FINAL FOCUSED FEASIBILITY STUDY
PART I – VAPOR INTRUSION

CTS Printex Superfund Site
Mountain View, California

Prepared for:

United States Environmental Protection Agency

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EXECUTIVE SUMMARY

In February 1990, the former CTS Printex site in Mountain View, California was placed on the National Priority List (NPL) for environmental cleanup as a result of past operations releasing volatile organic compounds (VOCs) into groundwater. The primary contaminant of concern (COC) is trichloroethene (TCE), a common chlorinated solvent used in the electronics industry, with a groundwater cleanup level established at 5 micrograms per liter (ug/L) for this Site. The CTS Printex Superfund Site (Site) includes the location of the former CTS Printex manufacturing facility and the land overlying the impacted groundwater. A Record of Decision (ROD) was issued in 1991 by the United States Environmental Protection Agency, Region 9 (EPA) that selected a remedy to restore Site groundwater to drinking water standards.

However, neither the 1991 ROD nor a subsequent 1991 San Francisco Bay Regional Water Quality Control Board (RWQCB) Cleanup and Abatement Order (CAO) included a remedy to address potential long-term exposure risks from TCE or other Site COCs through a vapor intrusion pathway. After RWQCB's second five-year review was performed at the Site in 2005, EPA recommended that an evaluation be completed to address potential vapor intrusion risk from VOCs in groundwater. Therefore, this Focused Feasibility Study (FFS) serves as EPA's evaluation of the vapor intrusion pathway at the Site.

Based on both past and recent sampling performed at the Site, EPA has assessed the vapor intrusion pathway using multiple lines of evidence and has determined that for existing buildings at the Site there is no current health risk from exposure to TCE or other COCs through the vapor intrusion pathway. Therefore, additional vapor intrusion control measures are not warranted for existing buildings in their present, unmodified state.

A 2010 Supplemental Remedial Investigation (RI) performed at the downgradient portion of the Site also showed that no immediate or long-term health risk exists due to vapor intrusion. However, a risk-based analysis performed using soil gas results from the Supplemental RI indicated that vapor intrusion could occur during future construction over specific areas of the groundwater plume. Therefore, as a precautionary and conservative measure, EPA determined that vapor intrusion control measures for new construction (i.e., subsurface disturbance during new construction on existing buildings or construction of completely new buildings) may need to be implemented and enforcement measures put in place to ensure that no adverse exposure to human health or the environment could occur.

The Site has mixed land use, so evaluation of vapor intrusion control methods in this FFS considered both commercial and residential buildings. Identification and screening of appropriate engineering control technologies and institutional controls (ICs) for vapor intrusion control considered these different land uses. After an initial screening, the following four (4) remedial alternatives were developed and evaluated as part of this FFS:

- Alternative 1 - No Action (Required by regulatory guidance);
- Alternative 2 – Monitoring and Institutional Controls (ICs);
- Alternative 3 - Mechanical Indoor Air Ventilation and ICs; and
- Alternative 4 – Vapor Barrier, Sub-Slab/Sub-Membrane Passive Ventilation, and ICs

Vapor intrusion control measures consistent with Alternative 4 have already been adopted as part of the construction of residential units on the former property of the CTS Printex facility (Gables End development). The success of the installed vapor intrusion control measures in preventing potential vapor intrusion has been documented by EPA.

Section 7.4 of this FFS includes EPA's recommendation of how the recommended vapor intrusion alternatives would be applied at the Site for existing buildings, new construction on existing buildings, and future new buildings.

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LIST OF ACRONYNMS

ARARs	applicable or relevant and appropriate requirements
ATSDR	Agency for Toxic Substances and Disease Registry
ATT	Aqua Terra Technologies
BAAQMD	Bay Area Air Quality Management District
bgs	below ground surface
BHRA	baseline health risk assessment
Cal/EPA	California EPA
CAO	Cleanup and Abatement Order
CARB	California Air Resources Board
CCR	California Code of Regulations
CEQA	California Environmental Quality Assessment
CFR	Code of Federal Regulations
CHHSLs	California Human Health Screening Levels
COC	chemical of concern
CSM	Conceptual Site Model
CTS	CTS Corporation
DCA	dichloroethane
EPA	United States Environmental Protection Agency, Region 9
ESA	Environmental Site Assessment
ESL	Environmental Screening Levels
FFS	Focused Feasibility Study
GeoSyntec	GeoSyntec Consultants
GRAs	General Response Actions
HDPE	high-density polyethylene
HVAC	heating, ventilation, and air conditioning
ICs	institutional controls
ICIAP	Institutional Control Implementation and Assurance Plan
IUR	Inhalation unit risk
J&E	Johnson and Ettinger
LLDPE	linear low-density polyethylene
MCL	Maximum Contaminant Level
MIP	Membrane Interface Probe
MRLs	minimal risk levels
NPL	National Priority List
OEHHA	Office of Environmental Health Hazard Assessment
OMMP	Operations, Monitoring, and Maintenance Plan
PCE	tetrachloroethene

ppmw	parts per million by weight
PVC	polyvinyl chloride
RAOs	remedial action objectives
RI	Remedial Investigation
RMP	Risk Management Plan
ROD	Record of Decision
RSLs	Regional Screening Levels
RWQCB	San Francisco Bay Regional Water Quality Control Board
SCR	Site Cleanup Requirement
SEP	Site Excavation Plan
Site	CTS Printex Superfund Site
TBC	to be considered
1,1,1-TCA	1,1,1-trichloroethane
TCE	Trichloroethene
UECA	Uniform Environmental Covenants Act
ug/kg	micrograms per kilogram
ug/L	micrograms per liter
ug/m^3	micrograms per cubic meter
VOCs	volatile organic compounds

1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA), under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. §§ 9601-9675 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act, has conducted a focused feasibility study (FFS) to provide an evaluation of technical and administrative factors prior to amending the Record of Decision (ROD) for the CTS Printex Superfund Site (Site) located in Mountain View, California (Figure 1-1). The FFS is being developed in two parts: Part 1, as presented herein, assesses alternatives for preventing possible vapor intrusion of volatile organic compounds (VOCs) from the shallow groundwater into buildings at the Site; and Part 2 (ITSI, 2011b) assesses alternatives for cleaning up groundwater to achieve remediation goals (RGs). This two part FFS will support a future planned amendment to the Site's Record of Decision (ROD) that was issued in 1991 (EPA, 1991).

This FFS is focused on the potential vapor intrusion pathway at the Site and presents an evaluation of remedial alternatives to prevent potential vapor intrusion into existing and future buildings/structures overlying the impacted, shallow groundwater at the Site. The shallow groundwater is contaminated with VOCs, with the primary contaminant of concern (COC) being trichloroethene (TCE). As a result, TCE is also the primary COC for potential vapor intrusion. The area of vapor intrusion being evaluated for this FFS is defined as the area immediately overlying the impacted, shallow groundwater plume exhibiting TCE concentrations above 5 ug/L as shown on Figure 1-2.

Operations at the former CTS Printex facility ceased in 1985 and subsequent environmental investigations (ATT, 1991) were conducted under oversight of the San Francisco Bay Regional Water Quality Control Board (RWQCB) to evaluate potential environmental impacts that may have resulted from CTS Printex's printed circuit board manufacturing operations. In February 1990, the United States Environmental Protection Agency, Region 9 (EPA) placed the Site on the National Priority List (NPL) based on sampling results that indicated past operations at the former printed circuit board manufacturing facility likely had released VOCs into the groundwater. As the lead regulatory agency for the Site, the RWQCB issued Cleanup and Abatement Order (CAO) No. 91-081 and Site Cleanup Requirements (SCR) for the Site in May 1991 (RWQCB, 1991). The CAO identified CTS Corporation and ADN Corporation (aka Nearon Enterprises) as the responsible parties for the Site and summarized the final cleanup plan. The SCR mandated that unacceptable risks due to exposures to groundwater were to be controlled by a deed restriction that prohibited the use of groundwater for the properties associated with the former CTS Printex manufacturing operations.

In 1991, EPA issued a ROD (EPA, 1991) that identified a selected remediation approach to restore impacted groundwater at the Site to drinking water standards. The selected remedy in the ROD was to continue operation of a groundwater extraction system to remove contaminated, shallow groundwater, with discharge of the extracted water directly into the sanitary sewer under a permit from the City of Mountain View. Annual groundwater monitoring, initially performed to monitor the remediation approach in accordance with RWQCB CAO No. 91-081, continues at the Site. Groundwater extraction was discontinued in 1996 by approval of the RWQCB, the lead regulatory agency at the time, due to decreasing effectiveness of the selected remedy. A remedy for vapor intrusion was not included in the 1991 ROD, CAO, or SCR.

After the second five-year review of the Site (EPA, 2005), EPA recommended that the original ROD be amended to include institutional controls prohibiting the use of shallow groundwater at the Site. In addition, EPA was concerned that occupants of buildings overlying the Site could be exposed to vapor emissions attributable to VOCs in shallow groundwater through a vapor intrusion pathway. Therefore, a further recommendation by EPA was to amend the existing ROD to establish remedial action objectives (RAOs) and to evaluate potential risk at the Site due to vapor intrusion. In 2006, lead agency status was transferred to EPA from the RWQCB, and in 2010 a Supplemental Remedial Investigation (RI) was performed (ITSI, 2011a) to evaluate the vapor intrusion exposure pathway further.

1.1 PURPOSE OF FOCUSED FEASIBILITY STUDY FOR VAPOR INTRUSION

The results of the 2010 supplemental remedial investigation (RI) (ITSI, 2011a) suggest that there is no immediate or long-term health risk associated with the vapor intrusion pathway into existing buildings at the Site. Since there are no current risks, vapor intrusion control measures for existing buildings are not required. However, there is a residual mass of VOCs in groundwater located north of Plymouth Street that could potentially contribute to vapor intrusion if Site use changes in the future. Additional discussion of this potential source is presented in Section 2. EPA is identifying remedial alternatives, including applicable institutional controls (ICs), which could be used to control or reduce vapor intrusion for existing buildings and under likely future commercial and residential building construction scenarios.

1.2 SITE BACKGROUND

The former CTS Printex facility occupied approximately 5.3 acres, with buildings located on the properties at 1904, 1940, 1950 Colony Street and at 1905, 1911, 1921, and 1931 Plymouth Street in the City of Mountain View, California (Figure 1-3). The only industrial activity known to have occurred on these properties was manufacturing of printed circuit boards. The Site is located in the northwest corner of Santa Clara Valley and is approximately 2.5 miles south of San Francisco Bay. The former CTS Printex manufacturing facility was bounded by Plymouth

Street on the north, Sierra Vista Avenue on the west, Colony Street on the south, and U.S. Highway 101 (Bayshore Freeway) on the east.

Within the ROD, the Site is defined to include not only the former manufacturing area, but also the downgradient area affected by the shallow groundwater plume. The land surrounding the Site is zoned for light industrial/manufacturing, commercial, residential, and agricultural use. Most buildings in the vicinity are low-rise residential units and commercial developments consisting of offices, warehouses, and research and development facilities.

CTS Printex ceased the manufacture of printed circuit boards at the Mountain View facility at the end of 1984, and undertook actions to close the facility. The property associated with the former CTS Printex manufacturing facility was sold in 2006 and redevelopment for residential land use began in 2007 through the Gables End development by Regis Homes. Control measures for vapor intrusion were designed by the developer as part of a Risk Management Plan (RMP) (Geosyntec, 2006b) that presented risk management and engineering control measures to minimize potential vapor intrusion risk in the planned development. EPA reviewed these proposed vapor intrusion control measures and did not object to the planned residential development provided that the requirements of the RMP were followed. As of September 2010, EPA has verified all requirements of the RMP have been met. An overview of all post-ROD investigations conducted at the Site since 1991 is presented in Section 2.0.

1.3 ORGANIZATION OF THE FOCUSED FEASIBILITY STUDY FOR VAPOR INTRUSION

In addition to the above introduction, the FFS consists of the following sections:

- **Section 2 –Summary of Supplemental Remedial Investigations at the Site:** Presents an overview of the supplemental remedial investigations and baseline health risk assessment for evaluating vapor intrusion.
- **Section 3 – Site Vapor Intrusion Pathways:** Describes the vapor intrusion control measures implemented at the Gables End development and the potential for vapor intrusion at other portions of the Site.
- **Section 4 – Applicable or Relevant and Appropriate Requirements (ARARs):** Identifies and describes ARARs.
- **Section 5 - Exposure Goals:** Discusses exposure goals that consider background or ambient air concentrations and action levels for short- and long-term exposures.
- **Section 6 – Identification and Screening of Vapor Intrusion Control Technologies and Institutional Controls:** Identifies general response actions and vapor intrusion control technologies and institutional controls applicable to existing buildings and/or future construction for buildings overlying the Site.

- **Section 7 – Development and Detailed Analysis of Vapor Intrusion Control Alternatives:** Presents a detailed evaluation of each alternative and a comparative analysis of the vapor control alternatives after initial screening. Also includes a decision-making rationale for existing/future commercial and residential buildings.
- **Section 8 – References:** Lists the references cited within this FFS.

2.0 SUMMARY OF SUPPLEMENTAL REMEDIAL INVESTIGATIONS (RI) AT THE SITE

This section is a comprehensive summary of findings from investigations conducted at the Site after issuance of the ROD in 1991. Information from the most recent Supplemental RI (ITSI, 2011a) was used to update the existing Site Conceptual Site Model (CSM) to describe the potential for the vapor intrusion pathway.

2.1 CONCEPTUAL SITE MODEL FOR VAPOR INTRUSION

The CSM identifies potential sources of VOCs in indoor air, defines COCs applicable to the Site, and defines potential pathways and specific receptors that are possible at the Site. Data from past and current sampling were applied to the CSM to determine the expected risk generated by vapor intrusion (if any). Figure 2-1 presents the Exposure Pathway Model showing how vapors from VOCs present in the subsurface could be transported upward and/or laterally and enter buildings through cracks in the foundation or via utility trenches/conduits. If VOCs enter the indoor environment, there is a potential risk to occupants through inhalation of indoor air.

Source of VOCs: Evaluation of the vapor intrusion pathway is based on exposures to COCs for the Site. However, it is also important to identify potential VOCs emanating from sources other than those arising from vapor intrusion, such as the following:

- VOCs present in outside (ambient) air that enter a building through windows, heating and air-conditioning systems, or other exterior building joints, and
- VOCs from products being used in the workplace or home.

Transport Mechanism: VOCs present in shallow groundwater could volatilize and the resulting vapors could move upwards from the water table, and enter structures through preferential pathways such as cracks in the slab and foundation, utility trenches, or subsurface utility conduits. VOCs could also remain trapped beneath the slab or foundation of structures if the foundation remains intact. Should the foundation integrity be compromised, then the accumulated VOCs could enter the indoor air space at that time.

Human Receptors: Receptors are the occupants of residences and commercial buildings overlying the TCE plume as presently defined.

Exposure Route: The exposure route (e.g., inhalation) of building occupants to vapor intrusion contaminants is the final step in a complete exposure pathway. A complete exposure pathway consists of: (a) presence of a subsurface source; (b) movement of VOCs from the source into the structure by means described above; (c) a receptor (such as an office worker or resident); and (d) an exposure route to the human receptor from the indoor air. For purposes of this FFS, inhalation of indoor air containing VOCs is the exposure route for a receptor.

Since all four exposure pathway factors may be present during future construction at the Site, this FFS assumes that a complete vapor intrusion exposure pathway could exist and therefore must be evaluated.

2.2 REMEDIAL INVESTIGATIONS TO EVALUATE VAPOR INTRUSION

This section discusses the scope and conclusions of investigations conducted at the Site since the ROD was implemented in 1991.

2.2.1 Types of Samples

Locations for Site soil, groundwater, air (indoor and outdoor), soil gas, and sub-slab vapor samples collected during the Supplemental RI (ITSI, 2011a) to evaluate vapor intrusion are shown on Figure 2-2. A description of the type, number, and procedures followed for each sample is presented in the Supplemental RI (ITSI, 2011a).

2.2.2 Criteria for Evaluation of Results

Although there are no promulgated standards for VOCs in indoor air, EPA has developed Regional Screening Levels (RSLs) applicable to specific compounds in air for both commercial and residential applications (USEPA, 2010a). RSLs are concentrations of specific contaminants that should not be exceeded in order to avoid health risk from inhalation of VOCs in indoor air. The acceptable indoor air RSL concentration for TCE is 1.2 micrograms per cubic meter ($\mu g/m^3$) in residential buildings, and 6.1 $\mu g/m^3$ in commercial buildings. For purposes of this FFS, EPA has conservatively established 1 $\mu g/m^3$ and 6 $\mu g/m^3$ as the TCE indoor air screening levels for residential and commercial buildings, respectively. These action levels are risk-based concentrations that have been determined as protective of cancer risks to potentially exposed residents and office workers.

2.2.3 Pre-2010 Site Investigations

CTS Corporation conducted soil gas and indoor air sampling in 2004. Three soil gas samples were collected outside of 1911 Plymouth Street, one soil gas sample was collected near downgradient monitoring well 17W, and three indoor air samples were collected at 1921 and 1931 Plymouth Street. Soil gas concentrations were below RWQCB Environmental Screening Levels (ESLs), but the TCE concentration in the soil gas sample collected near 17W was 5,000 $\mu g/m^3$, approximately four times the shallow soil gas ESL for residential exposure. CTS Corporation attributed the elevated concentrations to the presence of residual TCE in soil at 1914 Plymouth Street (CSS, 2004a).

RWQCB recommended further characterization of the horizontal and vertical extent of soil and groundwater contamination at 1914 Plymouth Street due to the high concentration of TCE found in the soil gas sample collected near groundwater monitoring well 17W. TCE concentrations in soil samples collected near the building at 1914 Plymouth Street were 350 micrograms per kilogram (µg/kg) and a grab groundwater sample had a maximum TCE concentration of 33 µg/L. Additional investigations were undertaken in July 2004 to assess whether there were known utility lines that could serve as preferential pathways. A utility line was determined to extend from the floor drains inside the building, and continue to the south towards Plymouth Street. However, CTS Corporation did not conduct additional follow-up investigations.

In 2005, an Environmental Site Assessment (ESA) was conducted by GeoSyntec (2006a) for properties located at 1905, 1911, 1921, and 1931 Plymouth Street and at 1916, 1930, 1940, and 1950 Colony Street for the Regis Homes residential redevelopment. As part of the due diligence activities associated with the purchase, a baseline health risk assessment (BHRA) (GeoSyntec, 2006c) was performed to evaluate whether occupants of the proposed homes, as well as construction workers associated with the redevelopment, would have unacceptable exposures due to TCE from vapor intrusion. Soil samples were collected to evaluate the potential exposure potential of future residents and construction workers through ingestion, dermal contact, and inhalation of dust-borne particulates and outdoor air emissions. Regis Homes also collected a total of 32 soil vapor samples at locations across the footprint of the redevelopment area in March 2005, April 2005, and March 2006 (GeoSyntec, 2006a).

The BHRA concluded that there was acceptable risk to residents and/or construction workers due to vapors arising from soil exposure. Data from soil gas samples were used to predict indoor air concentrations by applying conservative assumptions drawn from underlying soil properties, the volume of the building, and the air exchange rate. Indoor air exposures were also estimated based on TCE concentrations in groundwater and soil gas samples. The Johnson and Ettinger (J&E) Model (USEPA, 2004) was used to estimate indoor air concentrations in proposed homes at the Site (ITSI, 2011a). These estimated indoor air concentrations provided the basis for identifying the potential risks to future residents due to vapor intrusion.

When the maximum groundwater concentration was used to estimate indoor air concentrations, the predicted TCE concentration in indoor air was 0.04 $\mu g/m^3$, which is significantly lower than the acceptable indoor air screening level of 1 $\mu g/m^3$. Based on soil gas data, however, the predicted indoor air concentration of TCE was 2 $\mu g/m^3$, which was slightly higher than the acceptable indoor air screening level of 1 $\mu g/m^3$. The estimated increased risk of cancer due to this predicted indoor air concentration of TCE was 2×10^{-6}. Although the BHRA (GeoSyntec, 2006c) asserted that this risk level was within EPA's risk management range of 1×10^{-6} to 1×10^{-4}, the estimated increased risk of cancer due to TCE alone was higher than the residential risk standard of 1×10^{-6}. Therefore, risk management measures were proposed to eliminate the vapor intrusion pathway and a Site Excavation Plan (SEP) (GeoSyntec, 2007d) was implemented to remove backfill material exhibiting VOC concentrations exceeding RWQCB ESLs.

To control potential vapor intrusion into the proposed Gables End development, previous excavations that had been backfilled either with sand or pea gravel were removed because these materials could provide an enhanced conduit for the migration of VOCs. These excavations were backfilled with clean fill exhibiting similar impermeability characteristics as the surrounding soil (GeoSyntec, 2007). As an additional precautionary measure, the Regis Homes' RMP included construction details for these new homes with engineering controls to prevent vapor intrusion. The implemented engineering controls at the Gables Home development included the installation of a vapor barrier and passive sub-barrier ventilation system to prevent potential vapor intrusion into the planned development buildings (GeoSyntec, 2007a and 2007b). A detailed description of these RMP-driven engineering controls is discussed further in Section 3.

To assess the effectiveness of these engineering controls, indoor air samples were collected after construction but prior to occupancy. Regis Homes also collected ambient or outdoor air samples prior to occupancy of each condominium building and concurrent with indoor air sampling to compare indoor and outdoor air quality directly.

Conclusions and actions resulting from the investigations and vapor intrusion control measures at the Gables Home development were as follows:

- No health risk to construction workers and future residents of Gables End development exists due to soil exposure.
- TCE detected in soil gas beneath the building at 1911 Plymouth Street appeared to be a result of off-gassing from groundwater, as TCE was not detected in the soil. TCE concentrations presenting a vapor intrusion concern were detected in an excavation area that had been backfilled with sand and pea gravel. Since this could provide a pathway for VOCs in soil gas and contribute to indoor air concentrations, the sand and pea gravel were removed and replaced with fine-grained native soil prior to construction of the housing development.
- Indoor air concentrations of VOCs due to vapor intrusion from VOCs in groundwater do not pose a health risk to future residents because of engineered controls implemented during construction.
- Modeled indoor air concentration based on the highest TCE concentration in soil gas was estimated at 2.5 $\mu g/m^3$. However, actual measured concentrations of TCE in indoor air at the Gables End development were well below EPA's acceptable indoor air screening level of 1 $\mu g/m^3$ for residential buildings.

2.2.4 2010 Supplemental RI Activities North of Plymouth Street

Vapor intrusion at existing buildings located at the portion of the Site north of Plymouth Street, including 1905, 1914, and 1924 Plymouth Street and 917 and 935 Sierra Vista Avenue, was not evaluated in the 2004 and 2006 investigations. Therefore, EPA conducted additional remedial investigations in 2010 that focused on the downgradient portion of the Site, specifically north of Plymouth Street.

EPA collected indoor air, soil gas, sub-slab vapor, and additional groundwater samples necessary for evaluating risks associated with the vapor intrusion pathway in existing buildings. EPA (ITSI, 2011a) also evaluated potential exposures of workers in current office/light industrial buildings by comparing measured indoor air concentrations to acceptable indoor air levels in a commercial/industrial building. Potential exposures to hypothetical future residents were evaluated by comparing indoor air concentrations in these office buildings to acceptable indoor air levels for residential buildings. Measurement of indoor air levels was limited to buildings overlying the estimated groundwater plume area (see Figure 1-2) as defined by the TCE concentration contour of 5 µg/L (the current drinking water standard, or Maximum Contaminant Level [MCL]).

Again using the J&E Model, the TCE groundwater concentration that would result in a potential vapor intrusion risk of 1×10^{-6} in overlying buildings was calculated to be approximately 10 µg/L. Based on the results of the BHRA and concentrations in groundwater, TCE poses the greatest potential vapor intrusion risk among the COCs identified in the ROD (EPA, 1991). A summary discussion of the 2010 sampling design and sample results is presented in the Supplemental RI report (ITSI, 2011a).

