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REMEDIAL INVESTIGATION

Volume II of the Remedial Investigation
HHRA and SLERA

Commerce Street Plume Superfund Site
Williston, Vermont

Remedial Investigation / Feasibility Study
EPA Task Order No. 0036-RI-FS-019L

REMEDIAL ACTION CONTRACT
No. EP-S1-06-03

FOR

US Environmental Protection Agency
Region 1

BY

Nobis Engineering, Inc.

Nobis Project No. 80036

July 2015

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SECTION I

Human Health Risk Assessment

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ACRONYMS AND ABBREVIATIONS

1,2-DCA	1,2-Dichloroethane
2,3,7,8-TCDD	2,3,7,8-tetrachloro-dibenzo-p-dioxin
ACH	air changes per hour
ADAF	Age-Dependent Adjustment Factor
ADC	Average Daily Concentrations
ADD	Average Daily Dose
AIP	Alling Industrial Park
ARAR	Applicable or Relevant and Appropriate Regulation
AT	Averaging Time
Atlas	Vermont Natural Resources Atlas
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene and xylenes
CADD	Chronic Average Daily Dose
cis-1,2-DCE	cis-1,2-Dichloroethene
CLT	central limit theorem
cm	centimeter
COPC	Contaminant of Potential Concern
CSF	Cancer Slope Factors
CTE	Central Tendency Exposure
DABS	Dermal Absorption Factors
DAD	Dermally Absorbed Dose
dL	deciliter
DNAPL	dense non-aqueous phase liquid
ED	Exposure Duration
EPA	United States Environmental Protection Agency
EPC	Exposure Point Concentration
EV	Event Frequency
FS	Feasibility Study
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index

ACRONYMS AND ABBREVIATIONS (cont.)

HQ	Hazard Quotient
IEUBK	Integrated Exposure Uptake and Biokinetic
ILCR	Incremental Lifetime Cancer Risk
IRIS	Integrated Risk Information System
Kg	kilogram
KM	Kaplan-Meier
L	liter
LADD	Lifetime Average Daily Dose
LOAEL	Lowest-Observed-Adverse-Effect Level
m	meter
MCL	maximum contaminant levels
mg	milligram
Mitec	Mitec Systems Corporation
MVUE	Minimum Variance Un-biased Estimators
NCEA	National Center for Environmental Assessment
NHL	non-Hodgkin lymphoma
NJDEP	New Jersey Department of Environmental Protection
NOAEL	No-Observed-Adverse-Effect-Level
OABS	Oral Absorption Factors
OPP	Office of Pesticide Programs
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
PCE	tetrachloroethylene
PPRTV	Provisional Peer Reviewed Toxicity Value
RAGS HHEM	Risk Assessment Guidance for Superfund, Human Health Evaluation Manual
RfC	Reference Concentration
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RSL	Regional Screening Levels
SQL	Sample Quantitation Limit
SSAF	Soil or Sediment-to-Skin Adherence Factor

ACRONYMS AND ABBREVIATIONS (cont.)

STSC	Superfund Health Risk Technical Support Center
Site	Commerce Street Plume Superfund Site
TCE	trichloroethylene
TEF	Toxicity Equivalency Factor
TEQ	Toxicity Equivalent
UCL	upper confidence limit on the mean
URF	Unit Risk Factor
VDEQ	Virginia Department of Environmental Quality
VF	volatilization factor
VI	vapor intrusion
VISL	vapor intrusion screening level
VOC	Volatile Organic Compound
VT DOH	Vermont Department of Health
VT DEC	Vermont Department of Environmental Conservation
µg	microgram

1.0 INTRODUCTION

This document presents the Human Health Risk Assessment (HHRA) of the Commerce Street Plume Superfund Site (Site) as Volume 2 of the Remedial Investigation (RI) Report. The HHRA presents a description of the risk assessment methods used to evaluate potential cancer risk and non-cancer health hazards from contaminants in the soil, groundwater, sediment, and surface water at the Study Area in the absence of any remedial action or institutional controls. The results of the HHRA are used in developing remedial alternatives for these media as part of the Feasibility Study (FS) and by risk managers in the decision making process.

The HHRA evaluates non-cancer health hazards, cancer risks, and lead exposures through quantitative assessments. The potential for non-carcinogenic health effects is assessed by comparing an exposure estimate (dose) to a reference dose (RfD). Ratios of the intake dose to the RfD below 1.0 indicate that adverse non-carcinogenic effects are unlikely. Risks attributable to exposure to chemical carcinogens are estimated as the probability of an individual developing cancer over a lifetime as a result of potential exposure to a carcinogen. Superfund uses an acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. Risks below 1×10^{-6} (less than 1 in 1 million) are generally considered to be acceptable by the United States Environmental Protection Agency (EPA), and risks greater than 1×10^{-4} (1 in 10,000) are generally considered to be unacceptable. Potential risks from exposure to lead were evaluated using EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model to estimate the concentration of lead in blood of children. EPA's risk reduction goal is to limit the probability of a child's blood lead concentration exceeding 10 micrograms per deciliter (µg/dL) to 5 percent or less.

Study Area

The Site is located at an industrial park in Williston, Vermont (Figure 1-1). The Study Area encompasses the former Alling Industrial Park (AIP) and a portion of the adjacent residential area to the west (Figure 1-2). The Study Area is located within the Winooski River watershed. Current zoning allows for mixed residential, business, and industrial uses. Commerce Street and the areas to the east are predominantly commercially zoned lots that are currently developed or in the process of being developed. Kirby Lane is entirely residential. South Brownell Road is residential with some commercial developments. Public pedestrian access is unrestricted within the Study Area.

The ground surface over the entire area exhibits little relief and slopes gently to the southwest.

Surface water at the Study Area encompasses a small unnamed stream just east of Commerce Street, which flows in a southerly direction to Tributary #4 to Muddy Brook. A small wetland area is associated with the confluence of the unnamed stream and Tributary #4 at the southern end of Commerce Street.

All surface waters in Vermont are State-designated areas for protection and maintenance of aquatic life under the Clean Water Act. The unnamed stream and associated wetlands were assessed for and found to be unlikely potential habitat for the two Vermont-listed threatened species – the eastern sand darter and eastern pearlshell mussel (Normandeau Associates, 2004). No other rare, threatened or endangered species have been identified (VT DEC, 2014). Downstream of the Study Area, Muddy Brook flows into the Winooski River, which is a known fishery.

On the western edge of the Study Area near the intersection of Shunpike and South Brownell Roads is an “unmapped intermittent stream” – a topographic depression with culverts in some areas that conveys intermittent groundwater discharge (VT DEC, 2014).

Previous studies identified three properties/lots within the industrial park as locations of former manufacturing and/or fabrication operations that could have contributed to groundwater contamination. Compounds found in groundwater beneath the Study Area include trichloroethylene (TCE), tetrachloroethylene (PCE), benzene, toluene, ethylbenzene and xylene compounds (commonly referred to as BTEX), cadmium, and chromium. The three lots listed below and the potential sources are described in Section 1.3.1 of the RI Volume I.

- Lot 19-11 (Former Mitec Systems Corporation property/96 Commerce Street);
- Lot 19-12 (Bove-Fagan property/87 Commerce Street); and
- Lot 19-2 (Former EMCO property/63 Commerce Street).

In 2004, the Site was placed on the Superfund National Priorities List on the basis of the widespread occurrence of contaminants (TCE primarily) in the groundwater. The areas of interest for the RI encompass the soils in the Study Area, the contaminated groundwater plume, and the

unnamed stream. The Study Area is depicted in Figure 1-2. Sampling was conducted within the Study Area during RI activities.

Study Area History

Development in the industrial park started in 1946 when Alling Enterprises began manufacturing cup hooks and caster caps. Aerial photographs from 1937 show a vegetated area with a dirt road (later Commerce Street) surrounded by agricultural land (EPA, 2008). Since then, Commerce Street has had and continues to have various light industrial and commercial tenants.

Various commercial and manufacturing operations have occurred on the 96 Commerce Street property since 1960. The two primary potential sources of contamination on the property were identified as an unlined lagoon and a sanitary leach field, which were both created to dispose of liquid waste. From 1979 to 1986, Mitec Systems Corporation (Mitec) leased the property for manufacturing electronic and microwave components. Between 1979 and 1984, Mitec discharged an undetermined quantity of rinse waters and sludge wastes containing chromium, cadmium, cyanide, nickel, and industrial solvents associated with electroplating operations into the unlined lagoon (Weston, 1998). In 1984, monitoring wells detected chromium in groundwater downgradient of the lagoon. In July 1985, sampling by Vermont Department of Health (VT DOH) showed residential private drinking water wells downgradient of the lagoon and leach field to be contaminated with TCE. The drinking water wells were subsequently removed from service as drinking water sources, and residents were provided with an alternate drinking water supply.

Additionally, in 1989, elevated concentrations of PCE and TCE were detected in the indoor air of several South Brownell Road residences. A determination was made by the Vermont Department of Environmental Conservation (VT DEC) that the risks posed were minimal in all but one residence. In that home, the presence of volatile organic compound (VOC) vapors, which were attributed to the volatilization of contaminants from the groundwater that underlies the house and Study Area, were significant. Venting a sump pump in the basement to the exterior of the structure brought indoor air concentrations down to levels acceptable to VT DEC (HSI GeoTrans, 2000).

Numerous groundwater, surface water, sediment, residential indoor air, and soil sampling events occurred between 1984 and 2002. These previous investigations identified TCE, PCE, BTEX, chromium, and cadmium in groundwater concentrations above their applicable State and Federal

standards; TCE soil contamination directly downgradient of the leach field located at the Mitec property; and cis-1,2-dichloroethene (cis-1,2-DCE), chromium, TCE, and vinyl chloride contamination in the surface water in the unnamed stream and associated wetlands. Of these contaminants, TCE was found to be the most widespread and is present throughout the Study Area groundwater contaminant plume. Metal contamination was evaluated in the VT DEC Site Investigation (Brinkerd Environmental, 1996), and it was determined that metals contamination was confined to the areas near the former Mitec property, in the central portion of the Study Area. The report concluded that metals were not likely to migrate much farther and should not present a risk to surface water.

See Section 1.3 through 1.5 of the RI Volume I for further details.

Report Organization

Section 1.0 discusses the purpose of the HHRA, describes the Study Area, and summarizes the site history. Section 2.0 provides an overview of the risk assessment process. Sections 3.0 through 8.0 detail the methodology and results of the HHRA. Appendices A through L present supporting materials for the HHRA. This assessment uses EPA policy and guidance to evaluate current and future potential risks. The tables presented in Appendix A were prepared following the standard format in accordance with *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual (RAGS HHEM) Part D* (EPA, 2001).

2.0 OVERVIEW OF RISK ASSESSMENT PROCESS

EPA uses risk assessment to identify potential contaminants of concern, identify appropriate toxicological information for each contaminant, identify potentially exposed individuals, and assess the potential ways in which an individual may be exposed to the contaminants. This information is integrated to characterize the cancer risks and non-cancer health hazards. A risk assessment framework was first outlined in 1983 by the National Academy of Science, National Research Council (NRC, 1983). Building on that framework, EPA developed *RAGS HHEM Part A* (EPA, 1989), which describes the four main components of risk assessment:

- Data evaluation and identification of contaminants of potential concern (COPCs);
- Exposure assessment;

- Toxicity assessment; and
- Risk characterization.

Actions at Superfund sites are based on an estimate of the reasonable maximum exposure (RME) expected to occur under both current and future conditions at the site. The RME is defined as the highest exposure that is reasonably expected to occur at a site. EPA guidance also recommends that the EPA estimate risks based on central tendency, or average, exposures (CTE) at a site (EPA, 1995 and 2000b). The RME and CTE exposures are used to estimate cancer risks and non-cancer health hazards.

For cancer risks and non-cancer health hazards to be present, a complete exposure pathway for chemical contact and intake must exist. A complete pathway requires: a source of contaminants with toxic characteristics in environmental media; a release of contaminants by either natural processes or by human action; potential exposure points at the source or via migration pathways; and exposure routes. Risk depends on toxicity and exposure. If any one of the requirements listed above is absent for a specific site, the exposure pathway is regarded as incomplete and no potential risks will be considered for human receptors.

In the data evaluation component of the HHRA, the nature and extent of contamination is characterized, a risk-based screening is used to select COPCs and exposure point concentrations (EPCs) are calculated. Environmental data collected from the Study Area are compared to medium-specific concentrations including conservative risk-based screening levels. COPCs are selected for each medium that are representative of the type of expected potential human health exposure. The EPC is a conservative estimate of the average concentration an individual may be exposed to over time. A discussion of the data evaluation process and site-specific issues is contained in Section 3.0.

The exposure assessment identifies potential human exposure pathways. Exposure routes (i.e., ingestion, inhalation, and dermal absorption) are identified by medium (i.e., soil, sediment, surface water, groundwater, and indoor air), based on information on Study Area chemical concentrations, chemical release mechanisms, human activity patterns, and other pertinent information, to develop a conceptual site model. A discussion of the exposure assessment is contained in Section 4.0. A summary of the potentially significant exposures identified for quantitative evaluation is provided in Table 2-1 (the same table is also included in Appendix A as Table A-1).

The toxicity assessment presents the available human health dose-response toxicity values for all the selected COPCs. This assessment is contained in Section 5.0. A discussion of health effects and dose-response parameters, such as RfDs, reference concentrations (RfCs), cancer slope factors (CSFs), and inhalation unit risk factors (URFs), is presented.

The risk characterization section (Section 6.0) describes how the estimated intakes are combined with the toxicity information to estimate risks. Uncertainties associated with the risk assessment process are discussed qualitatively in Section 7.0. Section 8.0 summarizes the HHRA for the Study Area.

3.0 DATA EVALUATION

Data evaluation is a site-specific task that uses a variety of information to determine which of the detected chemicals in each medium are most likely to present a risk to potential receptors based on toxicity and detected concentrations. This section presents the approaches for identification of COPCs, distributional analysis of the data, and EPCs.

The end result of this selection process is a list of COPCs and representative EPCs. EPCs are defined as the contaminant concentrations at the point of exposure. The methodology used to identify COPCs for this HHRA is provided in Section 3.1. Section 3.2 presents the identified COPCs for each medium. The methodologies used to determine EPCs for the selected COPCs are presented in Section 3.3.

The media of human health concern selected for the Study Area are as follows:

- Sediment;
- Surface water;
- Groundwater;
- Indoor air; and
- Soil.

Sediment and surface water samples that were included in the HHRA evaluation were collected from the unnamed stream downstream of the Study Area and represent sediment and surface water that current or future recreational visitors may be exposed to.

Shallow groundwater data were used to determine potential risks to construction workers from direct contact with groundwater and volatilization of groundwater contaminants into trench air. Shallow groundwater samples were defined as those samples collected from screening depths of 0 to 10 feet below ground surface (bgs).

Shallow groundwater data from screening depths of 0 to 15 feet bgs were used as a preliminary screen to determine potential risks to local residents and industrial/commercial workers from volatilization of groundwater contaminants into indoor air.

Groundwater data from Study Area monitoring wells regardless of depth were considered for a quantitative evaluation of potential drinking water exposures. Groundwater within the Study Area is not currently used as drinking water. EPA guidance for evaluation of groundwater exposures recommends using groundwater data from the core of the plume (EPA, 2014b). Therefore, groundwater data from wells sampled within the core of the Commerce Street plume were included in the quantitative evaluation of potential drinking water exposures.

Soil samples were collected from depths of 0 to 10 feet bgs and are included in the qualitative HHRA evaluations of direct contact exposures. It is assumed that soil below 10 feet will not be disturbed. Contaminated soils were removed from the unlined lagoon in 1985 and 1989. For this reason, the evaluation of soils has been limited to a semi-quantitative evaluation. The semi-quantitative evaluation consists of a comparison of Study Area data (divided into samples collected at 96 Commerce Street and samples collected at properties along Shunpike Road and South Brownell Road) to residential screening levels, which is summarized in the EPA soil technical memorandum included as Appendix B, and discussed in the uncertainty section (Section 7).

EPA investigated the potential for vapor intrusion at five residential and two commercial buildings representative of conditions across the Study Area in June 2012 and January 2013, and a sixth residence in December 2014. The potential transport of volatile contaminants from groundwater to indoor air was investigated with sampling of indoor air and sub-slab soil gas. The investigation,

described in Appendix C, did not show the vapor intrusion pathway to be complete (EPA, 2002a) across the Study Area and is not evaluated in this HHRA beyond the preliminary shallow groundwater screen.

EPA also evaluated the health risk to residents at 830 South Brownell Road from direct vapor inhalation from contaminated groundwater that, but for an existing sump pump system, could flood the basement. That evaluation can be found in Appendix L.

Data utilized in this risk assessment consist of validated analytical results of known and sufficient quality for use in quantitative risk calculations. Groundwater screening data and vertical profiling samples were excluded from the HHRA. The soil, sediment, surface water, and groundwater data used were validated in accordance with EPA Tier II or higher validation levels (EPA, 1996) and determined to be of adequate quality for use in the risk assessment. Analytical results qualified as rejected, "R," during the data validation process, were not considered because of their potential unreliability. Estimated values (J-qualified) were used as the reported value. All U-qualified results represent non-detectible concentrations (non-detects) for the parameter evaluated. In these instances the concentration was assumed to be present in the sample at the sample quantitation limit (SQL). Blank-qualified results were treated as non-detects. If sample duplicates were collected and analyzed and one was a detection and the other was not, the detected concentration was used. If the results of a duplicate pair were similar (i.e., both detected or both non-detected), the average of the two reported concentrations was used for subsequent calculations unless there was a greater than 50 percent relative percent difference (or greater than 30 percent relative difference for groundwater), in which case the higher of the two concentrations was used.

The database considered for use in this risk assessment includes:

- Soil data from soil borings and surface soil samples collected in 2010, 2012, 2013, and 2014 (results described in Section 4.3 of the RI Volume I).

- Groundwater data from monitoring wells sampled in 2008 through 2013 (results described in Section 4.4 of the RI Volume I). The 2013 groundwater chromium speciation results were used qualitatively to confirm that total chromium concentrations in groundwater may contain significant concentrations of hexavalent chromium. See discussion in Section 7.1.

- Surface water data from samples collected in September 2012 (results described in Section 4.5 of the RI Volume I).

- Sediment data from samples collected in September 2012 (results described in Section 4.6 of the RI Volume I);

Appendix D provides lists of sample locations included in the HHRA for each medium and exposure point. Sample locations are shown on Figures 3-1 (sediment and surface water), 3-2 (groundwater), 3-3 (soil), and 3-4 (surficial soil and sump water). Analytical results for these samples are presented in the RI Volume I, Appendix D. See Section 2 of the RI Volume I for discussion of sample collection and the fixed laboratory analysis by standard EPA methods. See Section 4 of the RI Volume I for discussion of the analytical results.

3.1 Selection of COPCs

The selection of COPCs is a risk-based screening step to identify chemicals that should be included in the quantitative risk assessment. The selection of COPCs was based on chemical substances found at the Study Area including chemical-specific concentrations, occurrence, distribution, and toxicity. COPCs include only those chemicals with positive detections, and are limited to those chemicals that exceed the selection criterion. The EPA Regional Screening Levels (RSLs) (EPA, 2015) were used as selection criteria to reduce the number of chemicals considered in the risk assessment. The RSLs are risk-based screening levels that combine cancer and non-cancer toxicity values with exposure assumptions. Toxicity values for cancer effects include oral cancer slope factors and inhalation unit risks. Toxicity values for non-cancer include reference doses and reference concentrations. The values used are consistent with EPA's toxicity hierarchy (EPA, 2003). Screening levels based on residential exposure assumptions were used for this HHRA as a conservative screening tool to be protective of all current and potential future land and groundwater uses. Screening levels based on residential exposure assumptions are very conservative for screening sediment or surface water, for screening shallow groundwater for protection of construction worker exposures, or for screening soils from developed properties used for non-residential purposes. Exposures to sediment or surface water are limited to recreational exposures; however, no screening levels based on recreational exposure assumptions are available.

A chemical was selected as a COPC if the maximum detected concentration was greater than the associated RSL or when no RSL was available. Frequency of detection was not considered in COPC selection.

The criteria used to identify COPCs are presented in Appendix A, Tables A-2.1 through A-2.6. Chemicals with maximum concentrations greater than the COPC screening levels are discussed in Section 3.2. Discussions of the criteria used for COPC selection are provided in the remainder of this section.

Criteria for the Selection of COPCs in Sediment and Soil

The following screening criteria were used to identify sediment and soil COPCs:

- **EPA RSLs for Sediment and Soil Exposures.** The maximum concentration detected in each medium (sediment and soil) were compared to EPA RSLs for residential soil (EPA, 2015) as described below. The EPA RSL Table identifies concentrations of potential concern for nearly 600 chemicals in various media (air, drinking water, and soil) using certain reasonable maximum exposure default assumptions. Residential soil RSLs represent a conservative screen for sediment, since exposures to sediment would be more consistent with recreational land use. RSLs are not available for recreational exposures to sediment.

  The EPA RSL residential soil exposure values were developed by EPA based on the methodology presented in *RAGS HHEM, Part B* (EPA, 1991), and updated in 2014 (EPA, 2014a) and consider the ingestion, dermal, and inhalation exposure routes. The EPA RSL residential soil exposure values for carcinogens were developed by EPA using an age-adjusted exposure equation, which assumes that a receptor is exposed to soil at a frequency of 350 days per year for a 26-year exposure period (6 years as a child and 20 years as an adult). The EPA RSL criteria for chemicals with non-cancer effects are based on a child exposed to soil at a frequency of 350 days per year for a 6-year exposure period.

  For carcinogenic chemicals, the values used for COPC screening are based on a 1×10^{-6} target incremental lifetime cancer risk. EPA RSLs for chemicals with non-cancer effects are developed for target hazard quotient (HQ) of 1.0 and for a target HQ of 0.1. The RSLs

for a target HQ of 0.1 was used to select COPCs to avoid omitting chemicals that may contribute to a total hazard index (HI) of greater than 1.0. The estimation of cumulative target non-cancer risks is described in greater detail in Section 6.0. For contaminants with both carcinogenic effects and non-cancer effects, the lower of the RSL based on non-cancer HQ of 0.1 and the RSL based on 1 x 10^{-6} cancer risk, was used for COPC screening.

- **EPA Soil Lead Guidance.** EPA's IEUBK model, predicts that where the average lead in soil concentration is 400 milligrams per kilogram (mg/Kg) or less, blood lead levels will meet EPA's risk goal. This level is compared to maximum soil and sediment concentrations.

Criteria for the Selection of COPCs in Surface Water

The following screening criteria were used to identify surface water COPCs:

- **EPA RSLs for Tap Water Ingestion.** Surface water concentrations were screened against EPA RSLs for tap water (EPA, 2015). Tap water RSLs represent a conservative screen for surface water, since study area surface water is not used as a potable water source. RSLs are not available for recreational exposures to surface water.

  The EPA RSLs for tap water consider ingestion of drinking water and dermal absorption and inhalation of volatiles during household water use. The EPA RSL tap water values for carcinogens were developed by EPA using an age-adjusted exposure equation, which assumes that a receptor uses a water supply for household purposes at a frequency of 350 days per year for a 26-year exposure period (6 years as a child and 20 years as an adult). The EPA RSL criteria for chemicals with non-cancer effects are based on a child exposed at a frequency of 350 days per year for a 6-year exposure period.

  For carcinogenic chemicals, the values used for COPC screening are based on a 1 x 10^{-6} target incremental lifetime cancer risk. The criteria for chemicals with non-cancer effects are based on a target HQ of 0.1. For contaminants with both carcinogenic effects and non-cancer effects, the lower of the adjusted RSL based on non-cancer risk at an HQ of 0.1 and the RSL based on 1 x 10^{-6} cancer risk, was used for COPC screening.

Criteria for the Selection of COPCs in Groundwater

The following groundwater screening criteria were used to identify COPCs in groundwater for the protection of potential future use of groundwater as drinking water and direct contact exposures to shallow groundwater by construction workers during excavation work:

- **EPA RSLs for Tap Water Ingestion.** Groundwater concentrations were screened against EPA RSLs for tap water (EPA, 2015). Tap water RSLs represent a conservative screen for groundwater at the Study Area, since the underlying groundwater is not used as a potable water source.

  The EPA RSLs for tap water consider ingestion of drinking water and dermal absorption and inhalation of volatiles during household water use. The EPA RSL tap water values for carcinogens were developed by EPA using an age-adjusted exposure equation, which assumes that a receptor uses a water supply for household purposes at a frequency of 350 days per year for a 26-year exposure period (6 years as a child and 20 years as an adult). The EPA RSL criteria for chemicals with non-cancer effects are based on a child exposed at a frequency of 350 days per year for a 6-year exposure period.

  For carcinogenic chemicals, the values used for COPC screening are based on a $1x10^{-6}$ target incremental lifetime cancer risk. The criteria for chemicals with non-cancer effects are based on a target HQ of 0.1. For contaminants with both carcinogenic effects and non-cancer effects, the lower of the adjusted RSL based on non-cancer risk at an HQ of 0.1 and the RSL based on 1×10^{-6} cancer risk, was used for COPC screening.

- **EPA Lead Guidance.** EPA has not developed risk-based concentrations for lead in tap water. The EPA's Office of Ground Water and Drinking Water drinking water action level of 15 µg/L (EPA, 2009b) was used as the COPC selection criteria for lead.

The following groundwater screening criteria were used to identify COPCs in shallow groundwater for the protection of indoor air through potential vapor intrusion (VI):

- **EPA Vapor Intrusion Screening Level Tables.** Shallow groundwater concentrations were screened against EPA's Office of Solid Waste and Emergency Response (OSWER) residential 2014 vapor intrusion screening levels (VISLs) (groundwater concentration screening levels based on residential indoor air risks adjusted to correspond to a HQ of 1 and cancer risks of 1×10^{-6}) (EPA, 2014c). Sump water at one residential property was also compared to VISLs, using an attenuation factor of 1.

Chemical-Specific Considerations

Contaminants without RSLs, including 4-nitrophenol in sediment and 1,3-dichlorobenzene and methane in groundwater, were retained as COPCs. These COPCs are evaluated qualitatively in the uncertainty section.

The EPA RSL for hexavalent chromium was used as a screening criterion for total chromium to be conservative.

The EPA RSL for elemental mercury was used as a screening criterion for mercury.

The EPA RSL for vanadium and compounds was used as a screening criterion for vanadium.

For benzo(g,h,i)perylene for which EPA has little or no information regarding the chemical's toxicity, the screening value from naphthalene (selected based on similarity of molecular structure) was used as a surrogate screening value in sediment. The surrogate value was used as a qualitative approach for screening purposes only; surrogate toxicity values were not used to calculate risk. As a result of this screening, benzo(g,h,i)perylene was eliminated as a COPC.

Data evaluation for dioxins was evaluated through use of dioxin toxicity equivalents (TEQs) and toxicity equivalency factors (TEFs). The TEFs (presented in Appendix E) were used to convert concentrations of individual dioxin and furan congeners to TEQs of 2,3,7,8-tetrachloro-dibenzo-p-dioxin (2,3,7,8-TCDD) (van der Berg et al, 2006). These values were then totaled to yield total dioxin TEQs for each sample. The TEQs were then compared to the screening value for 2,3,7,8-TCDD in the COPC selection step.

Essential nutrients, including calcium, magnesium, potassium, and sodium, were not selected as COPCs.

Potential Applicable or Relevant and Appropriate Requirements (ARARs)

Vermont Water Quality Standards (Vermont NRB, 2014) are potential ARARs for surface water. These standards are presented in the COPC screening tables for surface water (Appendix A, Table A-2.2) for informational purposes.

The Vermont Water Supply Rule – Drinking Water Quality Requirements, Maximum Contaminant Levels (MCLs) Environmental Protection Rules, Chapter 21, Screening levels for public water system (VT DEC, 2010) and the Vermont Groundwater Rule and Protection Strategy, Environmental Protection Rules, Chapter 12 (VT DEC, 2005) are considered potential ARARs. The minimum of these two ARARs is presented in the COPC screening table for groundwater (Appendix A, Table A-2.5) for informational purposes.

Background

One sediment sample and one surface water sample were collected from an upstream location during RI activities. The results of these samples are used in discussions of background. These background concentrations are presented on the COPC selection tables for discussion purposes and are not used to eliminate COPCs. No background samples have been collected for groundwater or soil. Appendix F presents the sediment background data.

3.2 Identification of COPCs

Appendix A, Tables A-2.1 through A-2.6 identify the COPCs selected for quantitative risk assessment for the Study Area. Table 3-1 presents a summary of COPCs selected for each medium.

3.2.1 Sediment COPCs

Appendix A, Table A-2.1 presents the chemicals identified as COPCs in sediment within the Study Area exposure area.

3.2.2 Surface Water COPCs

Appendix A, Table A-2.2 presents the chemicals identified as COPCs in surface water within the Study Area exposure area.

3.2.3 Groundwater COPCs for the Protection of Construction Workers

Appendix A, Table A-2.3 presents the chemicals identified as COPCs in shallow groundwater (0 to 10 feet bgs) for the protection of construction workers in direct contact with shallow groundwater in excavation trenches within the Study Area.

3.2.4 Groundwater COPCs for the Protection of Indoor Air

Appendix A, Table A-2.4 presents the chemicals identified as COPCs in shallow groundwater (0 to 15 feet bgs) for the protection of indoor air within the Study Area.

1,2-Dibromo-3-chloropropane, chloroform, PCE, and TCE were detected in shallow groundwater at concentrations exceeding VISLs, indicating potential for VI. This pathway was further evaluated as described in Appendix C.

3.2.5 Groundwater COPCs for the Protection of Drinking Water

Appendix A, Table A-2.5 presents the chemicals identified as groundwater COPCs for the protection of potential future use of groundwater as drinking water. The dataset used to identify groundwater COPCs for the protection of potential future use of groundwater as drinking water includes only those wells identified above as representative of the core of the groundwater plume. The core of the plume is located in intermediate to deep overburden and is identified as the area of highest TCE concentrations. Based on a review of TCE groundwater data and well locations, the following eight wells were selected as representative of the core of the groundwater plume:

- MW-04D,
- MW-05D,
- MW-05D2,
- MW-06M,

- MW-06D,
- ASI-03D2,
- ASI-02D2, and
- ASI-14D2.

ASI-14S is located in the same well cluster as ASI-14D2, but is relatively clean and since the core is deeper, it was not included. The selected wells are highlighted on the Appendix D, Table B-5 sample list for overburden groundwater. See Figure 3-2 for well locations. Each of the selected wells was sampled in at least two sampling rounds between 2008 and 2012. Each well and each sampling round is considered a separate result for purposes of the Appendix A, Table A-2.5 data summary and COPC selection.

3.2.6 Soil COPCs

Appendix A, Table A-2.6 presents the chemicals identified as COPCs in soils (depths of 0 to 10 foot bgs) collected from the Study Area at 96 Commerce Street and at properties along Shunpike Road and South Brownell Road. See Figure 3-3 for soil sampling locations.

Table 3-1 presents a summary of COPCs selected in soils at 96 Commerce Street and in soils at properties along Shunpike Road and South Brownell Road. Several polycyclic aromatic hydrocarbons (PAHs) and metals were detected in soil at concentrations exceeding residential screening levels.

Based on this initial screen, EPA reviewed the soil data for accessible soil (0-10 feet bgs) from soil borings and surface soil samples collected in 2010, 2012, 2013, and 2014 and evaluated future residential exposure to soil semi-quantitatively by using a simplified ratio approach. The approach and results are provided in Appendix B (soil technical memo) and discussed in Section 6.2.4.

3.2.7 Indoor Air COPCs

EPA's investigation of the potential for vapor intrusion at five residential and two commercial buildings representative of conditions across the Study Area in June 2012 and January 2013, and a sixth in December 2014 did not show the vapor intrusion pathway to be complete across the Study Area and is not further evaluated in this HHRA. That investigation is summarized in Appendix C.

EPA also evaluated the health risk to residents at 830 South Brownell Road from direct vapor inhalation from contaminated groundwater that, but for an existing sump pump system, could flood the basement. The evaluation can be found in Appendix L, and is discussed in Section 6.2.5.

3.3 Exposure Point Concentrations (EPCs)

Risk assessments are conducted using an EPC for each COPC. The EPC represents an estimated concentration to which a receptor is assumed to be continuously exposed while in contact with an environmental medium. EPCs used in the risk assessment are presented in Appendix A, Tables A-3.1 through A-3.4.

EPCs for Sediment and Surface Water

For sediment and surface water exposures, the EPC is generally defined as the 95 percent upper confidence limit on the mean (UCL) and is calculated using EPA's ProUCL software (EPA, 2013). However, because of the small sample set sizes, maximum concentrations were selected as EPCs for these media. Appendix A, Table A-3.1 presents EPCs for sediment. Appendix A, Table A-3.2 presents EPCs for surface water.

EPCs for Groundwater

Because shallow groundwater exposure to construction workers is assumed to occur at any location and sample size at any given location is usually not sufficient to calculate a 95 percent UCL, the maximum concentration is used as the shallow groundwater EPC for the construction worker scenario. Appendix A, Table A-3.3a presents EPCs for shallow groundwater (0-10 feet bgs), to which construction workers may be exposed.

For potential exposures to groundwater as drinking water, the EPC is defined as the 95 percent UCL from wells at the core of the plume (EPA, 2014b) and is calculated using EPA's ProUCL software (EPA, 2013). As noted in Section 3.2.5, the core of the Commerce Street plume is located in intermediate to deep overburden and is identified as the area of highest TCE concentrations. Analytical results from the eight wells selected as representative of the core of the groundwater plume in Section 3.2.5 were utilized for purposes of developing EPCs. Each of

the selected wells was sampled in at least two sampling rounds between 2008 and 2012. Each well and each sampling round is considered a separate result for purposes of inputting data into ProUCL.

The following general guidelines were used to determine UCLs for the overburden groundwater. The same EPC value was used for both RME and CTE scenarios.

- If fewer than 8 samples were collected, the maximum detected concentration was selected as the EPC.

- If fewer than 4 samples were detected, the maximum detected concentration was selected as the EPC.

- If 8 or more samples were collected and the dataset contained more than 5 percent but less than 50 percent detects and at least 4 detects, a nonparametric-based UCL (either Kaplan-Meier (KM) or bootstrapping derived), as per ProUCL's non-parametric-based UCL recommendation, was calculated. Note that the bootstrapping method was not considered unless there were at least 10 detects.

- If 8 or more samples were collected and the dataset contained at least 50 percent detects, the appropriate distribution of the dataset was determined and UCLs were selected as guided by the ProUCL supporting documentation. Note that for datasets with censored results (i.e. non-detects), UCLs calculated using estimation procedures (e.g., KM, bootstrapping) were considered instead of employing the simple substitution method (e.g., using one-half the SQL for non-detects) for selecting appropriate UCLs as guided by the ProUCL supporting documentation.

Distributions and subsequent summary statistics were calculated using EPA's ProUCL Version 5.00.00 software (EPA, 2013). ProUCL calculates 95 percent UCLs on the mean using 15 different computation methods, 5 parametric and 10 non-parametric. Parametric methods rely on the estimation of parameters (such as the mean or the standard deviation) describing the distribution of the variable of interest in the population; non-parametric methods do not.

The five parametric UCL computation methods include:

1. Student's-t UCL,
2. Approximate gamma UCL using chi-square approximation,
3. Adjusted gamma UCL (adjusted for level significance),
4. Land's H-UCL, and
5. Chebyshev inequality based UCL (using Minimum Variance Un-biased Estimators (MVUEs) of parameters of a lognormal distribution).

The ten non-parametric methods included in ProUCL are:

1. The central limit theorem (CLT) based UCL,
2. Modified-t statistic (adjusted for skewness) based UCL,
3. Adjusted-CLT (adjusted for skewness) based UCL,
4. Chebyshev inequality based UCL (using sample mean and sample standard deviation),
5. Jackknife method based UCL,
6. UCL based upon standard bootstrap,
7. UCL based upon percentile bootstrap,
8. UCL based upon bias–corrected accelerated (BCA) bootstrap,
9. UCL based upon bootstrap-t, and
10. UCL based upon Hall's bootstrap.

ProUCL provides recommendations on which UCL to use depending upon distributional assumptions and the skewness (as represented by the standard deviation of the data). Distributions are tested for using a number of procedures:

- Graphical test based upon a Q-Q plot.
- Lilliefors test ($\alpha = 0.05$; tests for normality or log-normality for data sets with sample sizes greater than or equal to 50).
- Shapiro-Wilk W test ($\alpha = 0.05$; tests for normality or log-normality for data sets with samples sizes less than 50).
- Anderson Darling test ($\alpha = 0.05$; tests for gamma distribution).
- Kolmogorov-Smirnov test ($\alpha = 0.05$; tests for gamma distribution).

Occasionally, ProUCL recommends two different UCLs. In these instances, the greater of the two is selected as the recommended UCL. Support documentation (output from the ProUCL program) for the calculation of the UCLs is presented in Appendix G. Appendix A, Table A-3.4a presents EPCs for groundwater as drinking water.

EPCs for Trench Air

To estimate the EPC for air in a construction trench, the HHRA used a conservative approach suggested by the Virginia Department of Environmental Quality (VDEQ) (VDEQ, 2013), which is based on a combination of a vadose zone model (to estimate volatilization of gases from contaminated groundwater into a trench) and a box model (to estimate dispersion of the contaminants from the air inside the trench into the above-ground atmosphere). The VDEQ methodology is described in the following paragraphs.

The airborne concentration of a contaminant in a trench can be estimated based on maximum shallow groundwater concentrations using the following equation:

$$C_{air} = C_{GW} \times VF \times CF2$$

Where:

C_{air} = air concentration of contaminant in the trench mg/m^3
C_{GW} = concentration of contaminant in groundwater µg/L
VF = volatilization factor L/m^3
CF2 = Conversion factor (0.001 mg/µg)

It is assumed that a construction project could result in an excavation of 15 feet bgs or less. If the depth to groundwater at a site is less than 15 feet, the VDEQ model assumes that a worker would encounter groundwater when digging an excavation or a trench. The worker would then have direct exposure to the groundwater. The worker would also be exposed to contaminants in the air inside the trench that would result from volatilization from the groundwater pooling at the bottom of the trench.

The following equation is used to calculate the volatilization factor (VF) for a trench less than 15 feet deep, assuming a 3 feet wide, 8 feet deep, and 8 feet long trench):

$$VF = (K_i \times A \times F \times 10^{-3} \times 10^{4} \times 3{,}600) / (ACH \times V)$$

Where:

K_i	=	overall mass transfer coefficient of contaminant (centimeter per second (cm/second))
A	=	area of the trench (m^2) (2.23 m^2)
F	=	fraction of floor through which contaminant can enter (unitless)
ACH	=	air changes per hour (hr) = 2 hr^{-1}
V	=	volume of trench (m^3) (5.44 m^3)
10^{-3}	=	conversion factor (L/cm^3)
10^4	=	conversion factor (cm^2/m^2)
3,600	=	conversion factor (seconds/hr)

According to the VDEQ guidance, if the ratio of trench width to trench depth is less than or equal to 1, a circulation cell or cells will be set up within the trench that limits the degree of gas exchange with the atmosphere and the air changes per hour (ACH) is assumed to be 2. If the ratio of trench width to trench depth is greater than 1, the air exchange between the trench and above-ground atmosphere is not restricted, and the ACH is assumed to be 360. The exposure assessment performed for this HHRA conservatively assumes a width-to-trench depth ratio less than 1; therefore, the ACH is set at 2.

K_i is calculated using the following equation:

$$K_i = 1 / \{(1/k_iL) + [(RT) / (H_i\ k_iG)]\}$$

Where:

K_i	=	overall mass transfer coefficient of containment (cm/second)
k_iL	=	liquid-phase mass transfer coefficient of i (cm/second)
R	=	ideal gas constant (atm-m^3/mole-°K) = 8.2 x 10^{-5}
T	=	average system absolute temperature (°K) (Default = 298°K)
H_i	=	Henry's Law constant of i (atm-m^3/mole)
k_iG	=	gas-phase mass transfer coefficient of i (cm/second)

The formulas for calculating k_iL and k_iG are as follows:

$$k_iL = (MWO_2/MW_i)^{0.5} \times (T/298) \times kL,O_2$$

Where:

k_iL = liquid-phase mass transfer coefficient of component i (cm/second)
MWO_2 = molecular weight of oxygen (grams/mole)
MW_i = molecular weight of component i (grams/mole)
kL,O_2 = liquid-phase mass transfer coefficient of oxygen at 25°C (cm/ second) = 0.002 cm/second

$$k_iG = (MWH_2O/MW_i)^{0.335} \times (T/298)^{1.005} \times kG,H_2O$$

Where:

k_iG = gas-phase mass transfer coefficient of component i (cm/second)
MWH_2O = molecular weight of water (grams/mole)
kG,H_2O = gas-phase mass transfer coefficient of water vapor at 25°C (cm/second)= 0.833 cm/second (Superfund Exposure Assessment Manual, EPA, 1988).

Appendix A, Table A-3.3b presents EPCs for trench air modeled from shallow groundwater to which construction workers may be exposed. Table G-2 presents the supporting information used to develop the EPCs in trench air. Chemical properties were obtained from the Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (EPA, 2002b) and are presented in Appendix G, Table G-2.

EPCs for Groundwater Vapors during Household Water Use

For inhalation of groundwater vapors during household water use, the EPC in air is calculated from the groundwater EPC for potential exposures to groundwater as drinking water using the following equation from EPA RAGS B (EPA, 1991):

$$C_{air} = 0.0005 \times C_{GW} \times CF1 \times CF2$$

Where:

C_{air} = air concentration of contaminant resulting from household water use in milligrams per cubic meter (mg/m^3)

C_{GW} = concentration of contaminant in groundwater in micrograms per liter (µg/L)

CF1 = Conversion factor ($1000\ L/m^3$)

CF2 = Conversion factor (0.001 mg/µg)

Appendix A, Table A-3.4b presents EPCs for inhalation of groundwater vapors during household water use. Appendix G, Table G-3 presents the supporting information used to develop the EPCs for vapors during household water use.

4.0 EXPOSURE ASSESSMENT

The exposure assessment defines and evaluates the exposures that may be experienced by a receptor population. To have an exposure, several factors must be present: there must be a source of contamination, there must be a mechanism through which a receptor can come into contact with the contaminants in that medium, and there must actually or potentially be a receptor present at the point of contact.

The exposure assessment presented consists of several sections that characterize the physical setting and the receptors of concern, identify the potential contaminant migration and exposure pathways, and present the equations used to quantify exposure in terms of contaminant intake (dose). Section 4.1 presents the Study Area exposure setting. Section 4.2 presents the conceptual site model. Section 4.3 presents the equations and parameters for estimating chemical intake. Exposure assumptions for each scenario are presented in Appendix A, Tables A-4.1 through A-4.8. Intakes are presented in Appendix A, Tables A-7.1 through A-7.8.

4.1 Exposure Setting

As discussed in Section 1.0, the Study Area is located in the Town of Williston, Vermont. Areas investigated during the RI included the Study Area and the unnamed stream. The Study Area and site history are described in detail in Section 1.0 of the RI, Volume I and a brief summary is presented in Section 1.0 of this HHRA. The Study Area is depicted in Figures 1-1 and 1-2.

4.1.1 Local Land and Stream Use

Current zoning allows for mixed residential, business, and industrial uses. The industrial park is surrounded by light industrial, commercial, residential, and agricultural land. Commerce Street and the areas to the east are predominantly commercially zoned lots that are currently developed or in the process of being developed. Kirby Lane is entirely residential. South Brownell Road is residential, with some commercial developments. Public pedestrian access is unrestricted within the Study Area.

Surface water at the Study Area encompasses a small unnamed stream just east of Commerce Street, which flows in a southerly direction to Tributary #4 to Muddy Brook. A small wetland area is associated with the confluence of the unnamed stream and Tributary #4 at the southern end of Commerce Street. The Study Area stream has approximately 2.5 miles of wetland frontage. In the 15-mile downstream pathway from the Study Area, additional wetland frontage includes 4.7 miles of wetlands adjacent to Muddy Brook and 2.9 miles of wetland adjacent to the Winooski River. Downstream of the Study Area, Muddy Brook flows into the Winooski River. Both Muddy Brook and the Winooski River are documented fisheries.

On the western edge of the Study Area near the intersection of Shunpike and South Brownell Roads is an “unmapped intermittent stream” – a topographic depression with culverts in some areas that conveys intermittent groundwater discharge.

4.1.2 Local Water Use

Vermont groundwater protection statute defines all groundwater in Vermont as Class III, which is suitable for use as a potable water supply unless it is reclassified as Class IV (non-potable). Currently the groundwater within the Study Area is Class III.

Local municipal water is served by the Champlain Water District (Champlain Water District, 2011), which uses an off-shore source in Shelburne Bay (Lake Champlain). Lake Champlain is outside of the 15-mile surface water pathway.

The Vermont Natural Resources Atlas (VT ANR, 2012) contains a single category for potable water supply well, which may be used for industrial use in addition to public use. According to the

Atlas (accessed September 4, 2014), one public drinking water supply well (the Williston Fire District Well No. 1) is located 2.5 miles southeast of the property. However, this public water supply is located in a different hydrogeological area and is unlikely to be impacted by contamination migrating from the Study Area (VT DEC, 2013). No other public drinking water supply wells, wellhead protection areas or sole source aquifers were identified in close proximity to the Study Area. One private water supply well has been confirmed to be located within 0.5 miles and in the same hydrogeologic area as the current plume. The well serves a commercial property and is used for irrigation of a retail garden center south of the Study Area.

Based on the above review of local water use, receptors are not expected to contact groundwater as drinking water or during household water use. However, to be protective of future potential use of groundwater as drinking water groundwater data from Study Area monitoring wells from the core of the plume, which lies within intermediate to deep overburden, were included in a quantitative evaluation of potential drinking water exposures discussed in Section 4.2.3.

Groundwater at the Study Area is shallow. Contaminants in shallow groundwater may volatilize into indoor air spaces at the Study Area. EPA investigated the potential for vapor intrusion at five residential and two commercial buildings representative of conditions across the Study Area in June 2012 and January 2013, and a sixth residence in December 2014. The vapor intrusion pathway was not found to be complete and is not further evaluated in this HHRA. That investigation is summarized in Appendix C.

EPA also evaluated the health risk to residents at 830 South Brownell Road from direct vapor inhalation from contaminated groundwater that, but for an existing sump pump system, could flood the basement. The evaluation can be found in Appendix L.

4.2 Conceptual Site Model for Human Health Risk

This section and Figure 4-1 present the general conceptual site model as it pertains to contaminant exposure and risk to human receptors. A conceptual site model facilitates a consistent and comprehensive evaluation of the risks to human health by creating a framework for identifying the exposure routes or pathways by which human health may be impacted by contaminants predicted to exist at the source areas. A conceptual site model depicts the

relationships between the following elements necessary to construct a complete exposure pathway:

- Sources of contamination and potential COPCs,
- Contaminant release mechanisms and transport pathways,
- Exposure mechanisms and exposure routes, and
- Potentially exposed populations.

The conceptual site model was developed to provide the basis for identifying the potential risks to human health. The model considers the current and future conditions within the Study Area, and the actual or potential receptors that might come into contact with the COPCs, and indicates those exposure routes that are carried through the quantitative risk assessment for each receptor. An objective of developing the conceptual site model is to focus attention on those pathways that contribute the most to the potential impacts on human health and to provide the rationale for screening out other exposure pathways that are minor components of the overall risk.

4.2.1 Sources of Contamination and Potential COPCs

Several potential sources for the contaminated sediment, surface water, groundwater, and air at the Study Area have been identified. These include:

- A wastewater disposal lagoon and a sanitary leach field at the electroplating manufacturer at 96 Commerce Street, which are suspected sources of TCE, PCE, and/or metals;

- Two underground storage tanks removed from 87 Commerce Street in 1994, revealing a previous release of BTEX compounds; and

- A disposal pit and outfall pipe to the unnamed stream from manufacturing operations began in 1947 at 63 Commerce Street.

Plating rinse waste and sludge waste were released directly to an unlined lagoon on the former Mitec property. Other potential sources identified in previous reports are located in the northern portion of the Study Area. Dense non-aqueous phase liquid (DNAPL) that may have originated at primary surface source zones has likely migrated to secondary subsurface source zones where

limited amounts of residual phase DNAPL in the form of ganglia and small isolated blobs may be present, or, sorbed to the finer-grained material (fine sand, silt, clay) in the overburden aquifer.

4.2.2 Contaminant Release Mechanisms and Transport Pathways

Once organic and inorganic chemicals are released to the soil, a variety of processes occur that may cause them to become immobilized, degraded, or mobilized to another environmental medium such as volatilization, leaching and infiltration to the subsurface, migration through the subsurface soil to the water table, stormwater runoff, and wind erosion of surface soil. Very little contamination remains in the soils in the vicinity of the former unlined lagoon, from which 30 cubic yards of hazardous material was removed and transported off site for disposal in 1985. The contamination found in most of the Study Area is now located in groundwater. Natural processes affect the fate and transport of chemicals that have migrated downward into groundwater from the vadose zone through precipitation, infiltration, and leaching. Advection is the principal contaminant transport mechanism in an aquifer. However, it is significantly affected by diffusion and dispersion. Chemicals can also be transformed by degradation and retardation. Once released from the source, contaminants are transported to and in media such as groundwater, air, surface water, or sediment. Contaminant fate and transport mechanisms available for contaminants present in the Study Area are discussed in detail in Section 5.0 of the RI Volume I.

4.2.3 Exposure Mechanisms and Exposure Routes

The potential for exposure to the contamination within the Study Area is based on several factors, including current and future land, stream, and water uses, human activity patterns, site access controls, and chemical behavior in the environment. Based on these variables, exposure scenarios were developed to characterize the potential for current and future human exposure. The future scenario accounts for possible changes in land and water use and site characteristics that may alter exposure and/or concentrations of COPCs in a given medium, in addition to the exposures that may result from current uses of the land and stream.

The exposure assessment is based on the assumption that, in general, chemical compositions for environmental media are identical under current and future site conditions.

This HHRA defines an exposure route as a generalized description of the behavior that brings a receptor into contact with a contaminated medium. The exposure routes through which receptors at this Study Area may be exposed are:

- Incidental ingestion of sediment,
- Dermal contact with sediment,
- Incidental ingestion of surface water,
- Dermal contact with surface water,
- Inhalation of volatile contaminants in groundwater that may volatilize into excavation trenches,
- Incidental ingestion of shallow groundwater in excavation trenches,
- Dermal contact with shallow groundwater in excavation trenches,
- Ingestion of groundwater used as drinking water,
- Dermal contact with groundwater during household water use,
- Inhalation of groundwater vapors during showering,
- Inhalation of indoor air,
- Incidental ingestion of soils,
- Dermal contact with soils, and
- Inhalation of dust and volatiles from soils.

A summary of the potentially significant exposures identified for quantitative evaluation is provided in Table 2-1 (the same table is also included in Appendix A as Table A-1).

As noted in Section 3.2.6, several PAHs and metals, including chromium, were detected in soil at concentrations exceeding screening levels. Chromium was detected in soils at both 96 Commerce Street and at properties along Shunpike Road and South Brownell Road; however, chromium speciation data indicate hexavalent chromium in soil occurred only at the Mitec property and not at properties along Shunpike Road and South Brownell Road. The results of the chromium speciation investigation are discussed in greater detail in Section 7.1. EPA reviewed the soil data from soil borings, and surface soil samples collected in 2010, 2012, 2013, and 2014 and evaluated future residential exposure to soil semi-quantitatively by using a simplified ratio approach. See Appendix B and discussion in Section 6.2.4.

No further evaluation of soil exposures was performed in this HHRA.

4.2.3.1 Direct Contact with Sediment

Receptors may come into direct contact with sediment contaminated by the release of chemicals from the source area. During the receptor's period of contact, the individual may be exposed via inadvertent ingestion of a small amount of sediment or via dermal absorption of certain contaminants in the sediment.

Because of the limited guidance available to estimate sediment exposure via dermal contact, dermal risks can be evaluated quantitatively only for contaminants with available soil absorption factors. Several of these chemicals were selected as COPCs for the Study Area, including arsenic and several PAHs. Therefore, dermal risks associated with sediment for these COPCs were quantitatively addressed in the risk assessment. Dermal contact with other chemicals detected in the Study Area sediment may or may not result in a significant exposure. It should be noted that organics such as PAHs, which were selected as COPCs, tend to strongly adhere to organic matter in sediment. For these chemicals to be absorbed through the skin, they must first desorb from sediment. Various factors affect the rate of dermal absorption, including the amount of sediment on the skin surface, sediment characteristics (moisture, pH, organic carbon content, etc.), skin characteristics (thickness, temperature, hydration, etc.), volatilization losses, and chemical-specific properties.

4.2.3.2 Direct Contact with Surface Water

Receptors may come into direct contact with surface water contaminated by overland run off or groundwater discharge of contaminants from the source area. The individual may be exposed via inadvertent ingestion of a small amount of surface water or via dermal absorption of certain contaminants in the surface water. In general ingestion of surface water is only considered when swimming scenarios are considered. Because of the small size and intermittent nature of the unnamed stream, the exposure scenario is limited to wading and ingestion of surface water is excluded from the quantitative evaluation.

4.2.3.3 Contact with Shallow Groundwater Contaminants in Excavation Trenches

This pathway is based on the assumption that shallow groundwater is present in excavation trenches during construction or utility work. A construction worker may contact contaminants through dermal contact with groundwater or inhalation of trench air vapors resulting from volatilization of contaminants in shallow groundwater. The inadvertent ingestion of a small amount of groundwater was considered an insignificant pathway and was not further evaluated.

4.2.3.4 Contact with Groundwater Contaminants in Drinking and Household Water Use

This pathway is based on the assumption that a receptor uses groundwater as the primary drinking water and household water source, contacting contaminants through ingestion of drinking water, dermal contact, and inhalation of vapors during household water use. Currently, groundwater within the Study Area is not used as a drinking water source. Therefore, evaluation of these pathways is limited to a quantitative evaluation of hypothetical future use of groundwater as the primary drinking water and household water source.

4.2.3.5 Inhalation of Volatile Contaminants in Indoor Air

The potential transport of volatile contaminants from shallow groundwater to indoor air was investigated. COPCs for this pathway were identified by comparing shallow groundwater data (0-15 feet bgs) to EPA's VISLs (http://www.epa.gov/oswer/vaporintrusion/guidance.html#Item6). This comparison is presented in Appendix A, Table A-2.4, as described in Section 3.1. Several contaminants were detected in shallow groundwater at the Study Area exceeding VISLs. Shallow groundwater data, as opposed to the full groundwater data sets used in the evaluation of potential future use of groundwater as drinking water scenario, are used in the Appendix A, Table A-2.4 evaluation of this pathway. The shallow groundwater dataset is comprised of samples collected from the uppermost portions of the water table as represented by the shallowest wells sampled at each location. Deep groundwater data were not used because they were not considered representative of groundwater available for VI.

Following comparison to VISLs, EPA investigated the potential for vapor intrusion at five residential and two commercial buildings in June 2012 and January 2013, and a sixth residence in December 2014. The potential transport of volatile contaminants from groundwater to indoor air was investigated with sampling of indoor air and sub-slab soil gas. The investigation, described in Appendix C, did not show a complete vapor intrusion pathway across the Study Area and is not further evaluated in this HHRA.

EPA also evaluated the health risk to residents at 830 South Brownell Road from direct vapor inhalation from contaminated groundwater that, but for an existing sump pump system, could flood the basement. The evaluation can be found in Appendix L.

4.2.4 Potentially Exposed Populations

Potentially exposed receptor populations have been identified by analyzing the interaction of current and anticipated future land use practices with the identified sources of contamination.

The receptors included in the current use exposure scenario for the Study Area include recreational visitors exposed to sediments and surface water at the unnamed stream and construction workers exposed to shallow groundwater and vapors in excavation trenches.

The receptors included in the future use exposure scenario for the Study Area include local residents exposed to groundwater as drinking water or soil. Future residential use of groundwater as drinking water represents the most conservative future use of groundwater in the Study Area. Future residential exposure to soil was evaluated semi-quantitatively by using residential soil RSLs to calculate cumulative cancer and non-cancer risks of maximum contaminant concentrations of COPCs in accessible soil (0-10 feet bgs), as described in Appendix B (soil technical memo).

Figure 4-1 indicates which exposure routes are considered for each receptor. Table 2-1 presents receptors and exposure pathways identified for the Study Area and provides the rationale for the quantitative evaluation of selected exposure pathways.

4.3 Identification of Exposure Equations and Parameters

To estimate the potential risk to human health that may be posed by the presence of COPCs at the Study Area, it is first necessary to estimate the potential Average Daily Dose (ADD) of each COPC. The ADD is estimated for each COPC via each exposure pathway by which the receptor is assumed to be exposed. ADD equations combine the estimates of compound concentration in the environmental medium of interest with assumptions regarding the type and magnitude of each receptor's potential exposure to provide a numerical estimate of the exposure dose. The exposure dose is defined as the amount of COPC taken into the receptor and is expressed in units of milligrams of COPC per kilogram of body weight per day (mg/Kg-day).

Exposure doses are defined differently for potential carcinogenic and non-carcinogenic effects. The Chronic Average Daily Dose (CADD) is used to estimate a receptor's potential intake from exposure to a COPC with non-carcinogenic effects. According to EPA guidance (EPA, 1989), the CADD should be calculated by averaging the dose over the period of time for which the receptor is assumed to be exposed. Therefore, the averaging period is the same as the exposure duration. For COPCs with potential carcinogenic effects, however, the Lifetime Average Daily Dose (LADD) is employed to estimate potential exposures. In accordance with EPA guidance (EPA, 1989), the LADD is calculated by averaging exposure over the receptor's assumed lifetime (70 years). Therefore, the averaging period is the same as the receptor's assumed lifetime. All equations used to estimate potential exposure doses follow EPA guidelines (EPA, 1989) and use the most recent EPA exposure factors (EPA, 2014a).

Exposures depend on the estimated concentrations of chemicals in environmental media at the exposure points, and on scenario-specific assumptions based on current local land use practices and future potential land use. Appendix A, Table A-1 presents a summary of the exposure pathways evaluated in the quantitative risk assessment.

Exposure model parameters are described in Section 4.3 and presented in Appendix A, Tables A-4.1 through A-4.8. The standardized intake equations for estimating a receptor's ADD, dermally absorbed dose (DAD), and average daily concentrations (ADC) (both lifetime and chronic) are also presented on the tables. The parameters are used in the intake equations, along with the EPCs presented in Appendix A, Tables A-3.1 through A-3.4, to calculate intakes, which in combinations with toxicity values presented in Appendix A, Tables A-5.1, A-5.2, A-6.1, and

A-6.2 are used to determine risks. Individual chemical intakes for each receptor/exposure route combination are presented in Appendix A, Tables A-7.1 through A-7.8.

This HHRA includes evaluation of both RME and CTE scenarios for evaluation of construction worker exposures to groundwater in excavation trenches and potential future residential exposure to groundwater as drinking water. However, evaluations of exposures to surface water and sediment were limited to RME scenarios only. The EPA's semi-quantitative evaluation of potential future residential exposure to accessible soil utilized maximum detected concentrations and RSLs based on RME parameters. See Appendix B and discussion in Section 6.2.4. The RME scenarios were developed according to EPA guidance (EPA, 1989) using values that represent the upper distribution or "high-end" of population exposure for exposure parameters. The RME scenario is intended to provide an upper bound of the possible risk. The RME is conceptually the "high end" exposure, above the 90th percentile of the population distribution, but not higher than the individual in the population with the highest exposure. The CTE receptor was developed using professional judgment regarding site-specific conditions. The CTE scenario uses the same exposure point concentrations, toxicity values, and equations as the RME, but uses average values for exposure parameters and represents an "average case" exposure scenario.

Exposure scenarios for each of the receptor groups defined above are discussed below with exposure model parameters presented in Appendix A, Tables A-4.1 through A-4.8.

The values presented in these tables reflect current EPA guidance. The sources for all parameters are referenced in footnotes on each table.

4.3.1 General Exposure Parameter Assumptions

Several parameters are used in multiple scenarios.

- Body weight is the same for each adult (80 Kg) and child (15 Kg), irrespective of scenario.
- Averaging Time (AT) is always the years of the exposure duration (ED) times 365 days per year for CADD and 70 years times 365 days per year for LADD.
- Event Frequency (EV) was set at one per day for all scenarios.

- Chemical-specific volatilization factors used in evaluations of inhalation of groundwater vapors were obtained from the EPA RSL table (EPA, 2015).

- The fraction of sediment intake derived from the contaminated source was set at one for all scenarios.

- Oral absorption factors (OABS) are conservatively assumed to be one for all ingestion routes.

- Chemical-specific dermal absorption factors (DABS), presented in *RAGS HHEM, Part E, Supplemental Guidance for Dermal Risk Assessment* (EPA, 2004), were used to estimate exposure doses for soil and sediment exposures. Unfortunately, limited information regarding dermal absorption is available. The DABS values that are available for the COPCs are presented in Appendix H.

4.3.2 Scenario-specific Exposure Parameter Assumptions

The following subsections present scenario-specific exposure assumptions.

4.3.2.1 Current and Future Recreational Visitors, Exposure to Sediment

Recreational visitors, potentially exposed to sediment via incidental ingestion and dermal contact, were evaluated for exposures to the unnamed stream.

The exposure frequency assumptions for adult and child recreational visitors were 22 days per year (2 days per week during 11 weeks per year). Adult recreational visitors were assumed to ingest an average of 100 mg of sediment per day for 20 years. Child recreational visitors were assumed to ingest an average of 200 mg of sediment per day for 6 years. The proposed exposure duration values were based on EPA guidance for RME evaluation of residential exposures (EPA, 2014a). Values for small children reflect the entire age span for the receptor evaluated.

Hands, forearms, lower legs, feet, and head were assumed to be available for dermal contact with sediment for both adults and young children. The calculated available skin surface areas for

dermal contact with sediment for adults and small children (ages 0-6 years) were 6,032 cm^2 and 2,690 cm^2, respectively.

A value of 0.3 milligrams per square centimeter per event (mg/cm^2-event) was used as the sediment-to-skin adherence factor (SSAF) for adult exposures. The adult SSAF of 0.3 mg/cm^2-event corresponds to the 50th percentile weighted adherence values for reed gatherers. A value of 0.2 mg/cm^2-event was used as the sediment-to-skin adherence factor for child exposures. The child recreational sediment-to-skin adherence factor of 0.2 mg/cm^2-event corresponds to the 50th percentile weighted adherence values for children playing in wet soil (EPA, 2004).

Appendix A, Tables A-4.1 and A-4.2 present the exposure parameters for current and future adult and child recreational visitor exposures to sediment.

4.3.2.2 Current and Future Recreational Visitors, Exposure to Surface Water

Recreational visitors, potentially exposed to surface water via dermal contact, were evaluated for exposures to the unnamed stream.

The exposure frequency assumptions for adult and child recreational visitors were 22 days per year (2 days per week during 11 weeks per year) for 2 hours per day (t_{event}). Adult recreational visitors were assumed to be exposed for 20 years. Child recreational visitors were assumed to be exposed for 6 years. The proposed exposure duration values were based on EPA guidance for RME evaluation of residential exposures (EPA, 2014a). Values for small children reflect the entire age span for the receptor evaluated.

Hands, forearms, lower legs, feet, and head were assumed to be available for dermal contact with sediment for both adults and young children. The calculated available skin surface areas for dermal contact with soil for adults and small children (ages 0-6 years) were 6,032 cm^2 and 2,690 cm^2, respectively.

Appendix A, Tables A-4.3 and A-4.4 present the exposure parameters for future adult and child recreational visitor exposures to surface water.

4.3.2.3 Current and Future Construction/Utility Workers, Exposure to Groundwater

Construction/utility workers potentially exposed to shallow groundwater through dermal contact and inhalation of vapors during excavation activities were evaluated. Possible exposures of construction/utility workers to site-related contaminants would be through excavation activities during a project lasting no more than 1 year. The construction/utility worker may be in direct contact with groundwater as deep as 10 feet bgs.

Construction/utility workers were assumed to be exposed to study area shallow groundwater for 130 days per year (5 days per week during 6 months per year) under the RME scenario and 26 days per year (1 day per week during 6 months per year) under the CTE scenario. Exposure durations were set at 1 year.

Head, hands, and forearms were expected to be available for dermal contact with shallow groundwater. The calculated available skin surface area for these body parts was 3,470 cm^2.

Construction/utility workers were assumed to inhale vapors from groundwater for 8 hours per day (exposure time).

Appendix A, Table A-4.5 presents the exposure parameters for construction/utility worker exposures to shallow groundwater and vapors in trench air.

4.3.2.4 Future Residents, Exposure to Groundwater as Drinking Water and During Household Water Use

Future residents, potentially exposed to groundwater as drinking water via ingestion, dermal contact, and inhalation of vapors during household water use were evaluated.

The exposure frequency assumptions for adult and child residents were 350 days per year. Adult residents were assumed to ingest an average of 2.5 Liters per day (L/day) of water for 20 years for the RME and 2.5 L/day of water for 6 years for the CTE with the fraction obtained from the Study Area versus total ingestion per day set at 0.5 for CTE. Child residents were assumed to ingest an average of 0.78 L/day of water for 6 years for the RME and 0.78 L/day of water for 2 years for the CTE with the fraction obtained from the Study Area versus total ingestion per day

set at 0.5 for CTE. The proposed exposure duration values were based on EPA guidance for RME and CTE evaluation of residential exposures (EPA, 2014a). RME values for small children reflect the entire age span for the receptor evaluated. CTE values for small children reflect the approximately one third of the age span for the receptor evaluated. The calculated available skin surface areas for dermal contact with groundwater used as tap water for showering and bathing for adults and small children (ages 0-6 years) were 20,900 cm^2 and 6,378 cm^2, respectively under both RME and CTE scenarios. Time per shower (t_{event}) was assumed to be 0.71 hours per day for adults. Time per bath (t_{event}) was assumed to be 0.54 hours per day for children. Residents were assumed to inhale vapors during household water use for 24 hours per day (exposure time).

Appendix A, Tables A-4.6, A-4.7, and A-4.8 present the exposure parameters for future adult, child, and lifetime age-adjusted resident exposures to groundwater as drinking water via ingestion, dermal contact, and inhalation of vapors during household water use.

4.3.3 Intake Equations

The standardized intake equations for estimating a receptor's average daily dose, dermally absorbed dose, and average daily concentrations (both lifetime and chronic) are presented below.

Incidental Ingestion of Sediment

This pathway was evaluated for recreational visitors exposed to sediment in the unnamed stream. In general, intakes associated with sediment ingestion were calculated using the following equation from *RAGS HHEM, Part A* (EPA, 1989):

ADD (Lifetime and Chronic) Following Ingestion of Sediment (mg/kg-day):

$$ADD = \frac{CS \times IR \times OABS \times FI \times EF \times ED \times CF}{BW \times AT}$$

Where:

ADD = Average daily dose of contaminant from sediment (mg/Kg-day)

CS = Exposure concentration for sediment (mg/Kg)

IR = Ingestion rate (mg/day)

OABS = Oral absorption factor

FI = Fraction ingested from contaminated source (decimal fraction)

EF = Exposure frequency (days/year)

ED = Exposure duration (year)

CF = Conversion factor (1×10^{-6} Kg/mg)

BW = Body weight (Kg)

AT = Averaging time (days);
for non-carcinogens, AT=ED*365 days/year;
for carcinogens, AT=70 years*365 days/year

Dermal Contact with Sediment

This pathway was evaluated for recreational visitors exposed to sediment in the unnamed stream. The following equations from *RAGS HHEM, Part E, Supplemental Guidance for Dermal Risk Assessment* (EPA, 2004) were used to estimate the ADD (lifetime and chronic) and the DAD for sediment:

ADD (Lifetime and Chronic) Following Dermal Contact with Sediment (mg/Kg-day):

$$\mathrm{ADD} = \mathrm{DAD}$$

Where:

ADD = Average daily dose (mg/Kg-day)

DAD = Dermally absorbed dose (mg/Kg-day)

DAD (Lifetime and Chronic) Following Dermal Contact with Sediment (mg/Kg-day):

$$\mathrm{DAD} = \frac{\mathrm{DA_{event}} \times \mathrm{EF} \times \mathrm{ED} \times \mathrm{EV} \times \mathrm{SA}}{\mathrm{BW} \times \mathrm{AT}}$$

Where:

DAD	=	Dermally absorbed dose (mg/Kg-day)
DA_{event}	=	Absorbed dose per event (mg/cm^2-event))
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
EV	=	Event frequency (events/day)
SA	=	Surface area (cm^2)
BW	=	Body weight (Kg)
AT	=	Averaging time (days);
		for non-carcinogens, AT=ED*365 days/year;
		for carcinogens, AT=70 yr*365 days/year

The calculation of the dose absorbed per unit area per event (DA_{event}) is as follows:

$$DA_{event} = CS x SSAF x DABS x CF$$

Where:

DA_{event}	=	Absorbed dose per event (mg/cm^2-event)
CS	=	Exposure concentration for sediment (mg/Kg)
SSAF	=	Sediment-to-skin adherence factor (mg/cm^2-event)
DABS	=	Dermal absorption fraction (unitless)
CF	=	Conversion factor (1 x 10^{-6} Kg/mg)

Dermal Contact with Surface Water, Groundwater, and Groundwater as Tap Water

This pathway was evaluated for recreational visitors exposed to surface water in the unnamed stream, construction workers exposed to shallow groundwater in construction trenches, and residents exposed to groundwater as tap water during showering or bathing. Calculation of the average daily dose from dermal exposure to water follows EPA guidance (EPA, 2004) that differentiates between organics and inorganics, as presented below. The following equations from *RAGS HHEM, Part E, Supplemental Guidance for Dermal Risk Assessment* (EPA, 2004) were used to estimate the average daily dose (lifetime and chronic) and the DAD following dermal contact with surface water or groundwater:

ADD (Lifetime and Chronic) Following Dermal Contact with Water (mg/Kg-day):

$$ADD = DAD$$

Where:

ADD = Average daily dose (mg/Kg-day)

DAD = Dermally absorbed dose (mg/Kg-day)

DAD (Lifetime and Chronic) Following Dermal Contact with Water (mg/Kg-day):

$$DAD = \frac{DA_{event} \text{ x } EV \text{ x } EF \text{ x } ED \text{ x } SA}{BW \text{ x } AT}$$

Where:

DAD = Dermally absorbed dose (mg/Kg-day)

DA_{event} = Absorbed dose per event (mg/cm^2-event)

EV = Event frequency (events/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

SA = Surface area (cm^2)

BW = Body weight (Kg)

AT = Averaging time (days)

The calculation of the DA_{event} is as follows for inorganics:

$$DA_{event} = CW \text{ x } Kp \text{ x } t_{event} \text{ x } CF$$

Where:

DA_{event} = Absorbed dose per event (mg/cm^2-event)

CW = Concentration in water (milligrams per liter (µg/L))

Kp = Permeability coefficient (centimeter per hour (cm/hr))

t_{event} = Event time (hr/event)

CF = Conversion factor (1×10^{-6} mg-L/µg-cm^3)

The calculation of DA_{event} is as follows for organics:

$$DA_{event} = 2FA \times Kp \times CW \times CF \sqrt{\frac{6 \times T \times t_{event}}{\pi}}$$

[If $t_{event} < t^*$]

$$DA_{event} = FA \times Kp \times CW \times CF \times \left[\frac{t_{event}}{1+B} + 2 \times T \left(\frac{1+3B+3B^2}{(1+B)^2} \right) \right]$$

[If $t_{event} > t^*$]

Where:

DA_{event} = Absorbed dose per event (mg/cm^2-event)

FA = Fraction absorbed (dimensionless, chemical specific)

Kp = Permeability coefficient (cm/hr)

CW = Concentration in water (µg/L)

t_{event} = Event time (hr/event)

T = Lag time (hr/event)

t* = Time to steady state (hr/event)

B = Dimensionless constant

CF = Conversion factor (1×10^{-6} mg-L/µg-cm^3)

Estimating Potential Exposure from Inhalation of Trench Air or Vapors from Household Water Use

Inhalation of vapors in trench air was evaluated for construction/utility workers. Inhalation of vapors from household water use was evaluated for future residents using groundwater for drinking water and household water use. Inhalation exposures were evaluated using ADCs in combination with RfCs or inhalation unit risk factors following EPA guidance (EPA, 2009a).

The following equation from *RAGS HHEM, Part F, Supplemental Guidance for Inhalation Risk Assessment* (EPA, 2009a) was used to calculate potential risks from inhalation of groundwater vapors in air:

ADD (Lifetime and Chronic) Following Inhalation of COPC (µg/m^3):

$$ADC = \frac{CA \text{ x } ET \text{ x } EF \text{ x } ED \text{ x } CF \text{ x } CF2}{AT}$$

Where:

ADC	=	Average daily concentration (µg/m^3)
CA	=	Exposure concentration for air (mg/m^3)
ET	=	Exposure time (hr/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (year)
CF	=	Conversion factor (1 x 10^3 µg/mg)
CF2	=	Conversion factor (days/hr)
AT	=	Averaging time (days)

The exposure concentration in trench air was modeled from shallow groundwater as described in Section 3.3. The exposure concentration in household air resulting from household water use was modeled from groundwater as described in Section 3.4.

Ingestion of Groundwater as Drinking Water

This pathway was evaluated for future residents potentially exposed to groundwater as drinking water. In general, intakes associated with drinking water ingestion were calculated using the following equation from *RAGS HHEM, Part A* (EPA, 1989):

ADD (Lifetime and Chronic) Following Ingestion of Drinking Water (mg/Kg-day):

$$ADD = \frac{CW \times IR \times FI \times EF \times ED \times CF}{BW \times AT}$$

Where:

ADD	=	Average daily dose of contaminant from drinking water (mg/Kg-day)
CW	=	Exposure concentration for drinking water (mg/L)
IR	=	Ingestion rate (L/day)
FI	=	Fraction ingested from contaminated source (decimal fraction)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (year)
CF	=	Conversion factor (1×10^{-3} Kg/g)
BW	=	Body weight (Kg)
AT	=	Averaging time (days); for non-carcinogens, AT=ED*365 days/year; for carcinogens, AT=70 yr*365 days/year

5.0 TOXICITY ASSESSMENT

The toxicity assessment for the COPCs examines information concerning the potential human health effects of exposure to COPCs. The goal of the toxicity assessment is to provide, for each COPC, a quantitative estimate of the relationship between the magnitude and type of exposure and the severity or probability of human health effects. The toxicity values presented in this section are integrated with the exposure assessment (Section 4.0) to characterize the potential for the occurrence of adverse health effects (Section 6.0).

The toxicological evaluation involves a critical review and interpretation of toxicity data from epidemiological, clinical, animal, and in vitro studies. This review of the data ideally determines both the nature of the health effects associated with a particular chemical and the probability that a given quantity of a chemical could result in the referenced effect. This analysis defines the relationship between the dose received and the incidence of an adverse effect for the COPCs.

CSFs and URFs are the dose-response values used to evaluate potential carcinogens. Non-carcinogenic effects, such as organ damage or reproductive effects, are evaluated by RfDs for oral exposure and RfCs for inhalation exposure. The entire toxicological database is used to guide the derivation of these toxicity values. These data may include epidemiological studies, long-term animal bioassays, short-term tests, and evaluations of molecular structure. Data from these sources are reviewed to determine if a chemical is likely to be toxic to humans. Because of the lack of available human studies, however, the majority of the toxicity data used to derive CSFs, URFs, RfDs, and RfCs comes from animal studies.

The EPA's Integrated Risk Information System (IRIS) database (http://www.epa.gov/iris/) was consulted as the primary source for RfD and RfC values, as well as for CSFs and URFs. EPA intends that IRIS supersedes all other sources of toxicity information for risk assessment. Additional sources for the dose-response values used in the risk assessment were the EPA National Center for Environmental Assessment (NCEA) in Cincinnati, Ohio, and the Health Effects Assessment Summary Tables (HEAST) (EPA, 1997). The following hierarchy was used for selection for toxicity values (EPA, 2003):

- Tier 1 – EPA's IRIS;

- Tier 2 – EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) – The Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (STSC) develops PPRTVs on a chemical specific basis when requested by EPA's Superfund program; and

- Tier 3 – Other toxicity values – Tier 3 includes additional EPA and non-EPA sources of toxicity information. The Tier 3 hierarchy is provided in the RSL Tables User's Guide (EPA, 2014d).

The EPA RSLs Table (EPA, 2015) provides a source of NCEA values. Appendix A, Tables A-5.1 and A-6.1 present oral non-carcinogenic and carcinogenic toxicity values, respectively. Appendix A, Tables A-5.2 and A-6.2 present inhalation non-carcinogenic and carcinogenic toxicity values, respectively.

Toxicity profiles summarizing the available literature on carcinogenic and non-carcinogenic effects associated with human exposure to specific chemicals are available from EPA or the Agency for Toxic Substances and Disease Registry (ATSDR) at www.epa.gov/iris or www.atsdr.cdc.gov.

5.1 Non-Carcinogenic Effects

For non-carcinogenic effects, it is assumed that there exists a dose, below which, adverse health effects are unlikely to be seen.

The potential for non-carcinogenic health effects resulting from oral or dermal exposure to chemicals is assessed by comparing an exposure estimate (intake or dose) to an RfD. The RfD is expressed in units of mg/kg-day and represents a daily intake of contaminant per kilogram of body weight below which adverse health effects are unlikely. Chronic RfDs used in this assessment are developed to be protective of long-term exposure.

The potential for non-carcinogenic health effects resulting from inhalation exposure to chemicals is assessed by comparing an exposure concentration in air to an RfC. The RfC is expressed in units of milligrams per cubic meter (mg/m^3).

To derive an RfD or RfC, EPA reviews all relevant human and animal studies for each compound and selects the study (studies) pertinent to the derivation of the specific RfD or RfC. For non-carcinogenic effects, the most appropriate animal model (the species most biologically similar to the human) is identified. Pharmacokinetic data often enter into this determination. In the absence of sufficient data to identify the most appropriate animal model, the most sensitive species is chosen. The RfD or RfC is generally derived from the most comprehensive toxicology study that characterizes the dose-response relationship for the critical effect of the chemical. Preference is given to studies using the exposure route of concern; in the absence of such data, however, an RfD or RfC for one route of exposure may be extrapolated from data from a study that evaluated a different route of exposure. Such extrapolation must take into account pharmacokinetic and toxicological differences between the routes of exposure.

Each study is evaluated to determine the no-observed-adverse-effect-level (NOAEL) or, if the data are inadequate for such a determination, the lowest-observed-adverse-effect-level (LOAEL).

The NOAEL corresponds to the dose (in mg/kg-day) or concentration (in mg/m^3) that can be administered over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose or concentration that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect."

To derive an RfD or RfC, the NOAEL (or LOAEL) is divided by uncertainty factors to ensure that the RfD or RfC will be protective of human health. Uncertainty factors are applied to account for extrapolation of data from laboratory animals to humans (interspecies extrapolation), variation in human sensitivity to the toxic effects of a compound (intraspecies differences), derivation of a chronic RfD or RfC based on a subchronic rather than a chronic study, or derivation of an RfD or RfC from the LOAEL rather than the NOAEL. In addition to these uncertainty factors, modifying factors between 1 and 10 may be applied to reflect additional qualitative considerations in evaluating the data. For most compounds, the modifying factor is one.

Dermal toxicity factors are based on route-to-route extrapolation (oral to dermal) for systemic effects as described in EPA RAGS E (EPA, 2004). To derive the dermal RfD, the oral RfD (based on an administered dose) is multiplied by the gastrointestinal tract absorption efficiency factor to determine an RfD based on an absorbed dose rather than an administered dose. The resulting dermal RfD is used to evaluate the dermal (absorbed) dose calculated by the dermal exposure algorithms.

Oral RfDs for the COPCs for the Study Area are presented in Appendix A, Table A-5.1. Dermal RfDs and the absorption efficiencies used in their determination are also included in Appendix A, Table A-5.1. The absorption efficiencies were obtained from EPA's Table 4.1, "Summary of Gastrointestinal Absorption Efficiencies and Recommendations for Adjustment of Oral Slope Factors for Specific Compounds" in *RAGS HHEM, Part E, Supplemental Guidance for Dermal Risk Assessment* (EPA, 2004). Inhalation RfCs for the COPCs are presented in Appendix A, Table A-5.2. The tables also include the primary target organs affected by each listed chemical, where information is available. This information may be used in the risk characterization (Section 6.0) to segregate risks by target organ effects when the total HI is greater than 1.0.

Chemical-Specific Considerations

The toxicity and non-cancer risk characterization for total chromium were evaluated through use of hexavalent chromium RfDs and RfCs to be conservative.

The toxicity and non-cancer risk characterization for total mercury were evaluated through use of elemental mercury RfDs and RfCs.

An oral RfD for vanadium and compounds used in this HHRA, is derived from the IRIS oral RfD for vanadium pentoxide by factoring out the molecular weight of the oxide ion. Vanadium pentoxide has a molecular weight of 181.88 grams per mole per Section 5.4 of the EPA RSL User's Guide (EPA, 2014d). The two atoms of vanadium contribute 56 percent of the molecular weight. Vanadium pentoxide's oral RfD of 9×10^{-3} mg/Kg day multiplied by 56 percent gives a vanadium oral RfD of 5.04×10^{-3} mg/Kg day.

5.2 Carcinogenic Effects

The toxicity information considered in the assessment of potential carcinogenic risks includes chemical-specific CSFs, URFs, and a weight-of-evidence narrative consistent with *Guidelines for Carcinogenic Risk Assessment* (EPA, 2005). These revised guidelines use standard narrative descriptors (Carcinogenic to Humans, Likely to Be Carcinogenic to Humans, Suggestive Evidence of Carcinogenic Potential, Inadequate Information to Assess Carcinogenic Potential, and Not Likely to Be Carcinogenic to Humans) to describe the likelihood that a chemical is a human carcinogen and are based on an evaluation of the available data from human and animal studies.

The CSFs and URFs are plausible upper bound estimates of carcinogenic potency used to calculate cancer risk from exposure to carcinogens, by relating estimates of lifetime average chemical intake to the incremental probability of an individual developing cancer over a lifetime.

CSFs and URFs are derived from studies of carcinogenicity in humans and/or laboratory animals. For animal studies, preference is given to studies using the route of exposure of concern, in which normal physiologic function was not impaired, and in which exposure occurred during most of the animal's lifetime. Exposure and pharmacokinetic considerations are used to estimate equivalent human doses for computation of the CSF. CSFs are specific to a chemical and route of exposure and are expressed in units of $(mg/kg\text{-}day)^{-1}$ for oral routes.

In the absence of dermal toxicity values, route-to-route extrapolation is applied to CSFs in evaluation of systemic cancer effects as a result of dermally absorbed contaminants.

Inhalation risks are determined through use of inhalation URFs (EPA, 2009a). An inhalation URF is an upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air.

Oral CSFs for COPCs at the Study Area are presented in Appendix A, Table A-6.1. Dermal CSFs and the absorption efficiencies used in their determination are also included in Appendix A, Table A-6.1. The absorption efficiencies were obtained from EPA's Table 4.1, "Summary of Gastrointestinal Absorption Efficiencies and Recommendations for Adjustment of Oral Slope Factors for Specific Compounds" in *RAGS HHEM, Part E, Supplemental Guidance for Dermal Risk Assessment* (EPA, 2004). Inhalation URFs for the COPCs are presented in Appendix A, Table A-6.2.

EPA's *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposures to Carcinogens* (EPA, 2005) was followed when assessing carcinogens that act with a mutagenic mode of action. EPA's Age-Dependent Adjustment Factors (ADAFs) were used to assess the increased susceptibility of children to carcinogens (EPA, 2005). Further discussion is provided in Section 6.1.2.

Chemical-Specific Considerations

Risk estimates for PAHs have, in the past, assumed that all carcinogenic PAHs have a potency equal to that for benzo(a)pyrene. Although benzo(a)pyrene was well studied, other carcinogenic PAHs had insufficient data with which to calculate a CSF. EPA has published provisional guidance to assess PAHs (EPA, 1993). Estimated orders of potential potency (rather than a toxicity equivalency factor or TEF) were developed based on skin painting tests and are rounded to one significant figure (based on an order of magnitude). The values are based on a comparable endpoint (complete carcinogenesis after repeated exposure to mouse skin). The quality of the data does not support any greater precision. The orders of potential potency used in this HHRA are presented in Appendix I. EPA has determined that the oral CSF for benzo(a)pyrene is 7.3 $(mg/kg\text{-}day)^{-1}$. Oral CSFs for other carcinogenic PAHs were determined by multiplying the oral

CSF for benzo(a)pyrene by the estimated order of potential potency for the PAH. These oral CSFs for PAHs became the basis for deriving the dermal CSFs used to evaluate dermal risk from PAHs.

Toxicity and cancer risk characterization for total chromium via oral and dermal exposures were evaluated using the following Tier 3 toxicity information provided in the RSL User's Guide for hexavalent chromium (EPA, 2014d):

- "The New Jersey Department of Environmental Protection (NJDEP) determined that hexavalent chromium by ingestion is likely to be carcinogenic in humans. NJDEP derived an oral cancer slope factor, based on cancer bioassays conducted by the National Toxicology Program (http://www.state.nj.us/dep/dsr/chromium/soil-cleanup-derivation.pdf). The New Jersey assessment did not make a determination that hexavalent chromium was mutagenic by mode of action for carcinogenesis (NJDEP, 2009).

- EPA's Office of Pesticide Programs (OPP) made a determination that hexavalent chromium has a mutagenic mode of action for carcinogenesis in all cells regardless of type, following administration via drinking water. OPP recommended that ADAFs be applied when assessing cancer risks from early-life exposure (< 16 years of age). This determination was reviewed by OPP's Cancer Assessment Review Committee and published in a peer review journal.

In 2009 the RSL workgroup adopted the Tier III NJDEP values and the OPP recommendation with respect to mutagenicity.

Toxicity and cancer risk characterization for total chromium via inhalation exposures were evaluated using the hexavalent chromium air unit risk of 8.42×10^{-2} per ($\mu g/m^3$) provided in the RSL tables (EPA, 2015). IRIS lists an air unit risk of 1.2×10^{-2} per ($\mu g/m^3$) for hexavalent chromium. According to the RSL User's Guide (EPA, 2014d), "While the exact ratio of hexavalent chromium to trivalent chromium in the data used to derive the IRIS air unit risk value is not known, it is likely that both hexavalent chromium and trivalent chromium were present. The RSLs, calculated using the IRIS air unit risk, assume that the hexavalent chromium to trivalent chromium ratio is 1:6."

Chromium is under review by the IRIS program.

The toxicity and cancer risk characterization for vinyl chloride were evaluated through use of CSFs and URFs for continuous lifetime exposure during adulthood. Cancer risk estimates for scenarios including childhood exposures were estimated using vinyl chloride specific cancer risk equations, which account for early-life sensitivity to carcinogenesis and are presented in Section 6.1.2.

6.0 RISK CHARACTERIZATION

This section provides a characterization of the potential human health risks associated with the potential exposure to COPCs in various media within the Study Area. Section 6.1 outlines the methods used to estimate the type and magnitude of health risks and Section 6.2 presents the risk characterization results for the current and potential future land use conditions.

6.1 Risk Characterization Methodology

Potential human health risks resulting from exposure to COPCs were estimated using algorithms established by EPA. The methods are protective of human health and are likely to overestimate (rather than underestimate) risk. The methodology uses specific algorithms to calculate risk as a function of chemical concentration, human exposure parameters, and toxicity.

Risks from hazardous chemicals are calculated for either carcinogenic or non-carcinogenic effects. Some carcinogenic chemicals may also exhibit non-carcinogenic effects, in which case, potential impacts are characterized for both types of health effects.

6.1.1 Non-Cancer Effects

The hazards associated with non-cancer effects of COPCs are evaluated by comparing an ADD to an RfD or an ADC to an RfC. The ratio of the ADD to an RfD or an ADC to an RfC is called the HQ and is defined as follows (EPA, 1989):

$$\mathrm{HQ} = \frac{\mathrm{ADD}}{\mathrm{RfD}} \; or \; \frac{\mathrm{ADC}}{\mathrm{RfC}}$$

Where:

HQ	=	Hazard Quotient (unitless)
ADD	=	Average daily dose (mg/Kg-day or mg/m^3), a function of exposure and chemical concentration
ADC	=	Average daily concentration (mg/m^3), a function of exposure and chemical concentration
RfD	=	Reference dose (mg/Kg-day)
RfC	=	Reference concentration (mg/m^3)

If the ratio of the ADD to the RfD or the ADC to the RfC exceeds 1.0, there exists a potential for non-carcinogenic (toxic) effects to occur. A HI is generated by summing the individual HQs for all COPCs. If the value of the HI exceeds 1.0, there is a potential for non-carcinogenic health effects associated with that particular chemical mixture, and therefore it is necessary to segregate the HQs by target organ effects. The HQ should not be construed as a probability, but rather as a numerical indicator of the extent to which a predicted intake exceeds or is less than an RfD or RfC.

6.1.2 Carcinogens

Risks attributable to exposure to chemical carcinogens are estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. The incremental lifetime cancer risk (ILCR) is determined as follows (EPA, 1989):

$$ILCR = ADD \times CSF \ or \ ADC \times URF$$

Where:

ILCR	=	Incremental lifetime cancer risk, expressed as a unitless probability
ADD	=	Average daily dose (mg/Kg-day)
ADC	=	Average daily concentration ($\mu g/m^3$)
CSF	=	Cancer slope factor $(mg/Kg\text{-}day)^{-1}$
URF	=	Unit risk factor $(\mu g/m^3)^{-1}$

Risks below 1 x 10^{-6} (less than 1 in 1 million) are generally considered to be acceptable by EPA, and risks greater than 1 x 10^{-4} (1 in 10,000) are generally considered to be unacceptable. Risks between 1 x 10^{-6} and 1 x 10^{-4} are generally considered to be within EPA's targeted cancer risk range.

Risks are estimated for all carcinogenic COPCs with available CSFs or URFs, regardless of the narrative descriptors described in Section 5.2.

Carcinogens That Act with a Mutagenic Mode of Action

For carcinogens that act with a mutagenic mode of action for carcinogenesis, ADAFs were applied to the cancer slope factor to address early lifetime exposures and the increased susceptibility of children to carcinogens (EPA, 2005). As presented in the RSL Table (EPA, 2015), the following COPCs exhibit a mutagenic mode of action for carcinogenesis:

Benzo(a)anthracene	Dibenz(a,h)anthracene
Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene
Benzo(b)fluoranthene	Chromium (hexavalent form)
1,2-Dibromo-3-chloropropane	Trichloroethylene
Methylene chloride	Vinyl chloride

The ADAFs for specific age-groups classes are presented below:

Age (years)	ADAF (unitless)
0 – <2	10
2 – <16	3
≥16	1

Potential risk to a recreational child visitor (sediment and surface water exposures) was assessed using the information presented below.

Age (years)	Exposure Factors	Exposure Duration (years)	ADAF (unitless)
0 – <2	Child	2	10
2 – <6	Child	4	3

Total Risk for child recreational exposures = $\text{Risk}_{0-<2} + \text{Risk}_{2-<6}$

RME residential lifetime exposure factors were divided into two age groupings: child – 0 to 6 years and adult – 6 to 26 years. Potential risk to an individual resident (groundwater as drinking water) was assessed using the information presented below.

Age (years)	Exposure Factors	Exposure Duration (years)	ADAF (unitless)
0 – <2	Child	2	10
2 – <6	Child	4	3
6 – <16	Adult	10	3
16 – <26	Adult	10	1

Total Risk for lifetime exposures = $\text{Risk}_{0-<2} + \text{Risk}_{2-<6} + \text{Risk}_{6-<16} + \text{Risk}_{16-<26}$

CTE residential lifetime exposure factors were divided into two age groupings: child – 0 to 2 years and adult – 6 to 12 years. Potential risk to an individual resident (groundwater as drinking water) was assessed using the information presented below.

Age (years)	Exposure Factors	Exposure Duration (years)	ADAF (unitless)
0 – <2	Child	2	10
6 – <12	Adult	6	3

Total Risk for lifetime exposures = $\text{Risk}_{0-<2} + \text{Risk}_{6-<12}$

Appendix J presents the risk calculations for the COPCs with a mutagenic mode of action for carcinogenesis. These risks are then included in the Appendix A RAGS D tables.

TCE

TCE was identified as a COPC in both surface water and groundwater used as drinking water. As discussed in the IRIS, TCE is carcinogenic by a mutagenic mode of action for induction of kidney tumors. There is also more limited evidence for non-Hodgkin lymphoma (NHL) and liver carcinogenicity. In order to account for the mutagenic mode of action for kidney tumors, EPA recommends applying ADAFs when estimating kidney cancer risks from early life exposure to TCE. However, NHL and liver cancer must also be accounted for in the cancer risk estimates. To accommodate all three carcinogenic effects, a cancer risk was derived for each age group (0 – <2, 2 – <6, 6 – <16, and 16 – <26), including adjusted kidney cancer potency values and unadjusted potency values for liver cancer and NHL. These risks were then summed across age groups to obtain the total risk for the exposure period of interest. Appendix J, Tables J-2b, J-4b RME and J-4b CTE present the results of the residential mode of action calculations for TCE for surface water and groundwater used for drinking water and during household water use.

The following equation is used to evaluate lifetime residential cancer risks from drinking water ingestion exposures to TCE:

$$\text{Risk} = \text{CW x} \sum_i \left(\left(\left(\frac{\text{IR x FI x EF x ED x CF}}{\text{BW x AT}} \right) \text{x CSF}_{\text{kidney}} \text{ x ADAF} \right) + \left(\left(\frac{\text{IR x FI x EF x ED x CF}}{\text{BW x AT}} \right) \text{x CSF}_{\text{liver+NHL}} \right) \right)$$

Where:

CW	=	Exposure concentration for drinking water (µg/L)
IR	=	Ingestion Rate during age span (L/day)
FI	=	Fraction Ingested from contaminated source (decimal fraction)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (year)
CF	=	Conversion Factor (1×10^{-3} milligram per microgram (mg/µg))
BW	=	Body Weight during age span (Kg)
AT	=	Averaging Time (days)
CSF	=	Cancer slope factor $(\text{mg/Kg-day})^{-1}$
ADAF	=	Age-Dependent Adjustment Factor (unitless)

The following equation is used to evaluate child recreational cancer risks from dermal exposures to surface water and lifetime residential cancer risks from drinking water dermal contact exposures to TCE:

$$\text{Risk} = \sum_i \left(\left(\left(\frac{\text{DA}_{\text{event}} \text{ x SA x EV x EF x ED}}{\text{BW x AT}} \right) \text{x CSF}_{\text{kidney}} \text{ x ADAF} \right) + \left(\left(\frac{\text{DA}_{\text{event}} \text{ x SA x EV x EF x ED}}{\text{BW x AT}} \right) \text{x CSF}_{\text{liver+NHL}} \right) \right)$$

Where:

DA_{event} = Absorbed dose per event (mg/cm^2-event)
SA = Surface area for age span (cm^2)
EV = Events per day
SA = Surface area for age span (cm^2)
EF = Exposure frequency (days/year)
ED = Exposure duration (year)
BW = Body Weight during age span (Kg)
AT = Averaging Time (days)
CSF = dermal Cancer slope factor (mg/Kg-day)$^{-1}$
ADAF = Age-Dependent Adjustment Factor (unitless)

The following equation is used to evaluate lifetime residential cancer risks from household vapor inhalation exposures to TCE:

$$\text{Risk} = \sum_i \left(\left(\text{CA x ED x URF}_{\text{kidney}} \text{ x ADAF} \right) + \left(\text{CA x ED x URF}_{\text{liver+NHL}} \right) \right)$$

Where:

CA = Exposure concentration for air (µg/m^3)
ED = Exposure duration (year)
URF = Inhalation unit risk factor (µg/m^3)$^{-1}$
ADAF = Age-Dependent Adjustment Factor (unitless)

Vinyl Chloride

Vinyl chloride is also considered to act via a mutagenic mode of action and was identified as a COPC in both surface water and groundwater used as drinking water. Several studies have provided evidence for early-life sensitivity to carcinogenesis associated with vinyl chloride exposure (EPA, 2000a). This sensitivity is independent of later life chronic exposures. For this reason, the cancer risk equations for evaluation of vinyl chloride exposures in scenarios including young children differ from those of other contaminants and those used in adult only exposures. Because chemical-specific information is available for evaluating vinyl chloride risks, unique equations are used rather than the equations using general ADAF factors. The lifetime cancer risk can be approximated by adding risks from the non-overlapping exposures in early life and later. The later-life exposure is prorated over the life span. The risk from early-life exposure is not prorated over exposure duration.

