assumes remaining wells achieve MCLs by Year 15. Abandon remaining wells (4) by Year 16. .
- Prepare annual groundwater monitoring and sampling report.

Contingency, management and technical support are applied to O&M Cost subtotal at the following rates:

- Contingency at 20%
- Project Management at 10%
- Technical Support at 15%

Appendix C-3
Capital Costs for Alternative 3A
CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit	Unit Cost	Total Cost	Notes
ALTERNATIVE 3A						
1	**Capital Cost**					
1.1	Capital Cost Subtotal	1	LS	$1,230,000.00	$1,230,000.00	Breakdown details are included in Alternative 3 - Direct Cost Estimate in Appendix C-3
1.2	Direct Contractor G&A and Fee	$1,230,000	Percent	20.00%	$246,000.00	G&A at 12% and Fee at 8% applied to the subtotal
Subtotal - Direct Capital Cost with G&A and Fee					**$1,476,000.00**	
	Contingency					
2	Contigency	$1,476,000	Percent	20.00%	$296,000.00	
Subtotal - Capital with contingency					**$1,772,000.00**	
3	**Design and Management**					
3.1	Treatability Study	1	LS	150,000.00	$150,000.00	Lump Sum Estimate
3.2	Remedial Design		Percent	15.00%	$265,800.00	Based on EPA FS Cost Estimate guidance. Percent of capital cost with contingency subtotal
3.3	Project Management		Percent	10.00%	$177,200.00	Based on EPA FS Cost Estimate guidance. Percent of capital cost with contingency subtotal
Note:	Construction Management costs are included in direct Capital Cost					
Subtotal - Project Management					**$593,000.00**	
Total Cost for Alternative 3A					**$2,365,000.00**	

CTS Printex Superfund Site Focused Fesibility Study Report - Alternate 3A

Innovative Technical Solutions, Inc.
A Gilbane Company

Estimated By:

Type of Contract:
Revision #:

Alternate Name	WBS2	Item Description	Takeoff Qty	Unit	Labor Total	Mat Total	Subs Total	Equip Total	Other Total	Subcontractor Name	Subs Total	Total $/Unit	Grand Total
		(Unassigned)											
	*** General Conditions**	*** General Conditions**						**343.48**					**343.48**
Alt 3A - Wells to Sanitary Sewer	* General Conditions	Rent toilet portable chemical - Rent per month	2.0	mnth				343.48		ITSI		171.74	343.48
	Oversight	**Oversight**			**12,600.00**			**1,214.01**					**13,814.01**
Alt 3A - Wells to Sanitary Sewer	Oversight	Field Personnel, superintendent, maximum	6.0	week	12,600.00							2,100.00	12,600.00
Alt 3A - Wells to Sanitary Sewer	Oversight	Rent truck flatbed 1axle 1-1/2 ton rating - Rent per month	2.0	mnth				1,214.01				607.01	1,214.01
	Site Restoration	**Site Restoration**			**646.72**	**5,999.88**		**585.12**					**7,231.73**
Alt 3A - Wells to Sanitary Sewer	Site Restoration	Asphaltic concrete, parking lots & driveways, 6" stone base, 2" binder course, 2" topping, no asphalt hauling included	2,040.0	SF	646.72	5,999.88		585.12				3.54	7,231.73
	Travel	**Travel**							**360.00**				**360.00**
	Trenching	**Trenching**					**1,208,191**				**1,208,191.00**		**1,208,191.00**
Alt 3A - Wells to Sanitary Sewer	Trenching	Injection inject 40% Na Mn O4 in 98 points	1.0	lsum			1,208,191				1,208,191.00	1,208,191.00	1,208,191.00
		(Unassigned) Total			**13,246.72**	**5,999.88**	**1,208,191**	**2,142.61**			**1,208,191.00**		**1,229,580.21**
		Grand Total			**13,246.72**	**5,999.88**	**1,208,191**	**2,142.61**			**##########**		**1,229,580.21**

2/24/2011

CSI	Division	Labor	Mat	Subs	Equip	Other	User	Total
01	General Requirements	12,600			1,557			14,157
02	Site Construction	647	6,000	1,208,191	585			1,215,423

Total Estimate 1,229,580

Appendix C-3

Alternative 3A - In-Situ Chemical Oxidation (ISCO) to Remediate the Area with High Residual Contaminant Mass

Year 1 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Groundwater Monitoring**					
	Semi -Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs).
	Dispose of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Parameters**					
	Analysis for MNA parameters (13 samples)	2	$1,450	Event	$2,900	Geochemical characterization for monitoring wells, excluding 17W with ISCO.
	Microbial degrader population (10 samples)	2	$1,200	Event	$2,400	Microbial population of TCE to ethene degraders.
1.2	**ISCO Rebound Evaluation**					
	Quarterly sampling at 17W and VOC analysis	2	$485	Quarterly	$970	Conducted during quarters w/o semi-annual monitoring. Tech at a daily rate cost includes 3 hours of Tech and trip (3x$95.00+$80.00= $365.00). VOC analysis at $120.
1.4	**Reporting**					
	Quarterly Report in 17W area	2	$8,000	Each	$16,000	
	Semi -Annual Groundwater Monitoring	2	$15,000	Each	$30,000	
				O&M Subtotal Raw	**$73,670**	
2	**Contingency**					
	Contingency	20%			$14,734	
				O&M Subtotal	**$88,404**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$8,840	Based on EPA FS Cost Estimate guidance
	Technical Support	20%	of O&M Subtotal		$17,681	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$26,521**	
				YEAR 1 Annual O&M Cost	**$115,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 1:
- Year 1 includes evaluation for rebound after ISCO treatment. The ISCO treatment included treating of residual high CAH concentratrions in 17W area using sodium permanganate at 40% dillution. Treatment area of 8,000 sq-ft using 98 locations with injection depths from 10 to 40 feet bgs. Includes Direct push drilling costs and subcontractor management.
- Sampling of monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.

Appendix C-3

Alternative 3A - In-Situ Chemical Oxidation (ISCO) to Remediate the Area with High Residual Contaminant Mass

Year 2 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Groundwater Monitoring**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs)
	Dispose of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Parameters**					
	Analysis for MNA parameters (13 samples)	2	$1,450	Event	$2,900	Geochemical characterization for monitoring wells, excluding 17W.
	Microbial degrader population (10 samples)	2	$1,200	Event	$2,400	Microbial population of TCE to ethene degraders.
1.3	**Reporting**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$15,000	Each	$30,000	
				O&M Subtotal Raw	**$56,700**	
2	**Contingency**					
	Contingency	20%			$11,340	
				O&M Subtotal	**$68,040**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$6,804	Based on EPA FS Cost Estimate guidance
	Technical Support	15%	of O&M Subtotal		$10,206	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$17,010**	
				YEAR 2 Annual O&M Cost	**$86,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 2:

- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.

Appendix C-3

Alternative 3A - In-Situ Chemical Oxidation (ISCO) to Remediate the Area with High Residual Contaminant Mass

Year 3 thru 10 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Groundwater Monitoring**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs)
	Dispose of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Parameters**					
	Analysis for MNA parameters (13 samples)	2	$1,450	Event	$2,900	Geochemical characterization for monitoring wells, excluding 17W.
1.3	**Reporting**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$15,000	Each	$30,000	
				O&M Subtotal Raw	**$54,300**	
2	**Contingency**					
	Contingency	20%			$10,860	
				O&M Subtotal	**$65,160**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$6,516	Based on EPA FS Cost Estimate guidance
	Technical Support	15%	of O&M Subtotal		$9,774	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$16,290**	
				YEAR 3 - 10 Annual O&M Cost	**$82,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 3-10:

- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.
- Achieve MCLs by Year 10 in 5 A-zone monitoring wells (7W, 12W, 13W, 34W, and 38W) and 3 B-zone monitorinng well (8W, 11W, and 14W).

Appendix C-3

Alternative 3A - In-Situ Chemical Oxidation (ISCO) to Remediate the Area with High Residual Contaminant Mass

Year 10 thru 15 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit Cost	Unit	Total Cost	Notes
YEAR 1						
1.1	**Groundwater Monitoring**					
	Annual Groundwater Monitoring and Sampling	1	$6,240	Event	$6,240	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs). Sampling program reduced to 60% of original cost.
	Dispose of decontaminated water and purged groundwater	1	$300	Ea	$300	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Parameters**					
	Analysis for MNA parameters (6 samples)	1	$700	Event	$700	Geochemical characterization for monitoring wells.
1.3	**Reporting**					
	Annual Groundwater Monitoring	1	$15,000	Each	$15,000	
				O&M Subtotal Raw	**$22,240**	
2	**Contingency**					
	Contingency	20%			$4,448	
				O&M Subtotal	**$26,688**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$2,669	Based on EPA FS Cost Estimate guidance
	Technical Support	15%	of O&M Subtotal		$4,003	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$6,672**	
				YEAR 10 thru 15 Annual O&M Cost	**$34,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 10-15:
- Monitoring wells (total of 6) consist of 4 A-zone (17W, 20W, 23W, and 33W) and 2 B-zone (19W, and 22W) wells.
- Abandon 5 A-zone monitoring wells (7W, 12W, 13W, 34W, and 38W) and 3 B-zone monitoring wells (8W, 11W, and 14W) in Year 11.
- Acheivement of MCLs in 6 wells being monitored: 4 A-zone (17W, 20W, 23W, and 33W) and 2 B-zone (19W and 22W) wells by Year 15.
- Abandon 6 monitoring wells: 4 A-zone (17W, 20W, 23W, and 33W) and 2 B-zone (19W, and 22W) wells in Year 16.

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APPENDIX C-4

Alternative 3B Direct Capital Cost Estimate

Labor Rate Table – 2010 RS Means Standard
Equipment Rate Table – 2010 RS Means Equipment

Alternative 3B O&M Cost Estimate

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Basis of Cost Estimates - Capital and Operation and Maintenance for Alternative 3B

Assumptions and the scope of work associated with constructing the Groundwater Recirculating System for Enhanced Anaerobic Bioremediation included in the capital costs for Alternative 3B are described below. The rationale, site characteristics, and discussions of the remedial components and system functionality are presented in Table 4-6.

Treatability Study (time frame 3 weeks)

- Conduct treatability study to evaluate and select the actual substrate, appropriate nutrients, bioaugmentation, and other design requirements. Assumed lump sum of $150,000 to perform this task.

Injection of Organic Substrate and Amendments (time frame 6 weeks)

- Prepare work plan for injection activities.
- Inject organic substrate using direct push technology to distribute substrates through 7 injection points at depths between 10 and 40 feet bgs. Organic substrate consisting of 60% sodium lactate at estimated mass of 1,900 kg would be used to enhance and/or promote anaerobic conditions in the treatment area of high residual CAH mass. In addition to organic substrate, amendments consisting of Dehalococcoides microbial cultures and nutrients will also be distributed within the treatment zone.

Re-circulating Well System (construction time frame estimated at 1 month)

- Develop work plan for well installation.
- Perform utility survey to clear utility interferences from drilling locations.
- Drill and install 2 extraction wells (1 in A-zone and 1 in B-zone) and 6 re-injection wells (3 pairs of co-located A- and B-zone wells) as shown on Figure 4-4.
- Develop all wells.
- Dispose of drilling and well development wastes. Assumes disposal of approximately 7.5 cubic yard of soil cuttings and 2,000 gallons of purged water.

Installation of Pumps (construction time frame estimated at 1 week)

- Install 2 submersible pumps (0.5 HP) and associated piping.
- Install a well vault for extraction wells, electrical power supply with service box, process control (water level and timer) to control pump operation, associated valves (shut-off, check, etc.), and inline flow meter and totalizer.

Electrical (construction time frame estimated at 1 week)

- Electrical service drop to well vault from PG&E's nearest available power source at the extraction well location.
- Complete electrical service connection in each well vault.
- Electrical contingency ($11,000) assumed due to uncertainty.

Trench (construction time frame estimated at 1 month)

- Conduct utility clearance for proposed trench lines from the extraction wells location to the re-injection wells. Approximately 300 linear feet will be trenched across the 17W well paved parking lot.
- Saw cut asphalts and/or concrete pavement.

- Excavate trenches to 3.5 feet deep, place piping bedding of sand, and install PVC piping connecting the extraction wells to the re-injection wells. See Figure 4-4 for assumed utility trench routing.
- Backfill and compact soil in trenches at 6-inch incremental layers. Assumes use of excavated soil for backfill.
- Dispose of asphalt and concrete debris.

Site Restoration (construction time frame estimated at one week)

- Restore asphalt within the trenched lines in the well 17W's parking lot.
- Replace removed trees from clearing, grubbing and tree removal in congested areas.

Fees and contingency estimated as a percent of the direct Capital Cost subtotal at the following rates:

- G&A at 20%
- Contingency at 20%

Design and management costs estimated as a percent of the total Capital Cost (direct capital costs plus fees and contingency) at the following rates:

- Remedial Design at 15%
- Project Management at 10%

The basis for the operation and maintenance costs for Alternative 3B are summarized below. A total O&M time frame of 15 years assumed based on modeling results. Details for costing and rationale are presented in Appendix C-4.

Assumptions for Year 1

- Perform semi-annual monitoring and sampling on all existing site wells (14 monitoring wells).   Include analysis for MNA parameters and microbial degrader population.
- Conduct bi-weekly inspection and maintenance on re-circulating wells and quarterly sampling of well 17W.
- Prepare quarterly EAB report.
- Prepare semi-annual groundwater monitoring and sampling report.