EPA's 2010 supplemental RI included the collection of groundwater samples from existing monitoring wells and temporary wells, indoor air samples at 1914 and 1924 Plymouth Street and at 917 and 935 Sierra Vista Avenue, ambient outdoor air samples, soil gas samples, sub-slab vapor samples, and MIP samples. Data from existing monitoring wells and temporary wells were used to establish the estimated, current extent of the TCE groundwater plume. Indoor air samples were collected and used to assess health risks associated with exposures due to vapor intrusion for occupants of the existing buildings at 917 and 935 Sierra Vista Avenue and at 1914 and 1924 Plymouth Street. Soil gas and sub-slab vapor sampling was also conducted at 935 Sierra Vista Avenue and at 1914 and 1924 Plymouth Street.

MIP and groundwater data were used to update the geological conceptual site model for the Site. EPA used information gathered from this data collection effort to assess potential vapor intrusion pathways applicable to the Site. These pathways were evaluated using multiple lines of evidence to estimate potential health risks from exposure to TCE for building occupants and to evaluate remedial alternatives to control and protect against vapor intrusion for future buildings north of Plymouth Street, as necessary.

2.2.4.1 Delineation of Current VOC Plume in Groundwater

Table 3-3 of the Supplemental RI (ITSI, 2011a) presents groundwater data collected from May 1992 through December 2010. This table also indicates which monitoring wells have been properly decommissioned and/or abandoned. Temporary wells installed for the 2010 investigation were screened within two shallow groundwater depths: 1) A zone screening from 10 to 20 feet below ground surface (bgs); and 2) B zone screening from 30 to 40 feet bgs. As described in the FFS-GW (ITSI, 2011b), the TCE plume in the shallow groundwater has generally decreased in size laterally compared to the areal extent presented in the ROD (EPA, 1991).

2.2.4.2 Vapor Intrusion Evaluation at 1914 and 1924 Plymouth Street, 917 and 935 Sierra Vista Avenue

The indoor air samples collected in 2010 applied the procedures described in the Supplemental RI (ITSI, 2011a). A duplicate indoor air sample in one of the office spaces and a trip blank were also collected as quality assurance samples.

The indoor air sampling was conducted in three phases. For the commercial buildings at 1914 Plymouth Street and 935 Sierra Vista Avenue, the first and second phases were conducted in March 2010 and when the heating, ventilation, and air conditioning (HVAC) system was running in order to represent conditions when workers are in the building. The third phase, consisting of the same buildings and also the commercial building at 1924 Plymouth Street, was conducted in June 2010 with the HVAC system off in order to represent worst case conditions. It is expected that the pressure differential caused by having the HVAC system turned off could result in increased potential for vapor entry from subsurface soils to the interior of the building. A duplicate indoor air sample in one of the office spaces and a trip blank were again collected during indoor air sampling to serve as quality assurance samples. An ambient air sample was collected at a location upwind of 935-C Sierra Vista Avenue (Sequetech) over a 24- hour period, with sampling initiated at least 30 minutes before the start of the indoor air sampling.

Sub-slab vapor sampling was also conducted to evaluate whether vapors underneath the slab could be a potential source of vapors and possibly impact the indoor air for the commercial buildings at 1914 and 1924 Plymouth Street, and at 935 Sierra Vista Avenue.

Indoor air samples were also collected in August 2010 from three ground floor units in the apartment building located at 917 Sierra Vista Avenue. Indoor air sampling was started after the product survey was completed and ambient air samples were also collected outside of each unit.

Indoor and sub-slab air sample results and the conclusions drawn from these data were presented in the Supplemental RI Report (ITSI, 2011a) and are summarized below:

- Indoor air concentrations of TCE in the office spaces at 935 Sierra Vista Avenue, 1914 Plymouth Street, 1924 Plymouth Street, and in the apartments located at 917 Sierra Vista Avenue do not exceed the TCE indoor air screening levels of 1 $\mu g/m^3$ for residential buildings and 6 $\mu g/m^3$ for commercial buildings.
- Indoor air concentrations were consistently below the indoor air screening levels of 1 $\mu g/m^3$ for residential buildings and 6 $\mu g/m^3$ for commercial buildings regardless of whether the HVAC system was on or off. TCE was not detected in any of the samples collected inside the apartment units at 917 Sierra Vista Avenue.
- Benzene concentrations in indoor air were lower than levels present in outdoor air, suggesting that no vapor intrusion pathway exists for benzene at the Site.
- Slight temperature variations did not seem to affect the measured indoor air concentrations of TCE at the Site.
- Sub-slab vapor samples collected at 1914 and 1924 Plymouth Street (commercial buildings) had TCE concentrations that ranged from 2,900 to 8,500 $\mu g/m^3$, indicating an attenuation factor of 0.001 to almost 0.0001 based on the measured indoor air TCE concentration for these buildings.
- Sub-slab vapor samples were also collected at 935 Sierra Vista Avenue, but leakage occurred and the vapor samples were not analyzed. A soil gas sample was collected just to the north of the building at location MIP-4-4 (see Figure 2-2) and at a depth of 3 feet bgs. VOCs detected in the soil gas were 2-propanol (50 $\mu g/m^3$), toluene (90 $\mu g/m^3$), ethylbenzene (20 $\mu g/m^3$), total xylenes (110 $\mu g/m^3$), PCE (70 $\mu g/m^3$), acetaldehyde (400 $\mu g/m^3$), methyl butane (300 $\mu g/m^3$), isobutene (300 $\mu g/m^3$), pentane (300 $\mu g/m^3$), hexafluoroethene (15,000 $\mu g/m^3$), and total hydrocarbons (4,500 $\mu g/m^3$). Current VOC concentrations in shallow groundwater at the Site indicate that the VOCs detected in this soil gas sample are not attributable to shallow groundwater.

2.2.4.3 Membrane Interface Probe (MIPs) Investigation

Information from the MIP investigations indicated that the subsurface at the evaluated locations (see Figure 2-2 for locations) is primarily clay, with interbedded sandy material. This confirmed prior investigation data that the subsurface soils are relatively impermeable and would generally hinder vapor movement upward to the ground surface or building foundations. The MIP data also indicated the presence of very small in situ transport channels that could provide potential VOC transport between the A zone and B zone within the shallow groundwater. The MIP results also show that residual VOCs are present at their highest concentrations in the subsurface soil in the vicinity of monitoring well 17W between 1914 Plymouth Street and 935 Sierra Vista Avenue.

Relatively high levels of VOCs were also observed in groundwater at a depth of approximately 15 to 18 feet bgs near the southeast end of the building located at 935 Sierra Vista Avenue. Since the MIP cannot speciate the types of VOCs, a soil gas sample was collected near the area where these high levels of VOCs in groundwater were detected. TCE was not detected in this soil gas sample, suggesting that off-gassing of VOCs from shallow groundwater may be minimal at this location.

2.3 SITE-SPECIFIC GEOLOGICAL CONCEPTUAL SITE MODEL

Based on data collected during the 2010 Supplemental RI (ITSI, 2011a), a Site-specific geological conceptual model describing the fate and transport of VOCs in groundwater to the near-surface is shown on Figures 2-3 and 2-4. Similar to the Gables End development issue where pea gravel backfill could provide a conduit for VOC migration, a similar phenomenon could exist beneath 1914 Plymouth Street since it is common construction practice to use sand and gravel as fill material beneath the slab of buildings. Therefore, residual levels of VOCs in groundwater could be considered a source of vapors migrating to the near-surface beneath the slab of the buildings at 1914 Plymouth Street. This may explain the moderately high VOC concentrations in the sub-slab vapor sample collected at this location. Nevertheless, indoor air levels averaged 1.1 $\mu g/m^3$, which is much lower than the 6 $\mu g/m^3$ indoor air screening level applicable for commercial buildings. Based on indoor air concentrations from the 2010 investigation, the data indicate that occupants at 1914 Plymouth Street are not currently exposed to unacceptable levels of TCE. Indoor air samples collected during two subsequent sampling events (March and June 2010) at 1914 Plymouth Street also had reported indoor air levels of TCE consistently below the acceptable levels for commercial and residential buildings (ITSI, 2011a). Samples collected from 1924 Plymouth Street also showed that levels of TCE are either non-detect or below indoor air screening levels for both commercial and residential buildings.

Because the residual contaminant mass in the vicinity of well 17W and near (and possibly extending under) the building at 935 Sierra Vista Avenue is located several feet below the water table, the presence of shallow groundwater above the highest detected concentration of VOCs in the subsurface appears to effectively retard volatilization of these VOCs and thus further minimizes vertical transport of vapors to the near-surface for this property. In addition, VOCs were either not detected or detected at very low levels in indoor air at 917 and 935 Sierra Vista Avenue. Therefore, vapor intrusion is not a likely pathway of concern for the existing buildings at 1914/1924 Plymouth Street and 917/935 Sierra Vista Avenue even though they overly the Site's shallow groundwater TCE plume.

3.0 SITE VAPOR INTRUSION PATHWAYS

The pre-2010 investigations described in Section 2 showed that some building areas at the Site could require vapor intrusion control measures due to the potential for TCE concentrations to exceed acceptable indoor TCE levels for future residents, and also to ensure that construction workers would not be exposed to TCE vapors generated from subsurface VOCs. This section summarizes the vapor intrusion control measures implemented at the Gables End development as a result of these findings.

3.1 GABLES END DEVELOPMENT (SOUTH OF PLYMOUTH STREET)

As described earlier, sand and pea gravel backfill that could serve as a vapor intrusion conduit was removed and replaced with clean, compacted backfill consisting of native material with a much lower permeability than the sand and pea gravel (GeoSyntec, 2007d).

Engineering controls installed during and after construction activities to control vapor intrusion at the Gables End development included the following (GeoSyntec, 2007a, 2007c, 2007d, 2009, and 2010):

- Low-permeability fill was placed along utility trenches to reduce potential lateral transport of VOCs arising from the groundwater.
- Sub-slab vapor barriers and enhanced passive sub-slab depressurization systems were installed beneath all occupied buildings as part of the construction of new homes.
- Construction plans were submitted to the City of Mountain View to show compliance with risk management measures.
- Indoor air levels were measured after each phase of construction prior to occupancy.
- Post-construction maintenance of engineering controls was implemented to assure that the vapor intrusion control system is maintained and working.

A deed restriction in place since 1992 prohibits use of groundwater underlying the properties previously occupied by the CTS Printex manufacturing facility. On April 20, 2010, an environmental restrictive covenant was recorded that: 1) prevents groundwater from below the Gables End site to be used for any purpose without prior written approval by EPA; 2) prohibits activities at the Gables End site that may impact the groundwater beneath that site or interfere with groundwater monitoring conducted in accordance with remedies described in the ROD (as it may be amended) unless approved in writing by EPA; and 3) that all elements of the vapor intrusion prevention and monitoring systems described in the RMP (GeoSyntec, 2006b) shall be operated and maintained in accordance with an EPA-approved Operations, Monitoring and Maintenance Plan (OMMP); and that RWQCB and/or any persons acting pursuant to RWQCB orders shall have reasonable access to specified portions of the Gables End site for the purposes of inspection, surveillance, maintenance, or monitoring.

3.2 1914 AND 1924 PLYMOUTH STREET, 917 AND 935 SIERRA VISTA AVENUE (NORTH OF PLYMOUTH STREET)

Results of the 2010 groundwater sampling suggest that most of the 2-story apartment building at 917 Sierra Vista Avenue lies outside the current TCE plume boundary of 5 µg/L, indicating that vapor intrusion is not likely to be a concern. Nevertheless, EPA conducted confirmatory indoor air sampling at this location and detected no COCs above RSLs. The commercial buildings at 1914 and 1924 Plymouth Street and 935 Sierra Vista Avenue, however, do overlie the TCE plume, but results of the indoor air investigations show that vapor intrusion is not occurring in these buildings (ITSI, 2011a).

Therefore, it appears that the vapor intrusion pathway for these buildings is either incomplete or that TCE levels do not present unacceptable risk. Groundwater monitoring and MIP data suggest that VOCs in the subsurface could be a potential source for vapor intrusion if Site conditions change in the future. The results of the sampling performed north of Plymouth Street are provided below.

Sub-slab vapor sampling was conducted in the work area and warehouse area inside the building located at 1914 Plymouth Street. Detected VOCs in the vapors below work area slabs were 1,1-dichloroethane (1,1-DCA) at 30 $\mu g/m^3$, 1,1,1-trichloroethane (1,1,1-TCA) at 3,000 $\mu g/m^3$,TCE at 6,800 $\mu g/m^3$, and tetrachloroethene (PCE) at 20 $\mu g/m^3$. The sub-slab sample from the warehouse area showed detected concentrations of 1,1,1-TCA (900 $\mu g/m^3$), TCE (2,900 $\mu g/m^3$), and PCE (30 $\mu g/m^3$).

Detected VOCs in the sub-slab vapor samples collected at 1924 Plymouth Street were 40 $\mu g/m^3$ of 1,1-DCE, 30 $\mu g/m^3$ of chloroform, 1,400 $\mu g/m^3$ of 1,1,1-TCA, 8,500 $\mu g/m^3$ of TCE, 40 $\mu g/m^3$ of PCE, and 6 $\mu g/m^3$ of toluene. Benzene and 1,1-DCA exhibited estimated levels in the sub-slab samples at 4 and 7 $\mu g/m^3$, respectively.

Indoor air samples from three units in the apartment building located at 917 Sierra Vista Avenue were collected by EPA using Radiello samplers, which are sorbent samplers that were left for a period of one week inside the sampled units. Some studies have shown that the ability to collect indoor air samples over a longer period of time would be a better indicator of vapor intrusion. The results from the Radiello samplers showed that TCE was not present at detectable levels in any of the sampled units. Therefore, the vapor intrusion pathway is incomplete for occupants of the apartments at 917 Sierra Vista Avenue.

Indoor air results in all buildings sampled did not have detectable levels of vinyl chloride, 1,1-DCE, trans-1, 2-DCE, or 1,1-DCA. An estimated level of PCE at 0.18 µg/ m^3 was detected once at 935 Sierra Vista Avenue (Sequetech) during the first sampling event, but this level is lower than PCE values collected from the outside air. Other indoor air samples collected in 935-C Sierra Vista Avenue (Sequetech) and in all other buildings did not have detectable levels of PCE.

Detected levels of methylene chloride, benzene, toluene, chloroform, 1,1,1-TCA, 1,2-DCA, and TCE were all below the EPA's regional screening levels for commercial buildings. In summary, based on the supplemental investigation results, the human health risk assessment determined that there are no human health concerns based on measured indoor air concentrations in the existing residential and office buildings located north of Plymouth Street and overlying the TCE plume (ITSI, 2011a).

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4.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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. Potential ARARs are identified in Section 4-1.

"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 involves 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.

4.1 POTENTIAL ARARS BY CATEGORY

4.1.1 Chemical-Specific ARARS

EPA sets site-specific cleanup levels in one of two ways. Where there is a regulatory standard for exposure to a chemical at a site, cleanup levels may be set at that standard. EPA may also set site-specific, risk-based cleanup levels that apply specifically to the contaminants and exposures at the site. The site-specific risk analysis can be based on multiple considerations, including chemical-specific ARARs and other applicable regulations (e.g., criteria found in "to be considered" [TBC] guidance).

Indoor Air Cleanup Levels based on EPA Region 9 Regional Screening Levels (RSLs) for Indoor Air: For this Site, EPA is using RSLs and site-specific information to determine appropriate risk-based indoor air cleanup levels. The indoor air RSLs for TCE is 1.2 µg/m³ for residential occupancy and 6.1 µg/m³ for commercial worker/non-residential occupancy. EPA derived these TCE indoor air cleanup levels using Cal-EPA's chronic toxicity value for TCE.

4.1.2 Location-Specific ARARS

There are no location-specific ARARs for the vapor intrusion evaluation.

4.1.3 Action-Specific ARARs

Action-specific ARARs depend on the type of remedial alternative chosen. This section describes only the action-specific ARARs associated with remedial actions related to the vapor intrusion remedy.

Air Emissions: Bay Area Air Quality Management District (BAAQMD) Regulation 8, Rule 47 addresses emission control requirements for organic compound emissions from air stripping and soil vapor extraction systems. This Rule is potentially relevant and appropriate for emissions of VOCs from Active Sub-slab Depressurization systems or Sub-membrane Depressurization systems, with organic compound emissions not to exceed 0.5 pounds per day. Additionally, Section 8-47-301 does not apply to operations with total emissions of less than one pound per day of benzene, vinyl chloride, PCE, methylene chloride, and/or TCE.
BAAQMD Regulation 8, Rule 40 is potentially relevant and appropriate to activities during the construction phase of the chosen remedial actions. Where more than 8 cubic yards of contaminated soil are removed for construction of a remedial system beneath buildings at the

Site, and where the soil has organic content above 50 parts per million by weight (ppmw), Section 8-40-304 would require that inactive storage piles be appropriately covered. Thus, these requirements are ARARs where more than 8 cubic yards of contaminated soil are removed for remedy construction.

Environmental Restrictive Covenants: California Civil Code § 1471(a) sets forth the requirements for an environmental restriction covenant in California and is potentially relevant and appropriate for Alternatives 2, 3, and 4.

4.2 TO BE CONSIDERED GUIDANCE

As described earlier, guidance not directly enforceable at the time of ARAR development can fall into the "to be considered" (TBC) classification. However, TBCs that are not legally binding, and are not generally enforceable, may have specific bearing on all or part of the Site-specific action, and upon inclusion in a ROD, would become legally binding at the Site.

EPA Regional Screening Levels (RSLs) are risk-based screening concentrations that are used, in conjunction with Site-specific information, to formulate Site-specific risk-based cleanup levels for indoor air. The RSLs are potential TBCs for Alternatives 2, 3, and 4.

California Human Health Screening Levels (CHHSLs) were developed by the Office of Environmental Health Hazard Assessment (OEHHA) on behalf of the California Environmental Protection Agency (Cal-EPA, 2005), and are potential TBCs for future development of Site-specific risk-based soil gas screening level criteria for Alternatives 2, 3, and 4.

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5.0 EXPOSURE GOALS

With no promulgated cleanup standards for VOCs in indoor air, several guidance values can be used to assist in the initial screening of measured or estimated indoor air concentrations. These guidance values include:

- Background and outdoor air concentrations,
- Exposure levels for inhalation, and
- Indoor air preliminary screening levels.

5.1 BACKGROUND AND OUTDOOR AIR CONCENTRATIONS

The California Air Resources Board (CARB) and BAAQMD monitor ambient air concentrations of toxic air pollutants that include benzene, methylene chloride, chloroform, PCE, TCE, vinyl chloride, 1,2-DCA, and 1,1,1-TCA. As discussed in the Supplemental RI (ITSI, 2011a), the detection of benzene in some indoor air samples was not attributable to vapor intrusion due to the benzene levels in outdoor air being the source of the benzene in indoor air.

Consideration of background or outdoor (ambient) air concentrations provides additional perspective on the evaluation of risk due to vapor intrusion. Emissions of toxics from industrial operations and releases to the atmosphere from typical and nearby outdoor sources (e.g., Bayshore Freeway) can affect outdoor air quality at the Site. As a comparison of the effect of ambient air concentrations on evaluating indoor air quality, Table 5-1 lists ambient air concentrations of various toxic pollutants from: 1) a BAAQMD air monitoring station located six miles from the Site; and 2) ambient outdoor air samples collected simultaneously with the indoor air concentration samples collected during the supplemental RI. As shown in this table, outdoor air concentrations of TCE at the Site are higher than levels detected six miles away. As a result, Site ambient concentrations can affect indoor air monitoring results and thus can affect a realistic evaluation of whether vapor intrusion is actually occurring at the Site.

Table 5-1
Ambient Air Concentrations of VOCs
CTS Printex Superfund Site
Mountain View, California

Chemical of Concern	Concentration[2, 3] (µg/m³)[1]		Site Ambient Air Concentration (µg/m³)[4]		Site Ambient Air Concentration (µg/m³)[5]		
	Mean	Maximum	Phase 1	Phase 2	Event 1	Event 2	Event 3
Methylene Chloride	1	0.51	NA	NA	0.51	2.8	0.2
Chloroform	0.2	0.14	NA	NA	0.14	0.95	0.14
1,2-DCA	0.2	0.2	NA	NA	0.11	0.17	<0.2
1,1-DCE	NA	NA	NA	NA	<0.2	0.10	<0.2
1,1-DCA	NA	NA	NA	NA	<0.2	0.13	<0.2
1,1,1-TCA	0.06	0.11	NA	NA	<0.27	1.3	<0.27
TCE	0.0115	0.2	0.017-0.035	0.041 – 0.087	0.45	0.89	<0.27
PCE	0.1	0.6	NA	NA	0.24	<0.34	<0.34
trans-1,2-DCE	NA	NA	NA	NA	<0.2	<0.2	<0.2
Benzene	0.485	1.37	NA	NA	1	1.5	0.14
Toluene	1.7	4.14	NA	NA	3.2	15	0.47

Note: [1] Data collected by BAAQMD and incorporated into EPA's air quality database (http://www.epa.gov/oar/data/index.html).
[2] The mean and listed maximum concentrations are for 26 sampling events in 2008.
[3] Each observation and associated concentration was a 24-hour sampling event.
[4] Regis Homes Parcel Investigations
[5] 2010 Supplemental RI (ITSI, 2011a)

5.2 SHORT TERM EXPOSURE LEVELS FOR INHALATION

The Agency for Toxic Substances and Disease Registry (ATSDR) has developed acute and sub-chronic minimal risk levels (MRLs) to address short-term exposures that are less than the 70-year lifetime duration assumed in typical risk-based concentrations. MRLs are based on non-cancer health effects only and thus do not consider carcinogenic effects. The MRL is an estimate of the maximum chemical concentration in air that would not cause non-cancer health effects in a person exposed to that concentration for 1 to 14 days (acute exposures), 15 to 364 days (intermediate exposures), and 365 days and longer (chronic exposures). MRLs are intended to serve as screening levels that could be used as the basis for a more detailed evaluation, and are not intended to define cleanup or action levels. Table 5-2 lists the MRLs for COCs associated with the Site.

Table 5-2
Minimal Risk Levels for Inhalation Exposures
CTS Printex Superfund Site
Mountain View, California
Source: ATSDR, 2009[1]

Chemical of Concern	Acute (1-14 days) (μg/m^3)	Intermediate (15-364 days) (μg/m^3)	Chronic (365 days and longer) (μg/m^3)
Methylene chloride	2084	1042	1042
Chloroform	488	244	97
1,2-Dichloroethane	Not Available	Not Available	Not Available
1,1-Dichloroethene	Not Available	80	Not Available
Trans-1,2-dichloroethylene	793	793	Not Available
1,1,1-Trichloroethane	10914	3820	Not Available
Trichloroethene	10748	537	Not Available
Tetrachloroethene	1357	Not Available	271
Benzene	29	19	10
Toluene	3768	Not Available	301
1,1-dichloroethane	Not Available	Not Available	Not Available

Note: [1]MRLs listed in units of ppm by ATSDR (2009). Conversion to µg/m^3 assumed ppm concentrations at 25ºC.

5.3 INDOOR AIR REGIONAL SCREENING LEVELS (RSLS)

EPA's published RSLs, last updated in November 2010, are used as points of comparison in determining whether concentrations in soil and air are protective of commercial workers and residents. RSLs are risk-based concentrations determined to be levels of concern at the low end of the risk range and are not cleanup standards. The indoor air RSLs are based on default exposure assumptions recommended by EPA and represents the upper range of reasonable long-term exposures for a resident or an office worker.

Residential RSLs for indoor air are based on an individual's exposure to a chemical for 24 hours a day, 350 days a years, for 30 years. The resident is assumed to be away from home for two weeks a year. In the case of an office worker, the individual is assumed to be working for eight hours a day, 5 days a week, for 50 weeks a year. Indoor air RSLs are more appropriate for evaluating long-term exposures to COCs at the Site and are listed in Table 5-3. Both commercial and residential RSLs are provided, along with the basis for these RSLs (i.e., whether the concentration is based on cancer or other health effects risk).