The following equation is used to evaluate lifetime residential cancer risks from drinking water ingestion exposures to vinyl chloride:

$$\text{Risk} = (\text{ADD x CSF}) + \left(\frac{\text{CW x IR}_c \text{ x FI x CF}}{\text{BW}_c} \text{ x CSF} \right)$$

Where:

ADD	=	Average daily dose of contaminant from groundwater (mg/Kg-day) (lifetime)
CW	=	Exposure concentration for drinking water (µg/L)
IR_c	=	Ingestion Rate during childhood (L/day)
FI	=	Fraction Ingested from contaminated source (decimal fraction)
CF	=	Conversion Factor (1×10^{-3} milligram per microgram (mg/µg))
BW_c	=	Body Weight during childhood (Kg)
CSF	=	Cancer slope factor $(\text{mg/Kg-day})^{-1}$

The following equation is used to evaluate child recreational cancer risks from dermal exposures to surface water and lifetime residential cancer risks from drinking water dermal contact exposures to vinyl chloride:

$$\text{Risk} = (\text{DAD x CSF}) + \left(\frac{\text{DA}_{\text{event}} \text{ x } \text{SA}_{\text{c}} \text{ x EV}}{\text{BW}_{\text{c}}} \text{ x CSF} \right)$$

Where:

DAD = Dermally absorbed dose (mg/Kg-day) (lifetime drinking water or childhood surface water)

DA_{event} = Absorbed dose per event (mg/cm^2-event)

SA_c = Surface area during childhood (cm^2)

EV = Events per day

BW_c = Body Weight during childhood (Kg)

CSF = Dermal Cancer slope factor (mg/Kg-day)$^{-1}$

The following equation is used to evaluate lifetime residential cancer risks from household vapor inhalation exposures to vinyl chloride:

$$\text{Risk} = (\text{ADC x URF}) + (\text{CA x URF})$$

Where:

ADC = Average Daily Concentration (µg/m^3)

CA = Exposure concentration for air (µg/m^3)

CF = Conversion factor (1 x 10^3 µg/mg)

URF = Inhalation unit risk factor (µg/m^3)$^{-1}$

6.1.3 Lead

Risks from lead exposure are not evaluated using the same methodology as other contaminants. The IEUBK Model is used to assess childhood exposures to lead. This model estimates blood lead concentrations. Blood lead concentration is the most widely used index of internal lead body burdens associated with potential adverse health effects of lead. Studies indicate that infants and young children are most susceptible to adverse effects from exposure to lead. Considerable behavioral and developmental impairments have been noted in children with elevated blood lead levels. Evaluation of the young child in a residential scenario is considered protective of adults,

including pregnant women; and adolescents. The EPA risk reduction goal for contaminated sites is to limit the probability of a child's blood lead concentration exceeding 10 µg/dL to 5 percent or less.

Potential residential child exposure to lead in drinking water was evaluated using EPA's IEUBK model for lead in children (EPA, 1994 and 2007). The IEUBK Model is designed to estimate blood levels of lead in children (under 7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure.

Concentrations (i.e., blood lead levels) calculated using this approach are compared to the established blood lead level of concern of 10 µg/dL. An additional step in the process estimates the probability that blood lead levels will exceed 10 µg/dL. EPA's risk reduction goal for lead is that individuals exposed would have no more than a 5 percent probability of exceeding the level of concern of 10 µg/dL.

An EPC, as well as default parameters for some input parameters, was used in the evaluations. Average concentrations are used as the EPC in the lead models. The input parameters used, the results of the lead model, and estimated blood lead level are presented in Appendix K.

The results of the IEUBK model evaluation are discussed in Sections 6.2.3.

6.2 Risk Characterization Results

A summary of the quantitative risk assessment is provided in this section.

Table 6-1 summarizes the non-cancer and cancer results, identifies major contributors to cancer risks greater than 1×10^{-6} or hazard indices greater than 1.0, and summarizes the lead evaluation results for the each of the evaluated scenarios. Non-carcinogenic risks are evaluated separately for adult and child residents and recreational visitors. Cancer risks for residents are evaluated for lifetime (age-adjusted) exposures.

Details of the risk estimates are presented in Appendix A, as follows:

- Appendix A, Tables A-7.1 through A-7.8, present non-cancer and cancer risk estimates for each receptor.

- Appendix A, Tables A-9.1 through A-9.8 present summaries of cancer risks and health hazard indices from all applicable media and pathways for each exposure scenario.

- Appendix A, Tables A-10.1 through A-10.8 present summaries of cancer risks and health hazard indices from all applicable media and pathways for each exposure scenario for only the major contributors to risk (individual contaminants with cancer risk greater than 1×10^{-6} or hazard indices greater than one).

Results of the evaluation of estimated lead exposures are presented in Appendix K.

The following sections discuss results by exposure scenario, including hazard indices, cancer risks, and blood lead levels, if applicable.

6.2.1 Recreational Visitors

Potential receptors include recreational visitors exposed to sediment and surface water. Only the RME scenarios were evaluated.

Non-Carcinogenic Risks

Hazard indices developed for the recreational visitors are as follows:

Receptor (Timeframe)	RME HI
Adult Recreational Visitor – sediment (Current/Future)	0.004
Child Recreational Visitor – sediment (Current/Future)	0.04
Adult Recreational Visitor – surface water (Current/Future)	0.008
Child Recreational Visitor – surface water (Current/Future)	0.02

RME HIs are less than 1.0 for adult and child recreational visitors exposed to sediment and surface water. Estimated HIs indicate potential adverse non-cancer effects are not expected for recreational visitors exposed to sediment and surface water in the unnamed stream.

Carcinogenic Risks

Cancer Risks developed for the recreational visitors are as follows:

Receptor (Timeframe)	RME Cancer Risk
Adult Recreational Visitor – sediment (Current/Future)	5.6×10^{-7}
Child Recreational Visitor – sediment (Current/Future)	5.1×10^{-6}
Adult Recreational Visitor – surface water (Current/Future)	8.5×10^{-7}
Child Recreational Visitor – surface water (Current/Future)	8.6×10^{-6}

The RME cancer risk estimates for adult and child recreational visitors exposed to sediment and surface water are within or less than the EPA targeted cancer risk range (1×10^{-4} to 1×10^{-6}).

Exposure to Lead

Lead was not identified as a COPC in surface water or sediment.

6.2.2 Construction Worker

Potential receptors include current/future construction workers exposed to shallow groundwater and volatiles in trench air during excavation activities. Both RME and CTE scenarios were evaluated.

Non-Carcinogenic Risks

Hazard indices developed for the construction workers are as follows:

Receptor (Timeframe)	RME HI	CTE HI
Construction Worker – shallow groundwater (Current/Future)	3.0	0.6

The RME HI is greater than 1.0 for current/future construction workers exposed to shallow groundwater and volatiles in trench air during excavation activities. The estimated HI indicates potential adverse non-cancer effects for these construction workers. Under the RME scenario, TCE, with its impacts to the immune system, is the sole contaminant with an HI in excess of 1.0. The HI for the immune system is the only target organ-specific HI greater than 1.0. The CTE HI is less than 1.0.

Carcinogenic Risks

Cancer Risks developed for the construction workers are as follows:

Receptor (Timeframe)	RME Cancer Risk	CTE Cancer Risk
Construction Worker – shallow groundwater (Current/Future)	2.0×10^{-6}	4.1×10^{-7}

The RME and CTE cancer risk estimates for current/future construction workers exposed to shallow groundwater and volatiles in trench air during excavation activities are within or below the EPA targeted cancer risk range (1×10^{-4} to 1×10^{-6}).

Exposure to Lead

Lead was not selected as a COPC for shallow groundwater.

6.2.3 Residents

Potential receptors include hypothetical future residents exposed to groundwater as drinking water. Both RME and CTE scenarios were evaluated.

Non-Carcinogenic Risks

Hazard indices developed for hypothetical future residents using groundwater as drinking water are as follows:

Receptor (Timeframe)	RME HI	CTE HI
Adult Resident – groundwater (Future)	2778	2478
Child Resident – groundwater (Future)	3181	2687

Both RME and CTE HIs are greater than 1 for hypothetical future residents using groundwater as drinking water. Estimated HIs indicate potential adverse non-cancer effects for these future residents exposed to groundwater as drinking water. TCE is the greatest contributor to the total hazard indices. Individual HQs for cis-1,2-DCE, methylene chloride, cobalt, arsenic, iron, and chromium are also greater than 1. Target organ-specific HIs exceed 1 for immune system, kidney, liver, thyroid, skin, and gastrointestinal tract.

Carcinogenic Risks

Cancer Risks developed for future hypothetical residents using groundwater as drinking water are as follows:

Receptor (Timeframe)	RME Cancer Risk	CTE Cancer Risk
Age-Adjusted Lifetime Resident – groundwater (Future)	9.2×10^{-2}	3.6×10^{-2}

Both the RME and CTE cancer risk estimates for hypothetical future residents using groundwater as drinking water exceed the EPA targeted cancer risk range (1×10^{-4} to 1×10^{-6}). As detailed in Table 6-1, the greatest contributors to cancer risk for hypothetical future residents using groundwater as drinking water are TCE, chromium, methylene chloride, vinyl chloride, arsenic, and 1,2- dichloroethane (1,2-DCA). Individual cancer risk estimates for each of these contributors are greater than 1×10^{-6} under the RME scenario.

Exposure to Lead

Lead was selected as a COPC for groundwater based on the maximum detected concentration. The average lead concentration in the overburden groundwater data set was 9 µg/L. As stated in Section 6.1.3, average lead concentrations are used as EPCs in the lead model.

EPA's IEUBK model estimated that the geometric mean blood lead concentration among future residential children exposed to groundwater as drinking water would be 3.1 µg/dL (Appendix K, Table K-1). The estimate is less than EPA's established level of concern of 10 µg/dL. The probability that the child's blood lead concentration exceeds 10 µg/dL is 0.6 percent for future residential children exposed to groundwater as drinking water. These estimates are less than EPA's target probability of 5 percent or less. In conclusion, future potential exposures to lead in groundwater used as drinking water do not exceed EPA's target level of concern for child residents.

6.2.4 Soil

A semi-quantitative comparison of the analytical results of soil samples collected at 96 Commerce Street and at properties along South Brownell and Shunpike Roads to risk based screening levels indicates the presence of PAHs and metals at concentrations above screening levels at 96 Commerce Street and metals concentrations above screening levels at the properties along South Brownell and Shunpike Roads.

EPA reviewed the soil data for accessible soil (0-10 feet bgs) from soil borings and surface soil samples collected in 2010, 2012, 2013, and 2014 and evaluated future residential exposure to soil semi-quantitatively by using a simplified ratio approach. EPA's review and evaluation is provided as Appendix B. The hazards associated with non-cancer effects of soil COPCs were evaluated by comparing the maximum soil concentrations to the EPA's non-cancer based RSLs for residential soil (EPA, 2015). The ratio of the soil concentrations to the non-cancer based RSL is equal to the HQ. The total HI is generated by summing the individual HQs for all COPCs. The risks associated with cancer effects of surface soil COPCs were evaluated by comparing the soil concentrations to the EPA's cancer based RSLs for residential soil (EPA, 2015) and multiplying by 1×10^{-6}. Total cancer risk is generated by summing the individual cancer risks for all COPCs. Total chromium results at 96 Commerce Street were evaluated using hexavalent chromium RSLs. However, based on conclusions of the soil chromium speciation investigation, total chromium

results at properties along South Brownell and Shunpike Roads were evaluated using trivalent chromium RSLs.

The results of the soil investigation suggest that the risks both at properties along Shunpike Road and South Brownell Road and at the Mitec property are lower than EPA's maximum non-cancer risk limit (HQ of 1) and are within EPA's acceptable cancer risk range of 1×10^{-4} to 1×10^{-6} at Superfund sites. However, because of the uncertainty about whether elevated chromium at the former Mitec property may be hexavalent chromium, it is recommended that soil be removed from 96 Commerce Street, with a goal to reduce the concentration of PAHs and total chromium.

6.2.5 Vapor Intrusion

EPA investigated the potential for vapor intrusion at five residential and two commercial buildings representative of conditions across the Study Area in June 2012 and January 2013, and a sixth residence in December 2014. The potential transport of volatile contaminants from groundwater to indoor air was investigated with sampling of indoor air and sub-slab soil gas. The investigation, described in Appendix C, did not show the vapor intrusion pathway to be complete across the Study Area and is not further evaluated in this HHRA.

EPA also evaluated the health risk to residents at 830 South Brownell Road from direct vapor inhalation from contaminated groundwater that, but for an existing sump pump system, could flood the basement. Using the VISL calculator and an attenuation factor of 1 which is more indicative of exposure to vapors from contaminated groundwater in the basement, a cancer risk above EPA's maximum acceptable risk of 1×10^{-4} and HI of 1 was calculated (see Appendix L).

7.0 UNCERTAINTY ANALYSIS

There are uncertainties and variability associated with all HHRAs. This section summarizes these uncertainties and provides a qualitative assessment of whether the uncertainties may over or underestimate risks.

Although there are various sources of uncertainty throughout the risk assessments, assumptions were made to provide conservative estimates that are protective of public health such that the risk estimates are unlikely to underestimate potential risks.

Once the risk calculations are complete, the results must be viewed considering the uncertainties inherent in the process. An understanding of the risk assessment and associated uncertainties provides the risk manager with additional information for consideration in the risk management decision.

Consistent with EPA guidance and policy (EPA, 1992 and 1995) exposure and toxicity assumptions from the "high end" and the "central tendency" of their distributions were used. These values correspond to the RME and CTE scenarios. The RME is conceptually the “high end” exposure above the 90th percentile of the population distribution but not higher than the individual in the population with the highest exposure. The CTE reflects the central (average) estimates of exposure. For sediment and surface water exposures, only RME scenarios were evaluated. Results of the RME risk estimates for sediment and surface water exposures indicated risks are within or less than the EPA targeted cancer risk range (1×10^{-4} to 1×10^{-6}) and HI of 1; therefore, estimation of CTE risks were not warranted. Both RME and CTE risk estimates are provided for construction worker exposures to groundwater and volatiles in trenches and for hypothetical future residential use of groundwater as drinking water.

Uncertainties within individual components of the HHRA for the Study Area are discussed below.

7.1 Uncertainty in Data Evaluation

Conservative screening values were used to select COPCs and contaminants without screening values were retained as COPCs; thus, it is unlikely that any contaminant that may pose a risk was eliminated from the risk assessment during the data evaluation step. There were a few chemicals detected for which screening values were not available. For benzo(g,h,i)perylene, the screening value from naphthalene (selected based on similarity of molecular structure) was used as a surrogate screening value. The surrogate value was used as a qualitative approach for screening purposes only; surrogate toxicity values were not used to calculate risk. As a result of this screening, benzo(g,h,i)perylene was eliminated as a COPC. Additional contaminants without RSLs, including 4-nitrophenol in sediment and methane in groundwater, were retained as COPCs.

There are many chemicals that are not part of EPA’s list of routine analytes. Therefore, additional chemicals could be present that were not detected in the laboratory analysis that could increase potential risk.

A COPC was selected if the maximum detected concentration in sediments, surface water, groundwater, or soils exceeded its respective risk-based screening criterion. Frequency of detection was not used to eliminate COPCs. Even if the compound was detected at a very low frequency, i.e., less than 5 percent across the entire study area, the compound was still retained for evaluation in the risk assessment if the maximum detected concentration within a dataset exceeded the screening criterion. Because of the small size of the sediment and surface water datasets, elimination of COPCs based on low frequency of detection is unreasonable. For the larger groundwater datasets, elimination of COPCs based on low frequency of detection would be possible. For the shallow groundwater dataset used to evaluate construction worker exposures, three of the COPCs (benzo(a)pyrene, chloroform, and naphthalene) were each detected in just one or two samples; in contrast TCE was detected in almost half the samples. Retention of these infrequently detected contaminants as COPCs results in an increased risk. However, since these COPCs were not identified as risk drivers, the impacts to total risk are minor.

For the groundwater dataset used to evaluate potential drinking water exposures, vinyl chloride was detected in just one of the eighteen samples collected from within the core of the plume; in contrast TCE was detected in 94 percent of the groundwater samples collected from within the core of the plume. Retention of infrequently detected contaminants as COPCs such as vinyl chloride, results in an increased risk. However, because the risks from TCE are significantly higher than risks from vinyl chloride, the impacts to total risks are minimal.

Total chromium was selected as a COPC in sediment, groundwater, and soil based on screening criteria for the more toxic hexavalent chromium form. For soils, the maximum total chromium concentration was 320 mg/kg at 96 Commerce Street (former Mitec facility). For soils at the properties along South Brownell and Shunpike Roads, the maximum total chromium concentration was 29 mg/kg. For groundwater, the maximum total chromium concentration within the core of the plume was 53 µg/L. Sampling of soil and groundwater with specific analysis for hexavalent versus trivalent forms of chromium was conducted in December 2013. The groundwater sampling locations are displayed on Figure 3-2 and the soil sampling locations are displayed on Figure 3-3. Results are presented in the RI Volume I report as appropriate.

The chromium speciation soil results indicate that the dominant form of chromium in soils in the Study Area is the less toxic trivalent form. The December 2013 sampling included three soil borings; two in the former unlined lagoon area in the rear of the former Mitec property and one to the southwest of the intersection of South Brownell Road and Shunpike Road. These locations were selected based on the historical concentrations of total chromium previously observed in the vicinity. Total chromium was detected in every soil sample, with concentrations ranging from 7.5 mg/Kg to 16 mg/Kg. Hexavalent chromium was detected in only one sample at a concentration of 0.85 mg/Kg and exceeded EPA's action level for hexavalent chromium of 0.29 mg/Kg. The sole detection of hexavalent chromium was in a sample collected from boring SB-13-02 from the 3 to 6 feet bgs interval in the southern end of the former unlined lagoon area. Complete results are provided in the RI. As discussed in Appendix B (soil tech memo), based on review of this data, it is concluded that hexavalent chromium in soil occurred only at the Mitec property and not at the other areas. However, because of the detected presence of hexavalent chromium in soils at 96 Commerce Street, use of a hexavalent RSL for COPC selection is a protective approach to identifying COPCs in soil.

Because of the detected presence of hexavalent chromium in soils, it is reasonable to assume some of the total chromium detected in sediment may also be in the hexavalent form. Use of a hexavalent RSL for COPC selection is a protective approach to identifying COPCs in sediment.

The groundwater chromium speciation results can be used to qualitatively confirm that total chromium concentrations in groundwater may contain significant concentrations of hexavalent chromium.

The results of the December 2013 chromium speciation groundwater sampling reported two detections of hexavalent chromium of the 4 groundwater samples. The two detections (both 19 µg/L) were at ten times the detection limit and were in the duplicate pair sampled along Kirby Lane; however, total chromium in the pair varied significantly (130 µg/L versus 23 µg/L). The maximum detected total concentration in this round exceeded the maximum detected concentration in prior sampling. Although hexavalent chromium was not detected in the well located within the core of the plume, because of the results in the Kirby Lane well, use of a hexavalent RSL for COPC selection is a protective approach to identifying COPCs in groundwater at the study area.

Since total cancer risks for other significant contributors (specifically TCE) to risk from potential groundwater exposure are already above 1 x 10^{-4}, assuming that the chromium in groundwater is hexavalent does not change the overall conclusions of this risk assessment.

7.2 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises from the selection of receptors and selection of exposure parameters. Each is discussed below.

7.2.1 Exposure Point Concentrations

Ideally, for sediment and surface water datasets, 95 percent UCLs on the mean are selected as EPCs. However, the sample set sizes for sediment and surface water data are small. These small datasets make the estimation of the 95 percent UCL limit on the mean somewhat uncertain. For both sediment and surface water, where the number of samples is fewer than 8, maximum detected concentrations were used as the EPC. A single detection or small number of detections of a contaminant in these small data sets can drive risk calculations. The use of maximum concentrations likely results in an overestimate of risks from sediment and surface water exposures.

For the shallow groundwater dataset, maximum detected concentrations are used as EPCs because excavation trenches could be installed in a limited area. The use of maximum concentrations likely results in an overestimate of risks from trenches installed in less contaminated areas. This is particularly true for contaminants where the maximum detection is the only detection.

For the overburden groundwater dataset, 95 percent UCLs from wells representative of the core of the plume are used as EPCs. This approach results in a conservative estimate of risk from exposure to study area groundwater as drinking water and likely overestimates risks for future potential wells drawing groundwater from less contaminated areas of the aquifer.

7.2.2 Exposure Scenarios and Receptor Identification

Exposure scenarios were selected to represent a range of current and future potential uses. The scenarios are conservative and likely to overestimate risk to individuals whose exposure is more limited.

Uncertainty exists in the evaluation of the hypothetical use of groundwater as drinking water scenario. Groundwater is not currently used or expected to be used in the future as a drinking water source. Risks were calculated for this scenario to be protective of all possible future uses of groundwater in the Study Area, but are not representative of likely future use.

7.2.3 Selection of Exposure Parameters

Each exposure factor selected for use in this risk assessment has some associated uncertainty. The RME estimates were obtained by combining estimates of likely “high-end” exposure factors with average factors. The resulting point estimate (or single value) is the reasonable maximum exposure. These RME risks are not likely to underestimate risk, even for the most frequently or intensely exposed individual. CTE risk estimates were also prepared for scenarios with RME risks exceeding EPA’s target risk levels. The CTE estimates represent an “average case” exposure scenario and therefore are less likely to overestimate risks.

This HHRA uses exposure assumptions recommended by EPA. VT DOH has expressed concerns that these assumptions differ from assumptions commonly recommended by VT DOH. EPA has reviewed the differences between EPA recommended exposure factors and factors that EPA assumes would be recommended by VT DOH based on the VT DEC guidance (VT DEC, 2012) and notes the only significant difference appears to be the use of a 26 year exposure duration by EPA versus a 70 year exposure duration by VT DOH (EPA, 2014e). Use of this higher exposure duration would result in 2.3 times higher risks than use of the EPA default exposure duration for residential exposures.

Direct contact to and inhalation of shallow groundwater with TCE concentrations in excess of 2.3 µg/L pose a risk to the construction/utility worker based on exposure eight hours per day, five days per week for six months in a narrow trench. This scenario is highly conservative because trenching work by utility workers would take much less time, and excavation of foundations by construction workers would be completed in much less time than six months and have much

higher air exchange rates due to the wider foundations. In addition, the TCE plume is generally at depths ranging from 10 to 15 feet bgs, and any groundwater collection in excavations would be pumped out during excavations. As a result, a cleanup level of 5 µg/L (the MCL) is more appropriate.

7.3 Uncertainty in the Toxicological Evaluation

The toxicity values used in the quantitative assessment were those available in EPA databases.

7.3.1 Cancer Slope Factors and Inhalation Unit Risk Factors

CSFs and URFs are plausible upper-bound estimates of carcinogenic potency used to calculate cancer risk from exposure to carcinogens by relating estimates of lifetime average chemical intake to the incremental probability of an individual developing cancer over a lifetime as a result of exposure to site contaminants. Because the CSFs and URFs are upper-bound estimates, EPA is reasonably confident that the actual cancer risks are unlikely to be underestimated.

CSFs and URFs were not available for all chemicals. The lack of a CSF or URF may underestimate risk.

The use of hexavalent chromium CSFs and URFs to evaluate risks from exposures to total chromium in groundwater and sediment presents a conservative approach and likely overestimates risks from total chromium. As noted above, results of 2013 sampling to collect soil and groundwater chromium speciation data confirmed the presence of hexavalent chromium in soils at 96 Commerce Street (former Mitec property) and in groundwater. It was concluded that hexavalent chromium occurs in soil only at the former Mitec property and that total chromium concentrations in groundwater may contain significant concentrations of hexavalent chromium. This evaluation supports the use of hexavalent toxicity values as a conservative approach to estimating risks from total chromium in groundwater and sediment. Actual risks from total chromium are expected to be lower.

The oral cancer slope factor used to estimate potential cancer risks associated with exposure to hexavalent chromium is consistent with the Tier III adopted by the EPA RSL workgroup. There is uncertainty associated with this value as described in the RSL User Guide Section 5.6. The toxicity of hexavalent chromium is under review by the IRIS program.

This HHRA uses toxicity factors recommended by EPA. VT DOH has expressed concerns that these toxicity factors differ from toxicity factors commonly recommended by VT DOH for TCE, vinyl chloride, PCE, and dioxins. EPA has reviewed the differences between EPA recommended toxicity factors and VT DOH/VT DEC toxicity factors and the combined impacts of these differences and the exposure duration differences discussed in Section 7.2.3 (EPA, 2014e). Use of both the VT DOH/VT DEC toxicity factors and the higher exposure duration would result in ingestion cancer risks that would be higher than EPA, but within the same order of magnitude for vinyl chloride, and one order of magnitude higher for TCE for residential exposures. PCE and dioxins were not identified as COPCs for this HHRA.

7.3.2 Chronic Reference Doses and Chronic Reference Concentrations

The RfD and RfC represent estimates (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime.

Non-cancer or cancer toxicity values were not available for all chemicals. A few contaminants selected as COPCs because of a lack of screening values have no available toxicity values for quantitative calculations of risk. These contaminants include: 4-nitrophenol, detected in one of four sediment samples at a concentration very close to the detection limit; and methane, detected in three of three overburden groundwater samples from within the core of the plume at concentrations ranging from 16 to 140 µg/L. Based on the low detected concentration, lack of toxicity values for 4-nitrophenol is unlikely to impact risk conclusions for the Study Area. The lack of toxicity values for methane may underestimate risk.

7.3.3 Subchronic Reference Doses

Subchronic toxicity values are applicable to short-term exposure to construction workers. Chronic toxicity values were used for these exposures, which would tend to overestimate risks for these receptors.

7.3.4 Lead

Uncertainty is associated with evaluating exposures to lead. Exposures of future hypothetical residents to lead in groundwater as drinking water were evaluated by use of the IEUBK model. This model represents a conservative approach for predicting blood lead levels in children and is designed to overestimate risks. Use of this model to predict child blood lead levels is considered protective of adults.

7.4 Uncertainty Associated with Risk Characterization

The conservative assumptions applied in conducting this risk assessment result in estimates that EPA is confident do not underestimate the potential risks.

Cancer risks are added to estimate the total incremental risk as a result of exposure to chemicals at the Study Area. Summing cancer risks may overestimate total risks. The lack of information on synergistic effects of multiple contaminants may underestimate risks and the lack of information on antagonistic effects may overestimate risks.

8.0 SUMMARY OF HUMAN HEALTH RISK ASSESSMENT

This section and Table 6-1 present a summary of the quantitative risk assessment findings for the Study Area. This section also presents the findings of the qualitative evaluation of study area soils and a summary of the vapor intrusion evaluation.

Exposures to sediment and surface water, collected from the unnamed stream; construction worker exposures to shallow groundwater and volatiles in trench air; and hypothetical future residential exposures to groundwater used as drinking water were evaluated quantitatively. Table 6-1 presents the results of the quantitative risks calculations. The following summaries focus only on HIs greater than 1 with individual contaminant HQs or organ-specific HIs exceeding 1, cancer risks exceeding EPA targeted cancer risk range (1×10^{-4} to 1×10^{-6}), and lead evaluation results with the IEUBK model estimating the probability of a child's blood lead concentration exceeding 10 µg/dL to be 5 percent or greater. Major contributors to cancer risks (exceeding 1×10^{-6}) and hazard indices (exceeding HQ of 1) identified for one or more receptors are also listed.

Exposures to soil were evaluated semi-quantitatively and are summarized in Section 8.4. Exposures via the vapor intrusion pathway were evaluated separately and are summarized in Section 8.5.

8.1 Recreational Visitors

The cancer risk estimates for recreational visitors exposed to sediment and surface water at the unnamed stream are within or less than the EPA targeted cancer risk range (1×10^{-4} to 1×10^{-6}).

Estimated HIs indicate potential adverse non-cancer effects are not expected for recreational visitors exposed to sediment and surface water in the unnamed stream.

Lead was not identified as a COPC in sediment and surface water at the unnamed stream.

8.2 Construction Worker

The cancer risk estimates for current/future construction workers exposed to shallow groundwater and volatiles in trench air during excavation activities are within or less than the EPA targeted cancer risk range (1×10^{-4} to 1×10^{-6}).

Estimated RME HI indicates potential adverse non-cancer effects for construction workers exposed to shallow groundwater and volatiles in trench air during excavation activities. TCE, with its impacts to the immune system, is the sole contaminant with an HI in excess of 1. The HI for the immune system is the only target organ-specific HI greater than 1.

Lead was not identified as a COPC in the shallow groundwater to which construction workers may be exposed.

8.3 Residents

Groundwater located beneath the Study Area is not currently used as a source of potable water. Local residents are not expected to contact groundwater. However, to be protective of future potential use of groundwater as drinking water all groundwater data from study area monitoring wells regardless of depth were included in a quantitative evaluation of potential drinking water exposures. The cancer risk estimates for future residents exposed to groundwater as drinking

water exceed the EPA targeted cancer risk range (1×10^{-4} to 1×10^{-6}) with cancer risks as high as 9.2×10^{-2}. The greatest contributors to cancer risk for hypothetical future residents using groundwater as drinking water are TCE, chromium, methylene chloride, vinyl chloride, arsenic, and 1,2-DCA. Individual cancer risk estimates for each of these contributors are greater than 1×10^{-6} under the RME scenario. .

Note that total chromium was evaluated as the more toxic hexavalent chromium species. Sampling was conducted in December 2013 to provide chromium speciation data to aid in determining whether or not total chromium represents this toxic species. The results confirm that total chromium concentrations in groundwater may contain significant concentrations of the more toxic hexavalent chromium species.

Estimated HIs indicated potential adverse non-cancer effects for hypothetical future residents exposed to groundwater as drinking water, with the child RME HI over 3,000. TCE is the greatest contributor to the total hazard indices. Individual hazard quotients for cis-1,2-DCE, methylene chloride, cobalt, arsenic, and iron are also greater than 1. Target organ-specific HIs exceed 1 for immune system, liver, kidney, thyroid, skin, and gastrointestinal tract.

Lead was identified as a COPC in groundwater. However, results of the IEUBK model for future child residents show that exposure to lead in groundwater would not result in child blood lead levels in excess of EPA's blood lead goals

8.4 Soil

A semi-quantitative comparison of the analytical results of soil samples collected at 96 Commerce Street and at properties along South Brownell and Shunpike Roads to risk based screening levels indicates the presence of PAHs and metals at concentrations above screening levels at 96 Commerce Street and metals concentrations above screening levels at the properties along South Brownell and Shunpike Roads. As detailed in Appendix B (soil tech memo), the non-cancer risks were calculated by using a risk ratio approach in which the maximum concentration of non-carcinogenic chemicals was divided by the non-cancer screening level (for HQ = 1) to estimate an HQ for each chemical. Similarly, the cancer risks were calculated by dividing the maximum concentration of carcinogenic chemicals by the cancer screening level (for cancer risk = 1×10^{-6}) to estimate cancer risk. The simplified ratio approach to estimating risk from residential soil

exposure indicates that the risks both at properties along Shunpike Road and South Brownell Road and at the Mitec property are lower than EPA's maximum non-cancer risk limit (HQ of 1) and are within EPA's acceptable cancer risk range of 1×10^{-4} to 1×10^{-6} at Superfund sites. The majority of COPCs appear to be consistent with typical background associated with the northeast and do not appear to be site-related. A possible exception is the presence of elevated chromium at the Mitec property, which used hexavalent chromium. As detailed in Appendix B, hexavalent chromium was detected in only one of five soil samples analyzed for this form of chromium at the Mitec property. However, if the maximum concentration of total chromium is other soil samples (not analyzed for hexavalent chromium) were actually hexavalent chromium, the risks would be higher than EPA's risk limits. Because of this uncertainty about whether elevated chromium at the former Mitec property may be hexavalent chromium, it is recommended that soil be removed from 96 Commerce Street, with a goal to reduce the concentration of PAHs, arsenic and hexavalent chromium to acceptable risk-based concentrations or background, whichever is higher.

8.5 Vapor Intrusion

Exposure to indoor air through vapor intrusion of shallow groundwater contaminants was evaluated qualitatively through comparison of shallow groundwater to vapor intrusion based screening levels. Based on this screening evaluation, the vapor intrusion pathway was initially considered a potential future concern for residents with homes above the plume.

In order to investigate this pathway further, EPA collected indoor air (and sub-slab soil gas) from five residential and two commercial buildings in June 2012 and January 2013, and a sixth residence in December 2014. The results of this investigation did not show a complete vapor intrusion pathway and no contaminant associated with the Site was detected above conservative health-risk based screening levels. The investigation is described in Appendix C.

A health risk above EPA acceptable risk criteria may exist to residents at 830 South Brownell Road from direct vapor inhalation from contaminated groundwater that, but for an existing sump pump system, could flood the basement. The evaluation can be found in Appendix L. It is recommended that the adequacy of the existing vapor mitigation system to protect residents at this location be evaluated and based on an analysis of risk, the existing system be enhanced or replaced.

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TABLES

TABLE 2-1
SELECTION OF EXPOSURE PATHWAYS
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Sediment	Sediment	Sediment unnamed stream	River Recreational Visitor	Adult	Ingestion	Quantitative	Adult recreational visitors may be exposed to contaminated sediment through inadvertent contact.
						Dermal	Quantitative	Adult recreational visitors may be exposed to contaminated sediment through inadvertent contact.
					Child	Ingestion	Quantitative	Child recreational visitors may be exposed to contaminated sediment through inadvertent contact.
						Dermal	Quantitative	Child recreational visitors may be exposed to contaminated sediment through inadvertent contact.
	Surface Water	Surface Water	Surface Water unnamed stream	River Recreational Visitor	Adult	Ingestion	None	
						Dermal	Quantitative	Adult recreational visitors may be exposed to contaminated surface water through inadvertent contact while wading.
					Child	Ingestion	None	
						Dermal	Quantitative	Child recreational visitors may be exposed to contaminated surface water through inadvertent contact while wading.
	Groundwater	Groundwater	Shallow Groundwater in construction trenches	Construction worker	Adult	Dermal	Quantitative	Construction/Excavation Workers may be exposed to contaminated groundwater through inadvertent contact.
						Inhalation	Quantitative	Construction/Excavation Workers may be exposed to volatiles in groundwater through inhalation of vapors.
		Indoor air	Indoor air in homes and commercial buildings	Resident and workers	Adult	Inhalation	Qualitative	Adult residents or workers may be exposed to volatiles in groundwater through vapor intrusion into indoor air.*
					Child	Inhalation	Qualitative	Child residents may be exposed to volatiles in groundwater through vapor intrusion into indoor air.*
	Indoor air	Indoor air	Indoor air in homes and commercial buildings	Resident and workers	Adult	Inhalation	Quantitative	Adult residents or workers may be exposed to volatiles in indoor air through vapor intrusion.
					Child	Inhalation	Quantitative	Child residents may be exposed to volatiles in indoor air through vapor intrusion.
Future	Soil	Soil	Aggregate Soil (0-10 ft) at S Brownwell and Shunpike Roads	Resident	Adult	Ingestion	Semi-quantitative	Adult Residents may be exposed to contaminated soil through inadvertent contact.
						Dermal	Semi-quantitative	Adult Residents may be exposed to contaminated soil through inadvertent contact.
						Inhalation	Semi-quantitative	Adult Residents may be exposed to contaminated soil through contact with fugitive dust and volatiles.
					Child	Ingestion	Semi-quantitative	Child Residents may be exposed to contaminated soil through inadvertent contact.
						Dermal	Semi-quantitative	Child Residents may be exposed to contaminated soil through inadvertent contact.
						Inhalation	Semi-quantitative	Child Residents may be exposed to contaminated soil through contact with fugitive dust and volatiles.
	Soil	Soil	Aggregate Soil (0-10 ft) at 96 Commerce Street	Industrial/Commercial worker	Adult	Ingestion	Semi-quantitative	Workers may be exposed to contaminated soil through inadvertent contact.
						Dermal	Semi-quantitative	Workers may be exposed to contaminated soil through inadvertent contact.
						Inhalation	Semi-quantitative	Workers may be exposed to contaminated soil through inadvertent contact.
	Groundwater	Groundwater	Tap Water	Resident	Adult	Ingestion	Quantitative	Adult residents may be exposed to contaminated groundwater through drinking water.
						Dermal	Quantitative	Adult residents may be exposed to contaminated groundwater while showering.
						Inhalation	Quantitative	Adult residents may be exposed to volatile contaminants in groundwater while showering.
					Child	Ingestion	Quantitative	Child residents may be exposed to contaminated groundwater through drinking water.
						Dermal	Quantitative	Child residents may be exposed to contaminated groundwater while bathing.

* This evaluation compares shallow groundwater against vapor intrusion screening levels to identify the potential indoor air pathway. Further evaluation of the indoor air pathway through subslab soilgas and indoor air sampling was conducted by EPA. Brief summaries of EPA findings are included in this report.

TABLE 3-1
CONTAMINANTS OF POTENTIAL CONCERN (COPCs)
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

COPC	Exposure Medium						
	Sediment	Surface Water	Shallow[1] Groundwater for Protection of Construction Workers	Shallow[2] Groundwater for Protection of Indoor Air	Groundwater for Protection of Drinking Water	Soil at 96 Commerce Street	Soil at Properties along Shunpike Road and South Brownell Road
2,3,7,8-TCDD TEQ							
1,1,2-Trichloroethane					√		
1,1'-Biphenyl							
1,2,4-Trichlorobenzene							
1,2-Dibromo-3-chloropropane							
1,2-Dichloroethane					√		
1,2-Dichloropropane							
1,3-Dichlorobenzene							
4-Nitrophenol	√						
4,6-Dinitro-2-methylphenol							
Bis(2-ethylhexyl)phthalate							
Chloroform			√	√			
cis-1,2-Dichloroethene		√			√		
Methane					√		
Methylene chloride					√		
N-nitroso-di-n-propylamine							
Tetrachloroethene							
trans-1,2-Dichloroethene							
Trichloroethene		√	√	√	√		√
Vinyl Chloride		√			√		
PAHs							
Benzo(a)anthracene	√					√	
Benzo(a)pyrene	√		√	√		√	
Benzo(b)fluoranthene	√					√	
Dibenz(a,h)anthracene	√						
Indeno(1,2,3-cd)pyrene	√						
Naphthalene			√	√			
Metals							
Aluminum					√	√	√
Antimony			√				
Arsenic	√		√		√	√	√
Barium							
Cadmium			√				
Chromium	√		√		√	√	√
Cobalt	√		√		√	√	√
Copper							
Iron	√		√		√	√	√
Lead					√		
Manganese			√		√	√	√
Mercury							
Nickel					√		
Thallium			√		√		
Vanadium					√		

Notes:
1) Shallow groundwater defined as 0-10 feet below ground surface, measured at top of the well screen.
2) Shallow groundwater defined as 0-15 feet below ground surface, measured at top of the well screen.

TABLE 6-1
SUMMARY OF RECEPTOR RISKS AND HAZARDS
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

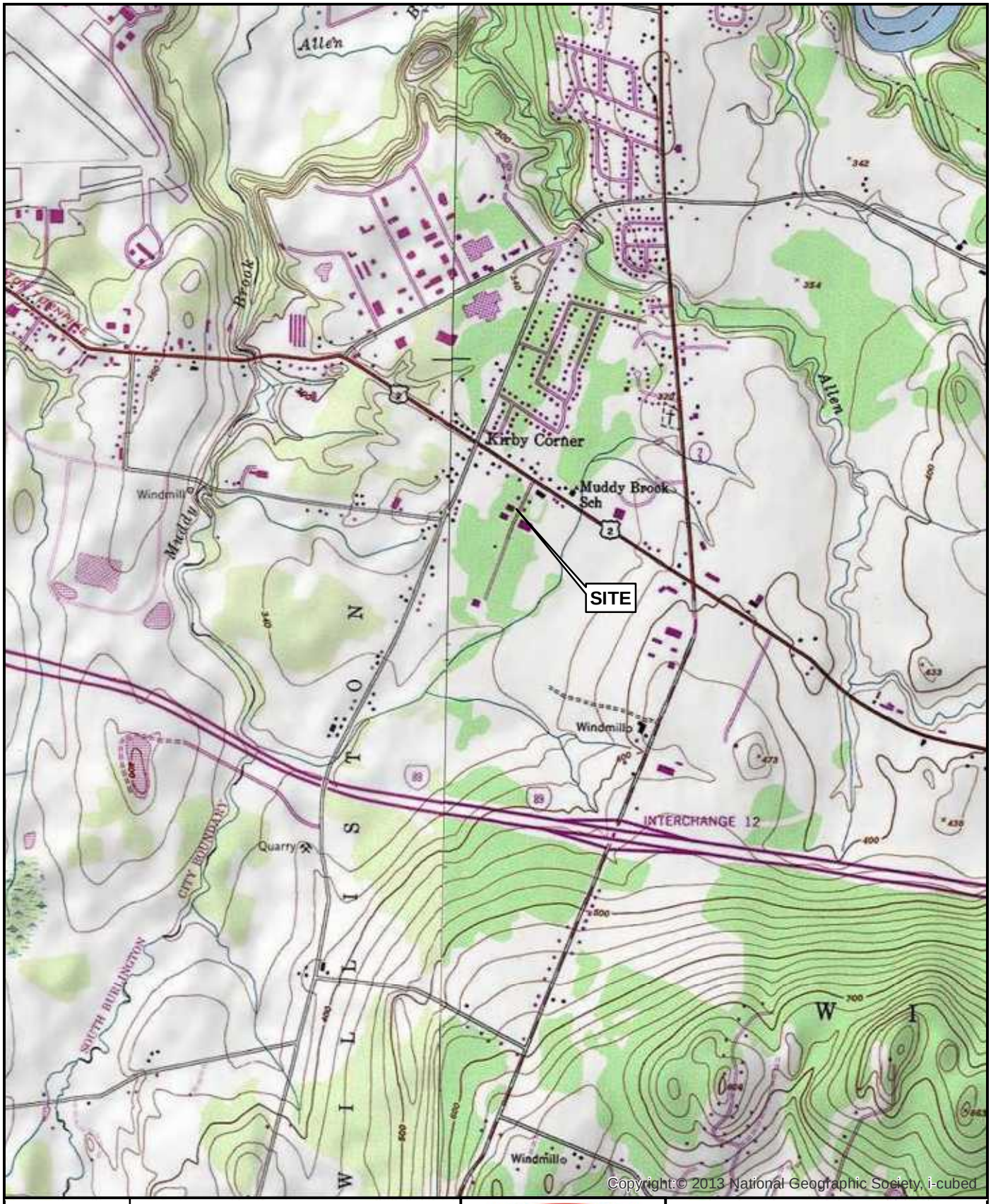
Media	Exposure Area	Scenario Timeframe	Receptor	RME								CTE		
				CR>1E-04 or HI>1	Total CR[a]	Major Contributors to Total CR (Individual CR >1E-06)	Individual COPC CR	Total NC HI	Organ-Specific HI Above 1.0	Major Contributors to Total HI (Individual HQ > 1.0)	Individual COPC HQ	CR>1E-04 or HI>1	Total CR	Total NC HI
Sediment	Sediment unnamed stream	Current	Adult River Recreational Visitor	No	5.6E-07	---	---	0.0043	---	---	---	---	---	---
			Child River Recreational Visitor	No	5.1E-06	Dibenz(a,h)anthracene Chromium	1.4E-06 2.0E-06	0.041	---	---	---	---	---	---
Surface Water	Surface Water unamed stream	Current	Adult River Recreational Visitor	No	8.5E-07	---	---	0.0075	---	---	---	---	---	---
			Child River Recreational Visitor	No	8.6E-06	Vinyl chloride	8.5E-06	0.018	---	---	---	---	---	---
Groundwater	Shallow Groundwater in construction trenches	Current	Construction Worker	Yes	2.0E-06	---	---	3.0	Immune System	Trichloroethene	2.1	No	4.1E-07	0.59
	Site	Future	Age-Adjusted Resident	Yes	9.2E-02	1,2-Dichloroethane Methylene chloride Trichloroethene Vinyl Chloride Arsenic Chromium	6.5E-06 9.2E-04 8.9E-02 1.9E-04 1.8E-04 1.1E-03	NE	---	---		Yes	3.6E-02	NE
			Adult Resident	Yes	NE	---		2778	Liver	Methylene chloride	3.5	Yes	---	2478
										Vinyl Chloride	0.057			
									Kidney	cis-1,2-Dichloroethene	4.9			
										1,2-Dichloroethane	0.075			
									Immune System	Trichloroethene	2765			
									Thyroid	Cobalt	0.96			
			Child Resident	Yes	NE	---		3181	Liver	Methylene chloride	5.5	Yes	---	2687
										Vinyl Chloride	0.082			
									Kidney	cis-1,2-Dichloroethene	8.1			
										1,2-Dichloroethane	0.079			
									Immune System	Trichloroethene	3159			
									Skin	Arsenic	1.5			
									Thyroid	Cobalt	1.6			
									Gastrointestinal	Iron	1.3			

Notes:

[a] Note that for conservatism, total chromium results are based on hexavalent chromium toxicity criteria.

COPC	Contaminant of Potential Concern
CR	Cancer Risk
CTE	Central Tendency Exposure
HI	Hazard Index
HQ	Hazard Quotient
NC	Noncancer
NE	Not Evaluated
RME	Reasonable Maximum Exposure
	Total Cancer Risks are above 1E-04 or Hazard Indices are above 1.
	Total Cancer Risks fall in the range of 10^{-6} to 10^{-4}.

FIGURES



Map Location

USGS Topographic Map
Essex Junction, Vermont
Burlington, Vermont
Revised 1987

0 1,000 2,000 4,000
Feet
1 inch = 2,000 feet

N

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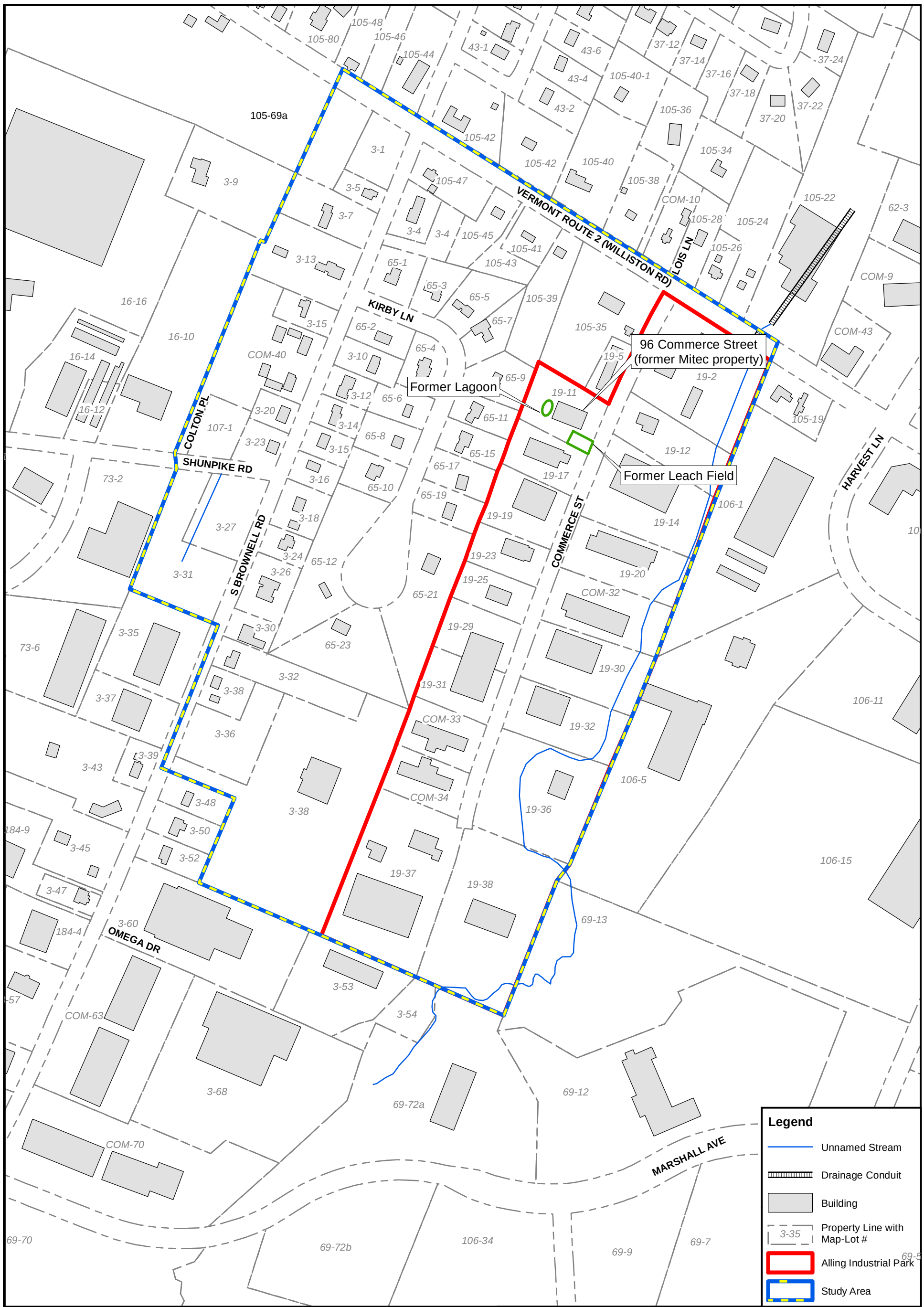
FIGURE 1-1

LOCUS MAP
COMMERCE STREET PLUME
SUPERFUND SITE
WILLISTON, VERMONT

PREPARED BY: CJ	CHECKED BY: DG
PROJECT NO. 80036	DATE: JULY 2015

Path: K:\Technical Data (TD)\GIS\Maps\HHRA\Figure 1-1 Locus Plan.mxd Date Printed: 7/1/2015



Notes:

1. Site features are depicted for display purposes only.

0 150 300 600
Feet
1 inch = 300 feet

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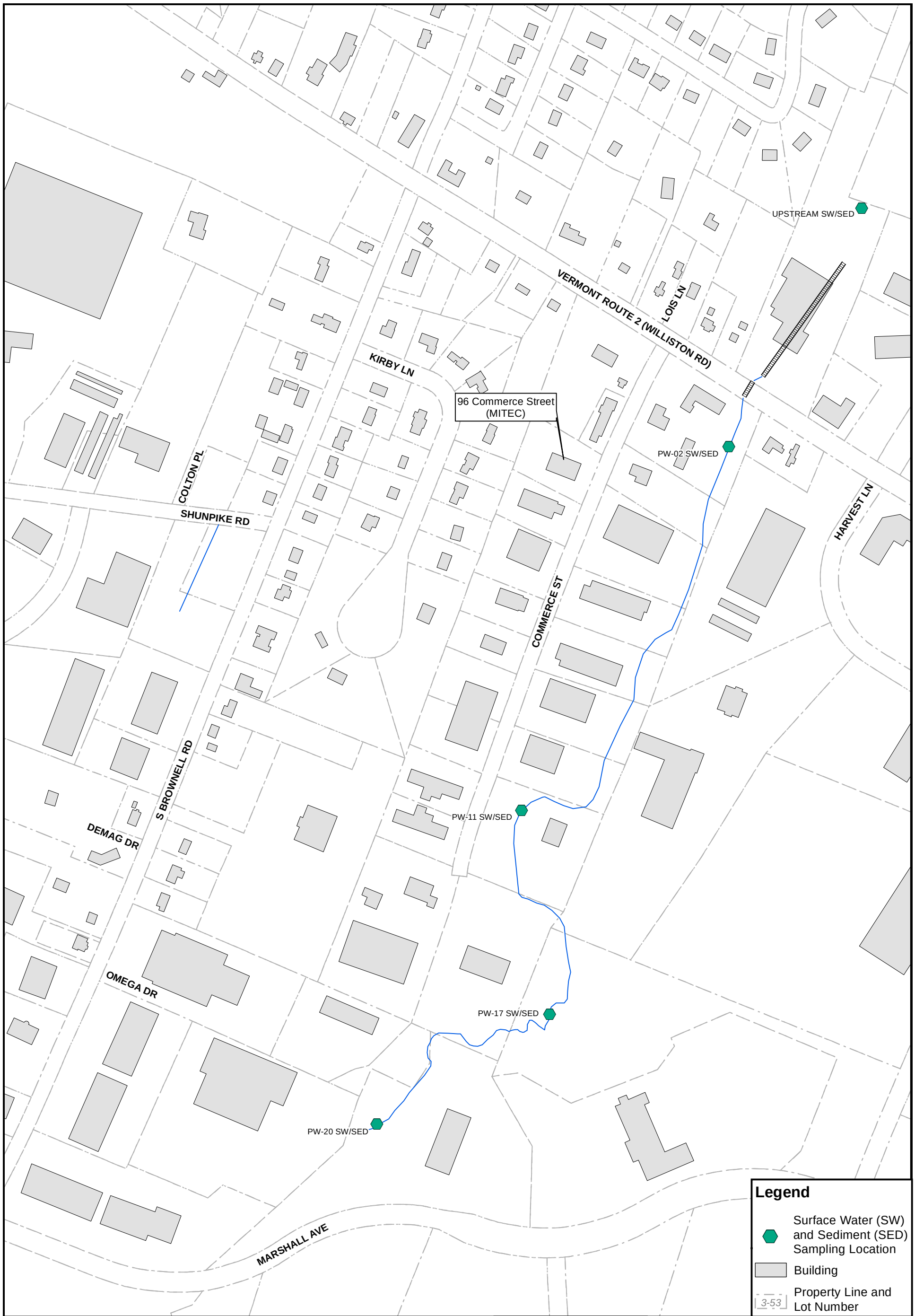
FIGURE 1-2

STUDY AREA
COMMERCE STREET PLUME
SUPERFUND SITE
WILLISTON, VERMONT

PREPARED BY: DG	CHECKED BY: SH
PROJECT NO. 80036	DATE: JULY 2015

Path: L:\80036 Commerce Street Plume\Technical Data (TD)\GIS\Maps\HHRA\Figure 1-2 Study Area.mxd Date Printed: 7/9/2015



Notes:

1. Surface water and sediment samples were colocated with the pore water samples.

2. Surface water and sediment samples collected by Nobis Engineering, Inc. between September 11, 2012 and September 14, 2012.

0 150 300 600
Feet
1 inch = 300 feet

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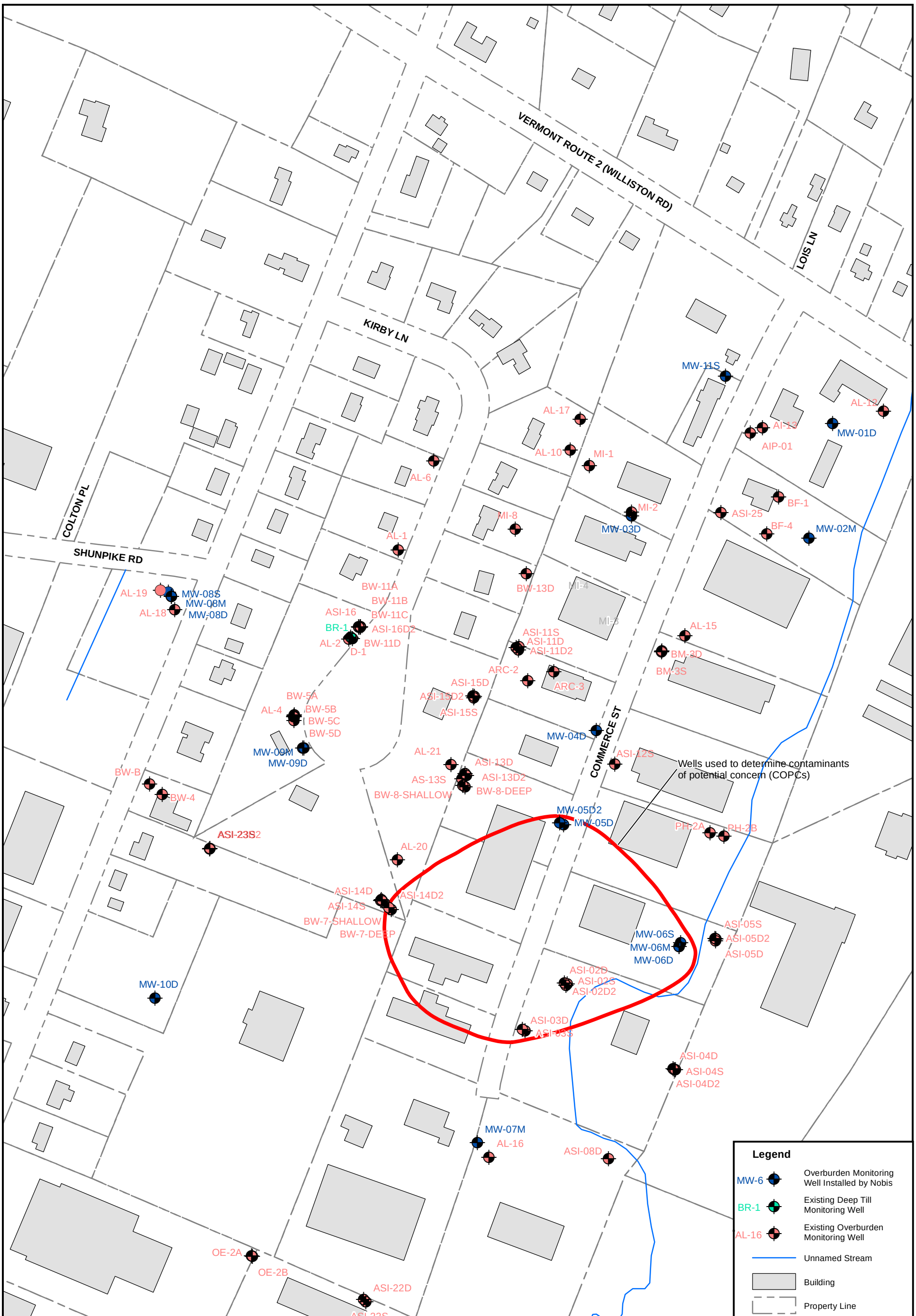
FIGURE 3-1

SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
COMMERCE STREET PLUME
SUPERFUND SITE
WILLISTON, VERMONT

PREPARED BY: CJ	CHECKED BY: DG
PROJECT NO. 80036	DATE: JULY 2015

Path: L:\80036 Commerce Street Plume\Technical Data (TD)\GIS\Maps\HHRA\Figure 3-1 Surface Water and Sediment Sampling Locations1.mxd Date Printed: 7/8/2015



Notes:

1. Monitoring wells installed by Nobis or observed during the well inventory were surveyed by American Consulting Engineers and Surveyors of Williamstown, Vermont 2008 and 2011. Locations for wells not found or presumed destroyed reference previous reports and site plans.

0 100 200 400
Feet
1 inch = 200 feet

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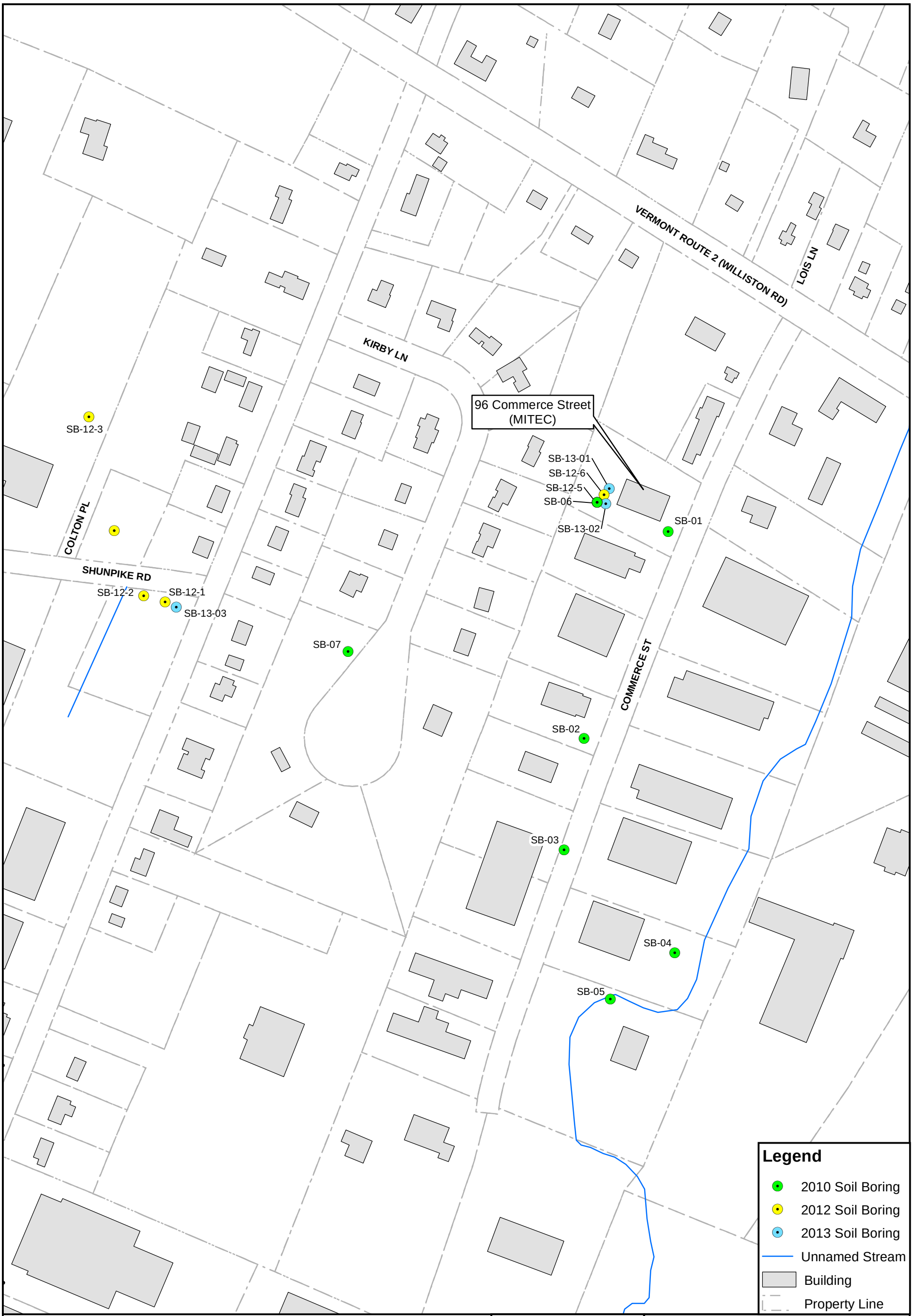
FIGURE 3-2

GROUNDWATER SAMPLING LOCATIONS
COMMERCE STREET PLUME
SUPERFUND SITE
WILLISTON, VERMONT

PREPARED BY: CJ	CHECKED BY: DG
PROJECT NO. 80036	DATE: JULY 2015

Path: I:\80036 Commerce Street Plume\Technical Data (TD)\GIS\Maps\HHRA\Figure 3-2 Groundwater Sampling Locations.mxd Date Printed: 7/6/2015



Notes:

1. Soil boring locations were located based on measurements from fixed structures or with GPS technology and are approximate and for information purposes only. The soil borings were performed during the years specified in the legend.

0 100 200 400
Feet
1 inch = 200 feet

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FIGURE 3-3

SOIL BORING LOCATIONS
COMMERCE STREET PLUME
SUPERFUND SITE
WILLISTON, VERMONT

PREPARED BY: CJ	CHECKED BY: DG
PROJECT NO. 80036	DATE: JULY 2015

Path: K:\Technical Data (TD)\GIS\Maps\HHRA\Figure 3-3 Soil Sampling Locations.mxd Date Printed: 7/1/2015

Notes:

1. Location of all features is approximate. Map is for reference purposes only. Nobis Engineering, Inc. makes no claims, warranties, representations, expressed or implied, relating to the completeness, accuracy, or reliability of the data shown.

2. Sump water and surficial soil samples collected by Nobis Engineering, Inc. on June 30, 2014 and July 1, 2014.

0 100 200 400
Feet
1 inch = 200 feet

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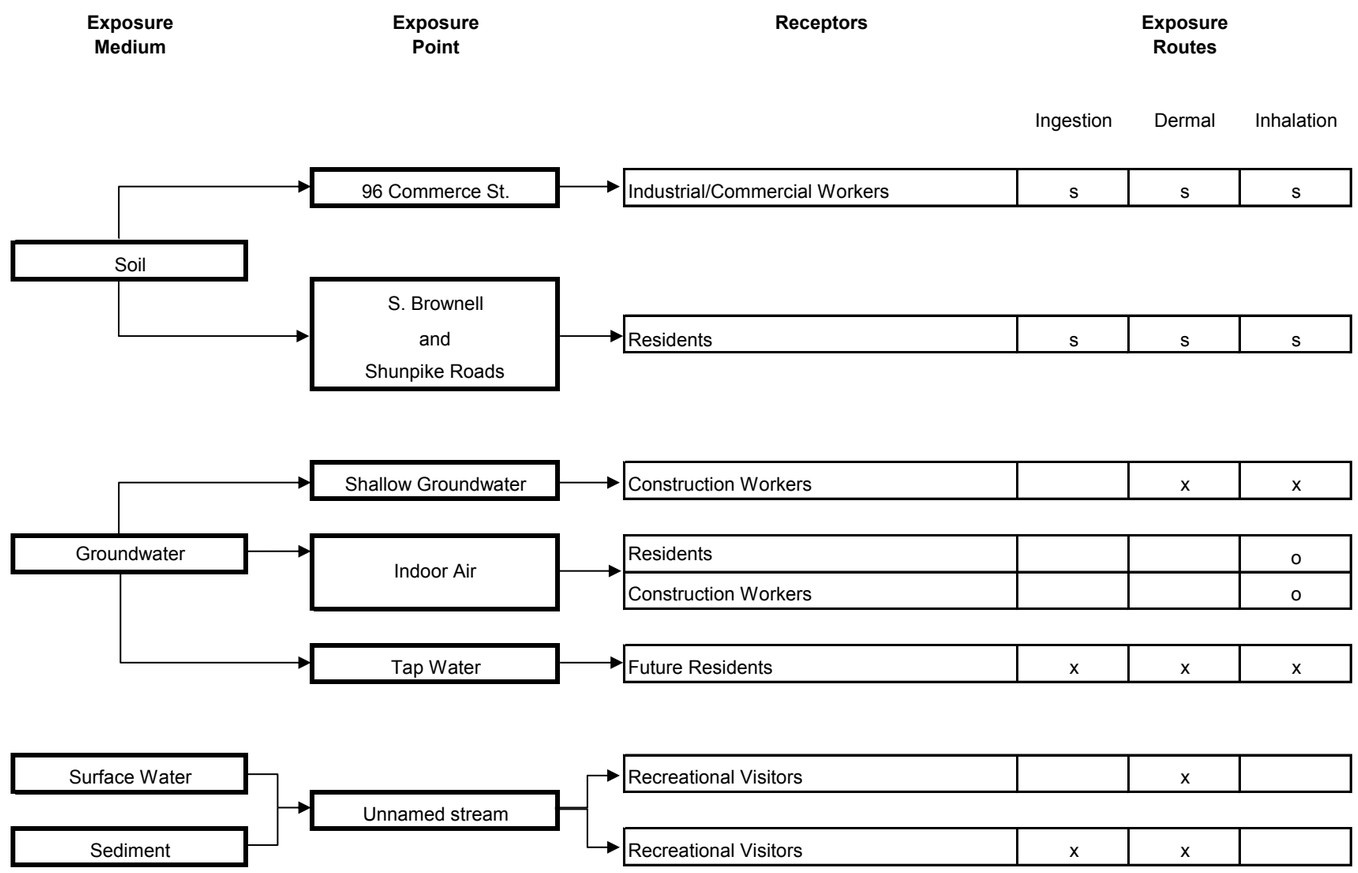
FIGURE 3-4

SURFICIAL SOIL AND SUMP INVESTIGATION LOCATIONS
COMMERCE STREET PLUME
SUPERFUND SITE
WILLISTON, VERMONT

PREPARED BY: NZ | CHECKED BY: SH
PROJECT NO. 80036 | DATE: JULY 2015

Path: K:\Technical Data (TD)\GIS\Maps\HHRA\Figure 3-4 Residential Soil and Sump Investigation Locations.mxd Date Printed: 7/2/2015

FIGURE 4-1
HUMAN HEALTH RECEPTOR EXPOSURES
COMMERCE STREET SUPERFUND SITE
WILLISTON, VERMONT



Notes:
x = Quantitative analysis.
s = Semi-quantitative analysis.
o = Qualitative analysis.

APPENDIX A

TABLE A-1
SELECTION OF EXPOSURE PATHWAYS
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current	Sediment	Sediment	Sediment unnamed stream	River Recreational Visitor	Adult	Ingestion	Quantitative	Adult recreational visitors may be exposed to contaminated sediment through inadvertent contact.
						Dermal	Quantitative	Adult recreational visitors may be exposed to contaminated sediment through inadvertent contact.
					Child	Ingestion	Quantitative	Child recreational visitors may be exposed to contaminated sediment through inadvertent contact.
						Dermal	Quantitative	Child recreational visitors may be exposed to contaminated sediment through inadvertent contact.
	Surface Water	Surface Water	Surface Water unnamed stream	River Recreational Visitor	Adult	Ingestion	None	
						Dermal	Quantitative	Adult recreational visitors may be exposed to contaminated surface water through inadvertent contact while wading.
					Child	Ingestion	None	
						Dermal	Quantitative	Child recreational visitors may be exposed to contaminated surface water through inadvertent contact while wading.
	Groundwater	Groundwater	Shallow Groundwater in construction trenches	Construction worker	Adult	Dermal	Quantitative	Construction/Excavation Workers may be exposed to contaminated groundwater through inadvertent contact.
						Inhalation	Quantitative	Construction/Excavation Workers may be exposed to volatiles in groundwater through inhalation of vapors.
		Indoor air	Indoor air in homes and commercial buildings	Resident and workers	Adult	Inhalation	Qualitative	Adult residents or workers may be exposed to volatiles in groundwater through vapor intrusion into indoor air.*
					Child	Inhalation	Qualitative	Child residents may be exposed to volatiles in groundwater through vapor intrusion into indoor air.*
	Indoor air	Indoor air	Indoor air in homes and commercial buildings	Resident and workers	Adult	Inhalation	Quantitative	Adult residents or workers may be exposed to volatiles in indoor air through vapor intrusion.
					Child	Inhalation	Quantitative	Child residents may be exposed to volatiles in indoor air through vapor intrusion.
Future	Soil	Soil	Aggregate Soil (0-10 ft) at S Brownwell and Shunpike Roads	Resident	Adult	Ingestion	Semi-quantitative	Adult Residents may be exposed to contaminated soil through inadvertent contact.
						Dermal	Semi-quantitative	Adult Residents may be exposed to contaminated soil through inadvertent contact.
						Inhalation	Semi-quantitative	Adult Residents may be exposed to contaminated soil through contact with fugitive dust and volatiles.
					Child	Ingestion	Semi-quantitative	Child Residents may be exposed to contaminated soil through inadvertent contact.
						Dermal	Semi-quantitative	Child Residents may be exposed to contaminated soil through inadvertent contact.
						Inhalation	Semi-quantitative	Child Residents may be exposed to contaminated soil through contact with fugitive dust and volatiles.
	Soil	Soil	Aggregate Soil (0-10 ft) at 96 Commerce Street	Industrial/Commercial worker	Adult	Ingestion	Semi-quantitative	Workers may be exposed to contaminated soil through inadvertent contact.
						Dermal	Semi-quantitative	Workers may be exposed to contaminated soil through inadvertent contact.
						Inhalation	Semi-quantitative	Workers may be exposed to contaminated soil through inadvertent contact.
	Groundwater	Groundwater	Tap Water	Resident	Adult	Ingestion	Quantitative	Adult residents may be exposed to contaminated groundwater through drinking water.
						Dermal	Quantitative	Adult residents may be exposed to contaminated groundwater while showering.
						Inhalation	Quantitative	Adult residents may be exposed to volatile contaminants in groundwater while showering.
					Child	Ingestion	Quantitative	Child residents may be exposed to contaminated groundwater through drinking water.
						Dermal	Quantitative	Child residents may be exposed to contaminated groundwater while bathing.

* This evaluation compares shallow groundwater against vapor intrusion screening levels to identify the potential indoor air pathway. Further evaluation of the indoor air pathway through subslab soil gas and indoor air sampling was conducted by EPA. Brief summaries of EPA findings are included in this report.

TABLE A-2.1
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN - SEDIMENT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	CAS Number	Contaminant	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value	Screening Toxicity Value (N/C) (2)		COPC Flag (Y/N)	Rationale for Selection or Deletion
Site	100027	4-Nitrophenol	0.46	0.46	mg/kg	PW20-SED	1/4	0.41 - 0.52	0.46	NA	NBA		YES	NBA
	140578	Aramite	0.21	0.21	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.21	NA	21	c	NO	BSL
	56553	Benzo(a)anthracene	0.27	0.27	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.27	NA	0.15	c	YES	ASL
	50328	Benzo(a)pyrene	0.24	0.24	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.24	NA	0.015	c	YES	ASL
	205992	Benzo(b)fluoranthene	0.57	0.57	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.57	NA	0.15	c	YES	ASL
	191242	Benzo(g,h,i)perylene	0.61	0.61	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.61	NA	3.8	c	NO	BSL
	207089	Benzo(k)fluoranthene	0.54	0.54	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.54	NA	1.5	c	NO	BSL
	117817	Bis(2-ethylhexyl)phthalate	0.25	0.25	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.25	NA	38	c	NO	BSL
	85687	Butylbenzylphthalate	0.30	0.30	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.30	NA	280	c	NO	BSL
	510156	Chlorobenzilate	0.24	0.24	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.24	NA	4.8	c	NO	BSL
	218019	Chrysene	0.68	0.68	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.68	NA	15	c	NO	BSL
	53703	Dibenz(a,h)anthracene	0.51	0.51	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.51	NA	0.015	c	YES	ASL
	117840	Di-n-octyl phthalate	0.26	0.26	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.26	NA	62	n	NO	BSL
	193395	Indeno(1,2,3-cd)pyrene	0.50	0.50	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.50	NA	0.15	c	YES	ASL
	87865	Pentachlorophenol	0.86	0.86	mg/kg	PW20-SED	1/4	0.81 - 1	0.86	NA	0.99	c	NO	BSL
	62442	Phenacetin	0.32	0.32	mg/kg	PW20-SED	1/4	0.2 - 0.26	0.32	NA	240	c	NO	BSL
	7429905	Aluminum	3300	5800	mg/kg	PW17-SED	4/4	NA	5800	7400	7700	n	NO	BSL
	7440382	Arsenic	2.1	4.5	mg/kg	PW17-SED	2/4	2 - 2.2	4.5	3.7	0.67	c	YES	ASL
	7440393	Barium	12	39	mg/kg	PW17-SED	4/4	NA	39	50	1500	n	NO	BSL
	7440702	Calcium	1100	1700	mg/kg	PW17-SED	4/4	NA	1700	2300	NUT		NO	See text
	7440473	Chromium	7.4	11	mg/kg	PW17-SED	4/4	NA	11	15	0.30	c	YES	ASL
	7440484	Cobalt	2.4	4.1	mg/kg	PW17-SED	4/4	NA	4.1	5.6	2.3	n	YES	ASL
	7440508	Copper	5.6	44	mg/kg	PW17-SED	4/4	NA	44	13	310	n	NO	BSL
	7439896	Iron	6600	12000	mg/kg	PW17-SED	4/4	NA	12000	14000	5500	n	YES	ASL
	7439921	Lead	3.5	9.4	mg/kg	PW17-SED	3/4	4 - 4.1	9.4	12	400		NO	BSL
	7439954	Magnesium	1500	2400	mg/kg	PW11-SED	4/4	NA	2400	2800	NUT		NO	See text
	7440020	Nickel	7.8	12	mg/kg	PW17-SED	4/4	NA	12	15	150	n	NO	BSL
	7440622	Vanadium	6.4	9.6	mg/kg	PW17-SED	4/4	NA	9.6	15	39	n	NO	BSL
	7440666	Zinc	28	54	mg/kg	PW2-SED	4/4	NA	54	240	2300	n	NO	BSL

Notes/sources:
(1) Maximum detected concentration used for screening.
(2) Risk-based residential soil concentrations obtained from the Regional Screening Level (RSL) Table (January, 2015).
Surrogate screening values used:
- Hexavalent chromium used for chromium.
- Naphthalene used for benzo(g,h,i)perylene.

NBA = no benchmark available.
ASL = above screening level.
BSL = below screening level.
C = cancer based screening value set at a target risk of 1E-06.
mg/kg = milligrams per kilogram.
NA = not available.
NC = noncancer based screening value set at a target hazard quotient of 0.1.
NUT = essential nutrient.

TABLE A-2.2
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN - SURFACE WATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Point	CAS Number	Contaminant	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value	Screening Toxicity Value (N/C) (2)		Potential ARAR/TBC Value	Potential ARAR/TBC Source (3)	COPC Flag (Y/N)	Rationale for Selection or Deletion
Site	156592	cis-1,2-Dichloroethene	3.8	39	ug/L	PW11-DUP-SW	3/4	1 - 1	39	NA	3.6	n	NBA	-- -	YES	ASL
	79016	Trichloroethene	2.6	15	ug/L	PW11-SW	3/4	1 - 1	15	NA	0.28	n	2.5	VWQS	YES	ASL
	75014	Vinyl chloride	3.2	3.4	ug/L	PW11-DUP-SW	1/4	1 - 1	3.4	NA	0.019	c	0.025	VWQS	YES	ASL

Notes/sources:
(1) Maximum detected concentration used for screening.
(2) Risk-based residential tapwater concentrations obtained from the Regional Screening Level (RSL) Table (January, 2015).
(3) Vermont Surface Water Quality Criteria - Human Health (Water + Organisms) (VWQS) (Vermont DEC, 2014).

ASL = above screening level.
BSL = below screening level.
C = cancer based screening value set at a target risk of 1E-06.
NA = not available.
NBA = no benchmark available.
NC = noncancer based screening value set at a target hazard quotient of 0.1.
µg/L = micrograms per liter.

TABLE A-2.3
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN - SHALLOW GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater (0-10 ft)

Exposure Point	CAS Number	Contaminant	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value	Screening Toxicity Value (N/C) (2)		COPC Flag (Y/N)	Rationale for Selection or Deletion
Shallow Groundwater	106467	1,4-Dichlorobenzene	0.22	0.23	ug/L	AL-014-121608A	2/29	0.5 - 5	0.23	NA	0.48	c	NO	BSL
	67641	Acetone	3.8	7.5	ug/L	ARC-003-121708A	10/29	5 - 10	7.5	NA	1400	n	NO	BSL
	98862	Acetophenone	0.21	1.1	ug/L	MI-008-052010A	10/27	4.5 - 5	1.1	NA	190	n	NO	BSL
	100527	Benzaldehyde	0.19	1.4	ug/L	MI-008-052010A	10/27	4.5 - 5	1.4	NA	190	n	NO	BSL
	50328	Benzo(a)pyrene	0.15	0.15	ug/L	AL-014-051810A	1/27	4.5 - 5	0.15	NA	0.0034	c	YES	ASL
	117817	Bis(2-ethylhexyl)phthalate	0.28	1.6	ug/L	ASI-023S-051810A	17/27	4.5 - 5	1.6	NA	5.6	c	NO	BSL
	85687	Butylbenzylphthalate	0.21	0.29	ug/L	AL-012-052010A	2/27	4.5 - 5	0.29	NA	16	c	NO	BSL
	105602	Caprolactam	0.16	0.51	ug/L	BW-013S-052010A	5/27	4.5 - 5	0.51	NA	990	n	NO	BSL
	75150	Carbon disulfide	0.38	0.38	ug/L	ASI-023S-051810A	1/29	0.5 - 5	0.38	NA	81	n	NO	BSL
	67663	Chloroform	0.46	1.9	ug/L	ASI-023S-121608A	2/29	0.5 - 5	1.9	NA	0.22	c	YES	ASL
	156592	cis-1,2-Dichloroethene	0.28	0.28	ug/L	AL-014-121608A	1/29	0.5 - 5	0.28	NA	3.6	n	NO	BSL
	110827	Cyclohexane	9.7	9.7	ug/L	BF-004-1110A	1/29	0.5 - 5	9.7	NA	1300	n	NO	BSL
	75718	Dichlorodifluoromethane	2.7	2.7	ug/L	AL-012-052010A	1/29	0.5 - 5	2.7	NA	20	n	NO	BSL
	84662	Diethylphthalate	0.17	0.17	ug/L	MI-008-121908A	1/27	4.5 - 5	0.17	NA	1500	n	NO	BSL
	84742	Di-n-butyl phthalate	0.22	0.22	ug/L	BW-013S-052010A	1/27	4.5 - 5	0.22	NA	90	n	NO	BSL
	100414	Ethylbenzene	0.12	0.12	ug/L	BF-004-121908A	1/29	0.5 - 5	0.12	NA	1.5	c	NO	BSL
	98828	Isopropylbenzene	0.21	1.0	ug/L	BF-004-1110A	2/29	0.5 - 5	1.0	NA	45	n	NO	BSL
	75092	Methylene chloride	0.13	4.8	ug/L	MI-008-1110A	5/29	0.5 - 5	4.8	NA	11	n	NO	BSL
	91203	Naphthalene	0.53	1.8	ug/L	BF-004-1110A	2/27	4.5 - 5	1.8	NA	0.17	c	YES	ASL
	108952	Phenol	0.15	0.21	ug/L	BW-013S-052010A	2/27	4.5 - 5	0.21	NA	580	n	NO	BSL
	127184	Tetrachloroethene	0.46	0.63	ug/L	MI-008-052010A	2/29	0.5 - 5	0.63	NA	4.1	n	NO	BSL
	79016	Trichloroethene	0.10	4.8	ug/L	AL-015-1110A	12/29	0.5 - 5	4.8	NA	0.28	n	YES	ASL
	7429905	Aluminum	22	1985	ug/L	BF-004-052010A	22/27	200 - 200	1985	NA	2000	n	NO	BSL
	7440360	Antimony	0.25	1.4	ug/L	ASI-023S-1110A	10/27	2 - 2	1.4	NA	0.78	n	YES	ASL
	7440382	Arsenic	2.0	11.8	ug/L	BF-004-1110A	5/27	10 - 11.1	11.8	NA	0.052	c	YES	ASL
	7440393	Barium	7.5	324	ug/L	AL-015-051910A	27/27	NA	324	NA	380	n	NO	BSL
	7440417	Beryllium	0.030	0.065	ug/L	AL-015-051910A	7/27	1 - 1	0.065	NA	2.5	n	NO	BSL
	7440439	Cadmium	0.13	54.3	ug/L	MI-008-121908A	10/27	5 - 5.6	54.3	NA	0.92	n	YES	ASL
	7440702	Calcium	2634	42700	ug/L	AL-012-1110A	27/27	NA	42700	NA	NUT		NO	See text
	7440473	Chromium	0.29	27.1	ug/L	MI-008-052010A	10/27	10 - 11.1	27.1	NA	0.035	c	YES	ASL
	7440484	Cobalt	1.0	7.1	ug/L	AL-012-1110A	11/27	50 - 55.6	7.1	NA	0.60	n	YES	ASL
	7440508	Copper	1.0	20.7	ug/L	AL-012-052010A	13/27	25 - 27.8	20.7	NA	80	n	NO	BSL
	7439896	Iron	12.2	34400	ug/L	ASI-023S-1110A	26/27	100 - 100	34400	NA	1400	n	YES	ASL
	7439921	Lead	1.9	1.9	ug/L	BF-004-052010A	1/27	10 - 11.1	1.9	NA	15		NO	BSL
	7439954	Magnesium	719	12300	ug/L	AL-012-1110A	27/27	NA	12300	NA	NUT		NO	See text
	7439965	Manganese	28	4420	ug/L	ASI-023S-121608A	27/27	NA	4420	NA	43	n	YES	ASL
	7440020	Nickel	0.56	13.2	ug/L	MI-008-121908A	20/27	40 - 44.4	13.2	NA	39	n	NO	BSL
	7440097	Potassium	212	8630	ug/L	AL-012-1110A	27/27	NA	8630	NA	NUT		NO	See text
	7782492	Selenium	3.5	3.5	ug/L	ASI-014S-121608A	1/27	35 - 38.9	3.5	NA	10	n	NO	BSL

TABLE A-2.3
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN - SHALLOW GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater (0-10 ft)

Exposure Point	CAS Number	Contaminant	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value	Screening Toxicity Value (N/C) (2)		COPC Flag (Y/N)	Rationale for Selection or Deletion
Shallow Groundwater (Cont'd)	7440224	Silver	2.2	5.7	ug/L	BW-013S-121808A	2/27	10 - 11.1	5.7	NA	9.4	n	NO	BSL
	7440235	Sodium	1920	188000	ug/L	AL-012-1110A	27/27	NA	188000	NA	NUT		NO	See text
	7440280	Thallium	0.021	0.29	ug/L	AL-014-051810A	14/27	1 - 1	0.29	NA	0.02	n	YES	ASL
	7440622	Vanadium	2.2	2.7	ug/L	BF-004-052010A	2/27	50 - 55.6	2.7	NA	8.6	n	NO	BSL
	7440666	Zinc	0.70	38.4	ug/L	MI-008-121908A	21/27	60 - 66.7	38.4	NA	600	n	NO	BSL
	7429905	Aluminum (Dissolved)	22.3	138	ug/L	OE-02B-121708A	6/7	222 - 222	138	NA	2000	n	NO	BSL
	7440360	Antimony (Dissolved)	0.11	0.39	ug/L	AL-014-121608A	7/7	NA	0.39	NA	0.78	n	NO	BSL
	7440393	Barium (Dissolved)	13.5	332	ug/L	MI-008-121908A	7/7	NA	332	NA	380	n	NO	BSL
	7440439	Cadmium (Dissolved)	0.74	54.3	ug/L	MI-008-121908A	2/7	5.6 - 5.6	54.3	NA	0.92	n	YES	ASL
	7440702	Calcium (Dissolved)	3020	39000	ug/L	BW-013S-121808A	7/7	NA	39000	NA	NUT		NO	See text
	7440473	Chromium (Dissolved)	0.49	17.4	ug/L	MI-008-121908A	6/7	11.1 - 11.1	17.4	NA	0.035	c	YES	ASL
	7440484	Cobalt (Dissolved)	0.56	5.7	ug/L	MI-008-121908A	5/7	55.6 - 55.6	5.7	NA	0.60	n	YES	ASL
	7440508	Copper (Dissolved)	5.2	7.4	ug/L	MI-008-121908A	2/7	27.8 - 27.8	7.4	NA	80	n	NO	BSL
	7439896	Iron (Dissolved)	9.0	13200	ug/L	ASI-014S-121608A	7/7	NA	13200	NA	1400	n	YES	ASL
	7439921	Lead (Dissolved)	1.5	1.5	ug/L	ASI-023S-121608A	1/7	11.1 - 11.1	1.5	NA	15		NO	BSL
	7439954	Magnesium (Dissolved)	763	9390	ug/L	BW-013S-121808A	7/7	NA	9390	NA	NUT		NO	See text
	7439965	Manganese (Dissolved)	11.9	5970	ug/L	ASI-023S-121608A	7/7	NA	5970	NA	43	n	YES	ASL
	7440020	Nickel (Dissolved)	0.93	14.2	ug/L	MI-008-121908A	7/7	NA	14.2	NA	39	n	NO	BSL
	7440097	Potassium (Dissolved)	306	2230	ug/L	AL-014-121608A	7/7	NA	2230	NA	NUT		NO	See text
	7440224	Silver (Dissolved)	1.3	3.3	ug/L	ASI-023S-121608A	2/7	11.1 - 11.1	3.3	NA	9.4	n	NO	BSL
	7440235	Sodium (Dissolved)	2530	152000	ug/L	ASI-023S-121608A	7/7	NA	152000	NA	NUT		NO	See text
	7440666	Zinc (Dissolved)	2.5	40.5	ug/L	MI-008-121908A	5/7	66.7 - 66.7	40.5	NA	600	n	NO	BSL

Notes/sources:
(1) Maximum detected concentration used for screening.
(2) Risk-based residential tapwater concentrations obtained from the Regional Screening Level (RSL) Table (January, 2015).
Surrogate screening values used:
- Hexavalent chromium used for chromium.

ASL = above screening level.
BSL = below screening level.
C = cancer based screening value set at a target risk of 1E-06.
NA = not available.
NC = noncancer based screening value set at a target hazard quotient of 0.1.
NUT = essential nutrient.
µg/L = micrograms per liter.

TABLE A-2.4
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN - VAPOR INTRUSION EXPOSURE PATHWAY - SHALLOW GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater (0-15 ft)

Exposure Point	CAS Number	Contaminant	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value	Screening Toxicity Value (2)	COPC Flag (Y/N)	Rationale for Selection or Deletion
Shallow Groundwater	79005	1,1,2-Trichloroethane	0.68	0.68	ug/L	MW-008S-1110A	1/39	0.5 - 50	0.68	NA	5.2	NO	BSL
	120821	1,2,4-Trichlorobenzene	0.58	0.58	ug/L	MI-001-121508A	1/39	0.5 - 50	0.58	NA	36	NO	BSL
	96128	1,2-Dibromo-3-chloropropane	0.84	0.84	ug/L	MI-001-121508A	1/51	0.05 - 50	0.84	NA	0.028	YES	ASL
	541731	1,3-Dichlorobenzene	0.22	0.22	ug/L	MI-001-121508A	1/39	0.5 - 50	0.22	NA	NBA	NO	NBA
	106467	1,4-Dichlorobenzene	0.22	0.23	ug/L	AL-014-121608A	2/39	0.5 - 50	0.23	NA	2.6	NO	BSL
	67641	Acetone	3.8	7.5	ug/L	ARC-003-121708A	11/39	1 - 50	7.5	NA	22597943	NO	BSL
	98862	Acetophenone	0.21	1.1	ug/L	MI-008-052010A	12/35	4.5 - 5	1.1	NA	NBA	NO	NBA
	100527	Benzaldehyde	0.19	1.4	ug/L	MI-008-052010A	12/35	4.5 - 5	1.4	NA	NBA	NO	NBA
	50328	Benzo(a)pyrene	0.15	0.15	ug/L	AL-014-051810A	1/35	4.5 - 5	0.15	NA	NBA	NO	NBA
	117817	Bis(2-ethylhexyl)phthalate	0.28	2.0	ug/L	MI-001-051910A	21/35	4.5 - 5	2.0	NA	NBA	NO	NBA
	85687	Butylbenzylphthalate	0.21	0.30	ug/L	MI-001-121508A	3/35	4.5 - 5	0.30	NA	NBA	NO	NBA
	105602	Caprolactam	0.16	0.51	ug/L	BW-013S-052010A	5/35	4.5 - 5	0.51	NA	NBA	NO	NBA
	75150	Carbon disulfide	0.38	0.38	ug/L	ASI-023S-051810A	1/39	0.5 - 50	0.38	NA	1240	NO	BSL
	67663	Chloroform	0.46	1.9	ug/L	ASI-023S-121608A	2/39	0.5 - 50	1.9	NA	0.81	YES	ASL
	156592	cis-1,2-Dichloroethene	0.28	4.1	ug/L	MW-008S-1110A	2/39	0.5 - 50	4.1	NA	NBA	NO	NBA
	110827	Cyclohexane	9.7	9.7	ug/L	BF-004-1110A	1/37	0.5 - 5	9.7	NA	1021	NO	BSL
	75718	Dichlorodifluoromethane	2.7	2.7	ug/L	AL-012-052010A	1/39	0.5 - 50	2.7	NA	7.4	NO	BSL
	84662	Diethylphthalate	0.17	1.2	ug/L	MI-001-121508A	3/35	4.5 - 5	1.2	NA	NBA	NO	NBA
	84742	Di-n-butyl phthalate	0.22	0.29	ug/L	MI-001-121508A	2/35	4.5 - 5	0.29	NA	NBA	NO	NBA
	100414	Ethylbenzene	0.12	0.12	ug/L	BF-004-121908A	1/39	0.5 - 50	0.12	NA	3.5	NO	BSL
	98828	Isopropylbenzene	0.21	1.0	ug/L	BF-004-1110A	2/39	0.5 - 50	1.0	NA	887	NO	BSL
	75092	Methylene chloride	0.13	4.8	ug/L	MI-008-1110A	6/39	0.5 - 50	4.8	NA	763	NO	BSL
	91203	Naphthalene	0.53	1.8	ug/L	BF-004-1110A	2/37	1 - 50	1.8	NA	4.6	NO	BSL
	108952	Phenol	0.15	0.21	ug/L	BW-013S-052010A	2/35	4.5 - 5	0.21	NA	NBA	NO	NBA
	127184	Tetrachloroethene	0.46	25	ug/L	MW-008S-1110A	3/39	0.5 - 50	25	NA	15	YES	ASL
	79016	Trichloroethene	0.1	4900	ug/L	MW-08S-0612A	16/39	0.5 - 5	4900	NA	0.6	YES	ASL
	55684941	Hexachlorodibenzofuran (total)	0.0000087	0.0000087	ug/L	MI-001-121508A	1/7	0.0000012 - 0.0000068	0.0000087	NA	NBA	NO	NBA
	30402154	Pentachlorodibenzofuran (total)	0.0000059	0.0000059	ug/L	MI-001-121508A	1/7	0.00000084 - 0.0000020	0.0000059	NA	NBA	NO	NBA
	55722275	Tetrachlorodibenzofuran (total)	0.0000076	0.0000076	ug/L	MI-001-121508A	1/7	0.0000023 - 0.0000034	0.0000076	NA	NBA	NO	NBA
	TEQ_M	2,3,7,8-TCDD TEQ	0.00000063	0.00000063	ug/L	MI-001-121508A	1/7	NA	0.00000063	NA	NBA	NO	NBA
	7439976	Mercury	0.020	0.022	ug/L	MW-08S-0612A	2/37	0.2 - 0.2	0.022	NA	0.67	NO	BSL

Notes/sources:
(1) Maximum detected concentration used for screening.
(2) EPA Residential Vapor Intrusion Screening Levels (VISLs) (May, 2014). VISLs were updated to reflect changes based on January 2015 RSL table.

ASL = above screening level.
BSL = below screening level.
NA = not available.
NBA = no benchmark available.
µg/L = micrograms per liter.