Assumptions for Year 2

- Perform semi-annual monitoring and sampling on all existing site wells (14 monitoring wells).   Include the analysis for MNA parameters and microbial degrader population.
- Conduct monthly inspection and maintenance on re-circulating wells and quarterly sampling of well 17W.
- Prepare quarterly EAB report.
- Prepare semi-annual groundwater monitoring and sampling report.

Assumptions for Year 3 through 5

- Perform semi-annual monitoring and sampling on all existing site wells (14 monitoring wells).   Include the analysis for MNA parameters.
- Prepare semi-annual groundwater monitoring and sampling report.
- Shut off the re-circulating system and assumes no rebounding of concentrations are observed.

Assumptions for Year 6 through 10

- Perform semi-annual monitoring and sampling on all existing site wells (14 monitoring wells). Include the analysis for MNA parameters.
- Prepare semi-annual groundwater monitoring and sampling report.
- Abandon re-circulating system wells (2 extraction and 6 re-injection wells).
- Assumes that 5 A-zone wells and 3 B-zone wells achieve MCLs by Year 10.

Assumptions for Year 11 through 15

- Perform annual monitoring and sampling on all existing site wells (6 monitoring wells). Include the analysis for MNA parameters.
- Prepare annual groundwater monitoring and sampling report.
- Abandon 5 A-zone wells and 3 B-zone wells by Year 11.
- Assumes remaining of the 6 wells achieving MCLs by Year 15.
- Abandon 4 A-zone wells and 2 B-zone wells by Year 16.

Contingency, management and technical support are applied to O&M Cost subtotal at the following rates:

- Contingency at 20%
- Project Management at 10%
- Technical Support at 15%

Appendix C-4
Capital Costs for Alternative 3B
CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit	Unit Cost	Total Cost	Notes
					ALTERNATIVE 3B	
1	**Capital Cost**					
1.1	Capital Cost Subtotal	1	LS	$393,000.00	$393,000.00	Breakdown details are included in Alternative 3 - Direct Cost Estimate in Appendix C-4
1.2	Direct Contractor G&A and Fee	$393,000	Percent	20.00%	$79,000.00	G&A at 12% and Fee at 8% applied to the subtotal
				Subtotal - Direct Capital Cost with G&A and Fee	**$472,000.00**	
	Contingency					
2	Contigency	$472,000	Percent	20.00%	$95,000.00	
				Subtotal - Capital with contingency	**$567,000.00**	
3	**Design and Management**					
3.1	Treatability Study	1	LS	150,000.00	$150,000.00	Lump Sum Estimate
3.2	Remedial Design		Percent	15.00%	$85,050.00	Based on EPA FS Cost Estimate guidance. Percent of capital cost with contingency subtotal
3.3	Project Management		Percent	10.00%	$56,700.00	Based on EPA FS Cost Estimate guidance. Percent of capital cost with contingency subtotal
Note:	Construction Management costs are included in direct Capital Cost					
				Subtotal - Project Management	**$292,000.00**	
				Total Cost for Alternative 3B	**$859,000.00**	

Project Name	**CTS Printex Superfund Site Focused Fesibility Study Report**
Labor Rate Table	**2010 RS Means Standard with O&P**
Equipment Rate Table	**2010 RS Means Equipment with O&P**
Alternate Activator Mode	**Selectable**
Active Alternates	**Alternative 3B**

WBS2	Item Description	Takeoff Qty	Unit	Labor Total	Mat Total	Subs Total	Equip Total	Other Total	Subs Total	Total $/Unit	Grand Total
	(Unassigned)										
*** General Conditions**	*** General Conditions**			**947.10**	**2,674.65**		**2,364.65**				**5,986.40**
* General Conditions	Project Signs	1.0	SF		29.15					29.15	29.15
* General Conditions	Dumpsters	1.0	mnth		1.87					1.87	1.87
* General Conditions	Storage Boxes and Tools	2.0	mnth		341.00					170.50	341.00
* General Conditions	Temporary Fencing, chain link, rented up to 12 months, 6' high, 11 ga, to 1000'	420.0	LF	947.10	2,300.76					7.73	3,247.86
* General Conditions	Rent toilet portable chemical - Rent per month	1.0	mnth				188.91			188.91	188.91
* General Conditions	FOGM - Rental Truck	1.0	mnth				553.71			553.71	553.71
* General Conditions	Safety Equipment & Supplies	1.0	lsum								
* General Conditions	Field Personnel, superintendent, maximum	2.0	week	4,200.00						2,100.00	4,200.00
Area 3 Demo	**Area 3 Demo**			**1,013.57**	**138.91**		**586.18**				**1,738.66**
Area 3 Demo	Selective demolition, saw cutting, asphalt, up to 3" deep	308.0	LF	286.46	138.91		167.71			1.93	593.08
Area 3 Demo	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	34.2	SY	201.46			115.94			9.27	317.40
Area 3 Demo	Asphalt Hauling and Disposal	7.5	ton	525.65			302.53			110.00	828.18
Area 3 Electrical	**Area 3 Electrical**			**13,644.20**	**7,389.56**						**21,033.76**
Area 3 Electrical	Temporary electrical power equipment (pro-rated per job), feeder, EMT and CU wire, 100 amp	500.0	LF	4,006.75	4,207.50					16.43	8,214.25
Area 3 Electrical	Temporary electrical power equipment (pro-rated per job), spider box, 50 Amp, 3 uses	2.0	EA	160.27	343.20					251.74	503.47
Area 3 Electrical	Temporary electrical power equipment (pro-rated per job), connections, compressor or pump, 30 Amp	2.0	EA	183.17	43.56					113.36	226.73
Area 3 Electrical	Combination starter & nonfusible disconnect, 1-2 pole, 240 volt, .75 HP motor	1.0	EA	407.41	681.91					1,089.32	1,089.32
Area 3 Electrical	Electrical Contingency	1.0	EA	8,886.61	2,113.39					11,000.00	11,000.00
Area 3 Piping	**Area 3 Piping**			**24,183.86**	**5,791.06**	**11,000**			**11,000.00**		**40,974.92**
Area 3 Piping	Pipe, plastic, PVC, 2" diameter, schedule 40, includes couplings 10' OC, and hangers 3 per 10'	616.0	LF	17,678.36	2,221.40					32.30	19,899.77
Area 3 Piping	Elbow, 90 Deg., plastic, PVC, white, socket joint, 2", schedule 40	3.0	EA	138.97	7.61					48.86	146.59
Area 3 Piping	Tee, plastic, PVC, white, socket joint, 2", schedule 40	8.0	EA	560.41	25.07					73.19	585.48
Area 3 Piping	Coupling, plastic, PVC, white, socket joint, 2", schedule 40	60.0	EA	2,779.47	91.23					47.85	2,870.71
Area 3 Piping	Adapter, plastic, PVC, white, female, socket weld x female thread, 2", schedule 40	22.0	EA	889.88	36.62					42.11	926.50
Area 3 Piping	Fab Chemical Hopper and Misc Pipe & fittings	1.0	EA			5,500			5,500.00	5,500.00	5,500.00
Area 3 Piping	Misc Budget for Piping Repairs in Parking Lots	1.0	EA			5,500			5,500.00	5,500.00	5,500.00
Area 3 Piping	Pipe, plastic, PVC, 1-1/2" diameter, schedule 40, includes couplings 10' OC, and hangers 3 per 10'	60.0	LF	1,142.35	192.72					22.25	1,335.07
Area 3 Piping	Coupling, plastic, PVC, white, socket joint, 1-1/2", schedule 40	6.0	EA	207.70	6.40					35.68	214.10
Area 3 Piping	Wells domestic water, pumps, 1/2 HP, 4" submersible, 1/2 HP , installed in wells to 100 ft. deep	2.0	EA	698.25	910.00					804.13	1,608.25
Area 3 Piping	Control Components, pressure controllers & switches, circulating pump sequencer	2.0	EA	88.44	2,300.00					1,194.22	2,388.44
Area 3 Trenching	**Area 3 Trenching**			**1,314.04**			**306.35**				**1,620.39**

WBS2	Item Description	Takeoff Qty	Unit	Labor Total	Mat Total	Subs Total	Equip Total	Other Total	Subs Total	Total $/Unit	Grand Total
Area 3 Trenching	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	68.1	B.C.Y.	476.40			191.47			9.80	667.87
Area 3 Trenching	Backfill and compact, by hand, 6" layers, air rammer/tamper	68.1	E.C.Y.	837.64			114.88			13.98	952.52
Asphalt Patch Area 3	**Asphalt Patch Area 3**			**119.47**	**2,070.26**		**68.94**				**2,258.67**
Asphalt Patch Area 3	Asphalt Paving, plant mixed asphaltic base courses for roadways and large paved areas, bituminous concrete, 4" thick	34.2	SY	119.47	2,070.26		68.94			66.00	2,258.67
Chemicals	**Chemicals**				**8,404.00**						**8,404.00**
Chemicals	60% Sodium Lactate Solution Area 3	1,910.0	KG		8,404.00					4.40	8,404.00
Drilling	**Drilling**					**53,702**			**53,702.00**		**53,702.00**
Drilling	Installation of Injection and Extraction Wells Area 3	260.0	vlft			30,602			30,602.00	117.70	30,602.00
Drilling	Injection Points Area 3	5.0	days			23,100			23,100.00	4,620.00	23,100.00
Easement	**Easement**				**110,000.00**			**10,000.00**			**120,000.00**
Easement	Permits and Access Fees	1.0	lsum		110,000.00					110,000.00	110,000.00
Easement	Easement Contingency	10,000.0	EA					10,000.00		1.00	10,000.00
Plans & ITSI Oversight	**Plans & ITSI Oversight**					**120,289**			**120,288.75**		**120,288.75**
Plans & ITSI Oversight	Project Plans	91,605.8	lsum			45,345			45,344.85	0.50	45,344.85
Plans & ITSI Oversight	Project Field Oversight	54,045.0	lsum			26,752			26,752.28	0.50	26,752.28
Plans & ITSI Oversight	Final Plans	97,356.8	lsum			48,192			48,191.63	0.50	48,191.63
Site Restoration	**Site Restoration**			**8,031.93**	**2,659.61**		**3,816.38**				**14,507.92**
Site Restoration	Clearing & grubbing, tree removal congested area, 24" diameter, tree removal, aerial lift truck	12.0	EA	8,031.93			3,816.38			987.36	11,848.31
Site Restoration	Tree Replacement	8.0	EA		2,659.61					332.45	2,659.61
	(Unassigned) Total			**53,454.17**	**139,126.18**	**184,991**	**5,520.47**	**10,000.00**	**184,990.75**		**393,091.57**
	Grand Total			**53,454.17**	**139,126.18**	**184,991**	**5,520.47**	**10,000.00**	**184,990.75**		**393,091.57**

Total Estimate 393,092

Appendix C-4

Alternative 3B - Enhanced Anaerobic Bioremediation (EAB) to Remediate the Area with High Residual Contaminant Mass

Year 1 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Groundwater Monitoring**					
	Semi -Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs).
	Dispose of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Parameters**					
	Analysis for MNA parameters (13 samples)	2	$1,450	Event	$2,900	Geochemical characterization for monitoring wells, excluding 17W with active EAB.
	Microbial degrader population (10 samples)	2	$1,200	Event	$2,400	Microbial population of TCE to ethene degraders.
1.3	**EAB System**					
	Field Tech Visit and Lactate addition	24	$460	Monthly	$11,040	Tech visit at a daily rate cost includes 4 hours of Tech and trip (4x$95.00+$80.00= $460.00). Frequency of site visits estimated at weekly for first quarter, bi-weekly for second quarter and monthly in third and fourth quarter.
	Collect and sample 17W for VOC analysis	4	$120	Quarterly	$480	Data to monitor performance of the EAB treatment. VOC cost at $120.00 each sample.
	Well and Pump Maintenance	2	$350	LS	$700	Estimated average annual cost of $350,00 for maintaining pumps, associated connections and parts.
	Power for pumps	3,504	$0.15	kW-HR	$526	Power for 2 submersible pumps 0.5-HP. Consumption of each pump is approximately 0.4 Kw/hr. Assumes that pumps will operate in cycle, therefore the daily power usage is estimated for 2 pumps operating 12 hours each. Calculation is 0.4 KW-hr x 2 pumps x 12 hours = 48 KW-hr per day X 365 days.
	Lab Analytical for Organic Contents	4	$60	Each	$240	Chemical Oxygen Demand analysis
	Microbial analysis	4	$600	Each	$2,400	TCE degrader populationn
1.4	**Reporting**					
	Quarterly EAB Reports	2	$8,000	Each	$16,000	
	Semi -Annual Groundwater Monitoring	2	$15,000	Each	$30,000	
				O&M Subtotal Raw	**$88,086**	
2	**Contingency**					
	Contingency	20%			$17,617	
				O&M Subtotal	**$105,703**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$10,570	Based on EPA FS Cost Estimate guidance
	Technical Support	20%	of O&M Subtotal		$21,141	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$31,711**	
				YEAR 1 Annual O&M Cost	**$138,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 1:

- Scope includes: Treating of residual high CAH concentratrions in 17W with re-circulation system consisting of 2 extraction (1 A-zone and 1 B-zone) and 6 injection (3 A-zone and 3 B-zone) wells.

- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.

- Material cost for sodium lactate is included in the direct capital cost.