Table 5-3
Regional Screening Levels for Residential & Commercial Buildings
CTS Printex Superfund Site
Mountain View, California

Chemical	Regional Screening Level (µg/m^3)[1]		Comments[2]
	Residential	Commercial	
Methylene Chloride	5.2	26	Based on $1x10^{-6}$ lifetime cancer risk
Chloroform	0.11	0.53	Based on $1x10^{-6}$ lifetime cancer risk
1,2-DCA	0.094	0.47	Based on $1x10^{-6}$ lifetime cancer risk
1,1-DCA	1.5	7.7	Based on $1x10^{-6}$ lifetime cancer risk
1,1-DCE	210	880	Based on non-cancer hazard quotient of 1
trans-1,2-DCE	63	260	Based on non-cancer hazard quotient of 1
cis-1,2-DCE	63	260	Not established so based on screening levels for trans-1,2-DCE.
1,1,1-TCA	5,200	22,000	Based on non-cancer hazard quotient of 1
TCE	1.2	6.1	Based on $1x10^{-6}$ lifetime cancer risk
PCE	0.41	2.1	Based on $1x10^{-6}$ lifetime cancer risk
Benzene	0.31	1.6	Based on $1x10^{-6}$ lifetime cancer risk
Toluene	5,200	22,000	Based on non-cancer hazard quotient of 1
Vinyl Chloride	0.16	2.8	Based on $1x10^{-6}$ lifetime cancer risk

Notes: [1] For chemicals with a screening level for both carcinogenic and non-carcinogenic effects through the inhalation pathway, the lower concentration is listed in the table.
[2] Basis of listed screening level.

Indoor air data from Gables End development show that the implemented engineering controls have effectively controlled vapor intrusion. Despite detectable indoor air concentrations at 935 Sierra Vista Avenue and 1914 Plymouth Street being higher than ambient or outdoor air concentrations, the indoor air concentrations are still lower than RSLs for both residential and commercial buildings. Therefore, there is no risk associated with vapor intrusion in the buildings sampled to date at the Gables End development and at parcels overlying the down gradient portion of the TCE plume.

5.3.1 Indoor Air Action Levels

Based on EPA's RSLs for residential and commercial structures, EPA developed proposed indoor air action levels at the Site. Table 5-4 lists the indoor air action levels that EPA proposes for residential buildings and commercial buildings at the Site. These indoor air action levels are based on EPA's RSLs. As previously described, the RSLs, and therefore the proposed indoor air action levels, are risk-based concentrations that are protective of cancer risks to potentially exposed residents and office workers. For carcinogens, the acceptable indoor air levels are based on a one-in-one million (1×10^{-6}) target risk or increased likelihood of cancer risk to exposed individuals.

Table 5-4
Indoor Air Action Levels for Residential & Commercial Buildings
CTS Printex Superfund Site
Mountain View, California

Chemical[1]	Indoor Air Level ($\mu g/m^3$)[1]		Comments[2]
	Residential	Commercial	
1,1-DCA	2	8	Based on 1×10^{-6} lifetime cancer risk.
1,1-DCE	210	880	Based on non-cancer hazard quotient of 1.
trans-1,2-DCE	63	260	Based on non-cancer hazard quotient of 1.
cis-1,2-DCE	63	260	No values established. Based on trans-1,2-DCE non-cancer hazard quotient of 1.
TCE	1	6	Based on 1×10^{-6} lifetime cancer risk.
Vinyl Chloride[3]	0.2	3	Based on 1×10^{-6} lifetime cancer risk.

Notes: [1] Chemicals still considered COCs in shallow groundwater due to having concentrations above its MCL or potential to form from degradation of TCE or 1,2-DCE.
[2] Basis of listed screening level.
[3] Detected in shallow groundwater, but not at concentrations above its MCL.

The calculated acceptable indoor levels for TCE take into account the exposure duration and frequency of exposure for a resident or a commercial worker. The equation for estimating the acceptable indoor air level is shown below.

$$IA = \frac{TR \; x \; AT}{EF \; x \; ED \; x \; IUR}$$

Where:

IA	Acceptable indoor air concentration ($\mu g/m^3$);	
TR	Acceptable target risk of 1×10^{-6};	
AT	Averaging time (70 years × 365 days/year);	
EF	Exposure frequency	(350 days/year for a resident) (250 days a year for a commercial worker);
ED	Exposure duration	(30 years for a resident) (25 years for a commercial worker)
IUR	Inhalation unit risk (0.000002 per $\mu g/m^3$)	

The exposure duration for both a resident and a commercial worker assumes that the resident or commercial worker takes a 2-week vacation every year.

The IUR is defined as the upper-bound excess lifetime cancer risk that is estimated to result from a continuous exposure to a TCE concentration of 1 $\mu g/m^3$ in air.

5.3.2 Interpretation of TCE Action Level

The acceptable concentration for TCE, and for any hazardous chemical expected to be present in indoor air, is based on conservative assumptions representing the upper range of reasonable exposure conditions and long-term exposure. Acceptable indoor air level increases with shorter exposures, as shown in a TCE concentration of 6 $\mu g/m^3$ being health-protective of a worker who is only exposed for eight hours a day compared to the 24-hour exposure of a resident. In addition, the worker is assumed to be in the same place of employment for 25 years compared to a resident who is assumed to be in the same residence for 30 years. As a result, the length of exposure is a primary factor that influences the indoor air levels considered safe for a particular scenario.

5.3.3 After-Hours Exposure

Workers may be present in the workplace to perform maintenance or cleaning activities after hours. Businesses could also have visitors who spend a few hours at the workplace instead of eight hours. The length of time that these individuals will spend in the workplace is much shorter than the people who work in the offices. As discussed in the preceding section, there is lower risk associated with shorter exposures to the same indoor air concentrations. Therefore, to keep the risks at the same acceptable level under different exposure conditions, the acceptable indoor air levels will be different. This is demonstrated in the lower acceptable indoor air concentrations for TCE (1 $\mu g/m^3$) for a residential building when the exposure is for 24 hours a day, 350 days a year for 30 years compared to acceptable indoor air concentration of 6 $\mu g/m^3$ for a commercial building when exposure is for eight hours a day, 250 days a year for 25 years.

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6.0 IDENTIFICATION AND SCREENING OF VAPOR INTRUSION CONTROL TECHNOLOGIES AND INSTITUTIONAL CONTROLS

Initial screening of remediation technologies and institutional controls (ICs) allows for development of a range of tools that can be used individually or combined to address potential vapor intrusion at the Site. Each technology or IC is initially screened based on effectiveness, implementability, and cost. The technologies and ICs that are retained based on this analysis are selected as is or combined into remedial alternatives, as appropriate, to be evaluated in the detailed analysis of alternatives.

6.1 EVALUATION CRITERIA FOR TECHNOLOGY AND INSTITUTIONAL CONTROL SCREENING

The initial screening of vapor intrusion control technologies and ICs is performed using three key evaluation criteria: effectiveness, implementability, and costs. These three criteria are the primary factors determining whether a specific technology or IC will be retained for further consideration either alone or by combining, into alternatives to control vapor intrusion at the Site. The three key initial evaluation factors are described below.

Effectiveness: This evaluation includes the following considerations for each vapor intrusion control method:

- Potential effectiveness meeting the vapor intrusion prevention goals identified in the remedial action objectives (Section 6.2) for future construction at existing and future buildings at the Site.
- Potential impacts to human health and the environment during the construction and/or implementation phase.
- Reliability and proven history in addressing Site-specific contaminants and conditions, for both existing and future buildings.
- Likelihood of each vapor intrusion control method to remain effective during property ownership and use changes, and the ability to monitor and enforce the remedy in the future.

Effectiveness of each technology and IC is rated qualitatively as low, moderate, or high.

Implementability: This evaluation encompasses both the technical and administrative feasibility of implementing a technology or IC. Aspects of implementability include the ability to obtain permits, the availability of treatment methods, and the availability of required equipment and skilled workers. Implementing some methods, such as an IC, may include factors such as coordination between different agencies and affected parties, and whether the entity deemed responsible to implement the IC possesses the jurisdiction, authority, and willingness to establish, monitor, and enforce this IC. Technologies and ICs 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.

Implementability of each technology and IC is rated as low (difficult), moderate, or high (easy).

Costs: This evaluation is for relative costs (capital and operation and maintenance) with respect to other technologies or ICs. Costs for each vapor intrusion control method include the estimated life-cycle cost for implementing, monitoring, maintaining, and/or enforcing the technology or IC. The life-cycle assumed for this FFS evaluation is 15 years, present worth. Relative cost comparisons are based on engineering and administrative experience and judgment.

Cost for each technology and IC is rated qualitatively as low, moderate, or high.

6.2 REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) are typically developed for specific COCs with a defined exposure route that will provide protection against adverse health or environmental effects. The initial RAOs established for the Site in 1991were for impacted groundwater and defined the intent of the extraction/discharge treatment system to reduce VOC levels to acceptable levels in the shallow groundwater (i.e., suitable for drinking water use). RAOs for vapor intrusion pathways were not identified at that time.

For this Site, the RAO to address vapor intrusion is:

1. Protect occupants of commercial and residential buildings at the Site by preventing subsurface Site contamination from migrating into indoor air above indoor air action levels for long-term exposure.

Table 5-4 lists the indoor air action levels for residential and commercial buildings at the Site. Sufficiently reducing the concentrations of VOCs in groundwater would address the source of VOCs with regard to vapor intrusion. This would eliminate or minimize the need for a vapor intrusion remedy. This RAO will not be addressed by the proposed vapor intrusion remedy but by the groundwater remedy selected for the Site.

Of note is that the indoor air quality of existing buildings at the Site currently meets the vapor intrusion RAO. As described earlier in Section 3.0, vapor intrusion control methods were implemented for the Gables End redevelopment to prevent vapor intrusion into these buildings. After installation of the engineering controls, verification sampling for the new residential buildings indicated no unacceptable risk was present in the indoor air. Based on results from indoor air sampling of existing buildings within the Site and north of Plymouth Street (ITSI, 2011a), vapor intrusion is not creating an unacceptable risk by inhalation of indoor air.

6.3 GENERAL RESPONSE ACTIONS FOR VAPOR INTRUSION

The types of vapor intrusion control methods being evaluated in this FFS being considered for remedial alternative development will be grouped into the following General Response Actions (GRAs) for purposes of initial screening:

- No Action: No action would be taken to control vapor intrusion.
- Monitoring: This action involves monitoring for vapor intrusion. The monitored medium can be groundwater, soil gas, sub-slab vapor, and/or indoor air.
- Physical Barriers or Containment: Physical barriers reduce air concentrations in the occupied space of buildings by blocking migration of vapors from subsurface to the buildings.
- Sub-Slab Pressure Control: These technologies prevent the migration of vapors into indoor air by inducing a pressure differential that would force the soil gas to flow away from the building.
- Point-of-Exposure Control: These technologies are designed to directly reduce indoor air concentrations in the occupied space.
- Institutional Controls: ICs include administrative actions and legal tools that do not involve engineering controls, physical actions, or changes at the Site. EPA recognizes four types of institutional controls applicable to the Site: government controls, proprietary controls, enforcement tools, and informational devices (EPA 2010).

Vapor control measures for deep foundations such as drilled piers or driven piles are not considered here because soil conditions at the Site are assumed to not require the use of deep foundations. In the unlikely event that deep foundations are planned for new construction at the Site, a plan describing the proposed construction methods, groundwater monitoring requirements, and vapor management would be submitted to the City of Mountain View and then to EPA under an applicable IC "trigger," and appropriate reviews and approvals would be obtained prior to permitting the construction.

6.4 IDENTIFICATION OF VAPOR INTRUCTION CONTROL TECHNOLOGIES AND INSTITUTIONAL CONTROLS

Vapor intrusion control technologies and ICs proposed in this FFS focus on both source and vapor intrusion pathway control to prevent unacceptable human exposure to TCE and other VOCs in indoor air as a result of vapor intrusion impacting indoor air quality. Technologies and ICs considered for this FFS are grouped below under the GRA categories described earlier:

1. No Action - No action would be taken to address vapor intrusion.
2. Monitoring - Monitoring could include groundwater, indoor air, sub-slab vapor, and/or soil gas. Monitoring could be performed to verify that vapor intrusion is not impacting indoor air, and/or to confirm that applied vapor control measures are effective. In addition, some monitoring and characterization may occur to establish if another GRA is more suitable for protection of human health from vapor intrusion.
3. Physical Barriers or Containment - Technologies that provide a physical barrier to the vapor intrusion pathway, and include:
   - Vapor barriers;
   - Modified soil barriers;
   - Modified on-grade foundations;
   - Conduit sealing; and
   - Surface coatings.
4. Sub-Slab Pressure Control – These vapor intrusion control technologies prevent vapor migration into indoor air by applying differential pressure in the subsurface (below the building slab) to force soil gas away from the building enclosure. These technologies include:
   - Sub-slab passive ventilation;
   - Sub-slab pressurization;
   - Sub-slab depressurization;
   - Sub-membrane depressurization;
   - Air injection curtains.
5. Point-of-Exposure Control – These technologies are designed to reduce air concentrations in the building at the point of exposure, and include:
   - Exhaust of indoor space;
   - Mechanical heating, ventilation, and air-conditioning system adjustments; and
   - Air purification/filtration.
6. Institutional Controls – Non-engineered administrative and legal controls exercised through governmental and planning channels that restrict and define building and land use on specific parcels or areas, and include:
   - Government controls;
   - Proprietary controls;
   - Enforcement tools; and

- Informational devices.

6.5 INITIAL SCREENING OF VAPOR INSTRUSION CONTROL TECHNOLOGIES FOR FUTURE BUILDINGS

This section describes the results from initial screening (effectiveness, implementability, and cost) of the vapor intrusion control methods listed in the preceding section. As described earlier in this FFS, residences in the Gables End development are considered existing residential buildings with vapor intrusion control measures already in place. However, the vapor intrusion control measures implemented at Gables End (i.e., vapor barrier/sub-slab passive ventilation system and ICs) are among the technologies evaluated in this FFS for future construction at existing buildings or for future buildings; therefore, this initial screening applies to future construction at the Site.

6.5.1 No Action

For this option, no future action would be taken to address the vapor intrusion pathway at the Site. In accordance with EPA regulatory guidance, this option will be included in the detailed evaluation of vapor intrusion control alternatives. Inherent in the no action option is a building's natural ventilation through air exchange with exterior air. No action may be an appropriate choice if vapor intrusion is shown to pose an acceptable risk to human health.

Under applicable regulatory guidance, the no-action alternative is not included in this initial screening evaluation but is included in the detailed analysis.

6.5.2 Monitoring

Groundwater, indoor air, and/or soil gas sampling and analysis are included in monitoring, with specifics on each as follows:

- Groundwater monitoring provides information on plume boundaries and concentrations, notably the uppermost groundwater zone. Definition of plume boundaries (see Figure 1-2) would indicate whether the vapor intrusion study area should be modified. Long-term groundwater monitoring also provides data to assess if the potential for vapor intrusion exposure is increasing or decreasing.
- Indoor air monitoring provides information on the concentration of VOCs in the building. In addition, only this type of monitoring provides the ability to directly evaluate whether vapor intrusion is occurring at the Site. As part of indoor air monitoring, an assessment of chemicals stored or used inside the building needs to be conducted to assess if vapor intrusion is the source of detected concentrations.
- Soil gas samples provide one line of evidence in the vapor intrusion pathway assessment. Soil gas monitoring includes subsurface soil gas and sub-slab vapor sampling. Subsurface soil gas samples collected spatially apart and at multiple depths provide information to assess the vapor intrusion pathway. Sub-slab vapor

concentrations relative to indoor air concentration indicate if the building slab is providing effective attenuation.

Effectiveness: Monitoring can be used to evaluate changes in the potential for vapor intrusion. Monitoring groundwater concentrations near the water table provides information if the potential for vapor intrusion is changing in overlying buildings over time. Indoor air monitoring provides information for assessing if VOC concentrations are below long-term exposure goals and that vapor intrusion control measures are effective. Soil gas monitoring allows an evaluation of whether VOC concentrations in the subsurface could migrate into buildings.

<u>Rating:</u> Low - Monitoring by itself is not effective for vapor intrusion control if data indicate that the site of new construction is susceptible to potential vapor intrusion risk. The effectiveness is the same for residential or commercial buildings.

Implementability: Monitoring can be readily implemented prior to construction, and following construction. Established practices and procedures exist for monitoring groundwater, soil gas, or indoor air. Access is a key consideration in successfully implementing a monitoring plan. Long-term monitoring is preferred in establishing concentrations and trends in VOC concentrations (notably for groundwater and indoor air).

<u>Rating:</u> Easy - Subject to access approval, monitoring is a proven tool for evaluating VOC concentrations in media of concern with time. Access issues may result in monitoring not always occurring at the preferred location. Other than access considerations, implementability is the same for residential or commercial buildings.

Cost: Although established methods, procedures, and practices exist for monitoring, costs are typically moderate as monitoring occurs on multiple occasions over the long-term to confirm that conditions are still safe. Costs can vary depending on the level of monitoring required to confirm concentrations and establish if a future building has a potential vapor intrusion risk.

<u>Rating:</u> Moderate - Monitoring is an economical tool to assess potential vapor intrusion risk for a future building, whether residential or commercial, though costs increase significantly as additional monitoring events occur over time.

Screening Summary: Not retained as a stand-alone technology. Monitoring is not effective for preventing risk to human health. Monitoring, in conjunction with engineering controls to verify the effectiveness of the engineered controls, or in conducting pre-construction sampling, is retained.

6.5.3 Physical Barriers or Containment

Physical barriers are designed to lower indoor air concentrations by physically blocking vapor migration from the subsurface into building enclosures using the specific controls described below.

6.5.3.1 Vapor Barriers

Vapor barriers provide a physical barrier to chemical vapor migration. These barriers can be either synthetic liners or seamless, spray-applied membranes. Synthetic liners are typically constructed of high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE), or polyvinyl chloride as described further below.

- HDPE geomembrane liners have three layers of material. The material is stiff, strong, and resistant to tears and punctures. The correct installation and welding of HDPE liner material is of critical importance to ensure integrity and long-term performance of the liner. The seaming of the liner is performed by hot wedge welding and is performed by qualified installers. In addition, HDPE liners are rodent and root resistant.
- LLDPE liners are more flexible than HDPE liners and can be elongated in one or more directions to accommodate uneven or unsettled ground. High elongation properties make LLDPE liners ideal when increased puncture resistance is required due to ground irregularities. LLDPE is fusion and extrusion welded on-site.
- PVC liners are thinner and more flexible than LLDPE liners and are very easy to patch or seam together. PVC liners are less susceptible to stress, heat, or thermal expansion and can stretch to conform to moving or irregular ground surfaces.

A common spray-applied vapor barrier is Liquid Boot®, which is spray applied as a cold, water-based (i.e., no VOCs), seamless monolithic, membrane. It is typically applied at a thickness of 60-100 mils over a base fabric. For new construction, Liquid Boot® is applied under concrete slabs and sealed to all footings and pipe penetrations.

Effectiveness: Vapor barriers are typically applied in conjunction with passive venting as a low-cost additional safeguard against vapor intrusion. Together these two technologies have a proven record of preventing the migration of VOCs into buildings, though this effectiveness depends upon the design, installation quality, and long-term maintenance of the barrier. Post-construction modifications to building structures need to avoid puncturing the barrier. Properly sealed seams and sealing around utility penetrations are key factors in the effectiveness of vapor barriers.

Rating: High - Effective vapor barriers can be designed and installed for either residential or commercial buildings. If vapor barriers are installed without passive venting, then effectiveness is down-graded to moderate.

Implementability: Vapor barriers are easy to install for future building construction because designs and installation materials and practices are established. Qualified contractors are available. Care needs to be taken to prevent compromising the vapor barrier after installation of building modifications or new utilities. Implementation of repairs or other vapor barrier modifications may be difficult post-construction of a new building.

Rating: Relatively Easy - Incorporation of the design and installation of a vapor barrier is readily implemented for future buildings, whether residential or commercial.

Cost: Costs vary depending upon the size of the building, type of barrier, and extent of utility penetrations.

Rating: Moderate - Costs are moderate for installing a vapor barrier as part of new building construction.

Screening Summary: Retained. This is a proven method for limiting vapor intrusion as part of the construction of new buildings. Installation is commonly associated with a passive venting system because reliability of vapor barriers as a stand-alone technology has not been demonstrated.

6.5.3.2 Modified Soil Barriers

This technology consists of applying a bentonite-soil mixture under a building to create a barrier with minimal air pores. These relatively impermeable soils reduce the upward migration of VOCs.

Effectiveness: Modified soil barriers limit the migration of VOCs into buildings by establishing a low-permeability barrier under the building. This effectiveness depends upon the design, installation quality, and long-term maintenance of the barrier. Drying may limit the effectiveness of the barrier.

Rating: Moderate - Long-term effectiveness is less than that of the vapor barrier. This technology can be used for both residential and commercial buildings. Other technologies typically need to be included to achieve a suitable level of vapor intrusion prevention.

Implementability: Modified soil barriers are easy to install for future buildings as designs and installation materials and practices are established. Qualified contractors are available. Implementation of repairs or other vapor barrier modifications may be difficult post-construction of a new building.

Rating: Easy - Incorporation of the design and installation of a modified soil barrier is readily implemented for future buildings, whether residential or commercial.

Cost: Costs vary depending upon the size of the building.

Rating: Moderate - Costs are moderate for installing a modified soil barrier as part of new building construction.

Screening Summary: Not retained. This technology is most commonly used to minimize differential settlement for new building construction. Limited information is available on the long-term effectiveness of a modified soil barrier to control vapor intrusion, especially relative to vapor barriers.

6.5.3.3 Modified On-Grade Foundations

This technology includes monolithic concrete pours that limit cold joints and may include low air-entrainment, post-tension reinforcement, and thickened-mat slabs.

Effectiveness: This technology may reduce indoor air concentrations, but the technology does not eliminate pathways through the building slab. Long-term integrity of the monolithic concrete slab is hard to achieve for buildings with a larger footprint.

Rating: Low to Moderate - Effectiveness is less than that of the vapor barrier, and this technology does not limit vapor intrusion pathways into a building. This technology can be used for residential or commercial buildings, depending upon the area of the building footprint.

Implementability: Modified on-grade foundations can be implemented in new buildings as designs and installation materials and practices are established. Qualified contractors are available. Implementation of repairs or other vapor barrier modifications may be difficult post-construction of a new building.

Rating: Relatively Easy - Incorporation of the design and installation of a modified on-grade foundation is readily implemented for future buildings, whether residential or commercial.

Cost: Costs will vary with the size of the building footprint, and the requirements to reduce vapor intrusion pathways.

Rating: High - The costs are higher than installing a modified soil barrier and just as effective.

Screening Summary: Not retained. This technology is not a cost-effective containment technology for vapor intrusion prevention.

6.5.3.4 Conduit Sealing

Conduit sealing is used for dry conduits that serve as a direct pathway for vapors from the sub-slab into the building. Expanding foam, pourable polyurethane, and plugs are examples of conduit sealants.

Effectiveness: This technology is only effective at minimizing the vapor intrusion pathway associated with dry conduits. This technology needs to be combined with other technologies to achieve vapor intrusion control.

<u>Rating:</u> High for Dry Conduit vapor intrusion pathway only. This technology only addresses one possible vapor intrusion pathway, and needs to be combined with other technologies to suitably address all vapor intrusion control needs or pathways.

Implementability: This technology can be readily implemented in new construction on existing and future residential and commercial buildings. Proven materials and installation practices exist for conduit sealing.

<u>Rating:</u> Easy

Cost: The cost for implementing conduit sealing is low since this technology is easy to apply.

<u>Rating:</u> Low - Costs for conduit sealing are low.

Screening Summary: Retained. Conduit sealing may be combined with other technologies for vapor intrusion control alternatives.

6.5.3.5 Surface Coatings

Cracks or holes in floors can be sealed using expandable sealants to block a vapor intrusion migration pathway. These sealants can also be applied in the annulus around a conduit penetration of the floor.