TABLE A-2.5
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN - OVERBURDEN GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Overburden Groundwater

Exposure Point	CAS Number	Contaminant	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value	Screening Toxicity Value (N/C) (2)		Potential ARAR/TBC Value (3)	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Overburden Groundwater	79005	1,1,2-Trichloroethane	0.47	0.99	µg/L	ASI-003D2-1110A	4/18	1 - 5000	0.99	NA	0.041	n	5.0	VT MCL	YES	ASL
	75343	1,1-Dichloroethane	0.62	0.62	µg/L	MW-006M-1110A	1/18	1 - 5000	0.62	NA	2.7	c	70	VT GWPC	NO	BSL
	75354	1,1-Dichloroethene	5.9	6.7	µg/L	ASI-003D2-1110A	2/18	1 - 5000	6.7	NA	28	n	7	VT MCL	NO	BSL
	107062	1,2-Dichloroethane	4.6	8.9	µg/L	MW-006M-1110A	4/18	1 - 5000	8.9	NA	0.17	c	5.0	VT MCL	YES	ASL
	67641	Acetone	3.8	420	µg/L	MW-004D-1110A	4/18	1 - 10000	420	NA	1400	n	700	VT GWPC	NO	BSL
	98862	Acetophenone	0.26	0.5	µg/L	ASI-003D2-051810A	3/13	4.5 - 5	0.5	NA	190	n	NBA	---	NO	BSL
	100527	Benzaldehyde	0.32	0.44	µg/L	ASI-003D2-051810A	3/13	4.5 - 5	0.44	NA	190	n	NBA	---	NO	BSL
	117817	Bis(2-ethylhexyl)phthalate	0.3	1.2	µg/L	ASI-003D2-051810A	5/13	4.5 - 5	1	NA	5.6	c	6.0	VT MCL	NO	BSL
	105602	Caprolactam	0.18	0.26	µg/L	ASI-003D2-051810A	3/13	4.5 - 5	0.26	NA	990	n	NBA	---	NO	BSL
	156592	cis-1,2-Dichloroethene	7.6	2500	µg/L	ASI-003D2-051810A	12/18	1 - 5000	2500	NA	3.6	n	70	VT MCL	YES	ASL
	100414	Ethylbenzene	0.58	0.61	µg/L	MW-005D-1110A	2/18	1 - 5000	0.61	NA	1.5	c	700	VT MCL	NO	BSL
	mpxylene	m,p-Xylene	0.63	1.3	µg/L	MW-005D-1110A	2/18	2 - 5000	1.3	NA	19	n	10000	VT MCL	NO	BSL
	74828	Methane	16	140	µg/L	MW-06M-0612A	3/3	NA	140	NA	NBA		NBA	---	YES	NBA
	75092	Methylene chloride	0.82	590	µg/L	MW-004D-1110A	3/18	1 - 5000	590	NA	11	n	5.0	VT MCL	YES	ASL
	95476	o-Xylene	0.65	0.65	µg/L	MW-005D-1110A	1/18	1.0 - 5000	0.65	NA	19	n	10000	VT MCL	NO	BSL
	127184	Tetrachloroethene	2.60	3.5	µg/L	MW-006M-1110A	2/18	1 - 5000	3.5	NA	4.1	n	5.0	VT MCL	NO	BSL
	156605	trans-1,2-Dichloroethene	0.47	13	µg/L	ASI-003D2-051810A	5/18	1 - 5000	13	NA	36	n	100	VT MCL	NO	BSL
	79016	Trichloroethene	410	77000	µg/L	DUP-1110C	17/18	1 - 1	77000	NA	0.28	n	5.0	VT MCL	YES	ASL
	75014	Vinyl Chloride	3.7	3.7	µg/L	MW-006M-1110A	1/18	1 - 5000	3.7	NA	0.019	c	2.0	VT MCL	YES	ASL
	7429905	Aluminum	19.7	12300	µg/L	MW-006M-1110A	13/18	200 - 222	12300	NA	2000	n	200	VT MCL	YES	ASL
	7440360	Antimony	0.28	0.5	µg/L	ASI-014D2-051810A	3/18	2 - 2	0.5	NA	0.78	n	6.0	VT MCL	NO	BSL
	7440382	Arsenic	2.5	27	µg/L	MW-06D-0612A	15/18	10 - 11.1	27	NA	0.052	c	10	VT MCL	YES	ASL
	7440393	Barium	27.6	198	µg/L	ASI-002D2-1110A	18/18	NA	198	NA	380	n	2000	VT MCL	NO	BSL
	7440417	Beryllium	0.05	0.70	µg/L	MW-05D2-0612A	6/18	1 - 1	0.70	NA	2.5	n	4.0	VT MCL	NO	BSL
	7440439	Cadmium	0.26	0.8	µg/L	MW-05D2-0612A	2/18	1 - 5.6	0.8	NA	0.92	n	5.0	VT MCL	NO	BSL
	7440702	Calcium	65400	165000	µg/L	ASI-003D2-1110A	18/18	NA	165000	NA	NUT		NBA	---	NO	See text
	7440473	Chromium	0.35	53	ug/L	MW-05D-1213A	14/19	10 - 11.1	53	NA	0.035	c	100	VT MCL	YES	ASL
	7440484	Cobalt	1.8	29.5	µg/L	MW-05D2-0612A	10/18	50 - 55.6	29.5	NA	0.6	n	NBA	---	YES	ASL
	7440508	Copper	11.7	52.9	µg/L	MW-05D2-0612A	9/18	25 - 27.8	52.9	NA	80	n	1300	VT MCL	NO	BSL
	7439896	Iron	6019	39200	µg/L	MW-006M-1110A	18/18	NA	39200	NA	1400	n	300	VT MCL	YES	ASL
	7439921	Lead	1.2	23.6	µg/L	MW-05D2-0612A	7/18	10 - 11.1	23.6	NA	15		15	VT MCL	YES	ASL
	7439954	Magnesium	12000	33700	µg/L	DUP-1110C	18/18	NA	33700	NA	NUT		NBA	---	NO	See text
	7439965	Manganese	521	3270	µg/L	MW-05D2-0612A	18/18	NA	3270	NA	43	n	50	VT MCL	YES	ASL
	7439976	Mercury	0.016	0.026	µg/L	MW-05D2-0612A	3/18	0.2 - 0.2	0.026	NA	0.063	n	2.0	VT MCL	NO	BSL
	7440020	Nickel	0.9	73	µg/L	MW-05D2-0612A	13/18	40 - 44.4	73	NA	39	n	100	VT MCL	YES	ASL

TABLE A-2.5
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN - OVERBURDEN GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Overburden Groundwater

Exposure Point	CAS Number	Contaminant	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value	Screening Toxicity Value (N/C) (2)		Potential ARAR/TBC Value (3)	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Overburden Groundwater (Cont'd)	7440097	Potassium	1220	6140	µg/L	MW-005D-1110A	18/18	NA	6140	NA	NUT		NBA	---	NO	See text
	7782492	Selenium	4.1	4.3	µg/L	ASI-014D2-121608A	1/18	5 - 38.9	4.3	NA	10	n	50	VT MCL	NO	BSL
	7440224	Silver	4.0	4.1	µg/L	ASI-002D2-121808A	1/18	10 - 11.1	4.1	NA	9.4	n	100	VT MCL	NO	BSL
	7440235	Sodium	24300	398000	µg/L	ASI-002D2-1110A	18/18	NA	398000	NA	NUT		250000	VT MCL	NO	See text
	7440280	Thallium	0.020	0.11	µg/L	ASI-002D2-121808A	7/18	1 - 1	0.11	NA	0.02	n	2.0	VT MCL	YES	ASL
	7440622	Vanadium	1.4	22	µg/L	MW-05D2-0612A	10/18	50 - 55.6	22	NA	8.6	n	NBA	---	YES	ASL
	7440666	Zinc	0.31	104	µg/L	MW-06D-0612A	14/18	60 - 66.7	104	NA	600	n	5000	VT MCL	NO	BSL
	7429905	Aluminum (Dissolved)	23.1	23	µg/L	ASI-002D2-121808A	1/2	222 - 222	23	NA	2000	n	200	VT MCL	NO	BSL
	7440360	Antimony (Dissolved)	0.14	0.44	µg/L	ASI-002D2-121808A	2/2	NA	0.44	NA	0.78	n	6.0	VT MCL	NO	BSL
	7440393	Barium (Dissolved)	47	120	µg/L	ASI-002D2-121808A	2/2	NA	120	NA	380	n	2000	VT MCL	NO	BSL
	7440702	Calcium (Dissolved)	81500	111000	µg/L	ASI-002D2-121808AD	2/2	NA	111000	NA	NUT		NBA	---	NO	See text
	7440473	Chromium (Dissolved)	0.51	0.53	µg/L	ASI-014D2-121608AD	1/2	11.1 - 11.1	0.53	NA	0.035	c	100	VT MCL	YES	See Footnote
	7439896	Iron (Dissolved)	6580	11600	µg/L	ASI-002D2-121808AD	2/2	NA	11600	NA	1400	n	300	VT MCL	YES	See Footnote
	7439921	Lead (Dissolved)	1.9	1.9	µg/L	ASI-014D2-121608AD	1/2	11.1 - 11.1	1.9	NA	15		15	VT MCL	NO	BSL
	7439954	Magnesium (Dissolved)	17900	18200	µg/L	ASI-002D2-121808A	2/2	NA	18200	NA	NUT		NBA	---	NO	See text
	7439965	Manganese (Dissolved)	544	630	µg/L	ASI-014D2-121608A	2/2	NA	630	NA	43	n	50	VT MCL	YES	See Footnote
	7440097	Potassium (Dissolved)	1370	2090	µg/L	ASI-002D2-121808A	2/2	NA	2090	NA	NUT		NBA	---	NO	See text
	7782492	Selenium (Dissolved)	6.2	6.2	µg/L	ASI-002D2-121808A	1/2	38.9 - 38.9	6.2	NA	10	n	50	VT MCL	NO	BSL
	7440224	Silver (Dissolved)	2.3	2.5	µg/L	ASI-014D2-121608AD	1/2	11.1 - 11.1	2.5	NA	9.4	n	100	VT MCL	NO	BSL
	7440235	Sodium (Dissolved)	59500	175000	µg/L	ASI-002D2-121808A	2/2	NA	175000	NA	NUT		250000	VT MCL	NO	See text
	7440622	Vanadium (Dissolved)	1.4	1.9	µg/L	ASI-002D2-121808A	1/2	55.6 - 55.6	1.9	NA	8.6	n	NBA	---	NO	BSL

Notes/sources:
(1) Maximum detected concentration used for screening.
(2) Risk-based residential tapwater concentrations obtained from the Regional Screening Level (RSL) Table (January, 2015).
Surrogate screening values used:
- Hexavalent chromium used for chromium.
(3) Criteria based on minimum of Vermont Groundwater Protection Council (VT GWPC) Rule (VTDEC, 2005) and Vermont Water Supply Rule Maximum Contaminat Levels (MCLs) (VTDEC, 2010).

- Dissolved inorganics are shown for comparison purposes. COPC selection for inorganics uses total inorganics data.

ASL = above screening level.
BSL = below screening level.
C = cancer based screening value set at a target risk of 1E-06.
NA = not available.
NBA = no benchmark available.
NC = noncancer based screening value set at a target hazard quotient of 0.1.
NUT = essential nutrient.
µg/L = micrograms per liter.

TABLE A-2.6
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN - TOTAL SOIL
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Total soil (0-10 ft)

Exposure Point	CAS Number	Contaminant	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value	Screening Toxicity Value (N/C) (2)		COPC Flag (Y/N)	Rationale for Selection or Deletion
96 Commerce Street	56553	Benzo(a)anthracene	0.37	0.37	mg/kg	SB-12-5-1FT-0812	1/6	0.25 - 0.3	0.37	NA	0.15	c	YES	ASL
	50328	Benzo(a)pyrene	0.32	0.32	mg/kg	SB-12-5-1FT-0812	1/6	0.25 - 0.3	0.32	NA	0.015	c	YES	ASL
	205992	Benzo(b)fluoranthene	0.36	0.36	mg/kg	SB-12-5-1FT-0812	1/6	0.25 - 0.3	0.36	NA	0.15	c	YES	ASL
	207089	Benzo(k)fluoranthene	0.3	0.3	mg/kg	SB-12-5-1FT-0812	1/6	0.25 - 0.3	0.3	NA	1.5	c	NO	BSL
	218019	Chrysene	0.41	0.41	mg/kg	SB-12-5-1FT-0812	1/6	0.25 - 0.3	0.41	NA	15	c	NO	BSL
	206440	Fluoranthene	0.7	0.7	mg/kg	SB-12-5-1FT-0812	1/6	0.25 - 0.3	0.7	NA	230	n	NO	BSL
	129000	Pyrene	0.54	0.54	mg/kg	SB-12-5-1FT-0812	1/6	0.25 - 0.3	0.54	NA	170	n	NO	BSL
	7429905	Aluminum	5400	14000	mg/kg	SB-12-5-1FT-0812	6/6	NA	14000	NA	7700	n	YES	ASL
	7440382	Arsenic	2.6	4.4	mg/kg	SB-12-6-1FT-0812	6/6	NA	4.4	NA	0.67	c	YES	ASL
	7440393	Barium	14	28	mg/kg	SB-12-5-4FT-0812	6/6	NA	28	NA	1500	n	NO	BSL
	7440439	Cadmium	1.1	4.2	mg/kg	SB-12-5-4FT-0812	3/6	0.98 - 1	4.2	NA	7.0	n	NO	BSL
	7440702	Calcium	780	2000	mg/kg	SB-DUP-02	6/6	NA	2000	NA	NUT		NO	See text
	7440473	Chromium	7.5	320	mg/kg	SB-12-5-4FT-0812	10/10	NA	320	NA	0.30	c	YES	ASL
	18540299	Chromium-Hexavalent	0.85	0.85	mg/kg	SB-13-02-1213B	1/4	0.8 - 0.81	0.85	NA	0.30	c	NO	See text
	7440484	Cobalt	3.8	6.1	mg/kg	SB-12-6-6FT-0812	6/6	NA	6.1	NA	2.3	n	YES	ASL
	7440508	Copper	8.3	140	mg/kg	SB-12-5-4FT-0812	6/6	NA	140	NA	310	n	NO	BSL
	7439896	Iron	9800	15000	mg/kg	SB-12-5-6FT-0812	6/6	NA	15000	NA	5500	n	YES	ASL
	7439921	Lead	3.4	16	mg/kg	SB-12-5-1FT-0812	6/6	NA	16	NA	400		NO	BSL
	7439954	Magnesium	2000	3000	mg/kg	SB-12-5-6FT-0812	6/6	NA	3000	NA	NUT		NO	See text
	7439965	Manganese	110	260	mg/kg	SB-12-6-1FT-0812	6/6	NA	260	NA	180	n	YES	ASL
	7440020	Nickel	15	18	mg/kg	SB-12-6-6FT-0812	6/6	NA	18	NA	150	n	NO	BSL
	7440622	Vanadium	8.9	14	mg/kg	SB-12-6-4FT-0812	6/6	NA	14	NA	39	n	NO	BSL
	7440666	Zinc	23	67	mg/kg	SB-12-5-1FT-0812	6/6	NA	67	NA	2300	n	NO	BSL
S. Brownell and Shunpike Roads	67641	Acetone	0.19	0.19	mg/kg	SB-14-04-0001	1/18	0.054 - 0.11	0.187	NA	6100	n	NO	BSL
	79016	Trichloroethene	0.91	0.91	mg/kg	SB-14-04-0001	1/18	0.054 - 0.11	0.9094	NA	0.41	n	YES	ASL
	7429905	Aluminum	4200	12000	mg/kg	SB-14-13-0001	18/18	NA	12000	NA	7700	n	YES	ASL
	7440382	Arsenic	3	7.2	mg/kg	SB-14-09-0306	17/18	5.9 - 5.9	7.2	NA	0.67	c	YES	ASL
	7440393	Barium	9.2	50	mg/kg	SB-12-2-5FT-0812	18/18	NA	50	NA	1500	n	NO	BSL
	7440702	Calcium	960	3000	mg/kg	SB-14-04-0001	18/18	NA	3000	NA	NUT		NO	See text
	7440473	Chromium	11	29	mg/kg	SB-12-1-5FT-0812	20/20	NA	29	NA	0.30	c	YES	ASL
	7440484	Cobalt	3.6	11	mg/kg	SB-12-4-5FT-0812	17/18	5.9 - 5.9	11	NA	2.3	n	YES	ASL
	7440508	Copper	7.6	18	mg/kg	SB-12-4-5FT-0812	17/18	5.9 - 5.9	18	NA	310	n	NO	BSL
	7439896	Iron	6900	21000	mg/kg	SB-12-3-5FT-0812	18/18	NA	21000	NA	5500	n	YES	ASL
	7439921	Lead	3	18	mg/kg	SB-14-04-0001	17/18	5.9 - 5.9	18	NA	400		NO	BSL
	7439954	Magnesium	1900	3200	mg/kg	SB-14-09-0306	18/18	NA	3200	NA	NUT		NO	See text
	7439965	Manganese	120	360	mg/kg	SB-14-10-0306	18/18	NA	360	NA	180	n	YES	ASL
	7440020	Nickel	11	22	mg/kg	SB-14-09-0306	18/18	NA	22	NA	150	n	NO	BSL
	7440622	Vanadium	9	23	mg/kg	SB-14-13-0001	18/18	NA	23	NA	39	n	NO	BSL
	7440666	Zinc	18	63	mg/kg	SB-14-04-0001	18/18	NA	63	NA	2300	n	NO	BSL

Notes/sources:
(1) Maximum detected concentration used for screening.
(2) Risk-based residential soil concentrations obtained from the Regional Screening Level (RSL) Table (January, 2015).
Surrogate screening values used:
- Hexavalent chromium used for chromium.

ASL = above screening level.
BSL = below screening level.
C = cancer based screening value set at a target risk of 1E-06.
mg/kg = milligrams per kilogram.
NA = not available.
NC = noncancer based screening value set at a target hazard quotient of 0.1.
NUT = essential nutrient.

TABLE A-3.1
EXPOSURE POINT CONCENTRATION SUMMARY - SEDIMENT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	Contaminant of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Sediment	4-Nitrophenol	mg/kg	0.46	Not Determined	0.46	0.46	mg/kg	Maximum	See Footnote
	Benzo(a)anthracene	mg/kg	0.24	Not Determined	0.27	0.27	mg/kg	Maximum	See Footnote
	Benzo(a)pyrene	mg/kg	0.23	Not Determined	0.24	0.24	mg/kg	Maximum	See Footnote
	Benzo(b)fluoranthene	mg/kg	0.31	Not Determined	0.57	0.57	mg/kg	Maximum	See Footnote
	Dibenz(a,h)anthracene	mg/kg	0.30	Not Determined	0.51	0.51	mg/kg	Maximum	See Footnote
	Indeno(1,2,3-cd)pyrene	mg/kg	0.30	Not Determined	0.50	0.50	mg/kg	Maximum	See Footnote
	Arsenic	mg/kg	2.7	Not Determined	4.5	4.5	mg/kg	Maximum	See Footnote
	Chromium	mg/kg	9.1	Not Determined	11	11	mg/kg	Maximum	See Footnote
	Cobalt	mg/kg	3.0	Not Determined	4.1	4.1	mg/kg	Maximum	See Footnote
	Iron	mg/kg	8550	Not Determined	12000	12000	mg/kg	Maximum	See Footnote

Note: Maximum detected concentration used as the EPC in instances where n < 8 or detects < 4 and the median value exceeded the maximum detected concentration.

TABLE A-3.2
EXPOSURE POINT CONCENTRATION SUMMARY - SURFACE WATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Point	Contaminant of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Site	cis-1,2-Dichloroethene	ug/L	13	Not Determined	39	39	ug/L	Maximum	See Footnote
	Trichloroethene	ug/L	6.2	Not Determined	15	15	ug/L	Maximum	See Footnote
	Vinyl chloride	ug/L	1.6	Not Determined	3.4	3.4	ug/L	Maximum	See Footnote

Note: Maximum detected concentration used as the EPC in instances where n < 8 or detects < 4 and the median value exceeded the maximum detected concentration.

TABLE A-3.3a
EXPOSURE POINT CONCENTRATION SUMMARY - SHALLOW GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater (0-10 ft)

Exposure Point	Contaminant of Potential Concern	Units	Arithmetic Mean	Maximum Concentration	Exposure Point Concentration		
					Value	Units	Rationale (1)
Shallow Groundwater	Benzo(a)pyrene	ug/L	4.7	0.15	0.15	ug/L	Maximum
	Chloroform	ug/L	3.3	1.9	1.9	ug/L	Maximum
	Naphthalene	ug/L	4.6	1.8	1.8	ug/L	Maximum
	Trichloroethene	ug/L	2.3	4.8	4.8	ug/L	Maximum
	Antimony	ug/L	1.4	1.4	1.4	ug/L	Maximum
	Arsenic	ug/L	9.5	11.8	11.8	ug/L	Maximum
	Cadmium	ug/L	6.3	54.3	54.3	ug/L	Maximum
	Chromium	ug/L	8.9	27.1	27.1	ug/L	Maximum
	Cobalt	ug/L	32	7.1	7.1	ug/L	Maximum
	Iron	ug/L	5157	34400	34400	ug/L	Maximum
	Manganese	ug/L	561	4420	4420	ug/L	Maximum
	Thallium	ug/L	0.5	0.29	0.29	ug/L	Maximum

(1) The EPC defaults to the maximum detected concentration per EPA Region 1 guidelines.

TABLE A-3.3b
EXPOSURE POINT CONCENTRATION SUMMARY - SHALLOW GROUNDWATER - VAPORS IN CONSTRUCTION TRENCH
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater (0-10 ft)

Exposure Point	Contaminant of Potential Concern	Units	Maximum Concentration	Exposure Point Concentration (Cair)		
				Trench Air		
				Value	Units	Rationale[1]
Shallow Groundwater	Chloroform	ug/L	1.9	0.014	mg/m^3	Modeled from VDEQ gw VRP Table E-2
	Naphthalene	ug/L	1.8	0.012	mg/m^3	Modeled from VDEQ gw VRP Table E-2
	Trichloroethene	ug/L	4.8	0.035	mg/m^3	Modeled from VDEQ gw VRP Table E-2

[1]Cair calculated from the Virginia Department of Environmental Quality (VDEQ) 2013 groundwater Voluntary Remediation Program (VRP) model.

TABLE A-3.4a
EXPOSURE POINT CONCENTRATION SUMMARY - OVERBURDEN GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Overburden Groundwater

Exposure Point	Contaminant	Units	Arithmetic Mean	95% UCL	Maximum Concentration	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Overburden Groundwater	1,1,2-Trichloroethane	µg/L	601	0.15	0.99	0.15	µg/L	95% KM (t) UCL	See footnote
	1,2-Dichloroethane	µg/L	602	1.0	8.9	1.0	µg/L	95% KM (t) UCL	See footnote
	cis-1,2-Dichloroethene	µg/L	611	301	2500	301	µg/L	95% KM (Chebyshev) UCL	See footnote
	Methane	µg/L	60	NC	140	140	µg/L	Maximum	See footnote
	Methylene chloride	µg/L	355	NC	590	590	µg/L	Maximum	See footnote
	Trichloroethene	µg/L	21388	8910	77000	8910	µg/L	95% KM (t) UCL	See footnote
	Vinyl Chloride	µg/L	602	NC	3.7	3.7	µg/L	Maximum	See footnote
	Aluminum	µg/L	2486	10682	12300	10682	µg/L	97.5% KM (Chebyshev) UCL	See footnote
	Arsenic	µg/L	13	9.3	27.2	9.3	µg/L	95% KM (Chebyshev) UCL	See footnote
	Chromium	ug/L	18	53.7	53	53	ug/L	Maximum	See footnote
	Cobalt	µg/L	27	9.5	29.5	9.5	µg/L	95% KM (Chebyshev) UCL	See footnote
	Iron	µg/L	17394	18112	39200	18112	µg/L	95% Student's-t UCL	See footnote
	Lead	µg/L	9	6.1	23.6	6.1	µg/L	95% KM (BCA) UCL	See footnote
	Manganese	µg/L	1452	840	3270	840	µg/L	95% H-UCL	See footnote
	Nickel	µg/L	25	27	73.3	27	µg/L	95% KM (Chebyshev) UCL	See footnote
	Thallium	µg/L	1	0.071	0.11	0.071	µg/L	95% KM (t) UCL	See footnote
	Vanadium	µg/L	27	20	21.6	20	µg/L	95% KM (Chebyshev) UCL	See footnote

NC = Not calculated.

Note: Maximum detected concentration used as the EPC in instances where total samples were less than or equal to 8 and/or there were less than 4 detects. If the sample size was sufficient, the ProUCL recommendation was used.

TABLE A-3.4b
EXPOSURE POINT CONCENTRATION SUMMARY - OVERBURDEN GROUNDWATER - VAPORS DURING HOUSEHOLD WATER USE
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Overburden Groundwater

Exposure Point	Contaminant of Potential Concern	Units	Concentration of Contaminant in Groundwater (EPCgw) (µg/L)	Exposure Point Concentration (Cair)		
				Indoor Air		
				Value	Units	Rationale
Overburden	1,1,2-Trichloroethane	µg/L	0.15	0.000077	mg/m^3	Modeled from EPCgw Table E-3
	1,2-Dichloroethane	µg/L	1.0	0.00051	mg/m^3	Modeled from EPCgw Table E-3
	cis-1,2-Dichloroethene	µg/L	301	0.15	mg/m^3	Modeled from EPCgw Table E-3
	Methane	µg/L	140	0.070	mg/m^3	Modeled from EPCgw Table E-3
	Methylene chloride	µg/L	590	0.30	mg/m^3	Modeled from EPCgw Table E-3
	Trichloroethene	µg/L	8910	4.5	mg/m^3	Modeled from EPCgw Table E-3
	Vinyl Chloride	µg/L	3.7	0.0019	mg/m^3	Modeled from EPCgw Table E-3

TABLE A-4.1
VALUES USED FOR DAILY INTAKE CALCULATIONS - ADULT RECREATIONAL VISITOR CONTACT WITH SEDIMENT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Sediment
Receptor Population: River Recreational Visitor
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Ingestion	C_{Sed}	Concentration in Sediment	mg/kg	COPC-Specific	Table A-3.1	Intake (mg/kg-day) =
	IR-SD	Sediment Ingestion Rate	mg/day	100	EPA, 2014	C_{Sed} x IR-SD x FI x EF x ED x CF/(BW x AT)
	FI	Fraction Ingested From Contaminated Source	--	1	Professional judgment	
	OABS	Oral Absorption Factor	--	1	Professional judgment	
	EF	Exposure Frequency	days/year	22	(a)	
	ED	Exposure Duration	years	20	Professional judgment	
	CF1	Conversion Factor	kg/mg	1E-06	--	
	BW	Body Weight	kg	80	EPA, 2014	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	7300	ED x 365 days/year	
Dermal	C_{Sed}	Concentration in Sediment	mg/kg	COPC-Specific	Table A-3.1	Dermal Absorbed Dose (mg/kg-day) =
	SA	Surface Area	cm^2	6,032	(b)	C_{Sed} x SA x SSAF x DABS x EV x EF x ED x CF/(BW x AT)
	SSAF	Sediment-to-Skin Adherence Factor	mg/cm^2-event	0.3	(c)	
	DABS	Dermal Absorption Factor (Solid)	--	COPC-Specific	Table F-1	
	EV	Event Frequency	events/day	1	Professional judgment	
	EF	Exposure Frequency	days/year	22	(a)	
	ED	Exposure Duration	years	20	Professional judgment	
	BW	Body Weight	kg	80	EPA, 2014	
	CF1	Conversion Factor	kg/mg	1E-06	--	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	7300	ED x 365 days/year	

(a) Professional judgment. EF assumes RME 2 day/week, 11 weeks/year.
(b) Surface area represented by hands, head, feet, forearms, and lower legs of adult. EPA, 2014.
(c) Sediment to Skin Adherence Factor consistent with 50th percentile reed gatherer. EPA, 2004.

TABLE A-4.2
VALUES USED FOR DAILY INTAKE CALCULATIONS - CHILD RECREATIONAL VISITOR CONTACT WITH SEDIMENT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Sediment
Receptor Population: River Recreational Visitor
Receptor Age: Child (0-6 yrs)

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Ingestion	C_{Sed}	Concentration in Sediment	mg/kg	COPC-Specific	Table A-3.1	Intake (mg/kg-day) =
	IR-SD	Sediment Ingestion Rate	mg/day	200	EPA, 2014	C_{Sed} x IR-SD x FI x EF x ED x CF/(BW x AT)
	FI	Fraction Ingested From Contaminated Source	--	1	Professional judgment	
	OABS	Oral Absorption Factor	--	1	Professional judgment	
	EF	Exposure Frequency	days/year	22	(a)	
	ED	Exposure Duration	years	6	Professional judgment	
	CF1	Conversion Factor	kg/mg	1E-06	--	
	BW	Body Weight	kg	15	EPA, 2014	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	2190	ED x 365 days/year	
Dermal	C_{Sed}	Concentration in Sediment	mg/kg	COPC-Specific	Table A-3.1	Dermal Absorbed Dose (mg/kg-day) =
	SA	Surface Area	cm^2	2,690	(b)	C_{Sed} x SA x SSAF x DABS x EV x EF x ED x CF/(BW x AT)
	SSAF	Sediment-to-Skin Adherence Factor	mg/cm^2-event	0.2	(c)	
	DABS	Dermal Absorption Factor (Solid)	--	COPC-Specific	Table F-1	
	EV	Event Frequency	events/day	1	Professional judgment	
	EF	Exposure Frequency	days/year	22	(a)	
	ED	Exposure Duration	years	6	Professional judgment	
	BW	Body Weight	kg	15	EPA, 2014	
	CF1	Conversion Factor	kg/mg	1E-06	--	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	2190	ED x 365 days/year	

(a) Professional judgment. EF assumes RME 2 day/week, 11 weeks/year.
(b) Surface area represented by hands, head, feet, forearms, and lower legs of child (age 1-6). EPA, 2014.
(c) Child Sediment to Skin Adherence Factor consistent with 50th percentile older child playing in wet soil. EPA, 2004.

TABLE A-4.3
VALUES USED FOR DAILY INTAKE CALCULATIONS - ADULT RECREATIONAL VISITOR CONTACT WITH SURFACE WATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Surface Water
Receptor Population: River Recreational Visitor
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Dermal	DA_{event}	Absorbed Dose per Event	mg/cm^2-event	calculated	Table F-2	Dermal Absorbed Dose (mg/kg-day) =
	SA	Surface Area	cm^2	6032	(b)	DA_{event} x SA x EV x EF x ED /(BW x AT)
	EV	Event Frequency	events/day	1	Professional judgment	
	EF	Exposure Frequency	days/year	22	(a)	for inorganics:
	ED	Exposure Duration	years	20	Professional judgment	DA_{event} = CW x Kp x t_{event} x CF
	BW	Body Weight	kg	80	EPA, 2014	Equations for DA_{event} for organics:
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	If t_{event} < t*
	AT-N	Averaging Time (Non-Cancer)	days	7300	ED x 365 days/year	
	CW	Concentration in Surface Water	µg/L	COPC-Specific	Table A-3.2	$DA_{event} = 2FA x Kp x CW x CF \sqrt{\frac{6 x \tau_{event} x t_{event}}{\pi}}$
	Kp	Dermal Permeability Coefficients	cm/hr	COPC-Specific	Table F-2	
	t_{event}	Event Duration	hr/event	2	Professional judgment	
	CF	Conversion Factor	mg-L/µg-cm^3	1.00E-06	--	If t_{event} > t*
	FA	Fraction Absorbed Water	unitless	COPC-Specific	Table F-2	
	t*	Time to Reach Steady State	hr/event	COPC-Specific	Table F-2	$DA_{event} = FA x Kp x CW x CF x \left[\frac{t_{event}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$
	τ_{event}	Lag Time Per Event	hr/event	COPC-Specific	Table F-2	
	B	Ratio of Permeability Coefficient	unitless	COPC-Specific	Table F-2	

(a) Professional judgment. EF assumes RME 2 day/week, 11 weeks/year.
(b) Surface area of adult represented by hands, head, feet, forearms, and lower legs. EPA, 2014.

TABLE A-4.4
VALUES USED FOR DAILY INTAKE CALCULATIONS - CHILD RECREATIONAL VISITOR CONTACT WITH SURFACE WATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Surface Water
Receptor Population: River Recreational Visitor
Receptor Age: Child (0-6 yrs)

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Dermal	DA_{event}	Absorbed Dose per Event	mg/cm^2-event	calculated	Table F-2	Dermal Absorbed Dose (mg/kg-day) =
	SA	Surface Area	cm^2	2,690	(b)	DA_{event} x SA x EV x EF x ED /(BW x AT)
	EV	Event Frequency	events/day	1	Professional judgment	
	EF	Exposure Frequency	days/year	22	(a)	for inorganics:
	ED	Exposure Duration	years	6	Professional judgment	DA_{event} = CW x Kp x t_{event} x CF
	BW	Body Weight	kg	15	EPA, 2014	Equations for DA_{event} for organics:
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	If t_{event} < t*
	AT-N	Averaging Time (Non-Cancer)	days	2190	ED x 365 days/year	
	CW	Concentration in Surface Water	µg/L	COPC-Specific	Table A-3.2	$DA_{event} = 2FA \times Kp \times CW \times CF \sqrt{\frac{6 \times \tau_{event} \times t_{event}}{\pi}}$
	Kp	Dermal Permeability Coefficients	cm/hr	COPC-Specific	Table F-2	
	t_{event}	Event Duration	hr/event	2	Professional judgment	
	CF	Conversion Factor	mg-L/µg-cm^3	1.00E-06	--	If t_{event} > t*
	FA	Fraction Absorbed Water	unitless	COPC-Specific	Table F-2	
	t*	Time to Reach Steady State	hr/event	COPC-Specific	Table F-2	$DA_{event} = FA \times Kp \times CW \times CF \times \left[\frac{t_{event}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$
	τ_{event}	Lag Time Per Event	hr/event	COPC-Specific	Table F-2	
	B	Ratio of Permeability Coefficient	unitless	COPC-Specific	Table F-2	

(a) Professional judgment. EF assumes RME 2 day/week, 11 weeks/year.
(b) Surface area represented by hands, head, feet, forearms, and lower legs of child (age 1-6). EPA, 2014.

TABLE A-4.5
VALUES USED FOR DAILY INTAKE CALCULATIONS - ADULT CONSTUCTION WORKER CONTACT WITH GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Shallow Groundwater (0-10 ft)
Receptor Population: Construction Worker
Receptor Age: Adult

Exposure Route	Exposure Point	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name
Dermal	Shallow Groundwater in construction trenches	DA_{event}	Absorbed Dose Per Event	mg/cm^2-event	COPC-specific	Table F-3	COPC-specific	Table F-3	Dermal Absorbed Dose (mg/kg-day) =
		SA	Skin Surface Area Available for Contact	cm^2	3,470	EPA, 2014	3,470	EPA, 2014	DA_{event} x SA x EV x EF x ED /(BW x AT)
		EV	Event Frequency	event/day	1	Professional judgment	1	Professional judgment	
		EF	Exposure Frequency	days/year	130	Professional judgment	26	Professional judgment	for inorganics:
		ED	Exposure Duration	years	1	Professional judgment	1	Professional judgment	DA_{event} = CW x Kp x t_{event} x CF
		BW	Body Weight	kg	80	EPA, 2014	80	EPA, 2014	Equations for DA_{event} for organics:
		AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	25,550	EPA, 1989	If t_{event} < t*
		AT-N	Averaging Time (Non-Cancer)	days	365	ED x 365 days/year	365	ED x 365 days/year	
		CW	Chemical Concentration in Water	µg/L	COPC-specific	Table A-3.3a	COPC-specific	Table A-3.3a	$DA_{event} = 2FA x Kp x CW x CF \sqrt{\frac{6 x \tau_{event} x t_{event}}{\pi}}$
		Kp	Dermal Permeability Coefficients	cm/hr	COPC-Specific	Table F-3	COPC-Specific	Table F-3	
		CF	Conversion Factor	mg-L/µg-cm^3	1.00E-06	--	1.00E-06	--	
		FA	Fraction Absorbed Water	unitless	COPC-Specific	Table F-3	COPC-Specific	Table F-3	If t_{event} > t*
		t*	Time to Reach Steady State	hr/event	COPC-Specific	Table F-3	COPC-Specific	Table F-3	
		τ_{event}	Lag Time Per Event	hr/event	COPC-Specific	Table F-3	COPC-Specific	Table F-3	$DA_{event} = FA x Kp x CW x CF x \left[\frac{t_{event}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$
		B	Ratio of Permeability Coefficient	unitless	COPC-Specific	Table F-3	COPC-Specific	Table F-3	
		t_{event}	Event Duration	hr/event	8	Professional judgment	8	Professional judgment	
Inhalation	Vapors in construction trenches	EC	Exposure Concentrations	mg/m^3	Calculated	-----	Calculated	-----	Exposure Concentration (EC) (mg/m^3) =
		Cair	Chemical Concentration in Trench Air	mg/m^3	COPC-specific	Table E-2	COPC-specific	Table E-2	Cair x ET x EF x ED x CF1/AT
		CF1	Conversion Factor	1 day/24 hours	4.17E-02	-----	4.17E-02	-----	Cair modeled from shallow groundwater using the
		ET	Exposure Time	hrs/day	8	Professional judgment	8	Professional judgment	Virginia Department of Environmental Quality model
		EF	Exposure Frequency	days/year	130	Professional judgment	26	Professional judgment	
		ED	Exposure Duration	years	1	Professional judgment	1	Professional judgment	
		AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	25,550	EPA, 1989	
		AT-N	Averaging Time (Non-Cancer)	days	365	ED x 365 days/year	365	ED x 365 days/year	

TABLE A-4.6
VALUES USED FOR DAILY INTAKE CALCULATIONS - ADULT RESIDENT CONTACT WITH GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Receptor Population: Resident
Receptor Age: Adult

Exposure Route	Exposure Point	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Tap Water	EPC	Exposure Point Concentration	µg/L	COPC-specific	Table A-3.4a	COPC-specific	Table A-3.4a	Chronic daily intake (CDI) (mg/kg-day) =
		IRW	Ingestion Rate of Water	L/day	2.5	EPA, 2014	2.5	EPA, 2014	EPC x IRW x CF x FI x EF x ED x 1/BW x 1/AT-N
		FI	Fraction Ingested	unitless	1	EPA, 1989	0.5	EPA, 1989	
		EF	Exposure Frequency	days/year	350	EPA, 2014	350	EPA, 2014	
		ED	Exposure Duration	years	20	EPA, 2014	6	EPA, 2014	
		CF	Conversion Factor	mg/µg	1.00E-03	-----	1.00E-03	-----	
		BW	Body Weight	kg	80	EPA, 2014	80	EPA, 2014	
		AT-N	Averaging Time (Non-Cancer)	days	7,300	ED x 365 days/year	2,190	ED x 365 days/year	
Dermal	Tap Water while Showering	DA_{event}	Absorbed Dose Per Event	mg/cm^2-event	COPC-specific	Table F-4	COPC-specific	Table F-4	Dermally Absorbed Dose (DAD) (mg/kg-day) =
		SA	Skin Surface Area Available for Contact	cm^2	20,900	EPA, 2014	20,900	EPA, 2014	DA_{event} x EV x SA x EF x ED x 1/BW x 1/AT-N
		EV	Event Frequency	event/day	1	EPA, 2004	1	EPA, 2004	
		EF	Exposure Frequency	days/year	350	EPA, 2014	350	EPA, 2014	<u>DA_{event} Calculations</u>
		ED	Exposure Duration	years	20	EPA, 2014	6	EPA, 2014	if $t_{event} \leq t^*$, then DA_{event} (Organic) =
		BW	Body Weight	kg	80	EPA, 2014	80	EPA, 2014	2 FA x Kp x CW x CF1 x CF2 x $\sqrt{(6\tau_{event} \times t_{event}/\pi)}$
		AT-N	Averaging Time (Non-Cancer)	days	7,300	ED x 365 days/year	2,190	ED x 365 days/year	
		FA	Fraction Absorbed Water	unitless	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	otherwise if $t_{event} > t^*$, then DA_{event} (Organic) =
		Kp	Dermal Permeability Coefficient	cm/hour	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	FA x Kp x CW x CF1 x CF2 x
		CW	Chemical Concentration in Water	µg/L	COPC-specific	Table A-3.4a	COPC-specific	Table A-3.4a	$[((t_{event})/(1+B)) + 2\tau_{event}((1 + 3B + 3B^2)/(1+B)^2)]$
		CF1	Conversion Factor	mg/µg	1.0E-03	-----	1.0E-03	-----	
		CF2	Conversion Factor	L/cm^3	1.0E-03	-----	1.0E-03	-----	DA_{event} (Inorganic) =
		B	Ratio of Permeability Coefficient	unitless	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	Kp x CW x CF1 x CF2 x t_{event}
		t*	Time to Reach Steady State	hour	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	
		τ_{event}	Lag Time Per Event	hr/event	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	
		t_{event}	Event Duration	hr/event	0.71	EPA, 2014	0.36	Professional judgment	
Inhalation	Vapors during Household Water Use	EC	Exposure Concentrations	mg/m^3	Calculated	-----	Calculated	-----	Exposure Concentration (EC) (mg/m^3) =
		EPCgw	Exposure Point Concentration	µg/L	COPC-specific	Table A-3.4b	COPC-specific	Table A-3.4b	Cair x ET x EF x ED/AT-N x 24 hr/day
		Cair	Chemical Concentration in Air from Household Water Use	mg/m^3	COPC-specific	Table E-3	COPC-specific	Table E-3	
		CF1	Conversion Factor	L/m^3	1.0E+03	-----	1.00E+03	-----	Cair = 0.0005 x EPCgw ug/L x CF1 x CF2
		CF2	Conversion Factor	mg/µg	1.0E-03	-----	1.0E-03	-----	
		ET	Exposure Time	hrs/day	24	-----	24	-----	
		EF	Exposure Frequency	days/year	350	EPA, 2014	350	EPA, 2014	
		ED	Exposure Duration	years	20	EPA, 2014	6	EPA, 2014	
		AT-N	Averaging Time (Non-Cancer)	days	7,300	ED x 365 days/year	2,190	ED x 365 days/year	

TABLE A-4.7
VALUES USED FOR DAILY INTAKE CALCULATIONS - CHILD RESIDENT CONTACT WITH GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Receptor Population: Resident
Receptor Age: Child

Exposure Route	Exposure Point	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Tap Water	EPC	Exposure Point Concentration	µg/L	COPC-specific	Table A-3.4a	COPC-specific	Table A-3.4a	Chronic daily intake (CDI) (mg/kg-day) =
		IRW	Ingestion Rate of Water	L/day	0.78	EPA, 2014	0.78	EPA, 2014	EPC x IRW x CF x FI x EF x ED x 1/BW x 1/AT-N
		FI	Fraction Ingested	unitless	1	EPA, 1989	0.5	EPA, 1989	
		EF	Exposure Frequency	days/year	350	EPA, 2014	350	EPA, 2014	
		ED	Exposure Duration	years	6	EPA, 2014	2	EPA, 2014	
		CF	Conversion Factor	mg/µg	1.00E-03	-----	1.00E-03	-----	
		BW	Body Weight	kg	15	EPA, 2014	15	EPA, 2014	
		AT-N	Averaging Time (Non-Cancer)	days	2,190	ED x 365 days/year	730	ED x 365 days/year	
Dermal	Tap Water while Bathing	DA_{event}	Absorbed Dose Per Event	mg/cm^2-event	COPC-specific	Table F-4	COPC-specific	Table F-4	Dermally Absorbed Dose (DAD) (mg/kg-day) =
		SA	Skin Surface Area Available for Contact	cm^2	6,378	EPA, 2014	6,378	EPA, 2014	DA_{event} x EV x SA x EF x ED x 1/BW x 1/AT-N
		EV	Event Frequency	event/day	1	EPA, 2004	1	EPA, 2004	
		EF	Exposure Frequency	days/year	350	EPA, 2014	350	EPA, 2014	Da_{event} Calculations
		ED	Exposure Duration	years	6	EPA, 2014	2	EPA, 2014	if $t_{event} \leq t^*$, then DA_{event} (Organic) =
		BW	Body Weight	kg	15	EPA, 2014	15	EPA, 2014	2 FA x Kp x CW x CF1 x CF2 x $\sqrt{(6\tau_{event} \times t_{event}/\pi)}$
		AT-N	Averaging Time (Non-Cancer)	days	2,190	ED x 365 days/year	730	ED x 365 days/year	
		FA	Fraction Absorbed Water	unitless	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	otherwise if $t_{event} > t^*$, then DA_{event} (Organic) =
		Kp	Dermal Permeability Coefficient	cm/hour	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	FA x Kp x CW x CF1 x CF2 x
		CW	Chemical Concentration in Water	µg/L	COPC-specific	Table A-3.4a	COPC-specific	Table A-3.4a	$[((t_{event})/(1+B)) + 2\tau_{event}((1 + 3B + 3B^2)/(1+B)^2)$
		CF1	Conversion Factor	mg/µg	1.0E-03	-----	1.0E-03	-----	
		CF2	Conversion Factor	L/cm^3	1.0E-03	-----	1.0E-03	-----	DA_{event} (Inorganic) =
		B	Ratio of Permeability Coefficient	unitless	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	Kp x CW x CF1 x CF2 x t_{event}
		t*	Time to Reach Steady State	hour	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	
		τ_{event}	Lag Time Per Event	hr/event	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	
		t_{event}	Event Duration	hr/event	0.54	EPA, 2014	0.27	Professional judgment	
Inhalation	Vapors during Household Water Use	EC	Exposure Concentrations	mg/m^3	Calculated	-----	Calculated	-----	Exposure Concentration (EC) (mg/m^3) =
		EPCgw	Exposure Point Concentration	µg/L	COPC-specific	Table A-3.4b	COPC-specific	Table A-3.4b	Cair x ET x EF x ED/AT-N x 24 hr/day
		Cair	Chemical Concentration in Air from Household Water Use	mg/m^3	COPC-specific	Table E-3	COPC-specific	Table E-3	
		CF1	Conversion Factor	L/m^3	1.0E+03	-----	1.00E+03	-----	Cair = 0.0005 x EPCgw ug/L x CF1 x CF2
		CF2	Conversion Factor	mg/µg	1.0E-03	-----	1.0E-03	-----	
		ET	Exposure Time	hrs/day	24	-----	24	-----	
		EF	Exposure Frequency	days/year	350	EPA, 2014	350	EPA, 2014	
		ED	Exposure Duration	years	6	EPA, 2014	2	EPA, 2014	
		AT-N	Averaging Time (Non-Cancer)	days	2,190	ED x 365 days/year	730	ED x 365 days/year	

TABLE A-4.8
VALUES USED FOR DAILY INTAKE CALCULATIONS - LIFETIME RESIDENT CONTACT WITH GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Receptor Population: Resident
Receptor Age: Adult/Child

Exposure Route	Exposure Point	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Tap Water	EPC	Exposure Point Concentration	µg/L	COPC-specific	Table A-3.4a	COPC-specific	Table A-3.4a	Chronic daily intake (CDI) (mg/kg-day) =
		IFW_{adj}	Age-adjusted water ingestion factor	L-year/kg-day	0.94	Calculated	0.29	Calculated	EPC x IFW_{adj} x CF x FI x EF x 1/AT-C
		FI	Fraction Ingested	unitless	1	EPA, 1989	0.5	EPA, 1989	Where
		EF	Exposure Frequency	days/year	350	EPA, 2014	350	EPA, 2014	IFW_{adj} = (IRW_c x ED_c x 1/BW_c) + (IRW_a x ED_a x 1/BW_a)
		ED_c	Exposure Duration - child	years	6	EPA, 2014	2	EPA, 2014	
		ED_a	Exposure Duration - adult	years	20	EPA, 2014	6	EPA, 2014	
		IRW_c	Ingestion Rate of Water - child	L/day	0.78	EPA, 2014	0.78	EPA, 2014	
		IRW_a	Ingestion Rate of Water - adult	L/day	2.5	EPA, 2014	2.5	EPA, 2014	
		BW_c	Body Weight - child	kg	15	EPA, 2014	15	EPA, 2014	
		BW_a	Body Weight - adult	kg	80	EPA, 2014	80	EPA, 2014	
		CF	Conversion Factor	mg/µg	1.00E-03	-----	1.00E-03	-----	
		AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	25,550	EPA, 1989	
Dermal	Tap Water while Showering/Bathing	$DA_{event-adj}$	Absorbed Dose Per Event	mg/cm^2-event	COPC-specific	Table F-4	COPC-specific	Table F-4	Dermally Absorbed Dose (DAD) (mg/kg-day) =
		SFS_{adj}	Age-adjusted skin contact factor	event-year-cm^2/kg-day	7.78E+03	Calculated	2.42E+03	Calculated	$DA_{event-adj}$ x SFS_{adj} x EF x 1/AT-C
		SA_c	child	cm^2	6,378	EPA, 2014	6,378	EPA, 2014	
		SA_a	adult	cm^2	20,900	EPA, 2014	20,900	EPA, 2014	SFS_{adj} = (SA_c x EV_c x ED_c x 1/BW_c) +
		EV_c	Event Frequency - child	event/day	1	EPA, 2004	1	EPA, 2004	(SA_a x EV_a x ED_a x 1/BW_a)
		EV_a	Event Frequency - adult	event/day	1	EPA, 2004	1	EPA, 2004	<u>$DA_{event-adj}$ Calculations</u>
		EF	Exposure Frequency	days/year	350	EPA, 2014	350	EPA, 2014	$t_{event-adj}$ = (ED_c x $t_{event-c}$ + ED_a x $t_{event-a}$)/(ED_c + ED_a)
		ED_c	Exposure Duration - child	years	6	EPA, 2014	2	EPA, 2014	
		ED_a	Exposure Duration - adult	years	20	EPA, 2014	6	EPA, 2014	if $t_{event-adj} \leq t^*$, then $DA_{event-adj}$ (Organic) =
		BW_c	Body Weight - child	kg	15	EPA, 2014	15	EPA, 2014	2 FA x Kp x CW x CF1 x CF2 x $\sqrt{(6\tau_{event} \times t_{event-adj}/\pi)}$
		BW_a	Body Weight - adult	kg	80	EPA, 2014	80	EPA, 2014	
		AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	25,550	EPA, 1989	otherwise if $t_{event-adj} > t^*$, then $DA_{event-adj}$ (Organic) =
		$t_{event-adj}$	Age-adjusted event duration	hr/event	0.67	Calculated	0.33	Calculated	FA x Kp x CW x CF1 x CF2 x
		$t_{event-c}$	Event Duration - child	hr/event	0.54	EPA, 2014	0.27	Professional judgment	$[((t_{event-adj})/(1+B)) + 2\tau_{event}((1 + 3B + 3B^2)/(1+B)^2)$
		$t_{event-a}$	Event Duration - adult	hr/event	0.71	EPA, 2014	0.36	Professional judgment	
		FA	Fraction Absorbed Water	unitless	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	$DA_{event-adj}$ (Inorganic) =
		Kp	Dermal Permeability Coefficient	cm/hour	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	Kp x CW x CF1 x CF2 x $t_{event-adj}$
		CW	Chemical Concentration in Water	µg/L	COPC-specific	Table A-3.4a	COPC-specific	Table A-3.4a	
		CF1	Conversion Factor	mg/µg	1.0E-03	-----	1.0E-03	-----	
		CF2	Conversion Factor	L/cm^3	1.0E-03	-----	1.0E-03	-----	
		B	Ratio of Permeability Coefficient	unitless	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	
		t*	Time to Reach Steady State	hour	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	
		τ_{event}	Lag Time Per Event	hr/event	COPC-specific	EPA, 2004	COPC-specific	EPA, 2004	
Inhalation	Vapors during Household Water Use	EC	Exposure Concentrations	mg/m^3	Calculated	-----	Calculated	-----	Exposure Concentration (EC) (mg/m^3) =
		EPCgw	Exposure Point Concentration	µg/L	COPC-specific	Table A-3.4b	COPC-specific	Table A-3.4b	Cair x ET x EF x ED/AT-C x 24 hr/day
		Cair	Chemical Concentration in Air from Household Water Use	mg/m^3	COPC-specific	Table E-3	COPC-specific	Table E-3	Cair = 0.0005 x EPCgw ug/L x CF1 x CF2
Inhalation (Cont'd)	Vapors during Household Water Use	CF1	Conversion Factor	L/m^3	1.0E+03	-----	1.00E+03	-----	
		CF2	Conversion Factor	mg/µg	1.0E-03	-----	1.0E-03	-----	
		ET	Exposure Time	hrs/day	24	-----	24	-----	
		EF	Exposure Frequency	days/year	350	EPA, 2014	350	EPA, 2014	
		ED	Exposure Duration	years	26	EPA, 2014	8	EPA, 2014	
		AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	25,550	EPA, 1989	

TABLE A-5.1
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Contaminant of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal (1)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD: Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Dates (2)
1,1,2-Trichloroethane	Chronic	4.00E-03	mg/kg-day	1.0	4.00E-03	mg/kg-day	Blood	1,000	IRIS	1/28/2015
1,2-Dichloroethane	Chronic	6.00E-03	mg/kg-day	1.0	6.00E-03	mg/kg-day	Kidney	10,000	PPRTV Appendix	2015 RSL Table
4-Nitrophenol	---	NA	---	---	NA	---	---	---	---	---
Benzo(a)anthracene	---	NA	---	---	NA	---	---	---	---	---
Benzo(a)pyrene	---	NA	---	---	NA	---	---	---	---	---
Benzo(b)fluoranthene	---	NA	---	---	NA	---	---	---	---	---
Chloroform	Chronic	1.00E-02	mg/kg-day	1.0	1.00E-02	mg/kg-day	Liver, Blood	100	IRIS	1/28/2015
cis-1,2-Dichloroethene	Chronic	2.00E-03	mg/kg-day	1.0	2.00E-03	mg/kg-day	Kidney	3,000	IRIS	1/28/2015
Dibenz(a,h)anthracene	---	NA	---	---	NA	---	---	---	---	---
Indeno(1,2,3-cd)pyrene	---	NA	---	---	NA	---	---	---	---	---
Methane	---	NA	---	---	NA	---	---	---	---	---
Methylene chloride	Chronic	6.00E-03	mg/kg-day	1.0	6.00E-03	mg/kg-day	Liver	30	IRIS	1/28/2015
Naphthalene	Chronic	2.00E-02	mg/kg-day	1.0	2.00E-02	mg/kg-day	Body weight	3,000	IRIS	1/28/2015
Trichloroethene	Chronic	5.00E-04	mg/kg-day	1.0	5.00E-04	mg/kg-day	Immune System	100	IRIS	1/28/2015
Vinyl chloride	Chronic	3.00E-03	mg/kg-day	1.0	3.00E-03	mg/kg-day	Liver	30	IRIS	1/28/2015
Aluminum	Chronic	1.00E+00	mg/kg-day	1.0	1.00E+00	mg/kg-day	Nervous system	100	PPRTV	2015 RSL Table
Antimony	Chronic	4.00E-04	mg/kg-day	0.15	6.00E-05	mg/kg-day	Blood	1,000	IRIS	1/28/2015
Arsenic	Chronic	3.00E-04	mg/kg-day	1.0	3.00E-04	mg/kg-day	Skin	3	IRIS	1/28/2015
Cadmium-diet	Chronic	1.00E-03	mg/kg-day	0.025	2.50E-05	mg/kg-day	Kidney	10	IRIS	1/28/2015
Cadmium-water	Chronic	5.00E-04	mg/kg-day	0.05	2.50E-05	mg/kg-day	Kidney	10	IRIS	1/28/2015
Chromium, Total [3]	Chronic	3.00E-03	mg/kg-day	0.025	7.50E-05	mg/kg-day	None observed	900	IRIS	1/28/2015
Cobalt	Chronic	3.00E-04	mg/kg-day	1.0	3.00E-04	mg/kg-day	Thyroid	3,000	PPRTV	2015 RSL Table
Iron	Chronic	7.00E-01	mg/kg-day	1.0	7.00E-01	mg/kg-day	Gastrointestinal	1.5	PPRTV	2015 RSL Table
Lead	---	NA	---	---	NA	---	---	---	---	---
Manganese-diet	Chronic	1.40E-01	mg/kg-day	1.0	1.40E-01	mg/kg-day	Nervous system	1	IRIS	1/28/2015
Manganese-non-diet	Chronic	2.40E-02	mg/kg-day	0.04	9.60E-04	mg/kg-day	Nervous system	3	IRIS	1/28/2015
Nickel	Chronic	2.00E-02	mg/kg-day	0.04	8.00E-04	mg/kg-day	Body weight	300	IRIS	1/28/2015
Thallium	Chronic	1.00E-05	mg/kg-day	1.0	1.00E-05	mg/kg-day	Hair	3,000	PPRTV Appendix	2015 RSL Table
Vanadium[4]	Chronic	5.00E-03	mg/kg-day	0.026	1.30E-04	mg/kg-day	Hair	100	Derived from IRIS	2015 RSL Table

(1) Source: RAGS Part E Guidance.
(2) Represents date source was searched.
(3) Chromium VI value used.

(4) Vanadium and compounds - RfD derived from molecular weight (56%) adjustment of the RfD for vanadium pentoxide (EPA, 2015b) per Section 5.4 of the EPA RSL User guide. (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm)

Definitions: IRIS = Integrated Risk Information System.
NA = Not available.
PPRTV = Provisional Peer-Reviewed Toxicity Value.

RSL = Regional Screening Level.

TABLE A-5.2
NON-CANCER TOXICITY DATA -- INHALATION
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Contaminant of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC: Target Organ(s)	
		Value	Units			Source(s)	Dates (1)
1,1,2-Trichloroethane	Chronic	2.00E-04	mg/m^3	Respiratory System	3,000	PPRTV Appendix	2015 RSL Table
1,2-Dichloroethane	Chronic	7.00E-03	mg/m^3	Nervous System	3,000	PPRTV	2015 RSL Table
4-Nitrophenol	---	NA	mg/m^3	---	---	---	---
Benzo(a)anthracene	---	NA	mg/m^3	---	---	---	---
Benzo(a)pyrene	---	NA	mg/m^3	---	---	---	---
Benzo(b)fluoranthene	---	NA	mg/m^3	---	---	---	---
Chloroform	Chronic	9.80E-02	mg/m^3	Liver	100	ATSDR	2015 RSL Table
cis-1,2-Dichloroethene	---	NA	mg/m^3	---	---	---	---
Dibenz(a,h)anthracene	---	NA	mg/m^3	---	---	---	---
Indeno(1,2,3-cd)pyrene	---	NA	mg/m^3	---	---	---	---
Methane	---	NA	mg/m^3	---	---	---	---
Methylene chloride	Chronic	6.00E-01	mg/m^3	Liver	30	IRIS	1/28/2015
Naphthalene	Chronic	3.00E-03	mg/m^3	Respiratory System	3,000	IRIS	1/28/2015
Trichloroethene	Chronic	2.00E-03	mg/m^3	Immune System	100	IRIS	1/28/2015
Vinyl chloride	Chronic	1.00E-01	mg/m^3	Liver	30	IRIS	1/28/2015
Aluminum	Chronic	5.00E-03	mg/m^3	Nervous system	300	PPRTV	2015 RSL Table
Antimony	---	NA	mg/m^3	---	---	---	---
Arsenic	Chronic	1.50E-05	mg/m^3	Developmental, Cardiovascular system, Nervous system, Lung, Skin	30	CalEPA	2015 RSL Table
Cadmium	Chronic	1.00E-05	mg/m^3	Kidney and Respiratory tract	9	ATSDR	2015 RSL Table
Chromium, Total[2]	Chronic	1.00E-04	mg/m^3	Respiratory tract	300	IRIS	1/28/2015
Cobalt	Chronic	6.00E-06	mg/m^3	Respiratory System	300	PPRTV	2015 RSL Table
Iron	---	NA	mg/m^3	---	---	---	---
Lead	---	NA	mg/m^3	---	---	---	---
Manganese	Chronic	5.00E-05	mg/m^3	Nervous system	1,000	IRIS	1/28/2015
Nickel	Chronic	9.00E-05	mg/m^3	Respiratory tract	30	ATSDR	2015 RSL Table
Thallium	---	NA	mg/m^3	---	---	---	---
Vanadium	Chronic	1.00E-04	mg/m^3	Respiratory tract	30	ATSDR	2015 RSL Table

(1) Represents date source was searched.
(2) Chromium VI (particulates) value used.

Definitions: ATSDR = Agency for Toxic Substances and Disease Registry.
CalEPA = California Environmental Protection Agency.
IRIS = Integrated Risk Information System.
NA = Not available.
PPRTV = Provisional Peer-Reviewed Toxicity Value (EPA, various dates).
RSL = Regional Screening Level.

TABLE A-6.1
CANCER TOXICITY DATA -- ORAL/DERMAL
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Contaminant of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (1)	Absorbed Cancer Slope Factor for Dermal (1)		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s)	Dates (2)
1,1,2-Trichloroethane	5.70E-02	$(mg/kg\text{-}day)^{-1}$	0.1	1.00E+00	$(mg/kg\text{-}day)^{-1}$	C	IRIS	1/28/2015
1,2-Dichloroethane	9.10E-02	$(mg/kg\text{-}day)^{-1}$	0.1	1.00E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1/28/2015
4-Nitrophenol	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	No information	---	---
Benzo(a)anthracene	7.30E-01	$(mg/kg\text{-}day)^{-1}$	0.7	1.00E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1/28/2015
Benzo(a)pyrene	7.30E+00	$(mg/kg\text{-}day)^{-1}$	7.3	1.00E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1/28/2015
Benzo(b)fluoranthene	7.30E-01	$(mg/kg\text{-}day)^{-1}$	0.7	1.00E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1/28/2015
Chloroform	3.10E-02	$(mg/kg\text{-}day)^{-1}$	0.0	1.00E+00	$(mg/kg\text{-}day)^{-1}$	B2	CalEPA	2015 RSL Table
cis-1,2-Dichloroethene	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	Inadequate Information	---	---
Dibenz(a,h)anthracene	7.30E+00	$(mg/kg\text{-}day)^{-1}$	7.3	1.00E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1/28/2015
Indeno(1,2,3-cd)pyrene	7.30E-01	$(mg/kg\text{-}day)^{-1}$	0.7	1.00E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1/28/2015
Methane	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	No information	---	---
Methylene chloride	2.00E-03	$(mg/kg\text{-}day)^{-1}$	0.0	1.00E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1/28/2015
Naphthalene	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	C	---	---
Trichloroethene	4.60E-02	$(mg/kg\text{-}day)^{-1}$	0.0	1.00E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/28/2015
Vinyl chloride	7.20E-01	$(mg/kg\text{-}day)^{-1}$	0.7	1.00E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/28/2015
Aluminum	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	No information	---	---
Antimony	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	Not assessed under IRIS	---	---
Arsenic	1.50E+00	$(mg/kg\text{-}day)^{-1}$	1.5	1.00E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/28/2015
Cadmium	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	B1	---	---
Chromium, Total[3]	5.00E-01	$(mg/kg\text{-}day)^{-1}$	0.50	1.00E+00	$(mg/kg\text{-}day)^{-1}$	D	NJDEP	2015 RSL Table
Cobalt	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	No information	---	---
Iron	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	No information	---	---
Lead	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	B2	---	---
Manganese	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	D	---	---
Nickel	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	No information	---	---
Thallium	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	No information	---	---
Vanadium	NA	$(mg/kg\text{-}day)^{-1}$	---	NA	$(mg/kg\text{-}day)^{-1}$	No information	---	---

(1) Source: RAGS Part E Guidance.
(2) Represents date source was searched.

(3) Chromium VI value used.

Definitions: CalEPA = California Environmental Protection Agency.
IRIS = Integrated Risk Information System.
NA = Not available.
NJDEP = New Jersey Department of Environmental Protection.
PPRTV = Provisional Peer-Reviewed Toxicity Value.
A - Human carcinogen.
B1 - Probable human carcinogen - indicates that limited human data are available.
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans.
C - Possible human carcinogen.
D - Not classifiable as a human carcinogen.

TABLE A-6.2
CANCER TOXICITY DATA -- INHALATION
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Contaminant of Potential Concern	Unit Risk		Weight of Evidence/ Cancer Guideline Description	Unit Risk: Inhalation CSF	
	Value	Units		Source(s)	Dates (1)
1,1,2-Trichloroethane	1.60E-05	$(\mu g/m^3)^{-1}$	C	IRIS	1/28/2015
1,2-Dichloroethane	2.60E-05	$(\mu g/m^3)^{-1}$	B2	IRIS	1/28/2015
4-Nitrophenol	NA	$(\mu g/m^3)^{-1}$	No information	---	---
Benzo(a)anthracene	1.10E-04	$(\mu g/m^3)^{-1}$	B2	CalEPA	2015 RSL Table
Benzo(a)pyrene	1.10E-03	$(\mu g/m^3)^{-1}$	B2	CalEPA	2015 RSL Table
Benzo(b)fluoranthene	1.10E-04	$(\mu g/m^3)^{-1}$	B2	CalEPA	2015 RSL Table
Chloroform	2.30E-05	$(\mu g/m^3)^{-1}$	B2	IRIS	1/28/2015
cis-1,2-Dichloroethene	NA	$(\mu g/m^3)^{-1}$	Inadequate Information	---	---
Dibenz(a,h)anthracene	1.20E-03	$(\mu g/m^3)^{-1}$	B2	CalEPA	2015 RSL Table
Indeno(1,2,3-cd)pyrene	1.10E-04	$(\mu g/m^3)^{-1}$	B2	CalEPA	2015 RSL Table
Methane	NA	$(\mu g/m^3)^{-1}$	No information	---	---
Methylene chloride	1.00E-08	$(\mu g/m^3)^{-1}$	B2	IRIS	1/28/2015
Naphthalene	3.40E-05	$(\mu g/m^3)^{-1}$	C	CalEPA	2015 RSL Table
Trichloroethene	4.10E-06	$(\mu g/m^3)^{-1}$	A	IRIS	1/28/2015
Vinyl chloride	4.40E-06	$(\mu g/m^3)^{-1}$	A	IRIS	1/28/2015
Aluminum	NA	$(\mu g/m^3)^{-1}$	No information	---	---
Antimony	NA	$(\mu g/m^3)^{-1}$	Not assessed under IRIS	---	---
Arsenic	4.30E-03	$(\mu g/m^3)^{-1}$	A	IRIS	1/28/2015
Cadmium	1.80E-03	$(\mu g/m^3)^{-1}$	B1	IRIS	1/28/2015
Chromium, Total [2]	8.40E-02	$(\mu g/m^3)^{-1}$	A	IRIS	1/28/2015
Cobalt	9.00E-03	$(\mu g/m^3)^{-1}$	No information	PPRTV	2015 RSL Table
Iron	NA	$(\mu g/m^3)^{-1}$	No information	---	---
Lead	NA	$(\mu g/m^3)^{-1}$	B2	---	---
Manganese	NA	$(\mu g/m^3)^{-1}$	D	---	---
Nickel	2.60E-04	$(\mu g/m^3)^{-1}$	No information	CalEPA	2015 RSL Table
Thallium	NA	$(\mu g/m^3)^{-1}$	No information	---	---
Vanadium	NA	$(\mu g/m^3)^{-1}$	No information	---	---

(1) Represents date source was searched.
(2) Chromium VI value used.

Definitions: CalEPA = California Environmental Protection Agency.
IRIS = Integrated Risk Information System.
NA = Not available.
PPRTV = Provisional Peer-Reviewed Toxicity Value.
A - Human carcinogen.
B1 - Probable human carcinogen - indicates that limited human data are available.
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans.
C - Possible human carcinogen.
D - Not classifiable as a human carcinogen.

TABLE A-7.1-1 RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - SEDIMENT - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: River Recreational Visitor
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Sediment	Sediment	Sediment unnamed stream	Ingestion	Benzo(a)anthracene	2.70E-01	mg/kg	5.8E-09	mg/kg-day	7.3E-01	(mg/kg-day)^-1	4.2E-09	2.0E-08	mg/kg-day	NA	---	NA
				Benzo(a)pyrene	2.40E-01	mg/kg	5.2E-09	mg/kg-day	7.3E+00	(mg/kg-day)^-1	3.8E-08	1.8E-08	mg/kg-day	NA	---	NA
				Benzo(b)fluoranthene	5.70E-01	mg/kg	1.2E-08	mg/kg-day	7.3E-01	(mg/kg-day)^-1	9.0E-09	4.3E-08	mg/kg-day	NA	---	NA
				Dibenz(a,h)anthracene	5.10E-01	mg/kg	1.1E-08	mg/kg-day	7.3E+00	(mg/kg-day)^-1	8.0E-08	3.8E-08	mg/kg-day	NA	---	NA
				Indeno(1,2,3-cd)pyrene	5.00E-01	mg/kg	1.1E-08	mg/kg-day	7.3E-01	(mg/kg-day)^-1	7.9E-09	3.8E-08	mg/kg-day	NA	---	NA
				Arsenic	4.50E+00	mg/kg	9.7E-08	mg/kg-day	1.5E+00	(mg/kg-day)^-1	1.5E-07	3.4E-07	mg/kg-day	3.0E-04	mg/kg-day	0.0011
				Chromium	1.10E+01	mg/kg	2.4E-07	mg/kg-day	5.0E-01	(mg/kg-day)^-1	1.2E-07	8.3E-07	mg/kg-day	3.0E-03	mg/kg-day	0.00028
				Cobalt	4.10E+00	mg/kg	8.8E-08	mg/kg-day	NA	---	NA	3.1E-07	mg/kg-day	3.0E-04	mg/kg-day	0.0010
				Iron	1.20E+04	mg/kg	2.6E-04	mg/kg-day	NA	---	NA	9.0E-04	mg/kg-day	7.0E-01	mg/kg-day	0.0013
			Ingestion Total								4.0E-07					0.0037
			Dermal	Benzo(a)anthracene	2.70E-01	mg/kg	1.4E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	1.4E-08	4.8E-08	mg/kg-day	NA	---	NA
				Benzo(a)pyrene	2.40E-01	mg/kg	1.2E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	1.2E-08	4.3E-08	mg/kg-day	NA	---	NA
				Benzo(b)fluoranthene	5.70E-01	mg/kg	2.9E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	2.9E-08	1.0E-07	mg/kg-day	NA	---	NA
				Dibenz(a,h)anthracene	5.10E-01	mg/kg	2.6E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	2.6E-08	9.0E-08	mg/kg-day	NA	---	NA
				Indeno(1,2,3-cd)pyrene	5.00E-01	mg/kg	2.5E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	2.5E-08	8.9E-08	mg/kg-day	NA	---	NA
				Arsenic	4.50E+00	mg/kg	5.3E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	5.3E-08	1.8E-07	mg/kg-day	3.0E-04	mg/kg-day	0.00061
				Chromium	1.10E+01	mg/kg	NA	---	1.0E+00	(mg/kg-day)^-1	NA	NA	---	7.5E-05	mg/kg-day	NA
				Cobalt	4.10E+00	mg/kg	NA	---	NA	---	NA	NA	---	3.0E-04	mg/kg-day	NA
				Iron	1.20E+04	mg/kg	NA	---	NA	---	NA	NA	---	7.0E-01	mg/kg-day	NA
			Dermal Total								1.6E-07					0.00061
Sediment Total											5.6E-07					0.0043

TABLE A-7.2-1 RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - SEDIMENT - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: River Recreational Visitor
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Sediment	Sediment	Sediment unnamed stream	Ingestion	Benzo(a)anthracene	2.70E-01	mg/kg	Mutagenic Mode of Action Calculation; see Table H-1 RME				7.2E-08	2.2E-07	mg/kg-day	NA	---	NA
				Benzo(a)pyrene	2.40E-01	mg/kg	Mutagenic Mode of Action Calculation; see Table H-1 RME				6.4E-07	1.9E-07	mg/kg-day	NA	---	NA
				Benzo(b)fluoranthene	5.70E-01	mg/kg	Mutagenic Mode of Action Calculation; see Table H-1 RME				1.5E-07	4.6E-07	mg/kg-day	NA	---	NA
				Dibenz(a,h)anthracene	5.10E-01	mg/kg	Mutagenic Mode of Action Calculation; see Table H-1 RME				1.4E-06	4.1E-07	mg/kg-day	NA	---	NA
				Indeno(1,2,3-cd)pyrene	5.00E-01	mg/kg	Mutagenic Mode of Action Calculation; see Table H-1 RME				1.3E-07	4.0E-07	mg/kg-day	NA	---	NA
				Arsenic	4.50E+00	mg/kg	3.1E-07	mg/kg-day	1.5E+00	(mg/kg-day)^-1	4.6E-07	3.6E-06	mg/kg-day	3.0E-04	mg/kg-day	0.012
				Chromium	1.10E+01	mg/kg	Mutagenic Mode of Action Calculation; see Table H-1 RME				2.0E-06	8.8E-06	mg/kg-day	3.0E-03	mg/kg-day	0.0029
				Cobalt	4.10E+00	mg/kg	2.8E-07	mg/kg-day	NA	---	NA	3.3E-06	mg/kg-day	3.0E-04	mg/kg-day	0.011
				Iron	1.20E+04	mg/kg	8.3E-04	mg/kg-day	NA	---	NA	9.6E-03	mg/kg-day	7.0E-01	mg/kg-day	0.014
			Ingestion Total								4.9E-06					0.040
			Dermal	Benzo(a)anthracene	2.70E-01	mg/kg	Mutagenic Mode of Action Calculation; see Table H-1 RME				3.5E-08	7.6E-08	mg/kg-day	NA	---	NA
				Benzo(a)pyrene	2.40E-01	mg/kg	Mutagenic Mode of Action Calculation; see Table H-1 RME				3.1E-08	6.7E-08	mg/kg-day	NA	---	NA
				Benzo(b)fluoranthene	5.70E-01	mg/kg	Mutagenic Mode of Action Calculation; see Table H-1 RME				7.3E-08	1.6E-07	mg/kg-day	NA	---	NA
				Dibenz(a,h)anthracene	5.10E-01	mg/kg	Mutagenic Mode of Action Calculation; see Table H-1 RME				6.6E-08	1.4E-07	mg/kg-day	NA	---	NA
				Indeno(1,2,3-cd)pyrene	5.00E-01	mg/kg	Mutagenic Mode of Action Calculation; see Table H-1 RME				6.4E-08	1.4E-07	mg/kg-day	NA	---	NA
				Arsenic	4.50E+00	mg/kg	2.5E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	2.5E-08	2.9E-07	mg/kg-day	3.0E-04	mg/kg-day	0.0010
				Chromium	1.10E+01	mg/kg	Mutagenic Mode of Action Calculation; see Table H-1 RME				NA	NA	---	7.5E-05	mg/kg-day	NA
				Cobalt	4.10E+00	mg/kg	NA	---	NA	---	NA	NA	---	3.0E-04	mg/kg-day	NA
				Iron	1.20E+04	mg/kg	NA	---	NA	---	NA	NA	---	7.0E-01	mg/kg-day	NA
			Dermal Total								2.9E-07					0.0010
Sediment Total											5.1E-06					0.041

TABLE A-7.3-2 RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - SURFACE WATER - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: River Recreational Visitor
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water	Surface Water	Surface Water Unnamed stream	Dermal	cis-1,2-Dichloroethene	3.90E+01	ug/L	1.1E-06	mg/kg-day	NA	---	NA	3.8E-06	mg/kg-day	2.0E-03	mg/kg-day	0.0019
				Trichloroethene	1.50E+01	ug/L	7.9E-07	mg/kg-day	1.0E+00	(mg/kg-day)^-1	7.9E-07	2.8E-06	mg/kg-day	5.0E-04	mg/kg-day	0.0055
				Vinyl chloride	3.40E+00	ug/L	6.1E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	6.1E-08	2.1E-07	mg/kg-day	3.0E-03	mg/kg-day	0.000072
			Dermal Total								8.5E-07					0.0075
Surface Water Total											8.5E-07					0.0075

TABLE A-7.4-2 RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - SURFACE WATER - CHILD

COMMERCE STREET PLUME SUPERFUND SITE

WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: River Recreational Visitor
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water	Surface Water	Surface Water Unnamed stream	Dermal	cis-1,2-Dichloroethene	3.90E+01	ug/L	7.7E-07	mg/kg-day	NA	---	NA	9.0E-06	mg/kg-day	2.0E-03	mg/kg-day	0.0045
				Trichloroethene	1.50E+01	ug/L	Mutagenic Mode of Action Calculation; see Table H-2b RME				4.9E-08	6.6E-06	mg/kg-day	5.0E-04	mg/kg-day	0.013
				Vinyl chloride	3.40E+00	ug/L	4.4E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	8.5E-06	5.1E-07	mg/kg-day	3.0E-03	mg/kg-day	0.00017
			Dermal Total								8.6E-06					0.018
Surface Water Total											8.6E-06					0.018

TABLE A-7.5-3 RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - SHALLOW GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Shallow Groundwater in construction trenches	Dermal	Benzo(a)pyrene	1.50E-01	ug/L	3.0E-07	mg/kg-day	1.0E+00	(mg/kg-day)^-1	3.0E-07	2.1E-05	mg/kg-day	NA	---	NA
				Chloroform	1.90E+00	ug/L	2.6E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	2.6E-08	1.8E-06	mg/kg-day	1.0E-02	mg/kg-day	0.00018
				Naphthalene	1.80E+00	ug/L	1.8E-07	mg/kg-day	NA	---	NA	1.2E-05	mg/kg-day	2.0E-02	mg/kg-day	0.00062
				Trichloroethene	4.80E+00	ug/L	1.2E-07	mg/kg-day	1.0E+00	(mg/kg-day)^-1	1.2E-07	8.3E-06	mg/kg-day	5.0E-04	mg/kg-day	0.017
				Antimony	1.40E+00	ug/L	2.5E-09	mg/kg-day	NA	---	NA	1.7E-07	mg/kg-day	6.0E-05	mg/kg-day	0.0029
				Arsenic	1.18E+01	ug/L	2.1E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	2.1E-08	1.5E-06	mg/kg-day	3.0E-04	mg/kg-day	0.0049
				Cadmium	5.43E+01	ug/L	9.6E-08	mg/kg-day	NA	---	NA	6.7E-06	mg/kg-day	2.5E-05	mg/kg-day	0.27
				Chromium	2.71E+01	ug/L	9.6E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	9.6E-08	6.7E-06	mg/kg-day	7.5E-05	mg/kg-day	0.089
				Cobalt	7.10E+00	ug/L	1.3E-08	mg/kg-day	NA	---	NA	8.8E-07	mg/kg-day	3.0E-04	mg/kg-day	0.0029
				Iron	3.44E+04	ug/L	6.1E-05	mg/kg-day	NA	---	NA	4.3E-03	mg/kg-day	7.0E-01	mg/kg-day	0.0061
				Manganese	4.42E+03	ug/L	7.8E-06	mg/kg-day	NA	---	NA	5.5E-04	mg/kg-day	1.4E-01	mg/kg-day	0.0039
				Thallium	2.90E-01	ug/L	5.1E-10	mg/kg-day	NA	---	NA	3.6E-08	mg/kg-day	1.0E-05	mg/kg-day	0.0036
			Dermal Total								5.6E-07					0.40
		Total Trench Groundwater									5.6E-07					0.40
		Vapors in construction trenches	Inhalation	Chloroform	1.43E-02	mg/m^3	2.4E-05	mg/m^3	2.3E-05	(µg/m^3)^-1	5.6E-07	1.7E-03	mg/m^3	9.8E-02	mg/m^3	0.017
				Naphthalene	1.19E-02	mg/m^3	2.0E-05	mg/m^3	3.4E-05	(µg/m^3)^-1	6.9E-07	1.4E-03	mg/m^3	3.0E-03	mg/m^3	0.47
				Trichloroethene	3.48E-02	mg/m^3	5.9E-05	mg/m^3	4.1E-06	(µg/m^3)^-1	2.4E-07	4.1E-03	mg/m^3	2.0E-03	mg/m^3	2.1
			Inhalation Total								1.5E-06					2.6
		Total Trench Vapor									1.5E-06					2.6
Shallow Groundwater Total											2.0E-06					3.0

TABLE A-7.5-3 CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - SHALLOW GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Shallow Groundwater in construction trenches	Dermal	Benzo(a)pyrene	1.50E-01	ug/L	5.9E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	5.9E-08	4.2E-06	mg/kg-day	NA	---	NA
				Chloroform	1.90E+00	ug/L	5.1E-09	mg/kg-day	1.0E+00	(mg/kg-day)^-1	5.1E-09	3.6E-07	mg/kg-day	1.0E-02	mg/kg-day	0.000036
				Naphthalene	1.80E+00	ug/L	3.6E-08	mg/kg-day	NA	---	NA	2.5E-06	mg/kg-day	2.0E-02	mg/kg-day	0.00012
				Trichloroethene	4.80E+00	ug/L	2.4E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	2.4E-08	1.7E-06	mg/kg-day	5.0E-04	mg/kg-day	0.0033
				Antimony	1.40E+00	ug/L	4.9E-10	mg/kg-day	NA	---	NA	3.5E-08	mg/kg-day	6.0E-05	mg/kg-day	0.00058
				Arsenic	1.18E+01	ug/L	4.2E-09	mg/kg-day	1.0E+00	(mg/kg-day)^-1	4.2E-09	2.9E-07	mg/kg-day	3.0E-04	mg/kg-day	0.0010
				Cadmium	5.43E+01	ug/L	1.9E-08	mg/kg-day	NA	---	NA	1.3E-06	mg/kg-day	2.5E-05	mg/kg-day	0.054
				Chromium	2.71E+01	ug/L	1.9E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	1.9E-08	1.3E-06	mg/kg-day	7.5E-05	mg/kg-day	0.018
				Cobalt	7.10E+00	ug/L	2.5E-09	mg/kg-day	NA	---	NA	1.8E-07	mg/kg-day	3.0E-04	mg/kg-day	0.00058
				Iron	3.44E+04	ug/L	1.2E-05	mg/kg-day	NA	---	NA	8.5E-04	mg/kg-day	7.0E-01	mg/kg-day	0.0012
				Manganese	4.42E+03	ug/L	1.6E-06	mg/kg-day	NA	---	NA	1.1E-04	mg/kg-day	1.4E-01	mg/kg-day	0.00078
				Thallium	2.90E-01	ug/L	1.0E-10	mg/kg-day	NA	---	NA	7.2E-09	mg/kg-day	1.0E-05	mg/kg-day	0.00072
			Dermal Total								1.1E-07					0.080
			Inhalation	Chloroform	1.43E-02	mg/m^3	4.9E-06	mg/m^3	2.3E-05	(µg/m^3)^-1	1.1E-07	3.4E-04	mg/m^3	9.8E-02	mg/m^3	0.0035
				Naphthalene	1.19E-02	mg/m^3	4.0E-06	mg/m^3	3.4E-05	(µg/m^3)^-1	1.4E-07	2.8E-04	mg/m^3	3.0E-03	mg/m^3	0.094
				Trichloroethene	3.48E-02	mg/m^3	1.2E-05	mg/m^3	4.1E-06	(µg/m^3)^-1	4.8E-08	8.3E-04	mg/m^3	2.0E-03	mg/m^3	0.41
			Inhalation Total								3.0E-07					0.51
Shallow Groundwater Total											4.1E-07					0.59

TABLE A-7.6-4 RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - OVERBURDEN GROUNDWATER - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Site	Ingestion	1,1,2-Trichloroethane	1.54E-01	µg/L	---	---	---	---	---	4.6E-06	mg/kg-day	4E-03	(mg/kg-day)	0.0012
				1,2-Dichloroethane	1.02E+00	µg/L	---	---	---	---	---	3.1E-05	mg/kg-day	6E-03	(mg/kg-day)	0.0051
				cis-1,2-Dichloroethene	3.01E+02	µg/L	---	---	---	---	---	9.0E-03	mg/kg-day	2E-03	(mg/kg-day)	4.5
				Methane	1.40E+02	µg/L	---	---	---	---	---	4.2E-03	mg/kg-day	NA	---	NA
				Methylene chloride	5.90E+02	µg/L	---	---	---	---	---	1.8E-02	mg/kg-day	6E-03	(mg/kg-day)	2.9
				Trichloroethene	8.91E+03	µg/L	---	---	---	---	---	2.7E-01	mg/kg-day	5E-04	(mg/kg-day)	534
				Vinyl Chloride	3.70E+00	µg/L	---	---	---	---	---	1.1E-04	mg/kg-day	3E-03	(mg/kg-day)	0.037
				Aluminum	1.07E+04	µg/L	---	---	---	---	---	3.2E-01	mg/kg-day	1E+00	(mg/kg-day)	0.32
				Arsenic	9.26E+00	µg/L	---	---	---	---	---	2.8E-04	mg/kg-day	3E-04	(mg/kg-day)	0.92
				Chromium	5.30E+01	ug/L	---	---	---	---	---	1.6E-03	mg/kg-day	3E-03	(mg/kg-day)	0.53
				Cobalt	9.51E+00	µg/L	---	---	---	---	---	2.8E-04	mg/kg-day	3E-04	(mg/kg-day)	0.95
				Iron	1.81E+04	µg/L	---	---	---	---	---	5.4E-01	mg/kg-day	7E-01	(mg/kg-day)	0.78
				Lead	6.11E+00	µg/L	---	---	---	---	---	1.8E-04	mg/kg-day	NA	---	NA
				Manganese	8.40E+02	µg/L	---	---	---	---	---	2.5E-02	mg/kg-day	1E-01	(mg/kg-day)	0.18
				Nickel	2.66E+01	µg/L	---	---	---	---	---	8.0E-04	mg/kg-day	2E-02	(mg/kg-day)	0.040
				Thallium	7.14E-02	µg/L	---	---	---	---	---	2.1E-06	mg/kg-day	1E-05	(mg/kg-day)	0.21
Groundwater	Groundwater	Site	Ingestion	Vanadium	2.04E+01	µg/L	---	---	---	---	---	6.1E-04	mg/kg-day	5E-03	(mg/kg-day)	0.12
			Ingestion Total								---					546
			Dermal	1,1,2-Trichloroethane	1.54E-01	µg/L	---	---	---	---	---	4.5E-07	mg/kg-day	4E-03	(mg/kg-day)^-1	0.00011
				1,2-Dichloroethane	1.02E+00	µg/L	---	---	---	---	---	1.5E-06	mg/kg-day	6E-03	(mg/kg-day)^-1	0.00026
				cis-1,2-Dichloroethene	3.01E+02	µg/L	---	---	---	---	---	8.2E-04	mg/kg-day	2E-03	(mg/kg-day)^-1	0.41
				Methane	1.40E+02	µg/L	---	---	---	---	---	2.3E-04	mg/kg-day	NA	---	NA
				Methylene chloride	5.90E+02	µg/L	---	---	---	---	---	6.8E-04	mg/kg-day	6E-03	(mg/kg-day)^-1	0.11
				Trichloroethene	8.91E+03	µg/L	---	---	---	---	---	4.8E-02	mg/kg-day	5E-04	(mg/kg-day)^-1	95
				Vinyl Chloride	3.70E+00	µg/L	---	---	---	---	---	6.2E-06	mg/kg-day	3E-03	(mg/kg-day)^-1	0.0021
				Aluminum	1.07E+04	µg/L	---	---	---	---	---	1.9E-03	mg/kg-day	1E+00	(mg/kg-day)^-1	0.0019
				Arsenic	9.26E+00	µg/L	---	---	---	---	---	1.6E-06	mg/kg-day	3E-04	(mg/kg-day)^-1	0.0055
				Chromium	5.30E+01	ug/L	---	---	---	---	---	1.9E-05	mg/kg-day	8E-05	(mg/kg-day)^-1	0.25
				Cobalt	9.51E+00	µg/L	---	---	---	---	---	1.7E-06	mg/kg-day	3E-04	(mg/kg-day)^-1	0.0056
				Iron	1.81E+04	µg/L	---	---	---	---	---	3.2E-03	mg/kg-day	7E-01	(mg/kg-day)^-1	0.0046
				Lead	6.11E+00	µg/L	---	---	---	---	---	1.1E-06	mg/kg-day	NA	---	NA
				Manganese	8.40E+02	µg/L	---	---	---	---	---	1.5E-04	mg/kg-day	1E-01	(mg/kg-day)^-1	0.0011
				Nickel	2.66E+01	µg/L	---	---	---	---	---	9.5E-07	mg/kg-day	8E-04	(mg/kg-day)^-1	0.0012
				Thallium	7.14E-02	µg/L	---	---	---	---	---	1.3E-08	mg/kg-day	1E-05	(mg/kg-day)^-1	0.0013
				Vanadium	2.04E+01	µg/L	---	---	---	---	---	3.6E-06	mg/kg-day	1E-04	(mg/kg-day)^-1	0.028
			Dermal Total								---					96
	Total Site Groundwater										---					641

TABLE A-7.6-4 RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - OVERBURDEN GROUNDWATER - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Vapors in Air (during household water use)	Site	Inhalation	1,1,2-Trichloroethane	7.70E-05	mg/m^3	---	---	---	---	---	7.4E-05	mg/m^3	2E-04	mg/m^3	0.37
				1,2-Dichloroethane	5.10E-04	mg/m^3	---	---	---	---	---	4.9E-04	mg/m^3	7E-03	mg/m^3	0.070
				cis-1,2-Dichloroethene	1.51E-01	mg/m^3	---	---	---	---	---	1.4E-01	mg/m^3	NA	mg/m^3	NA
				Methane	7.00E-02	mg/m^3	---	---	---	---	---	6.7E-02	mg/m^3	NA	mg/m^3	NA
				Methylene chloride	2.95E-01	mg/m^3	---	---	---	---	---	2.8E-01	mg/m^3	6E-01	mg/m^3	0.47
				Trichloroethene	4.46E+00	mg/m^3	---	---	---	---	---	4.3E+00	mg/m^3	2E-03	mg/m^3	2136
				Vinyl Chloride	1.85E-03	mg/m^3	---	---	---	---	---	1.8E-03	mg/m^3	1E-01	mg/m^3	0.018
			Inhalation Total								---					2137
	Total Site Vapors in Air										---					2137
Overburden Groundwater Total											---					2778

TABLE A-7.6-4 CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - OVERBURDEN GROUNDWATER - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Site	Ingestion	1,1,2-Trichloroethane	1.54E-01	µg/L	---	---	---	---	---	2.3E-06	mg/kg-day	4E-03	(mg/kg-day)	0.00058
				1,2-Dichloroethane	1.02E+00	µg/L	---	---	---	---	---	1.5E-05	mg/kg-day	6E-03	(mg/kg-day)	0.0025
				cis-1,2-Dichloroethene	3.01E+02	µg/L	---	---	---	---	---	4.5E-03	mg/kg-day	2E-03	(mg/kg-day)	2.3
				Methane	1.40E+02	µg/L	---	---	---	---	---	2.1E-03	mg/kg-day	NA	---	NA
				Methylene chloride	5.90E+02	µg/L	---	---	---	---	---	8.8E-03	mg/kg-day	6E-03	(mg/kg-day)	1.5
				Trichloroethene	8.91E+03	µg/L	---	---	---	---	---	1.3E-01	mg/kg-day	5E-04	(mg/kg-day)	267
				Vinyl Chloride	3.70E+00	µg/L	---	---	---	---	---	5.5E-05	mg/kg-day	3E-03	(mg/kg-day)	0.018
				Aluminum	1.07E+04	µg/L	---	---	---	---	---	1.6E-01	mg/kg-day	1E+00	(mg/kg-day)	0.16
				Arsenic	9.26E+00	µg/L	---	---	---	---	---	1.4E-04	mg/kg-day	3E-04	(mg/kg-day)	0.46
				Chromium	5.30E+01	ug/L	---	---	---	---	---	7.9E-04	mg/kg-day	3E-03	(mg/kg-day)	0.26
				Cobalt	9.51E+00	µg/L	---	---	---	---	---	1.4E-04	mg/kg-day	3E-04	(mg/kg-day)	0.47
				Iron	1.81E+04	µg/L	---	---	---	---	---	2.7E-01	mg/kg-day	7E-01	(mg/kg-day)	0.39
				Lead	6.11E+00	µg/L	---	---	---	---	---	9.2E-05	mg/kg-day	NA	---	NA
				Manganese	8.40E+02	µg/L	---	---	---	---	---	1.3E-02	mg/kg-day	1E-01	(mg/kg-day)	0.090
				Nickel	2.66E+01	µg/L	---	---	---	---	---	4.0E-04	mg/kg-day	2E-02	(mg/kg-day)	0.020
				Thallium	7.14E-02	µg/L	---	---	---	---	---	1.1E-06	mg/kg-day	1E-05	(mg/kg-day)	0.11
Groundwater	Groundwater	Site	Ingestion	Vanadium	2.04E+01	µg/L	---	---	---	---	---	3.1E-04	mg/kg-day	5E-03	(mg/kg-day)	0.06
			Ingestion Total								---					273
			Dermal	1,1,2-Trichloroethane	1.54E-01	µg/L	---	---	---	---	---	3.2E-07	mg/kg-day	4E-03	(mg/kg-day)^-1	0.000079
				1,2-Dichloroethane	1.02E+00	µg/L	---	---	---	---	---	1.1E-06	mg/kg-day	6E-03	(mg/kg-day)^-1	0.00018
				cis-1,2-Dichloroethene	3.01E+02	µg/L	---	---	---	---	---	5.8E-04	mg/kg-day	2E-03	(mg/kg-day)^-1	0.29
				Methane	1.40E+02	µg/L	---	---	---	---	---	1.5E-04	mg/kg-day	NA	---	NA
				Methylene chloride	5.90E+02	µg/L	---	---	---	---	---	4.9E-04	mg/kg-day	6E-03	(mg/kg-day)^-1	0.081
				Trichloroethene	8.91E+03	µg/L	---	---	---	---	---	3.4E-02	mg/kg-day	5E-04	(mg/kg-day)^-1	68
				Vinyl Chloride	3.70E+00	µg/L	---	---	---	---	---	4.2E-06	mg/kg-day	3E-03	(mg/kg-day)^-1	0.0014
				Aluminum	1.07E+04	µg/L	---	---	---	---	---	9.6E-04	mg/kg-day	1E+00	(mg/kg-day)^-1	0.0010
				Arsenic	9.26E+00	µg/L	---	---	---	---	---	8.3E-07	mg/kg-day	3E-04	(mg/kg-day)^-1	0.0028
				Chromium	5.30E+01	ug/L	---	---	---	---	---	9.6E-06	mg/kg-day	8E-05	(mg/kg-day)^-1	0.13
				Cobalt	9.51E+00	µg/L	---	---	---	---	---	8.6E-07	mg/kg-day	3E-04	(mg/kg-day)^-1	0.0029
				Iron	1.81E+04	µg/L	---	---	---	---	---	1.6E-03	mg/kg-day	7E-01	(mg/kg-day)^-1	0.0023
				Lead	6.11E+00	µg/L	---	---	---	---	---	5.5E-07	mg/kg-day	NA	---	NA
				Manganese	8.40E+02	µg/L	---	---	---	---	---	7.6E-05	mg/kg-day	1E-01	(mg/kg-day)^-1	0.00054
				Nickel	2.66E+01	µg/L	---	---	---	---	---	4.8E-07	mg/kg-day	8E-04	(mg/kg-day)^-1	0.00060
				Thallium	7.14E-02	µg/L	---	---	---	---	---	6.4E-09	mg/kg-day	1E-05	(mg/kg-day)^-1	0.00064
				Vanadium	2.04E+01	µg/L	---	---	---	---	---	1.8E-06	mg/kg-day	1E-04	(mg/kg-day)^-1	0.014
			Dermal Total								---					68
	Total Site Groundwater										---					341