Appendix C-4

Alternative 3B - Enhanced Anaerobic Bioremediation (EAB) to Remediate the Area with High Residual Contaminant Mass

Year 2 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Groundwater Monitoring**					
	Semi -Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs).
	Dispose of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Parameters**					
	Analysis for MNA parameters (13 samples)	2	$1,450	Event	$2,900	Geochemical characterization for monitoring wells, excluding 17W with active EAB.
	Microbial degrader population (10 samples)	2	$1,200	Event	$2,400	Microbial population of TCE to ethene degraders.
1.3	**EAB System**					
	Field Tech Visit and Lactate addition	12	$460	Monthly	$5,520	Tech visit at a daily rate cost includes 4 hours of Tech and trip (4x$95.00+$80.00= $460.00). Frequency of site visits estimated monthly.
	Collect and sample 17W for VOC analysis	4	$120	Quarterly	$480	Data to monitor performance of the EAB treatment. VOC cost at $120.00 each sample.
	Well and Pump Maintenance	2	$350	LS	$700	Estimated average annual cost of $350,00 for maintaining pumps, associated connections and parts.
	Power for pumps	3,504	$0.15	kW-HR	$526	Power for 2 submersible pumps 0.5-HP. Consumption of each pump is approximately 0.4 Kw/hr. Assumes that pumps will operate in cycle, therefore the daily power usage is estimated for 2 pumps operating 12 hours each. Calculation is 0.4 KW-hr x 2 pumps x 12 hours = 48 KW-hr per day X 365 days.
	Lab Analytical for Organic Contents	4	$60	Each	$240	Chemical Oxygen Demand analysis
	Microbial analysis	4	$600	Each	$2,400	TCE degrader population
1.4	**Reporting**					
	Semi-Annual EAB Reports	2	$8,000	Each	$16,000	
	Semi -Annual Groundwater Monitoring and Sampling	2	$15,000	Each	$30,000	
				O&M Subtotal Raw	**$82,566**	
2	**Contingency**					
	Contingency	20%			$16,513	
				O&M Subtotal	**$99,079**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$9,908	Based on EPA FS Cost Estimate guidance
	Technical Support	20%	of O&M Subtotal		$19,816	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$29,724**	
				YEAR 2 Annual O&M Cost	**$129,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 2:

- Scope includes: Treating of residual high CAH concentratrions in 17W with re-circulation system consisting of 2 extraction (1 A-zone and 1 B-zone) and 6 injection (3 A-zone and 3 B-zone) wells.
- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.
- Reduced frequency of lactate injection.
- Material cost for sodium lactate is included in the direct capital cost.

Appendix C-4

Alternative 3B - Enhanced Anaerobic Bioremediation (EAB) to Remediate the Area with High Residual Contaminant Mass

Year 3 thru 5 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Groundwater Monitoring**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs)
	Dispose of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Parameters**					
	Analysis for MNA parameters (13 samples)	2	$1,450	Event	$2,900	Geochemical characterization for monitoring wells, excluding 17W with active EAB.
1.3	**Reporting**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$15,000	Each	$30,000	
				O&M Subtotal Raw	**$54,300**	
2	**Contingency**					
	Contingency	20%			$10,860	
				O&M Subtotal	**$65,160**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$6,516	Based on EPA FS Cost Estimate guidance
	Technical Support	15%	of O&M Subtotal		$9,774	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$16,290**	
				YEAR 3 thru 5 Annual O&M Cost	**$82,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 3-5:

- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.
- No EAB treatment. Extraction and re-injection ceases and verify no rebound occurs.

Appendix C-4

Alternative 3B - Enhanced Anaerobic Bioremediation (EAB) to Remediate the Area with High Residual Contaminant Mass

Year 6 thru 10 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Groundwater Monitoring**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs).
	Dispose of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Parameters**					
	Analysis for MNA parameters (13 samples)	2	$1,450	Event	$2,900	Geochemical characterization for monitoring wells, excluding 17W.
1.3	**Reporting**					
	Semi-Annual Groundwater Monitoring	2	$15,000	Each	$30,000	
				O&M Subtotal Raw	**$54,300**	
2	**Contingency**					
	Contingency	20%			$10,860	
				O&M Subtotal	**$65,160**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$6,516	Based on EPA FS Cost Estimate guidance
	Technical Support	15%	of O&M Subtotal		$9,774	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$16,290**	
				YEAR 6 thru 10 Annual O&M Cost	**$82,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 6-10:

- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.
- Achieve MCLs by Year 10 in 5 A-zone monitoring wells (7W, 12W, 13W, 34W, and 38W) and 3 B-zone monitoring wells (8W, 11W, and 14W).
- Abandon reclying wells (2 extraction and 6 injection wells) in Year 6.

Appendix C-4

Alternative 3B - Enhanced Anaerobic Bioremediation (EAB) to Remediate the Area with High Residual Contaminant Mass

Year 11 thru 15 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
YEAR 1						
1.1	**Groundwater Monitoring**					
	Annual Groundwater Monitoring and Sampling	1	$6,240	Event	$6,240	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs). Sampling program reduced to 60% of original cost.
	Dispose of decontaminated water and purged groundwater	1	$300	Ea	$300	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Paramters**					
	Analysis for MNA parameters (6 samples)	1	$700	Event	$700	Geochemical characterization for monitoring wells.
1.3	**Reporting**					
	Annual Groundwater Monitoring	1	$15,000	Each	$15,000	
				O&M Subtotal Raw	**$22,240**	
2	**Contingency**					
	Contingency	20%			$4,448	
				O&M Subtotal	**$26,688**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$2,669	Based on EPA FS Cost Estimate guidance
	Technical Support	15%	of O&M Subtotal		$4,003	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$6,672**	
				YEAR 10 thru 15 Annual O&M Cost	**$34,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 11-15:

- Monitoring wells (total of 6) consist of 4 A-zone (17W, 20W, 23W, and 33W) and 2 B-zone (19W, and 22W) wells.
- Abandon 5 A-zone monitoring wells (7W, 12W, 13W, 34W, and 38W) and 3 B-zone monitoring wells (8W, 11W, and 14W) in Year 11.
- Abandon 4 A-zone monitoring wells (17W, 20W, 23W, and 33W) and 2 B-zone monitoring wells (19W and 20W) in Year 16.

APPENDIX C-5

Alternative 3C Direct Capital Cost Estimate

Labor Rate Table – 2010 RS Means Standard
Equipment Rate Table – 2010 RS Means Equipment

Alternative 3C O&M Cost Estimate

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Basis of Cost Estimates - Capital and Operation and Maintenance for Alternative 3C

Assumptions and the scope of work associated with In Situ Chemical Reduction (ISCR) included in the capital costs for Alternative 3C are described below. The rationale, site characteristics, and discussions of the remedial components and design are presented in Table 4-7.

Bench-scale study (time frame estimated at 2 weeks)

- Prepare work plan for bench scale study.
- Conduct bench scale study to establish oxidant addition requirements and a field pilot study to establish injection spacing.

ISCR (time frame estimated at2 months)

- Prepare work plan for ISCR
- Mark injection points based on a grid pattern as shown on Figure 4-6.
- Conduct clearance of potential utility interferences from drilling and injection points.
- Perform injection through 98 points using a patented Adventus product EHC, a complex carbon plus zero valent iron (ZVI), to treat depths between 10 and 40 feet below grade surface. Assumes daily productivity of 2 to 3 locations injected simultaneously for a total of 40 days. Estimated injection volume of 34,000 gallons of EHC slurry.

Site Restoration (construction time frame estimated at one week)

- Restore asphalt within the parking lot in 17W area. Estimated area of restoration is approximately 2,000 square feet.

Fees and contingency estimated as a percent of the direct Capital Cost subtotal at the following rates:

- G&A at 20%
- Contingency at 20%

Design and management costs estimated as a percent of the total Capital Cost (direct capital costs plus fees and contingency) at the following rates:

- Treatability Study assumed cost at $150,000.00.
- Remedial Design at 15%
- Project Management at 10%

The basis for the operation and maintenance costs for Alternative 3C are summarized below. A total O&M time frame of 15 years assumed based on modeling results. Details for costing and rationale are presented in Appendix C-5.

Assumptions for Year 1

- Perform semi-annual monitoring and sampling on all existing site wells (14 monitoring wells).
- Perform quarterly sampling at well 17W area for ISCR rebound evaluation.
- Request analysis for MNA parameters and microbial degrader population to evaluate MNA conditions.
- Prepare semi-annual groundwater monitoring and sampling report.

Assumptions for Year 2

- Perform semi-annual monitoring and sampling on all existing site wells (14 monitoring wells).
- Request analysis for MNA parameters and microbial degrader population to evaluate MNA conditions.
- Prepare semi-annual groundwater monitoring and sampling report.

Assumptions for Year 3 thru 10

- Perform semi-annual monitoring and sampling on all existing site wells (14 monitoring wells).
- Request analysis for MNA parameters to evaluate MNA conditions.
- Prepare semi-annual groundwater monitoring and sampling report.
- Assumes 8 wells achieving MCL by Year 10.

Assumptions for Year 10 thru 15

- Reduction of sampling from 14 to 6 wells due to achievement of MCLs.
- Perform annual monitoring and sampling on 4 monitoring wells.
- Abandon 8 wells by Year 11.
- Assumes remaining wells achieve MCLs by Year 15. Abandon remaining wells (4) by Year 16. .
- Prepare annual groundwater monitoring and sampling report.

Contingency, management and technical support are applied to O&M Cost subtotal at the following rates:

- Contingency at 20%
- Project Management at 10%
- Technical Support at 15%

Appendix C-5
Capital Costs for Alternative 3C
CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit	Unit Cost	Total Cost	Notes
					ALTERNATIVE 3C	
1	**Capital Cost**					
1.1	Capital Cost Subtotal	1	LS	$771,390.00	$771,390.00	Breakdown details are included in Alternative 3 - Direct Cost Estimate in Appendix C-5
1.2	Direct Contractor G&A and Fee	$771,390	Percent	20.00%	$155,000.00	G&A at 12% and Fee at 8% applied to the subtotal
				Subtotal - Direct Capital Cost with G&A and Fee	**$927,000.00**	
	Contingency					
2	Contigency	$927,000	Percent	20.00%	$186,000.00	
				Subtotal - Capital with contingency	**$1,113,000.00**	
3	**Design and Management**					
3.1	Treatability Study	1	LS	150,000.00	$150,000.00	Lump Sum Estimate
3.2	Remedial Design		Percent	15.00%	$166,950.00	Based on EPA FS Cost Estimate guidance. Percent of capital cost with contingency subtotal
3.3	Project Management		Percent	10.00%	$111,300.00	Based on EPA FS Cost Estimate guidance. Percent of capital cost with contingency subtotal
Note:	Construction Management costs are included in direct Capital Cost					
				Subtotal - Project Management	**$429,000.00**	
				Total Cost for Alternative 3C	**$1,542,000.00**	

CTS Printex Superfund Site Focused Fesibility Study Report - Alternate 3C

Innovative Technical Solutions, Inc.
A Gilbane Company

Estimated By:

Type of Contract:
Revision #:

Alternate Name	WBS2	Item Description	Takeoff Qty	Unit	Labor Total	Mat Total	Subs Total	Equip Total	Other Total	Subcontractor Name	Subs Total	Total $/Unit	Grand Total
		(Unassigned)											
	*** General Conditions**	*** General Conditions**						**343.48**					**343.48**
Alt 3C - Wells to Sanitary Sewer	* General Conditions	Rent toilet portable chemical - Rent per month	2.0	mnth				343.48		ITSI		171.74	343.48
	Oversight	**Oversight**			**12,600.00**			**1,214.01**					**13,814.01**
Alt 3C - Wells to Sanitary Sewer	Oversight	Field Personnel, superintendent, maximum	6.0	week	12,600.00							2,100.00	12,600.00
Alt 3C - Wells to Sanitary Sewer	Oversight	Rent truck flatbed 1axle 1-1/2 ton rating - Rent per month	2.0	mnth				1,214.01				607.01	1,214.01
	Site Restoration	**Site Restoration**			**646.72**	**5,999.88**		**585.12**					**7,231.73**
Alt 3C - Wells to Sanitary Sewer	Site Restoration	Asphaltic concrete, parking lots & driveways, 6" stone base, 2" binder course, 2" topping, no asphalt hauling included	2,040.0	SF	646.72	5,999.88		585.12				3.54	7,231.73
	Trenching	**Trenching**					**750,000**				**750,000.00**		**750,000.00**
Alt 3C - Wells to Sanitary Sewer	Trenching	Inject EHC - ISCR in 98 Points	1.0	lsum			750,000				750,000.00	750,000.00	750,000.00
		(Unassigned) Total			**13,246.72**	**5,999.88**	**750,000**	**2,142.61**			**750,000.00**		**771,389.21**
		Grand Total			**13,246.72**	**5,999.88**	**750,000**	**2,142.61**			**750,000.00**		**771,389.21**

CSI	Division	Labor	Mat	Subs	Equip	Other	User	Total
01	General Requirements	12,600			1,557			14,157
02	Site Construction	647	6,000	750,000	585			757,232

Total Estimate 771,389

Appendix C-5

Alternative 3C - In-Situ Chemical Reduction (ISCR) to Remediate the Area with High Residual Contaminant Mass

Year 1 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit Cost	Unit	Total Cost	Notes
1.1	**Groundwater Monitoring**					
	Semi -Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs).
	Dispose of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Parameters**					
	Analysis for MNA parameters (13 samples)	2	$1,450	Event	$2,900	Geochemical characterization for monitoring wells, excluding 17W with ISCO.
	Microbial degrader population (10 samples)	2	$1,200	Event	$2,400	Microbial population of TCE to ethene degraders.
1.2	**ISCO**					
	Quarterly sampling at 17W and VOC analysis	2	$485	Quarterly	$970	Conducted during quarters w/o semi-annual monitoring. Tech at a daily rate cost includes 3 hours of Tech and trip (3x$95.00+$80.00= $365.00). VOC analysis at $120.
1.4	**Reporting**					
	Quarterly Report in 17W area	2	$8,000	Each	$16,000	
	Semi -Annual Groundwater Monitoring	2	$15,000	Each	$30,000	
				O&M Subtotal Raw	**$73,670**	
2	**Contingency**					
	Contingency	20%			$14,734	
				O&M Subtotal	**$88,404**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$8,840	Based on EPA FS Cost Estimate guidance
	Technical Support	20%	of O&M Subtotal		$17,681	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$26,521**	
				YEAR 1 Annual O&M Cost	**$115,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 1:
- Year 1 includes evaluation for rebound after ISCR treatment. The ISCR treatment included treating of residual high CAH concentratrions in 17W area using EHC, a complex carbon plus zero valent iron. Treatment area of 8,000 sq-ft using 98 locations with injection depths between 10 and 40 feet bgs. Includes Direct push drilling costs and subcontractor management, technical oversight , and reporting.
- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.