Effectiveness: While having been used for vapor intrusion mitigation, the effectiveness depends on the design and installation quality, as well as long-term maintenance. Re-application of the coating may be required for long-term maintenance. As all cracks, holes, or other penetrations in the building foundation that enables VI may not be accessible, the effectiveness of this technology will vary.

<u>Rating:</u> Low to Moderate - This technology would have to be combined with other technologies to achieve desired level of effectiveness.

Implementability: This technology can be implemented in new residential and commercial buildings. In new construction, proven materials and installation practices exist for surface coatings. Implementation of long-term maintenance of surface coatings is limited for those areas where carpeting or tile has been installed.

Rating: Easy to Moderate - Implementability will change with the life of a structure.

Cost: Costs vary depending on the type of surface coating used.

Rating: Low to Moderate - This technology is not as cost-effective as other vapor intrusion control measures.

Screening Summary: Not retained. For both existing and new buildings, this technology is not a cost-effective containment technology for vapor intrusion control.

6.5.4 Sub-Slab Pressure Control

Pressure controls below the foundation slab prevent vapor migration into indoor air by applying differential pressure in the subsurface (below the slab) to force soil gas flow away from the building enclosure.

6.5.4.1 Sub-Slab Passive Ventilation

A sub-slab passive ventilation system consists of perforated pipes within an aggregate or sand layer, manifolded to a vertical riser that conveys the vapors to a vent above the building roof. The roof vent riser typically terminates with a wind-driven turbine that would create a slight negative pressure in the subsurface, thus inducing vapor flow from the subsurface to the outside air via the vent. Being a passive system, no mechanical equipment is included with the ventilation.

Effectiveness: This technology is effective to the extent that the induced negative pressure and capture of vapors covers the extent of the building slab. As a pressure differential typically exists between the sub-slab and the building, a vapor barrier is commonly needed for this passive ventilation system to achieve the desired effectiveness for vapor intrusion control.

Rating: Moderate - Needs to be combined with a suitable vapor barrier to achieve vapor intrusion control.

Implementability: This technology can be readily integrated into the construction of new residential or commercial buildings. Standard construction procedures and practices would be involved. Installation commonly includes provisions to modify, if needed, to an active mechanical depressurization system, especially for larger commercial buildings.

Rating: Easy to Moderate - Readily integrated into new building construction. Implementation typically combined with suitable containment technology.

Cost: Cost will vary with the size of the building (i.e., number of vents to achieve sub-slab ventilation).

Rating: Low to Moderate - Technology uses readily available materials and construction procedures.

Screening Summary: Retained. For new buildings, combine with suitable containment technology to achieve cost-effective vapor intrusion control.

6.5.4.2 Sub-Slab Pressurization

Outside air is actively introduced below the building slab. The small, positive pressure created just below the building slab forces outside air into the pore spaces. This pressure layer eliminates the convective flow of vapors from the underlying soil. A system of exhaust vents is included to control the distribution of the sub-slab pressurization.

Effectiveness: VOC concentrations in ambient air would have to be sufficiently low as not to be of concern for vapor intrusion risk to human health. A layer of aggregate or sand placed below the slab enhances the effectiveness of this technology by creating a suitable pathway for uniform distribution of the air and associated sub-slab pressurization. If direct conduits or other seams are present allowing an undesired ventilation pathway, the pressure distribution may not be uniform under the building slab. Construction needs to be carefully performed to ensure that slab penetrations do not allow short-circuiting of the air.

Rating: Moderate - For new buildings, other vapor intrusion control technologies are more effective.

Implementability: This technology can be implemented in new buildings, whether residential or commercial. Installation and operation of this system would rely on standard construction practices and readily available materials. Vapor treatment, if required, may be an implementation issue for some buildings. This technology cannot be implemented for buildings with a basement below the water table; however, this is not expected to be an issue for new buildings at the Site.

Rating: Moderate - For new buildings, other vapor intrusion control technologies are more effective.

Cost: Cost will vary with the size of the building.

Rating: High - Relative to other technologies, cost is high.

Screening Summary: Not Retained. For new or future buildings, more cost-effective vapor intrusion control technologies are available.

6.5.4.3 Sub-Slab Depressurization

This technology is similar to sub-slab pressurization with regard to sub-slab construction in that a blower is connected to the system; however, in this case, the blower creates a slight negative sub-slab pressure by removing air beneath the foundation. This induces soil gas flow into sub-slab piping with discharge from the blower to a vent on the roof. The blower discharge is considered a point source and subject to rules and permit requirements of the BAAQMD and may require treatment depending upon VOC emissions.

Effectiveness: This technology has been shown to be effective in controlling vapor intrusion. Besides removing VOCs from under the building slab, the negative pressure contributes to a net air movement from the building to the sub-slab if air flow pathways exist in the building slab.

Rating: High - Proven technology for vapor intrusion control. Can be applied to both residential and commercial buildings, although generally more common in commercial applications due to the building footprint size.

Implementability: As with sub-slab pressurization, this technology can be implemented in new residential or commercial buildings using standard construction practices and readily available materials. This technology also may be subject to vapor treatment requirements and cannot be implemented for buildings with a basement below the water table. However, this is not expected to be an issue for new buildings at the Site.

Rating: Relatively Easy - Readily implemented and maintained for new buildings.

Cost: Costs will vary depending upon the size of the building. While applicable to both residential and commercial buildings, costs are higher for commercial buildings due to the areal extent of the building footprint.

Rating: Moderate to High - Costs for new residential units are moderate, while higher costs are typical of new commercial buildings.

Screening Summary: Retained. Sub-slab depressurization is an alternative associated with vapor intrusion control for new residential and commercial buildings. This alternative assumes that vapor treatment is not required.

6.5.4.4 Sub-Membrane Depressurization
This technology is the same as sub-slab depressurization except that the system is installation below a membrane instead of a building slab. The membrane prevents short circuiting of air during depressurization of the soil. The membrane can be made of polyethylene materials or plastic sheeting placed over the earthen or gravel area. Sealing must occur at any membrane penetrations as well as along the edges of the foundation wall or footings.

Effectiveness: This technology is effective for vapor intrusion control, especially for buildings with crawlspaces. The membrane hinders flow of air to the building and the depressurization conveys vapors below the membrane to the ambient air using a fan-powered vent.

Rating: High - Suitable for both new residential and commercial buildings, especially for buildings with crawlspaces.

Implementability: This technology can be implemented in new buildings (residential or commercial) with crawlspaces. Accessibility is an implementation issue for the crawlspace. Sufficient headspace is needed to install the membrane, and padding should be placed over the member so that future crawlspace access will not damage the membrane. In addition, access needed to seat membrane in footings, walls, and pipes.

Rating: Relatively Easy - Rating is for new buildings (residential or commercial) with crawlspaces.

Cost: Costs are similar to passive barriers and sub-slab depressurization.

Rating: Moderate to High - Cost depends upon ability to install and maintain integrity of membrane.

Screening Summary: Not Retained. Future buildings are not expected to have crawlspaces.

6.5.4.5 Air Injection Curtain
A series of air-injection wells are placed in a line between the source (e.g., groundwater plume) and structures. The injected air is intended to establish a barrier that prevents migration of vapors through the subsurface.

Effectiveness: This technology may reduce the horizontal migration of vapors, but not if the source of the vapors are below the building. As the primary pathway of vapor migration at the Site is vertical, this technology would not be effective for vapor intrusion control.

Rating: Low

Implementability: While easily implemented for the area surrounding a building, this technology is not readily implementable in the subsurface below a building, even for new buildings.

Rating: Difficult

Cost: Costs are high, and cost-effectiveness is low.

Rating: High

Screening Summary: Not retained.

6.5.5 Point-of Exposure Control

Point-of-Exposure measures directly reduce chemical air concentrations at the point of receptor exposure.

6.5.5.1 Exhaust of Indoor Space

Fans remove air from the building interior with ambient, make-up air moving into the building through doors, windows, or other openings. Similar to bulk air exhaust associated with bathrooms and kitchens, and large open buildings such as warehouses.

Effectiveness: While effective in removing air from a room, applying this technology to a whole building could result in negative pressure zones in the building. Such negative pressure zones could enhance vapor intrusion.

Rating: Low - Applicable to individual rooms, but not effective for vapor intrusion control for entire buildings.

Implementability: This technology could be implemented in new residential or commercial buildings. Implementation involves standard construction materials and procedures.

Rating: Easy to Moderate - Size of building, openness of building, and other factors influence implementability.

Cost: Technology uses common materials. Overall costs would be low.

Rating: Moderate - Costs are dependent on energy consumption, so cost-effectiveness can be low compared to other vapor intrusion control technologies.

Screening Summary: Not retained.

6.5.5.2 Mechanical Heating, Ventilation, and Air Conditioning System Adjustments

Mechanical heating, ventilation, and air conditioning (HVAC) systems provide ventilation for buildings by conveying outdoor air into building enclosures. This is a common method of improving indoor air quality through adjustments to this system. The air exchange rate associated with HVAC systems is the rate at which the indoor air is exchanged with outdoor air. As an example, an air exchange rate of 4 per hour means that the indoor air is exchanged 4 times per hour. An HVAC system can also induce a positive pressure in a building if operated at a sufficient level, thus reducing the migration of VOCs into buildings. The operation of HVAC system can also dilute VOC concentrations in indoor air, the extent dependent upon VOC concentrations in the ambient air.

Effectiveness: Exchanging indoor air with outdoor air, VOCs can be removed to the extent of the dilution potential of the ambient air. Tests at buildings have shown that sufficiently high air exchange rates are effective in keeping VOC concentrations below health risk goals, demonstrating the effectiveness of HVAC systems.

<u>Rating:</u> High - HVAC systems are especially applicable to commercial buildings which rely on the HVAC system for normal air exchange associated with ventilation and heating. Effectiveness is less for residential buildings as the HVAC system is not consistently used for ventilation control.

Implementability: An effective HVAC system for vapor intrusion prevention can be readily designed and installed in new residential or commercial buildings. Long-term implementation requires that the HVAC system operate as intended if vapor intrusion control is to be sustained.

<u>Rating:</u> Moderate - Implementation can be incorporated into the design and construction of new residential or commercial buildings. Appropriate operation of HVAC system is an issue for long-term implementation.

Cost: Costs will depend upon the extent that the HVAC system needs to be upgraded to achieve the desired air exchange rate and interior building positive pressure. Operating costs are high relative to most other vapor intrusion control technologies.

<u>Rating:</u> Moderate to High - Costs will vary for residential and commercial buildings.

Screening Summary: Retained. Technology has demonstrated performance in controlling vapor intrusion, notably in commercial buildings which tend to rely on the HVAC system for ventilation and heating. Technology is not retained for residential buildings which may not consistently rely on the HVAC system for ventilation and heating.

6.5.5.3 Air Purification/Filtration

This technology uses establishes technologies to remove VOCs from indoor air. A blower conveys indoor air to a purification vessel of vapor-phase granular activated carbon that removes the VOCs.

Effectiveness: This technology removes VOCs from indoor air, although the systems are not normally sized to enable treating the entire air flow through the HVAC system. This technology is mostly effective for air purification in small or enclosed rooms. Institutional controls would need to be established to make sure the air purification system was properly operated and maintained.

<u>Rating:</u> Moderate – This technology is relatively effective for vapor intrusion control for small, contained rooms in existing or new buildings (residential or commercial).

Implementability: This technology can be implemented, as standard procedures and construction practices are associated with the technology. Equipment and services to maintain the system are commercially available. An issue for implementation is space, although this could be incorporated into the design and construction for new buildings.

<u>Rating:</u> Moderate to Difficult - Implementability for the long-term is an issue for this technology.

Cost: Costs are high, especially relative to long-term effectiveness of this technology to achieve vapor intrusion control for an entire building.

<u>Rating:</u> High

Screening Summary: Not retained for an entire building. May be applicable on an individual building basis for small, contained rooms with VOC concentrations exceeding indoor air screening levels.

6.5.6 Institutional Controls

The effectiveness and/or implementability of a technology for vapor intrusion can be dependent upon effective concurrent application of appropriate ICs. This FFS will evaluate application of both stand-alone ICs and ICs in conjunction with other technologies. In particular, stand-alone ICs may be useful in instances where risk has been demonstrated not to be present for occupants under existing land and building use conditions. ICs are also commonly associated with properly operating and maintaining installed vapor intrusion control systems.

Four types of ICs are recognized by EPA (EPA, 2010b):

- ***Government Controls:*** Government controls use the regulatory authority of a governmental entity (normally a state or local government) to impose restrictions or requirements on citizens or property under the entity's jurisdiction. Examples of governmental controls include land use plans, zoning restrictions, ordinances, statutes, review of building permits, or other restrictions on land or resource use at a site (USEPA, 2000). Upon implementation, local and state entities use traditional police powers to regulate and enforce the ICs.
- ***Proprietary Controls:*** These controls have their basis in real property law and involve legal instruments placed in the chain of title of a property. Examples of proprietary controls are easements and covenants. The benefit of this type of IC is that they can be binding on subsequent purchasers of the property and transferable, which may make them more reliable in the long-term than other types of ICs. While proprietary controls are largely developed on a case-by-case basis, several states and national organizations (e.g., American Bar Association, Environmental Law Institute, US Navy, American Petroleum Institute) have adopted the Uniform Environmental Covenants Act (UECA) as a model for applying consistent application of ICs across state boundaries and on future activities at impacted sites. An example of an existing proprietary control at the Site is the environmental restrictive covenant that the vapor intrusion control system for the Gables Development will be maintained until the homeowners association is released from this responsibility by EPA.
- ***Enforcement and Permit Tools:*** These ICs include unilateral administrative orders and permits to compel a land owner to limit certain site activities, prohibit land use in certain ways, or from conducting certain activities at a property. Consent decrees and federal facility agreements requiring the performance of specific activities (e.g., monitoring and reporting on IC effectiveness) are also examples of this type of IC, which may be issued unilaterally or negotiated.
- ***Informational Devices:*** Informational tools 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.

ICs are response actions under CERCLA and are subject to the same FFS evaluation criteria as applied to active vapor intrusion control technologies. As such, ICs are expected to form part of the available alternatives to prevent vapor intrusion, and eventually be included within the expected ROD Amendment.

To determine whether a particular IC is applicable to the Site, the objective, mechanism, timing, and responsibility of an IC needs to be determined (USEPA, 2000) as described in greater detail below.

Objective - The objective of any IC is to ensure that the vapor intrusion prevention alternatives are implemented and monitored properly to minimize the potential for human exposure to contamination. The IC objectives for this Site are to: 1) ensure that any changes to the slab integrity of existing buildings at the Site is appropriately reviewed with regard to potential need for and appropriateness of engineering controls to prevent indoor air contamination due to vapor intrusion as required by the remedy; and 2) ensure that the appropriate engineering controls, if necessary, are installed, operated, maintained, and/or monitored for any future development or building modification at the Site. Commercial buildings may have different ICs from residential buildings and may differ based on the remedy chosen. Since different parties may be involved with the long-term operation and maintenance of a vapor intrusion remedy, layered ICs may be required to ensure that all parties (e.g., building owners, building operators, the responsible parties, and EPA) are appropriately involved and informed regarding the remedy implementation.

Mechanism - The types of ICs needed to meet the various remedial objectives encompass the proper implementation, including operation and maintenance, of the vapor intrusion control alternatives. These ICs include governmental controls, proprietary controls, enforcement tools, and informational devices. Coordination will be required to ensure that the appropriate remedy is installed, operational, and maintained at each building and property. This will require that all parties (EPA, City of Mountain View, responsible parties, property and building owners, and tenant/occupants) work together at the Site to develop the necessary "layers" of ICs to effectively implement the vapor intrusion remedy and ensure long-term protectiveness of the remedy.

Timing - Several IC mechanisms are already in place, including codes and local permits, for the new residential development at the Site. Continued monitoring and updating, as appropriate, will be needed for these ICs.

Responsibility - While the responsible parties have ultimate responsibility to ensure ICs are utilized for the vapor intrusion remedy, planned layering of ICs requires implementation, enforcement, maintenance, and cooperation by all parties. For instance, while the City of Mountain View will have responsibility for issuing governmental ICs, such as building permits associated with new construction at and in the vicinity of the Site, EPA will need to be notified and have time to review and approve the building modification plan and vapor intrusion control actions as determined from multiple lines of evidence. In addition, proper operation and maintenance of the vapor intrusion remedy requires cooperation by property and building owners, tenants, and remedy operators.

The ICs identified for the Site are described below with the same screening criteria evaluation of effectiveness, implementability, and cost as presented for the technology review.

6.5.6.1 Government Controls

Government control ICs consist of zoning and zoning overlays, municipal ordinances, and local permits/state codes. This includes discretionary land use permits, planning and building permits, and state codes that set forth specific requirements or provide for the imposition of specific conditions before an activity is performed. Building permit reviews conducted by the City of Mountain View would include notification to EPA and the responsible parties of any new construction (new building or modification of an existing building) at the Site. Following the example established for the MEW Superfund Site also in Mountain View, EPA will work with Mountain View to establish planning and permitting procedures for new construction at the Site.

Requiring engineering controls to address potential vapor intrusion into buildings would be enforceable based on building code compliance requirements, deed restrictions, and/or City of Mountain View development approvals and permits. Design drawings, showing the vapor intrusion control measures, would have to be signed and stamped by a registered professional engineer and approved by EPA. As part of construction for a new building or remodeling of an existing building where the building slab or subsurface is disturbed, an inspection of installed vapor intrusion control measures, if necessary, would be required by the City. This inspection would cover vapor barriers and/or other vapor intrusion control measures that may need to be installed prior to new construction. In addition, EPA would likely require their approval of a plan for the new construction detailing actions to be taken if multiple lines of evidence indicate the potential for vapor intrusion to impact indoor air quality for the newly constructed building.

Effectiveness: The City of Mountain View's current planning review and permitting process for new development requires preventive measures for properties identified as having residual contamination, such as at this Site. The following elements have been identified as part of the City of Mountain View's review and approval process for new buildings or developments:

- Coordination with regulatory agencies and responsible parties,
- Coordination among appropriate City departments,
- Independent consultant to review related environmental documents, including amended EPA decision documents,
- Planning department includes conditions on permit approval and coordinates with the City's building department and EPA, and
- Building department follows a checklist of permit conditions prior to approval ensuring that environmental conditions are met.

Besides EPA's review and approval of the new construction plan and determination of the need for vapor intrusion control, the City's building permit process and use of City planning tools assist in ensuring the effectiveness of this IC for new construction and development.

Rating: Moderate. The City has an existing program of working with the EPA to develop effective measures for the construction of new developments and modification of existing buildings. Codifying an IC will help ensure that vapor intrusion control measures at the Site are effective for both the short-term and long-term. The ability to sustain this IC is the primary reason for a moderate rating.

Implementability: The implementation of the vapor intrusion remedy would require a formal and enforceable mechanism, such as EPA approval and independent, signed confirmation, to ensure proper implementation. Also, the City of Mountain View must update and maintain their address database to ensure that any construction-related request involving Site properties triggers a meaningful response. Property owners and contractors also are bound to follow City guidelines and permitting requirements when implementing new construction. As a result, risk is present should the identified process to implement this IC be ignored.

Rating: Moderate. While the City of Mountain View has implemented this IC, long-term implementation and enforcement are not guaranteed and will require continued monitoring to maintain.

Cost: Costs for this IC would encompass multiple actions, somewhat similar to components of the California Environmental Quality Assessment (CEQA) process. As these costs are primarily associated with establishing the zoning overlay for properties of the Site and maintaining the controls, a range of annual costs can be expected in consideration of the size of the Site. However, costs are expected to fall on government (local and federal – through EPA), property owners, and the responsible parties to establish, administer, and adhere to the IC.

Rating: Moderate. Cost will depend upon the extent of application for this IC.

Screening Summary: Retained. This IC has already been applied in the City of Mountain View through a nearby and similar Superfund site, and likely will be applied in the future at this Site.

6.5.6.2 Proprietary Controls

Proprietary ICs consist of covenants to restrict specified activities on individual properties associated with or in the vicinity of the Site that could result in unacceptable risk to human health and/or the environment. A proprietary control in the form of a land use covenant was recorded in April 2010 by the owners who redeveloped the properties associated with the former CTS Printex facility. Among other things, this covenant prevents exposure to contaminated groundwater, prohibits all groundwater use, and restricts activities that may impact groundwater. In addition, the covenant requires implementation of an Operations, Maintenance, and Monitoring Plan (OMMP) outlining the procedures required to monitor and maintain the integrity of the vapor control system installed. The Gables End Home Owners Association is responsible for maintaining the integrity of the installed vapor control system.

Currently, there are no land use restrictions on the land overlying the downgradient portion of the Site. These properties, located north of Plymouth Street, are privately owned.

Effectiveness: Recorded covenants "run with the land," meaning that they are binding on subsequent property owners and would be in place permanently until revoked. The recorded language must be general enough to apply to future conditions yet specific enough to bind future owners to those conditions. Over the long term, recorded covenants could be effective in informing future property owners of vapor intrusion issues and remedial requirements.

Rating: High. Environmental covenants have been applied on a case by case basis already at the Site and would be effective in informing property owners regarding requirements for future construction to ensure that sufficient vapor control measures are in place.

Implementability: Recorded covenants would need to be negotiated with the current property owner s for the properties north of Plymouth Street at the Site. Once implemented, these covenants would run with the land, and apply to future owners until released by EPA. Obstacles to implementation of recorded covenants may include the fact that the current property owners are not named responsible parties under the Consent Decree for the CTS Printex Site, and the likelihood of resistance from property owners to recording such requirements on their title. For the portion of the Site north of Plymouth Street, there are four property owners. Negotiation of recorded covenants with owners of these properties could be time consuming and difficult, notably as existing buildings do not have indoor air impacted by vapor intrusion.

Rating: Moderate to Difficult. ICs of this type are property-specific instead of by zone/area; therefore, these ICs must be negotiated on a case-by-case basis with individual property owners.

Cost: There are transaction costs for negotiating the covenants and costs to record the restrictive covenants. Annual O&M costs associated with this IC include monitoring of the covenants, including notification of owner/tenant change and building modifications. O&M costs would also include third-party monitoring of property transactions. The annual O&M cost is expected to be minimal.

Rating: Moderate.

Screening Summary: Retained. This IC has already been applied and likely will be applied in the future at this Site.

6.5.6.3 Enforcement Tools

Enforcement ICs are a separate IC designed to also limit Site activities and/or require the performance of certain activities at the Site. These ICs include property-specific administrative orders and consent decrees.

Effectiveness: Similar to other ICs, Enforcement ICs are effective only as long as compliance with the mandated activities can be confirmed. Enforcement ICs can be grouped with other ICs in a layered approach; however, care must be taken to avoid misunderstandings through conflicting IC direction.

Rating: Moderate.

Implementability: Enforcement ICs are relatively more difficult to implement as they may require negotiation to achieve agreement between the enforcing entity and the affected landowner.

Rating: Moderate - Difficult

Cost: Costs for this IC are expected to be low to moderate, as costs are naturally dependent on the degree of enforcement required in the future, which in turn is heavily dependent on the type(s) of ICs applied to future Site use.

Rating: Moderate.

Screening Summary: Not Retained. This IC would be difficult to administer since it would bind third parties not affiliated with potentially responsible parties at the Site.

6.5.6.4 Informational Devices

Informational ICs consist of recorded notices and public notices, and as such are passive controls that have very limited enforcement capability to prompt a property owner to adhere to the guidance presented within the notice. The informational devices provide a means to inform property owners and tenants regarding Site issues and/or planned activities.

Effectiveness: While Informational ICs provide relatively high visibility to attempt to control Site activities, virtually no enforcement capability exists within these controls to ensure that requested actions are duly taking place.

Rating: Low

Implementability: Placing information of the Site through recorded notices, Site Registries, or other notification methods is relatively easy to implement.

Rating: Easy

Cost: Preparing informational notices is not cost-prohibitive unless this requirement is maintained for the long-term, with updating as necessary.

Rating: Low.