TABLE A-7.6-4 CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - OVERBURDEN GROUNDWATER - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Vapors in Air (during household water use)	Site	Inhalation	1,1,2-Trichloroethane	7.70E-05	mg/m^3	---	---	---	---	---	7.4E-05	mg/m^3	2E-04	mg/m^3	0.37
				1,2-Dichloroethane	5.10E-04	mg/m^3	---	---	---	---	---	4.9E-04	mg/m^3	7E-03	mg/m^3	0.070
				cis-1,2-Dichloroethene	1.51E-01	mg/m^3	---	---	---	---	---	1.4E-01	mg/m^3	NA	mg/m^3	NA
				Methane	7.00E-02	mg/m^3	---	---	---	---	---	6.7E-02	mg/m^3	NA	mg/m^3	NA
				Methylene chloride	2.95E-01	mg/m^3	---	---	---	---	---	2.8E-01	mg/m^3	6E-01	mg/m^3	0.47
				Trichloroethene	4.46E+00	mg/m^3	---	---	---	---	---	4.3E+00	mg/m^3	2E-03	mg/m^3	2136
				Vinyl Chloride	1.85E-03	mg/m^3	---	---	---	---	---	1.8E-03	mg/m^3	1E-01	mg/m^3	0.018
			Inhalation Total								---					2137
	Total Site Vapors in Air										---					2137
Overburden Groundwater Total											---					2478

TABLE A-7.7-4 RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - GROUNDWATER - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Site	Ingestion	1,1,2-Trichloroethane	1.54E-01	µg/L	---	---	---	---	---	7.7E-06	mg/kg-day	4E-03	(mg/kg-day)	0.0019
				1,2-Dichloroethane	1.02E+00	µg/L	---	---	---	---	---	5.1E-05	mg/kg-day	6E-03	(mg/kg-day)	0.0085
				cis-1,2-Dichloroethene	3.01E+02	µg/L	---	---	---	---	---	1.5E-02	mg/kg-day	2E-03	(mg/kg-day)	7.5
				Methane	1.40E+02	µg/L	---	---	---	---	---	7.0E-03	mg/kg-day	NA	---	NA
				Methylene chloride	5.90E+02	µg/L	---	---	---	---	---	2.9E-02	mg/kg-day	6E-03	(mg/kg-day)	4.9
				Trichloroethene	8.91E+03	µg/L	---	---	---	---	---	4.4E-01	mg/kg-day	5E-04	(mg/kg-day)	889
				Vinyl Chloride	3.70E+00	µg/L	---	---	---	---	---	1.8E-04	mg/kg-day	3E-03	(mg/kg-day)	0.061
				Aluminum	1.07E+04	µg/L	---	---	---	---	---	5.3E-01	mg/kg-day	1E+00	(mg/kg-day)	0.53
				Arsenic	9.26E+00	µg/L	---	---	---	---	---	4.6E-04	mg/kg-day	3E-04	(mg/kg-day)	1.5
				Chromium	5.30E+01	ug/L	---	---	---	---	---	2.6E-03	mg/kg-day	3E-03	(mg/kg-day)	0.88
				Cobalt	9.51E+00	µg/L	---	---	---	---	---	4.7E-04	mg/kg-day	3E-04	(mg/kg-day)	1.6
				Iron	1.81E+04	µg/L	---	---	---	---	---	9.0E-01	mg/kg-day	7E-01	(mg/kg-day)	1.3
				Lead	6.11E+00	µg/L	---	---	---	---	---	3.0E-04	mg/kg-day	NA	---	NA
				Manganese	8.40E+02	µg/L	---	---	---	---	---	4.2E-02	mg/kg-day	1E-01	(mg/kg-day)	0.30
				Nickel	2.66E+01	µg/L	---	---	---	---	---	1.3E-03	mg/kg-day	2E-02	(mg/kg-day)	0.066
				Thallium	7.14E-02	µg/L	---	---	---	---	---	3.6E-06	mg/kg-day	1E-05	(mg/kg-day)	0.36
Groundwater	Groundwater	Site	Ingestion	Vanadium	2.04E+01	µg/L	---	---	---	---	---	1.0E-03	mg/kg-day	5E-03	(mg/kg-day)	0.20
			Ingestion Total								---					908
			Dermal	1,1,2-Trichloroethane	1.54E-01	µg/L	---	---	---	---	---	6.3E-07	mg/kg-day	4E-03	(mg/kg-day)^-1	0.00016
				1,2-Dichloroethane	1.02E+00	µg/L	---	---	---	---	---	2.2E-06	mg/kg-day	6E-03	(mg/kg-day)^-1	0.00036
				cis-1,2-Dichloroethene	3.01E+02	µg/L	---	---	---	---	---	1.2E-03	mg/kg-day	2E-03	(mg/kg-day)^-1	0.58
				Methane	1.40E+02	µg/L	---	---	---	---	---	3.1E-04	mg/kg-day	NA	---	NA
				Methylene chloride	5.90E+02	µg/L	---	---	---	---	---	9.7E-04	mg/kg-day	6E-03	(mg/kg-day)^-1	0.16
				Trichloroethene	8.91E+03	µg/L	---	---	---	---	---	6.7E-02	mg/kg-day	5E-04	(mg/kg-day)^-1	135
				Vinyl Chloride	3.70E+00	µg/L	---	---	---	---	---	8.4E-06	mg/kg-day	3E-03	(mg/kg-day)^-1	0.0028
				Aluminum	1.07E+04	µg/L	---	---	---	---	---	2.4E-03	mg/kg-day	1E+00	(mg/kg-day)^-1	0.0024
				Arsenic	9.26E+00	µg/L	---	---	---	---	---	2.0E-06	mg/kg-day	3E-04	(mg/kg-day)^-1	0.0068
				Chromium	5.30E+01	ug/L	---	---	---	---	---	2.3E-05	mg/kg-day	8E-05	(mg/kg-day)^-1	0.31
				Cobalt	9.51E+00	µg/L	---	---	---	---	---	2.1E-06	mg/kg-day	3E-04	(mg/kg-day)^-1	0.0070
				Iron	1.81E+04	µg/L	---	---	---	---	---	4.0E-03	mg/kg-day	7E-01	(mg/kg-day)^-1	0.0057
				Lead	6.11E+00	µg/L	---	---	---	---	---	1.3E-06	mg/kg-day	NA	---	NA
				Manganese	8.40E+02	µg/L	---	---	---	---	---	1.9E-04	mg/kg-day	1E-01	(mg/kg-day)^-1	0.0013
				Nickel	2.66E+01	µg/L	---	---	---	---	---	1.2E-06	mg/kg-day	8E-04	(mg/kg-day)^-1	0.0015
				Thallium	7.14E-02	µg/L	---	---	---	---	---	1.6E-08	mg/kg-day	1E-05	(mg/kg-day)^-1	0.0016
				Vanadium	2.04E+01	µg/L	---	---	---	---	---	4.5E-06	mg/kg-day	1E-04	(mg/kg-day)^-1	0.034
			Dermal Total								---					136
	Total Site Groundwater										---					1044

TABLE A-7.7-4 RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - GROUNDWATER - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Vapors in Air (during household water use)	Site	Inhalation	1,1,2-Trichloroethane	7.70E-05	mg/m^3	---	---	---	---	---	7.4E-05	mg/m^3	2E-04	mg/m^3	0.37
				1,2-Dichloroethane	5.10E-04	mg/m^3	---	---	---	---	---	4.9E-04	mg/m^3	7E-03	mg/m^3	0.070
				cis-1,2-Dichloroethene	1.51E-01	mg/m^3	---	---	---	---	---	1.4E-01	mg/m^3	NA	mg/m^3	NA
				Methane	7.00E-02	mg/m^3	---	---	---	---	---	6.7E-02	mg/m^3	NA	mg/m^3	NA
				Methylene chloride	2.95E-01	mg/m^3	---	---	---	---	---	2.8E-01	mg/m^3	6E-01	mg/m^3	0.47
				Trichloroethene	4.46E+00	mg/m^3	---	---	---	---	---	4.3E+00	mg/m^3	2E-03	mg/m^3	2136
				Vinyl Chloride	1.85E-03	mg/m^3	---	---	---	---	---	1.8E-03	mg/m^3	1E-01	mg/m^3	0.018
			Inhalation Total								---					2137
	Total Site Vapors in Air										---					2137
Overburden Groundwater Total											---					3181

TABLE A-7.7-4 CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - OVERBURDEN GROUNDWATER - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Site	Ingestion	1,1,2-Trichloroethane	1.54E-01	µg/L	---	---	---	---	---	3.8E-06	mg/kg-day	4E-03	(mg/kg-day)	0.0010
				1,2-Dichloroethane	1.02E+00	µg/L	---	---	---	---	---	2.5E-05	mg/kg-day	6E-03	(mg/kg-day)	0.0042
				cis-1,2-Dichloroethene	3.01E+02	µg/L	---	---	---	---	---	7.5E-03	mg/kg-day	2E-03	(mg/kg-day)	3.8
				Methane	1.40E+02	µg/L	---	---	---	---	---	3.5E-03	mg/kg-day	NA	---	NA
				Methylene chloride	5.90E+02	µg/L	---	---	---	---	---	1.5E-02	mg/kg-day	6E-03	(mg/kg-day)	2.5
				Trichloroethene	8.91E+03	µg/L	---	---	---	---	---	2.2E-01	mg/kg-day	5E-04	(mg/kg-day)	444
				Vinyl Chloride	3.70E+00	µg/L	---	---	---	---	---	9.2E-05	mg/kg-day	3E-03	(mg/kg-day)	0.031
				Aluminum	1.07E+04	µg/L	---	---	---	---	---	2.7E-01	mg/kg-day	1E+00	(mg/kg-day)	0.27
				Arsenic	9.26E+00	µg/L	---	---	---	---	---	2.3E-04	mg/kg-day	3E-04	(mg/kg-day)	0.77
				Chromium	5.30E+01	ug/L	---	---	---	---	---	1.3E-03	mg/kg-day	3E-03	(mg/kg-day)	0.44
				Cobalt	9.51E+00	µg/L	---	---	---	---	---	2.4E-04	mg/kg-day	3E-04	(mg/kg-day)	0.79
				Iron	1.81E+04	µg/L	---	---	---	---	---	4.5E-01	mg/kg-day	7E-01	(mg/kg-day)	0.65
				Lead	6.11E+00	µg/L	---	---	---	---	---	1.5E-04	mg/kg-day	NA	---	NA
				Manganese	8.40E+02	µg/L	---	---	---	---	---	2.1E-02	mg/kg-day	1E-01	(mg/kg-day)	0.15
				Nickel	2.66E+01	µg/L	---	---	---	---	---	6.6E-04	mg/kg-day	2E-02	(mg/kg-day)	0.033
				Thallium	7.14E-02	µg/L	---	---	---	---	---	1.8E-06	mg/kg-day	1E-05	(mg/kg-day)	0.18
Groundwater	Groundwater	Site	Ingestion	Vanadium	2.04E+01	µg/L	---	---	---	---	---	5.1E-04	mg/kg-day	5E-03	(mg/kg-day)	0.10
			Ingestion Total								---					454
			Dermal	1,1,2-Trichloroethane	1.54E-01	µg/L	---	---	---	---	---	4.5E-07	mg/kg-day	4E-03	(mg/kg-day)^-1	0.00011
				1,2-Dichloroethane	1.02E+00	µg/L	---	---	---	---	---	1.5E-06	mg/kg-day	6E-03	(mg/kg-day)^-1	0.00026
				cis-1,2-Dichloroethene	3.01E+02	µg/L	---	---	---	---	---	8.2E-04	mg/kg-day	2E-03	(mg/kg-day)^-1	0.41
				Methane	1.40E+02	µg/L	---	---	---	---	---	2.0E-04	mg/kg-day	NA	---	NA
				Methylene chloride	5.90E+02	µg/L	---	---	---	---	---	6.8E-04	mg/kg-day	6E-03	(mg/kg-day)^-1	0.11
				Trichloroethene	8.91E+03	µg/L	---	---	---	---	---	4.8E-02	mg/kg-day	5E-04	(mg/kg-day)^-1	95
				Vinyl Chloride	3.70E+00	µg/L	---	---	---	---	---	5.9E-06	mg/kg-day	3E-03	(mg/kg-day)^-1	0.0020
				Aluminum	1.07E+04	µg/L	---	---	---	---	---	1.2E-03	mg/kg-day	1E+00	(mg/kg-day)^-1	0.0012
				Arsenic	9.26E+00	µg/L	---	---	---	---	---	1.0E-06	mg/kg-day	3E-04	(mg/kg-day)^-1	0.0034
				Chromium	5.30E+01	ug/L	---	---	---	---	---	1.2E-05	mg/kg-day	8E-05	(mg/kg-day)^-1	0.16
				Cobalt	9.51E+00	µg/L	---	---	---	---	---	1.0E-06	mg/kg-day	3E-04	(mg/kg-day)^-1	0.0035
				Iron	1.81E+04	µg/L	---	---	---	---	---	2.0E-03	mg/kg-day	7E-01	(mg/kg-day)^-1	0.0028
				Lead	6.11E+00	µg/L	---	---	---	---	---	6.7E-07	mg/kg-day	NA	---	NA
				Manganese	8.40E+02	µg/L	---	---	---	---	---	9.3E-05	mg/kg-day	1E-01	(mg/kg-day)^-1	0.00066
				Nickel	2.66E+01	µg/L	---	---	---	---	---	5.9E-07	mg/kg-day	8E-04	(mg/kg-day)^-1	0.00073
				Thallium	7.14E-02	µg/L	---	---	---	---	---	7.9E-09	mg/kg-day	1E-05	(mg/kg-day)^-1	0.00079
				Vanadium	2.04E+01	µg/L	---	---	---	---	---	2.2E-06	mg/kg-day	1E-04	(mg/kg-day)^-1	0.017
			Dermal Total								---					96
	Total Site Groundwater										---					550

TABLE A-7.7-4 CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - OVERBURDEN GROUNDWATER - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Vapors in Air (during household water use)	Site	Inhalation	1,1,2-Trichloroethane	7.70E-05	mg/m^3	---	---	---	---	---	7.4E-05	mg/m^3	2E-04	mg/m^3	0.37
				1,2-Dichloroethane	5.10E-04	mg/m^3	---	---	---	---	---	4.9E-04	mg/m^3	7E-03	mg/m^3	0.070
				cis-1,2-Dichloroethene	1.51E-01	mg/m^3	---	---	---	---	---	1.4E-01	mg/m^3	NA	mg/m^3	NA
				Methane	7.00E-02	mg/m^3	---	---	---	---	---	6.7E-02	mg/m^3	NA	mg/m^3	NA
				Methylene chloride	2.95E-01	mg/m^3	---	---	---	---	---	2.8E-01	mg/m^3	6E-01	mg/m^3	0.47
				Trichloroethene	4.46E+00	mg/m^3	---	---	---	---	---	4.3E+00	mg/m^3	2E-03	mg/m^3	2136
				Vinyl Chloride	1.85E-03	mg/m^3	---	---	---	---	---	1.8E-03	mg/m^3	1E-01	mg/m^3	0.018
			Inhalation Total								---					2137
	Total Site Vapors in Air										---					2137
Overburden Groundwater Total											---					2687

TABLE A-7.8-4 RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - OVERBURDEN GROUNDWATER - LIFETIME
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Age-adjusted

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Site	Ingestion	1,1,2-Trichloroethane	1.54E-01	µg/L	2.0E-06	mg/kg-day	5.7E-02	(mg/kg-day)^-1	1.1E-07	---	---	---	---	---
				1,2-Dichloroethane	1.02E+00	µg/L	1.3E-05	mg/kg-day	9.1E-02	(mg/kg-day)^-1	1.2E-06	---	---	---	---	---
				cis-1,2-Dichloroethene	3.01E+02	µg/L	3.9E-03	mg/kg-day	NA	---	NA	---	---	---	---	---
				Methane	1.40E+02	µg/L	1.8E-03	mg/kg-day	NA	---	NA	---	---	---	---	---
				Methylene chloride	5.90E+02	µg/L	Mutagenic Mode of Action; See Table H-4a RME				4.7E-05	---	---	---	---	---
				Trichloroethene	8.91E+03	µg/L	Mutagenic Mode of Action; See Table H-4b RME				7.1E-03	---	---	---	---	---
				Vinyl Chloride	3.70E+00	µg/L	Mutagenic Mode of Action; See Table H-4c RME/CTE				1.7E-04	---	---	---	---	---
				Aluminum	1.07E+04	µg/L	1.4E-01	mg/kg-day	NA	---	NA	---	---	---	---	---
				Arsenic	9.26E+00	µg/L	1.2E-04	mg/kg-day	1.5E+00	(mg/kg-day)^-1	1.8E-04	---	---	---	---	---
				Chromium	5.30E+01	ug/L	Mutagenic Mode of Action; See Table H-4a RME				1.1E-03	---	---	---	---	---
				Cobalt	9.51E+00	µg/L	1.2E-04	mg/kg-day	NA	---	NA	---	---	---	---	---
				Iron	1.81E+04	µg/L	2.3E-01	mg/kg-day	NA	---	NA	---	---	---	---	---
				Lead	6.11E+00	µg/L	7.8E-05	mg/kg-day	NA	---	NA	---	---	---	---	---
				Manganese	8.40E+02	µg/L	1.1E-02	mg/kg-day	NA	---	NA	---	---	---	---	---
				Nickel	2.66E+01	µg/L	3.4E-04	mg/kg-day	NA	---	NA	---	---	---	---	---
				Thallium	7.14E-02	µg/L	9.2E-07	mg/kg-day	NA	---	NA	---	---	---	---	---
Groundwater	Groundwater	Site	Ingestion	Vanadium	2.04E+01	µg/L	2.6E-04	mg/kg-day	NA	---	NA	---	---	---	---	---
			Ingestion Total								8.5E-03					---
			Dermal	1,1,2-Trichloroethane	1.54E-01	µg/L	1.8E-07	mg/kg-day	1.0E+00	(mg/kg-day)^-1	1.8E-07	---	---	---	---	---
				1,2-Dichloroethane	1.02E+00	µg/L	6.4E-07	mg/kg-day	1.0E+00	(mg/kg-day)^-1	6.4E-07	---	---	---	---	---
				cis-1,2-Dichloroethene	3.01E+02	µg/L	3.4E-04	mg/kg-day	NA	---	NA	---	---	---	---	---
				Methane	1.40E+02	µg/L	9.5E-05	mg/kg-day	NA	---	NA	---	---	---	---	---
				Methylene chloride	5.90E+02	µg/L	Mutagenic Mode of Action; See Table H-4a RME				8.7E-04	---	---	---	---	---
				Trichloroethene	8.91E+03	µg/L	Mutagenic Mode of Action; See Table H-4b RME				1.3E-03	---	---	---	---	---
				Vinyl Chloride	3.70E+00	µg/L	Mutagenic Mode of Action; See Table H-4c RME/CTE				9.1E-06	---	---	---	---	---
				Aluminum	1.07E+04	µg/L	7.6E-04	mg/kg-day	NA	---	NA	---	---	---	---	---
				Arsenic	9.26E+00	µg/L	6.6E-07	mg/kg-day	1.0E+00	(mg/kg-day)^-1	6.6E-07	---	---	---	---	---
				Chromium	5.30E+01	ug/L	Mutagenic Mode of Action; See Table H-4a RME				2.3E-05	---	---	---	---	---
				Cobalt	9.51E+00	µg/L	6.8E-07	mg/kg-day	NA	---	NA	---	---	---	---	---
				Iron	1.81E+04	µg/L	1.3E-03	mg/kg-day	NA	---	NA	---	---	---	---	---
				Lead	6.11E+00	µg/L	4.4E-07	mg/kg-day	NA	---	NA	---	---	---	---	---
				Manganese	8.40E+02	µg/L	6.0E-05	mg/kg-day	NA	---	NA	---	---	---	---	---
				Nickel	2.66E+01	µg/L	3.8E-07	mg/kg-day	NA	---	NA	---	---	---	---	---
				Thallium	7.14E-02	µg/L	5.1E-09	mg/kg-day	NA	---	NA	---	---	---	---	---
				Vanadium	2.04E+01	µg/L	1.5E-06	mg/kg-day	NA	---	NA	---	---	---	---	---
			Dermal Total								2.2E-03					---
	Total Site Groundwater										1.1E-02					---

TABLE A-7.8-4 RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - OVERBURDEN GROUNDWATER - LIFETIME
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Age-adjusted

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Vapors in Air (during household water use)	Site	Inhalation	1,1,2-Trichloroethane	7.70E-05	mg/m^3	2.7E-05	mg/m^3	1.6E-05	(µg/m3)^-1	4.4E-07	---	---	---	---	---
				1,2-Dichloroethane	5.10E-04	mg/m^3	1.8E-04	mg/m^3	2.6E-05	(µg/m3)^-1	4.7E-06	---	---	---	---	---
				cis-1,2-Dichloroethene	1.51E-01	mg/m^3	5.4E-02	mg/m^3	NA	---	NA	---	---	---	---	---
				Methane	7.00E-02	mg/m^3	2.5E-02	mg/m^3	NA	---	NA	---	---	---	---	---
				Methylene chloride	2.95E-01	mg/m^3	Mutagenic Mode of Action; See Table H-4b RME				2.9E-12	---	---	---	---	---
				Trichloroethene	4.46E+00	mg/m^3	Mutagenic Mode of Action; See Table H-4b RME				8.1E-02	---	---	---	---	---
				Vinyl Chloride	1.85E-03	mg/m^3	Mutagenic Mode of Action; See Table H-4c RME/CTE				1.1E-05	---	---	---	---	---
			Inhalation Total								8.1E-02					---
	Total Site Vapors in Air										8.1E-02					---
Overburden Groundwater Total											9.2E-02					---

TABLE A-7.8-4 CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - OVERBURDEN GROUNDWATER - LIFETIME
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Age-adjusted

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Site	Ingestion	1,1,2-Trichloroethane	1.54E-01	µg/L	3.1E-07	mg/kg-day	5.7E-02	(mg/kg-day)^-1	1.8E-08	---	---	---	---	---
				1,2-Dichloroethane	1.02E+00	µg/L	2.0E-06	mg/kg-day	9.1E-02	(mg/kg-day)^-1	1.9E-07	---	---	---	---	---
				cis-1,2-Dichloroethene	3.01E+02	µg/L	6.0E-04	mg/kg-day	NA	---	NA	---	---	---	---	---
				Methane	1.40E+02	µg/L	2.8E-04	mg/kg-day	NA	---	NA	---	---	---	---	---
				Methylene chloride	5.90E+02	µg/L	Mutagenic Mode of Action; See Table H-4a CTE				1.3E-05	---	---	---	---	---
				Trichloroethene	8.91E+03	µg/L	Mutagenic Mode of Action; See Table H-4b CTE				1.6E-03	---	---	---	---	---
				Vinyl Chloride	3.70E+00	µg/L	Mutagenic Mode of Action; See Table H-4c RME/CTE				1.4E-04	---	---	---	---	---
				Aluminum	1.07E+04	µg/L	2.1E-02	mg/kg-day	NA	---	NA	---	---	---	---	---
				Arsenic	9.26E+00	µg/L	1.8E-05	mg/kg-day	1.5E+00	(mg/kg-day)^-1	2.8E-05	---	---	---	---	---
				Chromium	5.30E+01	ug/L	Mutagenic Mode of Action; See Table H-4a CTE				2.9E-04	---	---	---	---	---
				Cobalt	9.51E+00	µg/L	1.9E-05	mg/kg-day	NA	---	NA	---	---	---	---	---
				Iron	1.81E+04	µg/L	3.6E-02	mg/kg-day	NA	---	NA	---	---	---	---	---
				Lead	6.11E+00	µg/L	1.2E-05	mg/kg-day	NA	---	NA	---	---	---	---	---
				Manganese	8.40E+02	µg/L	1.7E-03	mg/kg-day	NA	---	NA	---	---	---	---	---
				Nickel	2.66E+01	µg/L	5.3E-05	mg/kg-day	NA	---	NA	---	---	---	---	---
				Thallium	7.14E-02	µg/L	1.4E-07	mg/kg-day	NA	---	NA	---	---	---	---	---
Groundwater	Groundwater	Site	Ingestion	Vanadium	2.04E+01	µg/L	4.1E-05	mg/kg-day	NA	---	NA	---	---	---	---	---
			Ingestion Total								2.0E-03					---
			Dermal	1,1,2-Trichloroethane	1.54E-01	µg/L	4.0E-08	mg/kg-day	1.0E+00	(mg/kg-day)^-1	4.0E-08	---	---	---	---	---
				1,2-Dichloroethane	1.02E+00	µg/L	1.4E-07	mg/kg-day	1.0E+00	(mg/kg-day)^-1	1.4E-07	---	---	---	---	---
				cis-1,2-Dichloroethene	3.01E+02	µg/L	7.4E-05	mg/kg-day	NA	---	NA	---	---	---	---	---
				Methane	1.40E+02	µg/L	1.9E-05	mg/kg-day	NA	---	NA	---	---	---	---	---
				Methylene chloride	5.90E+02	µg/L	Mutagenic Mode of Action; See Table H-4a CTE				3.4E-04	---	---	---	---	---
				Trichloroethene	8.91E+03	µg/L	Mutagenic Mode of Action; See Table H-4b CTE				3.8E-04	---	---	---	---	---
				Vinyl Chloride	3.70E+00	µg/L	Mutagenic Mode of Action; See Table H-4c RME/CTE				7.9E-06	---	---	---	---	---
				Aluminum	1.07E+04	µg/L	1.2E-04	mg/kg-day	NA	---	NA	---	---	---	---	---
				Arsenic	9.26E+00	µg/L	1.0E-07	mg/kg-day	1.0E+00	(mg/kg-day)^-1	1.0E-07	---	---	---	---	---
				Chromium	5.30E+01	ug/L	Mutagenic Mode of Action; See Table H-4a CTE				6.3E-06	---	---	---	---	---
				Cobalt	9.51E+00	µg/L	1.0E-07	mg/kg-day	NA	---	NA	---	---	---	---	---
				Iron	1.81E+04	µg/L	2.0E-04	mg/kg-day	NA	---	NA	---	---	---	---	---
				Lead	6.11E+00	µg/L	6.7E-08	mg/kg-day	NA	---	NA	---	---	---	---	---
				Manganese	8.40E+02	µg/L	9.2E-06	mg/kg-day	NA	---	NA	---	---	---	---	---
				Nickel	2.66E+01	µg/L	5.8E-08	mg/kg-day	NA	---	NA	---	---	---	---	---
				Thallium	7.14E-02	µg/L	7.8E-10	mg/kg-day	NA	---	NA	---	---	---	---	---
				Vanadium	2.04E+01	µg/L	2.2E-07	mg/kg-day	NA	---	NA	---	---	---	---	---
			Dermal Total								7.3E-04					---
	Total Site Groundwater										2.8E-03					---

TABLE A-7.8-4 CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - OVERBURDEN GROUNDWATER - LIFETIME
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Age-adjusted

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Vapors in Air (during household water use)	Site	Inhalation	1,1,2-Trichloroethane	7.70E-05	mg/m^3	8.4E-06	mg/m^3	1.6E-05	(µg/m3)^-1	1.4E-07	---	---	---	---	---
				1,2-Dichloroethane	5.10E-04	mg/m^3	5.6E-05	mg/m^3	2.6E-05	(µg/m3)^-1	1.5E-06	---	---	---	---	---
				cis-1,2-Dichloroethene	1.51E-01	mg/m^3	1.7E-02	mg/m^3	NA	---	NA	---	---	---	---	---
				Methane	7.00E-02	mg/m^3	7.7E-03	mg/m^3	NA	---	NA	---	---	---	---	---
				Methylene chloride	2.95E-01	mg/m^3	Mutagenic Mode of Action; See Table H-4a CTE				1.5E-12	---	---	---	---	---
				Trichloroethene	4.46E+00	mg/m^3	Mutagenic Mode of Action; See Table H-4b CTE				3.3E-02	---	---	---	---	---
				Vinyl Chloride	1.85E-03	mg/m^3	Mutagenic Mode of Action; See Table H-4c RME/CTE				9.0E-06	---	---	---	---	---
			Inhalation Total								3.3E-02					---
	Total Site Vapors in Air										3.3E-02					---
Overburden Groundwater Total											3.6E-02					---

TABLE A-9.1-1 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - SEDIMENT - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: River Recreational Visitor
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Sediment	Sediment unnamed stream	Benzo(a)anthracene	4.24E-09	---	1.37E-08	1.79E-08	---	---	---	---	---
			Benzo(a)pyrene	3.77E-08	---	1.22E-08	4.99E-08	---	---	---	---	---
			Benzo(b)fluoranthene	8.96E-09	---	2.89E-08	3.78E-08	---	---	---	---	---
			Dibenz(a,h)anthracene	8.01E-08	---	2.58E-08	1.06E-07	---	---	---	---	---
			Indeno(1,2,3-cd)pyrene	7.86E-09	---	2.53E-08	3.32E-08	---	---	---	---	---
			Arsenic	1.45E-07	---	5.26E-08	1.98E-07	Skin	0.0011	---	0.00061	0.0017
			Chromium	1.18E-07	---	---	1.18E-07	None observed	0.00028	---	---	0.00028
			Cobalt	---	---	---	---	Thyroid	0.0010	---	---	0.0010
			Iron	---	---	---	---	Gastrointestinal	0.0013	---	---	0.0013
			Chemical Total	4.0E-07	---	1.6E-07	5.6E-07		0.0037	---	0.00061	0.0043
Sediment Total							5.6E-07					0.0043

Total Risk Across All Media: 5.6E-07

Total Hazard Across All Media: 0.0043

TABLE A-9.2-1 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - SEDIMENT - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: River Recreational Visitor
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Sediment	Sediment unnamed stream	Benzo(a)anthracene	7.24E-08	---	3.47E-08	1.07E-07	---	---	---	---	---
			Benzo(a)pyrene	6.44E-07	---	3.08E-08	6.74E-07	---	---	---	---	---
			Benzo(b)fluoranthene	1.53E-07	---	7.32E-08	2.26E-07	---	---	---	---	---
			Dibenz(a,h)anthracene	1.37E-06	---	6.55E-08	1.43E-06	---	---	---	---	---
			Indeno(1,2,3-cd)pyrene	1.34E-07	---	6.42E-08	1.98E-07	---	---	---	---	---
			Arsenic	4.65E-07	---	2.50E-08	4.90E-07	Skin	0.012	---	0.0010	0.013
			Chromium	2.02E-06	---	---	2.02E-06	None observed	0.0029	---	---	0.0029
			Cobalt	---	---	---	---	Thyroid	0.011	---	---	0.011
			Iron	---	---	---	---	Gastrointestinal	0.014	---	---	0.014
			Chemical Total	4.9E-06	---	2.9E-07	5.1E-06		0.040	---	0.0010	0.041
Sediment Total							5.1E-06					0.041

Total Risk Across All Media: 5.1E-06

Total Hazard Across All Media: 0.041

TABLE A-9.3-2 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - SURFACE WATER - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: River Recreational Visitor
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Surface Water Unnamed stream	cis-1,2-Dichloroethene	---	---	---	---	Kidney	---	---	0.0019	0.0019
			Trichloroethene	---	---	7.9E-07	7.9E-07	Immune System	---	---	0.0055	0.0055
			Vinyl chloride	---	---	6.1E-08	6.1E-08	Liver	---	---	0.000072	0.000072
			Chemical Total	---	---	8.5E-07	8.5E-07		---	---	0.0075	0.0075
Surface Water Total							8.5E-07					0.0075

Total Risk Across All Media: 8.5E-07

Total Hazard Across All Media: 0.0075

TABLE A-9.4-2 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - SURFACE WATER - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: River Recreational Visitor
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Surface Water Unnamed stream	cis-1,2-Dichloroethene	---	---	---	---	Kidney	---	---	0.0045	0.0045
			Trichloroethene	---	---	4.9E-08	4.9E-08	Immune System	---	---	0.013	0.013
			Vinyl chloride	---	---	8.5E-06	8.5E-06	Liver	---	---	0.00017	0.00017
			Chemical Total	---	---	8.6E-06	8.6E-06		---	---	0.018	0.018
Surface Water Total							8.6E-06					0.018

Total Risk Across All Media: 8.6E-06

Total Hazard Across All Media: 0.018

TABLE A-9.5-3 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - SHALLOW GROUNDWATER - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Groundwater in construction trenches	Benzo(a)pyrene	---	---	3.0E-07	3.0E-07	---	---	NA	---	---
			Chloroform	---	5.6E-07	2.6E-08	5.8E-07	Liver, Blood	---	0.017	0.00018	0.018
			Naphthalene	---	6.9E-07	---	6.9E-07	Body weight	---	0.47	0.00062	0.47
			Trichloroethene	---	2.4E-07	1.2E-07	3.6E-07	Immune System	---	2.1	0.017	2.1
			Antimony	---	---	---	---	Blood	---	NA	0.0029	0.0029
			Arsenic	---	---	2.1E-08	2.1E-08	Skin	---	NA	0.0049	0.0049
			Cadmium	---	---	---	---	Kidney	---	NA	0.27	0.27
			Chromium	---	---	9.6E-08	9.6E-08	None observed	---	NA	0.089	0.089
			Cobalt	---	---	---	---	Thyroid	---	NA	0.0029	0.0029
			Iron	---	---	---	---	Gastrointestinal	---	NA	0.0061	0.0061
			Manganese	---	---	---	---	Nervous system	---	NA	0.0039	0.0039
			Thallium	---	---	---	---	Hair	---	NA	0.0036	0.0036
			Chemical Total	---	1.5E-06	5.6E-07	2.0E-06		---	2.6	0.40	3.0
Shallow Groundwater Total							2.0E-06					3.0

Total Risk Across All Media	2.0E-06
Total Hazard Across All Media	3.0
Total Blood HI Across All Media	0.020
Total Liver HI Across All Media	0.018
Total Body and Organ Weight HI Across All Media	0.47
Total Immune System HI Across All Media	2.1
Total Nervous System HI Across All Media	0.0039
Total Skin HI Across All Media	0.0049
Total Kidney HI Across All Media	0.27
Total Thyroid HI Across All Media	0.0029
Total Gastrointestinal HI Across All Media	0.0061
Total Hair HI Across All Media	0.0036

TABLE A-9.5-3 CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - SHALLOW GROUNDWATER - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Groundwater in construction trenches	Benzo(a)pyrene	---	---	5.9E-08	5.9E-08	---	---	NA	---	---
			Chloroform	---	1.1E-07	5.1E-09	1.2E-07	Liver, Blood	---	0.0035	0.000036	0.0035
			Naphthalene	---	1.4E-07	---	1.4E-07	Body weight	---	0.094	0.00012	0.094
			Trichloroethene	---	4.8E-08	2.4E-08	7.2E-08	Immune System	---	0.41	0.0033	0.42
			Antimony	---	---	---	---	Blood	---	NA	0.00058	0.00058
			Arsenic	---	---	4.2E-09	4.2E-09	Skin	---	NA	0.0010	0.0010
			Cadmium	---	---	---	---	Kidney	---	NA	0.054	0.054
			Chromium	---	---	1.9E-08	1.9E-08	None observed	---	NA	0.018	0.018
			Cobalt	---	---	---	---	Thyroid	---	NA	0.00058	0.00058
			Iron	---	---	---	---	Gastrointestinal	---	NA	0.0012	0.0012
			Manganese	---	---	---	---	Nervous system	---	NA	0.00078	0.00078
			Thallium	---	---	---	---	Hair	---	NA	0.00072	0.00072
			Chemical Total	---	3.0E-07	1.1E-07	4.1E-07		---	0.51	0.080	0.59
Shallow Groundwater Total							4.1E-07					0.59

Total Risk Across All Media	4.1E-07
Total Hazard Across All Media	0.59
Total Blood HI Across All Media	0.0041
Total Liver HI Across All Media	0.0035
Total Body and Organ Weight HI Across All Media	0.094
Total Immune System HI Across All Media	0.42
Total Nervous System HI Across All Media	0.00078
Total Skin HI Across All Media	0.0010
Total Kidney HI Across All Media	0.054
Total Thyroid HI Across All Media	0.00058
Total Gastrointestinal HI Across All Media	0.0012
Total Hair HI Across All Media	0.00072

TABLE A-9.6-4 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - OVERBURDEN GROUNDWATER - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site	1,1,2-Trichloroethane	---	---	---	---	Blood	0.0012	0.37	0.00011	0.37
			1,2-Dichloroethane	---	---	---	---	Kidney	0.0051	0.070	0.00026	0.075
			cis-1,2-Dichloroethene	---	---	---	---	Kidney	4.5	---	0.41	4.9
			Methane	---	---	---	---	---	---	---	---	---
			Methylene chloride	---	---	---	---	Liver	2.9	0.47	0.11	3.5
			Trichloroethene	---	---	---	---	Immune System	534	2136	95	2765
			Vinyl Chloride	---	---	---	---	Liver	0.037	0.018	0.0021	0.057
			Aluminum	---	---	---	---	Nervous system	0.32	---	0.0019	0.32
			Arsenic	---	---	---	---	Skin	0.92	---	0.0055	0.93
			Chromium	---	---	---	---	None observed	0.53	---	0.25	0.78
			Cobalt	---	---	---	---	Thyroid	0.95	---	0.0056	1.0
			Iron	---	---	---	---	Gastrointestinal	0.78	---	0.0046	0.78
			Lead	---	---	---	---	---	---	---	---	---
			Manganese	---	---	---	---	Nervous system	0.18	---	0.0011	0.18
			Nickel	---	---	---	---	Body weight	0.040	---	0.0012	0.041
			Thallium	---	---	---	---	Hair	0.21	---	0.0013	0.22
			Vanadium	---	---	---	---	Hair	0.12	---	0.028	0.15
			Chemical Total	---	---	---	---		546	2137	96	2778
Overburden Groundwater Total							---					2778

Total Risk Across All Media	---
Total Hazard Across All Media	2778
Total Blood HI Across All Media	0.37
Total Kidney HI Across All Media	5.1
Total Liver HI Across All Media	3.6
Total Body and Organ Weight HI Across All Media	0.041
Total Nervous System HI Across All Media	0.50
Total Immune System HI Across All Media	2765
Total Skin HI Across All Media	0.93
Total Thyroid HI Across All Media	1.0
Total Gastrointestinal HI Across All Media	0.78
Total Hair HI Across All Media	0.37

TABLE A-9.6-4 CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - OVERBURDEN GROUNDWATER - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site	1,1,2-Trichloroethane	---	---	---	---	Blood	0.00058	0.4	0.000079	0.37
			1,2-Dichloroethane	---	---	---	---	Kidney	0.0025	0.07	0.00018	0.073
			cis-1,2-Dichloroethene	---	---	---	---	Kidney	2.3	---	0.29	2.5
			Methane	---	---	---	---	---	---	---	---	---
			Methylene chloride	---	---	---	---	Liver	1.5	0.47	0.081	2.0
			Trichloroethene	---	---	---	---	Immune System	267	2136	68	2471
			Vinyl Chloride	---	---	---	---	Liver	0.018	0.018	0.0014	0.038
			Aluminum	---	---	---	---	Nervous system	0.16	---	0.0010	0.16
			Arsenic	---	---	---	---	Skin	0.46	---	0.0028	0.47
			Chromium	---	---	---	---	None observed	0.26	---	0.13	0.39
			Cobalt	---	---	---	---	Thyroid	0.47	---	0.0029	0.48
			Iron	---	---	---	---	Gastrointestinal	0.39	---	0.0023	0.39
			Lead	---	---	---	---	---	---	---	---	---
			Manganese	---	---	---	---	Nervous system	0.090	---	0.00054	0.090
			Nickel	---	---	---	---	Body weight	0.020	---	0.00060	0.021
			Thallium	---	---	---	---	Hair	0.11	---	0.00064	0.11
			Vanadium	---	---	---	---	Hair	0.06	---	0.014	0.075
			Chemical Total	---	---	---	---		273	2137	68	2478
Overburden Groundwater Total							---					2478

Total Risk Across All Media	---
Total Hazard Across All Media	2478
Total Blood HI Across All Media	0.4
Total Kidney HI Across All Media	3
Total Liver HI Across All Media	2
Total Body and Organ Weight HI Across All Media	0.0
Total Nervous System HI Across All Media	0.3
Total Immune System HI Across All Media	2471
Total Skin HI Across All Media	0.5
Total Thyroid HI Across All Media	0.5
Total Gastrointestinal HI Across All Media	0.4
Total Hair HI Across All Media	0.18

TABLE A-9.7-4 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - OVERBURDEN GROUNDWATER - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site	1,1,2-Trichloroethane	---	---	---	---	Blood	0.0019	0.37	0.00016	0.37
			1,2-Dichloroethane	---	---	---	---	Kidney	0.0085	0.070	0.00036	0.079
			cis-1,2-Dichloroethene	---	---	---	---	Kidney	7.5	---	0.58	8.1
			Methane	---	---	---	---	---	---	---	---	---
			Methylene chloride	---	---	---	---	Liver	4.9	0.47	0.16	5.5
			Trichloroethene	---	---	---	---	Immune System	889	2136	135	3159
			Vinyl Chloride	---	---	---	---	Liver	0.061	0.018	0.0028	0.082
			Aluminum	---	---	---	---	Nervous system	0.53	---	0.0024	0.53
			Arsenic	---	---	---	---	Skin	1.5	---	0.0068	1.5
			Chromium	---	---	---	---	None observed	0.88	---	0.31	1.2
			Cobalt	---	---	---	---	Thyroid	1.6	---	0.0070	1.6
			Iron	---	---	---	---	Gastrointestinal	1.3	---	0.0057	1.3
			Lead	---	---	---	---	---	---	---	---	---
			Manganese	---	---	---	---	Nervous system	0.30	---	0.0013	0.30
			Nickel	---	---	---	---	Body weight	0.066	---	0.0015	0.068
			Thallium	---	---	---	---	Hair	0.36	---	0.0016	0.36
			Vanadium	---	---	---	---	Hair	0.20	---	0.034	0.24
			Chemical Total	---	---	---	---		908	2137	136	3181
Overburden Groundwater Total							---					3181

Total Risk Across All Media	---
Total Hazard Across All Media	3181
Total Blood HI Across All Media	0.37
Total Kidney HI Across All Media	8.4
Total Liver HI Across All Media	5.6
Total Body and Organ Weight HI Across All Media	0.068
Total Nervous System HI Across All Media	0.84
Total Immune System HI Across All Media	3159
Total Skin HI Across All Media	1.5
Total Thyroid HI Across All Media	1.6
Total Gastrointestinal HI Across All Media	1.3
Total Hair HI Across All Media	0.36

TABLE A-9.7-4 CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - OVERBURDEN GROUNDWATER - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site	1,1,2-Trichloroethane	---	---	---	---	Blood	0.0010	0.37	0.00011	0.37
			1,2-Dichloroethane	---	---	---	---	Kidney	0.0042	0.070	0.00026	0.074
			cis-1,2-Dichloroethene	---	---	---	---	Kidney	3.8	---	0.41	4.2
			Methane	---	---	---	---	---	---	---	---	---
			Methylene chloride	---	---	---	---	Liver	2.5	0.47	0.11	3.0
			Trichloroethene	---	---	---	---	Immune System	444	2136	95	2676
			Vinyl Chloride	---	---	---	---	Liver	0.031	0.018	0.0020	0.050
			Aluminum	---	---	---	---	Nervous system	0.27	---	0.0012	0.27
			Arsenic	---	---	---	---	Skin	0.77	---	0.0034	0.77
			Chromium	---	---	---	---	None observed	0.44	---	0.16	0.60
			Cobalt	---	---	---	---	Thyroid	0.79	---	0.0035	0.79
			Iron	---	---	---	---	Gastrointestinal	0.65	---	0.0028	0.65
			Lead	---	---	---	---	---	---	---	---	---
			Manganese	---	---	---	---	Nervous system	0.15	---	0.00066	0.15
			Nickel	---	---	---	---	Body weight	0.033	---	0.00073	0.034
			Thallium	---	---	---	---	Hair	0.18	---	0.00079	0.18
			Vanadium	---	---	---	---	Hair	0.10	---	0.017	0.12
			Chemical Total	---	---	---	---		454	2137	96	2687
Overburden Groundwater Total							---					2687

Total Risk Across All Media	---
Total Hazard Across All Media	2687
Total Blood HI Across All Media	0.37
Total Kidney HI Across All Media	4.4
Total Liver HI Across All Media	3.1
Total Body and Organ Weight HI Across All Media	0.034
Total Nervous System HI Across All Media	0.42
Total Immune System HI Across All Media	2676
Total Skin HI Across All Media	0.77
Total Thyroid HI Across All Media	0.79
Total Gastrointestinal HI Across All Media	0.65
Total Hair HI Across All Media	0.18

TABLE A-9.8-4 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - OVERBURDEN GROUNDWATER - LIFETIME
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Age-adjusted

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site	1,1,2-Trichloroethane	1.1E-07	4.4E-07	1.8E-07	7.4E-07	---	---	---	---	---
			1,2-Dichloroethane	1.2E-06	4.7E-06	6.4E-07	6.5E-06	---	---	---	---	---
			cis-1,2-Dichloroethene	---	---	---	---	---	---	---	---	---
			Methane	---	---	---	---	---	---	---	---	---
			Methylene chloride	4.7E-05	2.9E-12	8.7E-04	9.2E-04	---	---	---	---	---
			Trichloroethene	7.1E-03	8.1E-02	1.3E-03	8.9E-02	---	---	---	---	---
			Vinyl Chloride	1.7E-04	1.1E-05	9.1E-06	1.9E-04	---	---	---	---	---
			Aluminum	---	---	---	---	---	---	---	---	---
			Arsenic	1.8E-04	---	6.6E-07	1.8E-04	---	---	---	---	---
			Chromium	1.1E-03	---	2.3E-05	1.1E-03	---	---	---	---	---
			Cobalt	---	---	---	---	---	---	---	---	---
			Iron	---	---	---	---	---	---	---	---	---
			Lead	---	---	---	---	---	---	---	---	---
			Manganese	---	---	---	---	---	---	---	---	---
			Nickel	---	---	---	---	---	---	---	---	---
			Thallium	---	---	---	---	---	---	---	---	---
			Vanadium	---	---	---	---	---	---	---	---	---
			Chemical Total	8.5E-03	8.1E-02	2.2E-03	9.2E-02		---	---	---	---
Overburden Groundwater Total							9.2E-02					---

Total Risk Across All Media: 9.2E-02

Total Hazard Across All Media: ---

TABLE A-9.8-4 CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - OVERBURDEN GROUNDWATER - LIFETIME
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Age-adjusted

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site	1,1,2-Trichloroethane	1.8E-08	1.4E-07	4.0E-08	1.9E-07	---	---	---	---	---
			1,2-Dichloroethane	1.9E-07	1.5E-06	1.4E-07	1.8E-06	---	---	---	---	---
			cis-1,2-Dichloroethene	---	---	---	---	---	---	---	---	---
			Methane	---	---	---	---	---	---	---	---	---
			Methylene chloride	1.3E-05	1.5E-12	3.4E-04	3.5E-04	---	---	---	---	---
			Trichloroethene	1.6E-03	3.3E-02	3.8E-04	3.5E-02	---	---	---	---	---
			Vinyl Chloride	1.4E-04	9.0E-06	7.9E-06	1.6E-04	---	---	---	---	---
			Aluminum	---	---	---	---	---	---	---	---	---
			Arsenic	2.8E-05	---	1.0E-07	2.8E-05	---	---	---	---	---
			Chromium	2.9E-04	---	6.3E-06	3.0E-04	---	---	---	---	---
			Cobalt	---	---	---	---	---	---	---	---	---
			Iron	---	---	---	---	---	---	---	---	---
			Lead	---	---	---	---	---	---	---	---	---
			Manganese	---	---	---	---	---	---	---	---	---
			Nickel	---	---	---	---	---	---	---	---	---
			Thallium	---	---	---	---	---	---	---	---	---
			Vanadium	---	---	---	---	---	---	---	---	---
			Chemical Total	2.0E-03	3.3E-02	7.3E-04	3.6E-02		---	---	---	---
Overburden Groundwater Total							3.6E-02					---

Total Risk Across All Media: 3.6E-02

Total Hazard Across All Media: ---

TABLE A-10.2-1 RME
RISK SUMMARY - SEDIMENT - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: River Recreational Visitor
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Sediment	Sediment unnamed stream	Dibenz(a,h)anthracene	1.4E-06	---	---	1.4E-06	---	---	---	---	---
			Chromium	2.0E-06	---	---	2.0E-06	---	---	---	---	---
			Chemical Total	3.4E-06	---	---	3.4E-06		---	---	---	---
Sediment Total							3.4E-06					---

Total Risk Across All Media: 3.4E-06

Total Hazard Across All Media: ---

TABLE A-10.4-2 RME
RISK SUMMARY - SURFACE WATER - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: River Recreational Visitor
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Surface Water	Vinyl chloride	---	---	8.5E-06	8.5E-06	---	---	---	---	---
		Unnamed stream	Chemical Total	---	---	8.5E-06	8.5E-06		---	---	---	---
Surface Water Total							8.5E-06					---

Total Risk Across All Media: 8.5E-06

Total Hazard Across All Media: ---

TABLE A-10.5-3 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - SHALLOW GROUNDWATER -ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Current/Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Shallow Groundwater in construction trenches	Trichloroethene	---	---	---	---	Immune System	---	2.1	---	2.1
			Chemical Total	---	---	---	---		---	2.1	---	2.1
Shallow Groundwater Total							---					2.1

Total Risk Across All Media: ---

Total Hazard Across All Media: 2.1

TABLE A-10.6-4 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - OVERBURDEN GROUNDWATER - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site	cis-1,2-Dichloroethene	---	---	---	---	Kidney	4.5	---	---	4.5
			Methylene chloride	---	---	---	---	Liver	2.9	---	---	2.9
			Trichloroethene	---	---	---	---	Immune System	534	2136	95	2765
			Chemical Total	---	---	---	---		541	2136	95	2772
Overburden Groundwater Total							---					2772

Total Risk Across All Media: ---

Total Hazard Across All Media: 2772

TABLE A-10.6-4 CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - OVERBURDEN GROUNDWATER - ADULT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site	cis-1,2-Dichloroethene	---	---	---	---	Kidney	2.3	---	---	2.3
			Methylene chloride	---	---	---	---	Liver	1.5	---	---	1.5
			Trichloroethene	---	---	---	---	Immune System	267	2136	68	2471
			Chemical Total	---	---	---	---		271	2136	68	2474
Overburden Groundwater Total							---					2474

Total Risk Across All Media: ---

Total Hazard Across All Media: 2474

TABLE A-10.7-4 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - OVERBURDEN GROUNDWATER - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site	cis-1,2-Dichloroethene	---	---	---	---	Kidney	7.5	---	---	7.5
			Methylene chloride	---	---	---	---	Liver	4.9	---	---	4.9
			Trichloroethene	---	---	---	---	Immune System	889	2136	135	3159
			Arsenic	---	---	---	---	Skin	1.5	---	---	1.5
			Cobalt	---	---	---	---	Thyroid	1.6	---	---	1.6
			Iron	---	---	---	---	Gastrointestinal	1.3	---	---	1.3
			Chemical Total	---	---	---	---		905	2136	135	3176
Overburden Groundwater Total							---					3176

Total Risk Across All Media: ---

Total Hazard Across All Media: 3176

TABLE A-10.7-4 CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - OVERBURDEN GROUNDWATER - CHILD
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site	cis-1,2-Dichloroethene	---	---	---	---	Kidney	3.8	---	---	3.8
			Methylene chloride	---	---	---	---	Liver	2.5	---	---	2.5
			Trichloroethene	---	---	---	---	Immune System	444	2136	95	2676
			Chemical Total	---	---	---	---		450	2136	95	2682
Overburden Groundwater Total							---					2682

Total Risk Across All Media: ---

Total Hazard Across All Media: 2682

TABLE A-10.8-4 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - OVERBURDEN GROUNDWATER - LIFETIME
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Age-adjusted

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site	1,2-Dichloroethane	1.2E-06	4.7E-06	---	5.9E-06	---	---	---	---	---
			Methylene chloride	4.7E-05	---	8.7E-04	9.2E-04	---	---	---	---	---
			Trichloroethene	7.1E-03	8.1E-02	1.3E-03	8.9E-02	---	---	---	---	---
			Vinyl Chloride	1.7E-04	1.1E-05	9.1E-06	1.9E-04	---	---	---	---	---
			Arsenic	1.8E-04	---	---	1.8E-04	---	---	---	---	---
			Chromium	1.1E-03	---	2.3E-05	1.1E-03	---	---	---	---	---
			Chemical Total	8.5E-03	8.1E-02	2.2E-03	9.2E-02		---	---	---	---
Overburden Groundwater Total							9.2E-02					---

Total Risk Across All Media: 9.2E-02

Total Hazard Across All Media: ---

TABLE A-10.8-4 CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS - OVERBURDEN GROUNDWATER - LIFETIME
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Age-adjusted

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site	1,2-Dichloroethane	---	1.5E-06	---	1.5E-06	---	---	---	---	---
			Methylene chloride	1.3E-05	---	3.4E-04	3.5E-04	---	---	---	---	---
			Trichloroethene	1.6E-03	3.3E-02	3.8E-04	3.5E-02	---	---	---	---	---
			Vinyl Chloride	1.4E-04	9.0E-06	7.9E-06	1.6E-04	---	---	---	---	---
			Arsenic	2.8E-05	---	---	2.8E-05	---	---	---	---	---
			Chromium	2.9E-04	---	6.3E-06	3.0E-04	---	---	---	---	---
			Chemical Total	2.0E-03	3.3E-02	7.3E-04	3.6E-02		---	---	---	---
Overburden Groundwater Total							3.6E-02					---

Total Risk Across All Media: 3.6E-02

Total Hazard Across All Media: ---

APPENDIX B

FINAL TECHNICAL MEMORANDUM

To: Karen Lumino

From: Richard Sugatt

Date: June 25, 2015

Subject: Risk Evaluation of soil data at the Commerce Street Plume Superfund Site, Williston, VT

This technical memorandum summarizes the available soil data for samples taken at the former Mitec property at 96 Commerce Street and nearby residential areas, and provides a screening level risk assessment for residential receptors of the maximum detected concentrations of contaminants in soil at 0-10 feet below ground surface (ft bgs). This depth interval is the standard depth considered for residential receptors by EPA in New England because that is the depth of soil that may be brought to the surface during construction of typical house foundations in New England.

Executive Summary For non-cancer risk, the screening level hazard quotient (HQ) was less than 1 for the maximum detected concentration for all detected chemicals in samples taken from 0-10 ft bgs. For cancer risk, the total screening level Incremental Lifetime Cancer Risk (ILCR) was 4.3E-05, driven primarily by PAHs (2.6E-05) and arsenic 1.1E-05. PAHs and hexavalent chromium were detected in soil only at the former Mitec property, where hexavalent chromium was detected in only one of five samples analyzed for this form of chromium. The concentration of arsenic ranged from 2.6 mg/kg to 8.8 mg/kg and was not elevated at the former Mitec property relative to the residential properties. The results indicate that the risks are lower than EPA's maximum non-cancer risk limit (HQ=1) and are within EPA's acceptable cancer risk range of 1E-06 to 1E-04 at Superfund sites. However, if the elevated total chromium at the former Mitec property is comprised of hexavalent chromium, the maximum ILCR would be 1E-03, higher than the maximum risk limit. Due to this uncertainty, it is recommended to remove soil at this property.

Sampling Results Samples collected in August 2012 from the former Mitec property and residences on Shunpike Road were analyzed for VOCs, SVOCs, and total metals. Samples collected in December 2013 from the former Mitec property and one residential lot (currently vacant) on Shunpike Road were analyzed for hexavalent and total chromium. Samples collected in June and July 2014 from residences on South Brownell Road and Kirby Lane were analyzed for total metals and VOCs. The sample locations are shown in Figures 1 and 2. The detected concentrations in each sample are provided in Tables 1 to 5. These tables provide the concentration data for all soil samples as well as the average concentration, if calculable, and the EPA Regional Screening Levels (RSLs) for residential soil for HQ = 0.1, HQ = 1, and ILCR = 1E-06. The maximum concentrations in 0-10 foot soils in each area and for any area are provided in Table 6, along with RSLs and calculated risks.

Contaminants of Potential Concern (COPCs) were identified as those chemicals that were detected at least once in any soil sample and exceeded screening risk levels. Screening risk levels were January 2015 EPA RSLs for residential soil, set at a non-cancer Hazard Quotient (HQ) of 0.1 and an Incremental Lifetime Cancer Risk (ILCR) of 1E-06 (one in one million). The non-cancer risk was calculated by dividing the maximum measured concentration by the non-cancer based RSL (for HQ = 1). The cancer risk was calculated by dividing the maximum concentration by the cancer-based RSL (for ILCR = 1E-06) and then multiplying by 1E-06. The total ILCR of all carcinogenic chemicals was calculated by adding all of the ILCR

values. The total HQ was not calculated because all of the individual HQs were less than one, and HQs should be added together only for chemicals that have the same target tissue. The sum of the HQs for chemicals with the same target tissue is called the Hazard Index (HI).

At the former Mitec property (Table 1), seven samples taken in August 2012 were analyzed for VOCs, SVOCs, and total metals. Five samples taken in December 2013 were analyzed for total and hexavalent chromium. VOCs were not detected, and seven individual PAHs were detected in one sample. In the August 2012 samples, total chromium was detected at elevated levels (260 – 320 mg/kg) in three samples and between 12 and 46 mg/kg in four other samples. In December 2013, one of five samples analyzed for hexavalent chromium had detectable levels of hexavalent chromium at an estimated (J-qualified) concentration of 0.85 mg/kg. These five samples contained 7.5 to 16 mg/kg total chromium. As shown in Table 1, three individual PAHs in one sample, hexavalent chromium in one sample, and all arsenic samples exceeded the cancer-based RSL (for ICLR of 1E-06). The non-cancer RSL for HQ = 0.1 was exceeded in one or more samples by aluminum, arsenic, cobalt, iron, and manganese; however, none of these chemicals exceeded an HQ of one.

At Shunpike Road (south side) (Table 2), 16 samples collected in August, 2012 were analyzed for VOCs, SVOCs, and total metals. Two samples collected in December 2013 were analyzed for total and hexavalent chromium. Neither SVOCs nor hexavalent chromium were detected. Total chromium was measured at 11 mg/kg and 12 mg/kg. The only detected VOC was trichloroethene (TCE) which was detected in six of 16 samples at a maximum concentration of 2.1 mg/kg. TCE was not detected in soil less than 10 ft bgs. TCE exceeded the cancer-based RSL for ILCR = 1E-06 in one sample at a depth of 20-25 ft bgs. Since TCE was not detected in soil less than 10 ft bgs, TCE is not considered to be a COPC for direct residential soil exposure. Arsenic exceeded the cancer-based RSL of 0.61 mg/kg for ILCR = 1E-06 in all 16 samples. The non-cancer RSL for HQ = 0.1 was exceeded by one or more samples analyzed for aluminum, arsenic, cobalt, iron, manganese, and vanadium; however, none of these chemicals exceeded an HQ of one.

At Shunpike Road (north side) (Table 3), 17 samples collected in August 2012 were analyzed for VOCs, SVOCs, and total metals (hexavalent chromium was not analyzed for). VOCs and SVOCs were not detected. Arsenic exceeded the cancer-based RSL of 0.61 mg/kg for ILCR = 1E-06 in all 17 samples. The non-cancer RSL for HQ = 0.1 was exceeded by one or more samples analyzed for aluminum, arsenic, cobalt, iron, manganese, and vanadium; however, none of these chemicals exceeded an HQ of one.

At South Brownell Road (Table 4), ten samples collected in June and July 2014 were analyzed for total metals (hexavalent chromium was not analyzed for). Arsenic exceeded the cancer-based RSL of 0.61 mg/kg for ILCR = 1E-06 in all ten samples. The non-cancer RSL for HQ = 0.1 was exceeded by one or more samples analyzed for aluminum, arsenic, cobalt, iron, and manganese; however, none of these chemicals exceeded an HQ of one.

At South Brownell Road and Kirby Lane (Table 5), ten samples collected in June and July 2014 were analyzed for VOCs. All of these samples were collected from 0-1 ft bgs. The only detected VOCs were TCE (0.9094 mg/kg) and acetone (0.187 mg/kg), both from the same sample. TCE exceeded the non-cancer RSL (0.41 mg/kg) for HQ =0.1, but not the cancer-based RSL (0.94 mg/kg) for ILCR = 1E-06.

Data Analysis The maximum concentrations of COPCs in soil at 0-10 ft bgs in each area and the cancer and non-cancer risks for the maximum concentration in soil at 0-10 ft bgs at any location are presented

in Table 6. The maximum concentrations that exceed RSLs for HQ =0.1 or ILCR= 1E-06 are highlighted. Thirteen chemicals were detected at 0-10 ft bgs, but did not exceed RSLs for HQ=0.1 or ILCR = 1E-06. These chemicals are not COPCs in soil 0-10 ft bgs. These chemicals are acetone, fluoranthene, benzo(k)fluoranthene, chrysene, pyrene, barium, cadmium, total chromium, copper, lead, nickel, vanadium, and zinc. These chemicals were included in the risk calculations because some were detected at higher concentrations at soil depths greater than 10 feet.

As shown in Table 6, there were no chemicals that exceeded an HQ of 1. The highest HQ was 0.47 for cobalt, followed by 0.38 for iron, 0.22 for TCE, 0.21 for arsenic, 0.20 for manganese, and 0.18 for aluminum. As shown in Table 6, only aluminum and manganese had the same non-cancer target tissue (central nervous system). Therefore, the HQ values for these two chemicals were added to calculate a tissue-specific Hazard Index of 0.38.

As shown in Table 6, the total ILCR for all of the carcinogenic chemicals was 4.0E-05, driven primarily by benzo(a)pyrene (ILCR=2.1E-05) and arsenic (ILCR = 1.1E-05). The ILCR for all of the carcinogenic PAHs combined was 2.6E-05. Additional chemicals with cancer risks greater than 1E-06 included benz(a)anthracene, benzo(b)fluoranthene, and hexavalent chromium, all from the former Mitec property. As mentioned previously, the concentration of arsenic ranged from 2.6 mg/kg to 7.2 mg/kg and was not elevated at the former Mitec property relative to the residential properties. The average arsenic concentration was 3.7 mg/kg at the former Mitec property (Table 1), 5.2 mg/kg at Shunpike Road (Table 2), 4.1 mg/kg in the other samples at Shunpike Road, and 5.5 mg/kg at South Brownell Road. As a result, it is concluded that these arsenic concentrations represent background levels for this area.

If the cancer risks of background arsenic are removed from the calculation, then all of the remaining cancer risk is associated with the PAHs and hexavalent chromium at the former Mitec property and TCE at one property at the intersection of Shunpike Road and South Brownell Road (Table 5). The cancer risks of PAHs and hexavalent chromium were entirely from the same soil sample location at the former Mitec property. As shown in Table 1, three of the 12 soil samples at the former Mitec property analyzed for total chromium contained elevated concentrations (260 to 320 mg/kg), compared to 7.5 to 46 mg/kg in the other samples. Since hexavalent chromium was detected in one of five samples analyzed for this chemical, it is possible that the elevated concentrations of total chromium could actually be elevated concentrations of hexavalent chromium. If the maximum total chromium concentration of 320 mg/kg at the former Mitec property was 100% hexavalent chromium, the HQ would be 1, and the ILCR would be 1E-03 (Table 6a). Because of this possibility and the occurrence of PAHs only at the former Mitec property, it is recommended that additional soil be removed from 96 Commerce Street.

If the cancer risks for the detected hexavalent chromium, arsenic, and PAHs from the former Mitec property are removed from the calculation, the only cancer risk left would be an ILCR of 9.6E-07 for TCE at a property at the intersection of Shunpike Road and South Brownell Road (Table 6b).

This screening level risk assessment shows that the risks of the maximum detected concentrations of chemicals in soil 0-10 ft bgs do not exceed an HQ of 1 or an ILCR of 1E-04, EPA's maximum risk limits at Superfund sites, with the unlikely, but possible, exception of chromium at the former Mitec property, where the ILCR could be as high as 1E-03 if all of the highest detected level of total chromium were in the hexavalent form.

Recommendation Due to the uncertainty about whether elevated chromium at the former Mitec property may be hexavalent chromium, it is recommended that soil be removed from 96 Commerce Street, with a goal to reduce the concentration of PAHs, arsenic and hexavalent chromium to acceptable risk-based concentrations or background, whichever is higher.

Table 1. Detected Chemicals in Soil at the Mitec Area- 96 Commerce St. (Collected August, 2012 and December, 2013)

Chemical		Residential Soil RSL			Sample:	SB-13-1		SB-13-2			SB-12-5				SB-12-6			
		HQ		ILCR						DUP								
	Units	0.1	1	1E-06	ft bgs =	0-2	2-6	0-2	2-6	2-6	0-1	2-4	5-6	5-6	0-1	2-4	5-6	Mean
Fluoranthene	mg/kg	232	2,320								0.7	0.280U	0.300U	0.290U	0.250U	0.270U	0.280U	
Benz(a)anthracene	mg/kg			0.153							0.37	0.280U	0.300U	0.290U	0.250U	0.270U	0.280U	
Benzo(a)pyrene	mg/kg			0.0153							0.32	0.280U	0.300U	0.290U	0.250U	0.270U	0.280U	
Benzo(b)fluoranthene	mg/kg			0.153							0.36	0.280U	0.300U	0.290U	0.250U	0.270U	0.280U	
Benzo(k)fluoranthene	mg/kg			1.53							0.3	0.280U	0.280U	0.280U	0.280U	0.280U	0.280U	
Chrysene	mg/kg			15							0.41	0.280U	0.280U	0.280U	0.280U	0.280U	0.280U	
Pyrene	mg/kg	174	1,740								0.54	0.280U	0.300U	0.290U	0.250U	0.270U	0.280U	
Aluminum	mg/kg	7,700	77,000								14000	6100	6800	5800	5400	6700	6900	7386
Arsenic	mg/kg	3.44	34.4	0.67							3.7	2.6	3.7	3.5	4.4	4	3.7	3.657
Barium	mg/kg	1,500	15,000								24	28	19	16	15	14	17	19
Cadmium	mg/kg	7	70								2.2	4.2	0.98U	1U	1U	1U	1.1	
Chromium +3	mg/kg	12,000	120,000			7.5	9.6	8.3	13	16	46	320	300	260	12	14	17	85
Chromium (+6)	mg/kg	23.4	234	0.29		0.81UJ	0.8UJ	0.81UJ	0.85J	0.8UJ								
Cobalt	mg/kg	2.3	23.0								4.4	3.8	5	4.4	4.8	4.3	6.1	5
Copper	mg/kg	310	3,100								30	140	35	32	12	8.3	14	39
Iron	mg/kg	5,500	55,000								12000	9800	15000	14000	12000	14000	14000	12971
Lead [a]	mg/kg		400								16	15	5.5	5.2	4.4	3.4	4.4	8
Manganese	mg/kg	180	1,800								250	130	230	200	260	110	250	204
Nickel	mg/kg	150	1,500								16	16	17	15	16	16	18	16
Vanadium	mg/kg	39	390								12	8.9	13	12	10	14	12	12
Zinc	mg/kg	2,300	23,000								67	41	30	27	23	23	34	35

Only chemicals detected at least once at 96 Commerce St. are tabulated.
Highlighted concentrations exceed the RSL for HQ = 0.1 or ILCR = 1E-06
RSL = EPA Regional Screening Level
HQ = Hazard Quotient
ILCR = Incremental Lifetime Cancer Risk
U = non-detect at specified concentration
J = estimated
Highlighted concentrations exceed the RSL for HQ = 0.1 or ILCR = 1E-06
[a] The RSL for lead is a policy based acceptable concentration for residents.

Table 2. Detected Chemicals in Soil at Shunpike Road-South (samples collected August, 2012 and December, 2013)

Chemical	Units	Residential Soil RSL			Sample:	SB-12-1								SB-12-2								SB-13-3		Mean
		HQ		ILCR	ft.bgs=	3-5	5-10	10-15	15-20	20-25	25-30	30-35	35-48	3-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	0-2	2-6	
		0.1	1.0	1E-06																				
Trichloroethene	mg/kg	0.412	4.12	0.943		0.059U	0.054U	0.0927	0.13	0.095	0.11	0.070U	0.110U	0.059U	0.058U	0.061U	0.11	2.1	0.069U	0.070U	0.110U	NA	NA	NC
Aluminum	mg/kg	7740	77400			7000	5100	4300	4900	4400	4300	8800	36000	5800	5500	4600	6100	4200	4200	9300	33000	NA	NA	9219
Arsenic	mg/kg	3.44	34.4	0.670		6.6	6.4	3.9	3.8	4.3	3.9	4.2	9.2	5.9U	3	8.8	4.3	3.8	3.5	4.1	8.7	NA	NA	5.2
Barium	mg/kg	1530	15300			19	14	17	17	11	10	22	270	50	16	25	16	11	10	23	270	NA	NA	50
Cadmium	mg/kg	7	70			1U	1U	0.98U	1U	1U	1U	1U	3.1U	2.9U	0.98U	1U	1U	1U	0.98U	1U	3U	NA	NA	NC
Chromium (total)	mg/kg	11700	117000			29	21	14	14	12	12	18	65	23	27	14	15	13	12	18	60	11	12	23
Chromium (+6)	mg/kg	23.4	234	0.301		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.8UJ	0.81UJ	NC
Cobalt	mg/kg	2.34	23.4			4.2	3.7	5.7	5.8	5.6	5.4	8.4	20	5.9U	4.2	6.1	6.8	5.7	5.9	8.4	18	NA	NA	7.6
Copper	mg/kg	313	3130			9.3	7.8	10	13	14	18	20	45	5.9U	7.6	9.3	14	10	17	20	44	NA	NA	17
Iron	mg/kg	5480	54800			17000	15000	14000	18000	15000	14000	21000	44000	6900	13000	15000	18000	13000	14000	21000	43000	NA	NA	18869
Lead [a]	mg/kg		400			6.7	5.1	3.2	3.3	3.1	2.8	4.8	17	5.9U	4.4	3.2	3.8	2.8	3.4	5.3	14	NA	NA	5.5
Manganese	mg/kg	180	1800			150	150	350	500	290	300	490	880	120	150	1800	410	260	290	500	720	NA	NA	460
Nickel	mg/kg	155	1550			14	13	19	19	17	18	23	78	14	19	20	20	18	14	23	53	NA	NA	24
Vanadium	mg/kg	39.3	393			20	16	14	13	13	12	18	63	9	15	12	15	12	13	19	69	NA	NA	21
Zinc	mg/kg	2350	23500			22	19	21	25	23	24	43	100	18	24	23	32	24	26	42	100	NA	NA	35

Only chemicals detected at least once at Shunpike Road are tabulated.

Highlighted concentrations exceed HQ = 0.1 or ILCR = 1E-06, but not HQ=1 or ILCR = 1E-04

RSL = EPA Regional Screening Level

HQ = Hazard Quotient

ILCR = Incremental Lifetime Cancer Risk

U = non-detect at specified concentration

J = estimated

UJ = non-detect at estimated detection limit

NA = Not Analyzed

NC = Not Calculable

Note: PAHs were analyzed for, but not detected in these samples.

[a] The RSL for lead is a policy based acceptable level for residents.

Table 3. Detected Chemicals in Soil at Shunpike Road-North (samples collected August, 2012)

Chemical	Units	Residential Soil RSL			Sample:	SB-12-3									SB-12-4								Mean
		HQ		ILCR	ft.bgs=	3-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	
		0.1	1.0	1E-06																			
Aluminum	mg/kg	7740	77400			6000	4700	4000	4300	4500	4500	5500	7000	22000	4200	4400	5500	4300	4000	4200	6900	8500	6147
Arsenic	mg/kg	3.44	34.4	0.61		5.1	5.2	3.2	3.3	3	4.3	4.1	3.9	7.6	4.8	3.2	4.2	3.1	3.3	3.2	4.1	4.7	4.1
Barium	mg/kg	1530	15300			18	13	9.9	10	11	12	14	17	120	9.2	10	15	9.2	8.5	11	15	20	19
Cadmium	mg/kg	7	70			0.96U	0.98U	0.98U	0.96U	0.98U	0.98U	0.96U	0.96U	2.9U	1U	0.98U	0.98U	1U	1U	1U	1.1U	1.1U	NC
Chromium (total)	mg/kg	11700	117000			16	16	11	10	13	11	12	14	45	14	15	13	12	11	11	14	16	15
Cobalt	mg/kg	2.34	23.4			6.1	5.5	4.9	5.7	6.1	5.8	6.3	7.3	16	11	4.7	6.4	5.7	5.4	5.4	7.6	8.2	6.9
Copper	mg/kg	313	3130			14	11	9.8	12	13	14	16	17	33	18	12	15	11	17	14	19	21	16
Iron	mg/kg	5480	54800			21000	16000	12000	12000	15000	17000	16000	18000	40000	17000	13000	16000	13000	12000	12000	17000	19000	16824
Lead [a]	mg/kg		400			3.7	3.3	2.9	2.4	3.4	3	3	3.5	9.8	3.4	3	3.2	2.9	2.8	2.6	3.8	4.2	3.6
Manganese	mg/kg	180	1800			260	270	230	250	240	340	340	400	780	340	140	330	270	260	290	430	470	332
Nickel	mg/kg	155	1550			17	20	15	17	20	17	19	20	45	19	19	19	19	17	17	21	23	20
Vanadium	mg/kg	39.3	393			21	15	11	9.5	13	12	13	15	44	17	14	14	11	8.9	9.1	13	15	15
Zinc	mg/kg	2350	23500			25	21	19	23	24	23	28	35	88	18	21	27	24	20	22	34	41	29

Only chemicals detected at least once at Shunpike Road-North are tabulated.

Highlighted numbers exceed RSL for HQ = 0.1 or ILCR = 1E-06, but not HQ=1 or ILCR = 1E-04.

RSL = EPA Regional Screening Level

HQ = Hazard Quotient

ILCR = Incremental Lifetime Cancer Risk

NC = Not Calculated

U = Not Detected

Note: TCE and PAHs were analyzed for, but not detected in these samples.

[a] The RSL for lead is a policy based acceptable level for residents.

Table 4.Metals detected at South Brownell Road (samples collected June and July, 2014)

Chemical	Units	Residential Soil RSL			Sample:	SB-14-03	SB-14-04	SB-14-07	SB-14-09		SB-14-10	SB-14-11		SB-14-13	SB-14-15	Mean
		HQ		ILCR	Depth (ft bgs):	0-1	0-1	3-6	1-3	3-6	3-6	0-1	3-5	0-1	1-3	
		0.1	1.0	1.0E-06												
Aluminum	mg/kg	7740	77,400			5,200	9,400	6,000	7,200	7,500	5,400	11,000	5,400	12,000	8,900	7800
Arsenic	mg/kg	3.44	34.4	0.67		5.8	5.5	3.7	6.1	7.2	4.3	6.6	4.2	6.3	5.3	5.5
Barium	mg/kg	1530	15,300			15	42	16	22	23	14	38	13	43	23	24.9
Chromium +3	mg/kg	1170	11700			14	15	14	16	15	14	16	16	24	16	16
Cobalt	mg/kg	2.34	23.4			5.3	3.6	5.7	6.2	6.9	5.9	4.2	6.7	6.2	6.1	5.68
Copper	mg/kg	313	3,130			9.3	9.7	13	11	13	12	7.7	11	15	9.7	11.14
Iron	mg/kg	5480	54,800			15,000	18,000	14,000	18,000	18,000	14,000	17,000	17,000	19,000	17,000	16700
Lead [a]	mg/kg		400			6	18	4.9	5.9	5.7	4.6	12	4.1	9.6	5.8	7.66
Manganese	mg/kg	180	1,800			220	250	210	290	330	360	240	290	330	290	281
Nickel	mg/kg	155	1,550			18	11	16	19	22	16	12	19	17	15	16.5
Vanadium	mg/kg	39.3	393			14	22	15	18	17	14	21	17	23	18	17.9
Zinc	mg/kg	2350	23,500			29	63	27	30	32	28	34	25	43	38	34.9

Only chemicals detected at least once at South Brownell Road are tabulated.
Highlighted numbers exceed residential soil RSL for HQ =0.1 or ILCR = 1E-06, but not for HQ =1 or ILCR = 1E-04
RSL = EPA Regional Screening Level for residential soil
HQ = Hazard Quotient
ILCR = Incremental Liftime Cancer Risk
U = Not Detected
UJ = Not Detected at estimated detection limit
[a] The RSL for lead is a policy based acceptable level for residents.

Table 5. VOCs detected at South Brownell Road and Kirby Lane (samples collected June and July, 2014)

Chemical Name	Units	Residential Soil RSL			Sample:	SB-14-03	SB-14-04	SB-14-05	SB-14-06	SB-14-08	SB-14-09	SB-14-12	SB-14-15	SB-14-16	SB-14-17
		HQ		ILCR	Depth (ft bgs):	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1
		0.1	1	1.0E-06											
Acetone	mg/kg	6,100	61,000	NC		0.067U	0.187	.097U	0.110U	0.084U	0.067U	0.080U	0.074U	0.066U	0.079U
Trichloroethene	mg/kg	0.41	4.1	0.94		0.067U	0.9094	.097U	0.110U	0.084U	0.067U	0.080U	0.074U	0.066U	0.079U

Only VOCs detected at least once are tabulated.
Highlighted numbers exceed the RSL for HQ = 0.1 or ILCR = 1E-06, but not for HQ =1 or ILCR = 1E-04.
Samples collected June 30, 2014 and July 1, 2014 as part of Residential Soil and Sump Investigation (Nobis)
Samples were analyzed for VOCs and all chemicals were below detection limits except acetone and trichloroethene.
RSL = Regional Screening Level
U = Nondetect
HQ = Hazard Quotient
ILCR = Incremental Lifetime Cancer Risk

Table 6. Risks of the maximum concentration in 0-10 ft bgs soil at any area

Chemical	Units	Residential Soil RSL			Maximum Concentration at each area								Maximum Concentration at any area	Risk at Maximum Concentration		Target Tissue for HQ
		HQ		ILCR	96 Commerce St. (2012 & 2013)		Shunpike Rd. (2012 & 2013)		Shunpike Rd. (2012)		S. Brownell Rd & Kirby Ln (2014)					
		(0.1)	(1.0)	(1.0E-06)	Conc.	Location	Conc.	Location	Conc.	Location	Conc.	Location		ILCR	HQ	
Acetone	mg/kg	6070	60700								0.187	SB-14-04	0.187		3.1E-06	kidney
Trichloroethene	mg/kg	0.412	4.120	0.943	NA		ND	SB-12-1	NA		0.9094	SB-14-04	0.9094	9.6E-07	2.2E-01	IS
Fluoranthene	mg/kg	232	2,320		0.700	SB-12-5	NA		NA		NA		0.700		3.0E-04	kidney, blood
Benz(a)anthracene	mg/kg			0.153	0.370	SB-12-5	NA		NA		NA		0.370	2.4E-06		
Benzo(a)pyrene	mg/kg			0.0153	0.320	SB-12-5	NA		NA		NA		0.320	2.1E-05		
Benzo(b)fluoranthene	mg/kg			0.153	0.360	SB-12-5	NA		NA		NA		0.360	2.4E-06		
Benzo(k)fluoranthene	mg/kg			1.53	0.300	SB-12-5	NA		NA		NA		0.300	2.0E-07		
Chrysene	mg/kg			15.3	0.410	SB-12-5	NA		NA		NA		0.410	2.7E-08		
Pyrene	mg/kg	174	1,740		0.540	SB-12-5	NA		NA		NA		0.540		3.1E-04	
Aluminum	mg/kg	7,740	77,400		14000	SB-12-5	7000	SB-12-1	6000	SB-12-3	12000	SB-14-13	14000		1.8E-01	CNS
Arsenic	mg/kg	3.44	34.4	0.670	4.4	SB-12-5	6.6	SB-12-2	5.2	SB-12-3	7.2	SB-14-09	7.2	1.1E-05	2.1E-01	skin
Barium	mg/kg	1,530	15,300		28	SB-12-5	50	SB-12-2	18	SB-12-3	43	SB-14-13	50		3.3E-03	kidney
Cadmium	mg/kg	7	70		4.2	SB-12-5	ND	SB-12-2	ND	SB-12-4	ND		4.2		6.0E-02	kidney
Chromium (total)	mg/kg	11,700	117,000		320	SB-12-5	29	SB-12-1	16	SB-12-3	24	SB-14-13	320		2.7E-03	NR
Chromium (+6)	mg/kg	23.4	234	0.301	0.85 J	SB-13-2	ND	SB-13-3	NA		NA		0.85	2.8E-06	3.6E-03	NR
Cobalt	mg/kg	2.34	23.4		6.1	SB-12-5	4.2	SB-12-1	11	SB-12-4	6.9	SB-14-09	11		4.7E-01	thyroid
Copper	mg/kg	313	3,130		140	SB-12-5	9.3	SB-12-1	18	SB-12-4	15	SB-14-13	140		4.5E-02	NR
Iron	mg/kg	5,480	54,800		15000	SB-12-5	17000	SB-12-1	21000	SB-12-3	19000	SB-14-13	21000		3.8E-01	GI
Lead [a]	mg/kg		400		16	SB-12-5	6.7	SB-12-1	3.7	SB-12-3	18	SB-14-04	18		[a]	[a]
Manganese	mg/kg	180	1,800		260	SB-12-5	150	SB-12-2	340	SB-12-4	360	SB-14-10	360		2.0E-01	CNS
Nickel	mg/kg	155	1,550		18	SB-12-5	19	SB-12-2	20	SB-12-3	22	SB-14-09	22		1.4E-02	BW
Vanadium	mg/kg	39.3	393		14	SB-12-5	20	SB-12-1	21	SB-12-3	23	SB-14-13	23		5.9E-02	hair
Zinc	mg/kg	2,350	23,500		67	SB-12-5	24	SB-12-2	25	SB-12-3	63	SB-14-04	67		2.9E-03	blood

Data are for soil depths of 0-10 ft below ground surface (bgs)
Only chemicals detected at least once at any depth are tabulated.
Highlighted concentrations exceed RSLs for HQ =0.1 or ILCR = 1E-06.
RSL = EPA Regional Screening Level
HQ = Soil Concentration/(RSL for HQ = 1)
ILCR = (Soil Concentration/RSL for ILCR = 1E-06) x 1E-06
ILCR = Incremental Lifetime Cancer Risk
[a] The RSL for lead is a policy based acceptable level for residents
NR = Not Reported on EPA IRIS database

HQ = Hazard Quotient
HI = Hazard Index
GI = gastrointestinal
CNS = Central Nervous System
BW = Body Weight
IS = immune system
NA = Not Analyzed
J = estimated

Total Risks:	4.0E-05	1.9E+00
HI (CNS)=		3.8E-01
HI (IS)=		2.2E-01
HI(skin)=		2.1E-01
HI (kidney)=		6.3E-02
HI (thyroid)=		4.7E-01
HI (GI)=		3.8E-01
HI (BW)=		1.4E-02
HI (hair)=		5.9E-02
HI Chromium (total)=		2.7E-03
HI Chromium +6=		3.6E-03
HI Copper=		4.5E-02

Table 6a. Risks of the maximum concentration in 0-10 ft bgs soil at 96 Commerce St., assuming chromium is hexavalent.

		Residential Soil RSL			96 Commerce St.				Target
		HQ		ILCR	(2012 & 2013)		Risk		Tissue
Chemical	Units	(0.1)	(1.0)	(1.0E-06)	Conc.	Location	ILCR	HQ	for HQ
Trichloroethene	mg/kg	0.412	4.120	0.943	NA				
Fluoranthene	mg/kg	232	2,320		0.700	SB-12-5		3.0E-04	kidney,blood
Benz(a)anthracene	mg/kg			0.153	0.370	SB-12-5	2.4E-06		
Benzo(a)pyrene	mg/kg			0.0153	0.320	SB-12-5	2.1E-05		
Benzo(b)fluoranthene	mg/kg			0.153	0.360	SB-12-5	2.4E-06		
Benzo(k)fluoranthene	mg/kg			1.53	0.300	SB-12-5	2.0E-07		
Chrysene	mg/kg			15.3	0.410	SB-12-5	2.7E-08		
Pyrene	mg/kg	174	1,740		0.540	SB-12-5		3.1E-04	kidney
Aluminum	mg/kg	7,740	77,400		14000	SB-12-5		1.8E-01	CNS
Arsenic	mg/kg	3.44	34.4	0.670	4.4	SB-12-5	6.6E-06	1.3E-01	skin
Barium	mg/kg	1,530	15,300		28	SB-12-5		1.8E-03	kidney
Cadmium	mg/kg	7	70		4.2	SB-12-5		6.0E-02	kidney
Chromium (+6)	mg/kg	23.4	234	0.301	320	SB-13-2	1.1E-03	1.4E+00	NR
Cobalt	mg/kg	2.34	23.4		6.1	SB-12-5		2.6E-01	thyroid
Copper	mg/kg	313	3,130		140	SB-12-5		4.5E-02	NR
Iron	mg/kg	5,480	54,800		15000	SB-12-5		2.7E-01	GI
Lead [a]	mg/kg		400 [a]		16	SB-12-5		[a]	[a]
Manganese	mg/kg	180	1,800		260	SB-12-5		1.4E-01	CNS
Nickel	mg/kg	155	1,550		18	SB-12-5		1.2E-02	BW
Vanadium	mg/kg	39.3	393		14	SB-12-5		3.6E-02	hair
Zinc	mg/kg	2,350	23,500		67	SB-12-5		2.9E-03	blood
						Total Risk:	1.1E-03	2.5E+00	

Data are for soil depths of 0-10 ft below ground surface (bgs)
Only chemicals detected at least once at any depth are tabulated.
Highlighted concentrations exceed RSLs for HQ =0.1 or ILCR = 1E-06.
RSL = EPA Regional Screening Level
HQ = Soil Concentration/(RSL for HQ = 1)
ILCR = (Soil Concentration/RSL for ILCR = 1E-06) x 1E-06
ILCR = Incremental Lifetime Cancer Risk
[a] The RSL for lead is a policy based acceptable level for residents
HQ = Hazard Quotient
HI = Hazard Index
GI = gastrointestinal
CNS = Central Nervous System
BW = Body Weight
IS = immune system
NA = Not Analyzed
NR = Not Reported on IRIS database

HI (CNS)=	3.3E-01
HI(skin)=	1.3E-01
HI (kidney)=	1.3E-01
HI (thyroid)=	6.2E-02
HI (GI)=	2.7E-01
HI (BW)=	2.7E-01
HI (hair)=	1.2E-02
HI (blood)=	3.6E-02
HI (chromium) =	1.4E+00
HI (copper) =	4.5E-02

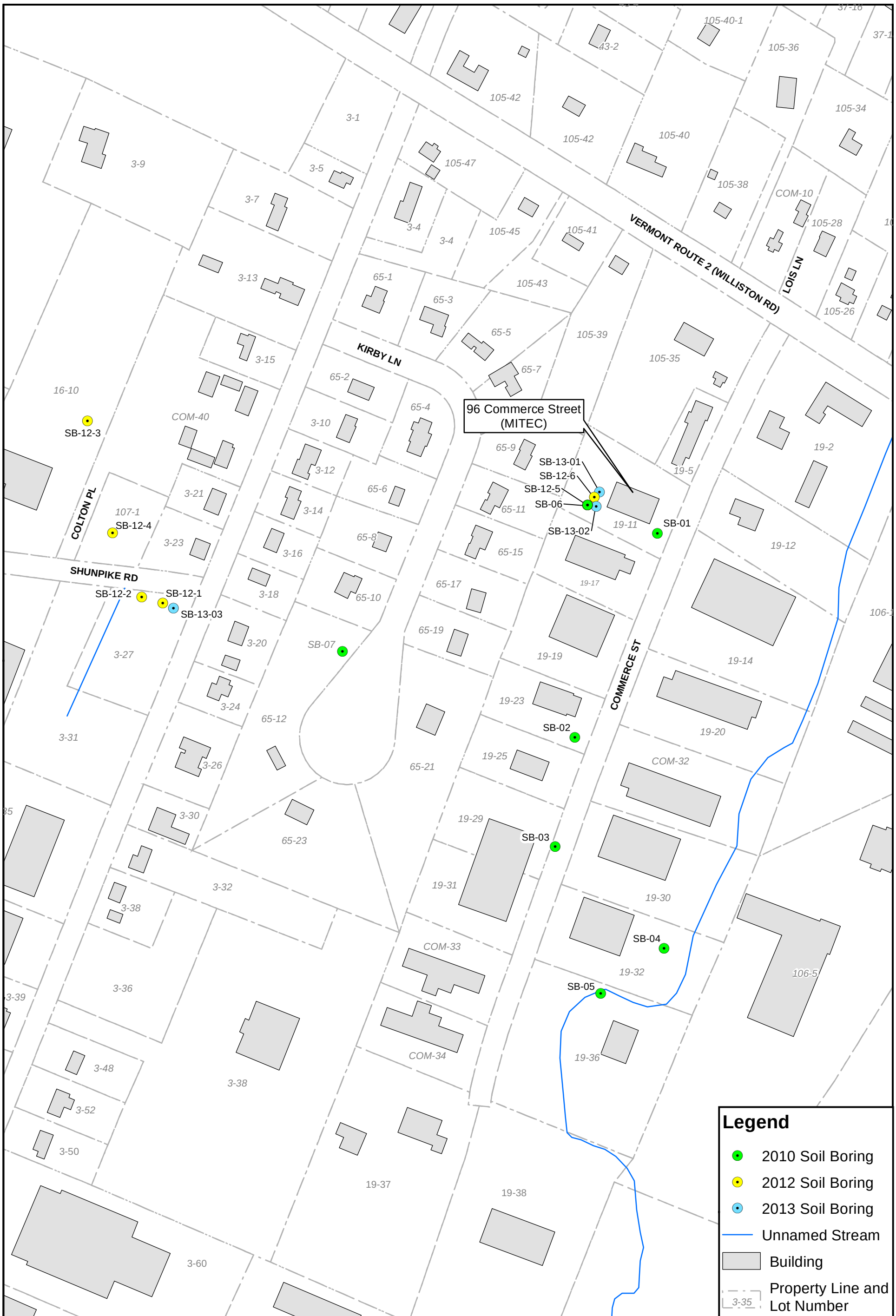
Table 6b. Risks of the maximum concentration in 0-10 ft bgs soil at Shunpike Rd., S. Brownell Rd., and Kirby Lane.

		Residential Soil RSL			Maximum Concentration						Maximum Concentration at any area	Risk at Maximum Concentration		Target Tissue for HQ
		HQ		ILCR	Shunpike Rd. (2012 & 2013)		Shunpike Rd. (2012)		S. Brownell Rd & Kirby Ln (2014)					
Chemical	Units	(0.1)	(1.0)	(1.0E-06)	Conc.	Location	Conc.	Location	Conc.	Location		ILCR	HQ	
Acetone	mg/kg	6070	60700		NA		NA		0.187	SB-14-04	0.187		3.1E-06	kidney
Trichloroethene	mg/kg	0.412	4.120	0.943	ND	SB-12-1	NA		0.9094	SB-14-04	0.9094	9.6E-07	2.2E-01	IS
Fluoranthene	mg/kg	232	2,320		NA		NA		NA					
Benz(a)anthracene	mg/kg			0.153	NA		NA		NA					
Benzo(a)pyrene	mg/kg			0.0153	NA		NA		NA					
Benzo(b)fluoranthene	mg/kg			0.153	NA		NA		NA					
Benzo(k)fluoranthene	mg/kg			1.53	NA		NA		NA					
Chrysene	mg/kg			15.3	NA		NA		NA					
Pyrene	mg/kg	174	1,740		NA		NA		NA					
Aluminum	mg/kg	7,740	77,400		7000	SB-12-1	6000	SB-12-3	12000	SB-14-13	12000		1.6E-01	CNS
Arsenic	mg/kg	3.44	34.4	0.670	6.6	SB-12-2	5.2	SB-12-3	7.2	SB-14-09	7.2	1.1E-05	2.1E-01	skin
Barium	mg/kg	1,530	15,300		50	SB-12-2	18	SB-12-3	43	SB-14-13	50		3.3E-03	kidney
Cadmium	mg/kg	7	70		ND	SB-12-2	ND	SB-12-4	ND		ND			
Chromium (total)	mg/kg	11,700	117,000		29	SB-12-1	16	SB-12-3	24	SB-14-13	29		2.5E-04	NR
Chromium (+6)	mg/kg	23.4	234	0.301	ND	SB-13-3	NA		NA					
Cobalt	mg/kg	2.34	23.4		4.2	SB-12-1	11	SB-12-4	6.9	SB-14-09	11		4.7E-01	thyroid
Copper	mg/kg	313	3,130		9.3	SB-12-1	18	SB-12-4	15	SB-14-13	18		5.8E-03	NR
Iron	mg/kg	5,480	54,800		17000	SB-12-1	21000	SB-12-3	19000	SB-14-13	21000		3.8E-01	GI
Lead [a]	mg/kg		400 [a]		6.7	SB-12-1	3.7	SB-12-3	18	SB-14-04	18	[a]	[a]	[a]
Manganese	mg/kg	180	1,800		150	SB-12-2	340	SB-12-4	360	SB-14-10	360		2.0E-01	CNS
Nickel	mg/kg	155	1,550		19	SB-12-2	20	SB-12-3	22	SB-14-09	22		1.4E-02	BW
Vanadium	mg/kg	39.3	393		20	SB-12-1	21	SB-12-3	23	SB-14-13	23		5.9E-02	hair
Zinc	mg/kg	2,350	23,500		24	SB-12-2	25	SB-12-3	63	SB-14-04	63		2.7E-03	blood
											Total Risks:	1.2E-05	1.7E+00	

Data are for soil depths of 0-10 ft below ground surface (bgs)
Only chemicals detected at least once at any depth are tabulated.
Highlighted concentrations exceed RSLs for HQ =0.1 or ILCR = 1E-06.
RSL = EPA Regional Screening Level
HQ = Soil Concentration/(RSL for HQ = 1)
ILCR = (Soil Concentration/RSL for ILCR = 1E-06) x 1E-06
ILCR = Incremental Lifetime Cancer Risk
[a] The RSL for lead is a policy based acceptable level for residents
NR = Not Reported on EPA IRIS database

HQ = Hazard Quotient
HI = Hazard Index
GI = gastrointestinal
CNS = Central Nervous System
BW = Body Weight
IS = immune system
NA = Not Analyzed
ND = Not Detected

HI (CNS)= 3.6E-01
HI (IS)= 2.2E-01
HI(skin)= 2.1E-01
HI (thyroid)= 4.7E-01
HI (GI)= 3.8E-01
HI (BW)= 1.4E-02
HI (hair)= 5.9E-02
HI (kidney)= 3.3E-03
HI (copper)= 5.8E-03
HI (chromium)= 2.5E-04



Notes:

1. Location of all features is approximate. Map is for reference purposes only. Nobis Engineering, Inc. makes no claims, warranties, representations, expressed or implied, relating to the completeness, accuracy, or reliability of the data shown.
2. Soil borings were observed and soil samples were collected by Nobis Engineering, Inc. in the years indicated in the legend.