Appendix C-5

Alternative 3C - In-Situ Chemical Reduction (ISCR) to Remediate the Area with High Residual Contaminant Mass

Year 2 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit Cost	Unit	Total Cost	Notes
1.1	**Groundwater Monitoring**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs)
	Dispose of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Parameters**					
	Analysis for MNA parameters (13 samples)	2	$1,450	Event	$2,900	Geochemical characterization for monitoring wells, excluding 17W.
	Microbial degrader population (10 samples)	2	$1,200	Event	$2,400	Microbial population of TCE to ethene degraders.
1.3	**Reporting**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$15,000	Each	$30,000	
				O&M Subtotal Raw	**$56,700**	
2	**Contingency**					
	Contingency	20%			$11,340	
				O&M Subtotal	**$68,040**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$6,804	Based on EPA FS Cost Estimate guidance
	Technical Support	15%	of O&M Subtotal		$10,206	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$17,010**	
				YEAR 2 Annual O&M Cost	**$86,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 2:
- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.

Appendix C-5

Alternative 3C - In-Situ Chemical Reduction (ISCR) to Remediate the Area with High Residual Contaminant Mass

Year 3 thru 10 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
YEAR 1						
1.1	**Groundwater Monitoring**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$10,400	Event	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs)
	Dispose of decontaminated water and purged groundwater	2	$300	Ea	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Parameters**					
	Analysis for MNA parameters (13 samples)	2	$1,450	Event	$2,900	Geochemical characterization for monitoring wells.
1.3	**Reporting**					
	Semi-Annual Groundwater Monitoring	2	$15,000	Each	$30,000	
				O&M Subtotal Raw	**$54,300**	
2	**Contingency**					
	Contingency	20%			$10,860	
				O&M Subtotal	**$65,160**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$6,516	Based on EPA FS Cost Estimate guidance
	Technical Support	15%	of O&M Subtotal		$9,774	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$16,290**	
				YEAR 3 thru 10 Annual O&M Cost	**$82,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 3-10:
- Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells.
- Achieve MCLs by Year 10 in 5 A-zone monitoring wells (7W, 12W, 13W, 34W, and 38W) and 3 B-zone monitorinng well (8W, 11W, and 14W).

Appendix C-5

Alternative 3C - In-Situ Chemical Reduction (ISCR) to Remediate the Area with High Residual Contaminant Mass

Year 3 thru 15 - O&M Costs (See Note 1)

CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
YEAR 1						
1.1	**Groundwater Monitoring**					
	Annual Groundwater Monitoring and Sampling	1	$6,240	Event	$6,240	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs). Sampling program reduced to 60% of original cost.
	Dispose of decontaminated water and purged groundwater	1	$300	Ea	$300	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Parameters**					
	Analysis for MNA parameters (6 samples)	1	$700	Event	$700	Geochemical characterization for monitoring wells.
1.3	**Reporting**					
	Annual Groundwater Monitoring	1	$15,000	Each	$15,000	
				O&M Subtotal Raw	**$22,240**	
2	**Contingency**					
	Contingency	20%			$4,448	
				O&M Subtotal	**$26,688**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$2,669	Based on EPA FS Cost Estimate guidance
	Technical Support	15%	of O&M Subtotal		$4,003	Based on EPA FS Cost Estimate guidance
				Project Management Subtotal	**$6,672**	
				YEAR 10 thru 15 Annual O&M Cost	**$34,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 10-15:

- Monitoring wells (total of 6) consist of 4 A-zone (17W, 20W, 23W, and 33W) and 2 B-zone (19W, and 22W) wells.
- Abandon 5 A-zone monitoring wells (7W, 12W, 13W, 34W, and 38W) and 3 B-zone monitoring wells (8W, 11W, and 14W) by Year 11.
- Achievement of MCLs in 6 wells being monitored: 4 A-zone (17W, 20W, 23W, and 33W) and 2 B-zone (19W and 22W) wells by Year 15.
- Abandon 6 monitoring wells: 4 A-zone (17W, 20W, 23W, and 33W) and 2 B-zone (19W, and 22W) wells in Year 16.

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APPENDIX C-6

Alternative 4 O&M Cost Estimate

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Basis of Cost Estimates - Operation and Maintenance for Alternative 4

The basis for the operation and maintenance costs for Alternative 4 – Monitored Natural Attenuation (MNA) remedy are summarized below. The rationale, site characteristics, and discussions of the remedial components are presented in Table 4-8. A total O&M time frame of 30 years was assumed, although modeling results indicate that a longer time frame will likely be required. Details for costing and rationale are presented in Appendix C-6.

Assumptions for Year 1

- Perform semi-annual monitoring and sampling on all existing site wells (14 monitoring wells). Include analysis for MNA parameters and compound specific isotope analysis (CSIA).
- Prepare semi-annual groundwater monitoring and sampling report.

Assumptions for Year 2 & 3

- Perform semi-annual monitoring and sampling on all existing site wells (14 monitoring wells).
- Prepare semi-annual groundwater monitoring and sampling report.

Assumptions for Year 4 through 30

- Perform annual monitoring and sampling on all existing site wells (14 monitoring wells).
- Prepare annual groundwater monitoring and sampling report.

Contingency, management and technical support are applied to O&M Cost subtotal at the following rates:

- Contingency at 15%
- Project Management at 10%
- Technical Support at 10%

Alternative 4 - Monitored Natural Attenuation
Year 1 - O&M Costs (See Note 1)
CTS Printex Superfund Site, Mountain View, California

Item	Description	Quantity	Unit Cost	Unit	Total Cost	Notes
1.1	**Groundwater Monitoring**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$10,400	Semi-Annual	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs)
	Dispose of decontaminated water and purged groundwater	2	$300	Semi-Annual	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Paramters**					
	Analysis for MNA parameters (16 samples) and microbial degrader population (10 samples).	2	$1,600	Semi-annually	$3,200	Geochemical characterization on all samples.
	Compound Specific Isotope analyses (CSIA) (8 samples)	2	$4,000	Semi-annually	$8,000	Data to monitor if MNA is resulting in CAH biodegradation.
1.3	**Reporting**					
	Semi Annual Groundwater Monitoring Reports	2	$15,000	Semi-Annual	$30,000	Includes reporting of VOC concentrations w/ trend evaluation, MNA parameters, and CSIA results.
				O&M Subtotal Raw	**$62,600**	
2	**Contingency**					
	Contingency	15%			$9,390	
				O&M Subtotal	**$71,990**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$7,199	Based on EPA FS Cost Estimate guidance.
	Technical Support	10%	of O&M Subtotal		$7,199	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$14,398**	
				YEAR 1 Annual O&M Cost	**$87,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 1:
- Scope includes: Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells. Semi-annual monitoring and analysis to quantify seasonal VOC concentration changes, MNA parameters, microbial contaminant-degrading population (one time only in YEAR 1), and semi-annual analyses to initiate MNA evaluation using CSIA.

Alternative 4 - Monitored Natural Attenuation
Year 2 and Year 3 - O&M Costs (See Note 1)
CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Groundwater Monitoring**					
	Semi-Annual Groundwater Monitoring and Sampling	2	$10,400	Semi-Annual	$20,800	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs)
	Dispose of decontaminated water and purged groundwater	2	$300	Semi-Annual	$600	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Paramters**					
	Analysis for MNA parameters (16 samples).	0	$1,600	Semi-annually	$0	Geochemical characterization on all samples.
	Compound Specific Isotope analyses (CSIA) (8 samples)	0	$4,000	Semi-annually	$0	Data to monitor if MNA is resulting in CAH biodegradation.
1.3	**Reporting**					
	Semi Annual Groundwater Monitoring Reports	2	$15,000	Semi-Annual	$30,000	Includes reporting of VOC concentrations w/ trend evaluation, MNA parameters, and CSIA results.
				O&M Subtotal Raw	**$51,400**	
2	**Contingency**					
	Contingency	15%			$7,710	
				O&M Subtotal	**$59,110**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$5,911	Based on EPA FS Cost Estimate guidance.
	Technical Support	10%	of O&M Subtotal		$5,911	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$11,822**	
				YEAR 2&3 Annual O&M Cost	**$71,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 2 and 3:

- Scope includes: Monitoring wells (total of 14) consist of 9 A-zone (7W, 12W, 13W, 17W, 20W, 23W, 33W, 34W, and 38W) and 5 B-zone (8W, 11W, 14W, 19W, and 22W) wells. Semi-annual monitoring and analysis to quantify seasonal VOC concentration changes, MNA parameters, and semi-annual analyses to initiate MNA evaluation using CSIA.

Alternative 4 - Monitored Natural Attenuation
Year 4 thru 30 - O&M Costs (See Note 1)
CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
YEAR 1						
1.1	**Groundwater Monitoring**					
	Annual Groundwater Monitoring and Sampling	1	$7,500	Annually	$7,500	Unit cost is based on billed cost for one event conducted for existing monitoring wells in 2010 (cost includes labor, analytical and ODCs) and prorated to reduced number of wells monitored.
	Dispose of decontaminated water and purged groundwater	1	$300	Ea	$300	Purged water from low-flow sampling method and equipment decontamination water. Approximately one 55-gallon drum generated per sampling event. Unit cost includes profiling and off-site transportation and disposal.
1.2	**MNA Paramters**					
	Analysis for MNA parameters (10 samples)	0	$1,150	Annually	$0	Geochemical characterization on all samples.
1.3	**Reporting**					
	Annual Groundwater Monitoring and Sampling	1	$12,500	Annually	$12,500	Includes reporting of VOC concentrations w/ trend evaluation and MNA parameters.
				O&M Subtotal Raw	**$20,300**	
2	**Contingency**					
	Contingency	15%			$3,045	
				O&M Subtotal	**$23,345**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$2,335	Based on EPA FS Cost Estimate guidance.
	Technical Support	10%	of O&M Subtotal		$2,335	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$4,670**	
				YEAR 4 thru 30 Annual O&M Cost	**$29,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 4 thru Year 30:
- Scope includes: Monitoring wells (total of 10) consist of 6 A-zone (12W, 13W, 17W, 20W, 23W, and 33W) and 4 B-zone (11W, 14W, 19W, and 22W) wells. Semi-annual monitoring and analysis to quantify VOC concentration changes.
- Wells not sampled are only monitored for water table elevation to determine the gradient.
- Wells abandoned in year 31.

APPENDIX D

Calculation of Present Worth

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Table D-1

Alternative 2A - Groundwater Extraction for the Entire Plume
Periodic Costs and Present Value Analysis
CTS Printex Superfund Site, Mountain View, California

Periodic Cost

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1	**Periodic Cost**					
1.1	**Well Decommissioning**					
	Well abandonment in Year 8	140	$55	Vertical LF	$7,700	Abandon 2 extraction wells (2 A-zone) + 4 monitoring wells (3 A-zone wells and 1 B-zone).
	Well abandonment in Year 13	220	$55	Vertical LF	$12,100	Abandon two extraction wells (1 A-zone and 1-B-zone) + five monitoring wells (2 A-zone wells and 3 B-zone).
	Well abandonment in Year 23	270	$55	Vertical LF	$14,850	Abandon 5 extraction wells (2 A-zone, 1 A/B-zone and 2 B-zone) + 5 monitoring wells (4 A-zone wells and 1 B-zone).
1.2	**Reporting**					
	5-Year Review Reports	4	$25,000	EA	$100,000	Occuring after end of years 6, 11, 16, and 21.
	Final Report	1	$50,000	EA	$50,000	Occuring in year 23.