Screening Summary: Retained. This IC is typically grouped with other ICs to help inform and therefore encourage compliance with more restrictive ICs. An example of this is creating a Site fact sheet that the City of Mountain View can provide to parties seeking a permit for new construction at the Site, thereby explaining the need for vapor intrusion control for specific properties. As a result, this IC can potentially be applied to future construction at the Site.

6.6 RETAINED TECHNOLOGIES

Table 6-1 presents a summary of retained technologies and institutional controls for alternative development.

Table 6-1
Retained Technologies and Institutional Controls for Alternative Development
CTS Printex Superfund Site
Mountain View, California

General Response Action	Vapor Intrusion Prevention Technology or Institutional Control	Retained for Alternatives Development
No Action	No Action	
Monitoring	Monitoring	√
Physical Barriers or Containment	Vapor Barriers	√
	Modified Soil Barriers	
	Modified On-Grade Foundations	
	Conduit Sealing	√
	Surface Coatings	
Sub-Slab Pressure Control	Sub-Slab Passive Ventilation	√
	Sub-Slab Pressurization	
	Sub-Slab Depressurization	√
	Sub-Membrane Depressurization	
	Air Injection Curtains	
Point of Exposure Control	Exhaust of Indoor Space	
	Mechanical HVAC Adjustments	√
	Air Purification/Filtration	
Institutional Controls	Government Controls	√
	Proprietary Controls	√
	Enforcement Tools	
	Informational Devices	√

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7.0 DEVELOPMENT, DETAILED ANALYSIS, AND APPLICATION OF VAPOR INTRUSION CONTROL ALTERNATIVES

This section presents the development, evaluation, and suggested application of alternatives for vapor intrusion control at the Site. As these alternatives are being developed for future application toward potentially varied land use and building scenarios, a suggested application of how to apply the most favorable alternative(s) to the likely future Site conditions is presented in Section 7.4.

7.1 DEVELOPMENT OF ALTERNATIVES

Vapor intrusion technologies and institutional controls retained (see Table 6-1) have been assembled into logical alternatives by applying best engineering judgment. Consistent with EPA RI/FS guidance (1988), the "No Action" alternative is considered a baseline against which other alternatives are compared, and must be included as an alternative. The development of more applicable alternatives considered existing vapor intrusion control technologies in existing buildings as well as applicability for new buildings. Both residential and commercial buildings were assumed during alternative development.

By reviewing the technologies and ICs presented in detail in section 6.0, EPA has developed a combination of alternatives that are considered the most appropriate vapor intrusion control approaches for Site requirements, both now and into the future. These selected alternatives are shown below.

- Alternative 1 - No Action
- Alternative 2 – Monitoring and Institutional Controls (ICs)
- Alternative 3 - Mechanical Indoor Air Ventilation and ICs
- Alternative 4 – Vapor Barrier, Sub-Slab/Sub-Membrane Passive Ventilation, and ICs

7.1.1 Common Elements for Vapor Intrusion Alternatives

ICs are applied to all but the No Action alternative (Alternative 1) and are necessary for several Site enforcement functions, including:

- Ensuring that engineering controls to prevent indoor air quality impacts from vapor intrusion are maintained and monitored as required by the installed remedy;
- Ensuring that appropriate vapor intrusion control measures are installed for future building construction (new buildings or modifications of existing buildings);
- Providing information to EPA and the responsible parties regarding new construction and property ownership changes at the Site; and

- Providing information about the Site and the vapor intrusion remedy for each building at the Site to property owners, prospective property owners, and building tenants/occupants.

A governmental control IC would cover the building permit review conducted by the City of Mountain View. Upon receipt of building permit applications for any property at the Site, the City of Mountain View would notify EPA and the responsible parties regarding the planned new construction. Working with the City of Mountain View, EPA would formalize the planning and permitting of vapor intrusion control measures, as needed. In consideration of multiple lines of evidence obtained for the planned building construction site relative to the potential of a vapor intrusion pathway. Information device ICs would be provided to property owners to understand the process that EPA will follow with regard to evaluating the vapor intrusion control requirements for the new construction.

For vapor intrusion control measures installed with new construction, recorded covenants would be completed to cover the necessary operation, maintenance, and monitoring of the vapor intrusion remedy. Inspection and monitoring of vapor intrusion control systems to verify the effectiveness of the remedy is a component of Alternatives 3 and 4. Ongoing monitoring of ICs will be necessary to ensure that the remedy is effective over the long-term. The frequency and intensity of monitoring will vary depending on which vapor intrusion control approach is the selected remedy for individual properties. An IC Implementation and Assurance Plan (ICIAP) will need to be prepared with sufficient detail to show monitoring activities, schedules, and task responsibilities. The ICIAP is typically included in the property's OMMP for future (new) construction or existing building modification. Recorded covenants also provide a means to ensure that future property owners are informed of the vapor intrusion issues and any requirements for maintaining the effectiveness of an installed vapor intrusion control remedy.

7.1.2 Alternative 1 - No Action

For this alternative, no future action would be taken to address the vapor intrusion pathway at the CTS Printex Superfund Site. The no action alternative is included in the detailed analysis to satisfy applicable regulatory guidance (EPA, 1988). Inherent in the no action alternative is natural ventilation that will occur in a building due to normal air exchange with the outdoor air.

7.1.3 Alternative 2 – Monitoring and Institutional Controls (ICs)

Primary ICs applicable to the Site will fall within local governmental controls in the form of planning and building permit reviews and informational outreach for all properties at the Site. While proprietary controls will be used if possible, EPA's prior experience at the MEW

Superfund Site also in the City of Mountain View found that proprietary controls were not easy to establish for existing buildings. Under local government controls, the City of Mountain View can designate an area (e.g., Areas A – F as shown on Figure 1-2) requiring special treatment under a zoning overlay. Building addresses falling within this zone would automatically "trigger" a notice to the City of Mountain View should a request for new construction on an existing building or an entirely new structure enter the city's permitting process. This notice would then be passed on to EPA and the responsible parties. EPA then would provide guidance to the responsible parties on work plan requirements to generate data to assess potential risk, and if necessary, design and construction considerations required to ensure safety against vapor intrusion.

The monitoring associated with Alternative 2 would be to generate suitable data to assess the vapor intrusion pathway and potential risk at the location of new construction. This monitoring would include the following at the location of the proposed new construction: (1) temporary wells and collection of shallow groundwater samples from depths just below the water table; (2) shallow borings to enable collection of soil gas samples; and (3) analysis of the shallow groundwater and soil gas samples for VOCs. EPA will review the resulting data and establish if engineered controls for vapor intrusion prevention are needed for the new construction.

Existing environmental covenants have been granted on a case by case basis, and this is expected to continue in the immediate future. If obtained for the properties with buildings B through F as shown in Figure 1-2, this covenant would establish practices that would be followed to sustain the suitability of existing buildings for vapor intrusion prevention, as well as requirements that the property owner will follow in conjunction with building modifications and/or new construction. As ICs have multiple applications and can be layered together, determining their application to the future is speculative.

7.1.4 Alternative 3 – Mechanical Indoor Air Ventilation and ICs

Ventilation (i.e., HVAC) systems are used extensively to control the indoor air quality in commercial buildings. The ventilation system provides a means to prevent vapor intrusion or improve indoor air quality. Increasing the air exchange rate associated with HVAC systems can dilute VOC concentrations in indoor air, the extent being dependent upon VOC concentrations in the ambient air. An HVAC system can also induce a positive pressure in a building if operated at a sufficient level, and if the building envelope is sealed, thus reducing the migration of VOCs into buildings. A recorded environmental restrictive covenant would be required to prohibit interference with the operation and maintenance of the HVAC system to ensure continued vapor intrusion control. This record covenant would also provide a means of informing potential or future property owners of the requirements for this vapor intrusion control remedy.

While potentially applicable to all buildings, indoor air quality control by the HVAC system is more common and consistently managed in a commercial building. HVAC systems are not consistently operated in residential units, and for this reason this alternative is **not** considered appropriate as a vapor intrusion control alternative for residential buildings.

7.1.5 Alternative 4 - Vapor Barrier, Sub-Slab/Sub-Membrane Passive Ventilation, & ICs

This alternative would consist of a vapor barrier along with a passive, sub-slab (or sub-membrane) ventilation system that could be converted to an active ventilation system, if necessary. The passive, sub-slab ventilation system would consist of a gravel and/or sand layer with perforated pipe (or an equivalent geomembrane for vapor collection) that would be designed to enable conversion to mechanical ventilation if necessary. Collected vapors would be conveyed by solid piping to one or more vertical risers that vent to the atmosphere. A wind-driven turbine, located at the top of the riser, generates a slight, negative pressure below the vapor barrier that induces vapor flow from the subsurface to the atmosphere via the riser(s). The design of the passive ventilation system would enable conversion to an active, mechanical ventilation system, if needed.

A recorded environmental restrictive covenant would be required to maintain, inspect, and monitor the operational functionality and integrity vapor barrier and sub-slab passive ventilation system. This record covenant would also provide a means of informing potential or future property owners of the requirements for this vapor intrusion control remedy.

7.2 DETAILED ANALYSIS OF ALTERNATIVES

This section provides an evaluation of the alternatives for vapor intrusion control with respect to the two threshold criteria and five primary criteria established by EPA (1988). These criteria are:

Threshold Criteria

- ***Overall protection of human health and the environment:*** The assessment against this criterion describes whether the alternative is protective of human health and the environment. This evaluation pertains to how potential risks from vapor intrusion are eliminated, reduced, or controlled by the alternative.
- ***Compliance with ARARs:*** This criterion describes how the alternative complies with the federal and state ARARs that were identified in Section 4.0. 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.

Primary Criteria

- ***Long-term effectiveness and permanence:*** The assessment against this criterion evaluates the long-term effectiveness of alternatives in maintaining protection of human health and the environment after response objectives have been met. The components of this assessment are:
  - The magnitude of residual risks remaining after conclusion of the remedial activity; and
  - The adequacy and reliability of controls used to manage these risks.
- ***Reduction of toxicity, mobility, or volume through treatment:*** For this criterion, the assessment evaluates whether through treatment the alternative reduces the toxicity, mobility, or volume of the hazardous substance. 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 examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation of the remediation alternative until objectives are met. Components included in the evaluation for this criterion include:
  - Protection of community health during the vapor intrusion control action,
  - Protection of workers' health during the vapor intrusion control action,
  - The time (duration) required to achieve the remedial action objectives, and
  - Any environmental impacts resulting from the activities associated with implementing the alternative.
- ***Implementability:*** This assessment evaluates the technical and administrative feasibility of alternatives and the availability of required materials and services. 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 - includes permits, regulatory (federal, state, and/or local) approval, and access.

  - 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 evaluation includes the estimated capital costs, operation and maintenance costs, and calculation of present worth for the alternative. The capital cost estimate includes engineering design, permitting, construction installation, system startup, and a contingency. The annual costs encompass operation, maintenance, and monitoring of the components of the alternative. The present worth assumes an interest rate of 7 percent, and a cost escalation rate of 2%. The costs are estimates, and their accuracy may be within -30 percent to +50 percent of the final cost for a remedy.

  Costs for the vapor intrusion control alternatives are also based on the following base assumptions:

  - Two commercial buildings, one 7,000 square feet and the other 12,000 square feet. Each is a one-story commercial building with a slab on grade foundation.
  - One residential building of 5,000 square feet that consists of more than one residential unit and has a slab on grade foundation.

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. The detailed analyses are presented below for each alternative.

7.2.1 Alternative 1 - No Action

Overall Protection of Human Health and the Environment: If vapor intrusion results in indoor air concentrations exceeding long-term exposure goals, this alternative would not be protective of human health. This alternative would not eliminate, reduce, or control risk through any engineering or management controls as long as vapor intrusion is a potential exposure pathway at the Site. This alternative does not ensure protection of human health.

Compliance with ARARs: If indoor air concentrations resulting from vapor intrusion exceed long-term exposure goals, this alternative would not reduce concentrations. If exposure goals are not met due to vapor intrusion, this alternative would not comply with the ARARs.

Long-term Effectiveness and Permanence: This alternative does not involve vapor intrusion control actions, and does not provide actions for long-term effectiveness and permanence. If indoor air concentrations resulting from vapor intrusion exceed the indoor air quality goals, this alternative would not be effective.

Reduction of Toxicity, Mobility, or Volume through Treatment: The No Action alternative does not include treatment or any actions to reduce the toxicity, mobility, or volume of VOCs associated with vapor intrusion.

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

Implementability: This alternative can be implemented for existing and new commercial and residential buildings and developments. No permits, long-term monitoring, or services are required for this alternative.

Cost: Costs for the no action alternative are zero.

7.2.2 Alternative 2 – Monitoring and Institutional Controls (ICs)

Overall Protection of Human Health and the Environment: Reliable control of the vapor intrusion pathway for existing buildings that overly the Site's shallow groundwater plume is available through this alternative. The degree of protectiveness is dependent on adequate adherence to the IC process by government agencies, property owners, and contractors; and by monitoring to confirm implementation, enforcement, and maintenance of identified and applicable ICs. Because ICs alone may not be sufficient to control identified vapor intrusion situations, this alternative includes monitoring for new construction to establish if engineering controls are needed to prevent vapor intrusion for future building changes.

Compliance with ARARs: EPA has determined that California Civil Code §1471(a) is a potential ARAR applicable to the Site. This regulation provides for the placement of a land use (environmental restrictive) covenant on properties where hazardous wastes, constituents, or substances "will remain at the property at levels which are not suitable for unrestricted use of the land." EPA acknowledges that there may be circumstances where it is determined that placement of a land use covenant is not feasible, and in those instances, other ICs may be used to ensure that future land use remains in compliance with Site requirements with regard to risk and vapor intrusion control.

Long-Term Effectiveness and Permanence: To monitor and enforce this remedy over the long-term, the database and process established by the City of Mountain View must be updated and maintained to ensure that new construction requests at the Site trigger immediate response. This response, in turn, must be acted upon by both City of Mountain View and EPA to ensure compliance with the applicable IC. This alternative is only as effective as the ability for government entities (e.g., City of Mountain View, EPA), property owners, developers, contractors, and responsible parties to follow the guidance set forth by the ICs. Alternative 2 may not provide long-term effectiveness because adherence to ICs is not guaranteed. If the ICs are adhered to, and appropriate monitoring conducted for planned new construction, this alternative would provide long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume through Treatment: ICs and monitoring for new construction do not include treatment to reduce toxicity, mobility, or volume of the Site contaminants.

Short-Term Effectiveness: As ICs do not include construction or field work, protection of workers health and safety is not applicable to this alternative. The monitoring required for new construction uses established site investigation equipment and field activities. By following standard field practices for the monitoring, workers health and safety would be protected. For short-term applications (i.e., during construction) not involving any possible impact to the integrity of the building slab, ICs in the form of Informational Devices are effective if they are available and provided ahead of time to the entities designing, developing, and performing new construction at the Site. The ICs could be implemented in a short time (less than one year).

Implementability: For ICs to be implementable, the entities responsible for implementing appropriate and applicable ICs must have the necessary jurisdiction, authority, and/or willingness to establish, enforce, and monitor the IC. The planning and permitting review approach associated with this alternative could be modeled after the similar approach adopted by the City of Mountain View for another Superfund site in Mountain View that has potential vapor intrusion pathways. The implementability of this alternative is limited to existing buildings and subject to suitable interaction between various governmental agencies at the local and federal (i.e., EPA) levels. Implementability is also dependent upon property owners (current and future), tenants, and contractors following appropriate procedures to maintain the effectiveness of the ICs. The monitoring to be performed for new construction is similar to that performed for the Supplemental RI (ITSI, 2011a) and is implementable.

Cost: Costs for this alternative are estimated assuming only governmental controls and informational outreach. Best engineering judgment and review of other, local, regulatory-driven vapor intrusion efforts provide the basis for this estimate.

No capital costs are associated with Alternative 2. Annual costs would consist of the database overlay and following established procedures for the zoning-controlled process where new construction applications/permits on or near Site addresses would trigger automatic environmental review. Other annual costs arise from developing, designing, printing, and distributing informational brochures and leaflets about the Site for general public use. Annual costs for these ICs are estimated at $5,000 to $15,000. The annual costs do not include costs associated with proprietary controls. Using annual costs of $10,000, the present worth for this alternative is $105,000. [Note: 15 years assumed for the present value determination for all alternatives as this is the estimated time frame for the groundwater remedy to achieve cleanup levels and eliminate the need for further vapor intrusion control.] The estimated cost for monitoring, if needed for new construction, is $12,000 (current dollars). As this monitoring cost would only be incurred if new construction were proposed, this cost is not included in the present worth estimate for Alternative 2.

7.2.3 Alternative 3 – Mechanical Indoor Air Ventilation and ICs

Overall Protection of Human Health and the Environment: Properly designed, installed, operated, and maintained HVAC systems are protective of human health by reducing vapor intrusion and sustaining VOC concentrations in indoor air at levels similar to outdoor air. This protection can occur by sufficient air exchange rates to suitably dilute indoor air concentrations, and/or by establishing a positive pressure in the building interior that significantly blocks or reduces the migration of sub-slab vapors into a building. While air purifiers can be used with HVAC systems, costs will increase if treating the entire building air exchange exhaust. The use of air purifiers is typically associated with vapor intrusion control for a single room(s) within a building, and the room(s) is not typically occupied. Air purifiers are not assumed to be included in this alternative. Institutional control requirements covering the operation and maintenance of the mechanical indoor air ventilation system would need to be monitored to confirm the systems effectiveness in protecting human health.

Compliance with ARARs: This vapor intrusion control method has been utilized with a demonstrated ability to comply with long-term exposure goals. When implemented with appropriate ICs, a properly designed, installed, operated, and maintained mechanical indoor air ventilation systems will satisfy the ARARs.

Long-Term Effectiveness and Permanence: HVAC systems that achieve sufficient air exchange rates have a demonstrated ability to reduce VOC concentrations in the indoor air if ambient air quality is good. While specific HVAC system operation and effectiveness have not been tested at the Site, monitoring of HVAC systems with suitable air exchange rates at similar commercial buildings in the City of Mountain View has demonstrated the effectiveness of HVAC systems in maintaining indoor air concentrations at levels similar to outdoor air and effectively abating vapor intrusion. Previous testing of local commercial buildings found that monitoring of indoor air quality was a better performance metric than induced pressure in buildings for long-term effectiveness (Haley & Aldrich, 2009).

An essential requirement to sustain the long-term effectiveness of HVAC systems for vapor intrusion control is continuous operation during building occupancy. Management controls are needed to ensure that the HVAC system is properly operated and maintained. The California State Energy Code and OSHA regulations have operating requirements for HVAC systems at commercial buildings. The California Code of Regulations (CCR Title 24, Part 6, Subchapter 3, Section 121) contains provisions regulating the construction of HVAC systems in new buildings. CCR Title 8, Division 1, Chapter 4, Section 5142 requires HVAC systems to be maintained and operated to provide an air exchange rate consistent with building codes in effect at the time the HVAC system was installed. These regulations focus on requirements for outdoor air exchange rates, and may not satisfy the requirements for vapor intrusion control at a given commercial building. Proprietary ICs that are associated with proper management, control, operation, and maintenance of the HVAC system would be included with this alternative.

Reduction of Toxicity, Mobility, or Volume through Treatment: This alternative does not include treatment to reduce the toxicity, mobility, or volume of VOCs. If operated at a sufficient pressure, HVAC systems can eliminate or reduce the migration of vapors into a building (i.e., mobility reduction). Reduction in volume may occur for VOCs in indoor air as a result of operating the HVAC system with sufficient air exchange rates subject to the quality of the outdoor air. Any reduction in toxicity is due to reduction in volume and associated lower VOC concentrations in the indoor air. HVAC systems do not typically include treatment to reduce toxicity, mobility, or volume of the VOCs. Filtration treatment to remove VOCs in indoor air is possible at additional costs.

Short-Term Effectiveness: HVAC systems are a standard component of commercial buildings and building codes and state regulations establish minimum requirements for construction, operation, and maintenance. Standard HVAC construction practices are employed for vapor intrusion control, so worker's health is protected during construction. No environmental risks are associated with implementation of a HVAC system for vapor intrusion control. Because HVAC systems are a standard component of commercial buildings, implementation of this alternative would occur in a short time (less than one year).

Implementability: HVAC system installations and modifications can easily be implemented in new and existing commercial buildings. Similar to residential buildings, HVAC systems for vapor intrusion control are not readily implementable for warehouse buildings. The natural ventilation of open doors and use of mechanical fans are typical for warehouses.

A complicating factor for implementation is the proper operation and maintenance of the HVAC system that is often being controlled by the building tenants/occupants rather than the responsible party. As building occupancy and ownership can change with time, and the extent of the groundwater plume encompasses multiple properties, a responsible party may need to monitor the HVAC system in each building to confirm the effectiveness of the HVAC system in meeting exposure goals. Besides indoor air sampling, this monitoring requires proper operation of the HVAC system. Security issues and access requirements are implementation considerations that can be addressed by ICs for third-party owned and occupied buildings. Most commercial buildings have HVAC systems, and modifications if necessary for vapor intrusion control are typically minor. Services and materials for HVAC systems are readily available.

Cost: Capital costs are associated with the incremental costs of installing an enhanced HVAC system estimated as $4,000 and $6,000 for commercial buildings with 7,000 and 12,000 square feet, respectively. Average annual costs are estimated at $13,300 and $15,700 for new commercial buildings with 7,000 and 12,000 square feet, respectively. This results in a 15-year present worth cost of $150,000 and $177,000 for commercial buildings with 7,000 to 12,000 square feet, respectively, with a new HVAC system. [Note: 15 years assumed for the present value determination for all alternatives as this is the estimated time frame for the groundwater remedy to achieve cleanup levels and eliminate the need for further vapor intrusion control.]

7.2.4 Alternative 4 - Vapor Barrier, Sub-Slab/Sub-Membrane Passive Ventilation, & ICs

Overall Protection of Human Health and the Environment: Properly designed, installed, and maintained vapor barriers with passive ventilation are protective of human health by reducing or eliminating the vapor intrusion migration pathway into a building. The passive ventilation system enhances the performance of the vapor barrier with respect to eliminating the vapor intrusion pathway by collecting and removing the sub-surface vapors. Monitoring after completing the building construction could be used to confirm that indoor air VOC concentrations are less than the exposure goals. Inspections and maintenance of the vapor barrier integrity and passive ventilation system through ICs provide a means to confirm protection of human health over time.

Compliance with ARARs: This vapor intrusion control alternative has been utilized with a demonstrated ability to prevent vapor intrusion. Vapor barriers with passive ventilation systems have been installed for other buildings in the City of Mountain View and at the new residential development in the area formerly associated with the former CTS Printex facility. This alternative will satisfy the ARARs.

Long-Term Effectiveness and Permanence: Typically, passive ventilation systems are included with vapor barriers to prevent migration of VOCs into buildings. Adding passive ventilation with a vapor barrier improves the overall effectiveness for vapor intrusion control. The long-term effectiveness depends upon the design and installation quality, as well as long-term care to ensure that the integrity of the vapor barrier is maintained. For example, future building modifications must be appropriately completed as not to puncture the vapor barrier or to re-establish the integrity of the vapor barrier. Vapor barrier seals on utility and other conduits entering the building must also be maintained to prevent leaks through improperly sealed utility penetrations.

By blocking the vapor intrusion migration pathway, indoor air concentrations would be similar to outdoor air concentrations. Vapor barriers with a passive ventilation system have a demonstrated long life, and the permanence of this vapor intrusion control alternative would be similar to that of the building. As modifications can be expected over the life of a building, appropriate institutional controls would need to be established to ensure that: 1) the modifications do not penetrate the barrier or 2) the design and construction includes appropriate repair, replacement, and/or sealing of the vapor barrier for modifications that penetrate the barrier. Being a passive system, minimum maintenance is typically needed to sustain the performance of the ventilation system, although provisions to inspect and maintain the integrity of the vapor barrier and ventilation system must still be established and implemented.