0 100 200 400
Feet
1 inch = 200 feet
N

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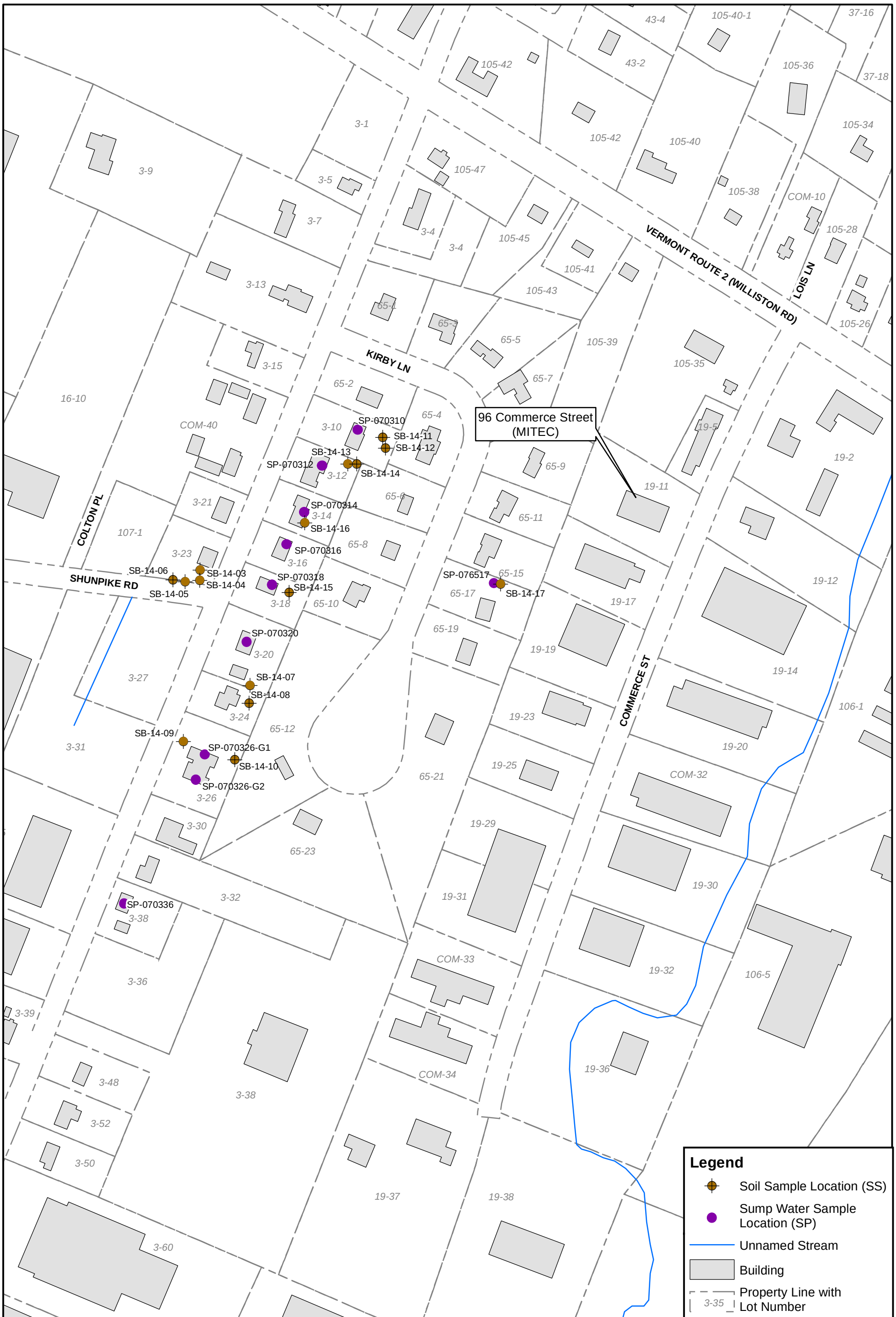
FIGURE 1

SOIL BORING LOCATIONS
COMMERCE STREET PLUME
SUPERFUND SITE
WILLISTON, VERMONT

PREPARED BY: JH	CHECKED BY: SH
PROJECT NO. 80036	DATE: JULY 2015

Path: K:\Technical Data (TD)\GIS\Maps\RI\Figure 1 Soil Boring Locations.mxd Date Printed: 7/1/2015



Notes:

1. Location of all features is approximate. Map is for reference purposes only. Nobis Engineering, Inc. makes no claims, warranties, representations, expressed or implied, relating to the completeness, accuracy, or reliability of the data shown.

2. Sump water and surficial soil samples collected by Nobis Engineering, Inc. on June 30, 2014 and July 1, 2014.

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FIGURE 2

SURFICIAL SOIL AND SUMP INVESTIGATION LOCATIONS
COMMERCE STREET PLUME
SUPERFUND SITE
WILLISTON, VERMONT

PREPARED BY: NZ	CHECKED BY: SH
PROJECT NO. 80036	DATE: JULY 2015

Path: K:\Technical Data (TD)\GIS\Maps\R\Figure 2 Residential Soil and Sump Investigation Locations.mxd Date Printed: 7/2/2015

APPENDIX C

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region 1
5 POST OFFICE SQUARE
BOSTON, MA 02109-3912

MEMORANDUM

DATE: December 18, 2013

SUBJECT: Vapor Intrusion Investigation, Commerce Street Superfund Site

FROM: Margaret McDonough, Human Health Risk Assessor

TO: Karen Lumino, Remedial Project Manager

EPA Region 1 investigated the potential for vapor intrusion at the Commerce Street Superfund Site, Williston, VT. The transport of volatile contaminants from groundwater to indoor air at five residential and two commercial properties was investigated with sampling of indoor air and sub-slab soil gas. The results do not show a complete vapor intrusion pathway, and no contaminants associated with the Commerce Street Site were detected above conservative health risk-based screening levels. The investigation and evaluation are discussed below.

Site Background Information

High levels of trichloroethylene (TCE) are present in groundwater at the Commerce Street site. Two distinct areas ("hotspots") of TCE have been mapped: 1) along Commerce Street which is entirely commercial, and 2) near the intersection of South Brownell Road and Shunpike Road, which is mostly residential with some commercial properties. The highest groundwater TCE concentrations (>50,000 ug/L) were found in the deepest portions (>30 feet below ground surface (bgs)) of the Commerce Street hotspot. TCE in groundwater along Commerce Street is not detected in the shallower groundwater and generally does not exceed the MCL (5 ug/L) at depths of less than 20 feet bgs. TCE in groundwater near South Brownell/Shunpike Roads is detected in excess of the MCL at depths of 10 to 15 feet bgs with the highest concentration (13,000 ug/L) at 20 feet bgs.

The water table is on average 5 feet bgs but fluctuates by as much as ten feet. Area homeowners with basements report running sump pumps seasonally. Groundwater flows generally from north to south with some amount of radial flow west toward Kirby Lane and east toward the unnamed stream. Vertical gradients are generally low and downward, although near the unnamed stream and in the central portions of the study area, upward flow has been recorded.

Vapor Intrusion Investigation

EPA conducted sampling to evaluate whether a vapor intrusion pathway is present, and if so, whether potential health risks are of concern.

Indoor air and sub-slab soil gas were sampled during heating and non-heating seasons at properties selected based on the following criteria:

- Proximity to groundwater hotspots
- Property owners willing to grant access
- Presence of sensitive populations
- Absence of practices at commercial properties that might impact results (e.g., cat hospital, print shop)

The two rounds of sampling were conducted in June 2012 and January 2013 by Region 1's Office of Environmental Measurement and Evaluation (OEME). The sampling, conducted at five residences and two commercial properties included:

- 24-hour sampling of indoor air for volatile compounds
- Grab-samples of sub-slab soil gas from 2 locations

Details of the sampling methods and analytical results are provided in reports dated August 2012 and June 2013.

Risk Evaluation

Residential indoor air concentrations were compared to health risk-based screening levels associated with excess lifetime cancer risk of 1x 10^{-6} and a non-cancer Hazard Index (HI) of one assuming exposure to indoor air occurs for 24 hours per day each day for 30 years. Risk-based screening levels for indoor air at commercial properties are also associated with 1 x 10^{-6} cancer risk and HI of one assuming workers are exposed 40hours per week over 25 years.
The health risk-based screening levels for TCE and PCE in indoor air and sub-slab soil gas are shown in Table 1. Sampling results are summarized below and in Tables 2 through 5.

Residential Properties

- TCE was found in the indoor air of only one home but not in the sub-slab soil gas beneath the structure. All other results were non-detect for TCE.
- PCE was detected in the indoor air and half the sub-slab soil gas samples in three of the five homes, but at levels that did not exceed conservative health-based screening concentrations. In a fourth home, PCE was detected in one sub-slab sample at a concentration well below risk-based screening levels, and not in the indoor air. PCE was not detected in any samples taken at the fifth residence.

Commercial Properties

- TCE was not detected in sub-slab soil gas at either of the two commercial properties. TCE was detected at a level well below risk-based screening concentrations in the indoor air at one property.
-
- PCE was detected in sub-slab soil gas at very low concentrations at both properties. PCE was not detected in indoor air.

Investigation Results

The investigation does not show the potential for unacceptable risks via the vapor intrusion pathway. EPA has made the determination that there is no need for further investigation.

Risk-based Screening Levels

	Indoor Air (ug/m^3)	Sub-Slab Soil Gas (ug/m^3)
Residential TCE PCE	 0.43 9.4	 4.3 94
Commercial TCE PCE	 2.99 47	 29.9 470

Results of Vapor Intrusion Investigation – TCE at Residential Properties

	Resident 1	Resident 2	Resident 3	Resident 4	Resident 5
Basement June 2012 Jan 2013	NA	0.27 4.3	NA	ND*	ND*
Basement Bedroom	NA	NA	ND*	NA	NA
Utility Room	NA	NA	ND*	NA	NA
Crawl Space	ND*	NA	NA	NA	NA
First Floor June 2012 Jan 2013	ND*	ND 4.0	ND*	ND*	ND*
Sub-slab 1	NA	ND*	ND*	ND*	ND*
Sub-slab2	NA	ND*	ND*	ND*	ND*

* ND for both June 2012 and January 2013 sample. Detection limit = 0.49 to 0.59 ug/m^3.
NA – not available, e.g., property without a basement

Results of Vapor Intrusion Investigation – PCE at Residential Properties

	Resident 1	Resident 2	Resident 3	Resident 4	Resident 5
Basement June 2012 Jan 2013	NA	0.51 1.3	NA	ND*	0.88 0.48
Basement Bedroom	NA	NA	0.54 9.4	NA	NA
Utility Room	NA	NA	6.3 6.6	NA	NA
Crawl Space	ND*	NA	NA	NA	NA
First Floor June 2012 Jan 2013	ND*	0.35 1.1	0.88 5.3	ND*	0.35 0.61
Sub-slab 1	NA	1.9 2.0	ND*	ND*	1.5 1.2
Sub-slab2	NA	ND*	ND 9.7	ND 14	ND*

* ND for both June 2012 and January 2013 sample. Detection limit = 0.48 to 0.75 ug/m^3.
NA – not available, e.g., property without a basement

Results of Vapor Intrusion Investigation – TCE at Commercial Properties

	Commercial Property 1	Commercial Property 2
First Floor Office June 2012 Jan 2013	0.59 ND	ND*
First Floor Lab June 2012 Jan 2013	0.81 ND	NA
First Floor Conference Room	NA	ND*
1st Floor Break Room	NA	NA
Sub-slab 1	ND*	ND*
Sub-slab 2	ND*	ND*
Sub-slab3	NA	ND*
Sub-slab 4	NA	ND*

* ND for both June 2012 and January 2013 sample. Detection limit = 0.46 to 0.7 ug/m^3.
NA – not available, e.g., property without a basement

Results of Vapor Intrusion Investigation – PCE at Commercial Properties

	Commercial Property 1	Commercial Property 2
1st Floor Office	ND*	ND*
1st Floor Lab	ND*	NA
1st Floor Conference Room	NA	ND*
1st Floor Break Room	ND*	NA
Sub-slab 1 June 2012 Jan 2013	2.6 4.0	ND*
Sub-slab 2	ND*	ND*
Sub-slab3 June 2012 Jan 2013	NA	1.9 9.5
Sub-slab 4	NA	19 23

* ND for both June 2012 and January 2013 sample. Detection limit = 0.46 to 0.7 ug/m^3.
NA – not available, e.g., property without a basement

Results of Vapor Intrusion Investigation – PCE at Commercial Properties

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 1

5 POST OFFICE SQUARE – SUITE 100

BOSTON, MASSACHUSETTS 02109-3912

Memorandum

DATE: 1/7/15

FROM: Alex Sherrin

TO: Site File

SUBJ: Indoor Air Sampling Report for 830 Brownell Road, Williston, VT for the Commerce Street Plume NPL Site.

Introduction

A private single family residence located at 830 South Brownell Road in Williston, VT, is the subject of this investigation. The surrounding area is residential. Groundwater in the area is impacted with trichloroethylene (TCE) and perchloroethylene (PCE) and indoor air data from the State of Vermont indicates that the air in the basement and first floor have elevated levels of TCE and PCE. EPA Region I's Removal Program is reviewing the site to determine eligibility for a removal action to address risks posed by these impacts to indoor air. The source of the chlorinated solvents is the Commerce St Plume NPL Site.

Site Conditions

The single story residence has an unfinished basement that is approximately 6-7 feet below ground surface. The basement floor is poured concrete which has some minor cracking in it. The basement walls are cinder block also with some minor cracking. Several pipes perforate the wall including the main water supply, waste outlet, and a waste inlet from the garage bathroom. These perforations appear to be sealed.

The groundwater level is very shallow, and a sump pump operates often to keep the basement dry although it did not operate while the EPA sampling team was on-site. This sump was open to the basement, but the State of VT sealed it using a plastic covered sump with two ½ horsepower sump pumps with backup batteries after discovering the elevated levels of TCE in the basement air. In the summer, the homeowner keeps the basement windows open and operates fans to exchange basement air to prevent mold, and lately to mitigate the TCE/PCE risks.

The basement contains many other household and personal items including the furnace, hot water tank, washer and dryer, a work bench, shelves, clothing hanging on a rack and packed in bins, toys, and miscellaneous household goods.

Previous Sampling

The State of VT has conducted two sampling events with the following results.

Table 1: VT DEC Sampling Results

	July 2014	April 2014	EPA Residential 1x 10-4	EPA Residential HI = 3
TCE upstairs µg/m^3	0.55	3.8	43 µg/m^3	6 µg/m^3
PCE upstairs µg/m^3	0.68	1.8	940 µg/m^3	126 µg/m^3
TCE Basement µg/m^3	26	7.8		
TCE Basement Duplicate	30	7.2		
PCE Basement µg/m^3	1.1	<1.4		
PCE Basement Duplicate	1.0	<1.4		
Sump water µg/l	104	75		

The following is taken from an email from Mike Smith of the State of Vermont describing the conditions under which their air samples were collected.

> "During the April sampling event, the homeowner had a couple of large vent fans blowing in the basement to try to evaporate some of the water accumulating in the basement. He also had a basement window open. He refused to turn the fans off as he was very concerned about mold which may have been a problem in the past. While we would normally never take a sample under these conditions, I didn't want to miss the chance considering how hard it had been to schedule the sample event. We put the canisters as far away from the fans as possible but again, while it was not ideal, it was the best we could do.
>
> During the July event, the basement window was closed and he had only one small fan operating. The summa canisters were located in approximately the same place as in April. The higher results may be a more true approximation of the air quality in the basement than the April event due to the fans."

EPA Sampling

EPA Region 1 removal Program mobilized to the site on December 8, 2014, arriving at approximately 1100 hrs. The homeowner was present to open the house. EPA personnel included OSC Alex Sherrin and chemist Scott Clifford. The scope of work included:

- Surveying the basement for materials that may contain volatile organic compounds (VOCs) that may interfere with the indoor air sampling;

- Collecting and analyzing grab samples of indoor air to assess indoor air quality and direct summa canister sample placement; and
- Collecting 24 hour 6 L Summa Canister to assess indoor air quality.

House Survey

EPA conducted a survey of the basement to ensure that no other sources of TCE/PCE are present. Many items were found which may contain VOCs including paints, spray cans, solvents, and dry cleaning products. Approximately 50 items were found and removed from the house.

Grab Samples

A total of twelve grab samples of indoor air were collected as noted in Table 2 below. The results of the on-site analyses is also presented.

Table 2: EPA Grab Sample Data

Sample Number	Location and Rational for Sampling.	TCE Result (ug/m^3)[A]	PCE Result (ug/m^3)[A]
G1	Basement behind the Furnace. General basement air.	ND (2.7)	ND (1.4)
G2	Basement at the clothes rack – Detect off-gassing from drycleaned clothes	ND (2.7)	ND (1.4)
G3	Basement above the ground water sump. Detect off-gassing from ground water	ND (2.7)	ND (1.4)
G4	Basement at the waste sump. Detect off-gassing of VOCs from waste sump.	ND (2.7)	ND (1.4)
G5	Basement at the main water inlet. Detect vapors entering through perforation in wall.	ND (2.7)	ND (1.4)
G6	Basement in the crack in the cinder block wall. Detect Vapors entering basement through cracks.	ND (2.7)	ND (1.4)
G7	Basement in the space at the top of the cinder block wall. Detect vapors entering basement through cinder block openings	ND (2.7)	ND (1.4)
G7 Dup	Basement in the space at the top of the cinder block wall (see G7).	ND (2.7)	ND (1.4)
G8	First Floor kitchen. Detect vapors on first floor.	ND (2.7)	ND (1.4)
G9	Basement at the wood bench for tools. General basement air.	ND (2.7)	ND (1.4)
G10	Basement above the tool box at the bottom of the stairs. General basement air.	ND (2.7)	ND (1.4)
G11	Basement at the washer and dryer. General basement air.	ND (2.7)	ND (1.4)
G12	Basement under the furnace in the sump. Detect vapors entering through sump under the furnace.	ND (2.7)	ND (1.4)

[A] The Detection Limits (DLs) of 2.7 and 1.4 ug/m^3 were calculated from the ppbv DLs provided in NERL's report.

Summa Canister Sampling Method

24-hour 6-L Summa Canister were used to collect indoor air samples to assess the air quality. Sampling method used was the Standard Operating Procedures are ECASOP-CanisterSampling.SOP.Rev5. The canisters were placed between 3 pm and 4 pm on December 8, 2014, at locations indicated in Table 3 below. Indoor canisters were placed at approximately waist height at locations noted below. The outside canister was placed in an open area in the yard upwind of the house. Note that this location was placed inside the backyard fence because the homeowner warned us that the canister would be stolen if it was placed in the front yard which was not fenced. A duplicate sample was also be collected in the basement. The canister pressure readings were all observed to be minus 30 mm Hg.

As noted in the sampling brief, the basement windows were closed for the entire 24 hour sampling period. The basement fans were not operating, and no smoking was observed.

Table 3: Summa Canister Sample Data

Sample Number	Location and Rational for Sampling.	TCE Result (ug/m^3)	PCE Result (ug/m^3)
S1	Basement near the clothes hanging on the rack. General basement air on the north side.	ND (<0.094)	ND (<0.094)
S2	Basement next to the ground water sump. General basement air on south side.	ND (<0.094)	ND (<0.094)
S2 Dup	Basement next to the ground water sump (See S2)	ND (<0.094)	ND (<0.094)
S3	First Floor Kitchen. General Kitchen air.	ND (<0.094)	1.3
S4	Outside in the backyard upwind of the house. Ambient Air/background sample.	ND (<0.094)	ND (<0.094)

TCE Screening level for residents is 6 ug/m^3 based on a non-cancer HI of 3.

PCE Screening level for residents is 125 ug/m^3 based on non-cancer HI of 3.

The summa canisters were collected on December 9, 2014, between 3 and 3:30 pm. The pressure readings were noted prior to closing the canisters. All readings were between minus 6 and minus 7 mm Hg. The regulators were removed and all equipment packed and the chain-of-custody forms were completed prior to transport. The samples were delivered to the New England Regional Laboratory (NERL) on December 10, 2014 at 4 pm by OSC Sherrin.

Analytical Method

The analytical method was EPA Method TO-15.

Reporting and Conclusions

The contaminants of concern at the site are TCE and PCE, and the results are summarized in the Table 2 above. The data show that TCE was not detected in any of the Grab Samples or the Summa Canister samples, and PCE was not detected in any of the Grab Samples or the Summa Canister samples with the exception of the kitchen sample S3. S3 contained 1.3 ug/m^3 of PCE. Since the basement air did not contain PCE, it is unlikely that vapor intrusion is the source. In addition, PCE was not detected in sample S4 collected outside so an ambient air source is unlikely. The homeowner stated that he dry cleaned his uniforms regularly and stored them in the bedroom closet. Since dry-cleaned clothes off-gas PCE, it is possible that this is the source of PCE detected in the kitchen which is located close to the bedroom.

Several other VOCs were detected in the summa canister samples including VOCs such as BTEXs (Benzene, Toluene, Ethylbenzene, and Xylene) and halogenated VOCs such as methylene chloride and dichlorodifluoromethane. These may be the result of storing paints, sprays cans, solvents, etc. in the basement by the homeowner. They are not contaminants of concern at the Commerce Street Plume NPL Site and are not considered to be attributable to the NPL site.

Data Quality

The sampling procedures followed the Standard Operating Procedures are ECASOP-CanisterSampling.SOP.Rev5. The sampling locations were appropriate for assessing the indoor air in the basement and first floor. The NERL analytical report indicates that all the data quality parameters were within QA limits. In addition, the lab blank only detected methyl ethyl ketone (MEK) which is not a contaminant of concern at the NPL site. The data presented is representative of site conditions and is appropriate for determining if a removal action is warranted.

APPENDIX D

TABLE D-1
SAMPLE LIST - SEDIMENT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Exposure Area	Sample Location	Collection Date
Site	PW-02	9/12/2012
Site	PW-11	9/12/2012
Site	PW-17	9/11/2012
Site	PW-20	9/11/2012
Background	UPSTREAM	9/13/2012

TABLE D-2
SAMPLE LIST - SURFACE WATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Exposure Area	Sample Location	Collection Date
Site	PW-02	9/12/2012
Site	PW-11	9/12/2012
Site	PW-17	9/11/2012
Site	PW-20	9/11/2012
Background	UPSTREAM	9/14/2012

TABLE D-3
SAMPLE LIST - SHALLOW GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Exposure Area	Sample Location	Depth (ft)	Collection Date
Site	AL-12	3-13	5/20/2010
			12/1/2010
Site	AL-14	6-16	12/16/2008
			5/18/2010
			11/30/2010
Site	AL-15	6.5-16.5	12/19/2008
			5/19/2010
			12/1/2010
Site	ARC-3	5-20	12/17/2008
			5/19/2010
			12/1/2010
Site	ASI-14S	8.5-18.5	12/16/2008
			5/18/2010
			11/30/2010
Site	ASI-23S	8-18	12/16/2008
			5/18/2010
			12/1/2010
Site	BF-4	1.5-11.5	12/19/2008
			5/20/2010
			12/1/2010
Site	BW-13S	5-6	12/18/2008
			5/20/2010
			12/2/2010
Site	MI-08	9.5-14.5	12/19/2008
			5/20/2010
			12/2/2010
			12/11/2013
Site	OE-2B	3-13	12/17/2008
			5/20/2010
			11/30/2010

TABLE D-4
SAMPLE LIST - SHALLOW GROUNDWATER FOR THE VAPOR INTRUSION PATHWAY
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Exposure Area	Sample Location	Depth (ft)	Collection Date
Site	AL-12	3-13	5/20/2010
			12/1/2010
Site	AL-14	6-16	12/16/2008
			5/18/2010
			11/30/2010
Site	AL-15	6.5-16.5	12/19/2008
			5/19/2010
			12/1/2010
Site	ARC-3	5-20	12/17/2008
			5/19/2010
			12/1/2010
Site	ASI-14S	8.5-18.5	12/16/2008
			5/18/2010
			11/30/2010
Site	ASI-23S	8-18	12/16/2008
			5/18/2010
			12/1/2010
Site	BF-4	1.5-11.5	12/19/2008
			5/20/2010
			12/1/2010
Site	BW-13S	5-6	12/18/2008
			5/20/2010
			12/2/2010
Site	MI-01	10-15	12/15/2008
			5/19/2010
			11/29/2010
Site	MI-02	10-15	12/15/2008
			5/18/2010
			11/29/2010
Site	MI-08	9.5-14.5	12/19/2008
			5/20/2010
			12/2/2010
			12/11/2013
Site	MW-08S	14-19	11/30/2010
			6/7/2012
Site	MW-11S	14.3-19.3	12/1/2010
			6/6/2012
Site	OE-2B	3-13	12/17/2008
			5/20/2010
			11/30/2010

TABLE D-5
SAMPLE LIST - OVERBURDEN GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Exposure Area	Sample Location	Depth (ft)	Collection Date
Site	AIP-01	-	5/19/2010
			12/2/2010
Site	AL-1	19.5-29.5	12/17/2008
Site	AL-2	15-25	5/19/2010
			12/1/2010
Site	AL-12	3-13	5/20/2010
			12/1/2010
Site	AL-14	6-16	12/16/2008
			5/18/2010
			11/30/2010
Site	AL-15	6.5-16.5	12/19/2008
			5/19/2010
			12/1/2010
Site	ARC-3	5-20	12/17/2008
			5/19/2010
			12/1/2010
Site	ASI-02D2	26-31	12/18/2008
			5/18/2010
			11/29/2010
Site	ASI-03D2	26-31	5/18/2010
			11/29/2010
Site	ASI-04D2	30.5-35.5	12/18/2008
			5/17/2010
			11/30/2010
			6/7/2012
Site	ASI-05D2	30.5-35.5	12/18/2008
			5/20/2010
			12/2/2010
			6/6/2012
Site	ASI-11D2	35-40	12/19/2008
			5/17/2010
			11/30/2010
Site	ASI-14D2	25-30	12/16/2008
			5/18/2010
			11/30/2010
Site	ASI-14S	8.5-18.5	12/16/2008
			5/18/2010
			11/30/2010
Site	ASI-15D2	35.5-40.5	12/18/2008
			5/20/2010
			12/1/2010
Site	ASI-16D2	30-35	5/19/2010
			12/1/2010
Site	ASI-23D2	25-30	12/16/2008
			5/18/2010
			12/1/2010
Site	ASI-23S	8-18	12/16/2008
			5/18/2010
			12/1/2010
Site	BW-13S	5-6	12/18/2008
			5/20/2010
			12/2/2010
Site	BM-3D	24-29	12/17/2008
			5/19/2010
			11/29/2010

TABLE D-5
SAMPLE LIST - OVERBURDEN GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Exposure Area	Sample Location	Depth (ft)	Collection Date
Site	BM-3S	13-23	12/19/2008
			5/19/2010
			11/29/2010
Site	BR-1	113-123	12/17/2008
			5/21/2010
			12/2/2010
			6/6/2012
Site	BF-4	1.5-11.5	12/19/2008
			5/20/2010
			12/1/2010
Site	MI-01	10-15	12/15/2008
			5/19/2010
			11/29/2010
Site	MI-02	10-15	12/15/2008
			5/18/2010
			11/29/2010
Site	MI-08	9.5-14.5	12/19/2008
			5/20/2010
			12/2/2010
Site	MW-01D	34.4-39.4	12/1/2010
			6/7/2012
Site	MW-02M	24.3-29.3	11/29/2010
Site	MW-03D	35.2-40.2	11/29/2010
			6/7/2012
Site	MW-04D	34.5-39.5	12/2/2010
			6/6/2012
Site	MW-05D	28.5-33.5	11/30/2010
			6/6/2012
			12/11/2013
Site	MW-05D2	39.4-44.4	11/30/2010
			6/5/2012
Site	MW-06D	32.9-37.9	11/30/2010
			6/6/2012
Site	MW-06M	23.9-28.9	11/30/2010
			6/6/2012
Site	MW-07M	29.3-34.3	12/2/2010
			6/5/2012
Site	MW-08M	19-24	11/30/2010
			6/6/2012
Site	MW-08S	14-19	11/30/2010
			6/7/2012
Site	MW-09D	34.6-39.6	12/2/2010
			6/5/2012
Site	MW-09M	24.5-29.5	12/1/2010
			6/5/2012
Site	MW-10D	30-35	12/2/2010
			6/5/2012
Site	MW-11S	14.3-19.3	12/1/2010
			6/6/2012
Site	OE-2A	25-35	12/17/2008
			5/20/2010
			11/30/2010
Site	OE-2B	3-13	12/17/2008
			5/20/2010
			11/30/2010

Note: Yellow Highlighted sample locations were selected as represntative of the core of the plume for purposes of human health risk evaluation.

TABLE D-6
SAMPLE LIST - SOIL
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Exposure Area	Sample Location	Depth (ft)	Collection Date
Brownell Shunpike	SB-12-1	3-5	8/6/2012
		5-10	8/6/2012
		10-15	8/6/2012
		15-20	8/6/2012
		20-25	8/6/2012
		25-30	8/6/2012
		30-35	8/6/2012
		35-48	8/6/2012
Brownell Shunpike	SB-12-2	3-5	8/7/2012
		5-10	8/7/2012
		10-15	8/7/2012
		15-20	8/7/2012
		20-25	8/7/2012
		25-30	8/7/2012
		30-35	8/7/2012
		35-40	8/7/2012
Brownell Shunpike	SB-12-3	3-5	8/7/2012
		5-10	8/7/2012
		10-15	8/7/2012
		15-20	8/7/2012
		20-25	8/7/2012
		25-30	8/7/2012
		30-35	8/7/2012
		35-40	8/7/2012
		40-45	8/7/2012
Brownell Shunpike	SB-12-4	0-5	8/7/2012
		5-10	8/7/2012
		10-15	8/7/2012
		15-20	8/7/2012
		20-25	8/7/2012
		25-30	8/7/2012
		30-35	8/7/2012
		35-40	8/7/2012
96 Commerce	SB-12-5	0-1	8/8/2012
		2-4	8/8/2012
		5-6	8/8/2012
96 Commerce	SB-12-6	0-1	8/8/2012
		2-4	8/8/2012
		5-6	8/8/2012
Brownell Shunpike	SB-13-01	0-2	12/11/2013
		2-6	12/11/2013
Brownell Shunpike	SB-13-02	0-2	12/11/2013
		2-6	12/11/2013
Brownell Shunpike	SB-13-03	0-2	12/11/2013
		2-6	12/11/2013

TABLE D-6
SAMPLE LIST - SOIL
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Exposure Area	Sample Location	Depth (ft)	Collection Date
Brownell Shunpike	SB-14-03	0-1	6/30/2014
Brownell Shunpike	SB-14-04	0-1	6/30/2014
Brownell Shunpike	SB-14-05	0-1	6/30/2014
Brownell Shunpike	SB-14-06	0-1	6/30/2014
Brownell Shunpike	SB-14-07	3-6	6/30/2014
Brownell Shunpike	SB-14-08	3-6	6/30/2014
Brownell Shunpike	SB-14-09	0-1	6/30/2014
		1-3	6/30/2014
		3-6	6/30/2014
Brownell Shunpike	SB-14-10	3-6	6/30/2014
Brownell Shunpike	SB-14-11	0-1	7/1/2014
		3-5	7/1/2014
Brownell Shunpike	SB-14-12	0-1	7/1/2014
Brownell Shunpike	SB-14-13	0-1	7/1/2014
Brownell Shunpike	SB-14-15	0-1	7/1/2014
		1-3	7/1/2014
Brownell Shunpike	SB-14-16	0-1	7/1/2014
Brownell Shunpike	SB-14-17	0-1	7/1/2014

APPENDIX E

TABLE E-1
DIOXIN AND FURAN TOXICITY EQUIVALENCY FACTORS[a]
COMMERCE STREET PLUMESUPERFUND SITE
WILLISTON, VERMONT

Compound	TEF
Dioxins	
Mono-, Di-, and Trichlorodibenzo-p-dioxins	0
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	1
Other TCDDs	0
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDDs)	1
Other PeCDDs	0
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxins (HxCDDs)	0.1
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxins (HxCDDs)	0.1
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxins (HxCDDs)	0.1
Other HxCDDs	0
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	0.01
Other HpCDDs	0
Octachlorodibenzo-p-dioxin (OCDD)	0.0003
Furans	
Mono-, Di-, and Trichlorodibenzo-p-furans	0
2,3,7,8-Tetrachlorodibenzo-p-furan (TCDF)	0.1
Other TCDFs	0
1,2,3,7,8-Pentachlorodibenzo-p-furan (PeCDF)	0.03
2,3,4,7,8-Pentachlorodibenzo-p-furans (PeCDF)	0.3
Other PeCDFs	0
1,2,3,4,7,8-Hexachlorodibenzo-p-furans (HxCDFs)	0.1
1,2,3,6,7,8-Hexachlorodibenzo-p-furans (HxCDFs)	0.1
1,2,3,7,8,9-Hexachlorodibenzo-p-furans (HxCDFs)	0.1
2,3,4,6,7,8-Hexachlorodibenzo-p-furans (HxCDFs)	0.1
Other HxCDFs	0
1,2,3,4,6,7,8-Heptachlorodibenzo-p-furans (HpCDFs)	0.01
1,2,3,4,7,8,9-Heptachlorodibenzo-p-furans (HpCDFs)	0.01
Other HpCDFs	0
Octachlorodibenzo-p-furan (OCDF)	0.0003

[a] **The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds.**
Martin van den Berg, Linda S. Birnbaum, Michael Denison, Mike De Vito, William Farland, Mark Feeley, Heidelore Fiedler, Helen Hakansson, Annika Hanberg, Laurie Haws, Martin Rose, Stephen Safe, Dieter Schrenk, Chiharu Tohyama, Angelika Tritscher, Jouko Tuomisto, Mats Tysklind, Nigel Walker, and Richard E. Peterson.

Toxicological Sciences Advance Access published **7 July 2006**.
http://www.who.int/ipcs/assessment/tef_update/en/

APPENDIX F

TABLE F-1
SEDIMENT BACKGROUND DATA
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Exposure Point	CAS Number	Contaminant	Units	Minimum Concentration	Maximum Concentration	Detection Frequency	Average Concentration
Sediment	206440	Fluoranthene	mg/kg	0.48	0.48	1/1	0.48
	129000	Pyrene	mg/kg	0.38	0.38	1/1	0.38
	7429905	Aluminum	mg/kg	7400	7400	1/1	7400
	7440382	Arsenic	mg/kg	3.7	3.7	1/1	3.7
	7440393	Barium	mg/kg	50	50	1/1	50
	7440702	Calcium	mg/kg	2300	2300	1/1	2300
	7440473	Chromium	mg/kg	15	15	1/1	15
	7440484	Cobalt	mg/kg	5.6	5.6	1/1	5.6
	7440508	Copper	mg/kg	13	13	1/1	13
	7439896	Iron	mg/kg	14000	14000	1/1	14000
	7439921	Lead	mg/kg	12	12	1/1	12
	7439954	Magnesium	mg/kg	2800	2800	1/1	2800
	7439965	Manganese	mg/kg	670	670	1/1	670
	7439976	Mercury	mg/kg	0.034	0.034	1/1	0.034
	7440020	Nickel	mg/kg	15	15	1/1	15
	7440622	Vanadium	mg/kg	15	15	1/1	15
	7440666	Zinc	mg/kg	240	240	1/1	240

TABLE F-2
SURFACE WATER BACKGROUND DATA
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Exposure Point	CAS Number	Contaminant	Units	Minimum Concentration	Maximum Concentration	Detection Frequency	Average Concentration
Surface Water	16887006	Chloride	ug/L	190000	190000	1/1	190000
	14797558	Nitrate	ug/L	1300	1300	1/1	1300
	14797558	Nitrate as Nitrogen	ug/L	1300	1300	1/1	1300
	14808798	Sulfate	ug/L	27000	27000	1/1	27000
All contaminants detected in surface water background data were conventionals.							

APPENDIX G

TABLE G-1
PROUCL OUTPUT - OVERBURDEN GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	1/23/2015 9:35:13 AM
From File	ProUCL Input_Overburden GW.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

1,1,2-Trichloroethane

General Statistics

Total Number of Observations	67	Number of Distinct Observations	33
Number of Detects	4	Number of Non-Detects	63
Number of Distinct Detects	3	Number of Distinct Non-Detects	30
Minimum Detect	0.47	Minimum Non-Detect	0.051
Maximum Detect	0.99	Maximum Non-Detect	5000
Variance Detects	0.0641	Percent Non-Detects	94.03%
Mean Detects	0.675	SD Detects	0.253
Median Detects	0.62	CV Detects	0.375
Skewness Detects	0.611	Kurtosis Detects	-2.581
Mean of Logged Detects	-0.445	SD of Logged Detects	0.372

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.864	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Detected Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.291	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Detected Data appear Normal at 5% Significance Level

Detected Data appear Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	0.103	Standard Error of Mean	0.0306
SD	0.184	95% KM (BCA) UCL	N/A
95% KM (t) UCL	0.154	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	0.153	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	0.195	95% KM Chebyshev UCL	0.236
97.5% KM Chebyshev UCL	0.294	99% KM Chebyshev UCL	0.408

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.453	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.657	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.33	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.395	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	9.72	k star (bias corrected MLE)	2.597
Theta hat (MLE)	0.0694	Theta star (bias corrected MLE)	0.26
nu hat (MLE)	77.76	nu star (bias corrected)	20.77
MLE Mean (bias corrected)	0.675	MLE Sd (bias corrected)	0.419

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.314	nu hat (KM)	42.12
Approximate Chi Square Value (42.12, α)	28.24	Adjusted Chi Square Value (42.12, β)	27.99
95% Gamma Approximate KM-UCL (use when n>=50)	0.154	95% Gamma Adjusted KM-UCL (use when n<50)	0.155

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	0.0506
Maximum	0.99	Median	0.01
SD	0.168	CV	3.312
k hat (MLE)	0.476	k star (bias corrected MLE)	0.465
Theta hat (MLE)	0.106	Theta star (bias corrected MLE)	0.109
nu hat (MLE)	63.81	nu star (bias corrected)	62.29
MLE Mean (bias corrected)	0.0506	MLE Sd (bias corrected)	0.0742
		Adjusted Level of Significance (β)	0.0464
Approximate Chi Square Value (62.29, α)	45.14	Adjusted Chi Square Value (62.29, β)	44.81
95% Gamma Approximate UCL (use when n>=50)	0.0698	95% Gamma Adjusted UCL (use when n<50)	N/A

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.852	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.297	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	0.104	Mean in Log Scale	-2.745
SD in Original Scale	0.161	SD in Log Scale	0.852
95% t UCL (assumes normality of ROS data)	0.137	95% Percentile Bootstrap UCL	0.138
95% BCA Bootstrap UCL	0.148	95% Bootstrap t UCL	0.166
95% H-UCL (Log ROS)	0.116		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-2.765	95% H-UCL (KM -Log)	0.0963
KM SD (logged)	0.706	95% Critical H Value (KM-Log)	2.019
KM Standard Error of Mean (logged)	0.118		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	80.82	Mean in Log Scale	-1.56
SD in Original Scale	337.9	SD in Log Scale	3.12
95% t UCL (Assumes normality)	149.7	95% H-Stat UCL	123.3

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	0.154	95% KM (Percentile Bootstrap) UCL	N/A

Warning: One or more Recommended UCL(s) not available!

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

1,2-Dichloroethane

General Statistics

Total Number of Observations	67	Number of Distinct Observations	34
Number of Detects	4	Number of Non-Detects	63
Number of Distinct Detects	4	Number of Distinct Non-Detects	30
Minimum Detect	4.6	Minimum Non-Detect	0.051
Maximum Detect	8.9	Maximum Non-Detect	5000
Variance Detects	3.683	Percent Non-Detects	94.03%
Mean Detects	7.05	SD Detects	1.919
Median Detects	7.35	CV Detects	0.272
Skewness Detects	-0.662	Kurtosis Detects	-1.317
Mean of Logged Detects	1.922	SD of Logged Detects	0.296

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.95	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Detected Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.225	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Detected Data appear Normal at 5% Significance Level

Detected Data appear Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	0.547	Standard Error of Mean	0.283
SD	1.846	95% KM (BCA) UCL	N/A
95% KM (t) UCL	1.019	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	1.013	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	1.397	95% KM Chebyshev UCL	1.781
97.5% KM Chebyshev UCL	2.316	99% KM Chebyshev UCL	3.365

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.301	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.657	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.26	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.394	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	16.29	k star (bias corrected MLE)	4.238
Theta hat (MLE)	0.433	Theta star (bias corrected MLE)	1.664
nu hat (MLE)	130.3	nu star (bias corrected)	33.9
MLE Mean (bias corrected)	7.05	MLE Sd (bias corrected)	3.425

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.0878	nu hat (KM)	11.76
Approximate Chi Square Value (11.76, α)	5.071	Adjusted Chi Square Value (11.76, β)	4.974
95% Gamma Approximate KM-UCL (use when n>=50)	1.268	95% Gamma Adjusted KM-UCL (use when n<50)	1.293

Gamma (KM) may not be used when k hat (KM) is < 0.1

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	0.458
Maximum	8.9	Median	0.01
SD	1.73	CV	3.776
k hat (MLE)	0.22	k star (bias corrected MLE)	0.22
Theta hat (MLE)	2.085	Theta star (bias corrected MLE)	2.084
nu hat (MLE)	29.45	nu star (bias corrected)	29.46
MLE Mean (bias corrected)	0.458	MLE Sd (bias corrected)	0.977
		Adjusted Level of Significance (β)	0.0464
Approximate Chi Square Value (29.46, α)	18.07	Adjusted Chi Square Value (29.46, β)	17.87
95% Gamma Approximate UCL (use when n>=50)	0.747	95% Gamma Adjusted UCL (use when n<50)	N/A

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.925	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.231	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	1.504	Mean in Log Scale	0.153
SD in Original Scale	1.551	SD in Log Scale	0.635
95% t UCL (assumes normality of ROS data)	1.82	95% Percentile Bootstrap UCL	1.832
95% BCA Bootstrap UCL	1.889	95% Bootstrap t UCL	1.997
95% H-UCL (Log ROS)	1.662		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-2.628	95% H-UCL (KM -Log)	0.223
KM SD (logged)	1.26	95% Critical H Value (KM-Log)	2.139
KM Standard Error of Mean (logged)	0.194		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	81.2	Mean in Log Scale	-1.419
SD in Original Scale	337.8	SD in Log Scale	3.22
95% t UCL (Assumes normality)	150	95% H-Stat UCL	216.7

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	1.019	95% KM (Percentile Bootstrap) UCL	N/A

Warning: One or more Recommended UCL(s) not available!

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Aluminum

General Statistics

Total Number of Observations	64	Number of Distinct Observations	45
Number of Detects	58	Number of Non-Detects	6
Number of Distinct Detects	43	Number of Distinct Non-Detects	2
Minimum Detect	19.7	Minimum Non-Detect	200
Maximum Detect	36000	Maximum Non-Detect	222
Variance Detects	40926510	Percent Non-Detects	9.375%
Mean Detects	6303	SD Detects	6397
Median Detects	4800	CV Detects	1.015
Skewness Detects	3.333	Kurtosis Detects	12.68
Mean of Logged Detects	8.195	SD of Logged Detects	1.542

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.617	**Normal GOF Test on Detected Observations Only**
5% Shapiro Wilk P Value	0	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.294	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.116	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	5714	Standard Error of Mean	795.5
SD	6309	95% KM (BCA) UCL	7098
95% KM (t) UCL	7042	95% KM (Percentile Bootstrap) UCL	7120
95% KM (z) UCL	7023	95% KM Bootstrap t UCL	8020
90% KM Chebyshev UCL	8101	95% KM Chebyshev UCL	9182
97.5% KM Chebyshev UCL	10682	99% KM Chebyshev UCL	13629

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	4.669	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.778	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.272	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.12	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	1.038	k star (bias corrected MLE)	0.996
Theta hat (MLE)	6072	Theta star (bias corrected MLE)	6329
nu hat (MLE)	120.4	nu star (bias corrected)	115.5
MLE Mean (bias corrected)	6303	MLE Sd (bias corrected)	6316

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.82	nu hat (KM)	105
Approximate Chi Square Value (105.02, α)	82.37	Adjusted Chi Square Value (105.02, β)	81.91
95% Gamma Approximate KM-UCL (use when n>=50)	7285	95% Gamma Adjusted KM-UCL (use when n<50)	7326

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	5724
Maximum	36000	Median	4500
SD	6350	CV	1.109
k hat (MLE)	0.581	k star (bias corrected MLE)	0.564
Theta hat (MLE)	9848	Theta star (bias corrected MLE)	10141
nu hat (MLE)	74.4	nu star (bias corrected)	72.24
MLE Mean (bias corrected)	5724	MLE Sd (bias corrected)	7619
		Adjusted Level of Significance (β)	0.0463
Approximate Chi Square Value (72.24, α)	53.67	Adjusted Chi Square Value (72.24, β)	53.31
95% Gamma Approximate UCL (use when n>=50)	7704	95% Gamma Adjusted UCL (use when n<50)	7758

Lognormal GOF Test on Detected Observations Only

Lilliefors Test Statistic	0.346	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.116	Detected Data Not Lognormal at 5% Significance Level

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	5748	Mean in Log Scale	7.979
SD in Original Scale	6329	SD in Log Scale	1.62
95% t UCL (assumes normality of ROS data)	7069	95% Percentile Bootstrap UCL	7072
95% BCA Bootstrap UCL	7414	95% Bootstrap t UCL	7878
95% H-UCL (Log ROS)	18410		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	5722	Mean in Log Scale	7.86
SD in Original Scale	6352	SD in Log Scale	1.804
95% t UCL (Assumes normality)	7047	95% H-Stat UCL	24998

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use

97.5% KM (Chebyshev) UCL 10682

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Arsenic

General Statistics

Total Number of Observations	64	Number of Distinct Observations	47
Number of Detects	56	Number of Non-Detects	8
Number of Distinct Detects	42	Number of Distinct Non-Detects	5
Minimum Detect	2.1	Minimum Non-Detect	2
Maximum Detect	27.2	Maximum Non-Detect	11.1
Variance Detects	30.84	Percent Non-Detects	12.5%
Mean Detects	6.708	SD Detects	5.554
Median Detects	4.3	CV Detects	0.828
Skewness Detects	2.182	Kurtosis Detects	4.572
Mean of Logged Detects	1.681	SD of Logged Detects	0.614

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.696	**Normal GOF Test on Detected Observations Only**
5% Shapiro Wilk P Value	1.421E-14	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.286	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.118	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	6.341	Standard Error of Mean	0.669
SD	5.278	95% KM (BCA) UCL	7.49
95% KM (t) UCL	7.458	95% KM (Percentile Bootstrap) UCL	7.439
95% KM (z) UCL	7.442	95% KM Bootstrap t UCL	7.8
90% KM Chebyshev UCL	8.349	95% KM Chebyshev UCL	9.258
97.5% KM Chebyshev UCL	10.52	99% KM Chebyshev UCL	13

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	3.726	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.761	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.241	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.12	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	2.402	k star (bias corrected MLE)	2.286
Theta hat (MLE)	2.792	Theta star (bias corrected MLE)	2.935
nu hat (MLE)	269.1	nu star (bias corrected)	256
MLE Mean (bias corrected)	6.708	MLE Sd (bias corrected)	4.437

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	1.443	nu hat (KM)	184.7
Approximate Chi Square Value (184.75, α)	154.3	Adjusted Chi Square Value (184.75, β)	153.7
95% Gamma Approximate KM-UCL (use when n>=50)	7.592	95% Gamma Adjusted KM-UCL (use when n<50)	7.623

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	6.274
Maximum	27.2	Median	4.25
SD	5.388	CV	0.859
k hat (MLE)	1.454	k star (bias corrected MLE)	1.397
Theta hat (MLE)	4.314	Theta star (bias corrected MLE)	4.493
nu hat (MLE)	186.1	nu star (bias corrected)	178.8
MLE Mean (bias corrected)	6.274	MLE Sd (bias corrected)	5.309
		Adjusted Level of Significance (β)	0.0463
Approximate Chi Square Value (178.75, α)	148.8	Adjusted Chi Square Value (178.75, β)	148.2
95% Gamma Approximate UCL (use when n>=50)	7.535	95% Gamma Adjusted UCL (use when n<50)	7.567

Lognormal GOF Test on Detected Observations Only

Lilliefors Test Statistic	0.2	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.118	Detected Data Not Lognormal at 5% Significance Level

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	6.332	Mean in Log Scale	1.617
SD in Original Scale	5.32	SD in Log Scale	0.631
95% t UCL (assumes normality of ROS data)	7.442	95% Percentile Bootstrap UCL	7.495
95% BCA Bootstrap UCL	7.698	95% Bootstrap t UCL	7.772
95% H-UCL (Log ROS)	7.187		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	6.365	Mean in Log Scale	1.62
SD in Original Scale	5.311	SD in Log Scale	0.645
95% t UCL (Assumes normality)	7.473	95% H-Stat UCL	7.301

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use

95% KM (Chebyshev) UCL	9.258

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Chromium

General Statistics

Total Number of Observations	65	Number of Distinct Observations	39
Number of Detects	59	Number of Non-Detects	6
Number of Distinct Detects	38	Number of Distinct Non-Detects	2
Minimum Detect	0.35	Minimum Non-Detect	10
Maximum Detect	320	Maximum Non-Detect	11.1
Variance Detects	2845	Percent Non-Detects	9.231%
Mean Detects	28.09	SD Detects	53.34
Median Detects	14	CV Detects	1.899
Skewness Detects	4.792	Kurtosis Detects	23.53
Mean of Logged Detects	2.667	SD of Logged Detects	1.212

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.392	**Normal GOF Test on Detected Observations Only**
5% Shapiro Wilk P Value	0	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.324	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.115	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	25.96	Standard Error of Mean	6.363
SD	50.84	95% KM (BCA) UCL	38.85
95% KM (t) UCL	36.58	95% KM (Percentile Bootstrap) UCL	38.39
95% KM (z) UCL	36.43	95% KM Bootstrap t UCL	61.2
90% KM Chebyshev UCL	45.05	95% KM Chebyshev UCL	53.7
97.5% KM Chebyshev UCL	65.7	99% KM Chebyshev UCL	89.27

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	4.435	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.786	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.2	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.12	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.877	k star (bias corrected MLE)	0.844
Theta hat (MLE)	32.02	Theta star (bias corrected MLE)	33.28
nu hat (MLE)	103.5	nu star (bias corrected)	99.58
MLE Mean (bias corrected)	28.09	MLE Sd (bias corrected)	30.58

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.261	nu hat (KM)	33.9
Approximate Chi Square Value (33.90, α)	21.58	Adjusted Chi Square Value (33.90, β)	21.36
95% Gamma Approximate KM-UCL (use when n>=50)	40.77	95% Gamma Adjusted KM-UCL (use when n<50)	41.2

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	25.5
Maximum	320	Median	14
SD	51.43	CV	2.017
k hat (MLE)	0.51	k star (bias corrected MLE)	0.496
Theta hat (MLE)	50.04	Theta star (bias corrected MLE)	51.38
nu hat (MLE)	66.24	nu star (bias corrected)	64.51
MLE Mean (bias corrected)	25.5	MLE Sd (bias corrected)	36.2
		Adjusted Level of Significance (β)	0.0463
Approximate Chi Square Value (64.51, α)	47.03	Adjusted Chi Square Value (64.51, β)	46.7
95% Gamma Approximate UCL (use when n>=50)	34.97	95% Gamma Adjusted UCL (use when n<50)	35.23

Lognormal GOF Test on Detected Observations Only

Lilliefors Test Statistic	0.244	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.115	Detected Data Not Lognormal at 5% Significance Level

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	25.79	Mean in Log Scale	2.52
SD in Original Scale	51.3	SD in Log Scale	1.248
95% t UCL (assumes normality of ROS data)	36.41	95% Percentile Bootstrap UCL	36.95
95% BCA Bootstrap UCL	42.53	95% Bootstrap t UCL	60.93
95% H-UCL (Log ROS)	38.09		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	25.98	Mean in Log Scale	2.572
SD in Original Scale	51.21	SD in Log Scale	1.192
95% t UCL (Assumes normality)	36.58	95% H-Stat UCL	37.15

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use

95% KM (Chebyshev) UCL	53.7

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

cis-1,2-Dichloroethene

General Statistics

Total Number of Observations	67	Number of Distinct Observations	40
Number of Detects	15	Number of Non-Detects	52
Number of Distinct Detects	15	Number of Distinct Non-Detects	25
Minimum Detect	3.8	Minimum Non-Detect	0.051
Maximum Detect	2500	Maximum Non-Detect	1700
Variance Detects	661048	Percent Non-Detects	77.61%
Mean Detects	356	SD Detects	813
Median Detects	38.5	CV Detects	2.284
Skewness Detects	2.411	Kurtosis Detects	4.485
Mean of Logged Detects	3.934	SD of Logged Detects	1.877

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.471	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.881	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.457	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.229	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	80.54	Standard Error of Mean	50.61
SD	400.1	95% KM (BCA) UCL	176.9
95% KM (t) UCL	165	95% KM (Percentile Bootstrap) UCL	178.5
95% KM (z) UCL	163.8	95% KM Bootstrap t UCL	1017
90% KM Chebyshev UCL	232.4	95% KM Chebyshev UCL	301.2
97.5% KM Chebyshev UCL	396.6	99% KM Chebyshev UCL	584.1

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.796	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.826	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.29	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.239	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.347	k star (bias corrected MLE)	0.322
Theta hat (MLE)	1026	Theta star (bias corrected MLE)	1106
nu hat (MLE)	10.41	nu star (bias corrected)	9.661
MLE Mean (bias corrected)	356	MLE Sd (bias corrected)	627.4

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.0405	nu hat (KM)	5.429
Approximate Chi Square Value (5.43, α)	1.356	Adjusted Chi Square Value (5.43, β)	1.312
95% Gamma Approximate KM-UCL (use when n>=50)	322.6	95% Gamma Adjusted KM-UCL (use when n<50)	333.3

Gamma (KM) may not be used when k hat (KM) is < 0.1

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	79.71
Maximum	2500	Median	0.01
SD	403.2	CV	5.058
k hat (MLE)	0.113	k star (bias corrected MLE)	0.118
Theta hat (MLE)	705.2	Theta star (bias corrected MLE)	676
nu hat (MLE)	15.15	nu star (bias corrected)	15.8
MLE Mean (bias corrected)	79.71	MLE Sd (bias corrected)	232.1
		Adjusted Level of Significance (β)	0.0464
Approximate Chi Square Value (15.80, α)	7.823	Adjusted Chi Square Value (15.80, β)	7.699
95% Gamma Approximate UCL (use when n>=50)	161	95% Gamma Adjusted UCL (use when n<50)	163.6

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.903	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.881	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.176	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.229	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	79.95	Mean in Log Scale	-1.013
SD in Original Scale	403.2	SD in Log Scale	3.163
95% t UCL (assumes normality of ROS data)	162.1	95% Percentile Bootstrap UCL	179.3
95% BCA Bootstrap UCL	209.2	95% Bootstrap t UCL	1159
95% H-UCL (Log ROS)	255		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-1.327	95% H-UCL (KM -Log)	122.7
KM SD (logged)	3.061	95% Critical H Value (KM-Log)	3.85
KM Standard Error of Mean (logged)	0.399		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	122.3	Mean in Log Scale	-0.92
SD in Original Scale	424.2	SD in Log Scale	3.774
95% t UCL (Assumes normality)	208.7	95% H-Stat UCL	4709

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Lognormal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (Chebyshev) UCL	301.2

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Cobalt

General Statistics

Total Number of Observations	64	Number of Distinct Observations	40
Number of Detects	53	Number of Non-Detects	11
Number of Distinct Detects	38	Number of Distinct Non-Detects	3
Minimum Detect	1.8	Minimum Non-Detect	5.9
Maximum Detect	29.5	Maximum Non-Detect	55.6
Variance Detects	22.31	Percent Non-Detects	17.19%
Mean Detects	6.767	SD Detects	4.723
Median Detects	5.7	CV Detects	0.698
Skewness Detects	3.039	Kurtosis Detects	10.92
Mean of Logged Detects	1.767	SD of Logged Detects	0.5

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.661	**Normal GOF Test on Detected Observations Only**
5% Shapiro Wilk P Value	5.773E-15	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.29	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.122	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	6.726	Standard Error of Mean	0.639
SD	4.647	95% KM (BCA) UCL	7.936
95% KM (t) UCL	7.793	95% KM (Percentile Bootstrap) UCL	7.849
95% KM (z) UCL	7.777	95% KM Bootstrap t UCL	8.42
90% KM Chebyshev UCL	8.642	95% KM Chebyshev UCL	9.51
97.5% KM Chebyshev UCL	10.72	99% KM Chebyshev UCL	13.08

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	2.987	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.755	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.219	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.123	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	3.605	k star (bias corrected MLE)	3.414
Theta hat (MLE)	1.877	Theta star (bias corrected MLE)	1.982
nu hat (MLE)	382.2	nu star (bias corrected)	361.9
MLE Mean (bias corrected)	6.767	MLE Sd (bias corrected)	3.662

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	2.095	nu hat (KM)	268.2
Approximate Chi Square Value (268.21, α)	231.3	Adjusted Chi Square Value (268.21, β)	230.5
95% Gamma Approximate KM-UCL (use when n>=50)	7.8	95% Gamma Adjusted KM-UCL (use when n<50)	7.827

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	1.8	Mean	6.664
Maximum	29.5	Median	5.65
SD	4.448	CV	0.668
k hat (MLE)	3.765	k star (bias corrected MLE)	3.599
Theta hat (MLE)	1.77	Theta star (bias corrected MLE)	1.852
nu hat (MLE)	481.9	nu star (bias corrected)	460.7
MLE Mean (bias corrected)	6.664	MLE Sd (bias corrected)	3.513
		Adjusted Level of Significance (β)	0.0463
Approximate Chi Square Value (460.69, α)	411.9	Adjusted Chi Square Value (460.69, β)	410.9
95% Gamma Approximate UCL (use when n>=50)	7.453	95% Gamma Adjusted UCL (use when n<50)	7.472

Lognormal GOF Test on Detected Observations Only

Lilliefors Test Statistic	0.175	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.122	Detected Data Not Lognormal at 5% Significance Level

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	6.633	Mean in Log Scale	1.762
SD in Original Scale	4.381	SD in Log Scale	0.475
95% t UCL (assumes normality of ROS data)	7.547	95% Percentile Bootstrap UCL	7.599
95% BCA Bootstrap UCL	7.91	95% Bootstrap t UCL	7.943
95% H-UCL (Log ROS)	7.279		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	9.731	Mean in Log Scale	1.99
SD in Original Scale	8.335	SD in Log Scale	0.72
95% t UCL (Assumes normality)	11.47	95% H-Stat UCL	11.39

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use

95% KM (Chebyshev) UCL	9.51

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Iron

General Statistics

Total Number of Observations	64	Number of Distinct Observations	36
		Number of Missing Observations	0
Minimum	6019	Mean	16245
Maximum	44000	Median	14000
SD	8947	Std. Error of Mean	1118
Coefficient of Variation	0.551	Skewness	1.78

Normal GOF Test

Shapiro Wilk Test Statistic	0.774	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	4.241E-13	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.223	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.111	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	18112	95% Adjusted-CLT UCL (Chen-1995)	18351
		95% Modified-t UCL (Johnson-1978)	18154

Gamma GOF Test

A-D Test Statistic	2.274	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.754	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.154	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.112	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	4.358	k star (bias corrected MLE)	4.164
Theta hat (MLE)	3728	Theta star (bias corrected MLE)	3901
nu hat (MLE)	557.8	nu star (bias corrected)	533
MLE Mean (bias corrected)	16245	MLE Sd (bias corrected)	7961
		Approximate Chi Square Value (0.05)	480.5
Adjusted Level of Significance	0.0463	Adjusted Chi Square Value	479.3

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	18022	95% Adjusted Gamma UCL (use when n<50)	18064

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.921	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk P Value	3.8403E-4	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.125	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.111	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	8.703	Mean of logged Data	9.576
Maximum of Logged Data	10.69	SD of logged Data	0.477

Assuming Lognormal Distribution

95% H-UCL	18061	90% Chebyshev (MVUE) UCL	19153
95% Chebyshev (MVUE) UCL	20523	97.5% Chebyshev (MVUE) UCL	22424
99% Chebyshev (MVUE) UCL	26159		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	18085	95% Jackknife UCL	18112
95% Standard Bootstrap UCL	18052	95% Bootstrap-t UCL	18457
95% Hall's Bootstrap UCL	18364	95% Percentile Bootstrap UCL	18100
95% BCA Bootstrap UCL	18334		
90% Chebyshev(Mean, Sd) UCL	19600	95% Chebyshev(Mean, Sd) UCL	21120
97.5% Chebyshev(Mean, Sd) UCL	23229	99% Chebyshev(Mean, Sd) UCL	27373

Suggested UCL to Use

95% Student's-t UCL	18112	or 95% Modified-t UCL	18154

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.
For additional insight the user may want to consult a statistician.

Lead

General Statistics

Total Number of Observations	64	Number of Distinct Observations	40
Number of Detects	50	Number of Non-Detects	14
Number of Distinct Detects	36	Number of Distinct Non-Detects	4
Minimum Detect	1.25	Minimum Non-Detect	4.1
Maximum Detect	23.6	Maximum Non-Detect	11.1
Variance Detects	20.84	Percent Non-Detects	21.88%
Mean Detects	5.566	SD Detects	4.565
Median Detects	3.6	CV Detects	0.82
Skewness Detects	2.192	Kurtosis Detects	4.872
Mean of Logged Detects	1.493	SD of Logged Detects	0.627

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.714	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.275	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.125	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	5.212	Standard Error of Mean	0.536
SD	4.137	95% KM (BCA) UCL	6.112
95% KM (t) UCL	6.106	95% KM (Percentile Bootstrap) UCL	6.117
95% KM (z) UCL	6.093	95% KM Bootstrap t UCL	6.321
90% KM Chebyshev UCL	6.819	95% KM Chebyshev UCL	7.547
97.5% KM Chebyshev UCL	8.557	99% KM Chebyshev UCL	10.54

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	2.949	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.761	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.192	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.127	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	2.391	k star (bias corrected MLE)	2.261
Theta hat (MLE)	2.328	Theta star (bias corrected MLE)	2.462
nu hat (MLE)	239.1	nu star (bias corrected)	226.1
MLE Mean (bias corrected)	5.566	MLE Sd (bias corrected)	3.702

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	1.587	nu hat (KM)	203.2
Approximate Chi Square Value (203.17, α)	171.2	Adjusted Chi Square Value (203.17, β)	170.5
95% Gamma Approximate KM-UCL (use when n>=50)	6.186	95% Gamma Adjusted KM-UCL (use when n<50)	6.21

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.699	Mean	5.233
Maximum	23.6	Median	3.6
SD	4.205	CV	0.804
k hat (MLE)	2.409	k star (bias corrected MLE)	2.306
Theta hat (MLE)	2.173	Theta star (bias corrected MLE)	2.269
nu hat (MLE)	308.3	nu star (bias corrected)	295.2
MLE Mean (bias corrected)	5.233	MLE Sd (bias corrected)	3.446
		Adjusted Level of Significance (β)	0.0463
Approximate Chi Square Value (295.17, α)	256.4	Adjusted Chi Square Value (295.17, β)	255.5
95% Gamma Approximate UCL (use when n>=50)	6.025	95% Gamma Adjusted UCL (use when n<50)	6.045

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.917	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Detected Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.16	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.125	Detected Data Not Lognormal at 5% Significance Level

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	5.24	Mean in Log Scale	1.459
SD in Original Scale	4.134	SD in Log Scale	0.583
95% t UCL (assumes normality of ROS data)	6.103	95% Percentile Bootstrap UCL	6.151
95% BCA Bootstrap UCL	6.334	95% Bootstrap t UCL	6.288
95% H-UCL (Log ROS)	5.872		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	5.39	Mean in Log Scale	1.501
SD in Original Scale	4.066	SD in Log Scale	0.568
95% t UCL (Assumes normality)	6.238	95% H-Stat UCL	6.044

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use

95% KM (BCA) UCL	6.112

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Manganese

General Statistics

Total Number of Observations	64	Number of Distinct Observations	51
		Number of Missing Observations	0
Minimum	80	Mean	666
Maximum	3270	Median	375
SD	713.3	Std. Error of Mean	89.16
Coefficient of Variation	1.071	Skewness	2.065

Normal GOF Test

Shapiro Wilk Test Statistic	0.722	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	5.551E-16	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.243	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.111	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	814.8	95% Adjusted-CLT UCL (Chen-1995)	837.2
		95% Modified-t UCL (Johnson-1978)	818.7

Gamma GOF Test

A-D Test Statistic	1.905	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.773	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.14	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.114	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.307	k star (bias corrected MLE)	1.256
Theta hat (MLE)	509.5	Theta star (bias corrected MLE)	530.1
nu hat (MLE)	167.3	nu star (bias corrected)	160.8
MLE Mean (bias corrected)	666	MLE Sd (bias corrected)	594.2
		Approximate Chi Square Value (0.05)	132.5
Adjusted Level of Significance	0.0463	Adjusted Chi Square Value	131.9

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	808.4	95% Adjusted Gamma UCL (use when n<50)	812

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.959	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk P Value	0.0755	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0935	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.111	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.382	Mean of logged Data	6.072
Maximum of Logged Data	8.093	SD of logged Data	0.907

Assuming Lognormal Distribution

95% H-UCL	840.4	90% Chebyshev (MVUE) UCL	903.8
95% Chebyshev (MVUE) UCL	1019	97.5% Chebyshev (MVUE) UCL	1180
99% Chebyshev (MVUE) UCL	1495		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	812.7	95% Jackknife UCL	814.8
95% Standard Bootstrap UCL	812.3	95% Bootstrap-t UCL	831.8
95% Hall's Bootstrap UCL	844.2	95% Percentile Bootstrap UCL	817.8
95% BCA Bootstrap UCL	850.9		
90% Chebyshev(Mean, Sd) UCL	933.5	95% Chebyshev(Mean, Sd) UCL	1055
97.5% Chebyshev(Mean, Sd) UCL	1223	99% Chebyshev(Mean, Sd) UCL	1553

Suggested UCL to Use

95% H-UCL	840.4

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.
For additional insight the user may want to consult a statistician.

ProUCL computes and outputs H-statistic based UCLs for historical reasons only.
H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.
It is therefore recommended to avoid the use of H-statistic based 95% UCLs.
Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.

Methane

General Statistics

Total Number of Observations	3	Number of Distinct Observations	3
		Number of Missing Observations	0
Minimum	16	Mean	60.33
Maximum	140	Median	25
SD	69.14	Std. Error of Mean	39.92
Coefficient of Variation	1.146	Skewness	1.699

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.804	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.767	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.362	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.512	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	176.9	95% Adjusted-CLT UCL (Chen-1995)	167.8
		95% Modified-t UCL (Johnson-1978)	183.4

Gamma GOF Test

Not Enough Data to Perform GOF Test

Gamma Statistics

k hat (MLE)	1.238	k star (bias corrected MLE)	N/A
Theta hat (MLE)	48.74	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	7.427	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
		Approximate Chi Square Value (0.05)	N/A
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	N/A	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.896	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.767	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.312	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.512	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.773	Mean of logged Data	3.644
Maximum of Logged Data	4.942	SD of logged Data	1.145

Assuming Lognormal Distribution

95% H-UCL	13450572	90% Chebyshev (MVUE) UCL	154.7
95% Chebyshev (MVUE) UCL	198.9	97.5% Chebyshev (MVUE) UCL	260.4
99% Chebyshev (MVUE) UCL	381.1		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	126	95% Jackknife UCL	176.9
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	180.1	95% Chebyshev(Mean, Sd) UCL	234.3
97.5% Chebyshev(Mean, Sd) UCL	309.6	99% Chebyshev(Mean, Sd) UCL	457.5

Suggested UCL to Use

95% Student's-t UCL	176.9

Recommended UCL exceeds the maximum observation

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.
For additional insight the user may want to consult a statistician.

Methylene Chloride

General Statistics

Total Number of Observations	67	Number of Distinct Observations	31
Number of Detects	3	Number of Non-Detects	64
Number of Distinct Detects	3	Number of Distinct Non-Detects	28
Minimum Detect	0.96	Minimum Non-Detect	0.051
Maximum Detect	590	Maximum Non-Detect	1700
Variance Detects	115345	Percent Non-Detects	95.52%
Mean Detects	197.8	SD Detects	339.6
Median Detects	2.55	CV Detects	1.717
Skewness Detects	1.732	Kurtosis Detects	N/A
Mean of Logged Detects	2.425	SD of Logged Detects	3.46

Warning: Data set has only 3 Detected Values.
This is not enough to compute meaningful or reliable statistics and estimates.

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.752	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.767	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.384	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.512	Detected Data appear Normal at 5% Significance Level

Detected Data appear Approximate Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	9.633	Standard Error of Mean	11.56
SD	74.31	95% KM (BCA) UCL	N/A
95% KM (t) UCL	28.92	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	28.64	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	44.31	95% KM Chebyshev UCL	60.01
97.5% KM Chebyshev UCL	81.81	99% KM Chebyshev UCL	124.6

Gamma GOF Tests on Detected Observations Only

Not Enough Data to Perform GOF Test

Gamma Statistics on Detected Data Only

k hat (MLE)	0.248	k star (bias corrected MLE)	N/A
Theta hat (MLE)	796.4	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	1.49	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.0168	nu hat (KM)	2.252
		Adjusted Level of Significance (β)	0.0464
Approximate Chi Square Value (2.25, α)	0.19	Adjusted Chi Square Value (2.25, β)	0.182
95% Gamma Approximate KM-UCL (use when n>=50)	113.9	95% Gamma Adjusted KM-UCL (use when n<50)	119.2

Gamma (KM) may not be used when k hat (KM) is < 0.1

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.861	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.767	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.333	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.512	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	8.858	Mean in Log Scale	-15.97
SD in Original Scale	72.07	SD in Log Scale	6.192
95% t UCL (assumes normality of ROS data)	23.55	95% Percentile Bootstrap UCL	26.46
95% BCA Bootstrap UCL	44.08	95% Bootstrap t UCL	1492869
95% H-UCL (Log ROS)	7034		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-2.688	95% H-UCL (KM -Log)	0.24
KM SD (logged)	1.343	95% Critical H Value (KM-Log)	2.186
KM Standard Error of Mean (logged)	0.215		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	52.17	Mean in Log Scale	-1.556
SD in Original Scale	169.2	SD in Log Scale	3.053
95% t UCL (Assumes normality)	86.65	95% H-Stat UCL	94.29

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Approximate Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	28.92	95% KM (Percentile Bootstrap) UCL	N/A

Warning: One or more Recommended UCL(s) not available!

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Nickel

General Statistics

Total Number of Observations	64	Number of Distinct Observations	31
Number of Detects	57	Number of Non-Detects	7
Number of Distinct Detects	29	Number of Distinct Non-Detects	2
Minimum Detect	0.9	Minimum Non-Detect	40
Maximum Detect	78	Maximum Non-Detect	44.4
Variance Detects	188.8	Percent Non-Detects	10.94%
Mean Detects	19.69	SD Detects	13.74
Median Detects	17	CV Detects	0.698
Skewness Detects	2.721	Kurtosis Detects	9.166
Mean of Logged Detects	2.74	SD of Logged Detects	0.841

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.668	**Normal GOF Test on Detected Observations Only**
5% Shapiro Wilk P Value	4.441E-16	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.306	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.117	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	19.34	Standard Error of Mean	1.668
SD	13.05	95% KM (BCA) UCL	22.31
95% KM (t) UCL	22.13	95% KM (Percentile Bootstrap) UCL	22.02
95% KM (z) UCL	22.08	95% KM Bootstrap t UCL	23.12
90% KM Chebyshev UCL	24.35	95% KM Chebyshev UCL	26.61
97.5% KM Chebyshev UCL	29.76	99% KM Chebyshev UCL	35.94

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	5.351	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.762	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.228	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.119	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	2.236	k star (bias corrected MLE)	2.13
Theta hat (MLE)	8.806	Theta star (bias corrected MLE)	9.244
nu hat (MLE)	254.9	nu star (bias corrected)	242.8
MLE Mean (bias corrected)	19.69	MLE Sd (bias corrected)	13.49

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	2.196	nu hat (KM)	281.1
Approximate Chi Square Value (281.10, α)	243.3	Adjusted Chi Square Value (281.10, β)	242.5
95% Gamma Approximate KM-UCL (use when n>=50)	22.35	95% Gamma Adjusted KM-UCL (use when n<50)	22.42

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.9	Mean	19.37
Maximum	78	Median	17
SD	13.14	CV	0.679
k hat (MLE)	2.401	k star (bias corrected MLE)	2.299
Theta hat (MLE)	8.067	Theta star (bias corrected MLE)	8.426
nu hat (MLE)	307.3	nu star (bias corrected)	294.2
MLE Mean (bias corrected)	19.37	MLE Sd (bias corrected)	12.77
		Adjusted Level of Significance (β)	0.0463
Approximate Chi Square Value (294.22, α)	255.5	Adjusted Chi Square Value (294.22, β)	254.7
95% Gamma Approximate UCL (use when n>=50)	22.3	95% Gamma Adjusted UCL (use when n<50)	22.38

Lognormal GOF Test on Detected Observations Only

Lilliefors Test Statistic	0.281	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.117	Detected Data Not Lognormal at 5% Significance Level

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	19.22	Mean in Log Scale	2.732
SD in Original Scale	13.17	SD in Log Scale	0.803
95% t UCL (assumes normality of ROS data)	21.97	95% Percentile Bootstrap UCL	22.13
95% BCA Bootstrap UCL	22.68	95% Bootstrap t UCL	22.98
95% H-UCL (Log ROS)	26.22		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	19.83	Mean in Log Scale	2.773
SD in Original Scale	12.97	SD in Log Scale	0.798
95% t UCL (Assumes normality)	22.53	95% H-Stat UCL	27.17

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use

95% KM (Chebyshev) UCL	26.61

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Thallium

General Statistics

Total Number of Observations	64	Number of Distinct Observations	20
Number of Detects	7	Number of Non-Detects	57
Number of Distinct Detects	7	Number of Distinct Non-Detects	13
Minimum Detect	0.02	Minimum Non-Detect	1
Maximum Detect	0.11	Maximum Non-Detect	6.1
Variance Detects	0.00121	Percent Non-Detects	89.06%
Mean Detects	0.0494	SD Detects	0.0348
Median Detects	0.029	CV Detects	0.704
Skewness Detects	1.196	Kurtosis Detects	-0.102
Mean of Logged Detects	-3.197	SD of Logged Detects	0.644

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.806	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.803	Detected Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.293	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.335	Detected Data appear Normal at 5% Significance Level

Detected Data appear Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	0.0494	Standard Error of Mean	0.0132
SD	0.0322	95% KM (BCA) UCL	0.0752
95% KM (t) UCL	0.0714	95% KM (Percentile Bootstrap) UCL	0.0727
95% KM (z) UCL	0.0711	95% KM Bootstrap t UCL	0.121
90% KM Chebyshev UCL	0.0889	95% KM Chebyshev UCL	0.107
97.5% KM Chebyshev UCL	0.132	99% KM Chebyshev UCL	0.18

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.582	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.713	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.3	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.314	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	2.789	k star (bias corrected MLE)	1.689
Theta hat (MLE)	0.0177	Theta star (bias corrected MLE)	0.0293
nu hat (MLE)	39.04	nu star (bias corrected)	23.64
MLE Mean (bias corrected)	0.0494	MLE Sd (bias corrected)	0.038

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	2.354	nu hat (KM)	301.4
Approximate Chi Square Value (301.37, α)	262.2	Adjusted Chi Square Value (301.37, β)	261.3
95% Gamma Approximate KM-UCL (use when n>=50)	0.0568	95% Gamma Adjusted KM-UCL (use when n<50)	0.057

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	0.0499
Maximum	0.143	Median	0.0448
SD	0.031	CV	0.621
k hat (MLE)	2.566	k star (bias corrected MLE)	2.456
Theta hat (MLE)	0.0195	Theta star (bias corrected MLE)	0.0203
nu hat (MLE)	328.4	nu star (bias corrected)	314.4
MLE Mean (bias corrected)	0.0499	MLE Sd (bias corrected)	0.0319
		Adjusted Level of Significance (β)	0.0463
Approximate Chi Square Value (314.38, α)	274.3	Adjusted Chi Square Value (314.38, β)	273.4
95% Gamma Approximate UCL (use when n>=50)	0.0572	95% Gamma Adjusted UCL (use when n<50)	0.0574

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.883	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.803	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.274	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.335	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	0.0482	Mean in Log Scale	-3.197
SD in Original Scale	0.0296	SD in Log Scale	0.578
95% t UCL (assumes normality of ROS data)	0.0544	95% Percentile Bootstrap UCL	0.0544
95% BCA Bootstrap UCL	0.0545	95% Bootstrap t UCL	0.0553
95% H-UCL (Log ROS)	0.0556		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-3.197	95% H-UCL (KM -Log)	0.0565
KM SD (logged)	0.597	95% Critical H Value (KM-Log)	1.93
KM Standard Error of Mean (logged)	0.244		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	1.117	Mean in Log Scale	-0.292
SD in Original Scale	0.799	SD in Log Scale	1.17
95% t UCL (Assumes normality)	1.284	95% H-Stat UCL	2.063

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	0.0714	95% KM (Percentile Bootstrap) UCL	0.0727

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Trichloroethene

General Statistics

Total Number of Observations	67	Number of Distinct Observations	44
Number of Detects	26	Number of Non-Detects	41
Number of Distinct Detects	25	Number of Distinct Non-Detects	20
Minimum Detect	0.0927	Minimum Non-Detect	0.052
Maximum Detect	76000	Maximum Non-Detect	1
Variance Detects	4.813E+8	Percent Non-Detects	61.19%
Mean Detects	14808	SD Detects	21938
Median Detects	2425	CV Detects	1.482
Skewness Detects	1.477	Kurtosis Detects	1.153
Mean of Logged Detects	5.798	SD of Logged Detects	5.026

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.723	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.92	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.279	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.174	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	5746	Standard Error of Mean	1896
SD	15220	95% KM (BCA) UCL	9327
95% KM (t) UCL	8910	95% KM (Percentile Bootstrap) UCL	8957
95% KM (z) UCL	8866	95% KM Bootstrap t UCL	10235
90% KM Chebyshev UCL	11435	95% KM Chebyshev UCL	14012
97.5% KM Chebyshev UCL	17589	99% KM Chebyshev UCL	24614

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.835	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.907	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.139	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.191	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.194	k star (bias corrected MLE)	0.197
Theta hat (MLE)	76222	Theta star (bias corrected MLE)	74978
nu hat (MLE)	10.1	nu star (bias corrected)	10.27
MLE Mean (bias corrected)	14808	MLE Sd (bias corrected)	33321

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.143	nu hat (KM)	19.1
Approximate Chi Square Value (19.10, α)	10.19	Adjusted Chi Square Value (19.10, β)	10.05
95% Gamma Approximate KM-UCL (use when n>=50)	10770	95% Gamma Adjusted KM-UCL (use when n<50)	10924

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	5746
Maximum	76000	Median	0.01
SD	15335	CV	2.669
k hat (MLE)	0.0893	k star (bias corrected MLE)	0.0952
Theta hat (MLE)	64367	Theta star (bias corrected MLE)	60343
nu hat (MLE)	11.96	nu star (bias corrected)	12.76
MLE Mean (bias corrected)	5746	MLE Sd (bias corrected)	18621
		Adjusted Level of Significance (β)	0.0464
Approximate Chi Square Value (12.76, α)	5.732	Adjusted Chi Square Value (12.76, β)	5.628
95% Gamma Approximate UCL (use when n>=50)	12792	95% Gamma Adjusted UCL (use when n<50)	13028

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.834	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.92	Detected Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.205	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.174	Detected Data Not Lognormal at 5% Significance Level

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	5746	Mean in Log Scale	-2.087
SD in Original Scale	15335	SD in Log Scale	7.392
95% t UCL (assumes normality of ROS data)	8872	95% Percentile Bootstrap UCL	9101
95% BCA Bootstrap UCL	9675	95% Bootstrap t UCL	10365
95% H-UCL (Log ROS)	3.976E+15		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	5746	Mean in Log Scale	0.286
SD in Original Scale	15335	SD in Log Scale	5.427
95% t UCL (Assumes normality)	8872	95% H-Stat UCL	3.472E+8

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Gamma Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	8910	95% GROS Approximate Gamma UCL	12792
95% Approximate Gamma KM-UCL	10770		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Vanadium

General Statistics

Total Number of Observations	64	Number of Distinct Observations	37
Number of Detects	55	Number of Non-Detects	9
Number of Distinct Detects	35	Number of Distinct Non-Detects	2
Minimum Detect	1.4	Minimum Non-Detect	50
Maximum Detect	69	Maximum Non-Detect	55.6
Variance Detects	142.9	Percent Non-Detects	14.06%
Mean Detects	14.3	SD Detects	11.95
Median Detects	12.5	CV Detects	0.836
Skewness Detects	3.32	Kurtosis Detects	12.53
Mean of Logged Detects	2.438	SD of Logged Detects	0.674

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.625	**Normal GOF Test on Detected Observations Only**
5% Shapiro Wilk P Value	0	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.277	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.119	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	14.02	Standard Error of Mean	1.457
SD	11.26	95% KM (BCA) UCL	16.89
95% KM (t) UCL	16.45	95% KM (Percentile Bootstrap) UCL	16.5
95% KM (z) UCL	16.42	95% KM Bootstrap t UCL	17.99
90% KM Chebyshev UCL	18.39	95% KM Chebyshev UCL	20.37
97.5% KM Chebyshev UCL	23.12	99% KM Chebyshev UCL	28.52

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	2.315	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.761	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.186	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.121	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	2.41	k star (bias corrected MLE)	2.291
Theta hat (MLE)	5.932	Theta star (bias corrected MLE)	6.241
nu hat (MLE)	265.1	nu star (bias corrected)	252
MLE Mean (bias corrected)	14.3	MLE Sd (bias corrected)	9.446

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	1.552	nu hat (KM)	198.6
Approximate Chi Square Value (198.63, α)	167	Adjusted Chi Square Value (198.63, β)	166.4
95% Gamma Approximate KM-UCL (use when n>=50)	16.68	95% Gamma Adjusted KM-UCL (use when n<50)	16.74

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	1.4	Mean	14.04
Maximum	69	Median	12.25
SD	11.33	CV	0.807
k hat (MLE)	2.517	k star (bias corrected MLE)	2.41
Theta hat (MLE)	5.577	Theta star (bias corrected MLE)	5.826
nu hat (MLE)	322.2	nu star (bias corrected)	308.4
MLE Mean (bias corrected)	14.04	MLE Sd (bias corrected)	9.043
		Adjusted Level of Significance (β)	0.0463
Approximate Chi Square Value (308.45, α)	268.8	Adjusted Chi Square Value (308.45, β)	267.9
95% Gamma Approximate UCL (use when n>=50)	16.11	95% Gamma Adjusted UCL (use when n<50)	16.16

Lognormal GOF Test on Detected Observations Only

Lilliefors Test Statistic	0.154	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.119	Detected Data Not Lognormal at 5% Significance Level

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	13.97	Mean in Log Scale	2.432
SD in Original Scale	11.25	SD in Log Scale	0.644
95% t UCL (assumes normality of ROS data)	16.31	95% Percentile Bootstrap UCL	16.31
95% BCA Bootstrap UCL	17.22	95% Bootstrap t UCL	17.79
95% H-UCL (Log ROS)	16.43		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	15.93	Mean in Log Scale	2.553
SD in Original Scale	11.8	SD in Log Scale	0.687
95% t UCL (Assumes normality)	18.4	95% H-Stat UCL	19.34

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use

95% KM (Chebyshev) UCL	20.37

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Vinyl Chloride

General Statistics

Total Number of Observations	67	Number of Distinct Observations	32
Number of Detects	2	Number of Non-Detects	65
Number of Distinct Detects	2	Number of Distinct Non-Detects	30
Minimum Detect	3.3	Minimum Non-Detect	0.051
Maximum Detect	3.7	Maximum Non-Detect	5000
Variance Detects	0.08	Percent Non-Detects	97.01%
Mean Detects	3.5	SD Detects	0.283
Median Detects	3.5	CV Detects	0.0808
Skewness Detects	N/A	Kurtosis Detects	N/A
Mean of Logged Detects	1.251	SD of Logged Detects	0.0809

Warning: Data set has only 2 Detected Values.
This is not enough to compute meaningful or reliable statistics and estimates.

Normal GOF Test on Detects Only
Not Enough Data to Perform GOF Test

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	0.186	Standard Error of Mean	0.133
SD	0.671	95% KM (BCA) UCL	N/A
95% KM (t) UCL	0.408	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	0.405	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	0.585	95% KM Chebyshev UCL	0.765
97.5% KM Chebyshev UCL	1.016	99% KM Chebyshev UCL	1.508

Gamma GOF Tests on Detected Observations Only
Not Enough Data to Perform GOF Test

Gamma Statistics on Detected Data Only

k hat (MLE)	305.9	k star (bias corrected MLE)	N/A
Theta hat (MLE)	0.0114	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	1224	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.0771	nu hat (KM)	10.34
		Adjusted Level of Significance (β)	0.0464
Approximate Chi Square Value (10.34, α)	4.153	Adjusted Chi Square Value (10.34, β)	4.066
95% Gamma Approximate KM-UCL (use when n>=50)	0.464	95% Gamma Adjusted KM-UCL (use when n<50)	0.473

Gamma (KM) may not be used when k hat (KM) is < 0.1

Lognormal GOF Test on Detected Observations Only
Not Enough Data to Perform GOF Test

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	1.572	Mean in Log Scale	0.419
SD in Original Scale	0.458	SD in Log Scale	0.249
95% t UCL (assumes normality of ROS data)	1.665	95% Percentile Bootstrap UCL	1.671
95% BCA Bootstrap UCL	1.685	95% Bootstrap t UCL	1.691
95% H-UCL (Log ROS)	1.653		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	80.98	Mean in Log Scale	-1.445
SD in Original Scale	337.9	SD in Log Scale	3.185
95% t UCL (Assumes normality)	149.8	95% H-Stat UCL	181.8

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics
Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	0.408	95% KM (% Bootstrap) UCL	N/A

Warning: One or more Recommended UCL(s) not available!

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

TABLE G-2
CALCULATION OF Cair FROM VAPOR IN CONSTRUCTION TRENCH MODEL
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Groundwater COPC	CAS No.	Molecular Weight MWi (g/mol)	Henry's Law Constant Hi (atm-m^3/mol)	Gas-Phase Mass Transfer Coefficient KiG (cm/s)	Liquid-Phase Mass Transfer Coefficient KiL (cm/s)	Overall Mass Transfer Coefficient Ki (cm/s)	Concentration of Contaminant in Groundwater Cgw (ug/L)	Volatilization Factor VF (L/m^3)	Concentration of Contaminant in Trench Air Cair (ug/m^3)	Concentration of Contaminant in Trench Air Cair (mg/m^3)
Volatile Organic Compounds (VOCs)										
Chloroform	67663	119.38	3.67E-03	4.42E-01	1.04E-03	1.02E-03	1.90E+00	7.53E+00	1.43E+01	1.43E-02
Naphthalene	91203	128.17	4.83E-04	4.32E-01	9.99E-04	8.95E-04	1.80E+00	6.60E+00	1.19E+01	1.19E-02
Trichloroethene	79016	131.39	1.03E-02	4.28E-01	9.87E-04	9.82E-04	4.80E+00	7.25E+00	3.48E+01	3.48E-02

Source: Model obtained from Virginia Department of Environmental Quality (VDEQ), 2013 Voluntary Remediation Program (VRP) for groundwater less than 15 feet.

TABLE G-3
CALCULATION OF Cair FROM VAPORS DURING HOUSEHOLD WATER USE
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Groundwater COPC	Concentration of Contaminant in Groundwater (EPCgw) (ug/L)	Concentration of Contaminant in Air from Household Water Use (Cair) (mg/m^3)
Volatile Organic Compounds (VOCs)		
1,1,2-Trichloroethane	1.54E-01	7.70E-05
1,2-Dichloroethane	1.02E+00	5.10E-04
cis-1,2-Dichloroethene	3.01E+02	1.51E-01
Methane	1.40E+02	7.00E-02
Methylene chloride	5.90E+02	2.95E-01
Trichloroethene	8.91E+03	4.46E+00
Vinyl Chloride	3.70E+00	1.85E-03

APPENDIX H

TABLE H-1
DERMAL ABSORPTION FACTORS FOR SEDIMENT EXPOSURE
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

COPC	Dermal Absorption Factor* (unitless)
4-Nitrophenol	NA
Benzo(a)anthracene	0.13
Benzo(a)pyrene	0.13
Benzo(b)fluoranthene	0.13
Dibenz(a,h)anthracene	0.13
Indeno(1,2,3-cd)pyrene	0.13
Arsenic	0.03
Chromium	NA
Cobalt	NA
Iron	NA

* Exhibit 3-4, Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part E – Supplemental Guidance for Dermal Risk Assessment (EPA, 2004a).

NA = Not available.

TABLE H-2
DERMALLY ABSORBED DOSE PER EVENT (DA_{event}) CALCULATIONS[a] - SURFACE WATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

COPC	EPC[b] (µg/L)	EPC[b] (mg/cm^3)	FA (unitless)	K_p (cm/hr)	τ_{event} (hr/event)	B (unitless)	t^* (hr)	Da_{event}[c] (mg/cm^2-event)
VOCs								
cis-1,2-Dichloroethene	3.90E+01	3.90E-05	1.0 [d]	7.67E-03 [e]	3.66E-01 [f]	2.90E-02 [g]	8.80E-01	8.32E-07
Trichloroethene	1.50E+01	1.50E-05	1.0	1.20E-02	5.80E-01	1.00E-01	1.39E+00	6.08E-07
Vinyl chloride	3.40E+00	3.40E-06	1.0	5.60E-03	2.40E-01	0.00E+00	5.70E-01	4.72E-08

[a] EPA, 2004.
[b] See Table A-3.2.
[c] Calculated based on Equation 3.2 or 3.3 for organics in EPA, 2004 where t_{event} equals 2.
[d] In the absence of chemical-specific data, the FA was conservatively assumed to be 1.0.
[e] Calculated based on Equation 3.8 in EPA, 2004.
[f] Calculated based on Equation A.4 in EPA, 2004.
[g] Calculated based on Equation A.1 in EPA, 2004.

B = Ratio of the permeability coefficient of a COPC through the stratum corneum relative to its permeability coefficient across the viable epidermis.
FA = Fraction absorbed.
K_p = Dermal permeability coefficient.
NA = Not applicable.
τ_{event} = Lag time per event.
t^* = Time to reach steady-state.

TABLE H-3 RME
DERMALLY ABSORBED DOSE PER EVENT (DA_{event}) CALCULATIONS[a] - SHALLOW GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

COPC	EPC[b] (µg/L)	EPC[b] (mg/cm^3)	FA (unitless)	K_p (cm/hr)	τ_{event} (hr/event)	B (unitless)	t^* (hr)	Da_{event}[c] (mg/cm^2-event)
VOCs								
Chloroform	1.90E+00	1.90E-06	1.0	6.80E-03	5.00E-01	0.00E+00	1.19E+00	1.16E-07
Trichloroethene	4.80E+00	4.80E-06	1.0	1.20E-02	5.80E-01	1.00E-01	1.39E+00	5.40E-07
SVOCs								
Benzo(a)pyrene	1.50E-01	1.50E-07	1.0	7.00E-01	2.69E+00	4.30E+00	1.17E+01	1.35E-06
Naphthalene	1.80E+00	1.80E-06	1.0	4.70E-02	5.60E-01	2.00E-01	1.34E+00	8.07E-07
Metals								
Antimony	1.40E+00	1.40E-06	NA	1.00E-03	NA	NA	NA	1.12E-08
Arsenic	1.18E+01	1.18E-05	NA	1.00E-03	NA	NA	NA	9.44E-08
Cadmium	5.43E+01	5.43E-05	NA	1.00E-03	NA	NA	NA	4.34E-07
Chromium (VI)	2.71E+01	2.71E-05	NA	2.00E-03	NA	NA	NA	4.34E-07
Cobalt	7.10E+00	7.10E-06	NA	1.00E-03	NA	NA	NA	5.68E-08
Iron	3.44E+04	3.44E-02	NA	1.00E-03	NA	NA	NA	2.75E-04
Manganese	4.42E+03	4.42E-03	NA	1.00E-03	NA	NA	NA	3.54E-05
Thallium	2.90E-01	2.90E-07	NA	1.00E-03	NA	NA	NA	2.32E-09

[a] EPA, 2004.
[b] See Table A-3.3a.
[c] Calculated based on Equation 3.2 or 3.3 for organics and Equation 3.4 for inorganics in EPA, 2004 where t_{event} equals 8.

B = Ratio of the permeability coefficient of a COPC through the stratum corneum relative to its permeability coefficient across the viable epidermis.
FA = Fraction absorbed.
K_p = Dermal permeability coefficient.
NA = Not applicable.
τ_{event} = Lag time per event.
t^* = Time to reach steady-state.

TABLE H-3 CTE
DERMALLY ABSORBED DOSE PER EVENT (DA_{event}) CALCULATIONS[a] - SHALLOW GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

COPC	EPC[b] (µg/L)	EPC[b] (mg/cm^3)	FA (unitless)	K_p (cm/hr)	τ_{event} (hr/event)	B (unitless)	t^* (hr)	Da_{event}[c] (mg/cm^2-event)
VOCs								
Chloroform	1.90E+00	1.90E-06	1.0	6.80E-03	5.00E-01	0.00E+00	1.19E+00	1.16E-07
Trichloroethene	4.80E+00	4.80E-06	1.0	1.20E-02	5.80E-01	1.00E-01	1.39E+00	5.40E-07
SVOCs								
Benzo(a)pyrene	1.50E-01	1.50E-07	1.0	7.00E-01	2.69E+00	4.30E+00	1.17E+01	1.35E-06
Naphthalene	1.80E+00	1.80E-06	1.0	4.70E-02	5.60E-01	2.00E-01	1.34E+00	8.07E-07
Metals								
Antimony	1.40E+00	1.40E-06	NA	1.00E-03	NA	NA	NA	1.12E-08
Arsenic	1.18E+01	1.18E-05	NA	1.00E-03	NA	NA	NA	9.44E-08
Cadmium	5.43E+01	5.43E-05	NA	1.00E-03	NA	NA	NA	4.34E-07
Chromium (VI)	2.71E+01	2.71E-05	NA	2.00E-03	NA	NA	NA	4.34E-07
Cobalt	7.10E+00	7.10E-06	NA	1.00E-03	NA	NA	NA	5.68E-08
Iron	3.44E+04	3.44E-02	NA	1.00E-03	NA	NA	NA	2.75E-04
Manganese	4.42E+03	4.42E-03	NA	1.00E-03	NA	NA	NA	3.54E-05
Thallium	2.90E-01	2.90E-07	NA	1.00E-03	NA	NA	NA	2.32E-09

[a] EPA, 2004.
[b] See Table A-3.3a.
[c] Calculated based on Equation 3.2 or 3.3 for organics and Equation 3.4 for inorganics in EPA, 2004 where t_{event} equals 8.

B = Ratio of the permeability coefficient of a COPC through the stratum corneum relative to its permeability coefficient across the viable epidermis.
FA = Fraction absorbed.
K_p = Dermal permeability coefficient.
NA = Not applicable.
τ_{event} = Lag time per event.
t^* = Time to reach steady-state.