Present Worth Analysis

Cost Type	*Year*	*Total Expenditure*	*Escalation Factor (2%)*	*Escalated Costs*	*Discount Factor (7%)*	*Present Worth*
Capital	0	$855,000	1.0000	$855,000	1.0000	$855,000
Annual O&M Cost	1	$311,000	1.0200	$317,220	0.9346	$296,474
Annual O&M Cost	2	$311,000	1.0404	$323,564	0.8734	$282,601
Annual O&M Cost	3	$311,000	1.0612	$330,033	0.8163	$269,406
Annual O&M Cost	4	$311,000	1.0824	$336,626	0.7629	$256,812
Annual O&M Cost	5	$311,000	1.1041	$343,375	0.7130	$244,826
Annual O&M Cost	6	$279,000	1.1262	$314,210	0.6663	$209,358
Annual O&M Cost	7	$279,000	1.1487	$320,487	0.6227	$199,567
Annual O&M Cost	8	$270,000	1.1717	$316,359	0.5820	$184,121
Annual O&M Cost	9	$270,000	1.1951	$322,677	0.5439	$175,504
Annual O&M Cost	10	$270,000	1.2190	$329,130	0.5083	$167,297
Annual O&M Cost	11	$234,000	1.2434	$290,956	0.4751	$138,233
Annual O&M Cost	12	$234,000	1.2682	$296,759	0.4440	$131,761
Annual O&M Cost	13	$225,000	1.2936	$291,060	0.4150	$120,790
Annual O&M Cost	14	$225,000	1.3195	$296,888	0.3878	$115,133
Annual O&M Cost	15	$225,000	1.3459	$302,828	0.3624	$109,745
Annual O&M Cost	16	$225,000	1.3728	$308,880	0.3387	$104,618
Annual O&M Cost	17	$225,000	1.4002	$315,045	0.3166	$99,743
Annual O&M Cost	18	$225,000	1.4282	$321,345	0.2959	$95,086
Annual O&M Cost	19	$225,000	1.4568	$327,780	0.2765	$90,631
Annual O&M Cost	20	$225,000	1.4859	$334,328	0.2584	$86,390
Annual O&M Cost	21	$225,000	1.5157	$341,033	0.2415	$82,359
Annual O&M Cost	22	$225,000	1.5460	$347,850	0.2257	$78,510
Total of O&M Costs		$5,641,000		$7,028,433		$3,539,000
Periodic Cost	6	$25,000	1.1262	$28,155	0.6663	$18,760
Periodic Cost	8	$7,700	1.1717	$9,022	0.5820	$5,251
Periodic Cost	11	$25,000	1.2434	$31,085	0.4751	$14,768
Periodic Cost	13	$12,100	1.2936	$15,653	0.4150	$6,496
Periodic Cost	16	$25,000	1.3728	$34,320	0.3387	$11,624
Periodic Cost	21	$25,000	1.5157	$37,893	0.2415	$9,151
Periodic Cost	23	$64,850	1.5769	$102,262	0.2109	$21,567
Total of Periodic Costs		$185,000		$258,390		$88,000
Total		**$6,681,000**		**$8,141,823**		**$4,482,000**

Note:
See Appendix C-1 for details of estimated Capital Cost and O&M Costs

Table D-2

Alternative 2B - Groundwater Extraction for Selected Areas plus Site-wide MNA
Periodic Costs and Present Value Analysis
CTS Printex Superfund Site, Mountain View, California

Periodic Cost

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1	**Periodic Cost**					
1.1	**Well Decommissioning**					
	Well abandonment in Year 11	280	$55	Vertical LF	$15,400	Abandon 8 monitoring wells (5 A-zone wells and 3 B-zone) and two extraction wells (1 A-zone and 1 B-zone).
	Well abandonment in Year 17	60	$55	Vertical LF	$3,300	Abandon two monitoring wells (1A-zone and 1 B-zone).
	Well abandonment in Year 23	250	$55	Vertical LF	$13,750	Abandon 5 extraction wells (2 A-zone, 1 A/B-zone and 2 B-zone) + 4 monitoring wells (3 A-zone wells and 1 B-zone).
1.2	**Reporting**					
	5-Year Review Reports	4	$25,000	EA	$100,000	Occuring after end of years 6, 11, 16, and 21.
	Final Report	1	$50,000	EA	$50,000	Occuring in year 23.

Present Worth Analysis

Cost Type	*Year*	*Total Expenditure*	*Escalation Factor (2%)*	*Escalated Costs*	*Discount Factor (7%)*	*Present Worth*
Capital	0	$695,000	1.0000	$695,000	1.0000	$695,000
Annual O&M Cost	1	$279,000	1.0200	$284,580	0.9346	$265,968
Annual O&M Cost	2	$279,000	1.0404	$290,272	0.8734	$253,524
Annual O&M Cost	3	$279,000	1.0612	$296,075	0.8163	$241,686
Annual O&M Cost	4	$279,000	1.0824	$301,990	0.7629	$230,388
Annual O&M Cost	5	$279,000	1.1041	$308,044	0.7130	$219,635
Annual O&M Cost	6	$279,000	1.1262	$314,210	0.6663	$209,358
Annual O&M Cost	7	$279,000	1.1487	$320,487	0.6227	$199,567
Annual O&M Cost	8	$279,000	1.1717	$326,904	0.5820	$190,258
Annual O&M Cost	9	$279,000	1.1951	$333,433	0.5439	$181,354
Annual O&M Cost	10	$279,000	1.2190	$340,101	0.5083	$172,873
Annual O&M Cost	11	$201,000	1.2434	$249,923	0.4751	$118,738
Annual O&M Cost	12	$201,000	1.2682	$254,908	0.4440	$113,179
Annual O&M Cost	13	$201,000	1.2936	$260,014	0.4150	$107,906
Annual O&M Cost	14	$201,000	1.3195	$265,220	0.3878	$102,852
Annual O&M Cost	15	$201,000	1.3459	$270,526	0.3624	$98,039
Annual O&M Cost	16	$201,000	1.3728	$275,933	0.3387	$93,459
Annual O&M Cost	17	$171,000	1.4002	$239,434	0.3166	$75,805
Annual O&M Cost	18	$171,000	1.4282	$244,222	0.2959	$72,265
Annual O&M Cost	19	$171,000	1.4568	$249,113	0.2765	$68,880
Annual O&M Cost	20	$171,000	1.4859	$254,089	0.2584	$65,657
Annual O&M Cost	21	$171,000	1.5157	$259,185	0.2415	$62,593
Annual O&M Cost	22	$171,000	1.5460	$264,366	0.2257	$59,667
Total of O&M Costs		$5,022,000		$6,203,029		$3,204,000
Periodic Cost	6	$25,000	1.1262	$28,155	0.6663	$18,760
Periodic Cost	11	$40,400	1.2434	$50,233	0.4751	$23,866
Periodic Cost	16	$25,000	1.3728	$34,320	0.3387	$11,624
Periodic Cost	17	$3,300	1.4002	$4,621	0.3166	$1,463
Periodic Cost	23	$63,750	1.5769	$100,527	0.2109	$21,201
Total of Periodic Costs		$158,000		$217,856		$77,000
Total		**$5,875,000**		**$7,115,885**		**$3,976,000**

Note:
See Appendix C-2 for details of estimated Capital Cost and O&M Costs

Table D-3

Alternative 3A -ISCO at Areas with Residual Contaminant Mass plus Site-wide MNA
Periodic Costs and Present Value Analysis
CTS Printex Superfund Site, Mountain View, California

Periodic Cost

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1	**Periodic Cost**					
1.1	**Well and EAB System Decommissioning**					
	Well abandonment in Year 11	220	$55	Vertical LF	$12,100	Abandon 8 monitoring wells (5 A-zone wells and 3 B-zone).
	Well abandonment in Year 16	160	$55	Vertical LF	$8,800	Abandon 6 monitoring wells (4 A-zone wells and 2 B-zone).
1.2	**Reporting**					
	5-Year Review Reports	2	$25,000	EA	$50,000	Occuring in years 6 and 11.
	Final Report	1	$50,000	EA	$50,000	Occuring in year 16.

Present Worth Analysis

Cost Type	*Year*	*Total Expenditure*	*Escalation Factor (2%)*	*Escalated Costs*	*Discount Factor (7%)*	*Present Worth*
Capital	0	$2,365,000	1.0000	$2,365,000	1.0000	$2,365,000
Annual O&M Cost	1	$115,000	1.0200	$117,300	0.9346	$109,629
Annual O&M Cost	2	$86,000	1.0404	$89,474	0.8734	$78,147
Annual O&M Cost	3	$82,000	1.0612	$87,018	0.8163	$71,033
Annual O&M Cost	4	$82,000	1.0824	$88,757	0.7629	$67,713
Annual O&M Cost	5	$82,000	1.1041	$90,536	0.7130	$64,552
Annual O&M Cost	6	$82,000	1.1262	$92,348	0.6663	$61,531
Annual O&M Cost	7	$82,000	1.1487	$94,193	0.6227	$58,654
Annual O&M Cost	8	$82,000	1.1717	$96,079	0.5820	$55,918
Annual O&M Cost	9	$82,000	1.1951	$97,998	0.5439	$53,301
Annual O&M Cost	10	$82,000	1.2190	$99,958	0.5083	$50,809
Annual O&M Cost	11	$34,000	1.2434	$42,276	0.4751	$20,085
Annual O&M Cost	12	$34,000	1.2682	$43,119	0.4440	$19,145
Annual O&M Cost	13	$34,000	1.2936	$43,982	0.4150	$18,253
Annual O&M Cost	14	$34,000	1.3195	$44,863	0.3878	$17,398
Annual O&M Cost	15	$34,000	1.3459	$45,761	0.3624	$16,584
Total of O&M Costs		$1,027,000		$1,173,662		$763,000
Periodic Cost	6	$25,000	1.1262	$28,155	0.6663	$18,760
Periodic Cost	11	$12,100	1.2434	$15,045	0.4751	$7,148
Periodic Cost	11	$25,000	1.2434	$31,085	0.4751	$14,768
Periodic Cost	16	$8,800	1.3728	$12,081	0.3387	$4,092
Periodic Cost	16	$50,000	1.3728	$68,640	0.3387	$23,248
Total of Periodic Costs		$121,000		$155,006		$69,000
Total		**$3,513,000**		**$3,693,668**		**$3,197,000**

Note:
See Appendix C-3 for details of estimated Capital Cost and O&M Costs

Table D-4

Alternative 3B - EAB at Areas with Residual Contaminant Mass plus Site-wide MNA
Periodic Costs and Present Value Analysis
CTS Printex Superfund Site, Mountain View, California

Periodic Cost

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1	**Periodic Cost**					
1.1	**Well and EAB System Decommissioning**					
	EAB System Abandonment Year 6 - Recycling (Injection and Extraction) Well Abandonment	260	$55	Vertical LF	$14,300	Abandonment of 1 A zone extraction well (25 vertical LF), 1 B zone extraction well (40 vertical LF), 3 A zone injection wells (25 vertical LF each), and 3 B zone injection wells (40 vertical LF). Occuring in year 6.
	EAB System Abandonment - Other components abandoned in-place - Year 6	1	$5,000	EA EAB System	$5,000	Abandonment by removing vaults and plugging piping.
	Well abandonment in Year 11	220	$55	Vertical LF	$12,100	Abandon 8 monitoring wells (5 A-zone wells and 3 B-zone).
	Well abandonment in Year 16	160	$55	Vertical LF	$8,800	Abandon 6 monitoring wells (4 A-zone wells and 2 B-zone).
1.2	**Reporting**					
	5-Year Review Reports	2	$25,000	EA	$50,000	Occuring in years 6 and 11.
	Final Report	1	$50,000	EA	$50,000	Occuring in year 16.

Present Worth Analysis

Cost Type	*Year*	*Total Expenditure*	*Escalation Factor (2%)*	*Escalated Costs*	*Discount Factor (7%)*	*Present Worth*
Capital	0	$859,000	1.0000	$859,000	1.0000	$859,000
Annual O&M Cost	1	$138,000	1.0200	$140,760	0.9346	$131,554
Annual O&M Cost	2	$129,000	1.0404	$134,212	0.8734	$117,221
Annual O&M Cost	3	$82,000	1.0612	$87,018	0.8163	$71,033
Annual O&M Cost	4	$82,000	1.0824	$88,757	0.7629	$67,713
Annual O&M Cost	5	$82,000	1.1041	$90,536	0.7130	$64,552
Annual O&M Cost	6	$82,000	1.1262	$92,348	0.6663	$61,531
Annual O&M Cost	7	$82,000	1.1487	$94,193	0.6227	$58,654
Annual O&M Cost	8	$82,000	1.1717	$96,079	0.5820	$55,918
Annual O&M Cost	9	$82,000	1.1951	$97,998	0.5439	$53,301
Annual O&M Cost	10	$82,000	1.2190	$99,958	0.5083	$50,809
Annual O&M Cost	11	$34,000	1.2434	$42,276	0.4751	$20,085
Annual O&M Cost	12	$34,000	1.2682	$43,119	0.4440	$19,145
Annual O&M Cost	13	$34,000	1.2936	$43,982	0.4150	$18,253
Annual O&M Cost	14	$34,000	1.3195	$44,863	0.3878	$17,398
Annual O&M Cost	15	$34,000	1.3459	$45,761	0.3624	$16,584
Total of O&M Costs		$1,093,000		$1,241,860		$824,000
Periodic Cost	6	$19,300	1.1262	$21,736	0.6663	$14,483
Periodic Cost	6	$25,000	1.1262	$28,155	0.6663	$18,760
Periodic Cost	11	$12,100	1.2434	$15,045	0.4751	$7,148
Periodic Cost	11	$25,000	1.2434	$31,085	0.4751	$14,768
Periodic Cost	16	$8,800	1.3728	$12,081	0.3387	$4,092
Periodic Cost	16	$50,000	1.3728	$68,640	0.3387	$23,248
Total of Periodic Costs		$141,000		$176,742		$83,000
Total		**$2,093,000**		**$2,277,602**		**$1,766,000**

Note:
See Appendix C-4 for details of estimated Capital Cost and O&M Costs

Table D-5

Alternative 3C - ISCR at Areas with Residual Contaminant Mass plus Site-wide MNA
Periodic Costs and Present Value Analysis
CTS Printex Superfund Site, Mountain View, California

Periodic Cost

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1	**Periodic Cost**					
1.1	**Well and EAB System Decommissioning**					
	Well abandonment in Year 11	220	$55	Vertical LF	$12,100	Abandon 8 monitoring wells (5 A-zone wells and 3 B-zone).
	Well abandonment in Year 16	160	$55	Vertical LF	$8,800	Abandon 6 monitoring wells (4 A-zone wells and 2 B-zone).
1.2	**Reporting**					
	5-Year Review Reports	2	$25,000	EA	$50,000	Occuring in years 6 and 11.
	Final Report	1	$50,000	EA	$50,000	Occuring in year 16.