Reduction of Toxicity, Mobility, or Volume through Treatment: This alternative does not include treatment to reduce the toxicity, mobility, or volume of VOCs. The vapor barrier in combination with the passive ventilation eliminates or reduces the mobility of sub-slab vapors into a building. With the passive ventilation included with a vapor barrier, this alternative can reduce the concentration (i.e., volume) of VOCs in the sub-slab vapors. No treatment or other methods for reduction in toxicity occurs for VOCs by this alternative. As with Alternative 3, proprietary ICs that are associated with proper management, control, and operation would be included in the vapor intrusion control remedy.

Short-Term Effectiveness: The installation of vapor barriers with passive ventilation does not create conditions that could impact workers health during construction. Established construction practices are used to install and appropriately seal the vapor barrier, as well as the passive ventilation system. A vapor barrier with passive ventilation can be readily incorporated into the design and construction of new buildings, commercial or residential. By incorporating into the design and construction plan, installation of the vapor barrier and passive ventilation system would occur in a short time (less than one year). By initially installing to enable future conversion of the ventilation system from passive to active, such a conversion can be readily completed if necessary.

Implementability: Vapor barrier with passive ventilation installation can be implemented in new commercial or residential buildings. An exception is that a vapor barrier with passive ventilation installation is not appropriate if a new building has a basement beyond the depth of the groundwater table. The passive ventilation and vapor barrier are reliable, and installation utilizes proven procedures and construction practices. No special building permits are required. Monitoring can be performed following completion of the building construction to verify VOC concentrations are below the exposure goals.

Services and materials for vapor barriers are readily available. Installation of vapor barriers requires specialized skills and appropriately licensed contractors. Post-installation testing is commonly used to verify the integrity of the vapor barrier installation with regard to blockage of vapor migration.

Cost: Costs for this alternative are presented for three scenarios, one residential and two commercial buildings as presented at the beginning of Section 7.2 when describing the basis for the cost evaluation criterion.

Residential: Capital costs are estimated at $75,000 for a multi-unit residential building of 5,000 square feet. Average annual maintenance costs are estimated at $2,600. This results in a 15-year present worth of $105,000 for a 5,000 square feet residential building.

Commercial: Capital costs are estimated at $105,000 and $180,000 for buildings of 7,000 and 12,000 square feet, respectively. Average annual maintenance costs are estimated at $2,600 for both building sizes. This results in a 15-year present worth of $134,000 and $210,000 for new commercial buildings of 7,000 and 12,000 square feet, respectively.

7.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section evaluates the performance of each vapor intrusion control alternative relative to the other alternatives using the same seven evaluation criteria used in the detailed analysis of alternatives. The purpose of this comparison is to focus on the relative advantages and disadvantages presented by each alternative as they would be applied to new construction (existing or future buildings) at the Site. A summary of this comparative analysis is presented in Table 7-1.

Table 7-1
Qualitative Evaluation[1] of Remedial Action Alternatives for Vapor Intrusion
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 (Per Building, 15-Year Present Worth)
Alternative 1 – No Action	Low[2]	Not Retained	Not Retained	Not Retained	Not Retained	Not Retained	$0
Alternative 2 – Monitoring and Institutional Controls (ICs)	Moderate (requires adherence to IC process by all parties)	Moderate (requires adherence to IC process by all parties)	Moderate (requires adherence to IC process by all parties)	Not Applicable (no treatment)	Not Applicable (no construction and the need for monitoring only associated with new construction)	Moderate (requires adherence to IC process by all parties)	$105,000
Alternative 3 – Mechanical Indoor Air Ventilation and ICs	High (requires proper design, installation, operation, and maintenance)	High	Moderate (requires monitoring of commercial building personnel to control use)	Not Applicable (no treatment)	Moderate	High (not applicable to residential buildings, requires adherence to ICs for HVAC operation at commercial building)	<u>Residential:</u> Not Applicable <u>Commercial:</u> $150,000 and $177,000 for 7,000 and 12,000 square ft. buildings, respectively
Alternative 4 – Vapor Barrier, Sub-Slab/Sub-Membrane Passive Ventilation and ICs	High (requires proper design, installation, operation, and maintenance)	High	High (requires inspection and monitoring to verify component operational integrity)	Not Applicable (no treatment)	High	High	<u>Residential:</u> $105,000 for 5,000 square ft. building <u>Commercial:</u> $134,000 and $210,000 for 7,000 and 12,000 square ft. buildings, respectively

Note: [1] Alternative qualitative evaluation with respect to the criterion:
Low - does not satisfy the criterion
Moderate - satisfies the criterion
High - satisfies the criterion and has higher rating with respect to criterion
[2] By not satisfying a threshold criterion, alternative is not retained for further comparison.

7.3.1 Overall Protection of Human Health and the Environment

The potential for long-term exposure remains as long as TCE groundwater concentrations exceed groundwater cleanup levels. Alternative 1 would not eliminate, reduce, or control risk to human health through engineered controls, management practices, and/or ICs and would not be protective of human health. Therefore by not satisfying a threshold criterion, Alternative 1 is eliminated from further consideration under the remaining criteria. Alternative 2 is protective of human health and the environment as long as IC requirements are enforced and existing building condition remains the same, i.e., no building modifications are made and indoor air concentrations are below the action levels. The monitoring associated with Alternative 2 enables determination if engineering controls for vapor intrusion prevention are needed for new construction. Alternatives 3 through 4 are both protective as an engineered vapor intrusion control system is installed and both are designed, installed, operated, and maintained properly. Alternative 2 would be the most cost-effective alternative, but ICs alone may not be sufficient to control vapor intrusion in the future. Alternative 4 would be the most cost-effective for residential and commercial buildings if engineering controls are needed.

7.3.2 Compliance with ARARs

With implementation of appropriate ICs, Alternatives 2, 3, and 4 would comply with ARARs. If for a future building with potential vapor intrusion pathway, Alternatives 3 and 4 would satisfy ARARs provided that the active vapor intrusion control system is designed, installed, operated, and maintained properly. For new construction, Alternative 2 includes monitoring to determine if engineered controls are needed to meet indoor air action levels.

Alternatives 3 and 4 would be equally the most cost-effective vapor intrusion control alternatives for compliance with the ARARs for commercial buildings. Alternative 4 would be the most cost-effective vapor intrusion control alternative for compliance with the ARARs for residential buildings.

7.3.3 Long-Term Effectiveness and Permanence

Alternatives 3 and 4 apply active engineered controls to prevent vapor intrusion and protect indoor air quality. Properly installed and maintained, these alternatives would result in indoor air of similar quality to outdoor air. Alternative 2 would provide long-term effectiveness and permanence for existing buildings at the Site as long as the indoor air concentrations remain below the action levels and the ICs are adhered to. With monitoring, Alternative 2 provides means to determine if engineering controls are needed for new construction to provide long-term effectiveness. The long-term effectiveness and permanence requires adherence to the ICs for the proper management, maintenance, and monitoring for the vapor intrusion control components of Alternatives 3 and 4. The management controls associated with mechanical ventilation systems (Alternative 3) are subject to full consent and cooperation of the property owner and building occupants. Therefore, the long-term effectiveness of Alternative 4 is easier to manage and secure than for Alternative 3.

Alternative 4 would be the most cost-effective vapor intrusion control alternative for compliance with long-term effectiveness and permanence.

7.3.4 Reduction of Toxicity, Mobility, or Volume by Treatment

Alternatives 2, 3, and 4 do not include treatment for reduction in toxicity, mobility, or volume for VOCs. Therefore a comparison of alternatives under this criterion is not applicable. Alternatives 3 and 4 only control or reduce the mobility and/or volume of VOCs. Reduction of toxicity, mobility, or volume by treatment for the vapor intrusion pathway will occur by groundwater remediation using EPA's selected remedy based on the groundwater remediation alternatives evaluated (ITSI, 2011b). Reduction in VOC concentrations in groundwater reduces the toxicity of the VOCs at the source of the vapor intrusion pathway, i.e., groundwater.

7.3.5 Short-Term Effectiveness

Alternative 2 is not applicable to a discussion of protection of workers' health during field/construction activities as long as new construction does not occur. Any monitoring required under Alternative 2 would apply standard field practices to protect workers' health and safety. Alternatives 3 and 4 are equally protective of workers' health assuming that standard practices for construction activities are implemented. Implementation of Alternatives 2, 3, and 4 would not create any additional risks to the environment and could be implemented in a short time frame (less than one year).

Alternatives 3 and 4 would be equally most cost-effective vapor intrusion control alternatives for compliance with short-term effectiveness for commercial buildings. Alternative 4 would be the most cost-effective vapor intrusion control alternative for short-term effectiveness for residential buildings.

7.3.6 Implementability

Alternative 2 is implementable, though subject to interaction between various governmental agencies and relying on future Site property owners, developers, and contractors to follow established procedures to conduct monitoring (if required for new construction) and maintain IC effectiveness. The City of Mountain View has formalized procedures for another Superfund site in Mountain View and a similar model would be applied for the Site. Alternatives 3 and 4 are equally implementable for new commercial buildings by incorporating each system's requirements into the design, construction, and operation of the building. Alternative 3 is not implementable for residential buildings due to the inability to consistently control indoor ventilation. Mechanical indoor air ventilation system operation require controls by building management to prevent adverse adjustments from taking place that could negate the usefulness of HVAC to prevent vapor intrusion.

Alternative 4 would be the most cost-effective active alternative for compliance with implementability for commercial and residential buildings.

7.3.7 Costs

A comparison of relative costs for the alternatives is presented below for residential and commercial buildings.

Residential – Alternative 4 has the highest cost as Alternative 3 is not applicable to residential buildings. Costs for Alternative 2 are estimated to be less than for Alternative 4, although for new construction Alternative 2 does not provide active vapor intrusion control.

Commercial – Alternative 3 has the highest present worth cost as compared to both Alternatives 2 and 4, as the energy costs operating the HVAC system for a commercial building increase the present worth cost for vapor intrusion control. Alternative 2 has the lowest present worth cost, although Alternative 2 does not provide active vapor intrusion control.

Alternative 2 would be the most cost-effective alternative for compliance with costs, though ICs alone may not be sufficient to control identified vapor intrusion situations in the future. The monitoring under Alternative 2 would only occur if new construction was planned, so the monitoring costs were not included in this evaluation. For alternatives with vapor intrusion engineered controls, Alternative 4 is the most cost-effective for commercial and residential buildings.

7.4 APPLICATION OF REMEDIAL ALTERNATIVES

The previous sections developed detailed analyses of selected remedial alternatives that would address the potential vapor intrusion pathway, and then presented a comparative evaluation to identify advantages/disadvantages of each alternative. This section provides recommendations for how these alternatives should be applied to existing buildings as well as new construction (i.e., modifications) on existing buildings and future construction of new buildings at the Site.

EPA has established vapor intrusion criteria and a classification system for the existing commercial and residential buildings based upon multiple lines of evidence from collected data from the Site that are applicable to the vapor intrusion pathway. For future construction, EPA has identified a tier system to evaluate and determine the appropriate level of action required at the Site. This methodology is based on:

- Existing property boundaries overlying the current extent of the groundwater plume,
- TCE groundwater concentrations,
- Potential for vapor intrusion (based on calculated risk derived from multiple lines of evidence from collected data),

- Vapor intrusion control measures already installed, and
- Assumptions of likely future developments.

7.4.1 Existing Buildings

For existing commercial and residential buildings identified on Figure 1-2, EPA established criteria to classify buildings into separate and distinct groups or "areas" to account for vapor intrusion alternative application. The building groups for the Site and potential vapor intrusion pathways are presented below.

Building Group A – (1900-1950 Cambridge Drive; 841-862 Avery Drive; 1900-1932 Aberdeen Lane; 851-863 Donovan Way; 1900 to 1938 Newbury Drive). These buildings overlie the location of the former CTS Printex facility and comprise the Gables End development. These buildings are grouped together as current residential units with engineering controls (same as Alternative 4) and ICs in place. Pre-occupancy indoor air sampling confirmed that vapor intrusion was not impacting indoor air quality. In accordance with the established IC, monitoring and maintenance of the vapor intrusion control components will be continued until determined by EPA that it is not necessary.

Building Groups B and E - (917 Sierra Vista Ave and 935 Sierra Vista, respectively). These properties are residential and commercial, respectively, but are similar with regard to multiple lines of evidence, including indoor air monitoring, indicating that there is no current or anticipated future risk with regard to vapor intrusion impacting indoor air quality.

Building Groups C and D - (924 Plymouth St and 914 Plymouth St, respectively). These properties are similar commercial buildings located adjacent to one another, and while no current indoor air risk was identified from indoor air monitoring, sub-slab vapor concentrations indicate that vapor intrusion is a potential risk if building use impacts the attenuation capability of the existing building slab.

Building Group F – (920 Sierra Vista Ave). This group is a parking lot overlying the distal end of the Site groundwater plume. Multiple lines of evidence do not exist to assess if vapor intrusion is a potential risk if a new building was constructed in the parking lot.

EPA's proposed response actions for existing buildings is presented in Table 7-2, and provides the basis for assigning the most applicable remedial alternative to residential and commercial buildings as shown in Section 7.4.3.

Table 7-2
Proposed Response Action for Existing Residential and Commercial Buildings
CTS Printex Superfund Site, Mountain View, California

Area	Description	Proposed Response Action
A	Residential buildings with engineering controls in place with confirmed indoor air concentrations below the indoor air action level.	Continue monitoring and maintenance of the installed vapor barrier with sub-slab passive ventilation system in accordance with the OMMP. Proprietary IC (environmental restriction covenant) in place.
B	Residential building with current indoor air concentrations below the indoor air action levels. Building has demonstrated through multiple lines of evidence that there is no potential for vapor intrusion into the building exceeding indoor air action levels.	No further action (engineered remedy or long-term monitoring) required.
C, D	Commercial buildings with current indoor air concentrations below the indoor air action levels. For these buildings, multiple lines of evidence have demonstrated that there is potential or anticipated future risk for vapor intrusion resulting in the buildings having indoor air exceeding indoor air action levels.	No engineered remedy or long-term monitoring required. Implement proprietary and/or governmental ICs to track new construction/development
E	Commercial building with current indoor air concentrations below the indoor air action levels. For this building, multiple lines of evidence have demonstrated that there is no potential or anticipated future risk for vapor intrusion resulting in the building having indoor air exceeding indoor air action levels.	No further action (engineered remedy or long-term monitoring) required.
F	Unoccupied Parking Area. Multiple lines of evidence do not exist to demonstrate that there is no potential or anticipated future risk for vapor intrusion if new buildings are constructed. Therefore, a new building could have indoor air exceeding indoor air action levels.	Implement proprietary and/or governmental ICs to track new construction.

7.4.2 Future Buildings

For future commercial and residential buildings, it is impossible to classify buildings and locations at this time. Therefore, EPA has created a "Tier" system to designate three classifications of new buildings that could be constructed at the Site in the future. To determine the appropriate tier, groundwater, soil gas, and other lines evidence will be collected and evaluated at the time of development or new construction. Once new construction has been assigned a tier, the new building will be subject to the selected engineering controls and/or ICs for that tier. The Tiers associated with these future buildings are presented below and proposed response actions are summarized in Table 7-3.

Tier 1 Building – Located on properties overlying the groundwater plume contour line of 5 ug/L where multiple lines of evidence indicate that a potential vapor intrusion pathway exists. This potential vapor intrusion could result in VOC concentrations exceeding the indoor air action levels (see Table 5-4).

Tier 2 Building – Located over the groundwater plume contour line of 5 ug/L with multiple lines of evidence indicating that vapor intrusion will not result in indoor air concentrations exceeding the action levels.

Tier 3 Building – Located outside of the groundwater plume contour line of 5 ug/L.

Table 7-3
Proposed Response Action for Future Residential and Commercial Buildings*
CTS Printex Superfund Site, Mountain View, California

Tier	Description	Proposed Response Action
1	Future (new) building(s) on properties where lines of evidence (soil gas, groundwater, etc.) indicate there is the potential for vapor intrusion into the new building above indoor air action levels.	Implement the EPA's selected remedy for vapor intrusion control. Perform confirmation indoor air sampling after construction to verify that the vapor intrusion control remedy is effective. Implement proprietary ICs.
2	Future (new) building(s) on properties where lines of evidence (soil gas, groundwater, etc.) indicate there is no potential for vapor intrusion into the new building above indoor air action levels.	Upon confirmation and with EPA approval, no further action is required.
3	Future (new) building(s) on properties overlying shallow groundwater with TCE concentrations not exceeding μg/l.	No response action required.

Note:
* Commercial or multi-family residential buildings constructed with aboveground raised foundations typically would be separated from the ground by a parking garage, which would allow adequate ventilation to prevent vapor intrusion into occupied spaces. For this construction, perform targeted confirmation air sampling after building is constructed to verify absence of preferred pathways into building and to confirm indoor air action levels are met.

7.4.3 Recommended Alternatives

This section describes the recommended alternative for each building scenario based on the alternative evaluation performed in Section 7.2, the comparative analysis described in Section 7.3, and the proposed response actions described in Sections 7.4.1 and 7.4.2 for existing buildings and future construction/buildings, respectively. As discussed previously, ICs will also form a fundamental portion of the recommended alternatives applied to each building group (for existing buildings) or tier level (for future buildings). Key to the effectiveness of these ICs is sufficient implementation, monitoring, and enforcement of these controls.

Existing Residential Buildings: During construction of the existing buildings in Area A in 2007, each building was constructed with engineering controls (i.e., Alternative 4) and an Environmental Restriction Covenant is in-place to ensure monitoring and maintenance of a vapor barrier and passive sub-slab ventilation system. This preventative barrier against vapor intrusion was installed as an additional measure by the developer constructing these buildings.

Existing Commercial Buildings: For existing buildings in Areas B, C, D, and E, current indoor air concentrations are below indoor action levels and, therefore, no further engineered remedy or long-term monitoring is required. A portion of Area F, which overlies the distal edge of the groundwater plume to the northwest, is a parking lot with no existing buildings.

ICs are required for Areas C, D, and F in order to ensure proper notification to EPA and the responsible parties of any changes in land use, new construction, or changes to existing buildings where the foundation or subsurface is modified (e.g., building expansion or replacement of connecting utilities). Should such changes be planned, a work plan would be necessary to collect sufficient data to support a comprehensive evaluation of whether vapor intrusion has high potential to impact specific locations.

Future Buildings: For future buildings, the tiered system described in Table 7-3 was developed to more easily manage and evaluate the potential for vapor intrusion. The appropriate tier for each future building (i.e., Tier 1, Tier 2, or Tier 3) is based on whether lines of evidence indicate there is (Tier 1), or is not (Tier 2), the potential for vapor intrusion into the new building at concentrations above indoor air cleanup levels. If a building is categorized as a Tier 1 building, EPA's selected action for Tier 1 buildings will be implemented as described below, including engineering and institutional controls. If multiple lines of evidence indicate there is no longer the potential for vapor intrusion into the building at levels of concern, then the building is categorized as a Tier 2 building. If confirmed and approved by EPA, then no further action is required for a Tier 2 building. If a building is proposed on a property outside the estimated lateral extent of shallow groundwater with TCE concentrations not exceeding 5 µg/l (Tier 3), then no further action is required.

As a result of the above analysis on new construction for both existing and future buildings, the remedial alternatives shown below apply to the Site to control potential vapor intrusion risk.

Existing Commercial Buildings

The alternatives applicable for existing commercial buildings are:

- Alternative 1: No Action
- Alternative 2: Monitoring and ICs
- Alternative 3: Mechanical Indoor Air Ventilation and ICs

Although there is no current risk to occupants of any of the existing commercial buildings overlying the plume, Alternative 2 best meets the proposed response actions for existing commercial buildings.

Existing Residential Buildings

The alternatives applicable for existing residential buildings are:

- Alternative 1: No Action
- Alternative 2: Monitoring and ICs
- Alternative 4: Vapor Barrier, Sub-Slab/Sub-Membrane Passive Ventilation, and ICs

All buildings in Area A have implemented Alternative 4. Because there is no vapor intrusion potential risk for Area B, Alternative 1 best meets the proposed response action for existing residential buildings in Area B.

Future Commercial Buildings

The alternatives applicable for future commercial buildings are:

- Alternative 1: No Action
- Alternative 3: Mechanical Indoor Air Ventilation and ICs
- Alternative 4: Vapor Barrier, Sub-Slab/Sub-Membrane Passive Ventilation, and ICs

Alternatives 3 or 4 would meet the proposed response actions for Tier 1 buildings. Tiers 2 and 3 buildings would qualify for Alternative 1.

Future Residential Buildings

The alternatives applicable for future residential buildings are:

- Alternative 1: No Action
- Alternative 4: Vapor Barrier, Sub-Slab/Sub-Membrane Passive Ventilation, and ICs

Only Alternative 4 would meet the proposed response action for Tier 1 buildings. Tiers 2 and 3 buildings would qualify for Alternative 1.

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8.0 REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR), 2009. Minimal Risk Levels. http://www.atsdr.cdc.gov/mrls/mrllist.asp#48tag.

Aqua Terra Technologies (ATT), 1991. Remedial Investigation and Feasibility Study Final Report, Former CTS Printex Facility, Mountain View, California. March 15.

California Environmental Protection Agency (Cal/EPA), 2001. A Guide to Health Risk Assessment. http://www.oehha.ca.gov/pdf/HRSguide2001.pdf.

CSS Environmental Services, Inc. and Geosyntec Consultants (CSS and Geosyntec), 2007. Revised Draft Focused Feasibility Study and Technical Impracticability Evaluation, Former CTS Printex Superfund Site, Mountain View, California. March 8.

EPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. Interim Final. EPA/540/G-89/004, OSWER Directive 9355.3-01. October.

EPA, 1991. Record of Decision CTS Printex Corporation Superfund Site Mountain View, California. June 28.

EPA, 1993. Radon Reduction Techniques for Existing Detached Houses, Technical Guidance for Active Soil Depressurization Systems. EPA/625/R-93/011. October.

EPA, 2000. A Site Manager's Guide to Identifying, Evaluating, and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups. OSWER 9355.0-74FS-P, EPA 540-F-00-005. September.

EPA, 2004. User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings. 22 February.

EPA, 2008. AirData: Access to Air Pollution Data. Hazardous Air Pollutant data from 2008 for BAAQMD monitoring station at 910 Ticonderoga Drive, Sunnyvale, California, ID 06-085-2007-43814-3.

EPA, 2010a. Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm. Updated November.

EPA, 2010b. Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites (Interim Final). OSWER 9355.0-89, EPA 540-R-09-001. November.

ERAS, 2004. Technical Summary Report, 1914 Plymouth Street, July 21.

Geosyntec Consultants (Geosyntec), 2006a. Environmental Site Assessment Report, Former CTS Printex Site, Mountain View, California. June 19.

GeoSyntec, 2006b. Final Draft Risk Management Plan. Former CTS Printex Site 1905, 1911, 1921, 1931 Plymouth Street and 1916, 1930, 1940, and 1950 Colony Street, Mountain View, California. June 29.

GeoSyntec, 2006c. Human Health Risk Assessment Report, Former CTS Printex Site, 1905, 1911, 1921, 1931 Plymouth Street and 1916, 1930, 1940, 1950 Colony Street, Mountain View, California. September 1.

GeoSyntec, 2007a. Engineering Design Report for the Construction of Vapor Control System, Plymouth and Colony Development, Mountain View, California. March 11.

GeoSyntec, 2007b. Technical Specification for the Construction of Vapor Control System at Plymouth & Colony Rowhomes, Mountain View, California. March 11.

GeoSyntec, 2007c. Construction Quality Assurance Plan for the Construction of Vapor Control System, Plymouth and Colony Development, Mountain View, California. March 11.

GeoSyntec, 2007d. Site Excavation Plan Implementation Report, Former CTS Printex Site, Mountain View, California. July 27.

GeoSyntec, 2009. Construction Quality Assurance Report Sub-slab Vapor Control System Installation, Gables End Townhomes Development, Mountain View, California. June 11.