TABLE H-4 RME
DERMALLY ABSORBED DOSE PER EVENT (DA_{event}) CALCULATIONS[a] - TAP WATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

COPC	EPC[b] (µg/L)	EPC[b] (mg/cm^3)	FA (unitless)	K_p (cm/hr)	τ_{event} (hr/event)	B (unitless)	t^* (hr)	$Da_{event-adj}$[c] (mg/cm^2-event)	DA_{event} (mg/cm^2-event)[d] Child	DA_{event} (mg/cm^2-event)[d] Adult
VOCs										
1,1,2-Trichloroethane	1.54E-01	1.54E-07	1.0	6.40E-03	6.00E-01	0.00E+00	1.43E+00	1.73E-09	1.55E-09	1.78E-09
1,2-Dichloroethane	1.02E+00	1.02E-06	1.0	4.20E-03	3.80E-01	0.00E+00	9.20E-01	5.97E-09	5.36E-09	6.15E-09
cis-1,2-Dichloroethene	3.01E+02	3.01E-04	1.0 [e]	7.67E-03 [f]	3.66E-01 [g]	2.90E-02 [h]	8.80E-01	3.16E-06	2.84E-06	3.26E-06
Methane	1.40E+02	1.40E-04	1.0 [e]	6.75E-03 [f]	1.29E-01 [g]	1.04E-02 [h]	3.10E-01	8.90E-07	7.67E-07	9.28E-07
Methylene chloride	5.90E+02	5.90E-04	1.0	3.50E-03	3.20E-01	0.00E+00	7.60E-01	2.64E-06	2.37E-06	2.72E-06
Trichloroethene	8.91E+03	8.91E-03	1.0	1.20E-02	5.80E-01	1.00E-01	1.39E+00	1.84E-04	1.65E-04	1.90E-04
Vinyl Chloride	3.70E+00	3.70E-06	1.0	5.60E-03	2.40E-01	0.00E+00	5.70E-01	2.38E-08	2.06E-08	2.47E-08
Metals										
Aluminum	1.07E+04	1.07E-02	NA	1.00E-03	NA	NA	NA	7.16E-06	5.77E-06	7.58E-06
Arsenic	9.26E+00	9.26E-06	NA	1.00E-03	NA	NA	NA	6.20E-09	5.00E-09	6.57E-09
Chromium (VI)	5.30E+01	5.30E-05	NA	2.00E-03	NA	NA	NA	7.10E-08	5.72E-08	7.53E-08
Cobalt	9.51E+00	9.51E-06	NA	1.00E-03	NA	NA	NA	6.37E-09	5.14E-09	6.75E-09
Iron	1.81E+04	1.81E-02	NA	1.00E-03	NA	NA	NA	1.21E-05	9.78E-06	1.29E-05
Lead	6.11E+00	6.11E-06	NA	1.00E-03	NA	NA	NA	4.10E-09	3.30E-09	4.34E-09
Manganese	8.40E+02	8.40E-04	NA	1.00E-03	NA	NA	NA	5.63E-07	4.54E-07	5.97E-07
Nickel	2.66E+01	2.66E-05	NA	2.00E-04	NA	NA	NA	3.57E-09	2.87E-09	3.78E-09
Thallium	7.14E-02	7.14E-08	NA	1.00E-03	NA	NA	NA	4.78E-11	3.86E-11	5.07E-11
Vanadium	2.04E+01	2.04E-05	NA	1.00E-03	NA	NA	NA	1.36E-08	1.10E-08	1.45E-08

[a] EPA, 2004.
[b] See Table A-3.4a.
[c] t_{event} was age-adjusted assuming t_{event} of 0.54 for the residential child and t_{event} of 0.71 for the residential adult. Adjusted value equals 0.67.
[d] Calculated based on Equation 3.2 or 3.3 for organics and Equation 3.4 for inorganics in EPA, 2004 where t_{event} equals 0.54 for children and 0.71 for adults.
[e] In the absence of chemical-specific data, the FA was conservatively assumed to be 1.0.
[f] Calculated based on Equation 3.8 in EPA, 2004.
[g] Calculated based on Equation A.4 in EPA, 2004.
[h] Calculated based on Equation A.1 in EPA, 2004.

B = Ratio of the permeability coefficient of a COPC through the stratum corneum relative to its permeability coefficient across the viable epidermis.
FA = Fraction absorbed.
K_p = Dermal permeability coefficient.
NA = Not applicable.
τ_{event} = Lag time per event.
t^* = Time to reach steady-state.

TABLE H-4 CTE
DERMALLY ABSORBED DOSE PER EVENT (DA_{event}) CALCULATIONS[a] - TAP WATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

COPC	EPC[b]		FA	K_p	τ_{event}	B	t^*	$Da_{event-adj}$[c]	DA_{event} (mg/cm^2-event)[d]	
	(µg/L)	(mg/cm^3)	(unitless)	(cm/hr)	(hr/event)	(unitless)	(hr)	(mg/cm^2-event)	Child	Adult
VOCs										
1,1,2-Trichloroethane	1.54E-01	1.54E-07	1.0	6.40E-03	6.00E-01	0.00E+00	1.43E+00	1.21E-09	1.10E-09	1.27E-09
1,2-Dichloroethane	1.02E+00	1.02E-06	1.0	4.20E-03	3.80E-01	0.00E+00	9.20E-01	4.19E-09	3.79E-09	4.38E-09
cis-1,2-Dichloroethene	3.01E+02	3.01E-04	1.0 [e]	7.67E-03 [f]	3.66E-01 [g]	2.90E-02 [h]	8.80E-01	2.22E-06	2.01E-06	2.32E-06
Methane	1.40E+02	1.40E-04	1.0 [e]	6.75E-03 [f]	1.29E-01 [g]	1.04E-02 [h]	3.10E-01	5.69E-07	4.88E-07	5.97E-07
Methylene chloride	5.90E+02	5.90E-04	1.0	3.50E-03	3.20E-01	0.00E+00	7.60E-01	1.86E-06	1.68E-06	1.94E-06
Trichloroethene	8.91E+03	8.91E-03	1.0	1.20E-02	5.80E-01	1.00E-01	1.39E+00	1.29E-04	1.17E-04	1.35E-04
Vinyl Chloride	3.70E+00	3.70E-06	1.0	5.60E-03	2.40E-01	0.00E+00	5.70E-01	1.61E-08	1.46E-08	1.68E-08
Metals										
Aluminum	1.07E+04	1.07E-02	NA	1.00E-03	NA	NA	NA	3.53E-06	2.88E-06	3.85E-06
Arsenic	9.26E+00	9.26E-06	NA	1.00E-03	NA	NA	NA	3.06E-09	2.50E-09	3.33E-09
Chromium (VI)	5.30E+01	5.30E-05	NA	2.00E-03	NA	NA	NA	3.50E-08	2.86E-08	3.82E-08
Cobalt	9.51E+00	9.51E-06	NA	1.00E-03	NA	NA	NA	3.14E-09	2.57E-09	3.42E-09
Iron	1.81E+04	1.81E-02	NA	1.00E-03	NA	NA	NA	5.98E-06	4.89E-06	6.52E-06
Lead	6.11E+00	6.11E-06	NA	1.00E-03	NA	NA	NA	2.02E-09	1.65E-09	2.20E-09
Manganese	8.40E+02	8.40E-04	NA	1.00E-03	NA	NA	NA	2.77E-07	2.27E-07	3.03E-07
Nickel	2.66E+01	2.66E-05	NA	2.00E-04	NA	NA	NA	1.76E-09	1.44E-09	1.92E-09
Thallium	7.14E-02	7.14E-08	NA	1.00E-03	NA	NA	NA	2.36E-11	1.93E-11	2.57E-11
Vanadium	2.04E+01	2.04E-05	NA	1.00E-03	NA	NA	NA	6.72E-09	5.50E-09	7.33E-09

[a] EPA, 2004.
[b] See Table A-3.4a.
[c] t_{event} was age-adjusted assuming t_{event} of 0.27 for the residential child and t_{event} of 0.36 for the residential adult. Adjusted value equals 0.33.
[d] Calculated based on Equation 3.2 or 3.3 for organics and Equation 3.4 for inorganics in EPA, 2004 where t_{event} equals 0.27 for children and 0.36 for adults.
[e] In the absence of chemical-specific data, the FA was conservatively assumed to be 1.0.
[f] Calculated based on Equation 3.8 in EPA, 2004.
[g] Calculated based on Equation A.4 in EPA, 2004.
[h] Calculated based on Equation A.1 in EPA, 2004.

B = Ratio of the permeability coefficient of a COPC through the stratum corneum relative to its permeability coefficient across the viable epidermis.
FA = Fraction absorbed.
K_p = Dermal permeability coefficient.
NA = Not applicable.
τ_{event} = Lag time per event.
t^* = Time to reach steady-state.

APPENDIX I

TABLE I-1
ESTIMATED ORDERS OF POTENTIAL POTENCY FOR CARCINOGENIC PAHs*
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Chemical	Weight-of-Evidence	Order of Potential Potency
Benzo(a)anthracene	B2	0.1
Benzo(b)fluoranthene	B2	0.1
Benzo(k)fluoranthene	B2	0.01
Benzo(a)pyrene	B2	1.0
Chrysene	B2	0.001
Dibenz(a,h)anthracene	B2	1.0
Indeno(1,2,3-cd)pyrene	B2	0.1

* EPA, 1993.

APPENDIX J

TABLE J-1 RME
CALCULATION OF CANCER RISKS - MUTAGENIC MODE OF ACTION - RIVER RECREATIONAL CHILD VISITOR EXPOSURE TO SEDIMENT
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Incidental Ingestion Risk

Where:

$$\text{Risk} = \text{EPC} \times \sum_i \frac{\text{IR-SD} \times \text{FI} \times \text{CF} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}} \times \text{CSFo} \times \text{ADAF}$$

Exposure Parameters (by age interval, i)			
Parameter	**Units**	**0-<2**	**2-<6**
EPC	mg/kg	See Table A-3.1	
IR-SD	mg/day	200	200
FI	unitless	1	1
CF	kg/mg	1E-06	1E-06
EF	days/year	22	22
ED	years	2	4
BW	kg	15	15
AT	days	25550	25550
CSFo	$(\text{mg/kg-day})^{-1}$	See Table A-6.1	
ADAF	unitless	10	3

	Incidential Ingestion Risks			
COPC	**EPC**	**CSFo**	**0-<2**	**2-<6**
Benzo(a)anthracene	2.70E-01	7.3E-01	4.5E-08	2.7E-08
Benzo(a)pyrene	2.40E-01	7.3E+00	4.0E-07	2.4E-07
Benzo(b)fluoranthene	5.70E-01	7.3E-01	9.6E-08	5.7E-08
Dibenz(a,h)anthracene	5.10E-01	7.3E+00	8.5E-07	5.1E-07
Indeno(1,2,3-cd)pyrene	5.00E-01	7.3E-01	8.4E-08	5.0E-08
Chromium	1.10E+01	5.0E-01	1.3E-06	7.6E-07

Dermal Contact Risk

Where:

$$\text{Risk} = \text{EPC} \times \sum_i \frac{\text{SA} \times \text{AF} \times \text{ABS} \times \text{EF} \times \text{ED} \times \text{CF}}{\text{BW} \times \text{AT}} \times \text{CSFd} \times \text{ADAF}$$

Exposure Parameters (by age interval, i)			
Parameter	**Units**	**0-<2**	**2-<6**
EPC	mg/kg	See Table A-3.1	
SA	cm^2/day	2690	2690
AF	mg/cm^2	0.2	0.2
ABS	unitless	See Appendix F-1	
EF	days/year	22	22
ED	years	2	4
CF	kg/mg	1E-06	1E-06
BW	kg	15	15
AT	days	25550	25550
CSFd	$(\text{mg/kg-day})^{-1}$	See Table A-6.1	
ADAF	unitless	10	3

	Dermal Contact Risks				
COPC	**EPC**	**CSFd**	**ABS**	**0-<2**	**2-<6**
Benzo(a)anthracene	2.70E-01	1.0E+00	0.13	2.2E-08	1.3E-08
Benzo(a)pyrene	2.40E-01	1.0E+00	0.13	1.9E-08	1.2E-08
Benzo(b)fluoranthene	5.70E-01	1.0E+00	0.13	4.6E-08	2.7E-08
Dibenz(a,h)anthracene	5.10E-01	1.0E+00	0.13	4.1E-08	2.5E-08
Indeno(1,2,3-cd)pyrene	5.00E-01	1.0E+00	0.13	4.0E-08	2.4E-08
Chromium	1.10E+01	1.0E+00	NA	NA	NA

	Total Cancer Risks		
COPC	**Ingestion**	**Dermal Contact**	**Total**
Benzo(a)anthracene	7.2E-08	3.5E-08	**1.1E-07**
Benzo(a)pyrene	6.4E-07	3.1E-08	**6.7E-07**
Benzo(b)fluoranthene	1.5E-07	7.3E-08	**2.3E-07**
Dibenz(a,h)anthracene	1.4E-06	6.6E-08	**1.4E-06**
Indeno(1,2,3-cd)pyrene	1.3E-07	6.4E-08	**2.0E-07**
Chromium	2.0E-06	NA	**2.0E-06**

TABLE J-2a RME
CALCULATION OF CANCER RISKS - MUTAGENIC MODE OF ACTION - RIVER RECREATIONAL
CHILD VISITOR EXPOSURE TO SURFACE WATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Dermal Contact Risk

Where:

$$\text{Risk} = \left(\frac{DA_{event} \times SA_c \times EV \times EF \times ED_c}{BW_c \times AT} + \frac{DA_{event} \times SA_c \times EV}{BW_c} \right) \times CSF_d$$

Exposure Parameters		
Parameter	**Units**	**Value**
DA_{event}	mg/cm^2-event	4.7E-08
SA	cm^2	2690
EV	event/day	1
EF	days/year	22
ED	years	6
BW	kg	15
AT	days	25550
CSFd	$(mg/kg\text{-}day)^{-1}$	1.0E+00

COPC	Dermal Contact Risk
Vinyl chloride	8.5E-06

TABLE J-2b RME
CALCULATION OF CANCER RISKS FROM TRICHLOROETHENE - MUTAGENIC MODE OF ACTION - RIVER
RECREATIONAL CHILD VISITOR EXPOSURE TO SURFACE WATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Dermal Contact Risk

Where:

$$Risk = \sum_i \left(\left(\frac{DAevent \times EV \times SA \times EF \times ED}{BW \times AT} \right) \times CSF_{kidney} \times ADAF \right) + \left(\left(\frac{DAevent \times EV \times SA \times EF \times ED}{BW \times AT} \right) \times CSF_{liver + NHL} \right)$$

Exposure Parameters (by age interval, i)			
Parameter	**Units**	**0-<2**	**2-<6**
DA_{event}	mg/cm^2-event	6.08E-07	
EV	event/day	1	1
SA	cm^2	2690	2690
EF	days/year	22	22
ED	years	2	4
BW	kg	15	15
AT	days	25550	25550
CSF_{kidney}	$(mg/kg\text{-}day)^{-1}$	9.3E-03	
ADAF	unitless	10	3
$CSF_{liver+NHL}$	$(mg/kg\text{-}day)^{-1}$	3.7E-02	

	Dermal Contact Risks		
COPC	**0-<2**	**2-<6**	**Total**
Trichloroethene	2.4E-08	2.4E-08	**4.9E-08**

TABLE J-4a CTE
CALCULATION OF CANCER RISKS - MUTAGENIC MODE OF ACTION - RESIDENT EXPOSURE TO GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Tapwater Ingestion Risk

Where:

$$\text{Risk} = \text{EPC x} \sum_i \frac{\text{IRW x FI x EF x ED x CF}}{\text{BW x AT}} \text{ x CSFo x ADAF}$$

Exposure Parameters (by age interval, i)			
Parameter	**Units**	**0-<2**	**6-<12**
EPC	µg/L	See Table A-3.4	
IRW	L/day	0.78	2.5
FI	unitless	0.5	0.5
CF	mg/µg	1E-03	1E-03
EF	days/year	350	350
ED	years	2	6
BW	kg	15	80
AT	days	25550	25550
CSFo	$(mg/kg\text{-}day)^{-1}$	See Table A-6.1	
ADAF	unitless	10	3

Dermal Contact Risk

Where:

$$\text{Risk} = \sum_i \frac{\text{DAevent x EV x SA x EF x ED}}{\text{BW x AT}} \text{ x CSFd x ADAF}$$

Exposure Parameters (by age interval, i)			
Parameter	**Units**	**0-<2**	**6-<12**
DA_{event}	mg/cm^2-event	See Table F-4	
EV	event/day	1	1
SA	cm^2	6378	20900
EF	days/year	350	350
ED	years	2	6
BW	kg	15	80
AT	days	25550	25550
CSFd	$(mg/kg\text{-}day)^{-1}$	See Table A-6.1	
ADAF	unitless	10	3

Inhalation Risk

Where:

$$\text{Risk} = \sum_i \frac{\text{Cair x ET x EF x ED}}{\text{AT x CF}} \text{ x IUR x ADAF}$$

Exposure Parameters (by age interval, i)			
Parameter	**Units**	**0-<2**	**6-<12**
Cair	mg/m^3	See Table E-2	
ET	hrs/day	24	24
EF	days/year	350	350
ED	years	2	6
AT	days	25550	25550
CF	hrs/day	24	24
IUR	$(mg/m^3)^{-1}$	See Table A-6.2	
ADAF	unitless	10	3

	Incidential Ingestion Risks			
COPC	**EPC**	**CSFo**	**0-<2**	**6-<12**
Methylene chloride	5.90E+02	2.0E-03	8.4E-06	4.5E-06
Chromium	5.30E+01	5.0E-01	1.9E-04	1.0E-04

	Dermal Contact Risks			
COPC	**DA_{event}**	**CSFd**	**0-<2**	**6-<12**
Methylene chloride	1.86E-06	1.0E+00	2.2E-04	1.2E-04
Chromium	3.50E-08	1.0E+00	4.1E-06	2.3E-06

	Dermal Contact Risks			
COPC	**Cair**	**IUR**	**0-<2**	**6-<12**
Methylene chloride	2.95E-01	1.0E-11	8.1E-13	7.3E-13
Chromium	-	8.4E-05	NA	NA

	Total Cancer Risks			
COPC	**Tapwater Ingestion**	**Dermal Contact**	**Inhalation**	**Total**
Methylene chloride	1.3E-05	3.4E-04	1.5E-12	**3.5E-04**
Chromium	2.9E-04	6.3E-06	NA	**3.0E-04**

TABLE J-4b RME
CALCULATION OF CANCER RISKS FROM TRICHLOROETHENE - MUTAGENIC MODE OF ACTION - RESIDENT EXPOSURE TO GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Tapwater Ingestion Risk

Where:

$$Risk = EPC \times \sum_i \left(\left(\frac{IRW \times FI \times EF \times ED \times CF}{BW \times AT} \right) \times CSF_{kidney} \times ADAF \right) + \left(\left(\frac{IRW \times FI \times EF \times ED \times CF}{BW \times AT} \right) \times CSF_{Liver+NHL} \right)$$

Exposure Parameters (by age interval, i)					
Parameter	**Units**	**0-<2**	**2-<6**	**6-<16**	**16-<26**
EPC	µg/L	8.9E+03			
IRW	L/day	0.78	0.78	2.5	2.5
FI	unitless	1	1	1	1
CF	mg/µg	1E-03	1E-03	1E-03	1E-03
EF	days/year	350	350	350	350
ED	years	2	4	10	10
BW	kg	15	15	80	80
AT	days	25550	25550	25550	25550
CSF_{kidney}	$(mg/kg\text{-}day)^{-1}$	9.3E-03			
ADAF	unitless	10	3	3	1
$CSF_{liver+NHL}$	$(mg/kg\text{-}day)^{-1}$	3.7E-02			

	Incidential Ingestion Risks				
COPC	**0-<2**	**2-<6**	**6-<16**	**16-<26**	**Total**
Trichloroethene	1.2E-03	1.6E-03	2.5E-03	1.8E-03	**7.1E-03**

Dermal Contact Risk

Where:

$$Risk = \sum_i \left(\left(\frac{DAevent \times EV \times SA \times EF \times ED}{BW \times AT} \right) \times CSF_{kidney} \times ADAF \right) + \left(\left(\frac{DAevent \times EV \times SA \times EF \times ED}{BW \times AT} \right) \times CSF_{Liver+NHL} \right)$$

Exposure Parameters (by age interval, i)					
Parameter	**Units**	**0-<2**	**2-<6**	**6-<16**	**16-<26**
DA_{event}	mg/cm^2-event	1.8E-04			
EV	event/day	1	1	1	1
SA	cm^2	6378	6378	20900	20900
EF	days/year	350	350	350	350
ED	years	2	4	10	10
BW	kg	15	15	80	80
AT	days	25550	25550	25550	25550
CSF_{kidney}	$(mg/kg\text{-}day)^{-1}$	9.3E-03			
ADAF	unitless	10	3	3	1
$CSF_{liver+NHL}$	$(mg/kg\text{-}day)^{-1}$	3.7E-02			

	Dermal Contact Risks				
COPC	**0-<2**	**2-<6**	**6-<16**	**16-<26**	**Total**
Trichloroethene	2.8E-04	2.8E-04	4.3E-04	3.1E-04	**1.3E-03**

Inhalation Risk

Where:

$$Risk = CA \times \sum_i \left(\left(\frac{ET \times EF \times ED \times CF}{AT} \right) \times IUR_{kidney} \times ADAF \right) + \left(\left(\frac{ET \times EF \times ED \times CF}{AT} \right) \times IUR_{Liver+NHL} \right)$$

Exposure Parameters (by age interval, i)					
Parameter	**Units**	**0-<2**	**2-<6**	**6-<16**	**16-<26**
CA	$\mu g/m^3$	3.9E+04			
ET	hrs/day	24	24	24	24
CF	day/hour	0.042	0.042	0.042	0.042
EF	days/year	350	350	350	350
ED	years	2	4	10	10
AT	days/year	25550	25550	25550	25550
IUR_{kidney}	$(\mu g/m^3)^{-1}$	1.0E-06			
ADAF	unitless	10	3	3	1
$IUR_{liver+NHL}$	$(\mu g/m^3)^{-1}$	3.1E-06			

	Inhalation Risks				
COPC	**0-<2**	**2-<6**	**6-<16**	**16-<26**	**Total**
Trichloroethene	1.4E-02	1.3E-02	3.2E-02	2.2E-02	8.1E-02

TABLE J-4a CTE
CALCULATION OF CANCER RISKS - MUTAGENIC MODE OF ACTION - RESIDENT EXPOSURE TO GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Tapwater Ingestion Risk

Where:

$$\text{Risk} = \text{EPC} \times \sum_i \frac{\text{IRW} \times \text{FI} \times \text{EF} \times \text{ED} \times \text{CF}}{\text{BW} \times \text{AT}} \times \text{CSFo} \times \text{ADAF}$$

Exposure Parameters (by age interval, i)			
Parameter	**Units**	**0-<2**	**6-<12**
EPC	µg/L	See Table A-3.4	
IRW	L/day	0.78	2.5
FI	unitless	0.5	0.5
CF	mg/µg	1E-03	1E-03
EF	days/year	350	350
ED	years	2	6
BW	kg	15	80
AT	days	25550	25550
CSFo	$(mg/kg\text{-}day)^{-1}$	See Table A-6.1	
ADAF	unitless	10	3

Dermal Contact Risk

Where:

$$\text{Risk} = \sum_i \frac{\text{DAevent} \times \text{EV} \times \text{SA} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}} \times \text{CSFd} \times \text{ADAF}$$

Exposure Parameters (by age interval, i)			
Parameter	**Units**	**0-<2**	**6-<12**
DA_{event}	mg/cm^2-ever	See Table F-4	
EV	event/day	1	1
SA	cm^2	6378	20900
EF	days/year	350	350
ED	years	2	6
BW	kg	15	80
AT	days	25550	25550
CSFd	$(mg/kg\text{-}day)^{-1}$	See Table A-6.1	
ADAF	unitless	10	3

Inhalation Risk

Where:

$$\text{Risk} = \sum_i \frac{\text{Cair} \times \text{ET} \times \text{EF} \times \text{ED}}{\text{AT} \times \text{CF}} \times \text{IUR} \times \text{ADAF}$$

Exposure Parameters (by age interval, i)			
Parameter	**Units**	**0-<2**	**6-<12**
Cair	mg/m^3	See Table E-2	
ET	hrs/day	24	24
EF	days/year	350	350
ED	years	2	6
AT	days	25550	25550
CF	hrs/day	24	24
IUR	$(mg/m^3)^{-1}$	See Table A-6.2	
ADAF	unitless	10	3

	Incidential Ingestion Risks			
COPC	**EPC**	**CSFo**	**0-<2**	**6-<12**
Methylene chloride	5.90E+02	2.0E-03	8.4E-06	4.5E-06
Chromium	5.30E+01	5.0E-01	1.9E-04	1.0E-04

	Dermal Contact Risks			
COPC	**DA_{event}**	**CSFd**	**0-<2**	**6-<12**
Methylene chloride	1.86E-06	1.0E+00	2.2E-04	1.2E-04
Chromium	3.50E-08	1.0E+00	4.1E-06	2.3E-06

	Dermal Contact Risks			
COPC	**Cair**	**IUR**	**0-<2**	**6-<12**
Methylene chloride	2.95E-01	1.0E-11	8.1E-13	7.3E-13
Chromium	-	8.4E-05	NA	NA

	Total Cancer Risks			
COPC	**Tapwater Ingestion**	**Dermal Contact**	**Inhalation**	**Total**
Methylene chloride	1.3E-05	3.4E-04	1.5E-12	**3.5E-04**
Chromium	2.9E-04	6.3E-06	NA	**3.0E-04**

TABLE J-4b CTE
CALCULATION OF CANCER RISKS FROM TRICHLOROETHENE - MUTAGENIC MODE OF ACTION - RESIDENT EXPOSURE TO GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Tapwater Ingestion Risk

Where:

$$Risk = EPC \times \sum_i \left(\left(\frac{IRW \times FI \times EF \times ED \times CF}{BW \times AT} \right) \times CSF_{kidney} \times ADAF \right) + \left(\left(\frac{IRW \times FI \times EF \times ED \times CF}{BW \times AT} \right) \times CSF_{Liver + NHL} \right)$$

Exposure Parameters (by age interval, i)			
Parameter	**Units**	**0-<2**	**6-<12**
EPC	µg/L	8.9E+03	
IRW	L/day	0.78	2.5
FI	unitless	0.5	0.5
CF	mg/µg	1E-03	1E-03
EF	days/year	350	350
ED	years	2	6
BW	kg	15	80
AT	days	25550	25550
CSF_{kidney}	$(mg/kg\text{-}day)^{-1}$	9.3E-03	
ADAF	unitless	10	3
$CSF_{liver+NHL}$	$(mg/kg\text{-}day)^{-1}$	3.7E-02	

	Incidential Ingestion Risks		
COPC	**0-<2**	**6-<12**	**Total**
Trichloroethene	8.3E-04	7.4E-04	**1.6E-03**

Dermal Contact Risk

Where:

$$Risk = \sum_i \left(\left(\frac{DAevent \times EV \times SA \times EF \times ED}{BW \times AT} \right) \times CSF_{kidney} \times ADAF \right) + \left(\left(\frac{DAevent \times EV \times SA \times EF \times ED}{BW \times AT} \right) \times CSF_{Liver + NHL} \right)$$

Exposure Parameters (by age interval, i)			
Parameter	**Units**	**0-<2**	**6-<12**
DA_{event}	mg/cm^2-event	1.3E-04	
EV	event/day	1	1
SA	cm^2	6378	20900
EF	days/year	350	350
ED	years	2	6
BW	kg	15	80
AT	days	25550	25550
CSF_{kidney}	$(mg/kg\text{-}day)^{-1}$	9.3E-03	
ADAF	unitless	10	3
$CSF_{liver+NHL}$	$(mg/kg\text{-}day)^{-1}$	3.7E-02	

	Dermal Contact Risks		
COPC	**0-<2**	**6-<12**	**Total**
Trichloroethene	2.0E-04	1.8E-04	**3.8E-04**

Inhalation Risk

Where:

$$Risk = CA \times \sum_i \left(\left(\frac{ET \times EF \times ED \times CF}{AT} \right) \times IUR_{kidney} \times ADAF \right) + \left(\left(\frac{ET \times EF \times ED \times CF}{AT} \right) \times IUR_{Liver + NHL} \right)$$

Exposure Parameters (by age interval, i)			
Parameter	**Units**	**0-<2**	**6-<12**
CA	$\mu g/m^3$	3.9E+04	
ET	hrs/day	24	24
CF	day/hour	0.042	0.042
EF	days/year	350	350
ED	years	2	6
AT	days/year	25550	25550
IUR_{kidney}	$(\mu g/m^3)^{-1}$	1.0E-06	
ADAF	unitless	10	3
$IUR_{liver+NHL}$	$(\mu g/m^3)^{-1}$	3.1E-06	

	Inhalation Risks		
COPC	**0-<2**	**6-<12**	**Total**
Trichloroethene	1.4E-02	1.9E-02	3.3E-02

TABLE J-4c RME/CTE
CALCULATION OF CANCER RISKS FROM VINYL CHLORIDE - MUTAGENIC MODE OF ACTION - RESIDENT EXPOSURE TO GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

Tapwater Ingestion Risk

$$\text{Risk} = \text{EPC} \times \left(\frac{\text{IRW}_{\text{adj}} \times \text{FI} \times \text{EF} \times \text{CF1}}{\text{AT}} + \frac{\text{IRW}_{\text{c}} \times \text{CF1}}{\text{BW}_{\text{c}}} \right) \times \text{CSF}_{\text{o}}$$

Dermal Contact Risk

$$\text{Risk} = \text{DA}_{\text{event-adj}} \times \left(\frac{\text{SFS}_{\text{adj}} \times \text{EF}}{\text{AT}} + \frac{\text{EV}_{\text{c}} \times \text{SA}_{\text{c}}}{\text{BW}_{\text{c}}} \right) \times \text{CSF}_{\text{d}}$$

Inhalation Risk

$$\text{Risk} = \left(\left(\frac{\text{Cair} \times \text{ET} \times \text{EF} \times \text{ED}}{\text{AT} \times \text{CF2}} \right) + \text{Cair} \right) \times \text{IUR}$$

Parameter	Units	Value	
		RME	CTE
EPC	µg/L	3.7	
IRW_{adj}	L-year/kg-day	0.94	0.29
FI	unitless	1	0.5
EF	days/year	350	350
CF1	mg/µg	0.001	0.001
AT	days	25550	25550
IRW_c	L/day	0.78	0.78
BW_c	kg	15	15
CSF_o	$(mg/kg\text{-}day)^{-1}$	0.72	0.72
$DA_{event\text{-}adj}$	mg/cm^2-event	2.38E-08	1.61E-08
SFS_{adj}	event-year-cm^2/kg-day	7776	2418
EV_c	event/day	1	1
SAc	cm^2	6378	6378
CSF_d	$(mg/kg\text{-}day)^{-1}$	0.72	0.72
Cair	mg/m^3	1.85E-03	1.85E-03
ED	years	26	8
ET	hrs/day	24	24
CF2	hrs/day	24	24
IUR	$(mg/m^3)^{-1}$	0.0044	0.0044

COPC	EPC (µg/L)	$DA_{event\text{-}adj}$ (mg/cm^2-event)		Cair (mg/m^3)	Vinyl Chloride Tapwater Risks							
					RME				CTE			
		RME	CTE		Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Vinyl Chloride	3.70E+00	2.38E-08	1.61E-08	1.85E-03	1.7E-04	9.1E-06	1.1E-05	1.9E-04	1.4E-04	7.9E-06	9.0E-06	1.6E-04

APPENDIX K

TABLE K-1
IEUBK MODEL OUTPUT – OVERBURDEN GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

LEAD MODEL FOR WINDOWS Version 1.1

==========

Model Version: 1.1 Build11
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research

==========

******** Air ********

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

******** Diet ********

Age	Diet Intake(µg/day)
.5-1	2.260
1-2	1.960
2-3	2.130
3-4	2.040
4-5	1.950
5-6	2.050
6-7	2.220

******** Drinking Water ********

Water Consumption:

Age	Water (L/day)
.5-1	0.200

TABLE K-1
IEUBK MODEL OUTPUT – OVERBURDEN GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 9.000 µg Pb/L

******** Soil & Dust ********

Multiple Source Analysis Used
Average multiple source concentration: 150.000 µg/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (µg Pb/g)	House Dust (µg Pb/g)
.5-1	200.000	150.000
1-2	200.000	150.000
2-3	200.000	150.000
3-4	200.000	150.000
4-5	200.000	150.000
5-6	200.000	150.000
6-7	200.000	150.000

******** Alternate Intake ********

Age	Alternate (µg Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

******** Maternal Contribution: Infant Model ********

Maternal Blood Concentration: 1.000 µg Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

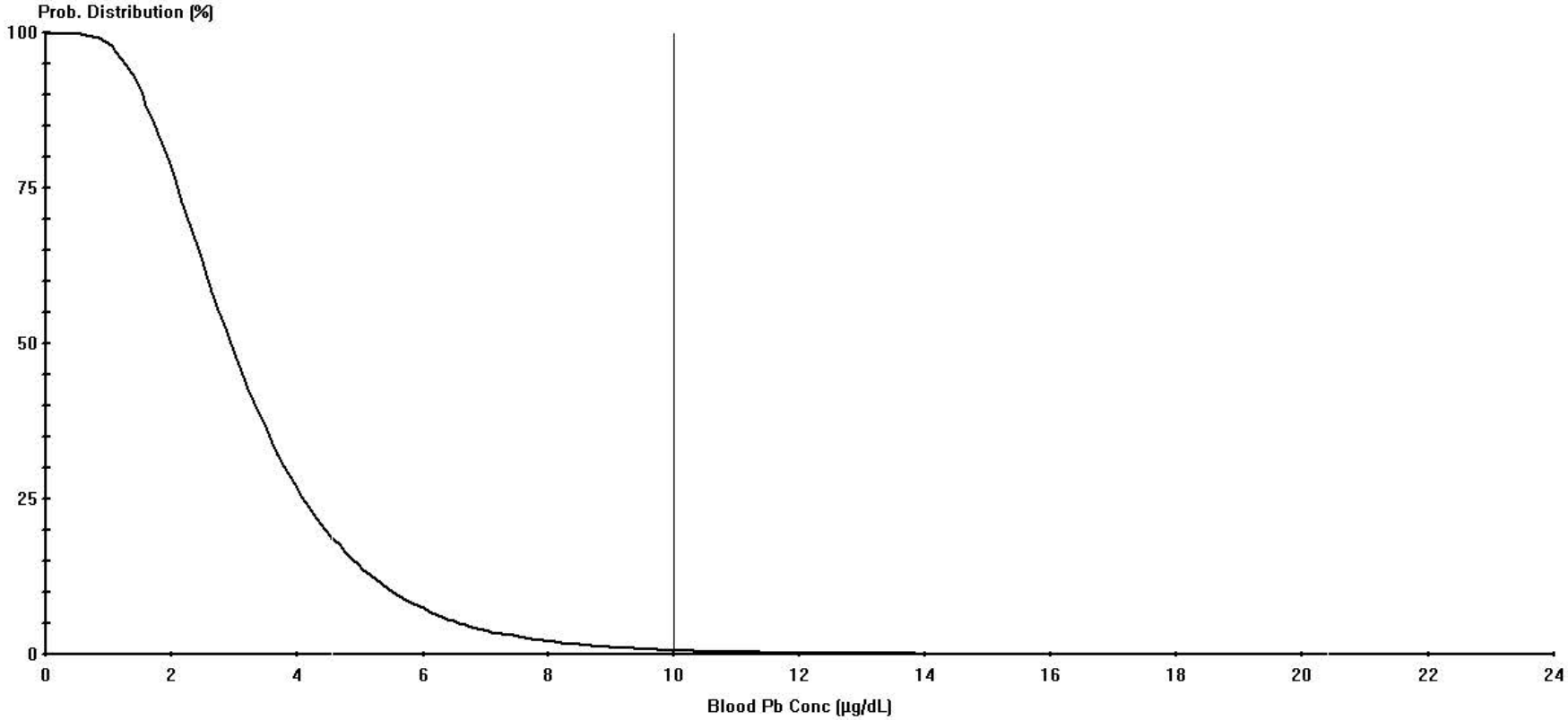
Year	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)

TABLE K-1
IEUBK MODEL OUTPUT – OVERBURDEN GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

.5-1	0.021	1.055	0.000	0.840
1-2	0.034	0.902	0.000	2.071
2-3	0.062	0.991	0.000	2.177
3-4	0.067	0.959	0.000	2.241
4-5	0.067	0.932	0.000	2.366
5-6	0.093	0.986	0.000	2.511
6-7	0.093	1.072	0.000	2.563

Year	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
.5-1	4.108	6.024	3.3
1-2	6.431	9.439	3.9
2-3	6.500	9.730	3.6
3-4	6.565	9.832	3.4
4-5	4.947	8.311	2.9
5-6	4.481	8.071	2.5
6-7	4.247	7.976	2.3

TABLE K-1
IEUBK MODEL OUTPUT – OVERBURDEN GROUNDWATER
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT



Cutoff = 10.000 µg/dl
Geo Mean = 3.106
GSD = 1.600
% Above = 0.643

Age Range = 0 to 84 months

Run Mode = Research

APPENDIX L

FINAL TECHNICAL MEMORANDUM

To: Karen Lumino

From: Richard Sugatt

Date: May 28, 2015

Subject: Risk Evaluation of Sump Water Data from 830 South Brownell Road, Williston, VT

In April 2014 and again in July 2014, VT DEC collected samples from the sump pump at the subject property. The concentration of trichloroethylene (TCE) during the first event was measured to be 75 ug/L and 104 ug/L during the second.

The EPA Vapor Intrusion Screening Level (VISL) calculator was used to calculate the indoor air risk as though the sump water were groundwater. The calculated residential indoor air risk for a TCE concentration of 104 ug/L in groundwater was a cancer risk of 8.8E-05 and a Hazard Index of 20. The VISL calculator uses a default attenuation factor of 0.001 for attenuation from groundwater to indoor air. Since there is no obstruction between the sump water and indoor air, it is assumed that the sump water in the basement has an attenuation factor of 1, which would increase the risks by a factor of 1000. Multiplying the VISL risks by 1000 results in a cancer risk of 8.8E-02 and a non-cancer Hazard Index of 20,000, both of which are elevated above EPA's maximum acceptable risk of 1E-04 cancer risk and Hazard Index of 1.

SECTION III

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SECTION II - TABLE OF CONTENTS
SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT (SLERA)
COMMERCE STREET PLUME SUPERFUND SITE
WILLISTON, VERMONT

REFINED SCREENING-LEVEL ECOLOGICAL RISK ASSESSMET (SLERA) – EPA FINAL TECHNICAL MEMORANDUM, AUGUST 8, 2013

ATTACHMENTS

NUMBER

1 Draft Screening-Level Ecological Risk Assessment, ESAT, May 2012

2 Aquatic Invertebrate, Sediment, and Surface Water Sampling in the Unnamed Stream, Final Technical Memorandum, ESAT, October 2012

Superfund Records Center
SITE: Commerce Street
BREAK: 03.10
OTHER: 550206

Final Technical Memorandum

To: Karen Lumino
From: Richard Sugatt
Date: August 8, 2013
Subject: Refined Screening-Level Ecological Risk Assessment (SLERA), Commerce Street Superfund Site, Williston, Vermont

INTRODUCTION

This technical memorandum provides a description and evaluation of the studies that were conducted to determine whether there were ecologically significant impacts on the benthic invertebrate community of an unnamed stream that intersects the contaminated groundwater plume of the Commerce Street Superfund Site in Williston, VT. This stream is the upper part of what Vermont Department of Environmental Conservation (VT DEC) calls Muddy Brook Tributary 4. These studies were initiated as a result of a screening level ecological risk assessment (SLERA) conducted for U. S. EPA by the Region 1 Environmental Services Assistance Team (ESAT) (2012a). This SLERA compared available freshwater surface water and sediment screening benchmarks against measured concentrations of metals and organics in surface water, pore water and sediment of the unnamed stream.

The SLERA identified the potential for ecological risk from exposure to trichloroethylene (TCE) in surface water and pore water of the unnamed stream. Based on comparison with benchmarks, no actionable risk was identified for tetrachloroethylene (PCE) or 1, 2-dichloroethylene (DCE) in sediment, or for metals in the Site-contaminated groundwater plume. PCE was not a concern in any of these media. There was high uncertainty concerning the potential for ecological risk from TCE because of variability in the surface water benchmarks. Although the EPA Region V benchmark for TCE is 47 micrograms/liter (ug/L) (EPA, 2003), a much higher benchmark (1000 ug/L) was calculated by ESAT (ESAT, 2003) using the Tier II approach for calculating surface water quality criteria published by EPA (40 CFR Part 132-Water Quality Guidance for the Great Lakes System, March 23, 1995). Similarly, Burgess et al (2008) reported that the Tier II secondary chronic value was 47 ug/L based on compilation of literature aquatic toxicity values, whereas the Tier II secondary chronic value based on equilibrium partitioning narcosis effects was 1400 ug/L. Because only the lower TCE benchmark was exceeded, the SLERA concluded that potential risk could not be eliminated and recommended that alternative approaches, such as *in-situ* toxicity tests or a benthic macroinvertebrate community survey, be considered to determine if the presence of TCE in the surface water and pore water of the unnamed stream represents actionable ecological risk.

Toxicity tests and benthic surveys both have advantages and disadvantages. It can be a challenge to determine the cause of toxicity or benthic community impact because toxicity could be caused by known or unknown stressors in the stream, and community changes could be caused by upstream stressors or differences in habitat among the sampled stations, rather than the presence of site-related chemicals. The presence of

SDMS DocID 550206

toxicity in samples collected from the impact area indicates only an effect on the particular test specie(s) which may not exist in the stream itself; and therefore would not necessarily speak to the survival of other species or the presence of a significant impact on the benthic community if other more resistant species survive. Similarly, toxicity does not speak to adverse ecological effects downstream if the benthic community recovers downstream of the Site after the toxicants volatilize or bind to sediment. Since volatile organic compounds (VOCs) will volatilize from any sediment or surface water sample if it is transported to a laboratory for testing, *in-situ* toxicity tests are the only valid type of toxicity test for VOC sites, except situations where surface water can be pumped continuously through test chambers in an on-site laboratory. *In situ* tests are difficult and expensive to perform because standard laboratory test organisms must be acclimated to upstream water and added to screened test chambers placed in or on the sediment for the defined test period and then retrieved for measurement of survival, growth or reproduction. Benthic macroinvertebrate surveys have the advantage of integrating the biological impact of all the stressors on the populations relative to an upstream reference location, as well as providing a method to evaluate whether there is recovery of populations downstream from the impact area. Disadvantages include the requirement that habitat must be similar at the sample stations and reference conditions must be determined for making comparisons to the impacted station, such as by establishing that one or more upstream control stations are not affected by the contaminants of concern at the impacted station.

The unnamed stream is known to be impacted by nonpoint source urban runoff because it originates and flows through a densely-developed area of office buildings typical of most landscaped suburban office parks. Nonpoint source pollutants from such developed areas include polycyclic aromatic hydrocarbons (PAHs) and metals in runoff from parking lots and roads, road salt, fertilizers and pesticides from landscaping, and particulates. Muddy Brook is considered by VT DEC to be impaired due to toxics (TCE, vinyl chloride) and high chloride levels. According to VTDEC, the impairment due to TCE and vinyl chloride is based on the previously known presence of these chemicals in the Commerce St. Superfund site groundwater plume. The current study may serve to inform VTDEC concerning future impairment determinations for this watershed.

Due primarily to the difficulty of conducting *in-situ* toxicity tests for VOCs and the associated uncertainty concerning ecological impact if toxicity were to be found, it was decided to conduct a benthic macroinvertebrate community survey using standard biological and habitat evaluations compatible with VT DEC procedures. Sampling for contaminants, habitat evaluation and collection of biological samples was conducted by ESAT under contract to EPA, according to an Agency-approved Quality Assurance Project Plan (QAPP) (ESAT, 2012b). Chemical analysis of surface water and sediment was conducted by EPA at the OEME laboratory in North Chelmsford, MA, and under EPA contract to Alpha Analytical.. The taxonomic analysis of the collected biological samples was conducted by EcoAnalysts under subcontract with Nobis Engineering. The methods of the habitat evaluation and biological sampling and sampling for contaminants are detailed in ESAT (2012c) and summarized below:

METHODS

Sample Stations

All the field activities took place at five specific sampling stations in the unnamed stream, four of which coincided with pore water sample stations used by Nobis Engineering in July 2010. The pore water sampling stations are provided in **Figure 1** to show the location and VOC concentrations in pore water in 2010. With the exception of the upstream off-site control location, the sampling stations for the present study were co-located with the 2010 pore water stations PW-2, PW-11, PW-17, and PW-20, as shown in **Figure 2**, taken from ESAT 2012c. Note that PW-2 was not mentioned in the QAPP (ESAT 2012b), but it was determined in the field to sample PW-2 instead of PW-1 because of a lack of suitable habitat at PW-1. The control location was determined in the field as well. The five sampling stations were as follows:

- PW-20: Recovery (far); located about 1,000 ft downstream from PW-17.
- PW-17: Recovery (near); located about 900 ft downstream from PW-11
- PW-11: site impacted area; this location had the highest levels of trichloroethylene during the July 2010 pore water sampling event.
- PW-2: study area control, located upstream from the site-impacted area just downstream from PW-1, not far from the culvert underneath Route 2.
- Off-site Control: located upstream from PW-1, north of Route 2 in a small watershed fed by urban runoff (just west of 209 Blair Part Rd. in Williston, VT).

The sampling effort started at the most downstream station (PW-20) and proceeded sequentially upstream from there from September 11 to 13, 2012.

Surface Water Sampling

The surface water at each station was measured for temperature, pH, dissolved oxygen, and specific conductance with a YSI Model 6 Data Logger. Two surface water samples were collected at each station. The first sample was collected in four 40 milliliter (mL) VOA (Volatile Organic Analysis) vials for VOC analysis, while the second sample was collected in one 250 mL plastic bottle for analysis of the inorganic constituents chloride, bromide, fluoride, nitrate, nitrite and sulfate. The samples were obtained by carefully immersing the sample bottles under the surface of the water with care taken to avoid disturbing or touching the soft substrate while filling the bottles. This approach was used to avoid suspending the sediment and contaminating the samples. A complete set of duplicate samples was collected at the impact station PW-11.

Sediment Sampling

Two separate sediment samples were collected at each station for VOC analysis. One composite sediment sample consisting of three subsamples was also collected from each sampling station for analysis of semi-volatile organic compounds (SVOCs), Target Analyte List (TAL) metals, and total organic carbon (TOC). The two samples for VOC analysis were collected by inserting a clean, 10 mL syringe with its tip cut off directly into the sediment bed and then transferring the sample into a 40 mL septum vial containing 10 mL of methanol. A second sample was collected and placed in a separate 40 mL VOA vial without methanol for determination of % moisture. A duplicate

sediment sample was collected at PW-11. An Eckman dredge was then used to collect sediment for SVOCs, TAL metals, and TOC. Three 6-inch deep sediment samples were collected with the dredge and placed into a clean 20 L cubitainer with the top cut off. Course debris was removed and excess water was decanted. The sediment was then homogenized with a clean plastic scoop and distributed into labeled sample containers. Every effort was made to ensure that all the sediment grabs had similar composition and were collected in water < 1 ft deep. A duplicate composite sample for SVOC, TAL metals, and TOC analyses was collected at PW-11.

Invertebrate Sampling

ESAT recorded major habitat characteristics at each sample station on standardized habitat worksheets. Additional descriptions were recorded in a field logbook. Infaunal invertebrates were collected by coring, and epifaunal invertebrates were collected by sweep bottom kick net sampling, as described below:

Infaunal Invertebrates

Four replicate sediment samples were collected in the vicinity of each sampling station using a percussion sediment corer. Each replicate sample consisted of four subsample cores collected near each other. A 2 ½ inch diameter clear plastic core tube was placed into the sediment 3 inches deep, carefully pulled out and then emptied into a no. 30 sieve bucket. This was done four times for one replicate and all subsamples were placed into the same sieve bucket. The sieve bucket was then placed in the stream, making sure not to completely submerge it, and swirled around to rinse fine sediment out of the sample. Debris was discarded and any remaining sediment and organisms were placed into a labeled 1 L plastic jar and preserved with 70% ethanol. In summary, four cores were collected from four locations per sampling station (16 cores per sampling station), resulting in at least 20 composite benthic invertebrate samples (four composites per sampling station from five different sampling stations). PW-11 underwent a full re-sample in order to generate a duplicate infaunal invertebrate sample.

Epifaunal invertebrates

A kick net was used to collect a total of four jabs from representative habitats as described in the QAPP. Sampling was performed by jabbing the net into debris dams, vegetation, or root mats pulling back rapidly to dislodge invertebrates, then sweeping forward again into the same areas to collect the dislodged invertebrates. This jabbing and sweeping motion was repeated several times at the same location and considered one of the four jabs. Each jab was taken in a general upstream direction from each subsequent point. All four jabs (from different points around the sample station) were combined into a single composite sample. Excess debris was first removed, and leaves and sticks were thoroughly rinsed off to prevent losing any attached invertebrates. The total contents were transferred to a labeled sample bottle(s) and preserved in 70% - 80% ethanol. Two replicates were collected at each sample station and a complete set of duplicate samples was collected at the impact station PW-11.

Habitat assessment
The stream habitat at each sampling station was photographed and then described using the Habitat Assessment Field Data Sheet-Low Gradient Streams (see ESAT, 2012c) using the descriptions and definitions provided in Chapter 5 (Habitat assessment and physicochemical parameters) of the Rapid Bioassessment Protocols (see QAPP). The habitat assessment field data sheet contains ten habitat parameters that were scored between a low of 1 (poorest condition) and a high of 20 (best possible condition). The data sheets were completed based on reaching a consensus among all the field biologists participating in the sampling event.

RESULTS

Surface water sampling
The physicochemical results obtained at the sample stations are presented in **Table 1**. The temperature was between 12.14 and 17.53 °C. The pH ranged from 7.42 to 8.21. Dissolved oxygen ranged between 7.75 and 9.62 mg/L, with a range of % saturation between 73.5 and 100.9 %. Conductivity was the most variable parameter with values of 965 microSiemens per centimeter (uS/cm) in the off-site control, 916 uS/cm in PW-2, 1004 uS/cm in PW-11, 2475 uS/cm in PW-17, and 1916 uS/cm in PW-20.

The results for VOCs and inorganics in surface water are presented in **Table 2**. VOCs were not detected in the off-site control or study area control PW-2. TCE, vinyl chloride (VC) and DCE were measured at 15 ug/L, 3.2 ug/L, and 38 ug/L, respectively in the impact station PW-11, with nearly identical results in the duplicate at this station. VOC concentrations decreased at the recovery near station PW-17 to 6 ug/L TCE, < 1 ug/L VC and 9.2 ug/L DCE. VOCs decreased even more in the recovery far station PW-20 to 2.6 ug/L TCE, < 1 ug/L VC, and 3.8 ug/L DCE.

Among the inorganics, bromide, fluoride, and nitrite were not detected at any of the five sample stations. Nitrate occurred at measured or estimated concentrations between 0.36 and 1.7 mg/L. Sulfate occurred at measured concentrations between 24 and 27 mg/L. Although sulfate and nitrate concentrations were relatively constant among stations, chloride concentration varied greatly in a pattern similar to the conductivity measurements. The chloride concentrations were 190 mg/L in both off-site control and study area control PW-2, increased slightly to 210 mg/L at the impact area PW-11, increased to 620 mg/L at the recovery near station PW-17 and then decreased to 450 mg/L at the recovery far station PW-20. PW-17 is immediately below a significant tributary to the northeast, which could be a drainage source of chloride. There is a large plant nursery located on this tributary; however, finding the source of the chloride input is beyond the scope of this memorandum.

Sediment sampling
The chemical analysis and TOC results for sediment are presented in **Table 3** along with sediment benchmarks from MacDonald *et al.* (2000). No VOCs were detected in any of the sediment samples. The only SVOCs detected in the off-site control station were two PAHs (fluoranthene and pyrene). No SVOCs were detected in sediment from PW-2,

impact area station PW-11, or recovery near station PW-17. Many SVOCs were measured at the recovery far station PW-20. These SVOCs included 9 PAHs, 2 phthalate esters, and several rarely detected SVOCs including, chlorobenzilate, aramite, pentachlorophenol, phenacetin, and nitrophenol.

Habitat Assessment

The results of the habitat assessment are summarized in **Table 4, Table 5, and Table 6**. **Table 4** contains the results for the Vermont Lotic Benthos Field Sheet. **Table 5** contains the results of the physical characterization/water quality field data sheet from the Rapid Bioasessment Protocol. **Table 6** provides an overall score for each station using Form 3 of the Rapid Bioassessment Protocol (Barbour et al, 1999). As shown in **Table 6**, the total habitat score was similar among the off-site control, PW-11, PW-17, and PW-20 with total scores of 161, 151, 152, and 154, respectively. PW-2 had a lower score of 95, reflecting the fact that it was more channelized, straighter, had less pool variability, and had less epifaunal substrate/available cover. All stations had the same surrounding commercial/industrial land use and entirely sandy/silty substrate, which is indicative of poor habitat quality. With the exception of PW-2 which was highly channelized, it is concluded that the habitat is sufficiently similar to justify comparing the other stations with the off-site control station, based on habitat similarity.

Benthos Assessment

The results of the benthic survey are provided in **Table 7, Table 8, and Table 9**. **Table 7** provides the results of the infauna survey. **Table 8** provides the results of the epifauna survey. The most important metrics are summarized in **Table 9**, which provides the same metrics for both epifaunal samples (sweep samples) and infaunal samples (cores). These results will be discussed separately and then integrated to determine if a discernible Site-related impact is present.

Infaunal Assessment

Several of the metrics suggest that the health of the infauna community decreases from a maximum in the off-site control to a minimum in either PW-11 or PW-17 and then recovers at the far recovery station PW-20. As shown in **Table 9**, examples of this trend include the following:

- Hilsenhoff Biotic Index (HBI) increases from 6.5 in the off-site control to 8.6 in PW-17; however, the HBI is higher in PW-20 than in the off-site control, indicating that recovery to control condition has not occurred. The HBI increases as water quality decreases.
- The % Tolerant Taxa increases from 25% in the off-site control to 66.8% in PW-17 and then decreases to 42.1% in PW-20; however, % Tolerant Taxa is higher in PW-20 than in the off-site control, indicating that recovery to off-site control condition has not occurred at the most downstream sample station in the unnamed stream. These metric increases as water quality decreases.

Other metrics do not show this trend. For instance, Corrected Abundance in PW-11, PW-17 and PW-20 is higher than in the off-site control. Similarly, Species Richness in PW-2,

PW-11 and PW-17 is about the same (2.5 to 3.8) as in the off-site control (3.3), but increases to 6.3 in PW-20, indicating that PW-20 has higher habitat quality than the off-site control. As a result, there is no clear trend indicating that infauna are impacted by Site contaminants. In general, the abundance and number of species were much lower than among the epifauna, described below.

Epifaunal Assessment

It appears that many of the metrics (EPT, Biotic Index, % tolerant taxa) are driven by the presence or absence of the Hydropsyche taxa Chuematophyche. This is a moderately tolerant filter feeding caddisfly. Several of the metrics suggest that the health of the epibenthic community decreases from a maximum in the off-site control to a minimum in either PW-11 or PW-17 and then recovers to levels similar to the off-site control at the recovery far station (PW-20) As shown in **Table 9 and Figures 1.a through 1.d.**, examples of this trend include the following:

- Corrected Abundance drops from 381 in the off-site control to 65 in PW-17 and then increases to 258 in PW-20.
- EPT Abundance drops from 115 in the off-site control to 6.5 in PW-17 and then increases to 122 in PW-20.
- Species Richness drops from 39 in the off-site control to 15 in PW-17 and then increases to 30 in PW-20.
- EPT Richness drops from 3.5 in the off-site control to 1 in PW-11 and then increases to 3.5 in PW-20.
- Hilsenhoff Biotic Index (HBI) increases from 5.9 in the off-site control to 6.4 in PW-17 and then decreases to 5.4 in PW-20. This metric increases as water quality decreases, due primarily to organic enrichment.
- The % Tolerant Individuals increases from 16.1% in the off-site control to 38.9% in PW-17 and then decreases to 5% in PW-20. This metric increases as the water quality decreases.

DISCUSSION

Comparison of the sediment results with available sediment benchmarks from MacDonald *et al.* (2000) and Kalf et al (1997) in **Table 3** indicate that the Threshold Effect Concentration (TEC) was exceeded by two PAHs and zinc in the off-site control and four PAHs and total PAH in PW-20. The TEC is the concentration below which benthic impacts are considered unlikely. No contaminants exceeded the Probable Effect Concentration (PEC), which is the concentration above which benthic impacts are considered likely. None of the PAHs exceeded the Dutch Maximum Permissible Concentration (MPC) from Kalf et al (1997). The MPC is the concentration above which the risk of adverse effects is considered unacceptable. Sediments with contaminants at levels between the TEC and PEC are not usually toxic so it is concluded that the metals and SVOCs in sediments at these stations probably do not have significant toxicity.

The impact of the sediment SVOCs without benchmarks, primarily in PW-20, is unknown. Chlorobenzilate is a persistent insecticide no longer used in the U. S. Aramite

is a little- used insecticide that is still registered for use in the U. S. Pentachlorophenol is a persistent chlorinated hydrocarbon that has been used as a disinfectant, pesticide, and wood preserver. Phenacetin is an analgesic drug that was ordered withdrawn by FDA in 1983. Nitrophenol is used as an intermediate in the synthesis of the analgesic drug paracetamol (acetaminophen) and as a precursor for preparation of the analgesic phenetidine (which is also a metabolite of phenacetin). The presence of pesticides may be related to the large commercial nursery that abuts a significant tributary to the northeast of the unnamed stream or to historic use of pesticides in landscaping around the numerous office buildings abutting this tributary. The presence of phenacetin and nitrophenol may be related to leakage of acetaminophen and its metabolites in human sewage from sewer lines into groundwater or surface water, or current or historic effluent from an analgesic manufacturer that has accumulated in the sediments of this most downstream station.

Since VOCs were not detected in sediments at any station, it is likely that Site VOCs do not have a toxic impact in sediment. As shown in Table 10, the detection limits for each VOC were lower than the available sediment benchmarks from EPA Region 3 and EPA Region 5. A sediment benchmark is unavailable for cis-1, 2-dichloroethene but would probably be similar to the benchmark of 654 ug/kg for trans-1, 2-dichloroethene from EPA Region 5, indicating that the detection limits for cis-1, 2-dichloroethene (52 to 110 ug/kg) is probably lower than the likely benchmark. The EPA Region 3 and 5 sediment benchmarks are based on equilibrium partitioning, which predicts the sediment pore water concentration based on equilibrium partitioning between the sediment pore water and the organic carbon in the sediment. More recently, narcosis-based equilibrium partitioning sediment benchmarks (ESBs) were derived by Burgess et al (2008) for a number of chemicals, including TCE (but not cis-1, 2-dichloroethene or vinyl chloride). The ESBs are expressed as organic carbon normalized concentrations, i.e. ug chemical per gram organic carbon. As shown in Table 10 the non-detect organic carbon normalized concentrations of TCE were < 14 to < 21.7 ug/g-oc. These concentrations are lower than the ESB of 650 ug/g-oc. Since the normalized concentrations of TCE in site sediment are less than the ESB (650 ug/g-oc), it is concluded that TCE is unlikely to have toxic effects in sediment.

It is also likely that Site VOCs do not have a toxic impact in surface water because the concentrations of VOCs detected in surface water were all below the ecological benchmarks for freshwater (Table 2). The concentration of TCE in surface water at the impact station was 15 ug/L which is the same order of magnitude as the benchmarks from EPA Region 3 (21 ug/L) and EPA Region 5 (47 ug/L); however the basis for these benchmarks is unknown. The chronic Tier II concentrations from EPA's Great Lakes Initiative Clearinghouse (http://www.epa.gov/gliclearinghouse) are based on an extensive search of the acute toxicity data and calculation of acute and chronic Tier II values based on methodology similar to that for calculating EPA's National Recommended Water Quality Criteria. The acute Tier II values (5500 ug/L for DCE, 2300 ug/L for TCE, and 8400 ug/L for VC) are about an order of magnitude higher than the chronic Tier II values. Trends in epifauna metrics suggest that the greatest impact on epifauna is in PW-17 which is about 900 feet downstream from the impact area PW-11. The trend is less clear

in the infauna metrics but there is no indication that community impacts are any greater in the impact area PW-11 than elsewhere. The VOCs concentrations are highest in the impact area PW-11 and then decrease by about half at PW-17, and then decrease even further at the most downstream station PW-20. If the VOCs were acting as the primary stressor in the stream, the maximum impacts on infauna and epifauna would be expected at the impact area; however, the maximum impact on the epifauna community occurs further downstream at PW-17 where VOC levels have decreased by about half.

Although the habitat characteristics of PW-11 and PW-17 are similar in most respects (i.e. depth, width, substrate, dominant aquatic vegetation), there are some differences that could have an influence. PW-17 had less large woody debris, and less canopy cover than PW-11 which could have accounted for some of the increased health impacts on epifauna in PW-17 than in PW-11. The macroinvertebrate community is generally more diverse as large woody debris and canopy increase.

It is more likely that the impacts on epifauna are due to increased conductivity and chloride. The conductivity and chloride concentration is nearly constant from the off-site control to the impact area PW-11 and then rises sharply at PW-17, with conductivity doubling and chloride nearly tripling. PW-17 is immediately below a significant tributary to the northeast that drains a wetland complex abutted by a large commercial nursery with several stormwater settling basins, as well as numerous office building parking lots. The spiking of chloride and conductivity in the recovery near station PW-17 suggests that there may have been long term heavy historical usage of road salt that has contaminated groundwater in this area and which enters the unnamed stream downstream from the impact area on a continuous or semi-continuous basis.

The surface water results indicated that all stations had conductivity of 916 ugS/cm or higher and chloride concentrations of 190 mg/L or higher. EPA's website on conductivity, (http://water.epa.gov/type/rsl/monitoring/vms59.cfm) states that studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range of 150 to 500 umhos/cm (which is equal to 150 and 500 uS/cm). Cormier et al (2013) derived a benchmark of 300 ugS/cm for protection of 95% of species from extirpation in West Virginia streams. Because the benchmark is not protective of all genera and protects against extirpation rather than reduction in abundance, this level may not fully protect sensitive species. Because all of the stations had a conductivity of 916 uS/cm or higher, this information suggests that there are conductivity-related impacts throughout the stream.

The EPA National Recommended Water Quality Criteria (NRWQC) for chloride are 860 mg/L as the acute Criterion Maximum Concentration (CMC) and 230 mg/L as the chronic Criterion Continuous Concentration (CCC). The NRWQC for chloride is based on data available in 1988 (EPA, 1988). More recently, Elphick et al (2011) derived a proposed water quality guideline of 307 mg/L for chloride based on acute and chronic toxicity tests with nine freshwater animal and plant species.

The chloride concentrations in off-site control (190 mg/L), PW-2 (190 mg/L), and the impact station PW-11 (210 mg/L) were below the CCC of 230 mg/L; however, the chloride concentration at PW-17 (620 mg/L) and PW-20 (450 mg/L) were higher than the chronic CCC (230 mg/L) but lower than the acute CMC (860 mg/L). The chloride concentration at PW-17 and PW-20 was also higher than the more recent proposed water quality guideline of 307 mg/L. These results suggest that chronic effects could be occurring in PW-17 and PW-20 due to chloride. Since chloride was lower than these criteria or guidelines at the impact areas PW-11 and further upstream, these results suggest that impacts are due to chloride rather than VOCs.

Therefore, the weight of evidence is that the most likely cause for the decreased health of the epifauna noted at PW-17 is conductivity/chloride, rather than Site contaminants. Although this conclusion cannot be definitive due to the variability in habitat characteristics among the stations, it is clear that there has been substantial recovery of the infauna and epifauna community at PW-20, attaining conditions nearly the same as in the off-site control station, or better. Therefore, even if VOCs have an impact on macroinvertebrates at the impact area PW-11, any such impact is lessened by 1900 feet (<0.4 mile) downstream from the impact area at PW-20 where other stressors appear to be of greater concern. It is concluded that VOCs entering the unnamed stream do not have a significant ecological impact on aquatic macroinvertebrates.

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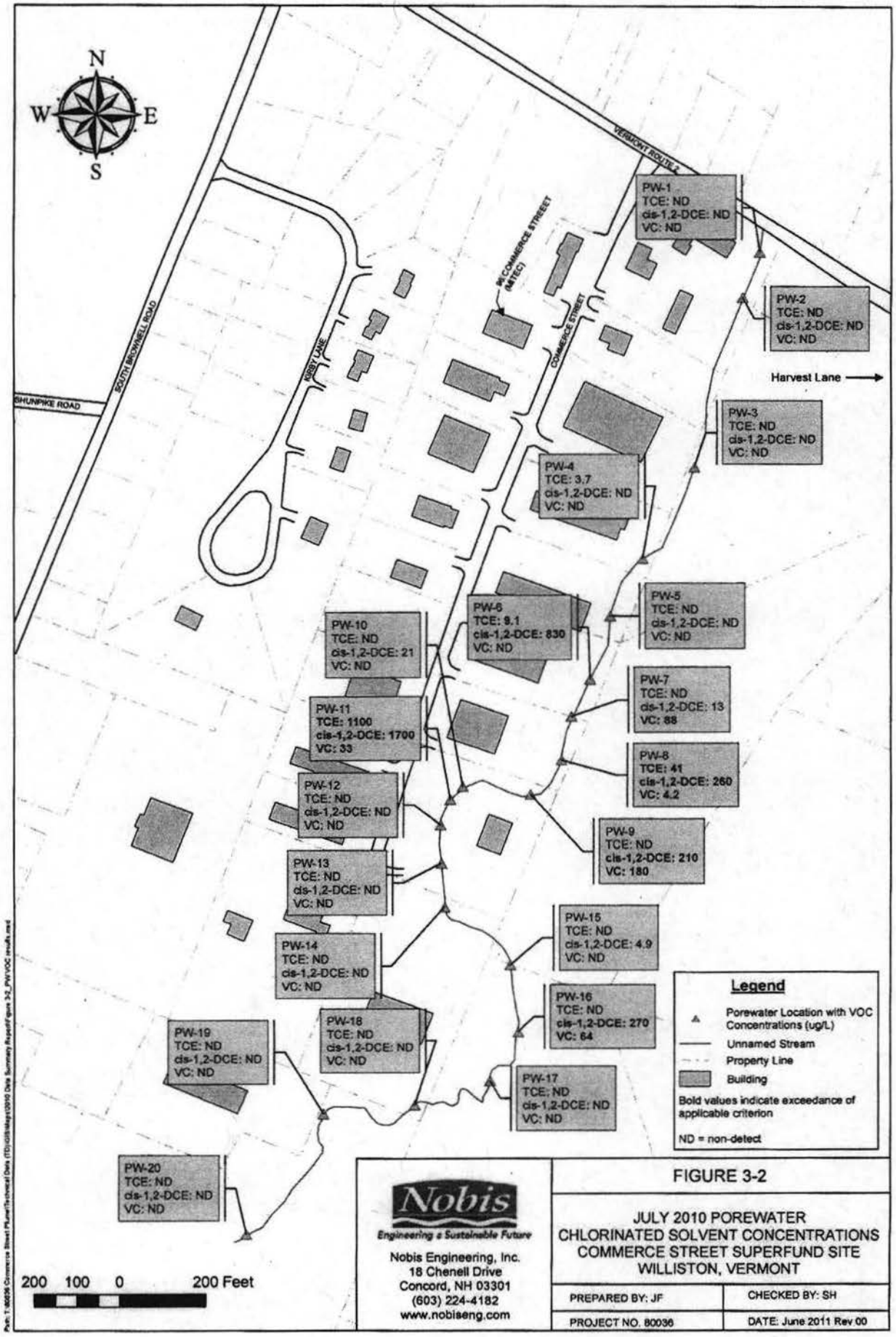
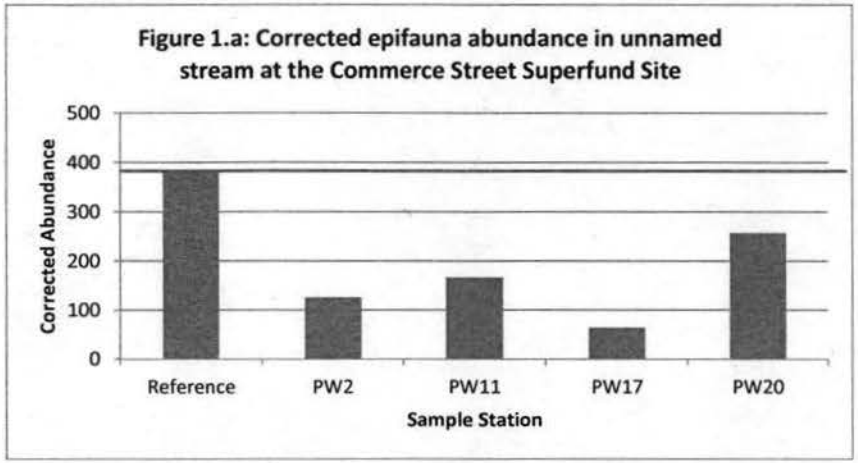
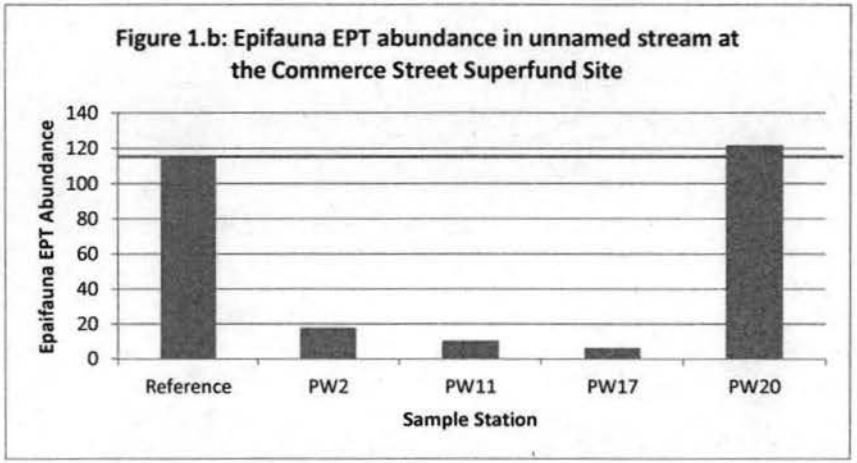
FIGURES

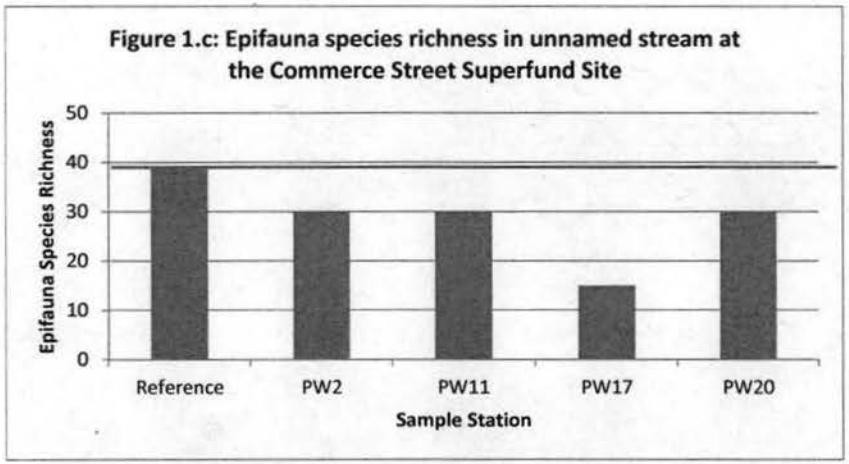
FIGURE 1


N
W
E
S
VERMONT ROUTE 2
SOUTH BROWNELL ROAD
SHUNPIKE ROAD
KIRBY LANE
COMMERCE STREET
96 COMMERCE STREET (MTEC)
Harvest Lane
PW-1
TCE: ND
cis-1,2-DCE: ND
VC: ND
PW-2
TCE: ND
cis-1,2-DCE: ND
VC: ND
PW-3
TCE: ND
cis-1,2-DCE: ND
VC: ND
PW-4
TCE: 3.7
cis-1,2-DCE: ND
VC: ND
PW-5
TCE: ND
cis-1,2-DCE: ND
VC: ND
PW-6
TCE: 9.1
cis-1,2-DCE: 830
VC: ND
PW-7
TCE: ND
cis-1,2-DCE: 13
VC: 88
PW-8
TCE: 41
cis-1,2-DCE: 260
VC: 4.2
PW-9
TCE: ND
cis-1,2-DCE: 210
VC: 180
PW-10
TCE: ND
cis-1,2-DCE: 21
VC: ND
PW-11
TCE: 1100
cis-1,2-DCE: 1700
VC: 33
PW-12
TCE: ND
cis-1,2-DCE: ND
VC: ND
PW-13
TCE: ND
cis-1,2-DCE: ND
VC: ND
PW-14
TCE: ND
cis-1,2-DCE: ND
VC: ND
PW-15
TCE: ND
cis-1,2-DCE: 4.9
VC: ND
PW-16
TCE: ND
cis-1,2-DCE: 270
VC: 64
PW-17
TCE: ND
cis-1,2-DCE: ND
VC: ND
PW-18
TCE: ND
cis-1,2-DCE: ND
VC: ND
PW-19
TCE: ND
cis-1,2-DCE: ND
VC: ND
PW-20
TCE: ND
cis-1,2-DCE: ND
VC: ND
Legend
Porewater Location with VOC Concentrations (ug/L)
Unnamed Stream
Property Line
Building
Bold values indicate exceedance of applicable criterion
ND = non-detect
200 100 0 200 Feet
Nobis
Engineering a Sustainable Future
Nobis Engineering, Inc.
18 Chenell Drive
Concord, NH 03301
(603) 224-4182
www.nobiseng.com
FIGURE 3-2
JULY 2010 POREWATER
CHLORINATED SOLVENT CONCENTRATIONS
COMMERCE STREET SUPERFUND SITE
WILLISTON, VERMONT
PREPARED BY: JF
CHECKED BY: SH
PROJECT NO. 80036
DATE: June 2011 Rev 00

Station	corrected abundance	EPT abundance	species richness	EPT richness
Reference	381	115	39	3.5
PW2	127	18	30	2
PW11	167	10.5	30	1
PW17	65	6.5	15	1
PW20	258	121.8	30	3.5







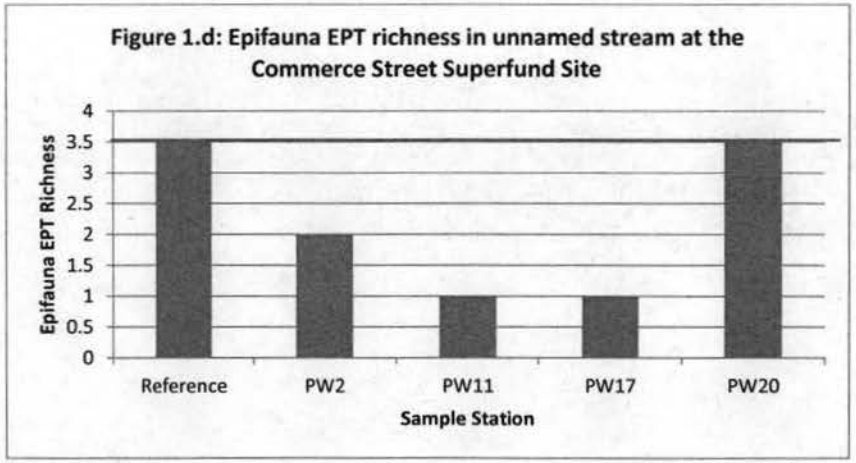
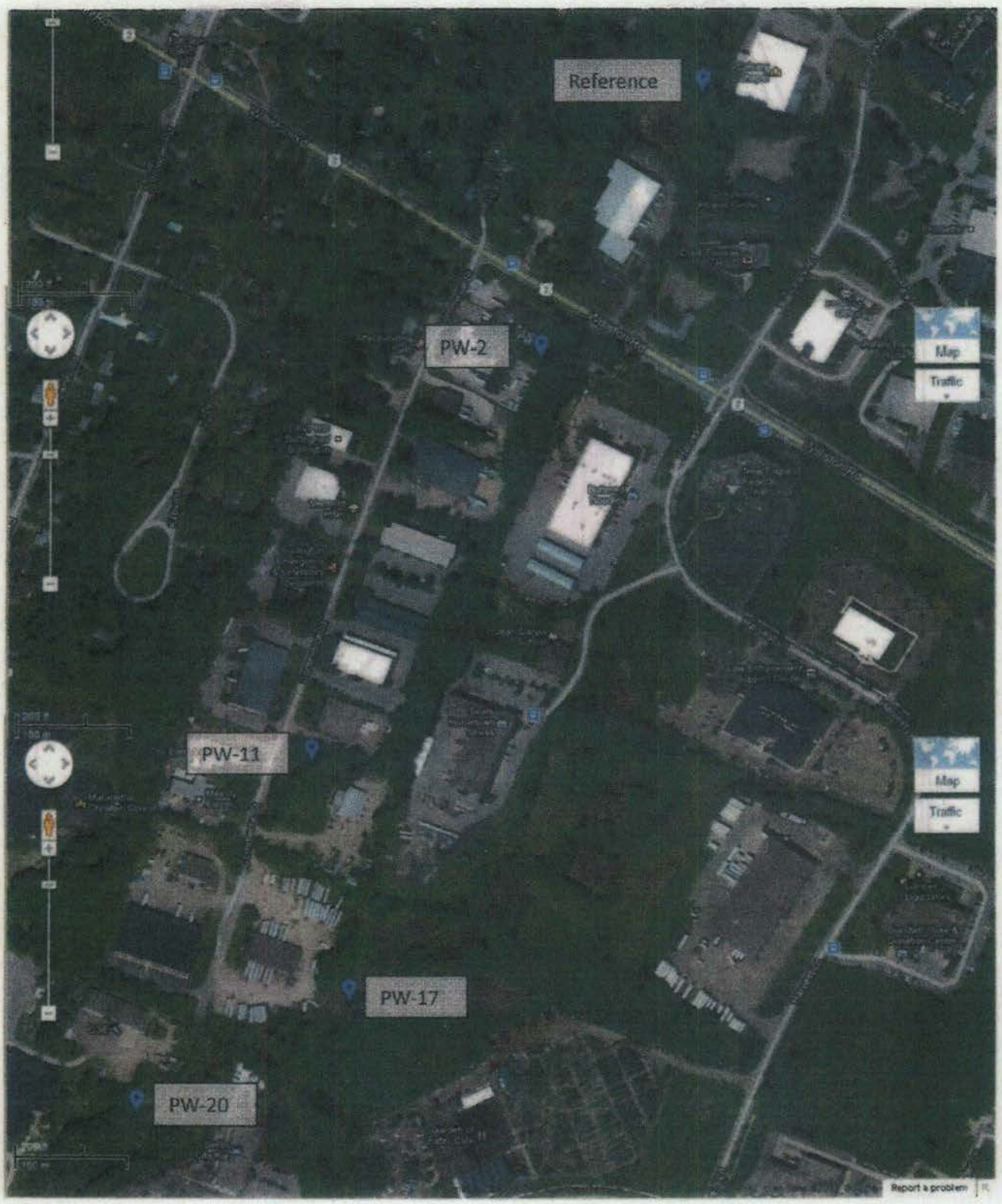


FIGURE 2

Attachment 2. September 2012 sampling locations (as seen on Google maps)
***Note this is a combination of 3 maps placed together to show the full extent of sampling.**



TABLES

Table 1. Physicochemical Results-Surface Water-Commerce St. Superfund Site-September, 2012

Parameter	Units	Control	PW2	PW11	PW17	PW20
Temperature	°C	17.53	16.83	13.4	15.52	12.14
Conductivity	uS/cm	965	916	1004	2475	1916
pH	units	8.21	7.85	7.57	7.58	7.42
Dissolved Oxygen	%	100.9	88.2	76	78.4	73.5
Dissolved Oxygen	mg/L	9.62	8.51	7.92	7.75	7.82

Table 2. Surface Water Results-Commerce St. Superfund Site-September, 2012

		Stations						Benchmarks			
Chemical	Units	Control	PW2	PW11	PW11-Dup	PW17	PW20	EPA R3	EPA R5	NOAA	GLI
Trichloroethylene	ug/L	<1.0	<1.0	15	15	6.0	2.6	21	47	200	260
Vinyl Chloride	ug/L	<1.0	<1.0	3.2	3.4	<1.0	<1.0	930	930	930	930
cis-1,2-Dichloroethylene	ug/L	<1.0	<1.0	38	39	9.2	3.8	590	970	590	620
Bromide	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	NA	NA	NA	NA
Chloride	mg/L	190	190	210	210	620	450	230	NA	NA	NA
Fluoride	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	NA	NA	NA	NA
Nitrate	mg/L	1.3	1.6	1.7	1.3	0.42	0.36	NA	NA	NA	NA
Nitrite	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	NA	NA	NA	NA
Sulfate	mg/L	27	26	24	24	26	24	NA	NA	NA	NA

NA = Not Available

EPA R3 = EPA Region 3 benchmark for fresh surface water (http://www.epa.gov/reg3hscd/risk/eco/btag/sbv/fw/screenbench.htm)

EPA R5 = EPA Region 5 benchmark for fresh surface water (http://www.epa.gov/R5Super/ecology/screeningbench.html)

NOAA= NOAA SQUIRT table (http://archive.orr.noaa.gov/book_shelf/122_NEW-SQuiRTs.pdf)

GLI = Great Lakes Initiative clearinghouse (http://www.epa.gov/gliclearinghouse)

GLI Tier II Chronic value for trichloroethylene from : http://www.epa.gov/gliclearinghouse/pdfs/in_al_471_06262001.pdf

GLI Tier II Chronic value for vinyl chloride from: http://www.epa.gov/gliclearinghouse/pdfs/il_al_432_06202006.pdf

GLI Tier II Chronic value for cis-1, 2-dichloroethylene from: http://www.epa.gov/gliclearinghouse/pdfs/in_al_471_06262001.pdf

Table 3. Sediment Results-Commerce St. Superfund Site-September, 2012

Chemical	Units	Control	PW2	PW11	PW11(DUP)	PW17	PW20	TEC	PEC	MPC
cis-1, 2-Dichloroethene	ug/kg	<110	<54	<63	<54	<80	<52			
Trichloroethene	ug/kg	<110	<54	<63	<54	<80	<52			
Vinyl chloride	ug/kg	<110	<54	<63	<54	<80	<52			
4-Nitrophenol	ug/kg						460			
Aramite	ug/kg						210			
Benzo(a)anthracene	ug/kg						**270**	108	1050	360
Benzo(a)pyrene	ug/kg						**240**	150	1450	2700
Benzo(b)fluoranthene	ug/kg						570			
Benzo(g,h,i)perylene	ug/kg						610			7500
Benzo(k)fluoranthene	ug/kg						540			2400
Bis(2-ethylhexyl)phthalate	ug/kg						250			
Butylbenzylphthalate	ug/kg						300			
Chlorobenzilate	ug/kg						240			
Chrysene	ug/kg						**680**	166	1290	10700
Di-n-octylphthalate	ug/kg						260			
Dibenz(a,h)anthracene	ug/kg						**510**	33		
Fluoranthene	ug/kg	**480**						423	2230	2600
Indeno(1,2,3-cd)pyrene	ug/kg						500			
Pentachlorophenol	ug/kg						860			
Phenacetin	ug/kg						320			
Pyrene	ug/kg	**380**						195	1520	
Total PAHs	ug/kg	860					**3920**	1610	22800	
VOCs	ug/kg									
Aluminum	mg/kg	7400	3900	3700	3300	5800	4100			
Antimony	mg/kg									
Arsenic	mg/kg	3.7		2.1		4.5		9.79	33	
Barium	mg/kg	50	21	12	13	39	17			
Beryllium	mg/kg									
Cadmium	mg/kg							0.99	4.98	
Calcium	mg/kg	2300	1100	1100	1400	1700	1200			
Chromium	mg/kg	15	7.4	9.7	8.6	11	8.9	43.4	111	
Cobalt	mg/kg	5.6	2.4	2.6	3.0	4.1	2.7			

Table 3. Sediment Results-Commerce St. Superfund Site-September, 2012

Chemical	Units	Control	PW2	PW11	PW11(DUP)	PW17	PW20	TEC	PEC	MPC
Copper	mg/kg	13	44	6.0	5.9	13	5.6	31.6	149	
Iron	mg/kg	14000	6600	8800	7800	12000	7300			
Lead	mg/kg	12	4.6		3.5	9.4		35.8	128	
Magnesium	mg/kg	2800	1500	2400	2200	2200	1900			
Manganese	mg/kg	670	80	92	93	170	99			
Nickel	mg/kg	15	7.8	12.0	12	12	9.7	22.7	48.6	
Selenium	mg/kg									
Silver	mg/kg									
Thallium	mg/kg									
Vanadium	mg/kg	15	7.9	7.3	6.5	9.6	6.4			
Zinc	mg/kg	**240**	54	34	33	48	28	121	459	
Mercury	mg/kg	0.034				0.030				
TOC-Rep 1	%	1.81	0.543	0.282	0.243	1.04	0.392			
TOC-Rep 2	%	1.47	0.899	0.306	0.255	1.04	0.349			

Blank cells are nondetects Numbers in bold exceed the TEC

TEC = Threshold Effect Concentration from Macdonald et al (2000)

PEC = Probable Effect Concentration from MacDonald et al (2000)

MPC = Maximum Permisssible Concentration from Kalf et al (1997

Table 4. Vermont Lotic Benthos Field Sheet-Commerce St. Superfund Site-September, 2012

Parameter		Units	Control	PW2	PW11	PW17	PW20
Surrounding Land Use			comm/ind	comm/ind	comm/ind	comm/ind	comm/ind
Embeddedness		%	100 (poor)	100 (poor)	100 (poor)	100 (poor)	100 (poor)
Silt Rating	0=none, 5 = chocolate		1	2	2	4	3
CPOM Rating	0=none, 5=high		1	1	3	0	1
Large woody debris		%/m	2%/14 m	5%/14.6 m	4%/11.3 m	0	<5%
Water type			winder	winder	winder	winder	winder
Channelized?			no	yes	no	no	no
Upstream Dam?			no	no	no	no	no
B.F. Width		m	2.3	2.7	1.8	1.7	2.55
Wetted Width		m	1.7	1.7	1	1.8	2.25
Riffle Depth		m	0.26	0.17	0.2	0.2	0.5
Bank Stability			excellent	very good	excellent	very good	excellent
Velocity Estimate		ft/sec	<0.4	<0.4	<0.4	<0.4	<0.4
Riparian Width	left	m	12	6	>18	>18	>18
	right	m	>18	>18	12	>18	>18
Overstory	softwood	%	0	0	0	0	0
	hardwood	%	40	90	55	0	30
Understory	Shrub	%	0	0	20	0	25
	Grass	%	40	10	0	0	0
	Herb.	%	60	90	80	100	75
Canopy		%	10	90	80	0	40
Overhead			open	partly open	partly open	open	partly open
Air Temp.		°F	ca 70	ca 75	ca 82	ca 75	ca 61
Water Temp.		°C	17.53	16.83	13.4	15.52	12.14
field pH			8.21	7.85	7.57	7.58	7.42
field cond		µS/cm	965	916	1004	2475	1916
D.O.		% sat.	100.9	88.2	76	78.4	73.5
D.O.		mg/l	9.62	8.51	7.92	7.75	7.82
color			clear	clear	clear	clear	slightly milky
pollution			sand/silt trash, iron	sand, silt none	sand, silt oily sheen	sand, silt	sand, silt
water clarity			clear	clear	clear	clear	slightly turbid

Table 4. Vermont Lotic Benthos Field Sheet-Commerce St. Superfund Site-September, 2012

Parameter	Units	Control	PW2	PW11	PW17	PW20
water color		clear	clear	clear	clear	Green Milky
odors		none	none	none	none	none
Biota Observed		odonates snails dace species	crayfish, odonates stickleback	crayfish stickleback	stickleback	small fish, crayfish salamander, clams

Table 5. Rapid Bioassessment Protocol-Physical Characterization/Water Quality Field Data Sheet
Commerce St. Superfund Site-September, 2012

Parameter	Units	Control	PW2	PW11	PW17	PW20
Stream Origin		urban runoff	groundwater urban runoff	groundwater urban runoff	groundwater urban runoff	groundwater urban runoff
Watershed Features		comm./ind.	comm./ind.	comm./ind.	comm./ind.	comm./ind.
NPS Pollution		potential sources	obvious sources	obvious sources	obvious sources	obvious sources
Erosion		none	none	none	none	none
Dominant Riparian Vegetation		trees, grasses, herb.	trees, grasses, herb.	trees, grasses, herb.	grasses, herb.	trees, grasses, herb.
Dominant species		nightshade oak, maple birch jewelweed	none identified (even distribution)	alder, pine ash, birch. jewelweed grasses	cattail jewelweed phragmites loosestrife	alder jewelweed sensitive fern
Reach Length	m	14	14.6	11.3	14	16
Canopy Cover		partly open	partly shaded	partly shaded	partly open	partly shaded
Stream Width	m	1.7	1.7	1	1.8	2.25
High Water Mark	m	overflows to marsh	0.62	0.28	0.45	0.6
Sampling Reach Area	m^2	23.8	24.82	11.3	25.2	36
Area	km^2	0.0238	0.02482	0.0113	0.0252	0.086
Riffle	%	0	0	0	0	0
Run	%	90	90	90	100	80
Pool	%	10.	10	10	0	20
Stream Depth	m	0.26	0.17	0.2	0.2	0.5
Surface Velocity	m/sec	<0.1	<0.1	<0.1	<0.1	<0.1
Channelized?		no	yes	no	no	no
Dam Present?		no (culverts)	no	no	no	no
Large Woody Debris (LWD)	m^2	<.25	1	0.5	0	1
Density of LWD	m^2/km^2	10.5	40	44.25	0	27.8
Dominant Aquatic Vegetation		rooted submergent	none	rooted emergent rooted submergent	rooted submergent	none
Dominant Species Present		various unknown	none	unknown	unknown	none
Portion with aquatic vegetation	%	5	0	10	1	0
Temperature	°C	17.53	16.83	13.4	15.52	12.14
Spec. Cond.	µS/cm	965	916	1004	2475	1916

Table 5. Rapid Bioassessment Protocol-Physical Characterization/Water Quality Field Data Sheet
Commerce St. Superfund Site-September, 2012

Parameter	Units	Control	PW2	PW11	PW17	PW20
D.O.	%	100.9	88.2	76	78.4	73.5
	mg/l	9.62	8.51	7.92	7.75	7.82
pH		8.21	7.85	7.57	7.58	7.42
Water Surface Oils?		none	none	flecks,<.5 m^2	no	none
Turbidity?		clear	clear	clear	clear	milky
Odors?		normal	normal	normal	normal	normal
Deposits?		none	none	none	none	none
Oils?		absent	absent	absent	absent	absent
Sand	%	10	50	65	30	50
Silt	%	45	45	30	60	50
Clay	%	45	5	5	10	0
CPOM composition in area	%	50	40	30	40	20
FPOM composition in area	%	0	0	0	20	0
grey, shell fragments	%	0	0	0	0	0

Table 6. Rapid Bioassessment Protocol-Habitat Assessment Field Datasheet-Low Gradient
Commerce St. Superfund Site-September, 2012

Parameter		Control	PW2	PW11	PW17	PW20
1. Epifaunal Substrate/Available Cover		18	7	17	14	10
2. Pool Substrate Characterization		12	7	13	11	14
3. Pool Variability		7	0	3	2	2
4. Sediment Deposition		18	19	20	20	19
5. Channel Flow Status		19	10	15	17	16
6. Channel Alteration		20	6	19	20	20
7. Channel Sinuosity		14	0	10	14	15
8. Bank Stability	Left Bank	10	8	9	7	9
	Right Bank	10	8	9	7	9
9. Vegetative Protection	Left Bank	10	10	10	10	10
	Right Bank	10	8	9	10	10
10. Riparian Vegetation Zone Width	Left Bank	6	10	10	10	10
	Right Bank	10	2	7	10	10
Total Score		161	95	151	152	154

Form 3-"Rapid Bioassessment Protocols for Use in Streams and Wadeable rivers: Periphyton, Benthic Macroinvertebrates, and Fish", Second Edition