Present Worth Analysis

Cost Type	*Year*	*Total Expenditure*	*Escalation Factor (2%)*	*Escalated Costs*	*Discount Factor (7%)*	*Present Worth*
Capital	0	$1,542,000	1.0000	$1,542,000	1.0000	$1,542,000
Annual O&M Cost	1	$115,000	1.0200	$117,300	0.9346	$109,629
Annual O&M Cost	2	$86,000	1.0404	$89,474	0.8734	$78,147
Annual O&M Cost	3	$82,000	1.0612	$87,018	0.8163	$71,033
Annual O&M Cost	4	$82,000	1.0824	$88,757	0.7629	$67,713
Annual O&M Cost	5	$82,000	1.1041	$90,536	0.7130	$64,552
Annual O&M Cost	6	$82,000	1.1262	$92,348	0.6663	$61,531
Annual O&M Cost	7	$82,000	1.1487	$94,193	0.6227	$58,654
Annual O&M Cost	8	$82,000	1.1717	$96,079	0.5820	$55,918
Annual O&M Cost	9	$82,000	1.1951	$97,998	0.5439	$53,301
Annual O&M Cost	10	$82,000	1.2190	$99,958	0.5083	$50,809
Annual O&M Cost	11	$34,000	1.2434	$42,276	0.4751	$20,085
Annual O&M Cost	12	$34,000	1.2682	$43,119	0.4440	$19,145
Annual O&M Cost	13	$34,000	1.2936	$43,982	0.4150	$18,253
Annual O&M Cost	14	$34,000	1.3195	$44,863	0.3878	$17,398
Annual O&M Cost	15	$34,000	1.3459	$45,761	0.3624	$16,584
Total of O&M Costs		$1,027,000		$1,173,662		$763,000
Periodic Cost	6	$25,000	1.1262	$28,155	0.6663	$18,760
Periodic Cost	11	$12,100	1.2434	$15,045	0.4751	$7,148
Periodic Cost	11	$25,000	1.2434	$31,085	0.4751	$14,768
Periodic Cost	16	$8,800	1.3728	$12,081	0.3387	$4,092
Periodic Cost	16	$50,000	1.3728	$68,640	0.3387	$23,248
Total of Periodic Costs		$121,000		$155,006		$69,000
Total		**$2,690,000**		**$2,870,668**		**$2,374,000**

Note:
See Appendix C-5 for details of estimated Capital Cost and O&M Costs

Table D-6
Alternative 4 - Monitored Natural Attenuation
Periodic Costs and Present Value Analysis
CTS Printex Superfund Site, Mountain View, California

Periodic Cost

Item	Description	Quantity	Unit Cost	Unit	Total Cost	Notes
1	**Periodic Cost**					
1.1	**Well Decommissioning**					
	Monitoring Well Abandonment	480	$55	Vertical LF	$26,400	Abandonment of 10 A zone wells (20 vertical LF each) and 7 B zone wells (40 vertical LF each). Occuring in year 31.
1.2	**Reporting**					
	5-Year Review Reports	5	$25,000	LS	$125,000	Ocurring in years 6, 11, 16, 21, and 26.
	Final Report	1	$50,000	LS	$50,000	Occuring in year 31.

Present Worth Analysis

Cost Type	Year	Total Expenditure	Escalation Factor (2%)	Escalated Costs	Discount Factor (7%)	Present Worth
Capital	0	$0	1.0000	$0	1.0000	$0
Annual O&M Cost	1	$87,000	1.0000	$87,000	1.0000	$87,000
Annual O&M Cost	2	$71,000	1.0404	$73,868	0.8734	$64,516
Annual O&M Cost	3	$71,000	1.0612	$75,345	0.8163	$61,504
Annual O&M Cost	4	$29,000	1.0824	$31,390	0.7629	$23,947
Annual O&M Cost	5	$29,000	1.1041	$32,019	0.7130	$22,830
Annual O&M Cost	6	$29,000	1.1262	$32,660	0.6663	$21,761
Annual O&M Cost	7	$29,000	1.1487	$33,312	0.6227	$20,743
Annual O&M Cost	8	$29,000	1.1717	$33,979	0.5820	$19,776
Annual O&M Cost	9	$29,000	1.1951	$34,658	0.5439	$18,850
Annual O&M Cost	10	$29,000	1.2190	$35,351	0.5083	$17,969
Annual O&M Cost	11	$29,000	1.2434	$36,059	0.4751	$17,132
Annual O&M Cost	12	$29,000	1.2682	$36,778	0.4440	$16,329
Annual O&M Cost	13	$29,000	1.2936	$37,514	0.4150	$15,568
Annual O&M Cost	14	$29,000	1.3195	$38,266	0.3878	$14,840
Annual O&M Cost	15	$29,000	1.3459	$39,031	0.3624	$14,145
Annual O&M Cost	16	$29,000	1.3728	$39,811	0.3387	$13,484
Annual O&M Cost	17	$29,000	1.4002	$40,606	0.3166	$12,856
Annual O&M Cost	18	$29,000	1.4282	$41,418	0.2959	$12,256
Annual O&M Cost	19	$29,000	1.4568	$42,247	0.2765	$11,681
Annual O&M Cost	20	$29,000	1.4859	$43,091	0.2584	$11,135
Annual O&M Cost	21	$29,000	1.5157	$43,955	0.2415	$10,615
Annual O&M Cost	22	$29,000	1.5460	$44,834	0.2257	$10,119
Annual O&M Cost	23	$29,000	1.5769	$45,730	0.2109	$9,644
Annual O&M Cost	24	$29,000	1.6084	$46,644	0.1971	$9,194
Annual O&M Cost	25	$29,000	1.6406	$47,577	0.1842	$8,764
Annual O&M Cost	26	$29,000	1.6734	$48,529	0.1722	$8,357
Annual O&M Cost	27	$29,000	1.7069	$49,500	0.1609	$7,965
Annual O&M Cost	28	$29,000	1.7410	$50,489	0.1504	$7,594
Annual O&M Cost	29	$29,000	1.7758	$51,498	0.1406	$7,241
Annual O&M Cost	30	$29,000	1.8114	$52,531	0.1314	$6,903
Total of O&M Costs		$1,012,000		$1,345,690		$585,000
Periodic Cost	6	$25,000	1.1487	$28,718	0.6227	$17,883
Periodic Cost	11	$25,000	1.2682	$31,705	0.4440	$14,077
Periodic Cost	16	$25,000	1.4002	$35,005	0.3166	$11,083
Periodic Cost	21	$25,000	1.5460	$38,650	0.2257	$8,723
Periodic Cost	26	$25,000	1.7069	$42,673	0.1609	$6,866
Periodic Cost	31	$76,400	1.8476	$141,157	0.1228	$17,334
Total Periodic Cost		$201,400		$317,908		$76,000
Total		**$1,213,400**		**$1,663,598**		**$661,000**

Note:
See Appendix C-8 for details of estimated O&M Costs.

APPENDIX E

Physical Parameters for Chlorinated Aliphatic Hydrocarbons and Aromatic Hydrocarbons Associated with Groundwater at the Site

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Physical Parameters for Chlorinated Aliphatic Hydrocarbons and Aromatic Hydrocarbons Associated with Groundwater at the Site

Compound	Property (Source of Data[1])	Units	Value
Chloromethane	Melting Point(A)	°C	-91.7
	Boiling Point(A)	°C	-23.7
	Density(A)	g/mL	0.920 (20/4 °C)
	Partition constants:		
	Water Solubility, S_w(A)	mg/L	3,756 (25°C)
	Octanol-Water, K_{ow}(A)	Unitless	8.13
	Sediment-water, K_{oc}(B)	Unitless	4.3
	Henry's Constant, H (C_v/ C_w)(C)	Unitless	0.361 (25°C)
Dichloromethane (Methylene chloride)	Melting Point(A)	°C	-95.1
	Boiling Point(A)	°C	40
	Density(A)	g/mL	1.3182 (25°C)
	Partition constants:		
	Water Solubility, S_w(A)	mg/L	20,000 (20°C)
	Octanol-Water, K_{ow}(A)	Unitless	20.0
	Sediment-water, K_{oc}(A)	Unitless	25.1
	Henry's Constant, H (C_v/ C_w)(C)	Unitless	.0896 (25°C)
Chloroform (Trichloromethane)	Melting Point(A)	°C	-61.7
	Boiling Point(A)	°C	61.7
	Density(A)	g/cm^3	1.485 (20°C)
	Partition constants:		
	Water Solubility, S_w(A)	mg/L	743,000 (25°C)
	Octanol-Water, K_{ow}(A)	Unitless	93.3
	Sediment-water, K_{oc}(A)	Unitless	251
	Henry's Constant, H (C_v/ C_w)(A)	Unitless	0.12 (20°C)
Chloroethane	Melting Point(A)	°C	-138.7
	Boiling Point(B)	°C	12.3
	Density(A)	g/cm^3	0.9214 (0/4 °C)
	Partition constants:		
	Water Solubility, S_w(A)	mg/L	5,740 (20°C)
	Octanol-Water, K_{ow}(A)	Unitless	26.9

Physical Parameters for Chlorinated Aliphatic Hydrocarbons and Aromatic Hydrocarbons Associated with Groundwater at the Site

Compound	Property (Source of Data[1])	Units	Value
	Sediment-water, K_{oc} (A)	Unitless	33.1
	Henry's Constant, H (C_v/ C_w) (C)	Unitless	0.361 (25°C)
1,1-Dichloroethane (1,1-DCA)	Melting Point (A)	°C	-96.7
	Boiling Point (A)	°C	57.3
	Density (A)	g/cm^3	1.1747 (20°C)
	Partition constants:		
	Water Solubility, S_w (B)	mg/L	5,500 (20°C)
	Octanol-Water, K_{ow} (A)	Unitless	61.7
	Sediment-water, K_{oc} (A)	Unitless	57.5
	Henry's Constant, H (C_v/ C_w) (C)	Unitless	0.23 (25°C)
1.2-Dichloroethane (1,2-DCA)	Melting Point (A)	°C	-35.5
	Boiling Point (A)	°C	83.5
	Density (A)	g/cm^3	1.23 (20°C)
	Partition constants:		
	Water Solubility, S_w (A)	mg/L	8,690 (20°C)
	Octanol-Water, K_{ow} (A)	Unitless	30.2
	Sediment-water, K_{oc} (A)	Unitless	33.1
	Henry's Constant, H (C_v/ C_w) (C)	Unitless	.040 (25°C)
1,1,1-Trichloroethane (1,1,1-TCA)	Melting Point (A)	°C	-30.4
	Boiling Point (A)	°C	74.1
	Density (A)	g/mL	1.339 (20°C)
	Partition constants:		
	Water Solubility, S_w (A)	mg/L	1,500 (25°C)
	Octanol-Water, K_{ow} (A)	Unitless	309
	Sediment-water, K_{oc} (A)	Unitless	107
	Henry's Constant, H (C_v/ C_w) (A)	Unitless	0.26 (20°C)
Vinyl Chloride (Chloroethene)	Melting Point (A)	°C	-153.8
	Boiling Point (A)	°C	-13.37
	Density (A)	g/cm^3	0.9106 (20°C)
	Partition constants:		
	Water Solubility, S_w (A)	mg/L	2,763 (25°C)

Physical Parameters for Chlorinated Aliphatic Hydrocarbons and Aromatic Hydrocarbons Associated with Groundwater at the Site