GeoSyntec, 2010. Gables Phase 3 Results of Indoor Air Sampling, Phase 3 Buildings 13 and 14

Haley & Aldrich, Inc., 2009. Final Supplemental Feasibility Study for Vapor Intrusion Pathway, Middlefield-Ellis-Whisman Study Area, Mountain View and Moffett Field, California. June.

Innovative Technical Solutions, Inc. (ITSI), 2011a. Final Supplemental Remedial Investigation Report, CTS Printex Superfund Site, Mountain View, California. May.

Innovative Technical Solutions, Inc. (ITSI), 2011b. Final Focused Feasibility Study, Part II: Groundwater. May.

McCarty, P.L., 1997. Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water. In the USEPA's Proceedings of the Symposium on Natural Attenuation of Chlorinated Organics. EPA/540/R-97/504. May.

Regional Water Quality Control Board, San Francisco Bay (RWQCB), 1991. Final Order for Site Cleanup Requirements (No. 91-081). May 22.

RWQCB, 2008. Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater. http://www.swrcb.ca.gov/rwqcb2/water_issues/available_documents/ESL_May_2008.pdf May.

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FIGURES

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	CTS Printex Superfund Site Mountain View, California	**FIGURE 1-1** Site Location Maps

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CTS Printex Superfund Site
Mountain View, California

FIGURE 1-2
Building Group Area Classification and TCE Plume

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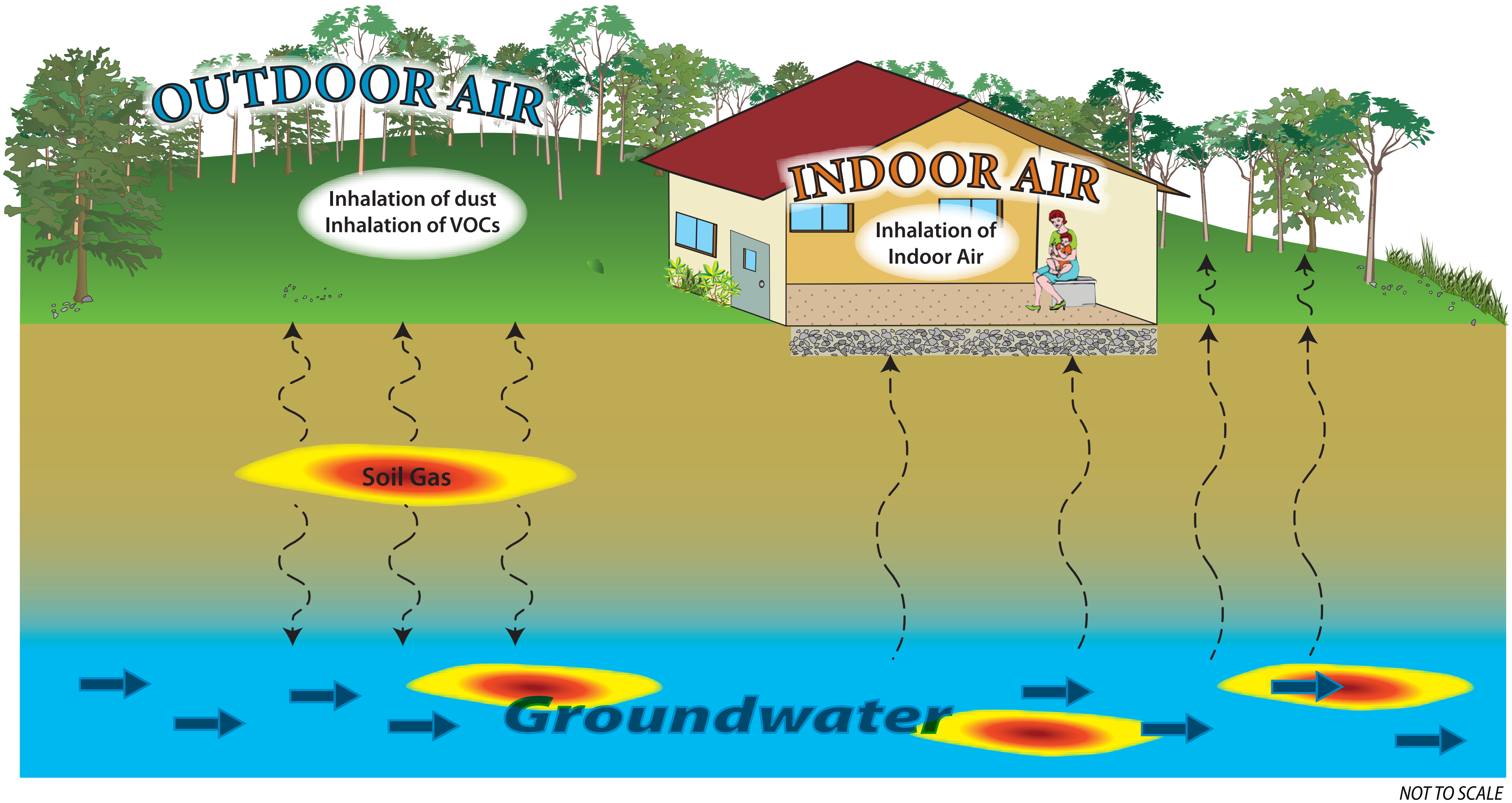
CTS Printex Superfund Site
Mountain View, California

FIGURE 1-3
Site Plan of Former CTS Printex Property



CTS PRINTEX SUPERFUND SITE
Mountain View, California

FIGURE 2-1
Exposure Pathway Model

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CTS Printex Superfund Site
Mountain View, California

FIGURE 2-2
Sampling Locations Map

CTS Printex Superfund Site
Mountain View, California

FIGURE 2-3
Cross-Section Line A-A'

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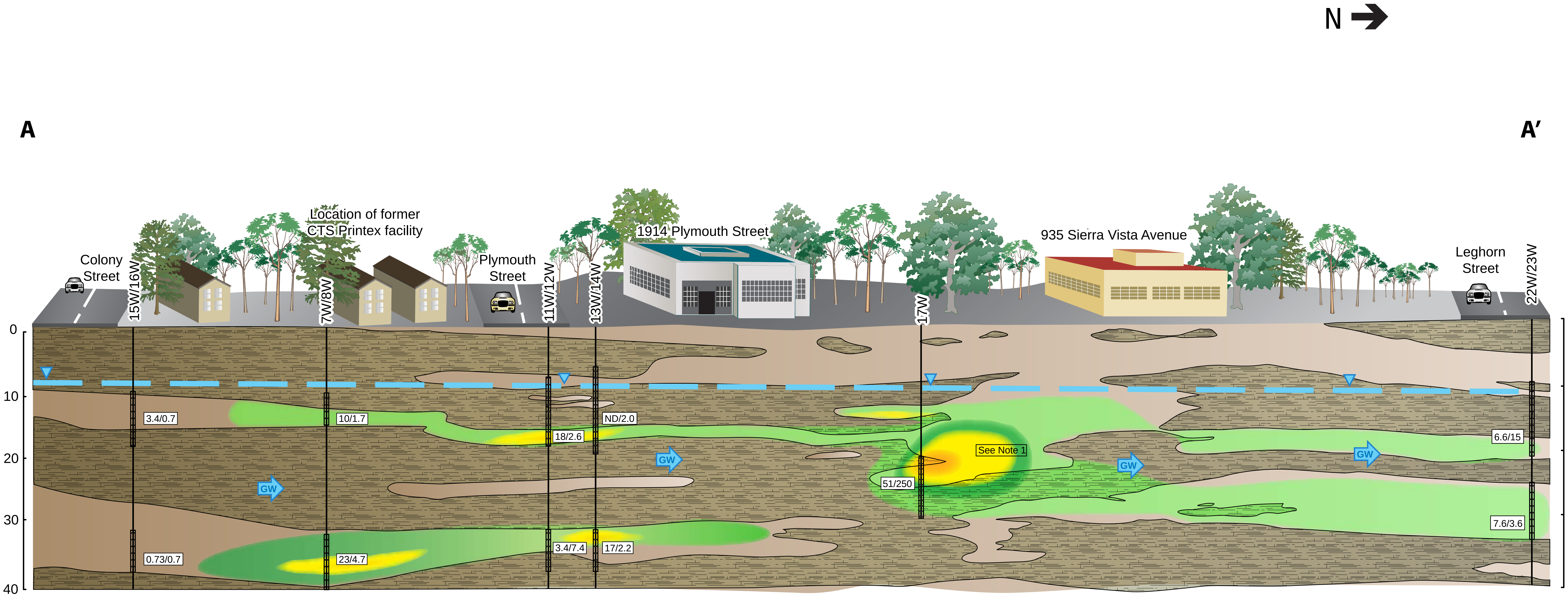

Sands and Gravel Predominant

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)

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CTS PRINTEX SUPERFUND SITE
Mountain View, California

FIGURE 2-4
Current Conceptual Site Model

APPENDIX A

COST ESTIMATES

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Alternative 2- Monitoring and Institutional Controls
Present Value Analysis (mid range)
CTS Printex Superfund Site, Mountain View, California

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	$10,000	1.0200	$10,200	0.9346	$9,533
Annual O&M Cost	2	$10,000	1.0404	$10,404	0.8734	$9,087
Annual O&M Cost	3	$10,000	1.0612	$10,612	0.8163	$8,663
Annual O&M Cost	4	$10,000	1.0824	$10,824	0.7629	$8,258
Annual O&M Cost	5	$10,000	1.1041	$11,041	0.7130	$7,872
Annual O&M Cost	6	$10,000	1.1262	$11,262	0.6663	$7,504
Annual O&M Cost	7	$10,000	1.1487	$11,487	0.6227	$7,153
Annual O&M Cost	8	$10,000	1.1717	$11,717	0.5820	$6,819
Annual O&M Cost	9	$10,000	1.1951	$11,951	0.5439	$6,500
Annual O&M Cost	10	$10,000	1.2190	$12,190	0.5083	$6,196
Annual O&M Cost	11	$10,000	1.2434	$12,434	0.4751	$5,907
Annual O&M Cost	12	$10,000	1.2682	$12,682	0.4440	$5,631
Annual O&M Cost	13	$10,000	1.2936	$12,936	0.4150	$5,368
Annual O&M Cost	14	$10,000	1.3195	$13,195	0.3878	$5,117
Annual O&M Cost	15	$10,000	1.3459	$13,459	0.3624	$4,878
Total of O&M Costs		$150,000		$176,394		$105,000
Averaged Annual O&M cost		$10,000				
Total						**$105,000**

Note:
Monitoirng costs not included as these costs are a contingency in case of new construction.
Average annual O&M cost is based on 15 years projection for achieving MCLs in contaminated groundwater through active remediation as proposed in Alternative 3B for groundwater remediation.

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

Assumptions and the scope of work associated with Mechanical Indoor Air Ventilation consisting of the heating, ventilation, and air-conditioning (HVAC) system included in the capital costs for Alternative 3 are described below.

Incremental cost of HVAC System to maintain positive indoor air pressure

- Incremental cost of $4,000 for HVAC system in a 7,000 square ft. commercial building size.
- Incremental cost of $6,000 for HVAC system in a 12,000 square ft. commercial building size.

Fees, contingency, and design costs included in the above incremental capital cost estimates.

The basis for the operation and maintenance costs for Alternative 3 are summarized below. A total O&M time frame of 15 years was assumed (based on the estimated time for the preferred groundwater remediation alternative to achieve compliance with the groundwater remedial action objectives).

Assumptions for Year 1 through 5

- Perform semi-annual air sampling.
- Perform semi-annual inspection and maintenance of the HVAC system.
- Prepare semi-annual indoor air sampling report.

Assumptions for Year 6 through 15

- Perform semi-annual air sampling.
- Perform semi-annual inspection and maintenance of the HVAC system.
- Prepare semi-annual indoor air 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%

Alternative 3- Mechanical Indoor Air Ventilation System with Monitoring in 7,000 Square Feet Commercial Building

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	**<u>Indoor Air Sampling</u>**					
	Perform semi-annual air sampling (24-hour) for a 7,000 square feet commercial building based on collection of one sample per every 2,000 square feet (4 samples).	2	$860	Semi-annual	$1,720	Unit cost is based on one technician at a rate of $95.00/hr for 8 hours + $100.00 ODCs (cooler, containers, shipping, gas) to collect grab samples.
	Sample Analysis for 4 VOC samples, 1 duplicate sample, and 1 outdoor sample per event	12	$300	Semi Annual	$3,600	Unit cost for TO-15 SIM VOCs at $300.00
1.2	**<u>HVAC System</u>**					
	HVAC system Inspection	0	$460	Semi Annual	$0	Assume HVAC inspection as part of regular building management. Semi-annual Inspection of HVAC systems based on a technician with daily rate cost of 4 hours that includes travel time (4x$95.00+$80.00= $460.00).
	HVAC System Maintenance	1	$500	LS	$500	Estimated average annual cost of $500 for maintaining HVAC System and parts.
	Electricity (incremental to normal HVAC operation for VI control)	15,777	$0.15	KW/hr	$2,367	HVAC of 50 horsepower, 3 phases, 480 Volts, 3.7 KW for commercial bulidings. Consumption quantities based on the difference of normal operation (14 hrs for 5 days + 16 hrs/day over weekends = 82 hrs) and integral operation (7 days x 24 hours = 168 hours) on a weekly basis. Exceeding annual consumption is 3.7 KW x 82 hrs per week X 52 weeks = 15,780 KWh.
1.3	**<u>Reporting</u>**					
	Semi-Annual Monitoring Letter Report	2	$3,000	Ea	$6,000	Letter Report
				O&M Subtotal Raw	**$14,187**	
2	**<u>Contingency</u>**					
	Contingency	15%	of O&M Subtotal Raw		$2,128	
				<u>O&M Subtotal</u>	**$16,315**	
3	**<u>Project Management, etc.</u>**					
	Project Management	10%	of O&M Subtotal		$1,632	Based on EPA FS Cost Estimate guidance.
	Technical Support	0%	of O&M Subtotal		$0	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$1,632**	
				Annual O&M Cost	**$18,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 1 thru 5:
Assumes collection of 1 indoor air sample per 2,000 square feet for commercial buildings.

Alternative 3- Mechanical Indoor Air Ventilation System with Monitoring in 7,000 Square Feet Commercial Building

Year 6 thru 15 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	**Indoor Air Sampling**					
	Perform annual air sampling (24-hour) for a 7,000 square feet commercial building based on collection of one sample per every 2,000 square feet (4 samples).	1	$860	Annual	$860	Unit cost is based on one technician at a rate of $95.00/hr for 8 hours + $100.00 ODCs (cooler, containers, shipping, gas) to collect grab samples.
	Sample Analysis for 4 VOC samples, 1 duplicate sample, and 1 outdoor sample per event	6	$300	Annual	$1,800	Unit cost for TO-15 SIM VOCs at $300.00
1.2	**HVAC System**					
	HVAC system Inspection	0	$460	Semi Annual	$0	Assume HVAC inspection as part of regular building management. Semi-annual Inspection of HVAC systems based on a technician with daily rate cost of 4 hours that includes travel time (4x$95.00+$80.00= $460.00).
	HVAC System Maintenance	1	$500	LS	$500	Estimated average annual cost of $500 for maintaining HVAC System and parts.
	Electricity (incremental to normal HVAC operation for VI control)	15,777	$0.15	KW/hr	$2,367	HVAC of 50 horsepower, 3 phases, 480 Volts, 3.7 KW for commercial bulidings. Consumption quantities based on the difference of normal operation (14 hrs for 5 days + 16 hrs/day over weekends = 82 hrs) and integral operation (7 days x 24 hours = 168 hours) on a weekly basis. Exceeding annual consumption is 3.7 KW x 82 hrs per week X 52 weeks = 15,780 KWh.
1.3	**Reporting**					
	Annual Monitoring Letter Report	1	$3,000	Ea	$3,000	Letter Report
				O&M Subtotal Raw	**$8,527**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$1,279	
				O&M Subtotal	**$9,806**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$981	Based on EPA FS Cost Estimate guidance.
	Technical Support	0%	of O&M Subtotal		$0	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$981**	
				Annual O&M Cost	**$11,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 6 thru 15:
Assumes collection of 1 indoor air sample per 2,000 square feet for commercial buildings.

Alternative 3- Mechanical Indoor Air Ventilation System with Monitoring in 12,000 Square Feet Commercial Building

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	**Indoor Air Sampling**					
	Perform semi-annual air sampling (24-hour) for a 12,000 square feet commercial building based on one sample per every 2,000 square feet	2	$860	Semi-annual	$1,720	Unit cost is based on one technician at a rate of $95.00/hr for 8 hours + $100.00 ODCs (cooler, containers, shipping, gas) to collect grab samples.
	Sample Analysis for 6 VOC samples, 1 duplicate sample, and 1 outdoor sample per event	16	$300	Semi Annual	$4,800	Unit cost for TO-15 SIM VOCs at $300.00
1.2	**HVAC System**					
	HVAC system Inspection	0	$460	Semi Annual	$0	Assume HVAC inspection as part of regular building management. Semi-annual Inspection of HVAC systems based on a technician with daily rate cost of 4 hours that includes travel time (4x$95.00+$80.00= $460.00).
	HVAC System Maintenance	1	$500	LS	$500	Estimated average annual cost of $500 for maintaining HVAC System and parts.
	Electricity (incremental to normal HVAC operation for VI control)	22,173	$0.15	KW/hr	$3,326	HVAC of 50 horsepower, 3 phases, 480 Volts, 5.2 KW for commercial bulidings. Consumption quantities based on the difference of normal operation (14 hrs for 5 days + 16 hrs/day over weekends = 82 hrs) and integral operation (7 days x 24 hours = 168 hours) on a weekly basis. Exceeding annual consumption is 5.2 KW x 82 hrs per week X 52 weeks = 22,173 KWhr .
1.3	**Reporting**					
	Semi-Annual Monitoring Letter Report	2	$3,000	Ea	$6,000	Letter Report
				O&M Subtotal Raw	**$16,346**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$2,452	
				O&M Subtotal	**$18,798**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$1,880	Based on EPA FS Cost Estimate guidance.
	Technical Support	0%	of O&M Subtotal		$0	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$1,880**	
				Annual O&M Cost	**$21,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 1 thru 5:
Assumes collection of 1 indoor air sample per 2,000 square feet for commercial buildings.

Alternative 3- Mechanical Indoor Air Ventilation System with Monitoring in 12,000 Square Feet Commercial Building

Year 6 thru 15 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	**Indoor Air Sampling**					
	Perform annual air sampling (24-hour) for a 12,000 square feet commercial building based on one sample per every 2,000 square feet	1	$860	Annual	$860	Unit cost is based on one technician at a rate of $95.00/hr for 8 hours + $100.00 ODCs (cooler, containers, shipping, gas) to collect grab samples.
	Sample Analysis for 6 VOC samples, 1 duplicate sample, and 1 outdoor sample per event	8	$300	Annual	$2,400	Unit cost for TO-15 SIM VOCs at $300.00
1.2	**HVAC System**					
	HVAC system Inspection	0	$460	Semi Annual	$0	Assume HVAC inspection as part of regular building management. Semi-annual Inspection of HVAC systems based on a technician with daily rate cost of 4 hours that includes travel time (4x$95.00+$80.00= $460.00).
	HVAC System Maintenance	1	$500	LS	$500	Estimated average annual cost of $500 for maintaining HVAC System and parts.
	Electricity (incremental to normal HVAC operation for VI control)	22,173	$0.15	KW/hr	$3,326	HVAC of 50 horsepower, 3 phases, 480 Volts, 5.2 KW for commercial bulidings. Consumption quantities based on the difference of normal operation (14 hrs for 5 days + 16 hrs/day over weekends = 82 hrs) and integral operation (7 days x 24 hours = 168 hours) on a weekly basis. Exceeding annual consumption is 5.2 KW x 82 hrs per week X 52 weeks = 22,173 KWhr .
1.3	**Reporting**					
	Annual Monitoring Letter Report	1	$3,000	Ea	$3,000	Letter Report
				O&M Subtotal Raw	**$10,086**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$1,513	
				O&M Subtotal	**$11,599**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$1,160	Based on EPA FS Cost Estimate guidance.
	Technical Support	0%	of O&M Subtotal		$0	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$1,160**	
				Annual O&M Cost	**$13,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 6 thru 15:
Assumes collection of 1 indoor air sample per 2,000 square feet for commercial buildings.

Alternative 3- Mechanical Indoor Air Ventilation System with Monitoring in 7,000 Square Feet Commercial Building
Present Worth Analysis
CTS Printex Superfund Site, Mountain View, California

Present Worth Analysis

Cost Type	***Year***	***Total Expenditure***	***Escalation Factor (2%)***	***Escalated Costs***	***Discount Factor (7%)***	***Present Worth***
Capital	0	$4,000	1.0000	$4,000	1.0000	$4,000
Annual O&M Cost	1	$18,000	1.0200	$18,360	0.9346	$17,159
Annual O&M Cost	2	$18,000	1.0404	$18,727	0.8734	$16,356
Annual O&M Cost	3	$18,000	1.0612	$19,102	0.8163	$15,593
Annual O&M Cost	4	$18,000	1.0824	$19,483	0.7629	$14,864
Annual O&M Cost	5	$18,000	1.1041	$19,874	0.7130	$14,170
Annual O&M Cost	6	$11,000	1.1262	$12,388	0.6663	$8,254
Annual O&M Cost	7	$11,000	1.1487	$12,636	0.6227	$7,868
Annual O&M Cost	8	$11,000	1.1717	$12,889	0.5820	$7,501
Annual O&M Cost	9	$11,000	1.1951	$13,146	0.5439	$7,150
Annual O&M Cost	10	$11,000	1.2190	$13,409	0.5083	$6,816
Annual O&M Cost	11	$11,000	1.2434	$13,677	0.4751	$6,498
Annual O&M Cost	12	$11,000	1.2682	$13,950	0.4440	$6,194
Annual O&M Cost	13	$11,000	1.2936	$14,230	0.4150	$5,905
Annual O&M Cost	14	$11,000	1.3195	$14,515	0.3878	$5,629
Annual O&M Cost	15	$11,000	1.3459	$14,805	0.3624	$5,365
Total of O&M Costs		$200,000		$231,191		$146,000
Averaged Annual O&M cost		$13,300		$15,412		
Total						**$150,000**

Note:
Capital cost is incremental cost for higher capacity ventilation system relative to a conventional ventilation system.
Average annual O&M cost is based on 15 years projection for achieving MCLs in contaminated groundwater through active remediation as proposed in the preferred Alternative 2B for groundwater remediation.

Alternative 3- Mechanical Indoor Air Ventilation System with Monitoring in 12,000 Square Feet Commercial Building
Present Worth Analysis
CTS Printex Superfund Site, Mountain View, California

Present Worth Analysis

Cost Type	*Year*	*Total Expenditure*	*Escalation Factor (2%)*	*Escalated Costs*	*Discount Factor (7%)*	*Present Worth*
Capital	0	$6,000	1.0000	$6,000	1.0000	$6,000
Annual O&M Cost	1	$21,000	1.0200	$21,420	0.9346	$20,019
Annual O&M Cost	2	$21,000	1.0404	$21,848	0.8734	$19,082
Annual O&M Cost	3	$21,000	1.0612	$22,285	0.8163	$18,191
Annual O&M Cost	4	$21,000	1.0824	$22,730	0.7629	$17,341
Annual O&M Cost	5	$21,000	1.1041	$23,186	0.7130	$16,532
Annual O&M Cost	6	$13,000	1.1262	$14,641	0.6663	$9,755
Annual O&M Cost	7	$13,000	1.1487	$14,933	0.6227	$9,299
Annual O&M Cost	8	$13,000	1.1717	$15,232	0.5820	$8,865
Annual O&M Cost	9	$13,000	1.1951	$15,536	0.5439	$8,450
Annual O&M Cost	10	$13,000	1.2190	$15,847	0.5083	$8,055
Annual O&M Cost	11	$13,000	1.2434	$16,164	0.4751	$7,680
Annual O&M Cost	12	$13,000	1.2682	$16,487	0.4440	$7,320
Annual O&M Cost	13	$13,000	1.2936	$16,817	0.4150	$6,979
Annual O&M Cost	14	$13,000	1.3195	$17,154	0.3878	$6,652
Annual O&M Cost	15	$13,000	1.3459	$17,497	0.3624	$6,341
Total of O&M Costs		$235,000		$271,777		$171,000
Averaged Annual O&M cost		$15,700		$18,118		
Total						**$177,000**

Note:
Capital cost is incremental cost for higher capacity ventilation system relative to a conventional ventilation system.
Average annual O&M cost is based on 15 years projection for achieving MCLs in contaminated groundwater through active remediation as proposed in the preferred Alternative 2B for groundwater remediation.