Table 7. Infauna Results-Commerce St. Superfund Site-Sept., 2012

	CONTROL					PW2					PW11									PW17					PW20				
Core Sample Station Location	REP1	REP2	REP3	REP4	AVG	REP1	REP2	REP3	REP4	AVG	REP1	REP1	REP2	REP2	REP3	REP3	REP4	REP4	AVG	REP1	REP2	REP3	REP4	AVG	REP1	REP2	REP3	REP4	AVG
												DUP		DUP		DUP		DUP											
Abundance Measures																													
Corrected Abundance	3.00	5.00	6.00	4.00	4.5	2.00	2.00	7.00	1.00	3.0	1.00	4.00	1.00	19.00	8.00	2.00	1.00	10.00	5.8	17.00	29.00	6.00	1.00	13.3	14.00	10.00	15.00	11.00	12.5
EPT Abundance	0.00	0.00	0.00	1.00	0.3	0.00	1.00	1.00	0.00	0.5	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.1	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
Dominance Measures																													
Dominant Taxon	Tany	Tany	Tany	Ptil		Ench	Phry	Poly	Chry		Phy	Pisi	Chry	Stic	Chry	Pisi	Nata	Stic		Limn	Pisi	Stic	Chir		Pisi	Spha	Stic	Chir	
Dominant Abundance	2.00	3.00	3.00	1.00	2.3	1.00	1.00	3.00	1.00	1.5	1.00	3.00	1.00	12.00	3.00	1.00	1.00	5.00	3.4	8.00	12.00	5.00	1.00	6.5	5.00	6.00	3.00	4.00	4.5
2nd Dominant Taxon	Para	Helo	Chir	Clin		Chry	Cryp	Calop				Phys		Chry	Phys	Calo		Pisi		Pisi	Tubi	Nema			Spha	Tany	Spha	Stic	
2nd Dominant Abundance	1.00	1.00	1.00	1.00	1.0	1.00	1.00	1.00	0.00	0.8	0.00	1.00	0.00	2.00	1.00	1.00	0.00	2.00	0.9	4.00	6.00	1.00	0.00	2.8	3.00	2.00	2.00	3.00	2.5
3rd Dominant Taxon		Erpo	Stic	Cryp				Phry						Nata	Spha			Foss		Chir	Stic				Poly	Pila	Cryp	Tany	
3rd Dominant Abundance	0.00	1.00	1.00	1.00	0.8	0.00	0.00	1.00	0.00	0.3	0.00	0.00	0.00	2.00	1.00	0.00	0.00	1.00	0.5	2.00	5.00	0.00	0.00	1.8	2.00	1.00	2.00	2.00	1.8
% Dominant Taxon	66.67	60.00	50.00	25.00	50.4	50.00	50.00	42.86	100.00	60.7	100.00	75.00	100.00	63.16	37.50	50.00	100.00	50.00	72.0	47.06	41.38	83.33	100.00	67.9	35.71	60.00	20.00	36.36	38.0
% 2 Dominant Taxa	100.00	80.00	66.67	50.00	74.2	100.00	100.00	57.14	100.00	89.3	100.00	100.00	100.00	73.68	50.00	100.00	100.00	70.00	86.7	70.59	62.07	100.00	100.00	83.2	57.14	80.00	33.33	63.64	58.5
% 3 Dominant Taxa	100.00	100.00	83.33	75.00	89.6	100.00	100.00	71.43	100.00	92.9	100.00	100.00	100.00	84.21	62.50	100.00	100.00	80.00	90.8	82.35	79.31	100.00	100.00	90.4	71.43	90.00	46.67	81.82	72.5
Richness Measures										0.0																			
Species Richness	2.00	3.00	4.00	4.00	3.3	2.00	2.00	5.00	1.00	2.5	1.00	2.00	1.00	6.00	6.00	2.00	1.00	5.00	3.0	5.00	7.00	2.00	1.00	3.8	6.00	4.00	10.00	5.00	6.3
EPT Richness	0.00	0.00	0.00	1.00	0.3	0.00	1.00	1.00	0.00	0.5	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.1	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
Ephemeroptera Richness	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
Plecoptera Richness	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
Trichoptera Richness	0.00	0.00	0.00	1.00	0.3	0.00	1.00	1.00	0.00	0.5	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.1	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
Chironomidae Richness	2.00	1.00	4.00	2.00	2.3	0.00	1.00	3.00	0.00	1.0	0.00	0.00	0.00	2.00	0.00	0.00	1.00	1.00	0.5	3.00	3.00	1.00	1.00	2.0	4.00	2.00	7.00	4.00	4.3
Oligochaeta Richness	0.00	0.00	0.00	0.00	0.0	1.00	0.00	0.00	0.00	0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	1.00	1.00	0.00	0.00	0.5	0.00	0.00	2.00	0.00	0.5
Non-Chiro. Non-Olig. Richness	0.00	2.00	0.00	2.00	1.0	1.00	1.00	2.00	1.00	1.3	1.00	2.00	1.00	4.00	6.00	2.00	0.00	4.00	2.5	1.00	3.00	1.00	0.00	1.3	2.00	2.00	1.00	1.00	1.5
Rhyacophila Richness	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
Community Composition										0.0																			
% Ephemeroptera	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Plecoptera	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Trichoptera	0.00	0.00	0.00	25.00	6.3	0.00	50.00	14.29	0.00	16.1	0.00	0.00	0.00	5.26	0.00	0.00	0.00	0.00	0.7	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% EPT	0.00	0.00	0.00	25.00	6.3	0.00	50.00	14.29	0.00	16.1	0.00	0.00	0.00	5.26	0.00	0.00	0.00	0.00	0.7	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Coleoptera	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Diptera	100.00	60.00	100.00	50.00	77.5	50.00	50.00	71.43	100.00	67.9	0.00	0.00	100.00	84.21	50.00	0.00	100.00	60.00	49.3	29.41	27.59	83.33	100.00	60.1	42.86	40.00	73.33	90.91	61.8
% Oligochaeta	0.00	0.00	0.00	0.00	0.0	50.00	0.00	0.00	0.00	12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	47.06	20.69	0.00	0.00	16.9	0.00	0.00	13.33	0.00	3.3
% Baetidae	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Brachycentridae	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Chironomidae	100.00	60.00	100.00	50.00	77.5	0.00	50.00	71.43	0.00	30.4	0.00	0.00	0.00	73.68	0.00	0.00	100.00	50.00	28.0	29.41	27.59	83.33	100.00	60.1	42.86	30.00	73.33	90.91	59.3
% Ephemerellidae	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Hydropsychidae	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Odonata	0.00	0.00	0.00	0.00	0.0	0.00	0.00	14.29	0.00	3.6	0.00	0.00	0.00	0.00	12.50	50.00	0.00	10.00	9.1	0.00	3.45	0.00	0.00	0.9	0.00	0.00	0.00	0.00	0.0
% Perlidae	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Pteronarcyidae	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Simuliidae	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
Functional Group Composition										0.0																			
% Filterers	66.67	60.00	50.00	0.00	44.2	0.00	0.00	0.00	0.00	0.0	0.00	75.00	0.00	5.26	12.50	50.00	0.00	20.00	20.3	23.53	48.28	0.00	0.00	18.0	64.29	80.00	33.33	27.27	51.2
% Gatherers	33.33	0.00	50.00	0.00	20.8	50.00	0.00	28.57	0.00	19.6	0.00	0.00	0.00	63.16	0.00	0.00	0.00	50.00	14.1	76.47	37.93	83.33	100.00	74.4	14.29	10.00	46.67	63.64	33.7
% Predators	0.00	40.00	0.00	100.00	35.0	50.00	50.00	14.29	100.00	53.6	0.00	0.00	100.00	26.32	75.00	50.00	100.00	20.00	46.4	0.00	13.79	16.67	0.00	7.6	7.14	10.00	13.33	9.09	9.9
% Scrapers	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	100.00	25.00	0.00	5.26	12.50	0.00	0.00	10.00	19.1	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Shredders	0.00	0.00	0.00	0.00	0.0	0.00	50.00	57.14	0.00	26.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	14.29	0.00	6.67	0.00	5.2
% Piercer-Herbivores	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Unclassified	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
Filterer Richness	1.00	1.00	1.00	0.00	0.8	0.00	0.00	0.00	0.00	0.0	0.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	0.6	1.00	2.00	0.00	0.00	0.8	3.00	2.00	3.00	2.00	2.5
Gatherer Richness	1.00	0.00	3.00	0.00	1.0	1.00	0.00	2.00	0.00	0.8	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.3	4.00	2.00	1.00	1.00	2.0	1.00	1.00	5.00	2.00	2.3
Predator Richness	0.00	2.00	0.00	4.00	1.5	1.00	1.00	1.00	1.00	1.0	0.00	0.00	1.00	3.00	4.00	1.00	1.00	2.00	1.5	0.00	3.00	1.00	0.00	1.0	1.00	1.00	1.00	1.00	1.0
Scraper Richness	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	1.00	1.00	0.00	1.00	1.00	0.00	0.00	1.00	0.6	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
Shredder Richness	0.00	0.00	0.00	0.00	0.0	0.00	1.00	2.00	0.00	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	1.00	0.00	1.00	0.00	0.5
Piercer-Herbivore Richness	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
Unclassified	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
Diversity/Evenness Measures												DUP		DUP		DUP		DUP											
Shannon-Weaver H' (log 10)	0.28	0.41	0.54	0.60	0.5	0.30	0.30	0.64	0.00	0.3	0.00	0.24	0.00	0.53	0.72	0.30	0.00	0.59	0.3	0.59	0.69	0.20	0.00	0.4	0.71	0.47	0.96	0.64	0.7
Shannon-Weaver H' (log 2)	0.92	1.37	1.79	2.00	1.5	1.00	1.00	2.13	0.00	1.0	0.00	0.81	0.00	1.77	2.41	1.00	0.00	1.96	1.0	1.97	2.30	0.65	0.00	1.2	2.35	1.57	3.19	2.12	2.3

Table 7. Infauna Results-Commerce St. Superfund Site-Sept., 2012

	CONTROL					PW2					PW11									PW17					PW20				
Core Sample Station Location	REP1	REP2	REP3	REP4	AVG	REP1	REP2	REP3	REP4	AVG	REP1	REP1	REP2	REP2	REP3	REP3	REP4	REP4	AVG	REP1	REP2	REP3	REP4	AVG	REP1	REP2	REP3	REP4	AVG
												DUP		DUP		DUP		DUP											
Shannon-Weaver H' (log e)	0.64	0.95	1.24	1.39	1.1	0.69	0.69	1.48	0.00	0.7	0.00	0.56	0.00	1.23	1.67	0.69	0.00	1.36	0.7	1.37	1.60	0.45	0.00	0.9	1.63	1.09	2.21	1.47	1.6
Margalef's Richness	0.91	1.24	1.67	2.16	1.5	1.44	1.44	2.06		1.6		0.72		1.70	2.40	1.44	1.6	1.74	1.6	1.41	1.78	0.56		1.3	1.89	1.30	3.32	1.67	2.0
Pielou's J'	0.92	0.86	0.90	1.00	0.9	1.00	1.00	0.92		1.0		0.81		0.69	0.93	1.00	0.9	0.84	0.9	0.85	0.82	0.65		0.8	0.91	0.79	0.96	0.91	0.9
Simpson's Heterogeneity	0.67	0.70	0.80	1.00	0.8	1.00	1.00	0.86		1.0		0.50		0.60	0.89	1.00	0.7	0.76	0.7	0.74	0.77	0.33		0.6	0.84	0.64	0.94	0.82	0.8
Biotic Indices																													
% Indiv. w/ HBI Value	100.00	80.00	100.00	75.00	88.8	100.00	100.00	100.00	100.00	100.0	100.00	100.00	100.00	100.00	87.50	100.00	100.00	100.00	98.4	100.00	100.00	100.00	100.00	100.0	100.00	100.00	100.00	100.00	100.0
Hilsenhoff Biotic Index	6.00	6.25	7.17	6.67	6.5	7.50	6.00	6.14	5.00	6.2	8.00	6.50	5.00	8.00	6.00	6.00	8.00	7.40	6.9	8.59	7.55	8.33	10.00	8.6	6.57	6.40	7.47	8.45	7.2
% Indiv. w/ MTI Value	100.00	80.00	83.33	25.00	72.1	50.00	50.00	14.29	0.00	28.6	0.00	0.00	0.00	5.26	12.50	0.00	0.00	10.00	3.5	17.65	6.90	16.67	100.00	35.3	7.14	20.00	40.00	72.73	35.0
Metals Tolerance Index	2.67	3.25	3.00	4.00	3.2	1	4.00	2.00		2.3				3.00	3.00			3.00	3.0	4.33	4.00	5.00	4.00	4.3	4.00	3.00	3.50	3.63	3.5
% Indiv. w/ FSBI Value	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
Fine Sediment Biotic Index																													
FSBI - average																													
FSBI - weighted average																													
% Indiv. w/ TPM Value	66.67	60.00	50.00	0.00	44.2	0.00	0.00	42.86	0.00	10.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	21.43	20.00	26.67	18.18	21.6
Temp. Pref. Metric - average	1.00	0.67	0.50		0.7			0.40		0.4															0.83	0.50	0.70	0.40	0.6
TPM - weighted average	2.00	2.00	2.00		2.0			2.00		2.0															2.33	2.00	2.25	2.00	2.1
Karr BIBI Metrics										0.0																			
Long-Lived Taxa Richness	0.00	0.00	0.00	0.00	0.0	0.00	0.00	1.00	0.00	0.3	0.00	1.00	0.00	1.00	2.00	2.00	0.00	2.00	1.0	1.00	3.00	0.00	0.00	1.0	2.00	1.00	1.00	1.00	1.3
Clinger Richness	1.00	1.00	1.00	0.00	0.8	0.00	0.00	0.00	0.00	0.0	1.00	1.00	0.00	1.00	1.00	0.00	0.00	1.00	0.6	0.00	0.00	0.00	0.00	0.0	1.00	1.00	2.00	1.00	1.3
% Clingers	66.67	60.00	50.00	0.00	44.2	0.00	0.00	0.00	0.00	0.0	100.00	25.00	0.00	5.26	12.50	0.00	0.00	10.00	19.1	0.00	0.00	0.00	0.00	0.0	7.14	20.00	20.00	18.18	16.3
Intolerant Taxa Richness	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0
% Tolerant Individuals	0.00	0.00	0.00	0.00	0.0	50.00	0.00	0.00	0.00	12.5	100.00	25.00	0.00	5.26	14.29	0.00	0.00	0.00	18.1	47.06	20.69	0.00	0.00	16.9	0.00	0.00	13.33	0.00	3.3
% Tolerant Taxa	0.00	0.00	50.00	50.00	25.0	50.00	50.00	20.00	0.00	30.0	100.00	50.00	0.00	50.00	16.67	0.00	100.00	20.00	42.1	60.00	57.14	50.00	100.00	66.8	33.33	25.00	50.00	60.00	42.1
Coleoptera Richness	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0

PW2 = near upstream control
PW11= potential impact area
PW 17= near downstream from impact area
PW 20= far downstream from impact area

Table 8. Epifauna Results-Commerce St. Superfund Site-September, 2012

	CONTROL			PW2			PW11					PW17			PW20		
Sweep Sample Station Location	REP1	REP2	AVG	REP1	REP2	AVG	REP1	REP1 DUP	REP2	REP2 DUP	AVG	REP1	REP2	AVG	REP1	REP2	AVG
Abundance Measures																	
Corrected Abundance	438.90	322.00	380.5	96.00	157.00	126.5	143.00	110.00	191.00	75.00	167.0	35.00	95.00	65.0	105.00	410.97	258.0
EPT Abundance	166.25	64.00	115.1	14.00	22.00	18.0	13.00	8.00	8.00	4.00	10.5	4.00	9.00	6.5	44.00	199.50	121.8
Dominance Measures																	
Dominant Taxon	Cheu	Calo		Cheu	Pisi		Calo	Pisi	Pisi	Phys		Phys	Phys		Cheu	Cheu	
Dominant Abundance	143.64	60.00	101.8	13.00	25.00	19.0	27.00	21.00	43.00	13.00	35.0	5.00	30.00	17.5	40.00	188.86	114.4
2nd Dominant Taxon	Calo	Cheu		Calo	Cheu		Pisi	Neop	Calo	Neop		Calo	Pisi		Calo	Spha	
2nd Dominant Abundance	55.86	47.00	51.4	12.00	21.00	16.5	25.00	17.00	21.00	13.00	23.0	5.00	14.00	9.5	12.00	54.53	33.3
3rd Dominant Taxon	Phys	Isch		Physa	Neop		Ptil	Phys	Phys	Pisi		Spha	Isch		Spha	Pisi	
3rd Dominant Abundance	46.55	32.00	39.3	10.00	20.00	15.0	13.00	10.00	17.00	10.00	15.0	4.00	11.00	7.5	9.00	37.24	23.1
% Dominant Taxon	32.73	18.63	25.7	13.54	15.92	14.7	18.88	19.09	22.51	17.33	20.7	14.29	31.58	22.9	38.10	45.95	42.0
% 2 Dominant Taxa	45.45	33.23	39.3	26.04	29.30	27.7	36.36	34.55	33.51	34.67	34.9	28.57	46.32	37.4	49.52	59.22	54.4
% 3 Dominant Taxa	56.06	43.17	49.6	36.46	42.04	39.3	45.45	43.64	42.41	48.00	43.9	40.00	57.89	48.9	58.10	68.28	63.2
Richness Measures																	
Species Richness	34.00	44.00	39.0	26.00	34.00	30.0	29.00	25.00	31.00	25.00	30.0	15.00	15.00	15.0	23.00	37.00	30.0
EPT Richness	3.00	4.00	3.5	2.00	2.00	2.0	1.00	1.00	1.00	1.00	1.0	1.00	1.00	1.0	4.00	3.00	3.5
Ephemeroptera Richness	0.00	1.00	0.5	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0
Plecoptera Richness	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0
Trichoptera Richness	3.00	3.00	3.0	2.00	2.00	2.0	1.00	1.00	1.00	1.00	1.0	1.00	1.00	1.0	4.00	3.00	3.5
Chironomidae Richness	14.00	11.00	12.5	8.00	13.00	10.5	8.00	6.00	7.00	3.00	7.5	1.00	3.00	2.0	6.00	12.00	9.0
Oligochaeta Richness	0.00	0.00	0.0	0.00	0.00	0.0	0.00	1.00	2.00	0.00	1.0	0.00	0.00	0.0	2.00	1.00	1.5
Non-Chiro. Non-Olig. Richness	20.00	33.00	26.5	18.00	21.00	19.5	21.00	18.00	22.00	22.00	21.5	14.00	12.00	13.0	15.00	24.00	19.5
Rhyacophila Richness	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0
Community Composition																	
% Ephemeroptera	0.00	0.31	0.2	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0
% Plecoptera	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0
% Trichoptera	37.88	19.57	28.7	14.58	14.01	14.3	9.09	7.27	4.19	5.33	6.6	11.43	9.47	10.5	41.90	48.54	45.2
% EPT	37.88	19.88	28.9	14.58	14.01	14.3	9.09	7.27	4.19	5.33	6.6	11.43	9.47	10.5	41.90	48.54	45.2
% Coleoptera	0.61	4.35	2.5	11.46	18.47	15.0	3.50	20.00	11.52	26.67	7.5	2.86	10.53	6.7	1.90	1.94	1.9
% Diptera	18.48	18.94	18.7	23.96	23.57	23.8	24.48	15.45	16.75	14.67	20.6	5.71	5.26	5.5	21.90	16.18	19.0
% Oligochaeta	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.91	1.05	0.00	0.5	0.00	0.00	0.0	2.86	1.29	2.1
% Baetidae	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0
% Brachycentridae	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0
% Chironomidae	13.94	13.35	13.6	16.67	18.47	17.6	15.38	5.45	7.85	5.33	11.6	2.86	4.21	3.5	14.29	12.30	13.3

Table 8. Epifauna Results-Commerce St. Superfund Site-September, 2012

	CONTROL			PW2			PW11					PW17			PW20		
Sweep Sample Station Location	REP1	REP2	AVG	REP1	REP2	AVG	REP1	REP1 DUP	REP2	REP2 DUP	AVG	REP1	REP2	AVG	REP1	REP2	AVG
% Ephemerellidae	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0
% Hydropsychidae	34.85	15.22	25.0	13.54	13.38	13.5	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	40.00	46.60	43.3
% Odonata	20.00	42.86	31.4	25.00	14.01	19.5	30.07	12.73	16.75	8.00	23.4	37.14	27.37	32.3	19.05	5.18	12.1
% Perlidae	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0
% Pteronarcyidae	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0
% Simuliidae	0.30	0.00	0.2	0.00	0.64	0.3	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.95	0.65	0.8
Functional Group Composition																	
% Filterers	47.88	18.32	33.1	21.88	32.48	27.2	17.48	20.91	23.04	13.33	20.3	11.43	14.74	13.1	54.29	72.82	63.6
% Gatherers	4.55	4.35	4.5	10.42	11.46	10.9	9.09	8.18	7.33	10.67	8.2	2.86	3.16	3.0	6.67	5.18	5.9
% Predators	31.82	59.01	45.4	41.67	37.58	39.6	58.04	50.00	51.31	41.33	54.7	57.14	46.32	51.7	26.67	14.89	20.8
% Scrapers	11.52	11.18	11.4	13.54	14.01	13.8	11.19	20.00	17.28	25.33	14.2	17.14	31.58	24.4	0.95	2.59	1.8
% Shredders	4.24	5.59	4.9	6.25	0.64	3.4	0.70	0.00	0.00	1.33	0.4	2.86	3.16	3.0	7.62	3.56	5.6
% Piercer-Herbivores	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	2.86	1.05	2.0	0.00	0.00	0.0
% Unclassified	0.00	1.24	0.6	6.25	3.82	5.0	3.50	0.91	1.05	6.67	2.3	5.71	0.00	2.9	3.81	0.97	2.4
Filterer Richness	6.00	4.00	5.0	3.00	4.00	3.5	1.00	3.00	2.00	1.00	1.5	1.00	1.00	1.0	6.00	7.00	6.5
Gatherer Richness	3.00	8.00	5.5	4.00	9.00	6.5	7.00	5.00	9.00	5.00	8.0	1.00	2.00	1.5	5.00	9.00	7.0
Predator Richness	15.00	17.00	16.0	11.00	13.00	12.0	14.00	13.00	16.00	10.00	15.0	7.00	8.00	7.5	7.00	13.00	10.0
Scraper Richness	3.00	6.00	4.5	3.00	5.00	4.0	2.00	3.00	3.00	4.00	2.5	2.00	1.00	1.5	1.00	3.00	2.0
Shredder Richness	7.00	5.00	6.0	2.00	1.00	1.5	1.00	0.00	0.00	1.00	0.5	1.00	2.00	1.5	2.00	3.00	2.5
Piercer-Herbivore Richness	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.0	1.00	1.00	1.0	0.00	0.00	0.0
Unclassified	0.00	3.00	1.5	3.00	2.00	2.5	4.00	1.00	1.00	3.00	2.5	2.00	0.00	1.0	2.00	2.00	2.0
Diversity/Evenness Measures																	
Shannon-Weaver H' (log 10)	1.08	1.25	1.2	1.25	1.27	1.3	1.21	1.18	1.23	1.20	1.2	1.09	0.92	1.0	1.01	0.96	1.0
Shannon-Weaver H' (log 2)	3.60	4.16	3.9	4.16	4.22	4.2	4.02	3.92	4.08	3.99	4.1	3.62	3.06	3.3	3.36	3.19	3.3
Shannon-Weaver H' (log e)	2.50	2.88	2.7	2.88	2.93	2.9	2.78	2.71	2.83	2.76	2.8	2.51	2.12	2.3	2.33	2.21	2.3
Margalef's Richness	5.42	7.45	6.4	5.48	6.53	6.0	5.64	5.11	5.71	5.56	5.7	3.94	3.07	3.5	4.73	5.98	5.4
Pielou's J'	0.71	0.76	0.7	0.88	0.83	0.9	0.83	0.84	0.82	0.86	0.8	0.93	0.78	0.9	0.74	0.61	0.7
Simpson's Heterogeneity	0.85	0.91	0.9	0.94	0.93	0.9	0.91	0.92	0.91	0.92	0.9	0.93	0.84	0.9	0.83	0.76	0.8
Biotic Indices																	
% Indiv. w/ HBI Value	97.27	94.10	95.7	86.46	84.71	85.6	92.31	79.09	81.68	76.00	87.0	91.43	92.63	92.0	94.29	97.73	96.0
Hilsenhoff Biotic Index	5.82	6.02	5.9	5.78	6.05	5.9	6.11	6.39	6.46	6.58	6.3	6.22	6.53	6.4	5.54	5.34	5.4
% Indiv. w/ MTI Value	48.48	37.58	43.0	26.04	39.49	32.8	23.78	18.18	18.85	20.00	21.3	17.14	17.89	17.5	62.86	60.19	61.5
Metals Tolerance Index	4.39	3.83	4.1	4.16	3.87	4.0	3.00	3.25	3.17	3.53	3.1	2.83	3.29	3.1	4.24	4.61	4.4
% Indiv. w/ FSBI Value	33.33	15.84	24.6	13.54	14.01	13.8	1.40	0.00	0.00	0.00	0.7	0.00	1.05	0.5	45.71	49.51	47.6

Table 8. Epifauna Results-Commerce St. Superfund Site-September, 2012

	CONTROL			PW2			PW11					PW17			PW20		
Sweep Sample Station Location	REP1	REP2	AVG	REP1	REP2	AVG	REP1	REP1 DUP	REP2	REP2 DUP	AVG	REP1	REP2	AVG	REP1	REP2	AVG
Fine Sediment Biotic Index	8.00	10.00	9.0	2.00	5.00	3.5	8.00						3.00		8.00	9.00	8.5
FSBI - average	0.24	0.23	0.2	0.08	0.15	0.1	0.28						0.20		0.35	0.24	0.3
FSBI - weighted average	2.02	2.12	2.1	2.00	2.05	2.0	4.00						3.00		2.17	2.05	2.1
% Indiv. w/ TPM Value	41.52	22.36	31.9	22.92	24.20	23.6	4.20	2.73	3.66	5.33	3.9	0.00	1.05	0.5	51.43	57.61	54.5
Temp. Pref. Metric - average	0.71	0.30	0.5	0.38	0.44	0.4	0.10	0.28	0.26	0.20	0.2		0.07		0.91	0.76	0.8
TPM - weighted average	1.27	1.35	1.3	1.45	1.47	1.5	1.83	2.33	2.00	1.50	1.9		1.00		1.41	1.35	1.4
Karr BIBI Metrics																	
Long-Lived Taxa Richness	6.00	7.00	6.5	5.00	5.00	5.0	6.00	4.00	5.00	3.00	5.5	6.00	6.00	6.0	6.00	10.00	8.0
Clinger Richness	8.00	14.00	11.0	8.00	12.00	10.0	5.00	7.00	6.00	8.00	5.5	3.00	3.00	3.0	8.00	13.00	10.5
% Clingers	49.39	30.43	39.9	36.46	33.12	34.8	13.99	27.27	20.94	33.33	17.5	20.00	34.74	27.4	48.57	55.99	52.3
Intolerant Taxa Richness	0.00	0.00	0.0	0.00	0.00	0.0	1.00	0.00	0.00	0.00	0.5	0.00	1.00	0.5	1.00	2.00	1.5
% Tolerant Individuals	10.77	21.45	16.1	16.87	15.79	16.3	17.42	32.18	26.92	40.35	22.2	31.25	46.59	38.9	7.07	2.99	5.0
% Tolerant Taxa	23.53	25.00	24.3	19.23	38.24	28.7	34.48	36.00	32.26	36.00	33.4	20.00	33.33	26.7	21.74	24.32	23.0
Coleoptera Richness	1.00	8.00	4.5	4.00	6.00	5.0	2.00	2.00	4.00	6.00	3.0	1.00	3.00	2.0	2.00	4.00	3.0

Cheu = Cheunatopsyche sp. Calo = Calopteryx sp. Phys = Physa sp. Neop = Neoporus sp.

Pisi = Pisidium sp. Isch = Ischnura sp. Spha = Sphaerium sp. Ptil = Ptilostomis sp.

PW2 = near upstream control PW11= potential impact area PW 17= near downstream from impact area

PW 20= far downstream from impact area

Table 9. Metrics Summary for Macroinvertebrates-Commerce St. Superfund Site-September, 2012

Metric	Epifauna (Sweeps)					Infauna (Cores)				
	Control	PW2	PW11	PW17	PW20	Control	PW2	PW11	PW17	PW20
Corrected Abundance	381	127	167	65	258	4.5	3	10	13.3	12.5
EPT Abundance	115	18	10.5	6.5	121.8	0.3	0.5	0.1	0	0
Species Richness	39	30	30	15	30	3.3	2.5	3	3.8	6.3
EPT Richness	3.5	2	1	1	3.5	0.3	0.5	0.1	0	0
Shannon-Weaver H' (log 10)	1.2	1.3	1.2	1	1	0.5	0.3	0.3	0.4	0.7
Hilsenhoff Biotic Index	5.9	5.9	6.3	6.4	5.4	6.5	6.2	6.9	8.6	7.2
% Tolerant Individuals	16.1	16.3	22.2	38.9	5	0	12.5	18.1	16.9	3.3
% Tolerant Taxa	24.3	28.7	33.4	26.7	23	25	30	42.1	66.8	42.1

Values are the average of 2 to 8 replicates

REF = Off site upstream reference

PW2= On site upstream reference

PW11= site impact area

PW17= near downstream from impact area

PW20 = far downstream from impact area

Table 10. Organic carbon normalized VOCs Concentrations in Sediment-Commerce St. Superfund Site-September, 2012

	Units	Control	PW2	PW11	PW11(DUP)	PW17	PW20	ESB
cis-1, 2-Dichloroethene	ug/kg-sed	< 110	< 54	< 63	< 54	< 80	< 52	
Trichloroethene	ug/kg-sed	< 110	< 54	< 63	< 54	< 80	< 52	
Vinyl chloride	ug/kg-sed	< 110	< 54	< 63	< 54	< 80	< 52	
cis-1, 2-Dichloroethene	ug/g-oc	< 6.7	< 7.5	< 21.4	< 21.7	< 7.7	< 14.0	NA
Trichloroethene	ug/g-oc	< 6.7	< 7.5	< 21.4	< 21.7	< 7.7	< 14.0	650
Vinyl chloride	ug/g-oc	< 6.7	< 7.5	< 21.4	< 21.7	< 7.7	< 14.0	NA
TOC-Replicate 1	%	1.81	0.543	0.282	0.243	1.04	0.392	
TOC-Replicate 2	%	1.47	0.899	0.306	0.255	1.04	0.349	
TOC-average	%	1.64	0.72	0.29	0.25	1.04	0.37	

ug/kg-sed= ug VOC per kg sediment

ug/g oc = microgram VOC per gram organic carbon

TOC = Total Organic Carbon

ESB = Equilibrium Partitioning Sediment Benchmark from Table 3-2 (Burgess et al, 2008)

NA = Not Available

ug VOC/g-oc = (ug VOC/kg-sed)/(%TOC *10)

ATTACHMENT 1

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May 30, 2012

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To: Mr. Bart Hoskins, EPA TOPO
Via: Mr. Louis Macri, ESAT Program Manager

TDF No. 2527 B
Task Order No. 86
Task No. 01

Subject: Document search and review of information and data pertaining to the Commerce Street Plume Superfund Site, Williston, VT; ESAT attendance at a scoping meeting conference call; and preparation of a draft Screening Level Risk Assessment (SLERA).

Dear Mr. Hoskins:

The Environmental Services Assistance Team (ESAT) has completed all tasks requested under Technical Direction Form (TDF) 2527 B. ESAT performed an internet search for documents and data related to the Commerce Street Superfund Site in Williston, VT (the Site). The following three documents were downloaded from the Environmental Protection Agency (EPA) website:

- **Site Investigation Report**. Prepared by HSI GeoTrans, Inc. dated July 25, 2000. This report included Volatile Organic Compound (VOC) data for surface water, pore water, sediment, and groundwater.
- **Corrective Action Feasibility Investigation**. Prepared by GeoTrans, Inc. dated January 29, 2001.
- **Data Summary Report Remedial Investigation Fall/Winter 2008.** This report included Volatile Organic Compounds (VOCs), Semi-volatile Organic Compounds (SVOCs), Polychlorinated Biphenyls (PCBs), and total plus dissolved metals data for groundwater.

The Task Order Project Officer (TOPO) provided a CD from the Remedial Project Manager (RPM) Karen Lumino containing all of the documents available relating to the Site. The documents listed above along with two other documents were included on the CD.

- **2010 Data Summary.** Prepared by Nobis Engineering, Inc. dated June 2011. This report included groundwater data collected from monitoring wells at the Site in 2010.
- **2011 Data Summary.** Prepared by Nobis Engineering, Inc. dated November 2011. This report included groundwater data collected from monitoring wells at the Site in 2011.

After reviewing these documents and the datasets, ESAT determined that enough data were available from the Commerce Street Plume Superfund Site to perform a Screening Level Risk Assessment (SLERA). VOC data for tetrachloroethene (PCE), trichloroethene (TCE) and 1,2 dichloroethene (DCE) in surface water, pore water, and sediment were selected from the Data Summary Report Remedial Investigation (RI) Fall/Winter 2008. Total metals data for groundwater were selected from the Final 2010 Data Summary Report for use in the SLERA. The data from the Data Summary Report RI were selected because they were the only datasets available for surface water, pore water, and sediment even though they are more than ten years old. The total inorganic dataset was selected from the Final 2010 Data Summary Report because it included on-Site monitoring wells located near the unnamed stream which is the habitat of interest to the SLERA. Also, no other metals data were presented in any of the other reports reviewed under the current TDF.

The SLERA determined that risk to aquatic receptors in the unnamed stream is present and warrants further investigation in a Baseline Ecological Risk Assessment (BERA). TCE was identified as the major potential risk driver in surface water and pore water in the unnamed stream. The recommendations to further investigate the potential risk of TCE in surface water and pore water are as follows:

- Perform a benthic survey in the unnamed stream.
- Perform an acute pore water toxicity test.
- Collect pore water and sediment samples for VOC analysis.

ESAT members Stan Pauwels, Michael Ferrier, and Erica Czerepak participated in a scoping meeting conference call on May 7, 2012 along with Karen Lumino (EPA, RPM), Rick Sugatt (EPA, risk assessor) and Nobis/Avitar personnel to discuss plans for sampling and other upcoming tasks related to the Site. ESAT prepared a PowerPoint presentation to summarize the findings of the SLERA and to suggest recommendations for further evaluation. This presentation was discussed during the conference call.

The task was requested by Mr. Hoskins, the Task Order Project Officer (TOPO), and was authorized under TDF No. 2527 B. The final completion date for this TDF is May 30, 2012.

Please do not hesitate to contact Erica Czerepak at (617) 918-8687 or Stan Pauwels at (617) 918-8669 the EPA/OEME Biology Section, North Chelmsford, MA with any questions or comments.

Sincerely,

Erica Czerepak

Erica Czerepak
Staff Consultant
TechLaw, Inc.

DRAFT

Screening-Level Ecological Risk Assessment

Commerce Street Plume Superfund Site
Williston, Vermont

EPA Contract: EP-W-06-017

Prepared for:

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May 2012

Executive Summary

This Screening-Level Ecological Risk Assessment (SLERA) evaluates the potential for ecological risk to aquatic receptors exposed to site-related contaminants from the Commerce Street Plume Superfund Site located in Williston, Vt. The land located on Commerce St., known as the Alling Industrial Park, has had light industrial and commercial tenants since 1946.

A facility leased property on Commerce Street starting in 1979 to manufacture electronic and microwave components. An unknown amount of rinse waters and sludge wastes was discharged into an unlined lagoon. Those wastes contained chromium, cadmium, cyanide, and nickel, plus industrial solvents (particularly perchloroethene [PCE], trichloroethene [TCE] and 1,2-dichloroethene [1,2-DCE]) associated with electroplating operations.

The Vermont Department of Environmental Conservation (VT DEC) identified violations of hazardous waste regulations in March of 1982 due to improper disposal of chromium-contaminated wastes. The Commerce Street Plume Site was placed on the Environmental Protection Agency's National Priorities List (NPL) in April of 2005.

The main habitat of concern to the SLERA is a small, unnamed stream which flows behind the Site and appears to receive runoff from several nearby parking lots. The stream is narrow (2-4 ft wide) and shallow (< 1 ft deep). The substrate is made up of sand and silt, and contains a large amount of leaf litter. The receptors of concern evaluated in the SLERA consist of benthic invertebrates (exposed to bulk sediment and pore water), epibenthic/water column invertebrates (exposed to surface water), and larval stages of amphibians (exposed to surface water).

Much sampling has occurred on-Site and in the unnamed stream. Past efforts consisted of collecting surface water, pore water, sediment, soil, residential indoor air, and groundwater. This SLERA focuses on surface water, pore water, and sediment data collected in 1997 and 1999 from the unnamed stream as part of the Site Investigation, plus groundwater data collected in 2010 as part of on-going monitoring efforts at the Site. The surface water, pore water, and sediment samples were analyzed only for PCE, TCE, and DCE. Groundwater samples collected from wells located in the vicinity of the unnamed stream are included in the SLERA to provide total metals data on the assumption that some of that groundwater recharges the nearby unnamed stream. The pore water data collected in the late 1990's were also compared to a more recent pore water dataset collected in 2010 to see if conditions changed over time.

Steps 1 and 2 of the SLERA compare maximum contaminant levels measured in surface water, pore water, sediment, and groundwater samples to conservative surface water and sediment screening benchmarks. The analytes with maximum concentrations above their benchmarks are retained as preliminary Contaminants of Potential Ecological Concern (COPECs) for further evaluation.

The Step 3.a refinement uses less conservative exposure assumptions based on Central Tendency Exposures (CTEs, represented by arithmetic means) and Reasonable Maximum Exposures (RMEs, represented by 95% Upper Confidence Limits [UCLs], if possible) to identify the final COPECs and refine the risk estimates.

CTEs are calculated for PCE, TCE, and 1,2-DCE in surface water, pore water, and sediment. RMEs cannot be calculated for these three analytes because the available datasets do not provide a Detection Limit (DL) value for non-detected analytes; the DLs are needed to calculate 95% UCLs when non-detects are present. Table ES-1 below shows the chlorinated compounds in surface water, pore water, and sediment from the unnamed stream that are retained as preliminary and final COPECs, along with their risk estimates.

CTEs and RMEs for total metals in ground water are calculated in the Step 3.a refinement for comparison to surface water screening benchmarks. Table ES-2 below shows which metals in groundwater collected at the Site in the vicinity of the unnamed stream are retained as preliminary and

final COPECs, together with their risk estimates. The risk from metals in groundwater evaluated in Steps 1 and 2 of the SLERA do not address local background levels, and are therefore reported as Hazard Quotients (HQs). The risk from metals evaluated in the Step 3.a refinement accounts for those background levels and are therefore reported as Residual Risk (RR = Site HQ – background HQ). The risk for total metals is also evaluated for "undiluted" ground water recharging the unnamed stream, which is assumed to represent pore water, and for ground water diluted by a factor of 10 and 100, which is assumed to represent overlaying surface water under low and high surface flow conditions, respectively.

The SLERA concludes that a potential for ecological risk is present for aquatic receptors in the unnamed stream exposed to TCE and 1,2-DCE in surface water and pore water, but not for sediment (see **Table ES-1**). The 2010 pore water data set confirms that TCE remains a risk driver in pore water and surface water. However, the Step 3.a refinement based on the newer data show that 1,2-DCE is no longer a concern in pore water. The TCE screening-level risk, which is derived from conservative assumptions, should be further investigated in a follow-up baseline ecological risk assessment.

Table ES-1: Summary of potential aquatic risks associated with surface water, pore water, and sediment COPECs

	Steps 1 & 2 of the SLERA						Steps 3.a of the SLERA					
	Surface Water		Pore Water		Sediment		Surface Water		Pore Water		Sediment	
Compounds	COPEC?	HQ	COPEC?	HQ	COPEC?	HQ	COPEC?	HQ	COPEC?	HQ	COPEC?	HQ
PCE	N	--	N	--	N	--	N	--	N	--	N	--
TCE	Y	8.3	Y	21.3	Y	1.4	Y	3.8	Y	8.6	N	--
1,2-DCE	N	--	Y	5.7*	Y	1.4	N	--	Y	1.3*	N	--

* DCE is not retained as a COPEC in pore water based on the results of the 2010 pore water data set presented in the Final 2010 Data Summary Report (June 10, 1011).

The risk associated with exposure to total metals in groundwater is minimal. Five metals (namely, aluminum, chromium, iron, lead, and manganese) have Residual Risk (RR) > 1.0 for conditions expected to exist in sediment pore water without groundwater dilution (see **Table ES-2**). Residual risk is calculated by subtracting background HQs from Site HQs. Of those five metals, aluminum, iron, lead, and manganese are not known to be Site-related and are therefore not further considered. The RR for the remaining metal (namely, chromium) equals 1.4, which barely exceeds unity. This RR also reflects total chromium, which is a worst-case exposure assumption. It is reasonable to expect that the amount of dissolved chromium in groundwater at the Site would be less than total chromium. The dissolved fraction is responsible for toxicity in aquatic receptors. As a result, it is anticipated that the RR for dissolved chromium would be lower than calculated in this SLERA. As such, the metal concentrations in Site groundwater collected next to the unnamed stream are not considered to be a concern to aquatic receptors in that stream.

Table ES-2: Summary of potential aquatic risks associated with metals in groundwater								
	Step 1&2 of the SLERA		Step 3.a of the SLERA					
	no GW dilution[a]		no GW dilution[b]		10X dilution[c]		100X dilution[d]	
Inorganics	COPEC?	HQ	COPEC?	RR	COPEC?	RR	COPEC?	RR
Aluminum	Y	228	Y	56	Y	5.6	N	--
Antimony	N	--	N	--	N	--	N	--
Arsenic	N	--	N	--	N	--	N	--
Barium	Y	1.5	N	--	N	--	N	--
Beryllium	N	--	N	--	N	--	N	--
Cadmium	Y	10	N	--	N	--	N	--
Chromium	Y	4.5	Y	1.4	N	--	N	--
Cobalt	Y	1.0	N	--	N	--	N	--
Copper	Y	6.7	Y	--	N	--	N	--
Iron	Y	54	Y	13	Y	1.3	N	--
Lead	Y	5.5	Y	3.5	N	--	N	--
Manganese	Y	25	Y	6.6	N	--	N	--
Mercury	N	--	N	--	N	--	N	--
Nickel	Y	1.0	N	--	N	--	N	--
Selenium	Y	3.5	N	--	N	--	N	--
Silver	Y	16	N	--	N	--	N	--
Thallium	N	--	N	--	N	--	N	--
Vanadium	Y	2.4	N	--	N	--	N	--
Zinc	N	--	N	--	N	--	N	--

[a] value used to calculate HQ is maximum detected, or 1/2 maximum detection limit, measured in ground water

[b] value used to calculate RR is 95% UCL, or maximum if a UCL could not be calculated, measured in ground water

[c] value used to calculate RR is 95% UCL, or maximum if a UCL could not be calculated, measured in ground water divided by 10

[d] value used to calculate RR is 95% UCL, or maximum if a UCL could not be calculated, measured in ground water divided by 100

COPEC = contaminant of potential ecological concern

GW = ground water

HQ = hazard quotient

RR = residual risk (i.e., Site HQ - background HQ)

SLERA = screening-level ecological risk assessment

UCL = upper confidence limit

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Figure 4: Groundwater sampling locations at Commerce Street Plume Site, Williston, VT

Attachments:

Attachment 1: Screening-Level Surface Water Data Summary, COPEC Selection, and Risk Analysis
Attachment 2: Screening-Level Pore Water Data Summary, COPEC Selection, and Risk Analysis
Attachment 3: Screening-Level Sediment Data Summary, COPEC Selection, and Risk Analysis
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Appendices:

Appendix 1: Raw Data for surface water, pore water, and sediment presented in the Site Investigation Report dated July 25, 2010 and Raw Data for groundwater presented in the Final 2010 Data Summary Report dated June 10, 2011.

Appendix 2: ProUCL Statistical Printouts for inorganic COPECs in groundwater

Appendix 3: Copy of the pore water VOC data summary table from the Final 2010 Data Summary Report, dated June 10, 2011 prepared by Nobis Engineering.

Appendix 4: Commerce Street Plume Site pictures from the March, 2012 Site visit.

Appendix 5: Memorandum prepared by Lockheed Martin (EPA Region 1 Environmental Services Assistance Team [ESAT] contractor) and entitled "Developing Tier I and Tier II Water Quality Criteria for Tetrachloroethylene, Trichloroethylene, Dichloroethylene, and Vinyl chloride", dated January 17, 2003.

List of Acronyms

BERA	baseline ecological risk assessment
BTEX	benzene, toluene, ethylbenzene, and xylene
COPEC	contaminant of potential ecological concern
CTE	Central Tendency Exposure
DCE	dichloroethene
DL	Detection Limit
EPA	environmental protection agency
EPC	exposure point concentration
ESAT	environmental services assistance team
HQ	hazard quotient
ML	Milliliters
NPL	national priorities list
PCE	perchloroethene (tetrachloroethene)
RME	Reasonable Maximum Exposure
ROC	receptor of concern
RR	Residual Risk
SCM	site conceptual model
SLERA	screening-level ecological risk assessment
SMDP	scientific management decision point
TCE	trichloroethene
UCL	Upper Confidence Limit
µg/Kg	Microgram per kilogram
µg/L	Microgram per liter
VOC	volatile organic compound
VTDEC	Vermont Department of Environmental Conservation

SECTION 1: General Introduction

1.1 Scope

This report presents a Screening-Level Ecological Risk Assessment (SLERA) to evaluate the potential risk to aquatic receptors exposed to Site-related contaminants from the Commerce Street Plume Superfund Site located in Williston, VT. The outcome of this process is a refined list of Chemicals of Potential Ecological Concern (COPECs) and their risks to aquatic receptors which may require further evaluation in a future Baseline Ecological Risk Assessment (BERA).

1.2 Screening Ecological Risk Assessment Approach

The following guidance and reference documents were used to prepare this SLERA:

- USEPA. 1997. Ecological Risk Assessment for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final. Environmental Response Team, Edison, NJ. EPA/540/R-97/006
- USEPA. 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F.
- USEPA. 2001. The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments. EPA/540/F-01/014.

USEPA (1997) provides the general framework for planning and conducting a risk assessment investigation. The screening process (Tier 1) consists of two broad steps. The first step in the Tier 2 baseline process, which refines the preliminary COPECs and their risk (Step 3.a), is also included in this SLERA to provide more context to the conservative Tier 1 risk estimates. These steps are described below in further detail.

STEP 1: Screening-level problem formulation and ecological effects evaluation

The screening-level problem formulation includes stressor characterization, identifying ecological Receptors of Concern (ROCs), selecting assessment endpoints and measures of effect, and developing a Site Conceptual Model (SCM).

The Screening-level ecological effects evaluation quantifies the toxicity of Site-related chemicals based on published screening benchmarks.

STEP 2: Screening-level exposure estimate and risk calculation

The screening-level exposure estimate identifies the Exposure Point Concentrations (EPCs) used in the evaluation. The maximum concentrations are selected as the EPCs to which ROCs can be exposed in the affected aquatic habitat.

The screening-level risk calculations use Hazard Quotients (HQs) obtained by dividing the EPCs by their respective screening benchmarks. An analyte is retained as a COPEC under two conditions: (1) the HQ exceeds 1.0, or (2) no screening benchmark is available to calculate an HQ.

STEP 3.a: Refinement of preliminary COPECs

The first step in the Baseline Risk Assessment (BERA) is included in this SLERA as a refinement step before conclusions are made about the potential for ecological risk at a site. Steps 1 and 2 use conservative exposure assumptions (maximum values) which overestimate risk, whereas Step 3.a uses more realistic exposure values (i.e., mean or 95% UCL) to refine the HQs. Section 4 of the SLERA

describes this refinement process. A Residual Risk (RR) evaluation for metals in groundwater and an uncertainty analysis provide context to the screening-level risk characterization.

Steps 1, 2 and 3.a are followed by a Scientific Management Decision Point (SMDP) where the risk assessor, risk managers, and stakeholders reach a consensus on the elements of the risk assessment, including risk management objectives, endpoint selection, and decision criteria before proceeding to the BERA.

1.3 Goals and Objectives

The ecological risk management goals and objectives for this Site are to determine if contamination from past Site-related activities pose a risk to the aquatic community in the unnamed stream. This goal is achieved by evaluating the concentrations of Perchloroethene (PCE), Trichloroethene (TCE) and 1,2-Dichloroethene (1,2-DCE) in surface water, pore water and sediment samples collected from the unnamed stream in 1997 and 1999, plus groundwater data (metals only) collected in 2010 from several groundwater monitoring wells located on-Site next to the unnamed stream. The greater of the maximum detected value or ½ of the highest Detection Limit (DL) for non-detected analytes from these datasets are compared to ecological screening values.

The following objectives are evaluated in this SLERA:

- Identify the presence of Site-related COPECs that may pose a threat to aquatic receptors in the unnamed stream.
- Document the nature and extent of the potential exposure and effects to those receptors.
- Identify COPECs, develop risk estimates, and describe uncertainties.
- Identify the need for a risk management decision to prevent ecological impacts and accomplish the ecological risk management goal.

The purpose of the SLERA is to provide enough information for risk managers to determine the potential for ecological risk and to support a risk management decision for either ending the assessment or continuing with a BERA.

SECTION 2: Step 1 – Screening- Level Problem Formulation and Ecological Effects Evaluation

2.1 NATURE AND EXTENT OF CONTAMINATION

2.1.1 Environmental Setting

The land located on Commerce St. in Williston, VT, known as the Alling Industrial Park, has been used by light industrial and commercial tenants since 1946. Three lots (19-11, 19-12, and 19-2) at the industrial park have been identified as locations of former manufacturing and/or fabrication operations that have released contaminants to the local groundwater table. Lot 19-11 contained a wastewater disposal lagoon and leach field. This lot supported several manufacturing and/or fabrication operations, since at least 1972. Two underground storage tanks removed from Lot 19-12 in 1994 revealed a previous release of Benzene, Toluene, Ethylbenzene, and Xylene (BTEX). Manufacturing operations began at Lot 19-2 in 1947. A disposal pit and an outfall pipe to the unnamed stream have been identified at this lot.

Lot 19-11 was leased in 1979 to a company which manufactured electronic and microwave components. An unknown amount of rinse waters and sludge wastes containing chromium, cadmium, cyanide, nickel, and industrial solvents associated with electroplating operations was discharged into an unlined lagoon. In March of 1982 the Vermont Department of Environmental Conservation (VT DEC) identified violations of hazardous waste regulations due to the improper disposal of chromium-contaminated wastes. The Commerce Street Plume was placed on the Environmental Protection Agencies National Priorities List (NPL) in April of 2005.

2.1.2 Current Site Conditions

The area along Commerce Street is zoned for mixed residential, business, and industrial uses. Commerce Street is mainly industrial/business while nearby roads (Kirby Lane and South Brownell Road) are residential. Commerce Street consists of office buildings along either side of the street with large parking lots and small plots of grass and a few shrubs and trees as landscaping features.

2.1.3 Aquatic Habitat Description

The only aquatic habitat present at the Commerce Street Plume Site is the unnamed stream that runs behind the buildings. This feature is a small drainage stream that flows in a general north to south direction. It is 2-4 ft wide, and < 1 ft deep. It appears that the stream receives runoff from nearby parking lots during rain or snow melt. Water has always been seen flowing through the unnamed stream during past site visits. This observation suggests that it is likely a permanent aquatic feature which receives year-round flow from the watershed further upstream of the Site. The available evidence also suggests that the local groundwater table recharges the stream across from the Site.

The stream substrate consists mainly of leaf litter and soft, mucky sediment. Woody debris derived from the riparian vegetation is scattered throughout the stream. The stream may offer suitable habitat for aquatic invertebrates, as well as marginal breeding habitat for local amphibian populations.

2.2 SITE CONCEPTUAL MODEL

2.2.1 Contaminant Fate and Transport

The available information about the Site was reviewed to determine which fate and transport mechanisms might result in complete exposure pathways to aquatic receptors in the unnamed stream. The goal was to identify the major components of a complete exposure pathway, which consists of the following components:

- Sources of contamination,

- Release and transport mechanisms,
- Contact points and exposure media,
- Routes of entry, and
- Key receptors.

Each component is discussed below.

2.2.1.1 Sources of Contamination

The major contaminant source present at the Site is a former unlined lagoon. Both features, which were created to dispose of liquid waste, are suspected to be the main sources of PCE, TCE, and metals in the local groundwater table. These contaminants are the primary COPECs for the Site.

The VT DEC evaluated metal contamination in groundwater. The Site Investigation Report from July 25, 2000 states that the metals contamination, which consist mainly of cadmium and chromium, is confined to the areas near Lot 19-11 and is not likely to migrate down gradient. The report concluded that metals should not present a risk to surface water. This hypothesis is tested in this SLERA (see further below) and is found to be correct.

2.2.1.2 Release and Transport Mechanisms

The contamination of groundwater at the Site originates from the lagoon and leach field on Lot 19-11. The main transport mechanism is groundwater migrating towards the unnamed stream and recharging into the stream. This migration can result in contaminated sediment, pore water and surface water.

Note that even though this transport mechanism is known to link Site-derived contamination (particularly TCE and 1,2-DCE) to the unnamed stream, it is not known how much of the water flowing in the unnamed stream across from the Site is derived from groundwater recharge versus from sources located further upstream in the watershed.

2.2.1.3 Contact Point and Exposure Media

The unnamed stream running behind the Site represents the potential contact point evaluated in the SLERA. The potential exposure media consist of surface water, pore water, and sediment.

2.2.1.4 Routes of Entry

The main routes of entry for the aquatic receptors in the unnamed stream are as follows:

- Direct contact with surface water, pore water and sediment via dermal and/or gill absorption.
- Ingestion of sediment during feeding.
- Ingestion of contaminated biota.

The SLERA evaluates the complete exposure pathways for the first route of entry (i.e., direct contact).

2.2.1.5 Key Receptors

Benthic invertebrates may live on or in the unnamed stream substrate. Epibenthic and water column invertebrates may live on the stream bottom substrate or in the water column. In addition, local amphibians may use the small pools in the unnamed stream as breeding habitat in the spring. Hence, tadpoles are included as a third aquatic receptor group for evaluation in the SLERA.

The presence of these receptor groups is anticipated in the unnamed stream, but is not confirmed.

2.2.2 Exposure Pathways

Exposure pathways are the means by which COPECs can be transferred from a contaminated medium to the ROCs. The ROCs and exposure pathways evaluated in the SLERA are as follows:

- *Aquatic invertebrates*: direct contact with sediment; direct contact with surface water, and direct contact with pore water. Ingesting sediment and biota are two other exposure pathways not evaluated in this SLERA.

- *Amphibians* (embryo-larval stages only): direct exposure to surface water. Ingesting sediment and biota are two other exposure pathways not evaluated in this SLERA.

The SCM in **Figure 1** shows the potential exposure pathways linking site contaminants to the ROCs in the unnamed stream. The primary exposure pathway is Site-derived groundwater recharging the unnamed stream, resulting in contaminated pore water, sediment and surface water.

2.2.3 Sample Collection

2.2.3.1 Introduction

Past sampling at the Site has consisted of collecting surface water, pore water, sediment, soil, residential indoor air, and ground water. This SLERA focuses specifically on the surface water, pore water, and sediment data collected in 1997 and 1999 as part of the Site Investigation. These sampling efforts only measured PCE, TCE, and DCE in surface water, pore water, and sediment collected from the unnamed stream. Metals were not analyzed in these media.

More recent total metals data from groundwater samples collected from on-Site monitoring wells located near the unnamed stream were also used in the evaluation. Those groundwater data were collected in 2010 as part of on-going monitoring efforts of the contaminated groundwater plume at the Site. The analytical data are used to estimate total metal concentrations in sediment pore water (without dilution) and in the overlying surface water (assuming a 10X and 100X dilution).

2.2.3.2 Surface Water Sampling

Surface water samples were collected in December 1997 and May 1999 as part of a Site investigation. Eight sampling locations were chosen from the surface water data presented in the Site Investigation Report dated July 25, 2000. Samples SW-1, SW-2, SW-3, SW-5, U-Trib-6, U-Trib-7, U-Trib-8, and U-Trib-14 are located in the TCE plume area or just downstream along the unnamed stream (see **Figure 3**). **Table 2 in Appendix 1** of this SLERA summarizes the surface water analytical data for PCE, TCE, and 1,2-DCE.

2.2.3.3 Pore Water Sampling

Pore water samples were collected during the month of May in 1999 using passive diffusion bag samplers embedded in the substrate. These samplers allowed PCE, TCE and 1,2-DCE present in the upwelling groundwater to cross a Volatile Organic Compound (VOC)-permeable membrane before dissolving in the 40 mL of distilled water that filled each bag. The samplers were deployed 6 inches below the streambed of the unnamed stream for three weeks. Previous research had shown that the concentration of VOCs inside passive diffusion bag samplers equilibrates with the VOC concentration in the pore water in less than two weeks.

Fifteen pore water sampling locations were chosen from the pore water data presented in the Site Investigation Report, 2000. Samples RS-01, RS-02, RS-03, RS-04, RS-05, RS-06, RS-07, RS-08, RS-09, RS-10, RS-11, RS-12, RS-13, RS-14, and RS-15 were all located in the unnamed stream within the TCE plume area or downstream from it (see **Figure 3**). The pore water samples collected from several

locations were analyzed by more than one method. The maximum value from each sample location was chosen among all analysis methods in order to ensure a conservative assessment. **Table 2 in Appendix 1** of this SLERA summarizes the pore water analytical data for PCE, TCE, and 1,2-DCE.

2.2.3.4 Sediment Sampling

Eleven sediment sampling locations were chosen from the sediment data presented in the Site Investigation Report, 2000. Samples RS-01, RS-02, RS-03, RS-04, RS-05, RS-06, RS-07, RS-08, RS-09, RS-10, and RS-11 are all located in the unnamed stream within the TCE plume area or downstream from it (see **Figure 3**). Samples from several sediment sample locations were analyzed by more than one method. The maximum value from each sample location was chosen from all analysis methods. **Table 2 in Appendix 1** of this SLERA summarizes the sediment analytical data for PCE, TCE, and 1,2-DCE.

2.2.3.5 Groundwater Sampling

Twelve monitoring wells (MW-03D, AL-15, BM-03D, BM-03S, MW-04D, MW-05D, MW-05D2, MW-06M, MW-06D, ASI-02D2, ASI-03D2, and MW-07M) at the Site were chosen to obtain total metals data from the 2010 groundwater data set presented in the Final 2010 Data Summary Report, dated June 2011 (see **Figure 4**).

These 12 wells were selected because they intersected the contaminated groundwater plume and were located close to the unnamed stream. The distance from the wells to the stream ranged from 50 ft to 500 ft. Groundwater is retained as a potential exposure medium in this SLERA because none of the surface water, pore water, or sediment samples collected from the unnamed stream are analyzed for metals, even though metals could be present in ground water as a result of past waste disposal practices at the Site. The assumption is that the local groundwater table recharges the unnamed stream. This assumptions appears to be valid because high levels of TCE and 1,2-DCE, which are assumed to originate from the contaminated groundwater plume, are present in sediment, pore water, and surface water from the unnamed stream.

Groundwater sampling took place between May 17th and May 21st, 2010 and between November 28th and December 3rd, 2010. The maximum detected values among the two sampling events are retained for use in the SLERA. The greater of the values is selected if the analysis at one location resulted in a detected and a non-detected value. **Table 1 in Appendix 1** of this SLERA summarizes the groundwater analytical metals data.

2.2.4 Risk management goals and objectives

As defined by U.S. EPA (2001), "a *risk management goal* is a general statement of the desired condition or direction of preference for the entity to be protected. It is often developed independently of the risk assessment process. [...], *management objectives*, while similar to management goals, differ in that they should be specific enough to use when developing assessment endpoints and measures."

The following risk management goal is proposed for this SLERA:

Maintain the quality of sediment, pore water, and surface water in order to support a functioning ecosystem for the aquatic receptors found in the unnamed stream at or down gradient from the Commerce Street Plume Superfund Site.

The management objectives that follow from this proposed management goal are as follows:

- Restore the quality of surface water, pore water and sediment in the unnamed stream receiving contaminated groundwater from the Site to the degree and quality that these media can support viable and self-sustaining populations of aquatic invertebrates and larval amphibians that depend on them for food and shelter.

- Ensure that sources of contamination originating from the Commerce Street Plume Superfund Site are managed so that they are prevented from re-contaminating the unnamed stream in the future.

2.2.5 Assessment Endpoints, Risk questions, and Measurement Endpoints

2.2.5.1 Introduction

Endpoints help quantify the risks to representative receptors that may be exposed to contamination associated with the Site.

Assessment endpoints represent explicit expressions of the key ecological resources to be protected from harm. They generally reflect sensitive populations, communities, or trophic guilds. Four criteria for selecting the assessment endpoints used in the SLERA are listed below. The ecological resource should:

- have relevance,
- be susceptible to the stressors of concern,
- have biological, social, and/or economic value, and
- be relevant to the risk management goals for the site.

By considering these selection criteria, risks identified to one or more of the assessment endpoints will influence the risk management decision process at the Site.

Measurement endpoints represent measurable ecological characteristics, quantified through laboratory or field experimentation, which can be related back to the valued ecological resources chosen as the assessment endpoints. Measurement endpoints are required because it is often not possible to directly quantify risk to an assessment endpoint. The measurement endpoints should represent the same exposure pathway(s) and mechanisms of toxicity as the assessment endpoints in order to be relevant and useful.

Risk questions establish a link between assessment endpoints and their predicted responses when exposed to COPECs. The risk questions should provide a basis to develop the study design and evaluate the results of the site investigation in the analysis phase and during risk characterization (USEPA, 1997).

2.2.5.2 Selecting Representative Assessment Endpoint Species or Communities

It is neither practical nor possible to evaluate the potential for ecological risk to all of the individual parts of the local aquatic ecosystem affected by Site-related chemical releases. Instead, key components are identified to select those species or groups most likely to experience exposure to the stressors.

Benthic invertebrates

Benthic invertebrates form an integral link in all aquatic ecosystems. They play a key role in nutrient and energy transfers within those systems. They also process and assimilate organic material, feed on other invertebrates, and are themselves food for higher trophic-level receptors.

COPECs with the potential to bioaccumulate can be transferred from the sediment into the benthic invertebrate community and up the food chain, thereby harming higher trophic-level receptors. Significant alterations in invertebrate communities could also impact the energy cycling at the base of the aquatic food chain.

The substrate in the unnamed stream should be able to support a diverse benthic invertebrate community. Key benthic invertebrates may include aquatic snails, leeches and oligochaetes and the aquatic life stages of numerous insect species (e.g., midgeflies, blackflies, caddisflies, etc.).

Water column invertebrates

The water column invertebrate community encompasses zooplankton (mostly crustaceans). Key species include diving beetles, copepods, and cladocerans. These types of organisms play a role in energy and nutrient transfer to higher trophic levels and also represent a potential food resource for some juvenile amphibians or benthic invertebrates. The presence of Site-derived chemicals in the surface water could result in direct mortality or decreased reproduction in water column invertebrates.

Amphibians

Amphibians are a key receptor group of concern. Amphibian populations are generally considered to be in broad decline in the U.S. due to habitat loss and environmental degradation. The contaminant levels in the unnamed stream should be such that amphibian eggs and larvae can survive and develop normally in order to maintain the local amphibian populations.

2.2.5.3 Endpoint selection

Assessment endpoints and risk questions:

The following assessment endpoints are used to evaluate the potential for ecological risks to the targeted aquatic receptors in the unnamed stream. A risk question is appended to each assessment endpoint.

It is assumed that by evaluating and protecting these assessment endpoints, all other aquatic receptors in the unnamed stream would be protected as well.

- **A stable and healthy benthic invertebrate community**: *Are the COPEC levels in sediment and pore water high enough to cause biologically-significant changes or impair the function of the benthic invertebrate community in the unnamed stream across from the Site?*

- **A stable and healthy water column invertebrate community**: *Are the COPEC levels in surface water high enough to cause biologically-significant changes or impair the function of the water column invertebrate community in the unnamed stream across from the Site?*

- **Stable and healthy amphibian populations**: *Are the COPEC levels in surface water high enough to cause biologically-significant changes or impair the function of the amphibian populations who may use the unnamed stream as breeding habitat?*

Measurement endpoints:

A stable and healthy benthic invertebrate community: *Are the COPEC levels in sediment and pore water high enough to cause biologically-significant changes or impair the function of the benthic invertebrate community in the unnamed stream across from the Site?*

Two measurement endpoints are used to assess the potential impacts of sediment and pore water COPECs to this receptor group:

- Compare the COPEC levels measured in bulk sediment samples to conservative sediment screening benchmarks.

- Compare the COPEC levels measured in sediment pore water samples to conservative surface water screening benchmarks.

A stable and healthy water column invertebrate community: *Are the COPEC levels in surface water high enough to cause biologically-significant changes or impair the function of the water column invertebrate community in the unnamed stream across from the Site?*

One measurement endpoint is used to assess the potential impacts of surface water COPECs to this receptor group:

- Compare COPEC levels measured in surface water samples to conservative surface water screening benchmarks.

Stable and healthy amphibian populations: *Are the COPEC levels in surface water high enough to cause biologically-significant changes or impair the function of the amphibian populations which may use the unnamed stream across from the Site as breeding habitat?*

One measurement endpoint is used to assess the potential impacts of COPECs to this receptor group:

- Compare the COPEC levels measured in surface water samples to conservative surface water screening benchmarks.

2.3 ECOLOGICAL EFFECTS EVALUATION

2.3.1 Introduction

The ecological effects evaluation for this SLERA uses contaminant-specific screening benchmarks developed by EPA or published in literature. These values represent contaminant levels which, if not exceeded, are not expected to cause long-term harm to ecological receptors.

The sources of those benchmarks are discussed below.

2.3.2 Surface water and pore water screening benchmarks

The surface water and pore water data sets available for use in the SLERA provide analytical data only for PCE, TCE, and 1,2-DCE. The surface water screening benchmarks used in the evaluation for these three chemicals are obtained from EPA (2003).

2.3.3 Sediment screening benchmarks

The sediment data set available for use in the SLERA provide analytical data only for PCE, TCE, and 1,2-DCE. The sediment screening benchmarks used in the evaluation for these three chemicals are obtained from EPA (2003).

2.3.4 Groundwater screening benchmarks

The groundwater data set for metals available for use in the SLERA are compared to surface water screening benchmarks obtained from the following sources (in order of preference) (**Attachment 13**):

- U.S. EPA 2006. National Recommended Water Quality Criteria. Available at http://water.epa.gov/scitech/swguidance/standards/current/index.cfm

- State of Vermont. 2006. Vermont Water Quality Standards.
- U.S. EPA. 1996. ECO Update: Ecotox Thresholds. EPA 540/F-95/038. January, 1996.
- USEPA 2003. Region V Ecological Screening Levels. www.epa.gov/RCRIS-region-5/ca/ESL.pdf
- Buchman, M.F. 1999. Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Coastal Protection Division, NOAA
- Suter, G.W. and C.L. Tsao. 1996 Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory

SECTION 3: STEP 2 SCREENING-LEVEL EXPOSURE ESTIMATES AND RISK CALCULATIONS

3.1 SCREENING-LEVEL EXPOSURE ESTIMATES

The screening-level exposure estimates use the maximum concentration of the analytes detected in surface water, pore water, sediment and groundwater collected in the unnamed stream or from on-Site wells located in the contaminant plume in the vicinity of the unnamed stream.

These values are compared to screening benchmarks to calculate analyte-specific Hazard Quotients (HQs), as follows:

$$HQ = \text{exposure} \div \text{toxicity}$$

Where:

HQ	= hazard quotient
Exposure	= an EPC for a surface water, pore water, sediment, or ground water analyte
Toxicity	= the COPEC-specific screening benchmark

3.2 COPEC SELECTION CRITERIA

COPECs are chemicals present at concentrations that have the potential to affect ecological receptors. COPECs are identified in surface water, pore water, sediment and groundwater by comparing maximum concentrations to conservative screening benchmarks. The following decision criteria are used in this process.

Decision Criterion 1: A chemical is retained as a COPEC if one of the following conditions is met:

- The maximum detected concentration, or ½ of the highest DL for a non-detected analyte, equals or exceeds its screening benchmark (i.e., HQ $\geq$ 1.0).

  Note: (a) the highest metal concentrations (either the maximum detected value or ½ of the highest DL) are selected when multiple groundwater samples are collected at different depths or on different sampling dates from the same monitoring well; (b) the surface water, pore water, and sediment data sets do not provide the DLs for non-detected values of PCE, TCE, or 1,2-DCE. Hence, only the maximum detected values of PCE, TCE, and 1,2-DCE are retained as exposure estimates.

- A chemical is present above its DL but lacks a screening benchmark.

  Note: This criterion was not a concern because screening benchmarks were available for all analytes assessed in this SLERA.

Decision Criterion 2: A chemical is excluded as a COPEC if one of the following conditions is met:

- The maximum concentration falls below the chemical's screening benchmark (HQ <1.0).

- ½ of the highest DL for a non-detected analyte falls below its screening benchmark. This decision criterion only applies to the metals data from the groundwater samples, since DLs are not provided for PCE, TCE, and 1,2-DCE in surface water, pore water, or sediment.

3.3 Screening-Level Risk Analysis

The screening-level risk analysis quantifies by how much the EPC for an analyte exceeds its screening benchmark. The EPCs for PCE, TCE, and 1,2-DCE in sediment, pore water, or surface water are the maximum detected concentrations. The EPCs for metals in groundwater are either the maximum detected concentrations or ½ the highest DLs for non-detected analytes, whichever is higher. The EPCs used in this screening-level risk analysis represent, by definition, "worst case" exposures in the unnamed stream.

3.3.1 Surface Water COPEC Selection and Risk Analysis

Surface water samples were collected from eight sampling locations in the unnamed stream within the TCE plume area or downstream from it.

PCE is not present above its DL at any of the eight sampling locations. PCE is not retained as a surface water COPEC because the data set does not provide the DLs needed to calculate ½ of the highest DL for use as a surrogate EPC.

TCE and 1,2-DCE are present at all eight sampling locations, with maximum detected values of 390 µg/L and 330 µg/L respectively. However, only the TCE EPC exceeds its screening benchmark (47 µg/L), resulting in an HQ of 8.3.

TCE is retained as a surface water COPEC for further evaluation in the Step 3.a refinement because the HQ identifies a potential for risk to the water column invertebrate community and larval stages of amphibians in the unnamed stream. **Attachment 1** presents the surface water data summary, the COPEC selection, and the HQs.

3.3.2 Pore Water COPEC Selection and Risk Analysis

Pore water samples were collected from fifteen sampling locations in the unnamed stream within the TCE plume area or downstream from it.

PCE is not present above its DL at any of the fifteen sampling locations. PCE is not retained as a pore water COPEC because the data set do not provide the DLs needed to calculate ½ of the highest DL for use as a surrogate EPC.

TCE was detected at 5 of the 15 sampling locations, with a maximum EPC of 1,000 µg/L. 1,2-DCE was detected at six of the fifteen sampling locations, with a maximum EPC of 5,500 µg/L. The maximum EPCs for both TCE and 1,2-DCE exceed their screening benchmarks, resulting in HQs of 21 and 5.7, respectively.

Both TCE and 1,2-DCE are retained as pore water COPECs for further evaluation in the Step 3.a refinement because the HQs identify a potential for risk to the benthic invertebrate community in the unnamed stream. **Attachment 2** presents the pore water data summary, the COPEC selection, and the HQs.

3.3.3 Sediment COPEC Selection and Risk Analysis

Sediment samples were collected from 11 sampling locations in the unnamed stream within the TCE plume and downstream from it.

PCE is only detected at one sample location with an EPC (11 µg/kg) which falls below the screening benchmark of 990 µg/Kg. PCE is not retained as a sediment COPEC because the data set do not provide the DLs needed to calculate ½ of the highest DL for use as a surrogate EPC.

TCE is detected at 9 of the 11 sampling locations, with a maximum EPC of 160 µg/Kg. This value exceeds the TCE screening benchmark of 112 µg/kg, resulting in a HQ of 1.4. 1,2-DCE is detected at 7 of the 11 sampling locations, with a maximum EPC of 920 µg/Kg. This value exceeds the 1,2-DCE screening benchmark of 654 µg/Kg, resulting in an HQ of 1.4.

TCE and 1,2-DCE are both retained as sediment COPECs for further evaluation in the Step 3.a refinement because the HQs identify a potential for risk to the benthic invertebrate community in the unnamed stream. **Attachment 3** presents the sediment data summary, the COPEC selection, and the HQs.

3.3.4 Groundwater COPEC Selection and Risk Analysis

Samples were collected from 12 monitoring wells located on-Site within the contaminated groundwater plume in the vicinity of the unnamed stream. The greater of either the maximum detected values or ½ the highest DLs for non-detected analytes are selected as the EPCs for comparison to their respective surface water screening benchmarks.

Aluminum, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, silver, and vanadium all have HQs above 1.0 (see **Attachment 4**). Aluminum exceeds its benchmark by the greatest margin (HQ = 228), followed by iron (HQ = 54) and manganese (HQ = 25). Nickel and cobalt just exceed unity, with HQs of 1.1 and 1.0, respectively. Calcium, magnesium, potassium, and sodium are not retained as COPECs because they are considered physiological electrolytes (US EPA, 2001). The other 13 metals with HQs ≥ 1.0 are retained as COPECs for further evaluation in the Step 3.a refinement.

SECTION 4.0: STEP 3.a REFINEMENT

4.1 INTRODUCTION

The preliminary COPECs identified in Step 2 of the SLERA were obtained using maximum EPCs which likely overestimate the potential risk to the aquatic receptors in the unnamed stream. These preliminary COPECs are re-evaluated below and then refined as the first task of the BERA. No additional data are collected for this purpose, nor are any changes made to the screening benchmarks. Instead, the COPECs are refined using more realistic EPCs. The following approach is used in the Step 3.a refinement:

- Use the arithmetic mean (which represents a CTE) for TCE and 1,2-DCE in surface water, pore water, and sediment instead of the maximum detected values. The 95% UCLs (which represent RMEs) cannot be calculated for these two analytes because their data sets do not include DL values.

- Use the arithmetic mean (which represents a CTE) and the 95% UCL (which represents a RME calculated using Pro UCL software Version 4.1.01) for the inorganic COPECs in groundwater. These values are used in place of the maximum detected values.

4.2 Final COPEC Selection and Risk Analysis

4.2.1 Surface Water

The Step 3.a refinement uses the mean concentration for TCE (the only preliminary surface water COPEC) as a CTE EPC for comparison to its surface water screening benchmark. The mean TCE value (178 µg/L) exceeds the surface water benchmark (47µg/L), resulting in an HQ of 3.8 (see **Attachment 5**).

The HQ for TCE shows a potential for ecological risk to aquatic invertebrates and larval stages of amphibians exposed to surface water in the unnamed stream. It is recommended to further evaluate this COPEC in a BERA.

4.2.2 Pore Water

The Step 3.a refinement uses the mean concentration for TCE and 1,2-DCE as CTE EPCs for comparison to their screening surface water benchmarks. The mean values for TCE (406 µg/L) and 1,2-DCE (1,239 µg/L) both exceed their surface water screening benchmarks (47 µg/L and 970 µg/L, respectively), resulting in HQs of 8.6 and 1.3, respectively (see **Attachment 6**).

The HQs for TCE and 1,2-DCE still show a potential for ecological risk to benthic invertebrates exposed to pore water in the unnamed stream. It is recommended to further evaluate these COPECs in a BERA.

4.2.3 Sediment

The Step 3.a refinement uses the mean concentration for TCE and 1,2-DCE as the CTE EPCs for comparison to their sediment screening benchmarks. The mean values for TCE (42 µg/L) and 1,2-DCE (303 µg/L) both fall below their sediment screening benchmarks (112 µg/L and 654 µg/L, respectively), resulting in HQs < 1.0 (see **Attachment 7**).

The HQs for TCE and 1,2-DCE show that ecological risk is unlikely to benthic invertebrates exposed to bulk sediment in the unnamed stream.

4.2.4 Groundwater

Thirteen metals were selected as preliminary groundwater COPECs in Step 2 of the SLERA. The exposures to these metals are further refined by calculating both arithmetic means (CTE EPCs) and 95% UCLs (RME EPCs) (see **Attachment 8**). These two refined EPCs are then compared to their surface water screening benchmarks.

This evaluation assumes that "undiluted" EPCs reflect pore water conditions from groundwater moving up through the sediment of the unnamed stream (see **Attachment 9**). The 10X and 100X dilutions are assumed to reflect the COPEC levels that might exist after groundwater emerges from the sediment and mixes with surface water in the unnamed stream (see **Attachment 10**).

The results of the refinement of the groundwater COPECs based on "undiluted" EPCs yields ten analytes (aluminum, cadmium, chromium, copper, iron, lead, manganese, selenium, silver, and vanadium) with CTE HQ and RME HQs above 1.0 (see **Attachment 9**). The RMEs and CTEs for cadmium, selenium and silver represent ½ of the highest DL for non-detected values as these three analytes were not present above their DLs at any of the twelve groundwater sampling locations. Selenium and silver are not considered to be Site-related.

The results of the refinement of the groundwater COPECs based on 10X "diluted" EPCs identifies five metals with HQs at or above 1.0, namely aluminum (HQ = 9.2), cadmium (HQ = 1.0), iron (HQ = 3.2), manganese (HQ = 1.4) and silver (HQ = 1.6) (see **Attachment 10**). The HQs for cadmium and silver are based on ½ of the highest DL as these two analytes are not present above their DLs at the twelve ground water sampling locations. Also, the presence of high levels of aluminum, iron, and manganese is not considered to reflect past waste-disposal practices at the Site. The available evidence shows a potential for ecological risk from Site-derived groundwater recharging the unnamed stream and mixing with the surface water. This risk, however, does not appear to be Site-related.

4.3 Residual Risk

Section 4.2 refines the inorganic COPECs in groundwater and recalculates risk using more realistic exposure assumptions, but without accounting for background levels of metals (note: TCE and 1,2-DCE are not considered in this discussion because they are not expected to be present above their DLs in background groundwater). Hence, it is not known how much of the risks presented in **Attachment 9 and 10** reflect Site conditions versus background conditions.

This issue is resolved by calculating a COPEC-specific Residual Risk (RR), as follows:

$$RR = \text{Site HQ} - \text{background HQ}$$

The CTE and RME values for the three background ground water samples (see **Attachment 11**) are subtracted from their corresponding Site CTE and RME values in order to calculate a metal-specific RR (see **Attachment 12**). The CTE and RME RR for aluminum, chromium, iron, lead, and manganese all fell above 1.0. Aluminum had the highest values (CTE = 54, RME = 56), followed by iron (CTE = 8.6 and RME = 13). The CTE RR for copper was also above 1.0 but only slightly (CTE = 1.6 and RME < 1).

High levels of aluminum, iron, and manganese are not considered to reflect past waste-disposal practices at the Site. The RR for lead is based on ½ of the highest DL as lead was not present above the DL at the three background sampling locations. The CTE RR for chromium (1.8), copper (1.6) and lead (1.7) exceed 1.0 but only slightly.

4.4 Uncertainty Analysis

The SLERA described in this report provides a conservative risk evaluation protective of aquatic receptors that may be present in the unnamed stream at the Commerce Street Plume Site. Many

assumptions used in this report deliberately overestimate risk in order to minimize the chances of eliminating an effect if it exists. The major sources of uncertainty are discussed below:

- The surface water and sediment analytical data used in this SLERA represent conditions as they existed around 15 years ago in the unnamed stream. It is not known if those conditions have remained the same, have improved or have worsened since then. This uncertainty could have a major impact on the risk conclusions if conditions have worsened.

- Steps 1 and 2 of the SLERA use the maximum detected values (or ½ of the maximum DLs for non-detected analytes) as EPCs to determine the potential for ecological risk. Using such values can greatly over-estimate risk because maximum concentrations do not represent realistic long-term exposures. The Step 3.a refinement uses more realistic EPCs based on arithmetic mean concentrations (CTE) and 95% UCLs (RMEs). These values are more likely to represent the types of exposures, experienced in the unnamed stream, resulting in decreased uncertainty.

- The ecological receptors selected as ROCs represent generic groups of invertebrates and amphibians that may or may not be present in the unnamed stream. The SLERA assumes that those receptor groups are available for exposure to Site-derived contaminants. The risk conclusions would be partially invalidated if one or more of the ROCs are absent from the unnamed stream and would therefore not be exposed as assumed in the SLERA. This observation represents a major uncertainty.

- Contaminated groundwater from the Site reaches and enters the unnamed stream, but to an unknown degree or extent. It is also uncertain what portion of the groundwater table (shallow, medium depth, or deep) recharges the unnamed stream. Considering these unknowns, the SLERA selected the worst-contaminated groundwater sample from each of the target monitoring wells sampled in spring and/or of fall 2010 to calculate the EPCs. This approach ensured that the worst-case exposure scenario derived from the 2010 ground water data was evaluated, which is conservative. As a result, less uncertainty is associated with the conclusion that the risk to benthic invertebrates exposed to metals in groundwater entering the unnamed stream is small to non-existent.

- The effects evaluation used only screening benchmarks. Such benchmarks are highly conservative and are intended to protect all aquatic receptors. There is therefore little uncertainty that risk is in fact present for those COPECs that were eliminated based on using such screening benchmarks.

- The analytical results for PCE, TCE, and 1,2-DCE presented in the Site Investigation Report (July 25, 2000) do not include the DLs for the non-detect values in the surface water, pore water, and sediment data sets. Hence, not enough information is available to determine if the non-detect values exceeded their respective screening benchmarks. This omission represents an uncertainty which cannot be resolved. The lack of DLs for those three analytes also precluded calculating RMEs based on the 95% UCLs for use in the Step 3.a refinement.

- Cadmium, selenium, and silver were not detected in any of the groundwater samples. The risk calculations for these three metals compares ½ of the highest DLs to the surface water screening benchmarks, which causes these three analytes to be retained as final COPECs in the Step 3.a refinement. Cadmium is known to have been released at the Site, whereas selenium and silver are not. The high DLs for cadmium in groundwater represent an uncertainty because it is possible that cadmium may in fact be present at levels of concern, even though the available data cannot be used to refine this assumption.

- The surface water, pore water, and sediment samples used in the SLERA were collected from the unnamed stream near where the Site-contaminated groundwater plume is believed to recharge the stream, as well as at locations further downstream from this area. The downstream samples

were invariably less contaminated than the samples collected in the contaminated plume recharge area. The CTE EPCs for PCE, TCE, and 1,2-DCE used in the HQ calculations were somewhat "diluted" by including the less contaminated downstream samples in the dataset. Hence, the actual risk experienced by aquatic receptors in the groundwater plume recharge area of the unnamed stream is likely to be higher than anticipated by the risk calculations.

- Only total metal concentrations are available from the ground water samples used in the risk calculations. However, dissolved metals are the fraction most toxic to aquatic receptors. Using total metals to calculate exposures likely overestimates the risk potential of the inorganic COPECs in pore water and surface water of the unnamed stream.

SECTION 5.0: SLERA DISCUSSION AND CONCLUSIONS

5.1 Discussion

5.1.1 Surface Water

The outcome of the Step 2 and Step 3.a risk assessment of surface water identified TCE as a potential risk driver for aquatic receptors in the water column of the unnamed stream (see **Attachment 14**). This conclusion is based on using a conservative surface water screening benchmark for TCE equal to 47 µg/L.

An alternative screening benchmark for TCE was prepared by Lockheed Martin (EPA Region 1 Environmental Services and Assistance Team [ESAT] contractor) using the Tier II approach for calculating surface water quality criteria published by EPA (40 CFR Part 132 - Water Quality Guidance for the Great Lakes System, March 23, 1995). This value, which was derived using data from an extensive literature review, equals 1,000 µg/L. It is provided in a technical memorandum entitled *Developing Tier I and Tier II Water Quality Criteria for Tetrachloroethylene, Trichloroethylene, Dichloroethylene, and Vinyl Chloride*, dated January 17, 2003 (see **Appendix 5**).

Using this alternative TCE surface water screening benchmark in the Step 3.a refinement produces an HQ of 0.2, as compared to 3.8 (calculations not shown). This information suggests that the presence of risk from TCE in the surface water of the unnamed stream depends entirely on which TCE screening benchmark is used in the risk calculation. Using a conservative screening value results in some risk, whereas using a less conservative but still defensible screening value removes all risk. Enough uncertainty remains with this COPEC and exposure pathway to warrant further investigation.

5.1.2 Pore Water

The outcome of the Step 2 and Step 3.a risk assessment of pore water identified TCE and 1,2-DCE as potential risk drivers for benthic invertebrates exposed to pore water in the sediment of the unnamed stream (see **Attachment 14**). This conclusion is based on using conservative surface water screening benchmarks for TCE and 1,2-DCE equal to 47 µg/L and 970 µg/L, respectively.

Lockheed Martin prepared alternative screening benchmarks for TCE (1,000 µg/L) and 1,2-DCE (390 µg/L) (see **Appendix 5**). The Step 3.a HQ for TCE in pore water drops from 8.6 to 0.4 when the alternative TCE surface water screening benchmark of 1,000 µg/L is used (calculation not shown). The alternative benchmark for 1,2-DCE presented in the Lockheed Martin technical memorandum (390 µg/L) is lower and more conservative than the surface water screening benchmark used in the Step 3.a risk calculations and therefore does not further decrease the HQ of 1,2-DCE.

A more recent pore water dataset is provided in the Final 2010 Data Summary Report, dated June 10, 2011 prepared by Nobis Engineering. This dataset includes results for PCE, TCE and DCE from pore water samples collected using semi-permeable membrane bags inserted in sediment at 20 locations along the unnamed stream (see **Appendix 3**). PCE, which was not detected in the 1999 dataset used in the SLERA, was also not detected in any of the samples collected in 2010. TCE, which was detected in 5 of 15 samples in the 1999 dataset (maximum value = 1,000 µg/L) was also detected in 3 of the 20 samples collected in 2010 (maximum value = 1,100 µg/L). The average values for TCE in 1999 (406 µg/L) and 2010 (383 µg/L) are comparable as well. 1,2-DCE, which was detected in 6 of 15 samples in the 1999 dataset (maximum value = 5,500 µg/L), was not detected in any of the 2010 samples. Hence, 1,2-DCE is eliminated as a risk driver in pore water due to its absence from all of the 2010 pore water samples, whereas TCE remains as a COPEC.

The presence of risk from TCE in the pore water of the unnamed stream depends on which TCE toxicity screening value is selected for use in the risk calculations. Using a conservative screening value

results in some risk, whereas using a less conservative (but defensible) screening value removes all risk. Enough uncertainty remains with this COPEC and exposure pathway to warrant further investigation.

5.1.3 Sediment

The outcome of the Step 2 and 3.a risk assessment of sediment at the Site results in no COPECs retained for further evaluation (see **Attachment 14**). TCE and 1,2-DCE are carried into the Step 3.a refinement but both analytes have HQs below 1.0 based on CTE EPCs. This evidence shows a lack of risk to aquatic receptors exposed to sediment in the unnamed stream. No further investigation is required.

5.1.4 Groundwater

The risk associated with exposure to total metals in groundwater is minimal. Five metals (namely, aluminum, chromium, iron, lead, and manganese) have RR > 1.0 for conditions expected to exist in sediment pore water without groundwater dilution (see **Attachment 15**). Of those five metals, aluminum, iron, lead, and manganese are not know to be Site-related and are therefore not further considered. The RR for the remaining metal (namely, chromium) equals 1.4, which barely exceeds unity. This RR also reflects total chromium, which is a worst-case exposure assumption. It is reasonable to expect that the amount of biologically-available dissolved chromium in Site groundwater would be less than total chromium. As a result, it is anticipated that the RR for dissolved chromium would be lower than calculated in this SLERA. As such, the metal concentrations in Site groundwater collected next to the unnamed stream are not considered to be a concern to aquatic receptors in that stream.

5.2 Conclusions and recommendations

This SLERA identifies the potential for ecological risk from exposure to TCE in surface water and pore water of the unnamed stream. No actionable risk is identified for TCE or 1,2-DCE in sediment, or for metals in the Site-contaminated groundwater plume. PCE is not a concern in any of these matrices.

Uncertainty is associated with the conclusion of risk for TCE in surface water and pore water depending on which screening benchmark is used in the evaluation. Based on this uncertainty, it is recommended to consider alternative approaches to determine if the presence of TCE in the surface water and pore water of the unnamed stream represents actionable risk.

Those approaches might include a benthic survey in the general groundwater plume recharge area of the unnamed stream and a 96-hr acute toxicity test in the laboratory using juveniles of the amphipod *Hyalella azteca*, exposed in sealed vials containing pore water and surface water collected in the same general area.

SECTION 6.0 REFERENCES

Buchman, M.F. 1999. Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Coastal Protection Division, NOAA.

Data Summary Report. Remedial Investigation Fall/ Winter 2008. Commerce Street Plume Superfund Site Williston, Vermont. Prepared by Nobis Engineering. June 2009.

Environmental Services Assistance Team (ESAT) memorandum. Developing Tier I and Tier II Water Quality Criteria for Tetrachloroethylene, Trichloroethylene, Dichloroethylene, and Vinyl Chloride. January 17, 2003.

Final 2010 Data Summary Report. Commerce Street Plume Superfund Site Williston, Vermont. Prepared by Nobis Engineering. June 2011.

Site Investigation Report. EPA Site Number VTD-098353545 (Lot 9-11) Prepared by HSI GeoTrans, Inc. July 25, 2000.

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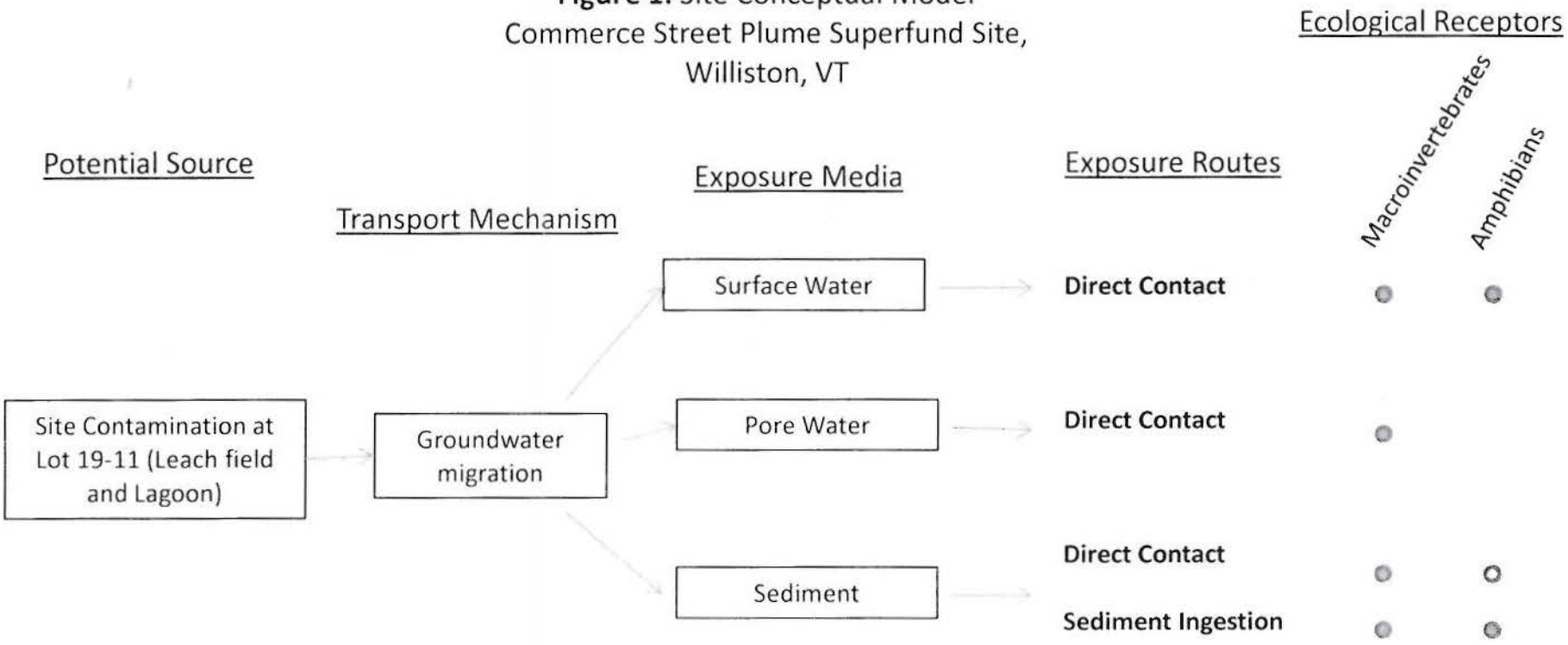
Suter, G.W. and C.L. Tsao. 1996 Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory

Figures

Figure 1: Site Conceptual Model
Commerce Street Plume Superfund Site,
Williston, VT



● = Potentially complete exposure pathway

○ = Potentially minor complete exposure pathway

Blank = incomplete or insignificant exposure pathway

Figure 2: Commerce Street Plume Site (Williston, VT)

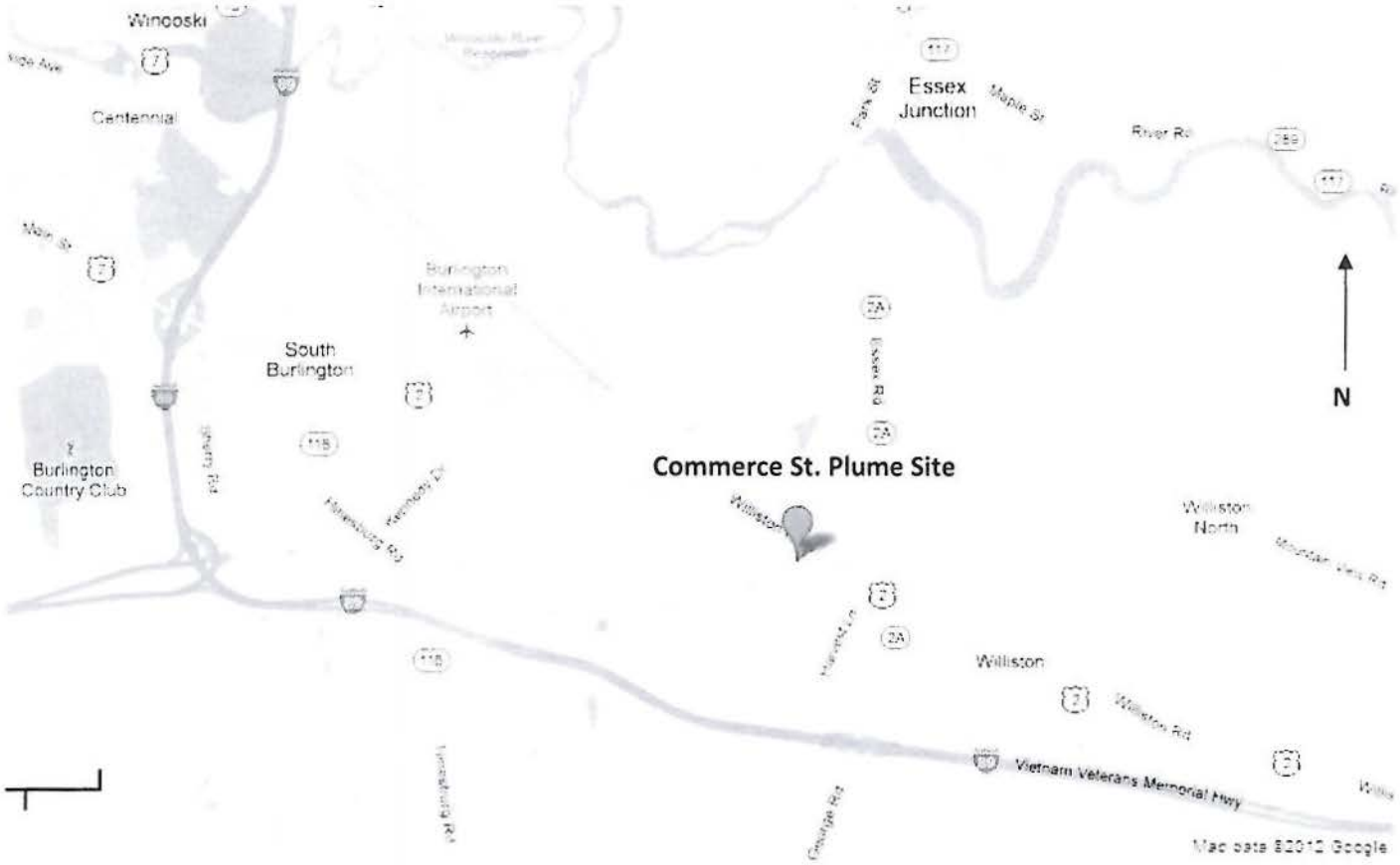


Figure 3: **Surface water, pore water, and sediment sample locations at Commerce Street Plume Site, Williston VT.**

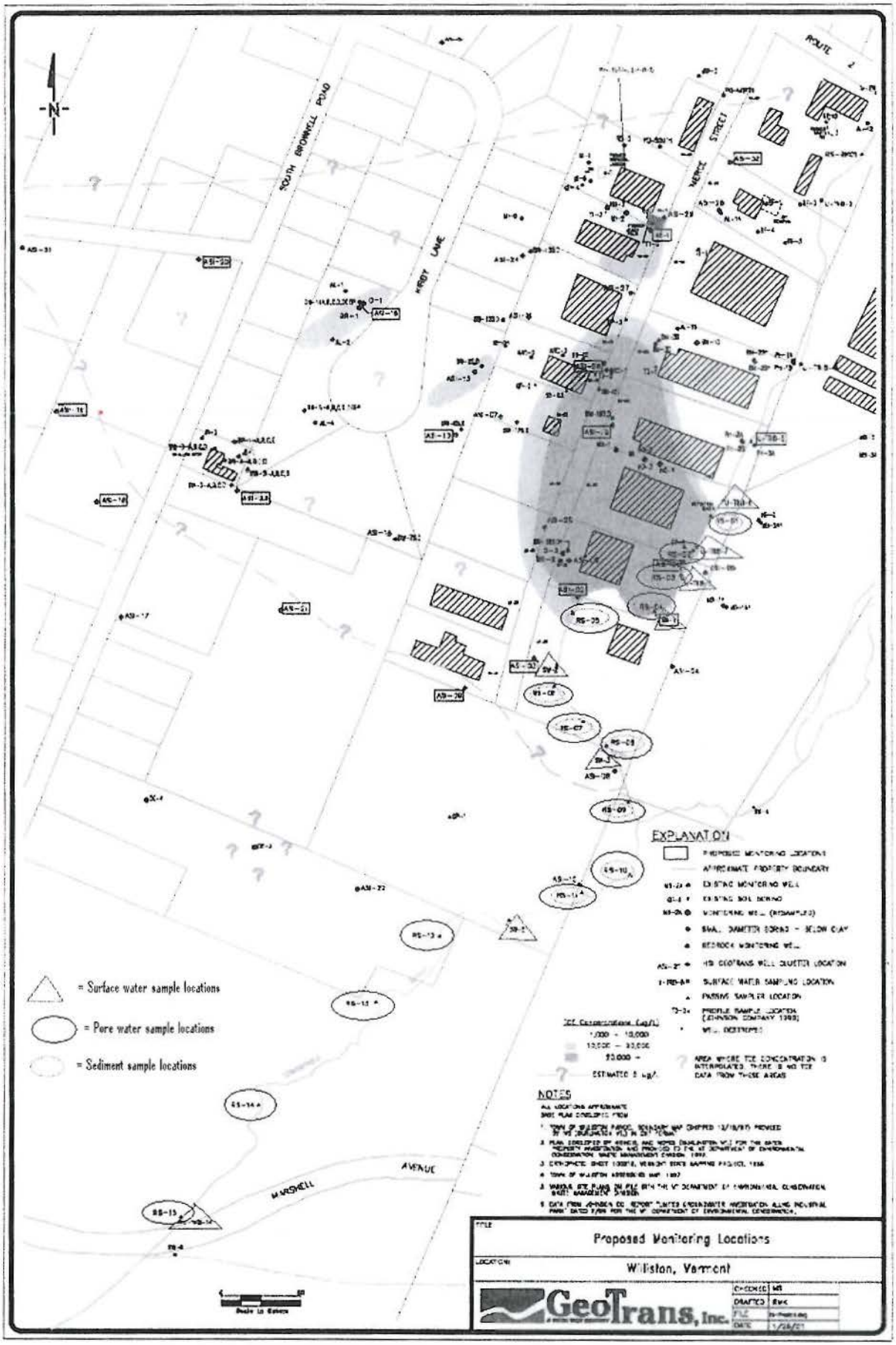
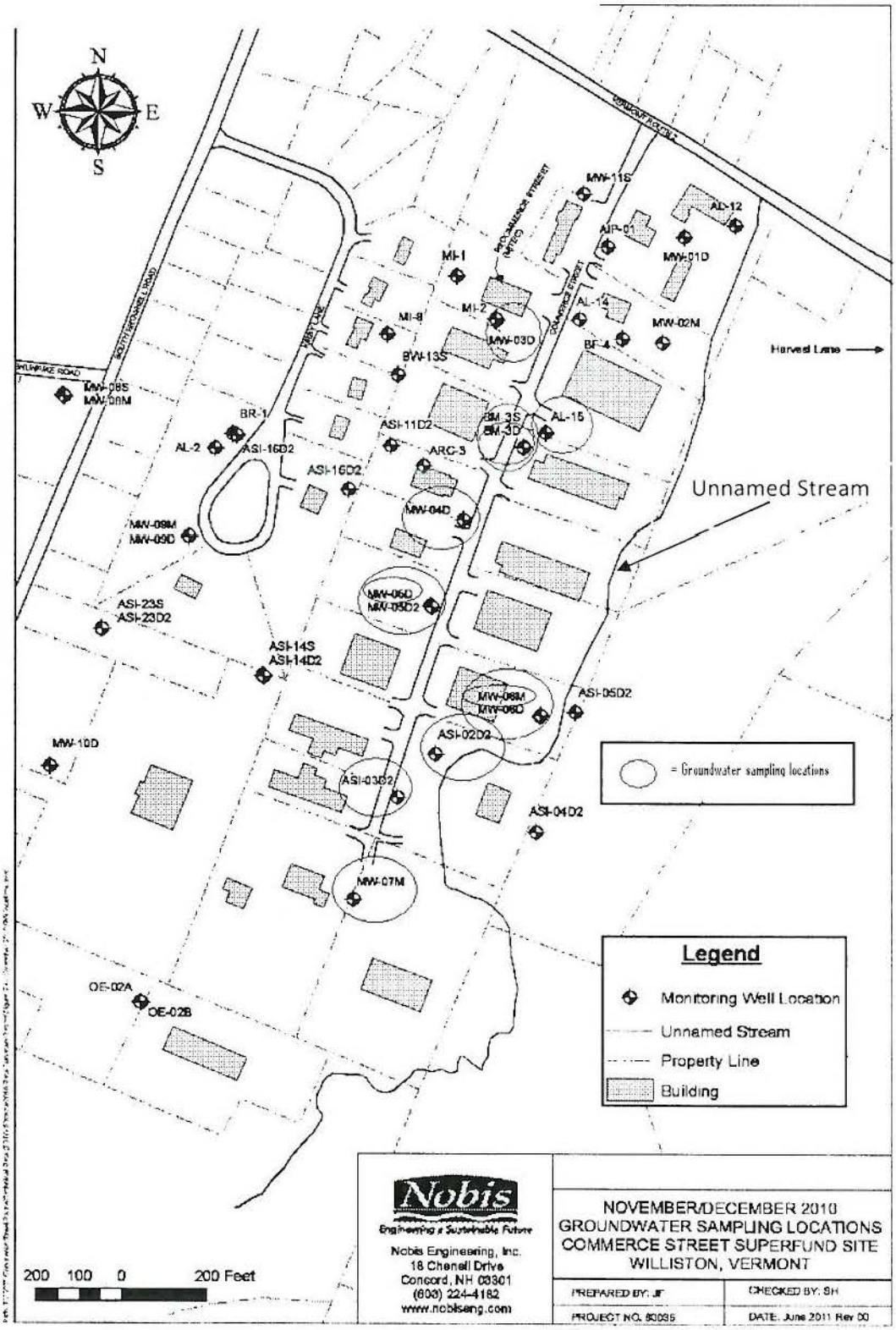


Figure 4: Groundwater sampling locations at Commerce Street Plume Site Williston, VT



Attachments

Attachment 1

Screening-Level Surface Water Data Summary, COPEC Selection, and Risk Analysis

Screening-Level Ecological Risk Assessment

Commerce Street Plume Superfund Site, Williston, VT

Parameters	Units	Frequency of detection +	Minimum detect	Maximum detect	Maximum location	Concentration used for screening	Benchmark (ug/L)	Benchmark source	Hazard Quotient (HQ)	COPEC Y/N	Reason code
Tetrachloroethene (PCE)	ug/L	0 / 8	--	--	--	--	45	(1)	--	N	b
Trichloroethene (TCE)	ug/L	8 / 8	24	390	SW-1	390	47	(1)	**8.3**	**Y**	a
1,2 Dichloroethene (DCE)	ug/L	8 / 8	8	330	U-Trib-8	330	970	(1)	< 1	N	b

-- PCE was not detected in any sample and a detection limit was not provided.