Compound	Property (Source of Data[1])	Units	Value
	Octanol-Water, K_{ow} (A)	Unitless	22.9
	Sediment-water, K_{oc} (A)	Unitless	97.7
	Henry's Constant, H (C_v/ C_w) (C)	Unitless	1.1 (25°C)
1,1-Dichloroethene (1,1-DCE)	Melting Point (A)	°C	-122.5
	Boiling Point (A)	°C	31.7
	Density (A)	g/cm^3	1.213 (20°C)
	Partition constants:		
	Water Solubility, S_w (A)	mg/L	2,500 (25°C)
	Octanol-Water, K_{ow} (A)	Unitless	20.9
	Sediment-water, K_{oc} (A)	Unitless	64.6
	Henry's Constant, H (C_v/ C_w) (C)	Unitless	1.07 (25°C)
trans-1,2-Dichloroethene (trans-1,2-DCE)	Melting Point (A)	°C	-50.0
	Boiling Point (A)	°C	48
	Density (A)	g/cm^3	1.2565 (20/4 °C)
	Partition constants:		
	Water Solubility, S_w (A)	mg/L	6,300 (25°C)
	Octanol-Water, K_{ow} (A)	Unitless	123
	Sediment-water, K_{oc} (A)	Unitless	36.3
	Henry's Constant, H (C_v/ C_w) (C)	Unitless	0.384 (25°C)
cis-1,2-Dichloroethene (cis-1,2-DCE)	Melting Point (A)	°C	-80.5
	Boiling Point (A)	°C	60.3
	Density (A)	g/cm^3	1.2837 (20/4 °C)
	Partition constants:		
	Water Solubility, S_w (A)	mg/L	3,500 (25°C)
	Octanol-Water, K_{ow} (A)	Unitless	72.4
	Sediment-water, K_{oc} (A)	Unitless	49.0
	Henry's Constant, H (C_v/ C_w) (C)	Unitless	0.167 (25°C)
Trichloroethene (Trichloroethylene) (TCE)	Melting Point (A) Boiling Point (A)	°C °C	-87.1 86.7
	Density (A)	g/mL	1.465 (20°C)
	Partition constants:		

Physical Parameters for Chlorinated Aliphatic Hydrocarbons and Aromatic Hydrocarbons Associated with Groundwater at the Site

Compound	Property (Source of Data[1])	Units	Value
	Water Solubility, S_w (A)	mg/L	1,070 (20°C)
	Octanol-Water, K_{ow} (A)	Unitless	263
	Sediment-water, K_{oc} (A)	Unitless	282
	Henry's Constant, H (C_v/ C_w) (C)	Unitless	0.421 (25°C)
Tetrachloroethene (Tetrachloroethylene or Perchloroethylene) (PCE)	Melting Point (A)	°C	-19
	Boiling Point (A)	°C	121
	Density (A)	g/mL	1.6227 (20°C)
	Partition constants:		
	Water Solubility, S_w (A)	mg/L	150 (25°C)
	Octanol-Water, K_{ow} (A)	Unitless	2,510
	Sediment-water, K_{oc} (A)	Unitless	316
	Henry's Constant, H (C_v/ C_w) (C)	Unitless	0.753 (25°C)
Benzene	Melting Point (A)	°C	5.5
	Boiling Point (A)	°C	80.1
	Density (A)	g/mL	0.8787 (15°C)
	Partition constants:		
	Water Solubility, S_w (B)	mg/L	1,780
	Octanol-Water, K_{ow} (A)	Unitless	135
	Sediment-water, K_{oc} (A)	Unitless	70.8
	Henry's Constant, H (C_v/ C_w) (A)	Unitless	0.22 (25°C)
Toluene	Melting Point (A)	°C	-95
	Boiling Point (A)	°C	110.6
	Density (A)	g/mL	0.8669
	Partition constants:		
	Water Solubility, S_w (A)	mg/L	535
	Octanol-Water, K_{ow} (A)	Unitless	525
	Sediment-water, K_{oc} (A)	Unitless	160
	Henry's Constant, H (C_v/ C_w) (C)	Unitless	0.272 (25°C)

APPENDIX F

REMChlor Modeling

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REMCHLOR ANALYSIS

1. Introduction

The REMChlor model was used to estimate the potential time required for TCE to reach its Maximum Contaminant Level (MCL) at the Site due to active groundwater extraction from specified wells (i.e., Alternatives 2A and 2B). Trichloroethene (TCE) concentration data from the first quarter 2010 groundwater sampling (ITSI, 2011a) were used for the modeling. In addition, the REMChlor model was also used to check the time estimate from BIOCHLOR (Appendix A) for TCE to reach MCL concentrations by natural attenuation only.

The REMChlor version 1.0 spreadsheet model was utilized for this assessment (USEPA, 2007). REMChlor is an analytical model that is based on a power function relationship between source mass and source discharge. REMChlor also predicts the natural attenuation of chlorinated solvents through sequential decay and partial source remediation. For Alternatives 2A and 2B, this model was used to calculate the concentration of TCE in groundwater throughout the Site with time. By incorporating a source model and plume model, REMChlor allows for simulation of enhanced plume degradation dependent on time, space, and chemical concentrations.

The REMChlor model allows calculation of concentrations along the centerline of the plume and in a three-dimensional array. The output of the model is regenerated each time any element of the input data is changed, which allows the user to see almost immediately the effects of changes due to the source remediation, plume remediation, and/or natural attenuation. The REMChlor model is intended for use with chlorinated solvents that may sorb to organic carbon in soil and/or may be subject to biotransformation. This model is used to evaluate partial source remediation and natural attenuation via reductive dechlorination.

The shallow groundwater at the Site is divided into two zones: (1) A zone is the shallow groundwater between 10 and 20 feet below ground surface (bgs) and (2) B zone is the shallow groundwater present between 30 and 40 feet bgs.

The sources of the model input parameters are as follows:

- Source Concentration (milligram/Liter, mg/L): The concentration of TCE detected in the plume in the first quarter 2010 groundwater sampling event (ITSI, 2011a). A TCE concentration of 0.079 mg/L was detected in 17W (A zone). In the B zone, a TCE concentration of 0.019 mg/L was detected in 14W.

- Darcy Velocity (meters per year, m/yr): 7.62 m/yr which is within the range of site-specific conditions.
- Effective Porosity (unitless): 0.4 which is within the range of site-specific conditions.
- First Order Decay Coefficient (1/year): 0.053 for TCE which was derived using site-specific data.
- Source Width (meter, m): 130 m for the A Zone and 85 m for the B Zone, estimated source width perpendicular to groundwater flow direction.
- Source Thickness: 3 m, the estimated thickness of the source in both zones.

These parameters are shown in the Attachment.

2. Limitations

A major limitation of any analytical groundwater transport model is that steady, uniform groundwater flow is assumed. REMChlor is primarily intended for use in unconsolidated (soil) aquifers with reasonably uniform physical and hydrogeologic properties, whereas the Site's soil has some degree of heterogeneities. These heterogeneities may create preferential constituent migration pathways, which could not be predicted by the model.

REMChlor approximates dispersion by using the Domenico (1987) method. When large dispersion coefficients are used, this could lead to errors in the distributions of the concentrations. The model also assumes that all dissolved constituents have the same retardation coefficient. This would result in the compounds moving at the same velocity.

3. Results

According to the model, TCE is anticipated to persist at the Site at a concentration above its MCL of 0.005 mg/L for between 13 and 22 years in the A Zone, and between 15 and 25 years in B Zone.

4. Calibration

In order to calibrate the REMChlor model, groundwater analytical results were plotted against model results. Monitoring wells 17W and 14W were considered to be the source of contamination in A and B Zones, respectively. Monitoring wells 20W, 23W, and 33W are located approximately 240, 600, and 680 feet, respectively, downgradient of 17W in the A zone. Monitoring well 22W is located approximately 1,040 feet, respectively, downgradient of 14W in the B zone. TCE concentrations at the various monitoring wells from groundwater analytical results were plotted for each zone and then values for dispersivity were adjusted until the model results were comparable to the plotted analytical results.

5. References

Domenico, P.A. (1987). An Analytical Model for Multidimensional Transport of a Decaying Contaminant Species. *Journal of Hydrology*. 91: 49-58.

United States Environmental Protection Agency (USEPA). 2007. REMChlor. Remediation Evaluation Model for Chlorinated Solvents. User's Manual. Version 1.0. September 7.

ATTACHMENT

To

APPENDIX F

```
***source zone parameters
czero (g/l), tzeromass (kg), gamma, xremove, t1, t2
0.016, 31.33, 1.17, 0.69, 0., 0.
***source zone parameters
rates (1/yr), ysource (m), zsource (m), vd (m/yr)
0.053, 130., 3., 7.62
***transport and streamtube velocity parameters
porosity, retard, sigmav, vmin, vmax, ntubes, alphay (m), alphaz (m)
0.4, 1.1, 0.2, 0., 1.8, 100, 0.5, 0.1
***distance to end of zone 1 and zone 2 for plume remediation
x1, x2 (m)
85., 170.
***length of period 1 and period 2 for plume remediation
tplume1, tplume2 (yr)
10., 30.
***lifetime cancer risk oral slope factors, per (mg/kg) per day
slopef(1), slopef(2), slopef(3), slopef(4)
0., 0., 0., 0.
***lifetime cancer risk inhalation slope factors, per (mg/kg) per day
slopef(1), slopef(2), slopef(3), slopef(4)
0., 0., 0., 0.
***yield coefficients for chain reactions
yield21, yield32, yield43
0.737, 0.64, 0.
**11COMPONENT 1 plume decay rate constants in zone 1 for 3 time periods **111**
ratep(1,1,1), ratep(1,1,2), ratep(1,1,3) (1/yr)
0.053, 0.053, 0.053
***COMPONENT 1 plume decay rate constants in zone 2 for 3 time periods
ratep(1,2,1), ratep(1,2,2), ratep(1,2,3) (1/yr)
0.053, 0.053, 0.053
***COMPONENT 1 plume decay rate constants in zone 3 for 3 time periods
ratep(1,3,1), ratep(1,3,2), ratep(1,3,3) (1/yr)
0.053, 0.053, 0.053
**22COMPONENT 2 plume decay rate constants in zone 1 for 3 time periods **222**
ratep(2,1,1), ratep(2,1,2), ratep(2,1,3) (1/yr)
0., 0., 0.
***COMPONENT 2 plume decay rate constants in zone 2 for 3 time periods
ratep(2,2,1), ratep(2,2,2), ratep(2,2,3) (1/yr)
0., 0., 0.
***COMPONENT 2 plume decay rate constants in zone 3 for 3 time periods
ratep(2,3,1), ratep(2,3,2), ratep(2,3,3) (1/yr)
0., 0., 0.
**33COMPONENT 3 plume decay rate constants in zone 1 for 3 time periods **333**
ratep(3,1,1), ratep(3,1,2), ratep(3,1,3) (1/yr)
0., 0., 0.
***COMPONENT 3 plume decay rate constants in zone 2 for 3 time periods
ratep(3,2,1), ratep(3,2,2), ratep(3,2,3) (1/yr)
0., 0., 0.
***COMPONENT 3 plume decay rate constants in zone 3 for 3 time periods
ratep(3,3,1), ratep(3,3,2), ratep(3,3,3) (1/yr)
0., 0., 0.
**44COMPONENT 4 plume decay rate constants in zone 1 for 3 time periods **444**
ratep(4,1,1), ratep(4,1,2), ratep(4,1,3) (1/yr)
0., 0., 0.
***COMPONENT 4 plume decay rate constants in zone 2 for 3 time periods
ratep(4,2,1), ratep(4,2,2), ratep(4,2,3) (1/yr)
0., 0., 0.
***COMPONENT 4 plume decay rate constants in zone 3 for 3 time periods
ratep(4,3,1), ratep(4,3,2), ratep(4,3,3) (1/yr)
0., 0., 0.
***x-direction locations
nx, xmin (m), xmax (m)
101, 0.1, 213.
```

```
***y-direction locations
ny, ymin (m), ymax (m)
11, -65., 65.
***z-direction locations
nz, zmin (m), zmax (m)
1, 0., 0.
***times
nt, tmin, tmax
80, 0., 40.
```

```
***source zone parameters
czero (g/l), tzeromass (kg), gamma, xremove, t1, t2
0.019, 31.33, 1.15, 0.69, 0., 0.
***source zone parameters
rates (1/yr), ysource (m), zsource (m), vd (m/yr)
0.053, 85., 3., 7.62
***transport and streamtube velocity parameters
porosity, retard, sigmav, vmin, vmax, ntubes, alphay (m), alphaz (m)
0.4, 1.1, 0.2, 0., 1.8, 100, 0.1, 1E-99
***distance to end of zone 1 and zone 2 for plume remediation
x1, x2 (m)
85., 170.
***length of period 1 and period 2 for plume remediation
tplume1, tplume2 (yr)
10., 30.
***lifetime cancer risk oral slope factors, per (mg/kg) per day
slopef(1), slopef(2), slopef(3), slopef(4)
0., 0., 0., 0.
***lifetime cancer risk inhalation slope factors, per (mg/kg) per day
slopef(1), slopef(2), slopef(3), slopef(4)
0., 0., 0., 0.
***yield coefficients for chain reactions
yield21, yield32, yield43
0.737, 0.64, 0.
**11COMPONENT 1 plume decay rate constants in zone 1 for 3 time periods **111**
ratep(1,1,1), ratep(1,1,2), ratep(1,1,3) (1/yr)
0.053, 0.053, 0.053
***COMPONENT 1 plume decay rate constants in zone 2 for 3 time periods
ratep(1,2,1), ratep(1,2,2), ratep(1,2,3) (1/yr)
0.053, 0.053, 0.053
***COMPONENT 1 plume decay rate constants in zone 3 for 3 time periods
ratep(1,3,1), ratep(1,3,2), ratep(1,3,3) (1/yr)
0.053, 0.053, 0.053
**22COMPONENT 2 plume decay rate constants in zone 1 for 3 time periods **222**
ratep(2,1,1), ratep(2,1,2), ratep(2,1,3) (1/yr)
0., 0., 0.
***COMPONENT 2 plume decay rate constants in zone 2 for 3 time periods
ratep(2,2,1), ratep(2,2,2), ratep(2,2,3) (1/yr)
0., 0., 0.
***COMPONENT 2 plume decay rate constants in zone 3 for 3 time periods
ratep(2,3,1), ratep(2,3,2), ratep(2,3,3) (1/yr)
0., 0., 0.
**33COMPONENT 3 plume decay rate constants in zone 1 for 3 time periods **333**
ratep(3,1,1), ratep(3,1,2), ratep(3,1,3) (1/yr)
0., 0., 0.
***COMPONENT 3 plume decay rate constants in zone 2 for 3 time periods
ratep(3,2,1), ratep(3,2,2), ratep(3,2,3) (1/yr)
0., 0., 0.
***COMPONENT 3 plume decay rate constants in zone 3 for 3 time periods
ratep(3,3,1), ratep(3,3,2), ratep(3,3,3) (1/yr)
0., 0., 0.
**44COMPONENT 4 plume decay rate constants in zone 1 for 3 time periods **444**
ratep(4,1,1), ratep(4,1,2), ratep(4,1,3) (1/yr)
0., 0., 0.
***COMPONENT 4 plume decay rate constants in zone 2 for 3 time periods
ratep(4,2,1), ratep(4,2,2), ratep(4,2,3) (1/yr)
0., 0., 0.
***COMPONENT 4 plume decay rate constants in zone 3 for 3 time periods
ratep(4,3,1), ratep(4,3,2), ratep(4,3,3) (1/yr)
0., 0., 0.
***x-direction locations
nx, xmin (m), xmax (m)
101, 0.1, 213.
```

```
***y-direction locations
ny, ymin (m), ymax (m)
11, -65., 65.
***z-direction locations
nz, zmin (m), zmax (m)
1, 0., 0.
***times
nt, tmin, tmax
80, 0., 40.
```