Basis of Cost Estimates - Capital and Operation and Maintenance for Alternative 4

Assumptions and the scope of work associated with Vapor Barrier with Sub-Slab Ventilation/ Sub-Membrane Ventilation System included in the capital costs for Alternative 4 are described below.

Construction of Vapor Barrier with Sub-Slab Ventilation

- Costs include site preparation, vapor barrier installation, and sub-slab ventilation network installation for:
    - 5,000 square ft. residential building size.
    - 7,000 square ft. commercial building size.
    - 12,000 square ft. commercial building size.
- Subcontractor oversight and logistical support included in costs.

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

- G&A at 9.63%
- 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:

- Design at 10%
- Profit at 10%

The basis for the operation and maintenance costs for Alternative 4 are summarized below for a 5,000 square ft. residential building, and 7,000 and 12,000 square ft. commercial buildings. A total O&M time frame of 15 years was assumed based estimated time for groundwater cleanup.

Assumptions for Year 1

- Perform one event of air sampling prior to human occupancy.
- Perform annual inspection of the sub-slab integrity.
- Prepare initial indoor air sampling report.

Assumptions for Year2 through 15

- Perform annual inspection on sub-slab integrity
- Prepare annual inspection and maintenance report.

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

- Contingency at 15%
- Project Management at 10%

INNOVATIVE TECHNICAL SOLUTIONS INC.

Project Name	**Alternative 4- Vapor Barrier with Sub-Slab Ventilation for Residential Building (5,000 Square Feet)**
Location	**CTS Printex Superfund Site**
Submittal Date:	May 2011

Sub Slab Ventilation	**Year 1 Rate**		Capital Costs		
1. Home Office Labor	**01/01/11 - 03/30/11**	**Unit**	**Hrs - Yr1**	**Hrs - Yr2**	**Cost ($)**
Project Manager	$58.80	hr	10.00		$587.96
Site Superintendent	$43.17	hr	20.00		$863.33
Subtotal Bare Cost			30.00		1,451.29
Fringe	35.70%				$518.11
Overhead	39.51%				$778.11
G&A	9.63%				$264.59
1. TOTAL HOME OFFICE LABOR			**30.00**		**$3,012.10**
2. Non Labor	Rate	Unit	**Qty - Yr1**	**Qty - Yr2**	**Cost ($)**
SUBCONTRACTS					
Sub Slab Ventilation - Residentail - 5000 sf	$10,000.00	LS	1.00		$10,000.00
Vapor Barrier - Residential - 5000 sf	$31,800.00	LS	1.00		$31,800.00
Subtotal Bare Subcontract Cost					**$41,800.00**
EQUIPMENT AND SUPPLIES					
Pick-up Truck	$975.00	month	0.50		$487.50
FGOM	$600.00		0.50		$300.00
Miscellaneous tools/Eyewash etc	$500.00	month	0.50		$250.00
TOTAL EQUIPMENT RENTAL					**$1,037.50**
Sales Tax on Rental Equipment	9.25%				$95.97
Subtotal Bare Equip & Supplies Cost					**$1,133.47**
Total Bare Non Labor Cost					**$42,933.47**
			42,933.47		
G&A	9.63%		42,933.47		$4,134.49
2. TOTAL NON LABOR					**$47,067.96**
Capital Cost Subtotal					**$50,080.06**
4. PROFIT / Other Costs	**Year 1**	**Unit**			
Profit	10.00%		$50,080.06		$5,008.01
Contingency	20.00%		55,088.07		$11,017.61
Design - Barrier w/sub-slab	10%		66,105.68		$6,610.57
Procurment	3%		66,105.68		$1,983.17
4. TOTAL PROFIT/Other Costs					**$24,619.36**
5. PROJECT TOTAL					**$74,699.42**

INNOVATIVE TECHNICAL SOLUTIONS INC.

Project Name **Alternative 4- Vapor Barrier with Sub-Slab Ventilation for Commercial Building (7,000 and 12,000 Square Feet)**

Location **CTS Printex Superfund Site**

Submittal Date: May 2011

Sub Slab Ventilation	**Year 1 Rate**		Commerical 7000 sf			Commerical 12000 sf		
1. Home Office Labor	**01/01/11 - 03/30/11**	**Unit**	**Hrs - Yr1**	**Hrs - Yr2**	**Cost ($)**	**Hrs - Yr1**	**Hrs - Yr2**	**Cost ($)**
Project Manager	$58.80	hr	14.00		$823.14	20.00		$1,175.92
Site Superintendent	$43.17	hr	30.00		$1,295.00	50.00		$2,158.33
Subtotal Bare Cost			**44.00**		**$2,118.14**	70.00		$3,334.25
Fringe	35.70%				**$756.18**			$1,190.33
Overhead	39.51%				**$1,135.64**			$1,787.66
G&A	9.63%				**$386.16**			$607.87
1. TOTAL HOME OFFICE LABOR			**44.00**		**$4,396.12**	**70.00**		**$6,920.10**
2. Non Labor	Rate	Unit	**Qty - Yr1**	**Qty - Yr2**	**Cost ($)**	**Qty - Yr1**	**Qty - Yr2**	**Cost ($)**
SUBCONTRACTS								
Vapor Barrier - Commercial - 7000 sf	$44,520.00	LS	1.00		$44,520.00			
Sub Slab Ventilation - Commercial - 7000 sf	$13,000.00	LS	1.00		$13,000.00			
Vapor Barrier - Commercial - 12000 sf	$76,300.00	LS				1.00		$76,300.00
Sub Slab Ventilation - Commercial - 12000 sf	$23,000.00					1.00		$23,000.00
Subtotal Bare Subcontract Cost					**$57,520.00**			**$99,300.00**
EQUIPMENT AND SUPPLIES								
Pick-up Truck	$975.00	month	1.50		$1,462.50	2.50		$2,437.50
FGOM	$600.00		1.50		$900.00	2.50		$1,500.00

INNOVATIVE TECHNICAL SOLUTIONS INC.

Project Name **Alternative 4- Vapor Barrier with Sub-Slab Ventilation for Commercial Building (7,000 and 12,000 Square Feet)**

Location **CTS Printex Superfund Site**

Submittal Date: May 2011

Sub Slab Ventilation	Year 1 Rate		Commerical 7000 sf			Commerical 12000 sf		
TOTAL EQUIPMENT RENTAL			3.00		**$2,362.50**	5.00		**$3,937.50**
Sales Tax on Rental Equipment	9.25%				$218.53			$364.22
Subtotal Bare Equip & Supplies Cost					**$2,581.03**			**$4,301.72**
Total Bare Non Labor Cost					**$60,101.03**			**$103,601.72**
			60,101.03			103,601.72		
G&A	9.63%		60,101.03		$5,787.73	103,601.72		$9,976.85
2. TOTAL NON LABOR					**$65,888.76**			**$113,578.56**
Capital Cost Subtotal					**$70,284.88**			**$120,498.67**
4. PROFIT / Other Costs	**Year 1**	**Unit**						
Profit	10.00%		$70,284.88		$7,028.49	$120,498.67		$12,049.87
Contingency	20.00%		77,313.37		$15,462.67	132,548.53		$26,509.71
Design - Barrier w/sub-slab	10%		92,776.04		$9,277.60	159,058.24		$15,905.82
Procurment	3%		92,776.04		$2,783.28	159,058.24		$4,771.75
4. TOTAL PROFIT/Other Costs					**$34,552.05**			**$59,237.14**
5. PROJECT TOTAL					**$104,836.93**			**$179,735.81**

Alternative 4- Vapor Barrier with Sub-Slab Ventilation/ Sub-Membrane Ventilation, Monitoring, and ICs for 5,000 Square Feet Residential Building

Year 1 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	**Indoor Air Sampling**					
	Perform initial air sampling in a 5,000 square feet residential building with five 1,000 sq ft units. Sampling frequency at 1 air sample per every 1,000 sq ft. (5 samples).	1	$480	Each	$480	Unit cost is based on one technician at a rate of $95.00/hr for 4 hours + $100.00 ODCs (cooler, containers, shipping, gas) to collect grab samples.
	Sample Analysis for 5 VOC samples, 1 duplicate sample, and 1 outdoor sample.	7	$300	Each	$2,100	Unit cost for TO-15 SIM VOCs at $300.00
1.2	**Venting System**					
	Routine Inspection	1	$460	Annual	$460	Annual inspection of venting system based on a technician with daily rate cost of 4 hours that includes travel time (4x$95.00+$80.00= $460.00).
1.3	**Reporting**					
	Initial Sampling Report	1	$5,000	Ea	$5,000	
	O&M Report	1	$1,000	Annual	$1,000	Letter submittal
				O&M Subtotal Raw	**$8,040**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$1,206	
				O&M Subtotal	**$9,246**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$925	Based on EPA FS Cost Estimate guidance.
	Technical Support	0%	of O&M Subtotal		$0	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$925**	
				Annual O&M Cost	**$11,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 1:
- Assumes collection of 1 air sample per 1,000 square feet for residential building.
- One time air sampling event to evaluate venting system effectiveness prior to human occupancy in buildings.

Alternative 4- Vapor Barrier with Sub-Slab Ventilation/ Sub-Membrane Ventilation, Monitoring, and ICs for 5,000 Square Feet Residential Building
Year 2 through 15 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	**Indoor Air Sampling**					
	Perform initial air sampling in a 5,000 square feet residential building with five 1,000 sq ft units. Sampling frequency at 1 air sample per every 1,000 sq ft.	0	$480	Each	$0	Unit cost is based on one technician at a rate of $95.00/hr for 4 hours + $100.00 ODCs (cooler, containers, shipping, gas) to collect grab samples.
	Sample Analysis for 5 VOC samples, 1 duplicate sample, and 1 outdoor sample.	0	$300	Each	$0	Unit cost for TO-15 SIM VOCs at $300.00
1.2	**Venting System**					
	Routine Inspection	1	$460	Annual	$460	Annual inspection of venting system based on a technician with daily rate cost of 4 hours that includes travel time (4x$95.00+$80.00= $460.00).
1.3	**Reporting**					
	Initial Sampling Report	0	$5,000	Ea	$0	
	O&M Report	1	$1,000	Annual	$1,000	Letter submittal
				O&M Subtotal Raw	**$1,460**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$219	
				O&M Subtotal	**$1,679**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$168	Based on EPA FS Cost Estimate guidance.
	Technical Support	0%	of O&M Subtotal		$0	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$168**	
				Annual O&M Cost	**$2,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 2-15:
- O&M costs asscoiated with routine inspection and maintenance of the venting system.

Alternative 4- Vapor Barrier with Sub-Slab Ventilation/ Sub-Membrane Ventilation, Monitoring, and ICs for 7,000 Square Feet Commercial Building
Year 1 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	**Indoor Air Sampling**					
	Perform initial air sampling in a 7,000 square feet commercial building. Sampling frequency at 1 air sample per every 2,000 sq ft.	1	$480	Each	$480	Unit cost is based on one technician at a rate of $95.00/hr for 4 hours + $100.00 ODCs (cooler, containers, shipping, gas) to collect grab samples.
	Sample Analysis for 4 VOC samples, 1 duplicate sample, and 1 outdoor sample.	6	$300	Each	$1,800	Unit cost for TO-15 SIM VOCs at $300.00
1.2	**Venting System**					
	Routine Inspection	1	$460	Annual	$460	Annual inspection of venting system based on a technician with daily rate cost of 4 hours that includes travel time (4x$95.00+$80.00= $460.00).
1.3	**Reporting**					
	Initial Sampling Report	1	$5,000	Ea	$5,000	
	O&M Report	1	$1,000	Annual	$1,000	Letter submittal
				O&M Subtotal Raw	**$7,740**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$1,161	
				O&M Subtotal	**$8,901**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$890	Based on EPA FS Cost Estimate guidance.
	Technical Support	0%	of O&M Subtotal		$0	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$890**	
				Annual O&M Cost	**$10,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 1:
- Assumes collection of 1 air sample per 2,000 square feet for commercial buildings.
- One time air sampling event to evaluate venting system effectiveness prior to human occupancy in buildings.

Alternative 4- Vapor Barrier with Sub-Slab Ventilation/ Sub-Membrane Ventilation, Monitoring, and ICs for 7,000 Square Feet Commercial Building
Year 2 thru 15 Annual O&M Costs (see Note 2)
CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Indoor Air Sampling**					
	Perform air sampling in a 7,000 square feet commercial building. Sampling frequency at 1 air sample per every 2,000 sq ft.	0	$480	Each	$0	Unit cost is based on one technician at a rate of $95.00/hr for 4 hours + $100.00 ODCs (cooler, containers, shipping, gas) to collect grab samples.
	Sample Analysis for 4 VOC samples and 1 duplicate sample.	0	$300	Each	$0	Unit cost for TO-15 SIM VOCs at $300.00
1.2	**Vapor Barrier Collection System**					
	Routine Inspection	1	$460	Annual	$460	Annual inspection of venting system based on a technician with daily rate cost of 4 hours that includes travel time (4x$95.00+$80.00= $460.00).
1.3	**Reporting**					
	Annual O&M Letter Report	1	$1,000	Annual	$1,000	Letter submittal
				O&M Subtotal Raw	**$1,460**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$219	
				O&M Subtotal	**$1,679**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$168	Based on EPA FS Cost Estimate guidance.
	Technical Support	0%	of O&M Subtotal		$0	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$168**	
				Annual O&M Cost	**$2,000**	Rounded up to the nearest thousand.

Note 2: Basis for costing Year 2 through 15:
- O&M costs asscoiated with routine inspection and maintenance of the venting system.

Alternative 4- Vapor Barrier with Sub-Slab Ventilation/ Sub-Membrane Ventilation, Monitoring, and ICs for 12,000 Square Feet Commercial Building

Year 1 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	**Indoor Air Sampling**					
	Perform initial air sampling in a 12,000 square feet commercial building. Sampling frequency at 1 air sample per every 2,000 sq ft.	1	$480	Each	$480	Unit cost is based on one technician at a rate of $95.00/hr for 4 hours + $100.00 ODCs (cooler, containers, shipping, gas) to collect grab samples.
	Sample Analysis for 6 VOC samples, 1 duplicate sample, and 1 outdoor sample.	8	$300	Each	$2,400	Unit cost for TO-15 SIM VOCs at $300.00
1.2	**Venting System**					
	Routine Inspection	1	$460	Annual	$460	Annual inspection of venting system based on a technician with daily rate cost of 4 hours that includes travel time (4x$95.00+$80.00= $460.00).
1.3	**Reporting**					
	Initial Sampling Report	1	$5,000	Ea	$5,000	
	O&M Report	1	$1,000	Annual	$1,000	Letter submittal
				O&M Subtotal Raw	**$8,340**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$1,251	
				O&M Subtotal	**$9,591**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$959	Based on EPA FS Cost Estimate guidance.
	Technical Support	0%	of O&M Subtotal		$0	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$959**	
				Annual O&M Cost	**$11,000**	Rounded up to the nearest thousand.

Note 1: Basis for costing Year 1:
- Assumes collection of 1 air sample per 2,000 square feet for commercial buildings.
- One time air sampling event to evaluate venting system effectiveness prior to human occupancy in buildings.

Alternative 4- Vapor Barrier with Sub-Slab Ventilation/ Sub-Membrane Ventilation, Monitoring, and ICs for 12,000 Square Feet Commercial Building
Year 2 thru 15 Annual O&M Costs (see Note 2)
CTS Printex Superfund Site, Mountain View, California

Item	*Description*	*Quantity*	*Unit Cost*	*Unit*	*Total Cost*	*Notes*
1.1	**Indoor Air Sampling**					
	Perform air sampling in a 12,000 square feet commercial building. Sampling frequency at 1 air sample per every 2,000 sq ft.	0	$480	Each	$0	Unit cost is based on one technician at a rate of $95.00/hr for 4 hours + $100.00 ODCs (cooler, containers, shipping, gas) to collect grab samples.
	Sample Analysis for 6 VOC samples, 1 duplicate sample, and 1 outdoor sample.	0	$300	Each	$0	Unit cost for TO-15 SIM VOCs at $300.00
1.2	**Vapor Barrier Collection System**					
	Routine Inspection	1	$460	Annual	$460	Annual inspection of venting system based on a technician with daily rate cost of 4 hours that includes travel time (4x$95.00+$80.00= $460.00).
1.3	**Reporting**					
	Annual O&M Letter Report	1	$1,000	Annual	$1,000	Letter submittal
				O&M Subtotal Raw	**$1,460**	
2	**Contingency**					
	Contingency	15%	of O&M Subtotal Raw		$219	
				O&M Subtotal	**$1,679**	
3	**Project Management, etc.**					
	Project Management	10%	of O&M Subtotal		$168	Based on EPA FS Cost Estimate guidance.
	Technical Support	0%	of O&M Subtotal		$0	Based on EPA FS Cost Estimate guidance.
				Project Management Subtotal	**$168**	
				Annual O&M Cost	**$2,000**	Rounded up to the nearest thousand.

Note 2: Basis for costing Year 2 through 15:
- O&M costs asscoiated with routine inspection and maintenance of the venting system.

Alternative 4 - Vapor Barrier with Sub-Slab Ventilation/Sub-Membrane Ventilation, Monitoring, and ICs for 5,000 Square Feet Residential Building

Present Value Analysis
CTS Printex Superfund Site, Mountain View, California

Present Worth Analysis

Cost Type	*Year*	*Total Expenditure*	*Escalation Factor (2%)*	*Escalated Costs*	*Discount Factor (7%)*	*Present Worth*
Capital	0	$75,000	1.0000	$75,000	1.0000	$75,000
Annual O&M Cost	1	$11,000	1.0200	$11,220	0.9346	$10,486
Annual O&M Cost	2	$2,000	1.0404	$2,081	0.8734	$1,818
Annual O&M Cost	3	$2,000	1.0612	$2,122	0.8163	$1,732
Annual O&M Cost	4	$2,000	1.0824	$2,165	0.7629	$1,652
Annual O&M Cost	5	$2,000	1.1041	$2,208	0.7130	$1,574
Annual O&M Cost	6	$2,000	1.1262	$2,252	0.6663	$1,501
Annual O&M Cost	7	$2,000	1.1487	$2,297	0.6227	$1,430
Annual O&M Cost	8	$2,000	1.1717	$2,343	0.5820	$1,364
Annual O&M Cost	9	$2,000	1.1951	$2,390	0.5439	$1,300
Annual O&M Cost	10	$2,000	1.2190	$2,438	0.5083	$1,239
Annual O&M Cost	11	$2,000	1.2434	$2,487	0.4751	$1,182
Annual O&M Cost	12	$2,000	1.2682	$2,536	0.4440	$1,126
Annual O&M Cost	13	$2,000	1.2936	$2,587	0.4150	$1,074
Annual O&M Cost	14	$2,000	1.3195	$2,639	0.3878	$1,023
Annual O&M Cost	15	$2,000	1.3459	$2,692	0.3624	$976
Total of O&M Costs		$39,000		$44,457		$30,000
Averaged Annual O&M cost		$2,600		$2,963		$2,000
Total						**$105,000**

Note:
Average annual O&M cost is based on 15 years projection for achieving MCLs in contaminated groundwater through active remediation as proposed in the preferred Alternative 2B for groundwater remediation.

Alternative 4 - Vapor Barrier with Sub-Slab Ventilation/Sub-Membrane Ventilation, Monitoring, and ICs for 7,000 Square Feet Commercial Building

Present Value Analysis
CTS Printex Superfund Site, Mountain View, California

Present Worth Analysis

Cost Type	***Year***	***Total Expenditure***	***Escalation Factor (2%)***	***Escalated Costs***	***Discount Factor (7%)***	***Present Worth***
Capital	0	$105,000	1.0000	$105,000	1.0000	$105,000
Annual O&M Cost	1	$10,000	1.0200	$10,200	0.9346	$9,533
Annual O&M Cost	2	$2,000	1.0404	$2,081	0.8734	$1,818
Annual O&M Cost	3	$2,000	1.0612	$2,122	0.8163	$1,732
Annual O&M Cost	4	$2,000	1.0824	$2,165	0.7629	$1,652
Annual O&M Cost	5	$2,000	1.1041	$2,208	0.7130	$1,574
Annual O&M Cost	6	$2,000	1.1262	$2,252	0.6663	$1,501
Annual O&M Cost	7	$2,000	1.1487	$2,297	0.6227	$1,430
Annual O&M Cost	8	$2,000	1.1717	$2,343	0.5820	$1,364
Annual O&M Cost	9	$2,000	1.1951	$2,390	0.5439	$1,300
Annual O&M Cost	10	$2,000	1.2190	$2,438	0.5083	$1,239
Annual O&M Cost	11	$2,000	1.2434	$2,487	0.4751	$1,182
Annual O&M Cost	12	$2,000	1.2682	$2,536	0.4440	$1,126
Annual O&M Cost	13	$2,000	1.2936	$2,587	0.4150	$1,074
Annual O&M Cost	14	$2,000	1.3195	$2,639	0.3878	$1,023
Annual O&M Cost	15	$2,000	1.3459	$2,692	0.3624	$976
Total of O&M Costs		$38,000		$43,437		$29,000
Averaged Annual O&M cost		$2,600		$2,895		$1,933
Total						**$134,000**

Note:
Average annual O&M cost is based on 15 years projection for achieving MCLs in contaminated groundwater through active remediation as proposed in the preferred Alternative 2B for groundwater remediation.

Alternative 4- Vapor Barrier with Sub-Slab Ventilation/Sub-Membrane Ventilation, Monitoring, and ICs for 12,000 Square Feet Commercial Building

Present Value Analysis
CTS Printex Superfund Site, Mountain View, California

Present Worth Analysis

Cost Type	***Year***	***Total Expenditure***	***Escalation Factor (2%)***	***Escalated Costs***	***Discount Factor (7%)***	***Present Worth***
Capital	0	$180,000	1.0000	$180,000	1.0000	$180,000
Annual O&M Cost	1	$11,000	1.0200	$11,220	0.9346	$10,486
Annual O&M Cost	2	$2,000	1.0404	$2,081	0.8734	$1,818
Annual O&M Cost	3	$2,000	1.0612	$2,122	0.8163	$1,732
Annual O&M Cost	4	$2,000	1.0824	$2,165	0.7629	$1,652
Annual O&M Cost	5	$2,000	1.1041	$2,208	0.7130	$1,574
Annual O&M Cost	6	$2,000	1.1262	$2,252	0.6663	$1,501
Annual O&M Cost	7	$2,000	1.1487	$2,297	0.6227	$1,430
Annual O&M Cost	8	$2,000	1.1717	$2,343	0.5820	$1,364
Annual O&M Cost	9	$2,000	1.1951	$2,390	0.5439	$1,300
Annual O&M Cost	10	$2,000	1.2190	$2,438	0.5083	$1,239
Annual O&M Cost	11	$2,000	1.2434	$2,487	0.4751	$1,182
Annual O&M Cost	12	$2,000	1.2682	$2,536	0.4440	$1,126
Annual O&M Cost	13	$2,000	1.2936	$2,587	0.4150	$1,074
Annual O&M Cost	14	$2,000	1.3195	$2,639	0.3878	$1,023
Annual O&M Cost	15	$2,000	1.3459	$2,692	0.3624	$976
Total of O&M Costs		$39,000		$44,457		$30,000
Averaged Annual O&M cost		$2,600		$2,963		$2,000
Total						**$210,000**

Note:
Average annual O&M cost is based on 15 years projection for achieving MCLs in contaminated groundwater through active remediation as proposed in the preferred Alternative 2B for groundwater remediation.