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ATTACHMENT

To

APPENDIX F

```
***source zone parameters
czero (g/l), tzeromass (kg), gamma, xremove, t1, t2
0.016, 31.33, 1.17, 0.69, 0., 0.
***source zone parameters
rates (1/yr), ysource (m), zsource (m), vd (m/yr)
0.053, 130., 3., 7.62
***transport and streamtube velocity parameters
porosity, retard, sigmav, vmin, vmax, ntubes, alphay (m), alphaz (m)
0.4, 1.1, 0.2, 0., 1.8, 100, 0.5, 0.1
***distance to end of zone 1 and zone 2 for plume remediation
x1, x2 (m)
85., 170.
***length of period 1 and period 2 for plume remediation
tplume1, tplume2 (yr)
10., 30.
***lifetime cancer risk oral slope factors, per (mg/kg) per day
slopef(1), slopef(2), slopef(3), slopef(4)
0., 0., 0., 0.
***lifetime cancer risk inhalation slope factors, per (mg/kg) per day
slopef(1), slopef(2), slopef(3), slopef(4)
0., 0., 0., 0.
***yield coefficients for chain reactions
yield21, yield32, yield43
0.737, 0.64, 0.
**11COMPONENT 1 plume decay rate constants in zone 1 for 3 time periods **111**
ratep(1,1,1), ratep(1,1,2), ratep(1,1,3) (1/yr)
0.053, 0.053, 0.053
***COMPONENT 1 plume decay rate constants in zone 2 for 3 time periods
ratep(1,2,1), ratep(1,2,2), ratep(1,2,3) (1/yr)
0.053, 0.053, 0.053
***COMPONENT 1 plume decay rate constants in zone 3 for 3 time periods
ratep(1,3,1), ratep(1,3,2), ratep(1,3,3) (1/yr)
0.053, 0.053, 0.053
**22COMPONENT 2 plume decay rate constants in zone 1 for 3 time periods **222**
ratep(2,1,1), ratep(2,1,2), ratep(2,1,3) (1/yr)
0., 0., 0.
***COMPONENT 2 plume decay rate constants in zone 2 for 3 time periods
ratep(2,2,1), ratep(2,2,2), ratep(2,2,3) (1/yr)
0., 0., 0.
***COMPONENT 2 plume decay rate constants in zone 3 for 3 time periods
ratep(2,3,1), ratep(2,3,2), ratep(2,3,3) (1/yr)
0., 0., 0.
**33COMPONENT 3 plume decay rate constants in zone 1 for 3 time periods **333**
ratep(3,1,1), ratep(3,1,2), ratep(3,1,3) (1/yr)
0., 0., 0.
***COMPONENT 3 plume decay rate constants in zone 2 for 3 time periods
ratep(3,2,1), ratep(3,2,2), ratep(3,2,3) (1/yr)
0., 0., 0.
***COMPONENT 3 plume decay rate constants in zone 3 for 3 time periods
ratep(3,3,1), ratep(3,3,2), ratep(3,3,3) (1/yr)
0., 0., 0.
**44COMPONENT 4 plume decay rate constants in zone 1 for 3 time periods **444**
ratep(4,1,1), ratep(4,1,2), ratep(4,1,3) (1/yr)
0., 0., 0.
***COMPONENT 4 plume decay rate constants in zone 2 for 3 time periods
ratep(4,2,1), ratep(4,2,2), ratep(4,2,3) (1/yr)
0., 0., 0.
***COMPONENT 4 plume decay rate constants in zone 3 for 3 time periods
ratep(4,3,1), ratep(4,3,2), ratep(4,3,3) (1/yr)
0., 0., 0.
***x-direction locations
nx, xmin (m), xmax (m)
101, 0.1, 213.
```

```
***y-direction locations
ny, ymin (m), ymax (m)
11, -65., 65.
***z-direction locations
nz, zmin (m), zmax (m)
1, 0., 0.
***times
nt, tmin, tmax
80, 0., 40.
```

```
***source zone parameters
czero (g/l), tzeromass (kg), gamma, xremove, t1, t2
0.019, 31.33, 1.15, 0.69, 0., 0.
***source zone parameters
rates (1/yr), ysource (m), zsource (m), vd (m/yr)
0.053, 85., 3., 7.62
***transport and streamtube velocity parameters
porosity, retard, sigmav, vmin, vmax, ntubes, alphay (m), alphaz (m)
0.4, 1.1, 0.2, 0., 1.8, 100, 0.1, 1E-99
***distance to end of zone 1 and zone 2 for plume remediation
x1, x2 (m)
85., 170.
***length of period 1 and period 2 for plume remediation
tplume1, tplume2 (yr)
10., 30.
***lifetime cancer risk oral slope factors, per (mg/kg) per day
slopef(1), slopef(2), slopef(3), slopef(4)
0., 0., 0., 0.
***lifetime cancer risk inhalation slope factors, per (mg/kg) per day
slopef(1), slopef(2), slopef(3), slopef(4)
0., 0., 0., 0.
***yield coefficients for chain reactions
yield21, yield32, yield43
0.737, 0.64, 0.
**11COMPONENT 1 plume decay rate constants in zone 1 for 3 time periods **111**
ratep(1,1,1), ratep(1,1,2), ratep(1,1,3) (1/yr)
0.053, 0.053, 0.053
***COMPONENT 1 plume decay rate constants in zone 2 for 3 time periods
ratep(1,2,1), ratep(1,2,2), ratep(1,2,3) (1/yr)
0.053, 0.053, 0.053
***COMPONENT 1 plume decay rate constants in zone 3 for 3 time periods
ratep(1,3,1), ratep(1,3,2), ratep(1,3,3) (1/yr)
0.053, 0.053, 0.053
**22COMPONENT 2 plume decay rate constants in zone 1 for 3 time periods **222**
ratep(2,1,1), ratep(2,1,2), ratep(2,1,3) (1/yr)
0., 0., 0.
***COMPONENT 2 plume decay rate constants in zone 2 for 3 time periods
ratep(2,2,1), ratep(2,2,2), ratep(2,2,3) (1/yr)
0., 0., 0.
***COMPONENT 2 plume decay rate constants in zone 3 for 3 time periods
ratep(2,3,1), ratep(2,3,2), ratep(2,3,3) (1/yr)
0., 0., 0.
**33COMPONENT 3 plume decay rate constants in zone 1 for 3 time periods **333**
ratep(3,1,1), ratep(3,1,2), ratep(3,1,3) (1/yr)
0., 0., 0.
***COMPONENT 3 plume decay rate constants in zone 2 for 3 time periods
ratep(3,2,1), ratep(3,2,2), ratep(3,2,3) (1/yr)
0., 0., 0.
***COMPONENT 3 plume decay rate constants in zone 3 for 3 time periods
ratep(3,3,1), ratep(3,3,2), ratep(3,3,3) (1/yr)
0., 0., 0.
**44COMPONENT 4 plume decay rate constants in zone 1 for 3 time periods **444**
ratep(4,1,1), ratep(4,1,2), ratep(4,1,3) (1/yr)
0., 0., 0.
***COMPONENT 4 plume decay rate constants in zone 2 for 3 time periods
ratep(4,2,1), ratep(4,2,2), ratep(4,2,3) (1/yr)
0., 0., 0.
***COMPONENT 4 plume decay rate constants in zone 3 for 3 time periods
ratep(4,3,1), ratep(4,3,2), ratep(4,3,3) (1/yr)
0., 0., 0.
***x-direction locations
nx, xmin (m), xmax (m)
101, 0.1, 213.
```

```
***y-direction locations
ny, ymin (m), ymax (m)
11, -65., 65.
***z-direction locations
nz, zmin (m), zmax (m)
1, 0., 0.
***times
nt, tmin, tmax
80, 0., 40.
```

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APPENDIX G

Concentration Trends for TCE and cis-1,2-DCE in the A and B Zones

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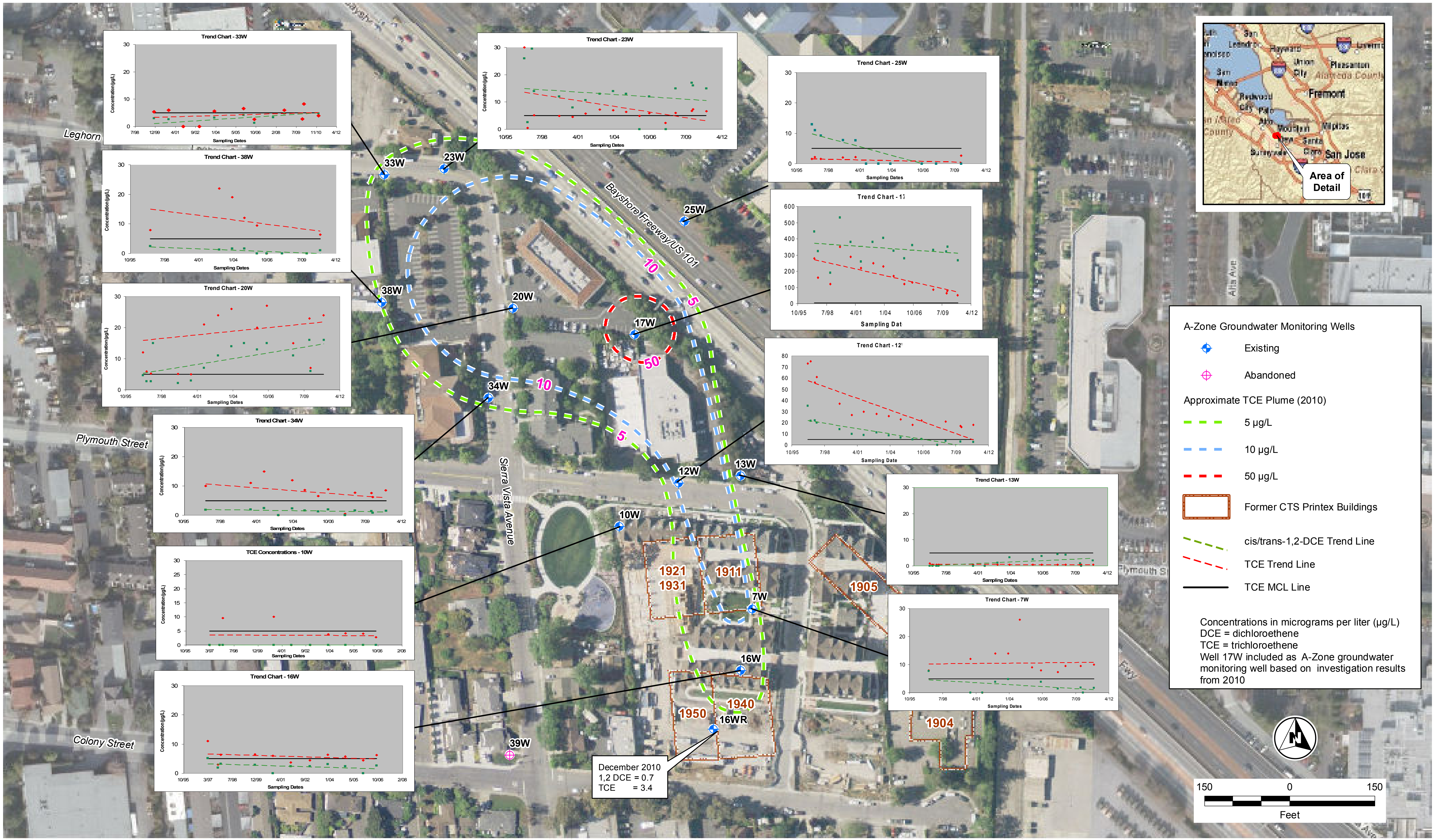

CTS Printex Superfund Site
Mountain View, California

FIGURE G-1
TCE and c/t-1,2-DCE in A-Zone Monitoring Wells

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CTS Printex Superfund Site
Mountain View, California

FIGURE G-2
TCE and c/t-1,2-DCE in B-Zone Monitoring Wells

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