Benchmark source:

(1): U.S. EPA, Region 5 RCRA Ecological Screening Levels, August 22, 2003.

Reason code:

a: The maximum concentration exceeded its benchmark

b: The maximum concentration did not exceed its benchmark

COPEC = chemical of potential ecological concern

+ The samples included in surface water data summary are: U-Trib-6, U-Trib-7, U-Trib-8, SW-1, SW-2, SW-3, SW-5 and U-Trib-14 (See Appendix 1)

Prepared by: EC 4/4/12

QC'd by: BK 4/10/12

Attachment 2

Screening-Level Pore Water Data Summary, COPEC Selection, and Risk Analysis

Screening-Level Ecological Risk Assessment

Commerce Street Plume Superfund Site, Williston, VT

Parameters	Units	Frequency of detection +	Minimum detect	Maximum detect	Maximum detected location	Concentration used for screening	Benchmark (ug/L)	Benchmark source	Hazard Quotient (HQ)	COPEC Y/N	Reason code
Tetrachloroethene (PCE)	ug/L	0 / 15	0	0	--	0	45	(1)	--	N	b
Trichloroethene (TCE)	ug/L	5 / 15	10	1000	RS-05	1000	47	(1)	**21**	**Y**	a
1,2 Dichloroethene (DCE)	ug/L	6 / 15	14	5500	RS-02	5500	970	(1)	**5.7**	**Y**	a

-- PCE was not detected in any sample and detection value was not provided.

Benchmark source:

(1): U.S. EPA, Region 5 RCRA Ecological Screening Levels, August 22, 2003.

Reason code:

a : The maximum concentration exceeded its benchmark

b: The maximum concentration did not exceed its benchmark

+ The samples included in the pore water data summary are RS-01, RS-02, RS-03, RS-04, RS-05, RS-06, RS-07, RS-08, RS-09 RS-10, RS-11, RS-12, RS-13, RS-14, RS-15 (See Appendix 1)

COPEC = chemical of potential ecological concern

Prepared by: EC 4/4/12

QC'd by: BK 4/10/12

Attachment 3

Screening-Level Sediment Data Summary, COPEC Selection, and Risk Analysis

Screening-Level Ecological Risk Assessment

Commerce Street Plume Superfund Site, Williston, VT

Parameters	Units	Frequency of detection +	Minimum detect	Maximum detect	Maximum location	Concentration used for screening	Benchmark (ug/Kg)	Benchmark source	Hazard Quotient (HQ)	COPEC Y/N	Reason code
Tetrachloroethene (PCE)	ug/Kg	1 / 11	11	11	RS-02	11	990	(1)	< 1	N	b
Trichloroethene (TCE)	ug/Kg	9 / 11	3	160	RS-05	160	112	(1)	**1.4**	Y	a
1,2 Dichloroethene (DCE)	ug/Kg	7 / 11	11	920	RS-03	920	654	(1)	**1.4**	Y	a

Benchmark source:

(1): U.S. EPA, Region 5 RCRA Ecological Screening Levels, August 22, 2003.

Reason code:

a: The maximum concentration exceeded its benchmark

b: The maximum concentration did not exceed its benchmark

Prepared by: EC 4/4/12

QC'd by: BK 4/10/12

+ The samples included in the sediment data summary are RS-01, RS-02, RS-03, RS-04, RS-05, RS-06, RS-07, RS-08, RS-09 RS-10, and RS-11, (See Appendix 1).

COPEC = chemical of potential ecological concern

Attachment 4

Screening-Level Groundwater Data Summary, COPEC Selection, and Risk Analysis

Screening-Level Ecological Risk Assessment

Commerce Street Plume Superfund Site, Williston, VT

Parameters	Frequency of detection	Minimum detect	Flag	Maximum detect	Flag	Maximum non-detect *	Maximum detect location	Concentration used for screening +	Benchmark (ug/L)	Benchmark source	Hazard Quotient (HQ)	COPEC Y/N	Reason code
Metals, Total (µg/L)													
Aluminum	9 / 12	121	J	19800		100	MW-07M	19800	87	(1)	**228**	Y	a
Antimony	1 / 12	0.3	J	0.3	J	1	MW-03D	1	80	(4)	0.01	N	b
Arsenic	9 / 12	5.4	J	23.7		5	MW-07M	23.7	150	(1)	0.16	N	b
Barium	12 / 12	27.6	J	324		--	AL-15	324	220	(4)	**1.5**	Y	a
Berryllium	7 / 12	0.079	J	0.37	J	0.5	MW-07M	0.5	3.6	(4)	0.14	N	b
Cadmium	0 / 12	--		--		2.5	--	2.5	0.25	(1)	**10**	Y	a
Calcium	12 / 12	24322		165000		--	ASI-03D2	165000	NA	--	NA	N	d
Chromium (total)	7 / 12	9.3	J	49.9		5	MW-07M	49.9	11	(1)	**4.5**	Y	a
Cobalt	7 / 12	3.9	J	20.2	J	25	MW-07M	25	24	(4)	**1.0**	Y	a
Copper	7 / 12	11.7	J	60.4		12.5	MW-07M	60.4	9.0	(1)	**6.7**	Y	a
Iron	12 / 12	198		53700		--	BM-03D	53700	1000	(1)	**54**	Y	a
Lead	3 / 12	5.9	J	13.8		5	MW-07M	13.8	2.5	(1)	**5.5**	Y	a
Magnesium	12 / 12	7536		33700		--	MW-04D	--	NA	--	NA	N	d
Manganese	12 / 12	85.2		2950		--	MW-06M	2950	120	(6)	**25**	Y	a
Mercury	0 / 12	--		--		0.1	--	0.1	0.77	(1)	0.13	N	b
Nickel	11 / 12	1.3	J	58.5		20	MW-07M	58.5	52	(1)	**1.1**	Y	a
Potassium	12 / 12	802	J	6140		--	MW-05D	--	NA	--	NA	N	d
Selenium	0 / 12	--		--		17.5	--	17.5	5.0	(1)	**3.5**	Y	a
Silver	0 / 12	--		--		5	--	5	0.32	(1)	**16**	Y	a
Sodium	12 / 12	28300		398000		--	ASI-02D2	--	NA	--	NA	N	d
Thallium	3 / 12	0.02	J	0.11	J	0.5	MW-07M	0.5	40	(5)	0.01	N	b
Vanadium	7 / 12	5.4	J	28.9	J	25	MW-07M	28.9	12	(4)	**2.4**	Y	a
Zinc	11 / 12	2.5	J	91.7		30	MW-07M	91.7	120	(1)	0.76	N	b

Source: see Appendix 1 in this SLERA

* Maximum non-detect represents 1/2 the maximum non-detected value

\+ The samples included in the groundwater data summary are MW-03D, AL-15, BM-03D, BM-03S, MW-04D, MW-05D, MW-05D2, MW-06M, MW-06D, ASI-02D2, ASI-03D2, and MW-07M

NA= no benchmark is available

-- Not applicable

Created by: EC 4/3/12

QC'd by: BK 4/10/12

Attachment 4

Screening-Level Groundwater Data Summary, COPEC Selection, and Risk Analysis

Screening-Level Ecological Risk Assessment

Commerce Street Plume Superfund Site, Williston, VT

COPEC = chemical of potential ecological concern

Benchmark source:

1. U.S. EPA 2006. National Recommended Water Quality Criteria: 2006
2. State of Vermont. 2006. Vermont Water Quality Standards
3. U.S. EPA. 1996. ECO Update: Ecotox Thresholds. EPA 540/F-95/038. January, 1996
4. USEPA 2003. Region V Ecological Screening Levels. www.epa.gov/RCRIS-region-5/ca/ESL.pdf
5. Buchman, M.F. 1999. Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Coastal Protection Division, NOAA
6. Suter, G.W. and C.L. Tsao. 1996 Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory

Reason code:

(a) The maximum concentration exceeded its benchmark

(b) The maximum concentration did no exceed its benchmark

(c) No benchmark was available

(d) The compound was a physiological electrolyte, the analyte was not selected as a COC (US EPA, 1995)

Attachment 5

Step 3a Refined Surface Water COPEC Selection and Risk Analysis

Commerce Street Plume Superfund Site, Williston, VT

Parameters	Units	Frequency of detection +	Minimum detect	Maximum detect	Mean	Concentration used for screening	Benchmark (ug/L)	Benchmark source	Hazard Quotient (HQ)	COPEC Y/N	Reason code
Trichloroethene (TCE)	ug/L	8 / 8	24	390	178	178	47	(1)	**3.8**	Y	a

Note: The lack of non-detect values in data report prevented the calculation of 95% UCL values.

Benchmark Source:

(1): U.S. EPA, Region 5 RCRA Ecological Screening Levels, August 22, 2003.

Prepared by: EC 4/4/12

QC'd by: BK 4/10/12

Reason code:

a : The maximum concentration exceeded its benchmark

+ The samples included in surface water data summary are: U-Trib-6, U-Trib-7, U-Trib-8, SW-1, SW-2, SW-3, SW-5 and U-Trib-14 (See Appendix 1)

COPEC = chemical of potential ecological concern

Attachment 6

Step 3a Refined Pore Water COPEC Selection and Risk Analysis

Commerce Street Plume Superfund Site, Williston, VT

Parameters	Units	Frequency of detection +	Minimum detect	Maximum detect	Mean	Concentration used for screening	Benchmark (ug/L)	Benchmark source	Hazard Quotient (HQ)	COPEC Y/N	Reason code
Trichloroethene (TCE)	ug/L	5 / 15	10	1000	406	406	47	(1)	**8.6**	Y	a
1,2 Dichloroethene (DCE)	ug/L	6 / 15	14	5500	1239	1239	970	(1)	**1.3**	Y	a

Note: The lack of non-detect values in data report prevented the calculation of 95% UCL values.

Benchmark source:

(1): U.S. EPA, Region 5 RCRA Ecological Screening Levels, August 22, 2003.

Reason code:

a : The maximum concentration exceeded its benchmark

+ The samples included in the Porewater data summary are RS-01, RS-02, RS-03, RS-04, RS-05, RS-06, RS-07, RS-08, RS-09 RS-10, RS-11, RS-12, RS-13, RS-14, RS-15 (See Appendix 1)

COPEC = chemical of potential ecological concern

Prepared by: EC 4/4/12

QC'd by: BK 4/10/12

Attachment 7

Step 3a Refined Sediment COPEC Selection and Risk Analysis

Commerce Street Plume Superfund Site, Williston, VT

Parameters	Units	Frequency of detection +	Minimum detect	Maximum detect	Mean	Concentration used for screening	Benchmark (ug/Kg)	Benchmark source	Hazard Quotient (HQ)	COPEC Y/N	Reason code
Trichloroethene (TCE)	ug/Kg	9 / 11	3	160	42	42	112	(1)	< 1	N	b
1,2 Dichloroethene (DCE)	ug/Kg	7 / 11	11	920	303	303	654	(1)	< 1	N	b

Note: The lack of non-detect values in data report prevented the calculation of 95% UCL values.

Benchmark source:

(1): U.S. EPA, Region 5 RCRA Ecological Screening Levels, August 22, 2003.

Reason code:

b: The maximum concentration did not exceed its benchmark

+ Samples included in the sediment data summary are RS-01, RS-02, RS-03, RS-04, RS-05, RS-06, RS-07, RS-08, RS-09 RS-10, and RS-11, (See Appendix 1).

COPEC = chemical of potential ecological concern

Prepared by: EC 4/4/12

QC'd by: BK 4/10/12

Attachment 8

Step 3a Refined Groundwater Exposure Point Concentrations

Commerce Street Plume Superfund Site, Williston, VT

COPECs	Frequency of Detection	Arithmetic Mean	Maximum Detect Concentration (qualifier) *	95% UCL of mean[1]			Exposure Point Concentration	
				Values	Distribution	Method	Central Tendency Concentration	Reasonable Maximum Concentration
Metals, Total (µg/L)								
Aluminum	9 / 12	6439	19800	8043	N	95% KM (t)	6439	8043
Barium	12 / 12	104	324	157	G	95% Approx. Gamma	104	157
Cadmium	0 / 12	2.5	2.5	NC	--	--	2.5	2.5
Chromium (total)	7 / 12	28.0	49.9	30.01	N	95% KM (Percentile Bootstrap)	28.0	30.0
Cobalt	7 / 12	9.07	20.2	12.94	N	95% KM (t)	9.07	12.9
Copper	7 / 12	29.5	60.4	31.76	N	95% KM (Percentile Bootstrap)	29.5	31.8
Iron	12 / 12	22889	53700	31980	N	95% Student's-t	22889	31980
Lead	3 / 12	9.33	13.8	13.8	N	95% KM (Percentile Bootstrap)	9.33	13.8
Manganese	12 / 12	1246	2950	1651	N	95% Student's-t	1246	1651
Nickel	11 / 12	22.4	58.5	30	N	95% KM (t)	22.4	30.4
Selenium	0 / 12	17.5	17.5	NC	--	--	17.5	17.5
Silver	0 / 12	5.00	5.0	NC	--	--	5.00	5.00
Vanadium	7 / 12	12.7	28.9 J	15.89	N	95% KM (t)	12.7	15.9

COPECs - Chemicals of Potential Ecological Concern

1 - Statistics were performed using Pro UCL Software version 4.1.01

J - estimated value

95% UCL - Upper Confidence Limit of mean concentration

NC - Not calculated because of a small sample size or small number of detects

Distribution: N- normal, G- Gamma, LN- Lognormal

* - Value represents one half of the maximum non-detect reporting limit (RL), if chemical was not detected.

-- not applicable

Prepared by: EC 4/9/12

QC'd by: BK 4/10/12

Attachment 9

Step 3a Refined Groundwater COPEC Selection and Risk Analysis for pore water

Commerce Street Plume Superfund Site, Williston, VT

Parameters	Frequency of Detection +	Central Tendency Concentration	Reasonable Maximum Concentration	No-Effect Benchmark	Benchmark Source	Central Tendency HQ	Resonable Maximum HQ	COPEC Y/N	Reason Code
Metals, Total (ug/L)									
Aluminum	9 / 12	6439	8043	87	(1)	**74**	**92**	Y	a
Barium	12 / 12	104	157	220	(2)	0.47	0.71	N	b
Cadmium	0 / 12	3	2.5	0.25	(1)	**10**	**10**	Y	a
Chromium (total)	7 / 12	28.0	30.0	11	(1)	**2.5**	**2.7**	Y	a
Cobalt	7 / 12	9.07	12.9	24	(2)	0.38	0.54	N	b
Copper	7 / 12	29.5	31.8	9	(1)	**3.3**	**3.5**	Y	a
Iron	12 / 12	22889	31980	1000	(1)	**23**	**32**	Y	a
Lead	3 / 12	9.33	13.8	2.5	(1)	**3.7**	**5.5**	Y	a
Manganese	12 / 12	1246	1651	120	(3)	**10**	**14**	Y	a
Nickel	11 / 12	22.4	30.4	52	(1)	0.43	0.59	N	b
Selenium	0 / 12	17.5	17.5	5	(1)	**3.5**	**3.5**	Y	a
Silver	0 / 12	5.00	5.00	0.32	(1)	**16**	**16**	Y	a
Vanadium	7 / 12	12.7	15.9	12	(2)	**1.1**	**1.3**	Y	a

Source: see Appendix 1 in this SLERA

Created by: EC 4/10/12

QC'd by: BK 4/10/12

+ The samples included in the groundwater data summary are MW-03D, AL-15, BM-03D, BM-03S, MW-04D, MW-05D, MW-05D2, MW-06M, MW-06D, ASI-02D2, ASI-03D2, and MW-07M

Benchmark Sources:

1. U.S. EPA 2006. National Recommended Water Quality Criteria: 2006
2. USEPA 2003. Region V Ecological Screening Levels. www.epa.gov/RCRIS-region-5/ca/ESL.pdf
3. Suter, G.W. and C.L. Tsao. 1996 Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory

Reason code:

(a) The maximum concentration exceeded its benchmark

(b) The maximum concentration did not exceed its benchmark

Attachment 10

Step 3a COPEC Selection and Risk Analysis for surface water with Dilutions Factors (10 and 100)

Screening-Level Ecological Risk Assessment

Commerce Street Plume Superfund Site, Williston, VT

Parameters	Concentration used for screening *	X 10 dilution	X 100 dilution	Benchmark	Benchmark source	Hazard Quotient (X10)	Hazard Quotient (X100)	COPEC Y/N	Reason code
Metals, Total (µg/L)									
Aluminum	8043	804.3	80.43	87	(1)	**9.2**	< 1	**Y**	a
Barium	157	15.7	1.57	220	(4)	< 1	< 1	N	b
Cadmium	2.50	0.25	0.025	0.25	(1)	**1.0**	< 1	**Y**	a
Chromium (total)	30.0	3.001	0.3001	11	(1)	< 1	< 1	N	b
Cobalt	12.9	1.294	0.1294	24	(4)	< 1	< 1	N	b
Copper	31.8	3.176	0.3176	9	(1)	< 1	< 1	N	b
Iron	31980	3198	319.8	1000	(1)	**3.2**	< 1	**Y**	a
Lead	13.8	1.38	0.138	2.5	(1)	< 1	< 1	N	b
Manganese	1651	165.1	16.51	120	(6)	**1.4**	< 1	**Y**	a
Nickel	30.4	3.043	0.3043	52	(1)	< 1	< 1	N	b
Selenium	17.5	1.75	0.175	5	(1)	< 1	< 1	N	b
Silver	5.00	0.5	0.05	0.32	(1)	**1.6**	< 1	**Y**	a
Vanadium	15.9	1.589	0.1589	12	(4)	< 1	< 1	N	b

* values from groundwater data summary and COPEC selection table (Appendix 1)

HQ = hazard quotient

COPEC= chemical of potential ecological

benchmark sources:

1. U.S. EPA 2006. National Recommended Water Quality Criteria: 2006
2. State of Vermont. 2006. Vermont Water Quality Standards
3. U.S. EPA. 1996. ECO Update: Ecotox Thresholds. EPA 540/F-95/038. January, 1996
4. USEPA 2003. Region V Ecological Screening Levels. www.epa.gov/RCRIS-region-5/ca/ESL.pdf
5. Buchman, M.F. 1999. Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Coastal Protection Division, NOAA
6. Suter, G.W. and C.L. Tsao. 1996 Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory

Created by: EC 4/4/12

QC'd by: BK 4/10/12

Reason code:

(a) The maximum concentration exceeded its benchmark

(b) The maximum concentration did no exceed its benchmark

Attachment 11
Summary of the Background Groundwater Data
Commerce Street Plume Superfund Site, Williston, VT

Parameters	Frequency of Detection+	Maximum Dectected Concentration	Central Tendency Concentration	Reasonable Maximum Concentration*	No-Effect Benchmark	Benchmark Source	Central Tendency HQ	Reasonable Maximum HQ
Metals, Total (µg/L)								
Aluminum	2 / 3	3160	1727	3160	87	(1)	**20**	**36**
Barium	3 / 3	101	66.2	101	220	(2)	< 1	< 1
Cadmium	0 / 3	--	2.5	2.5	0.25	(1)	**10**	**10**
Chromium (total)	2 / 3	14.6	8.43	14.6	11	(1)	< 1	**1.3**
Cobalt	2 / 3	82.2	37.2	82.2	24	(2)	**1.5**	**3.4**
Copper	2 / 3	27.2	15.4	27.2	9	(1)	**1.7**	**3.0**
Iron	3 / 3	19100	14307	19100	1000	(1)	**14**	**19**
Lead	0 / 3	--	5.0	5.0	2.5	(1)	**2.0**	**2.0**
Manganese	3 / 3	864	693	864	120	(3)	**5.8**	**7.2**
Nickel	2 / 3	122	53.1	122	52	(1)	**1.0**	**2.3**
Selenium	0 / 3	--	17.5	17.5	5	(1)	**3.5**	**3.5**
Silver	0 / 3	--	5.0	5.0	0.32	(1)	**16**	**16**
Vanadium	2 / 3	5.5	11.7	25	12	(2)	**1.0**	**2.1**

* Maximum non-detect represents 1/2 the maximum reported non-detect value

+ The samples included in the background groundwater data summary are MW-01D, MW-02M, and AIP-01

-- Not applicable

Created by: EC 4/3/12

QC'd by: BK 5/2/12

Benchmark Sources:

1. U.S. EPA 2006. National Recommended Water Quality Criteria: 2006
2. USEPA 2003. Region V Ecological Screening Levels. www.epa.gov/RCRIS-region-5/ca/ESL.pdf
3. Suter, G.W. and C.L. Tsao. 1996 Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory

Attachment 12

Step 3a Residual Risk for Groundwater

Commerce Street Plume Superfund Site, Williston, VT

	Hazard Quotient				Residual Risk*	
Parameters	Site-CTE	Site-RME	BKGD- CTE	BKGD-RME	CTE	RME
Total Metals (µg/L)						
Aluminum	**74**	**92**	**20**	**36**	**54**	**56**
Barium	0.47	0.71	0.30	0.46	< 1	< 1
Cadmium	**10**	**10**	**10**	**10**	< 1	< 1
Chromium (total)	**2.5**	**2.7**	0.77	**1.3**	**1.8**	**1.4**
Cobalt	0.38	0.54	**1.5**	**3.4**	< 1	< 1
Copper	**3.3**	**3.5**	**1.7**	**3.0**	**1.6**	< 1
Iron	**23**	**32**	**14**	**19**	**8.6**	**13**
Lead	**3.7**	**5.5**	**2**	**2**	**1.7**	**3.5**
Manganese	**10**	**14**	**5.8**	**7.2**	**4.6**	**6.6**
Nickel	0.43	0.59	1.0	**2.3**	< 1	< 1
Selenium	**3.5**	**3.5**	**3.5**	**3.5**	< 1	< 1
Silver	**16**	**16**	**16**	**16**	< 1	< 1
Vanadium	**1.1**	**1.3**	0.97	**2.1**	< 1	< 1

* The residual risk is the site hazard quotient minus the background hazard quotient.

RME- Reasonable Maximum Exposure (the maximum detect or 1/2 the non-detect value)

CTE- Central Tendency Exposure (mean)

BKGD - Background

Created by: EC 4/26/12

QC'd by: BK 5/2/12

Attachment 13: Screening Level Surface Water Benchmarks to Select Groundwater COPECs

Benchmark Type	National Chronic Water Quality Criteria	Average Allowable Conc. (AAC)	Ecotox Threshold (ET)	Ecological Screening Levels (ESLs)	NOAA SQuiRT	Secondary Chronic Values (SCV)
Reference	US EPA (2006)	State of Vermont (2006)	US EPA (1996)	US EPA (2003)	Buchman (1999)	Suter and Tsao (1996)
Preference	1	2	3	4	5	6
Inorganics (ug/L)						
Aluminum	87				87	
Antimony				80	30	30
Arsenic	150	190	190	148	150	
Barium				220		4.0
Beryllium				3.6	5.3	0.66
Cadmium	0.25[a]	1.13[a]	1.0[a]	0.15[b]	2.2[a]	
Chromium (III)	74[a]	207[a]	180[a]	42[b]	74[a]	
Chromium (VI)	11		10		11	
Cobalt				24		23
Copper	9.0[a]	11.8[a]	11[a]	1.58[b]	9.0[a]	
Cyanide	5.2	5.2	5.2	5.2	5.2	
Iron	1000	1000	1000		1000	
Lead	2.5[a]	3.2[a]	2.5[a]	1.17[b]	2.5[a]	
Manganese						120
Mercury (inorg.)	0.77	0.012	1.3	0.0013	0.77	1.3
Mercury (org.)				0.00246		0.0028
Molybdenum						370
Nickel	52[a]	158[a]	160[a]	28.9[b]	52[a]	
Selenium	5.0	5.0	5.0	5.0	5.0	
Silver	0.32[c]			0.12	0.12	0.36
Strontium						1500
Thallium					40	12
Tin				180		73
Vanadium				12		20
Zinc	120	106[a]	100[a]	65.7[b]	120[a]	

[a] value shown is for surface water with calcium carbonate hardness of 100 mg/L

[b] value shown is for surface water with calcium carbonate hardness of 50 mg/L

[c] value shown is the acute water quality criterion divided by 10

Created by: EC 4/3/12

QC'd by: BGK 4/3/12

Data sources for the freshwater benchmarks are as follows:

1. U.S. EPA 2006. National Recommended Water Quality Criteria: 2006
2. State of Vermont. 2006. Vermont Water Quality Standards
3. U.S. EPA. 1996. ECO Update: Ecotox Thresholds. EPA 540/F-95/038. January, 1996
4. USEPA 2003. Region V Ecological Screening Levels. www.epa.gov/RCRIS-region-5/ca/ESL.pdf
5. Buchman, M.F. 1999. Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Coastal Protection Division, NOAA
6. Suter, G.W. and C.L. Tsao. 1996 Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biot 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory

shaded benchmarks are recommended for use in selecting the groundwater COCPECs

Attachment 14: Summary of potential aquatic risks associated with surface water, pore water, and sediment COPECs

	Steps 1 & 2 of the SLERA						Steps 3.a of the SLERA					
	Surface Water		Pore Water		Sediment		Surface Water		Pore Water		Sediment	
Compounds	COPEC?	HQ	COPEC?	HQ	COPEC?	HQ	COPEC?	HQ	COPEC?	HQ	COPEC?	HQ
PCE	N	--	N	--	N	--	N	--	N	--	N	--
TCE	Y	8.3	Y	21.3	Y	1.4	Y	3.8	Y	8.6	N	--
1,2-DCE	N	--	Y	5.7 *	Y	1.4	N	--	Y *	1.3	N	--

* DCE is not retained as a COPEC in pore water based on the results of the 2010 pore water data set presented in the Final 2010 Data Summary Report (June 10, 2011).

Attachment 15: Summary of potential aquatic risks associated with metals in groundwater

	Step 1&2 of the SLERA		Step 3.a of the SLERA					
	no GW dilution[a]		no GW dilution[b]		10X dilution[c]		100X dilution[d]	
Inorganics	COPEC?	HQ	COPEC?	RR	COPEC?	RR	COPEC?	RR
Aluminum	Y	228	Y	56	Y	5.6	N	--
Antimony	N	--	N	--	N	--	N	--
Arsenic	N	--	N	--	N	--	N	--
Barium	Y	1.5	N	--	N	--	N	--
Beryllium	N	--	N	--	N	--	N	--
Cadmium	Y	10	N	--	N	--	N	--
Chromium	Y	4.5	Y	1.4	N	--	N	--
Cobalt	Y	1.0	N	--	N	--	N	--
Copper	Y	6.7	Y	--	N	--	N	--
Iron	Y	54	Y	13	Y	1.3	N	--
Lead	Y	5.5	Y	3.5	N	--	N	--
Manganese	Y	25	Y	6.6	N	--	N	--
Mercury	N	--	N	--	N	--	N	--
Nickel	Y	1.0	N	--	N	--	N	--
Selenium	Y	3.5	N	--	N	--	N	--
Silver	Y	16	N	--	N	--	N	--
Thallium	N	--	N	--	N	--	N	--
Vanadium	Y	2.4	N	--	N	--	N	--
Zinc	N	--	N	--	N	--	N	--

[a] value used to calculate HQ is maximum detected, or 1/2 maximum detection limit, measured in ground water

[b] value used to calculate RR is 95% UCL, or maximum if a UCL could not be calculated, measured in ground water

[c] value used to calculate RR is 95% UCL, or maximum if a UCL could not be calculated, measured in ground water divided by 10

[d] value used to calculate RR is 95% UCL, or maximum if a UCL could not be calculated, measured in ground water divided by 100

COPEC = contaminant of potential ecological concern

GW = ground water

HQ = hazard quotient

RR = residual risk (i.e., Site HQ - background HQ)

SLERA = screening-level ecological risk assessment

UCL = upper confidence limit

Appendices

Appendix 1

Raw Data for surface water, pore water, and sediment
Presented in the Site Investigation Report
Dated July 25, 2000

And

Raw Data for groundwater
Presented in the Final 2010 Data Summary Report
Dated June 10, 2011

Appendix 1

Table 1: 2010 Groundwater Total Metals Concentrations

Commerce Street Plume Superfund Site

Williston, VT

Sample Location:	MW-03D			AL-15			BM-03D			BM-03S			MW-04D			MW-05D			MW-05D2		
Sample Date:	Fall 2010			Spring and Fall 2010			Spring and Fall 2010			Spring and Fall 2010			Fall 2010			Fall 2010			Fall 2010		
Sample Name:	MA3M54			MA2PZ4 & MA3M32			MA2Q12 & MA3M45			MA2Q09 & MA3M46			MA3M55 & MA42Q0			MA3M56			MA3M57		
Station ID:	MW-003D-1110A			AL-015-051910A & AL-0151110A			BM-003D-051910A & BM-003D-1110A			BM-003S-051910A & BM-003S-1110A			MA-004D-1110A & DUP-1110C			MW-005D-1110A			MW-005D2-1110A		
Aquifer:	DOB			SOB			IOB			SOB			DOB			DOB			DOB		
Chemical	conc	1/2 nd[a]	Q[b]	conc	1/2 nd	Q	conc	1/2 nd	Q	conc	1/2 nd	Q	conc	1/2 nd	Q	conc	1/2 nd	Q	conc	1/2 nd	Q
Aluminum	6140			148		J	121		J		100	200U	3500			5230			3400		
Antimony	0.3		J		1	2U		1	2U		1	2U		1	2U		1	2U		1	2U
Arsenic	6.9		J		5	10U	5.4		J		5	10U	7.8		J	8.6		J	15.7		
Barium	43		J	324			59.7		J	31.2		J	67.5		J	101		J	27.6		J
Berryllium	0.16		J		0.5	1U		0.5	1U		0.5	1U	0.079		J	0.11		J	0.1		J
Cadmium		2.5	5U		2.5	5U		2.5	5U		2.5	5U		2.5	5U		2.5	5U		2.5	5U
Calcium	45300			24322			63709			33100			138000			95300			65400		
Chromium (total)	34.7				5	10U		5	10U		5	10U	18.2			36.5			9.3		J
Cobalt	7.4		J		25	50U		25	50U		25	50U	3.9		J	6.8		J	5.4		J
Copper	39.4				12.5	25U		12.5	25U		12.5	25U	18.5		J	26.8			11.7		J
Iron	29000			198			53700			785			19000			36200			10500		
Lead	5.9		J		5	10U		5	10U		5	10U		5	10U		5	10U		5	10U
Magnesium	12700			7536			8480			11600			33700			15700			12000		
Manganese	958			268			1177			85.2			1700			1180			849		
Mercury		0.1	0.2U		0.1	0.2U		0.1	0.2U		0.1	0.2U		0.1	0.2U		0.1	0.2U		0.1	0.2U
Nickel	26.2		J	3.2		J	1.7		J	1.3		J	15.1		J	22.3		J	15.4		J
Potassium	4330		J	957		J	2920		J	802		J	3960		J	6140			2110		J
Selenium		17.5	35U		17.5	35U		17.5	35U		17.5	35U		17.5	35U		17.5	35U		17.5	35U
Silver		5	10U		5	10U		5	10U		5	10U		5	10U		5	10U		5	10U
Sodium	77500			1.00E+05			1.00E+05			1.00E+05			34000			1E+05			33200		
Thallium		0.5	1U		0.5	1U		0.5	1U		0.5	1U		0.5	1U		0.5	1U		0.5	1U
Vanadium	11.6		J		25	50U		25	50U		25	50U	5.4		J	8.1		J	5.9		J
Zinc	28.4		J	3.7		J	3.4		J	2.5		J	21.8		J	29.2		J	21.2		J

Appendix 1

Table 1: 2010 Groundwater Total Metals Concentrations

Commerce Street Plume Superfund Site

Williston, VT

Sample Location:	MW-06M			MW-06D			ASI-02D2			ASI-03D2			MW-07M		
Sample Date:	Fall 2010			Fall 2010			Spring & Fall 2010			Spring & Fall 2010			Fall 2010		
Sample Name:	MA3M59			MA3M58			MA2Q00&01 & MA3M34 & 35			MA2Q02 & MA42Q1			MA3M60		
Station ID:	MW-006M-1110A			MW-006D-1110A			ASI-002D2-051810A & ASI-002D2-1110A			ASI-003D2-051810A& ASI-003D2-1110A			MW-007M-1110A		
Aquifer:	IOB			DOB			IOB			IOB			IOB		
Chemical	conc	1/2 nd	Q	conc	1/2 nd	Q	conc	1/2 nd	Q	conc	1/2 nd	Q	conc	1/2 nd	Q
Aluminum	12300			7310				100	200U		100	200U	19800		
Antimony		1	2U		1	2U		1	2U		1	2U		1	2U
Arsenic	17.2			21.2				5	10U	12.3			23.7		
Barium	102		J	56.1		J	198		J	114		J	123		J
Berryllium	0.2		J	0.1		J		0.5	1U		0.5	1U	0.37		J
Cadmium		2.5	5U		2.5	5U		2.5	5U		2.5	5U		2.5	5U
Calcium	1E+05			92100			135405			165000			113000		
Chromium (total)	21.7			26				5	10U		5	10U	49.9		
Cobalt	13.2		J	6.6		J		25	50U		25	50U	20.2		J
Copper	27.5			22.4		J		12.5	25U		12.5	25U	60.4		
Iron	39200			19000			15600			7090			44400		
Lead	8.3		J		5	10U		5	10U		5	10U	13.8		
Magnesium	28600			21200			25500			22700			29400		
Manganese	2950			1650			689			1511			1940		
Mercury		0.1	0.2U		0.1	0.2U		0.1	0.2U		0.1	0.2U		0.1	0.2U
Nickel	38.7		J	23.4		J	40		J		20	40U	58.5		
Potassium	4550		J	2810		J	4190		J	2560		J	5830		
Selenium		17.5	35U		17.5	35U		17.5	35U		17.5	35U		17.5	35U
Silver		5	10U		5	10U		5	10U		5	10U		5	10U
Sodium	62800			28300			398000			119000			115000		
Thallium	0.046		J	0.02		J		0.5	1U		0.5	1U	0.11		J
Vanadium	18.2		J	11		J		25	50U		25	50U	28.9		J
Zinc	63.9			45		J	60		J		30	60U	91.7		

Data from the Final 2010 Data Summary Report prepared by Nobis Engineering. June 2011.

Shaded values= maximum detected value

Data Entered: BGK 3/30/12

Data QC'ed: EC 4/2/12

DOB = deep overburden well

IOB = Intermediate overburden well

SOB = shallow overburden well

= max detected value for that analyte

All concentrations listed in microgrmas per liter (ug/L)

Note: two sampling events occurred at most sites, (Spring 2010 and Fall 2010) the greatest value between multiple sampling events was selected.

1/2 nd[a] = one half of the non-detect concentration

Q[b] = Data qualifier

Appendix 1

Table 2: 1997 and 1999 Surface Water, Pore water, and Sediment Raw Data

Commerce Street Plume Superfund Site

Williston, VT

Surface Water Raw Data

		U-Trib-6 12/3/1997	U-Trib-7 12/3/1997	U-Trib-8 12/3/1997	SW-1 12/3/1997	SW-2 12/3/1997	SW-3 12/3/1997	SW-5 12/4/1997	U-Trib-14 12/4/1997
Analytes	Units	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.
TCE	µg/L	24	67	300	390	360	310	63	43
1,2 DCE	µg/L	8	16	330	310	210	48	18	8
PCE	µg/L	ND	ND	ND	ND	ND	ND	ND	ND

Pore Water Raw Data

		RS-01 5/10/1999	RS-02 5/10/1999	RS-03 5/10/1999	RS-04 5/10/1999	RS-05 5/10/1999	RS-06 5/10/1999	RS-07 5/10/1999	RS-08 5/10/1999	RS-09 5/10/1999
Analytes	Units	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.
TCE	µg/L	770	230	ND	ND	1000	10	ND	21	ND
cis 1,2 DCE	µg/L	1600	5500	180	17	ND	14	ND	120	ND
PCE	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND

		RS-10 5/10/1999	RS-11 5/10/1999	RS-12 5/10/1999	RS-13 5/10/1999	RS-14 5/10/1999	RS-15 5/10/1999
Analytes	Units	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.
TCE	µg/L	ND	ND	ND	ND	ND	ND
cis 1,2 DCE	µg/L	ND	ND	ND	ND	ND	ND
PCE	µg/L	ND	ND	ND	ND	ND	ND

Sediment Raw Data

		RS-01 RS-01-SS	RS-02 RS-02-SS	RS-03 RS-03-SS	RS-04 RS-04-SS	RS-05 RS-05-SS	RS-06 RS-06-SS	RS-07 RS-07-SS	RS-08 RS-08-SS	RS-09 RS-09-SS	RS-10 RS-10-SS	RS-11 RS-11-SS
Analytes	Units	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.
TCE	µg/Kg	140	3	4	3	160	3	19	3	4	ND	ND
cis 1,2 DCE	µg/Kg	540	290	920	ND	18	11	38	92	ND	ND	ND
PCE	µg/Kg	ND	11	ND	ND	ND	ND	ND	ND	ND	ND	ND

Data from the Site Investigation Report prepared by HIS GeoTrans, Inc. July 25, 2000

Appendix 1

Table 3: 2010 Background Groundwater Total Metals Concentrations

Commerce Street Plume Superfund Site

Williston, VT

Sample Location:	MW-01D			MW-02M			AIP-01		
Sample Date	Fall 2010			Fall 2010			Fall 2010		
Sample Name:	MA3M52			MA3M53			MA42S6		
Station ID:	MW-001D-1110A			MW-002M-1110A			AIP-001-1110A		
Aquifer:	DOB			IOB			DOB		
Chemical	conc	1/2 nd [a]	Q[b]	conc	1/2 nd	Q	conc	1/2 nd	Q
Aluminum	**3160**			**1920**				**100**	200U
Antimony		**1**	2U		**1**	2U		**1**	2U
Arsenic	**9.1**		J	**3.3**		J	**8.4**		J
Barium	**45.6**		J	**101**		J	**52**		J
Berryllium	**0.097**		J		**0.5**	1U		**0.5**	1U
Cadmium		**2.5**	5U		**2.5**	5U		**2.5**	5U
Calcium	**76600**			**49300**			**60600**		
Chromium (total)	**14.6**			**5.7**		J		**5**	10U
Cobalt	**4.3**		J	**82.2**				**25**	50U
Copper	**27.2**			**6.5**		J		**12.5**	25U
Iron	**19100**			**15900**			**7920**		
Lead		**5**	10U		**5**	10U		**5**	10U
Magnesium	**19900**			**15400**			**14600**		
Manganese	**864**			**739**			**476**		
Mercury		**0.1**	0.2U		**0.1**	0.2U		**0.1**	0.2U
Nickel	**17.2**		J	**122**				**20**	40U
Potassium	**3150**		J	**6710**			**1940**		J
Selenium		**17.5**	35U		**17.5**	35U		**17.5**	35U
Silver		**5**	10U		**5**	10U		**5**	10U
Sodium	**59100**			**95000**			**53600**		
Thallium		**0.5**	1U		**0.5**	1U		**0.5**	1U
Vanadium	**5.5**		J	**4.5**		J		**25**	50U
Zinc	**19**		J	**25.5**		J		**30**	60U

Notes: Q = qualifier, U = below detection limit, J = quantitation approximate, D = diluted sample result,
IOB = Intermediate overburden well; DOB = Deep overburden well
All concentrations listed in micrograms per liter (ug/L)
= max detected value for that analyte
1/2nd [a] = one half of the non detect concentration
Q[b] = data qualifier

Appendix 2

Pro UCL Statistical Printouts for inorganic COPECs in groundwater

Aluminum	General UCL Statistics for Data Sets with Non-Detects
User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Aluminum

General Statistics

Number of Valid Data	12	Number of Detected Data	9
Number of Distinct Detected Data	9	Number of Non-Detect Data	3
		Percent Non-Detects	25.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	121	Minimum Detected	4.796
Maximum Detected	19800	Maximum Detected	9.893
Mean of Detected	6439	Mean of Detected	7.953
SD of Detected	6250	SD of Detected	1.822
Minimum Non-Detect	100	Minimum Non-Detect	4.605
Maximum Non-Detect	100	Maximum Non-Detect	4.605

Warning: There are only 9 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.877	Shapiro Wilk Test Statistic	0.811
5% Shapiro Wilk Critical Value	0.829	5% Shapiro Wilk Critical Value	0.829
Data appear Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	4842	Mean	6.943
SD	6063	SD	2.399
95% DL/2 (t) UCL	7985	95% H-Stat (DL/2) UCL	1255610

Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	3696	Mean in Log Scale	6.954
SD	7219	SD in Log Scale	2.409
95% MLE (t) UCL	7439	Mean in Original Scale	4845
95% MLE (Tiku) UCL	7544	SD in Original Scale	6060
		95% t UCL	7987
		95% Percentile Bootstrap UCL	7868
		95% BCA Bootstrap UCL	8573
		95% H UCL	1345644

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	0.564	Data appear Normal at 5% Significance Level	
Theta Star	11418		
nu star	10.15		
A-D Test Statistic	0.466	Nonparametric Statistics	
5% A-D Critical Value	0.753	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.753	Mean	4859
5% K-S Critical Value	0.29	SD	5790
Data appear Gamma Distributed at 5% Significance Level		SE of Mean	1773
		95% KM (t) UCL	8043
Assuming Gamma Distribution		95% KM (z) UCL	7776
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	7991
Minimum	1.00E-06	95% KM (bootstrap t) UCL	10181
Maximum	19800	95% KM (BCA) UCL	8317
Mean	4829	95% KM (Percentile Bootstrap) UCL	7872
Median	3450	95% KM (Chebyshev) UCL	12587
SD	6074	97.5% KM (Chebyshev) UCL	15931
k star	0.154	99% KM (Chebyshev) UCL	22500
Theta star	31369		
Nu star	3.695	Potential UCLs to Use	
AppChi2	0.605	95% KM (t) UCL	8043
95% Gamma Approximate UCL (Use when n >= 40)	29494	95% KM (Percentile Bootstrap) UCL	7872
95% Adjusted Gamma UCL (Use when n < 40)	39932		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Barium

General Statistics			
Number of Valid Observations	12	Number of Distinct Observations	12
Raw Statistics		Log-transformed Statistics	
Minimum	27.6	Minimum of Log Data	3.318
Maximum	324	Maximum of Log Data	5.781
Mean	103.9	Mean of log Data	4.392
Geometric Mean	80.81	SD of log Data	0.729
Median	84.25		
SD	84.29		
Std. Error of Mean	24.33		
Coefficient of Variation	0.811		
Skewness	1.858		
Relevant UCL Statistics			
Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.804	Shapiro Wilk Test Statistic	0.972
Shapiro Wilk Critical Value	0.859	Shapiro Wilk Critical Value	0.859
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	147.6	95% H-UCL	180.9
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	201
95% Adjusted-CLT UCL (Chen-1995)	157.9	97.5% Chebyshev (MVUE) UCL	243.6
95% Modified-t UCL (Johnson-1978)	149.8	99% Chebyshev (MVUE) UCL	327.2

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	1.66	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	62.6		
MLE of Mean	103.9		
MLE of Standard Deviation	80.66		
nu star	39.84		
Approximate Chi Square Value (.05)	26.38	Nonparametric Statistics	
Adjusted Level of Significance	0.029	95% CLT UCL	143.9
Adjusted Chi Square Value	24.72	95% Jackknife UCL	147.6
		95% Standard Bootstrap UCL	142
Anderson-Darling Test Statistic	0.305	95% Bootstrap-t UCL	187.1
Anderson-Darling 5% Critical Value	0.741	95% Hall's Bootstrap UCL	352.6
Kolmogorov-Smirnov Test Statistic	0.149	95% Percentile Bootstrap UCL	146.2
Kolmogorov-Smirnov 5% Critical Value	0.248	95% BCA Bootstrap UCL	159.3
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	210
		97.5% Chebyshev(Mean, Sd) UCL	255.9
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	346
95% Approximate Gamma UCL (Use when n >= 40)	157		
95% Adjusted Gamma UCL (Use when n < 40)	167.5		
Potential UCL to Use		Use 95% Approximate Gamma UCL	157

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Cadmium

General Statistics

Number of Valid Data	12	Number of Detected Data	0
Number of Distinct Detected Data	0	Number of Non-Detect Data	12
		Percent Non-Detects	100.00%

Warning: All observations are Non-Detects (NDs), therefore all statistics and estimates should also be NDs!
Specifically, sample mean, UCLs, UPLs, and other statistics are also NDs lying below the largest detection limit!
The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable Cadmium was not processed!

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Chromium

General Statistics			
Number of Valid Data	12	Number of Detected Data	7
Number of Distinct Detected Data	7	Number of Non-Detect Data	5
		Percent Non-Detects	41.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	9.3	Minimum Detected	2.23
Maximum Detected	49.9	Maximum Detected	3.91
Mean of Detected	28.04	Mean of Detected	3.217
SD of Detected	13.45	SD of Detected	0.552
Minimum Non-Detect	5	Minimum Non-Detect	1.609
Maximum Non-Detect	5	Maximum Non-Detect	1.609

Warning: There are only 7 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics			
Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.983	Shapiro Wilk Test Statistic	0.958
5% Shapiro Wilk Critical Value	0.803	5% Shapiro Wilk Critical Value	0.803
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	17.4	Mean	2.259
SD	16.48	SD	1.253
95% DL/2 (t) UCL	25.95	95% H-Stat (DL/2) UCL	75.66
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	11.71	Mean in Log Scale	2.6
SD	23.06	SD in Log Scale	0.902
95% MLE (t) UCL	23.66	Mean in Original Scale	18.89
95% MLE (Tiku) UCL	25.41	SD in Original Scale	15.13
		95% t UCL	26.73
		95% Percentile Bootstrap UCL	26.19
		95% BCA Bootstrap UCL	26.74
		95% H UCL	42.63

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	2.64	Data appear Normal at 5% Significance Level	
Theta Star	10.62		
nu star	36.96		
A-D Test Statistic	0.176	Nonparametric Statistics	
5% A-D Critical Value	0.71	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.71	Mean	20.23
5% K-S Critical Value	0.313	SD	13.26
Data appear Gamma Distributed at 5% Significance Level		SE of Mean	4.135
		95% KM (t) UCL	27.66
Assuming Gamma Distribution		95% KM (z) UCL	27.04
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	27.47
Minimum	1.00E-06	95% KM (bootstrap t) UCL	28
Maximum	49.9	95% KM (BCA) UCL	31.34
Mean	16.36	95% KM (Percentile Bootstrap) UCL	30.01
Median	13.75	95% KM (Chebyshev) UCL	38.26
SD	17.53	97.5% KM (Chebyshev) UCL	46.06
k star	0.145	99% KM (Chebyshev) UCL	61.38
Theta star	113		
Nu star	3.475	Potential UCLs to Use	
AppChi2	0.526	95% KM (t) UCL	27.66
95% Gamma Approximate UCL (Use when n >= 40)	108.1	95% KM (Percentile Bootstrap) UCL	30.01
95% Adjusted Gamma UCL (Use when n < 40)	147.8		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	C:\Documents and Settings\ekensey.AA\Desktop\ProUCL 4.1.01\Data\Commerce St. Metals data
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Cobalt

General Statistics

Number of Valid Data	12	Number of Detected Data	7
Number of Distinct Detected Data	7	Number of Non-Detect Data	5
		Percent Non-Detects	41.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	3.9	Minimum Detected	1.361
Maximum Detected	20.2	Maximum Detected	3.006
Mean of Detected	9.071	Mean of Detected	2.063
SD of Detected	5.703	SD of Detected	0.555
Minimum Non-Detect	25	Minimum Non-Detect	3.219
Maximum Non-Detect	25	Maximum Non-Detect	3.219

Warning: There are only 7 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.818	Shapiro Wilk Test Statistic	0.932
5% Shapiro Wilk Critical Value	0.803	5% Shapiro Wilk Critical Value	0.803
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	10.5	Mean	2.256
SD	4.567	SD	0.474
95% DL/2 (t) UCL	12.87	95% H-Stat (DL/2) UCL	14.43

Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	2.063
		SD in Log Scale	0.51
		Mean in Original Scale	8.913
		SD in Original Scale	4.95
		95% t UCL	11.48
		95% Percentile Bootstrap UCL	11.19
		95% BCA Bootstrap UCL	11.63
		95% H-UCL	12.48

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	2.191	Data appear Normal at 5% Significance Level	
Theta Star	4.14		
nu star	30.68		
A-D Test Statistic	0.459	Nonparametric Statistics	
5% A-D Critical Value	0.711	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.711	Mean	9.071
5% K-S Critical Value	0.313	SD	5.28
Data appear Gamma Distributed at 5% Significance Level		SE of Mean	2.156
		95% KM (t) UCL	12.94
Assuming Gamma Distribution		95% KM (z) UCL	12.62
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	13.07
Minimum	2.811	95% KM (bootstrap t) UCL	23.38
Maximum	20.2	95% KM (BCA) UCL	13.4
Mean	9.102	95% KM (Percentile Bootstrap) UCL	12.82
Median	7.1	95% KM (Chebyshev) UCL	18.47
SD	5.049	97.5% KM (Chebyshev) UCL	22.53
k star	2.813	99% KM (Chebyshev) UCL	30.52
Theta star	3.235		
Nu star	67.52	Potential UCLs to Use	
AppChi2	49.61	95% KM (t) UCL	12.94
95% Gamma Approximate UCL (Use when n >= 40)	12.39	95% KM (Percentile Bootstrap) UCL	12.82
95% Adjusted Gamma UCL (Use when n < 40)	13		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Copper

General Statistics			
Number of Valid Data	12	Number of Detected Data	7
Number of Distinct Detected Data	7	Number of Non-Detect Data	5
		Percent Non-Detects	41.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	11.7	Minimum Detected	2.46
Maximum Detected	60.4	Maximum Detected	4.101
Mean of Detected	29.53	Mean of Detected	3.266
SD of Detected	16.08	SD of Detected	0.526
Minimum Non-Detect	12.5	Minimum Non-Detect	2.526
Maximum Non-Detect	12.5	Maximum Non-Detect	2.526

Warning: There are only 7 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics			
Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.901	Shapiro Wilk Test Statistic	0.987
5% Shapiro Wilk Critical Value	0.803	5% Shapiro Wilk Critical Value	0.803
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	19.83	Mean	2.669
SD	16.88	SD	0.834
95% DL/2 (t) UCL	28.58	95% H-Stat (DL/2) UCL	39.55
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	12.89	Mean in Log Scale	2.868
SD	24.27	SD in Log Scale	0.661
95% MLE (t) UCL	25.47	Mean in Original Scale	21.62
95% MLE (Tiku) UCL	28.38	SD in Original Scale	15.52
		95% t UCL	29.67
		95% Percentile Bootstrap UCL	29.1
		95% BCA Bootstrap UCL	30.7
		95% H UCL	35.03

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	2.585	Data appear Normal at 5% Significance Level	
Theta Star	11.42		
nu star	36.19		
A-D Test Statistic	0.216	Nonparametric Statistics	
5% A-D Critical Value	0.71	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.71	Mean	22.1
5% K-S Critical Value	0.313	SD	14.37
Data appear Gamma Distributed at 5% Significance Level		SE of Mean	4.482
		95% KM (t) UCL	30.15
Assuming Gamma Distribution		95% KM (z) UCL	29.47
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	29.45
Minimum	1.00E-06	95% KM (bootstrap t) UCL	33.68
Maximum	60.4	95% KM (BCA) UCL	34.97
Mean	19.7	95% KM (Percentile Bootstrap) UCL	31.76
Median	17.11	95% KM (Chebyshev) UCL	41.64
SD	17.49	97.5% KM (Chebyshev) UCL	50.09
k star	0.243	99% KM (Chebyshev) UCL	66.7
Theta star	81.09		
Nu star	5.83	Potential UCLs to Use	
AppChi2	1.553	95% KM (t) UCL	30.15
95% Gamma Approximate UCL (Use when n >= 40)	73.91	95% KM (Percentile Bootstrap) UCL	31.76
95% Adjusted Gamma UCL (Use when n < 40)	92.39		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Iron

General Statistics			
Number of Valid Observations	12	Number of Distinct Observations	11
Raw Statistics		Log-transformed Statistics	
Minimum	198	Minimum of Log Data	5.288
Maximum	53700	Maximum of Log Data	10.89
Mean	22889	Mean of log Data	9.365
Geometric Mean	11672	SD of log Data	1.717
Median	19000		
SD	17536		
Std. Error of Mean	5062		
Coefficient of Variation	0.766		
Skewness	0.35		
Relevant UCL Statistics			
Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.948	Shapiro Wilk Test Statistic	0.791
Shapiro Wilk Critical Value	0.859	Shapiro Wilk Critical Value	0.859
Data appear Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	31980	95% H-UCL	484202
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	135207
95% Adjusted-CLT UCL (Chen-1995)	31762	97.5% Chebyshev (MVUE) UCL	176324
95% Modified-t UCL (Johnson-1978)	32066	99% Chebyshev (MVUE) UCL	257089
Gamma Distribution Test		Data Distribution	
k star (bias corrected)	0.709	Data appear Normal at 5% Significance Level	
Theta Star	32274		
MLE of Mean	22889		
MLE of Standard Deviation	27180		
nu star	17.02		
Approximate Chi Square Value (.05)	8.687	Nonparametric Statistics	
Adjusted Level of Significance	0.029	95% CLT UCL	31216
Adjusted Chi Square Value	7.794	95% Jackknife UCL	31980
		95% Standard Bootstrap UCL	30976
Anderson-Darling Test Statistic	0.559	95% Bootstrap-t UCL	33006
Anderson-Darling 5% Critical Value	0.761	95% Hall's Bootstrap UCL	31537
Kolmogorov-Smirnov Test Statistic	0.18	95% Percentile Bootstrap UCL	30991
Kolmogorov-Smirnov 5% Critical Value	0.254	95% BCA Bootstrap UCL	31465
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	44955
		97.5% Chebyshev(Mean, Sd) UCL	54503
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	73257
95% Approximate Gamma UCL (Use when n >= 40)	44847		
95% Adjusted Gamma UCL (Use when n < 40)	49986		
Potential UCL to Use		Use 95% Student's-t UCL	31980

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Lead

General Statistics			
Number of Valid Data	12	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	9
		Percent Non-Detects	75.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	5.9	Minimum Detected	1.775
Maximum Detected	13.8	Maximum Detected	2.625
Mean of Detected	9.333	Mean of Detected	2.172
SD of Detected	4.05	SD of Detected	0.428
Minimum Non-Detect	5	Minimum Non-Detect	1.609
Maximum Non-Detect	5	Maximum Non-Detect	1.609

Warning: There are only 3 Distinct Detected Values in this data set
The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics			
Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.951	Shapiro Wilk Test Statistic	0.987
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	4.208	Mean	1.23
SD	3.54	SD	0.596
95% DL/2 (t) UCL	6.044	95% H-Stat (DL/2) UCL	6.145
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	0.263	Mean in Log Scale	0.623
SD	7.088	SD in Log Scale	1.179
95% MLE (t) UCL	3.937	Mean in Original Scale	3.417
95% MLE (Tiku) UCL	7.617	SD in Original Scale	4.059
		95% t UCL	5.521
		95% Percentile Bootstrap UCL	5.401
		95% BCA Bootstrap UCL	6.006
		95% H UCL	11.84

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	N/A	Data appear Normal at 5% Significance Level	
Theta Star	N/A		
nu star	N/A		
A-D Test Statistic	N/A	Nonparametric Statistics	
5% A-D Critical Value	N/A	Kaplan-Meier (KM) Method	
K-S Test Statistic	N/A	Mean	6.758
5% K-S Critical Value	N/A	SD	2.224
Data not Gamma Distributed at 5% Significance Level		SE of Mean	0.786
		95% KM (t) UCL	8.17
Assuming Gamma Distribution		95% KM (z) UCL	8.051
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	8.537
Minimum	N/A	95% KM (bootstrap t) UCL	8.006
Maximum	N/A	95% KM (BCA) UCL	13.8
Mean	N/A	95% KM (Percentile Bootstrap) UCL	13.8
Median	N/A	95% KM (Chebyshev) UCL	10.19
SD	N/A	97.5% KM (Chebyshev) UCL	11.67
k star	N/A	99% KM (Chebyshev) UCL	14.58
Theta star	N/A		
Nu star	N/A	Potential UCLs to Use	
AppChi2	N/A	95% KM (t) UCL	8.17
95% Gamma Approximate UCL (Use when n >= 40)	N/A	95% KM (Percentile Bootstrap) UCL	13.8
95% Adjusted Gamma UCL (Use when n < 40)	N/A		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

manganese

General Statistics			
Number of Valid Observations	12	Number of Distinct Observations	12
Raw Statistics		Log-transformed Statistics	
Minimum	85.2	Minimum of Log Data	4.445
Maximum	2950	Maximum of Log Data	7.99
Mean	1246	Mean of log Data	6.838
Geometric Mean	932.3	SD of log Data	0.966
Median	1179		
SD	779.8		
Std. Error of Mean	225.1		
Coefficient of Variation	0.626		
Skewness	0.619		
Relevant UCL Statistics			
Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.964	Shapiro Wilk Test Statistic	0.852
Shapiro Wilk Critical Value	0.859	Shapiro Wilk Critical Value	0.859
Data appear Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	1651	95% H-UCL	3417
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	3243
95% Adjusted-CLT UCL (Chen-1995)	1660	97.5% Chebyshev (MVUE) UCL	4035
95% Modified-t UCL (Johnson-1978)	1657	99% Chebyshev (MVUE) UCL	5591
Gamma Distribution Test		Data Distribution	
k star (bias corrected)	1.459	Data appear Normal at 5% Significance Level	
Theta Star	854.4		
MLE of Mean	1246		
MLE of Standard Deviation	1032		
nu star	35.01		
Approximate Chi Square Value (.05)	22.48	Nonparametric Statistics	
Adjusted Level of Significance	0.029	95% CLT UCL	1617
Adjusted Chi Square Value	20.95	95% Jackknife UCL	1651
		95% Standard Bootstrap UCL	1606
Anderson-Darling Test Statistic	0.403	95% Bootstrap-t UCL	1690
Anderson-Darling 5% Critical Value	0.743	95% Hall's Bootstrap UCL	1768
Kolmogorov-Smirnov Test Statistic	0.155	95% Percentile Bootstrap UCL	1605
Kolmogorov-Smirnov 5% Critical Value	0.249	95% BCA Bootstrap UCL	1648
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	2228
		97.5% Chebyshev(Mean, Sd) UCL	2652
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	3486
95% Approximate Gamma UCL (Use when n >= 40)	1942		
95% Adjusted Gamma UCL (Use when n < 40)	2083		
Potential UCL to Use		Use 95% Student's-t UCL	1651

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	C:\Documents and Settings\ekensey.AA\Desktop\ProUCL 4.1.01\Data\Commerce St. Metals data
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Nickel

General Statistics			
Number of Valid Data	12	Number of Detected Data	11
Number of Distinct Detected Data	11	Number of Non-Detect Data	1
		Percent Non-Detects	8.33%
Raw Statistics		Log-transformed Statistics	
Minimum Detected	1.3	Minimum Detected	0.262
Maximum Detected	58.5	Maximum Detected	4.069
Mean of Detected	22.35	Mean of Detected	2.577
SD of Detected	18	SD of Detected	1.315
Minimum Non-Detect	20	Minimum Non-Detect	2.996
Maximum Non-Detect	20	Maximum Non-Detect	2.996
UCL Statistics			
Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.931	Shapiro Wilk Test Statistic	0.857
5% Shapiro Wilk Critical Value	0.85	5% Shapiro Wilk Critical Value	0.85
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	21.32	Mean	2.554
SD	17.53	SD	1.257
95% DL/2 (t) UCL	30.4	95% H-Stat (DL/2) UCL	102.7
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	19.45	Mean in Log Scale	2.49
SD	19.73	SD in Log Scale	1.289
95% MLE (t) UCL	29.68	Mean in Original Scale	20.87
95% MLE (Tiku) UCL	32.07	SD in Original Scale	17.9
		95% t UCL	30.15
		95% Percentile Bootstrap UCL	29.26
		95% BCA Bootstrap UCL	30.32
		95% H UCL	106.6

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	0.846	Data appear Normal at 5% Significance Level	
Theta Star	26.42		
nu star	18.6		
A-D Test Statistic	0.48	Nonparametric Statistics	
5% A-D Critical Value	0.75	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.75	Mean	21.1
5% K-S Critical Value	0.262	SD	17.05
Data appear Gamma Distributed at 5% Significance Level		SE of Mean	5.199
		95% KM (t) UCL	30.43
Assuming Gamma Distribution		95% KM (z) UCL	29.65
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	30.43
Minimum	1.3	95% KM (bootstrap t) UCL	33.2
Maximum	58.5	95% KM (BCA) UCL	29.79
Mean	20.97	95% KM (Percentile Bootstrap) UCL	29.13
Median	18.85	95% KM (Chebyshev) UCL	43.75
SD	17.81	97.5% KM (Chebyshev) UCL	53.56
k star	0.859	99% KM (Chebyshev) UCL	72.82
Theta star	24.41		
Nu star	20.62	Potential UCLs to Use	
AppChi2	11.31	95% KM (t) UCL	30.43
95% Gamma Approximate UCL (Use when n >= 40)	38.23	95% KM (Percentile Bootstrap) UCL	29.13
95% Adjusted Gamma UCL (Use when n < 40)	42.09		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	C:\Documents and Settings\ekensey.AA\Desktop\ProUCL 4.1.01\Data\Commerce St. Metals data
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Selenium

General Statistics

Number of Valid Data	12	Number of Detected Data	0
Number of Distinct Detected Data	0	Number of Non-Detect Data	12
		Percent Non-Detects	100.00%

Warning: All observations are Non-Detects (NDs), therefore all statistics and estimates should also be NDs!
Specifically, sample mean, UCLs, UPLs, and other statistics are also NDs lying below the largest detection limit!
The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable Selenium was not processed!

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	C:\Documents and Settings\ekensey.AA\Desktop\ProUCL 4.1.01\Data\Commerce St. Metals data
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Silver

General Statistics

Number of Valid Data	12	Number of Detected Data	0
Number of Distinct Detected Data	0	Number of Non-Detect Data	12
		Percent Non-Detects	100.00%

Warning: All observations are Non-Detects (NDs), therefore all statistics and estimates should also be NDs!
Specifically, sample mean, UCLs, UPLs, and other statistics are also NDs lying below the largest detection limit!
The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable Silver was not processed!

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	C:\Documents and Settings\ekensey.AA\Desktop\ProUCL 4.1.01\Data\Commerce St. Metals data
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Vanadium

General Statistics			
Number of Valid Data	12	Number of Detected Data	7
Number of Distinct Detected Data	7	Number of Non-Detect Data	5
		Percent Non-Detects	41.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	5.4	Minimum Detected	1.686
Maximum Detected	28.9	Maximum Detected	3.364
Mean of Detected	12.73	Mean of Detected	2.381
SD of Detected	8.341	SD of Detected	0.602
Minimum Non-Detect	25	Minimum Non-Detect	3.219
Maximum Non-Detect	25	Maximum Non-Detect	3.219

Warning: There are only 7 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics			
Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.853	Shapiro Wilk Test Statistic	0.95
5% Shapiro Wilk Critical Value	0.803	5% Shapiro Wilk Critical Value	0.803
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	12.63	Mean	2.441
SD	6.162	SD	0.451
95% DL/2 (t) UCL	15.83	95% H-Stat (DL/2) UCL	16.88
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	2.312
		SD in Log Scale	0.52
		Mean in Original Scale	11.52
		SD in Original Scale	6.792
		95% t UCL	15.05
		95% Percentile Bootstrap UCL	14.87
		95% BCA Bootstrap UCL	15.66
		95% H-UCL	16.24

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	1.94	Data appear Normal at 5% Significance Level	
Theta Star	6.561		
nu star	27.16		
A-D Test Statistic	0.302	Nonparametric Statistics	
5% A-D Critical Value	0.712	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.712	Mean	11.61
5% K-S Critical Value	0.314	SD	6.66
Data appear Gamma Distributed at 5% Significance Level		SE of Mean	2.388
		95% KM (t) UCL	15.89
Assuming Gamma Distribution		95% KM (z) UCL	15.53
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	15.96
Minimum	2.359	95% KM (bootstrap t) UCL	19.15
Maximum	28.9	95% KM (BCA) UCL	15.36
Mean	12.06	95% KM (Percentile Bootstrap) UCL	15.63
Median	11.3	95% KM (Chebyshev) UCL	22.02
SD	7.327	97.5% KM (Chebyshev) UCL	26.52
k star	2.202	99% KM (Chebyshev) UCL	35.37
Theta star	5.478		
Nu star	52.84	Potential UCLs to Use	
AppChi2	37.14	95% KM (t) UCL	15.89
95% Gamma Approximate UCL (Use when n >= 40)	17.16	95% KM (Percentile Bootstrap) UCL	15.63
95% Adjusted Gamma UCL (Use when n < 40)	18.13		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Appendix 3

Copy of the pore water VOC data summary table from the Final 2010 Data Summary Report, dated June 10, 2011 prepared by Nobis Engineering.

Table 3-4
July 2010 Porewater VOC Concentrations
Commerce Street Plume Superfund Site
Williston, Vermont

			Sample Name:	A3M00	A3M01	A3M02	A3M03	A3M04	A3M05	A3M06	A3M07	A3M08	A3M09	A3M10	A3M11	A3M12	A3M13	A3M14	A3M15	A3M16	A3M17	A3M18	A3M19	A3M20
			Sample Location:	PW-01	PW-02	PW-03	PW-04	PW-05	PW-06	PW-07	PW-08	PW-09	PW-09	PW-10	PW-11	PW-12	PW-13	PW-14	PW-15	PW-16	PW-17	PW-18	PW-19	PW-20
			Station ID:	PW-01-072210AX	PW-02-072210AX	PW-03-072210AX	PW-04-072210AX	PW-05-072210AX	PW-06-072210AX	PW-07-072210AX	PW-08-072210AX	PW-09-072210AD	PW-09-072210AX	PW-10-072210AX	PW-11-072210AX	PW-12-072210AX	PW-13-072210AX	PW-14-072210AX	PW-15-072210AX	PW-16-072210AX	PW-17-072210AX	PW-18-072210AX	PW-19-072210AX	PW-20-072210AX
Chemical	CRQL	VT	MCL																					
1,1,1-Trichloroethane	5	200	200	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2,2-Tetrachloroethane	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2-Trichloro-1,2,2-trifluoroethane	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2-Trichloroethane	5	5	5	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethane	5	70		5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene	5	7	7	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2,3-Trichlorobenzene	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2,4-Trichlorobenzene	5	70	70	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dibromo-3-chloropropane	5		0.2	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dibromoethane	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichlorobenzene	5	600	600	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloroethane	5	5	5	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloropropane	5	5	5	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,3-Dichlorobenzene	5	600		5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,4-Dichlorobenzene	5	75	75	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,4-Dioxane	100			100 U	100 U	100 U	100 U	100 U	200 U	100 U	100 U	100 U	100 U	100 U	400 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
2-Butanone	10	4200		10 U	10 U	10 U	10 U	10 U	20 U	10 U	10 U	10 U	10 U	10 U	40 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Hexanone	10			10 U	10 U	10 U	10 U	10 U	20 U	10 U	10 U	10 U	10 U	10 U	40 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Methyl-2-pentanone	10			10 U	10 U	10 U	10 U	10 U	20 U	10 U	10 U	10 U	10 U	10 U	40 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetone	10	700		10 U	10 U	10 U	10 U	10 U	20 U	10 U	10 U	10 U	10 U	10 U	40 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzene	5	5	5	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromochloromethane	5	90		5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromodichloromethane	5	80		5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromoform	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromomethane	5	10		5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Carbon disulfide	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Carbon tetrachloride	5	5	5	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chlorobenzene	5	100	100	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloroethane	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloroform	5	80	80	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloromethane	5	30		5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
cis-1,2-Dichloroethene	5	70	70	5 U	5 U	5 U	5 U	5 U	**630 D**	13	**260 D**	**120**	**210 D**	21	**1700 D**	5 U	5 U	5 U	4.9 J	**270 D**	5 U	5 U	5 U	5 U
cis-1,3-Dichloropropene	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Cyclohexane	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromochloromethane	5	80		5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dichlorodifluoromethane	5	1000		5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Ethylbenzene	5	700	700	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Isopropylbenzene	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
m,p-Xylene	5	10000	10000	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Methyl acetate	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Methyl tert-butyl ether	5	40	35	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Methylcyclohexane	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Methylene chloride	5	5		3.7 JB	3.8 JB	4.1 JB	4.2 JB	4.7 JB	**8.3 JB**	3.6 JB	4.9 JB	2.8 JB	5 U	5 U	**13 JB**	5 U	5 U	2.7 JB	3 JB	2.5 JB	3.4 JB	5 U	**5.6 B**	5 JB
o-Xylene	5	10000	10000	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Styrene	5	100	100	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Tetrachloroethene	5	5	5	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Toluene	5	1000	1000	5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,2-Dichloroethene	5	100	100	5 U	5 U	5 U	5 U	5 U	8.8 J	5 U	5 U	5 U	5 U	5 U	10 J	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,3-Dichloropropene	5			5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Trichloroethene	5	5	5	5 U	5 U	5 U	3.7 J	5 U	**9.1 J**	5 U	**41**	5 U	5 U	5 U	**1100 D**	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Trichlorofluoromethane	5	2100		5 U	5 U	5 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U	5 U	20 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Vinyl chloride	5	2	2	5 U	5 U	5 U	5 U	5 U	10 U	**88**	**4.2 J**	**170**	**180**	5 U	**33**	5 U	5 U	5 U	5 U	**64**	5 U	5 U	5 U	5 U
			Dilution Factor:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
			Sample Date:	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10	22-Jul-10

Notes: 1 U = below detection limit; J = quantitation approximate; B = compound found in associated lab blank; D = diluted sample result; CRQL = Contract Required Quantitation Limit
2 VT GWPR = Vermont Groundwater Protection Rule standard
3 MCL = Maximum Contaminant Level, EPA's National Primary Drinking Water Regulations, updated May 2009
4 **Bold** and shaded indicates exceedance of VT GWPR/MCL
5 All concentrations listed in micrograms per liter (µg/L)

Appendix 4

Commerce Street Plume Site pictures from the March, 2012 Site Visit.

Picture 1: Culvert from under Williston Rd and from a neighboring lot.

Picture 2: The bend in the unnamed stream.

Picture 3: Woody debris across and in the unnamed stream.

Picture 4: The unnamed stream up-stream of the bend and TCE plume.

Appendix 5

Environmental Services Assistance Team (ESAT) memorandum

Developing Tier I and Tier II Water Quality Criteria for Tetrachloroethylene, Trichloroethylene, Dichloroethylene, and Vinyl Chloride.

January 17, 2003

LOCKHEED MARTIN

Lockheed Martin Systems Support and Training Services Company
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January 17, 2003

Office of Environmental Measurement and Evaluation
US EPA - Region I
11 Technology Drive
North Chelmsford, Massachusetts 01863

To: Mr. David McDonald, EPA TOPO
Via: Louis Macri, ESAT Program Manager

TDF No. 762B
Task Order No. 01
Task No. 02

Subject: *Developing Tier I and Tier II Water Quality Criteria for Tetrachloroethylene, Trichloroethylene, Dichloroethylene, and Vinyl Chloride.*

Dear Mr. McDonald:

The Environmental Services Assistance Team (ESAT) performed a literature search on the aquatic toxicity of tetrachloroethylene, trichloroethylene, dichloroethylene, and vinyl chloride using the on-line data bases AQUIRE, Science Direct, Environmental Abstracts, and TOXNET. Papers and reports were obtained through the EPA Region 1 library. This information was used to calculate Tier I or Tier II water quality criteria based on EPA guidance provided with the TDF.

The data for tetrachloroethylene supported the calculation of a Tier I water quality criterion. The data for tri- and dichloroethylene were sufficient only to calculate Tier II water quality criteria. Vinyl chloride did not have sufficient data to develop a water quality criterion.

This work was requested by David McDonald, the Task Order Project Officer (TOPO), and was authorized under Technical Direction Form (TDF) No. 762A and B. The original completion date for this work was January 10, 2002. The completion date was varianced to 1/17/02. TDF 762 also requested an interim deliverable consisting of draft toxicity data tables generated on the basis of an AQUIRE search. Those tables were submitted to the TOPO on November 14, 2002.

Should you have any questions or comments, please contact Stan Pauwels of ESAT - Lockheed Martin at (617) 918-8669 at the EPA/OEME Biology Section, North Chelmsford, MA.

Sincerely,

Lockheed Martin Environmental Services

Stan Pauwels, Environmental Scientist

Developing Tier I and Tier II Water Quality Criteria for Tetrachloroethylene, Trichloroethylene, Dichloroethylene, and vinyl Chloride

TDF No. 762A and B
Task Order No. 01
Task No. 02

Submitted to the:

Task Order Project Officer
Office of Environmental Measurement and Evaluation
USEPA - New England Regional Laboratory
11 Technology Drive
North Chelmsford, MA 01863-2431

Submitted by:

ESAT - Region I
Lockheed Martin Environmental Services
Wannalancit Mills, 175 Cabot Street Box 6
Lowell, MA 01854

January 17, 2003

EPA Contract 68-W-01-008

1.0 INTRODUCTION

On November 13, 2002, EPA issued TDF No. 762 requesting ESAT to calculate Tier II secondary acute values (SAVs) and secondary chronic values (SCVs) for tetrachloroethylene (tetraCE), trichloroethylene (triCE), dichloroethylene (diCE), and vinyl chloride for use at the Devens site in Ayer, MA (formerly known as Fort Devens).

On December 13, 2002, EPA issued a modification to TDF No. 762 to extend the completion date to 1/10/2003. On December 27, 2002, EPA issued another modification requesting calculations of Tier I Ambient Water Quality Criteria (AWQC) for those chemicals with sufficient data to support such calculations. On January 7, 2003, ESAT varianced the completion date to 1/17/03 to allow more time for peer reviewing the final deliverable.

This technical memorandum is organized as follows: section 2.0 summarizes the literature search strategies used in support of this TDF, section 3.0 summarizes the Tier I and Tier II surface water criteria calculation methods, section 4.0 provides a summary and conclusions, section 5.0 shows the acronyms used in this technical memorandum, and section 6.0 provides the references used in the toxicity data tables attached to this memorandum.

2.0 LITERATURE SEARCH

2.1 Preliminary literature survey

An on-line search of EPA's AQUIRE (AQUatic Toxicity Information Retrieval) data base at http://www.epa.gov/med/databases/databases.htm was performed on the day the original TDF was received by ESAT. The goal was to satisfy EPA's request for an interim deliverable within two days of the November 13, 2002 authorization. The major search parameters used in this effort were as follows:

- 48 to 96 h LC_{50}/EC_{50} acute toxicity data for freshwater invertebrate and vertebrate species
- long-term chronic exposure data (e.g., 7 d *Ceriodaphnia dubia*, 21 d *Daphnia magna*, early life cycle tests for fish)
- only laboratory toxicity tests
- endpoints of interest: survival, immobilization, growth, reproduction

The data files generated by the search were downloaded directly from AQUIRE as comma delimited files (*.csv) and opened as Excel files. Those files were then formatted. The main step in this process was to select the lowest species-specific acute and chronic toxicity data point. This time saving and simplifying approach was implemented because several species were tested two or more times by different researchers. The lowest species-specific toxicity value was chosen because (a) it was conservative, (b) no hand calculations were required and (c) a specific reference was associated with each data point.

Several Excel tables with freshwater toxicity data for the target compounds were provided to EPA within 24 hours of receiving TDF No. 762. The original AQUIRE search results were subsequently used to complement the output from the in-depth literature survey.

2.2 In-depth literature survey

The initial search provided ecotoxicity data retrieved from AQUIRE. An in-depth search was performed to complement this initial effort because the data base could not be assumed to be comprehensive or up to date. The goal was to identify additional data for use in calculating water quality criteria.

2.2.1 Data bases

To complement the AQUIRE search, more in-depth searches were performed using the following three on line data bases:

- TOXNET (http://toxnet.nlm.nih.gov)

TOXNET is a data base maintained by the National Library of Medicine at the National Institute of Health. This comprehensive resource is available for free to the general public. It contains tens of thousands of references (titles + abstracts) obtained from human toxicological and ecotoxicological literature sources.

- Science Direct (http://www.sciencedirect.com)

Science Direct is a fee-based data base maintained by Elsevier Publishers. Recent papers in dozens of environmental journals published by Elsevier Publishers can be accessed on-line, searched and downloaded. Older papers may only be available as abstracts.

- Environment Abstract

Environment Abstract is a data base maintained on EPA's Intranet. It includes a large collection of references dealing with a range of environmental issues, including toxicity testing.

2.2.2 Search Strategy

Each data base was queried using a combination of the following terms:

- [chemical name] AND fish
- [chemical name] AND [specific fish name]
- [chemical name] AND amphibian
- [chemical name] AND invertebrate
- [chemical name] AND daphnia
- [chemical name] AND aquatic toxicity

When entering a chemical name, the TOXNET data base automatically searched for all its synonyms (note: the AQUIRE data base was searched by CAS number, which eliminated any confusion surrounding nomenclature). The other two data bases appeared to search only for the exact chemical name. When appropriate, alternative chemical names were included in the search (e.g., dichloroethylene is also known as ethylene dichloride and dichloroethene).

This search strategy generated between zero and several hundred returns, depending on the chemical name, species group, or data base. Each title was visually scanned to determine its potential relevance to this project. If a title looked promising, then the abstract was retrieved and read (if available).

2.2.3 Data compilation

All publications of interest were entered in a master reference list and provided to EPA's regional library for retrieval. The articles sent back by the library were reviewed to determine if they contained data useful to the project. Pertinent data were entered in the ecotoxicity data tables prepared for the four compounds of interest to this TDF (see **Attachments 1 to 5**)

3.0 CALCULATING WATER QUALITY CRITERIA

3.1 Introduction

EPA has published a two-tiered approach for calculating water quality criteria (40 CFR Part 132 - Water Quality Guidance for the Great Lakes System, March 23, 1995) referred to as the Water Quality Guidance below. The choice of one approach over the other depends on the availability and quality of toxicity data. The Tier I method is by far the most rigorous of the two. It is time consuming to implement and requires a high-quality data base. The Tier II method requires less data and is much simpler. Tier II values are meant to be more conservative; however, they also have a higher level of uncertainty.

For this TDF, the literature searches described in the previous section generated sufficient data to derive water quality criteria for tetraCE based on the Tier I method. TriCE and diCE did not meet the criteria for Tier I. However, they had sufficient data to derive criteria based on the Tier II method. Vinyl chloride lacked the data even for a Tier II calculation. This compound was dropped from further consideration.

3.2 Tier I Aquatic Life Criteria

3.2.1 Criterion Maximum Concentration (CMC)

The Water Quality Guidance described the Tier I methodology in great detail. It is not the purpose of this technical memorandum to reiterate all the requirements. However, the major points have been summarized below to show that the data base for tetraCE generally met the minimum requirements for use in Tier I calculations.

3.2.1.1 Taxonomic groups

A fundamental requirement for deriving a Tier I CMC was the need for toxicity data from a wide range of taxonomic groups. The minimum taxonomic coverage was as follows:

1. a representative of the family Salmonidae in the class Osteichthyes;
2. one other family (preferably a commercially or recreationally important warm water species) in the class Osteichthyes (e.g., bluegill, catfish);
3. a third family in the phylum Chordata (e.g., fish, amphibian);
4. a planktonic crustacean (e.g., cladoceran, copepod);
5. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish);
6. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge);
7. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelid, Mollusca);
8. a family in any order of insect or any phylum not already represented.

Attachment 1 (left-hand column next to the species name) indicates that the tetraCE data base met the minimum taxonomic requirement to proceed with the Tier I CMC calculation. **Attachments 3 and 5** (left-hand column next to the species name) indicate that the data for triCE and diCE did not meet the minimum taxonomic requirements for a Tier I CMC calculation. Only Tier II acute criteria could be calculated for these two compounds (see §3.3 below).

3.2.1.2 Other major requirements

Several additional major requirements had to be met in order to proceed with Tier I calculations. These requirements are summarized below.

a. Tests with daphnids must be started with organisms less then 24 h old and test with midges must be started with 2nd or 3rd instar larvae.

Attachment 1 indicates that the daphnid tests met the age requirement. The test with midges used

3rd or 4th instar larvae, which would have been a few days older than prescribed.

b. Results of tests with daphnids and midges should be reported as 48 h EC_{50} (preferred) or 48 h LC_{50} (acceptable alternative).

Attachment 1 indicates that this requirement was met for tetraCE.

c. Results of tests with all other aquatic animal species should be reported as 96 h EC_{50} (preferred) or 96 h LC_{50} (acceptable alternative).

Attachment 1 indicates that this requirement was met for tetraCE.

d. The agreement of the data within and between species must be considered. Acute values that appear to be questionable in comparison with other acute and chronic data for the same species and for other species in the same genus must not be used.

Attachment 1 indicates that this requirement was met for tetraCE.

e. The preferred test conditions include flow-through exposures using the most sensitive life stage in which the concentration of test material were measured. Acceptable alternative conditions include flow-through tests in which the concentrations were not measured, and the results of static and renewal tests based on initial concentrations of the test material.

Attachment 1 indicates that tetraCE met these requirements for the most part. The one potential exception revolves around the need to test the most sensitive life stage. For fish in particular, the life stages tended to be somewhat older (e.g., juveniles vs. embryo-larvae). For the purpose of the present calculation, however, the assumption was made that the available acute toxicity data for fish and invertebrates were acceptable for Tier I calculations.

3.2.1.3 Calculating a Species Mean Acute Value (SMAV)

The SMAV was calculated as the geometric mean of the results of all acceptable tests for each species for which at least one acceptable acute value was available. **Attachment 1** shows the SMAVs for tetraCE. Note that if only one acute data point was available for a particular species, then that data point became the SMAV.

3.2.1.4 Calculating the Genus Mean Acute Value (GMAV)

For each genus with one or more SMAVs, the GMAV was calculated as the geometric mean of the SMAVs available for the genus. Note that for TetraCE, the GMAVs and SMAVs were identical because each genus presented in **Attachment 1** consisted of only one species.

3.2.1.5 Calculating a Final Acute Value (FAV)

The formulae and supporting text for calculating a Tier I FAV are described in detail on p. 15396 in the Water Quality Guidance and will not be repeated here. Using the methodology described in the Water Quality Guidance, the data presented in **Attachment 1**, and the calculations shown in **Appendix 1**, the FAV for tetraCE was equal to 1.69 mg/l.

3.2.1.6 Calculating a CMC for tetraCE

The Water Quality Guidance defines the CMC as an estimate of the highest concentration of a

material in the water column to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The equation for calculating a CMC is as follows:

$$CMC = FAV / 2 \quad \text{(equation 1)}$$

Where CMC= criterion maximum concentration (mg/l)
FAV = final acute value (mg/l)

Using equation 1, and the FAV presented in Section 3.2.1.4, the CMC for tetraCE was obtained as follows:

$$CMC_{tetraCE} = 1.69 \text{ mg/l} / 2 = 0.845 \text{ mg/l}$$

3.2.2 Criterion Continuous Concentration (CCC)

3.2.2.1 Taxonomic requirements

A fundamental requirement for deriving a Tier I CCC was to have toxicity data from sufficient taxonomic groups to calculate an acute-to-chronic ratio (ACR) (note: the preferred method described in the Water Quality Guidance is to calculate a species-specific chronic value for *all* species in the eight taxonomic groups; the ACR approach described below represented an acceptable alternative). The minimum taxonomic coverage for calculating an ACR was as follows:

- at least one species of aquatic animal in at least three different families, provided that of the three species:
    - at least one was a fish;
    - at least one was an invertebrate;
    - at least one species was an acutely sensitive freshwater species

Attachment 2 (left-hand column next to the species name) indicates that the tetraCE chronic data base met the minimum taxonomic requirement to calculate an ACR based on the Tier I CCC method. The data for triCE and diCE did not meet the minimum taxonomic requirements for a Tier I CCC calculation. Chronic criteria for these two compounds were obtained using the Tier II approach (see Section 3.3).

The data for a chronic test were typically reported as the no observed effect concentration (NOEC) and the lowest observed effect concentration (LOEC). When necessary, those two data points were used to derive a maximum allowable toxicant concentration (MATC) by taking the geometric mean of the NOEC and LOEC.

3.2.2.2 Other major requirements

Several other major requirements needed to be met to proceed with Tier I chronic calculations. These requirements are summarized below.

a. Chronic data must be based on flow-through tests (renewal is acceptable for daphnids) in which the concentration of the test material was analyzed.

   Attachment 2 indicates that this requirement was met for tetraCE.

b. At a minimum, chronic values for fish should be derived from early life-stage toxicity tests consisting of 28- to 32-day (60 days post hatch for salmonids) exposures of the early life stages of a species of fish from shortly after fertilization through embryonic, larval, and early juvenile development.

Attachment 2 indicates that this requirement was met for tetraCE.

c. At a minimum, the ACR should be based on a chronic value for which at least one corresponding appropriate acute value is available. The order of preference is (1) an acute test which is part of the same study as the chronic test, (2) an acute test conducted as part of a different study in the same laboratory and dilution water, and (3) an acute test conducted in the same dilution water in a different laboratory.

The acute and chronic data for *D. magna* (Richter et al., 1983), *C. dubia* (Niederlehner et al., 1998), fathead minnow (U.S. EPA, 1984) and flagfish (Smith et al., 1991) were generated as part of the same studies.

3.2.2.3 Calculating a Species Mean Chronic Value (SMCV)

The SMCV was calculated for each species for which at least one acceptable chronic value was available. For tetraCE, the SMCVs were represented by the four species-specific chronic data points shown in **Attachment 2**.

3.2.2.4 Calculating an Acute-to-Chronic Ratio (ACR)

ACRs were calculated by dividing a species-specific acute value by its corresponding chronic value. Table 1 shows the results for tetraCE based on the data presented in **Attachments 1 and 2**.

Table 1: Calculating ACRs for tetrachloroethylene

Test Species	Acute Data Point	Chronic Data Point	ACR
D. magna	8.5 mg/l	0.75 mg/l	11.33
C. dubia	2.48 mg/l	0.47 mg/l	5.28
flagfish	8.4 mg/l	3.69 mg/l	2.28
fathead minnow	13.4 mg/l	0.84 mg/l	15.95

3.2.2.5 Calculating the Final Acute-to-Chronic Ratio (FACR)

The FACR represents the geometric mean of the available ACRs. For tetraCE, the geometric mean of the ACRs for the four species shown in Table 1 was equal to 6.83.

3.2.2.6 Calculating the Final Chronic Value (FCV)

The equation for calculating a FCV is as follows:

$$FCV = FAV / FACR \qquad \text{(equation 2)}$$

where: FCV = final chronic value (mg/l)
FAV = final acute value (mg/l)
FACR = final acute-to-chronic ratio (unitless)

For TetraCE, the FAV equals 1.69 mg/l (see Section 3.2.1.4); the FACR equals 6.83 (see Section 3.2.2.5). Hence, based on equation 2, the FCV for tetraCE was obtained as follows:

$FCV_{tetraCE}$ = 1.69 mg/l / 6.83
= 0.247 mg/l

3.2.2.7 Calculating a Criterion Continuous Concentration (CCC) for tetraCE

The Water Quality Guidance defined the CCC as an estimate of the highest concentration of a material in the water column to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. The CCC is calculated as follows:

CCC = FCV (equation 3)

It should be noted that the Water Quality Guidance specified that the CCC was equal to the *lowest* of either the FCV or the Final Plant Value (FPV), if plant toxicity data were available. Since plant toxicity data for tetraCE were not found during the in-depth literature survey, an FPV could not be calculated and the CCC was equal to the FCV.

Hence, based on equation 3, the CCC for tetraCE was obtained as follows:

$CCC_{tetraCE} = FCV_{tetraCE}$ = 0.247 mg/l

3.2.3 Water quality criterion for tetraCE

The calculations outlined in §3.2.1 and §3.2.2 produced the following results:

- $CMC_{tetraCE}$ = 0.845 mg/l
- $CCC_{tetraCE}$ = 0.247 mg/l

Based on these results and the wording provided in the Water Quality Guidance, the Tier I water quality criterion for tetraCE should be stated as follows:

"The procedures described in the Tier I methodology indicate that, except possibly where a commercially or recreationally important species is very sensitive, aquatic organisms should not be affected unacceptably if the four-day average concentration of tetrachloroethylene does not exceed 0.247 mg/l more than once every three years on the average and if the one-hour average concentration does not exceed 0.845 mg/l more than once every three years on average".

3.3 Tier II Aquatic Life Criteria

3.3.1 Introduction

The available toxicity information for triCE and diCE was insufficient to calculate Tier I CMCs or CCCs.

- **Attachment 3** shows that one taxonomic group (i.e., Salmonidae) was missing from the triCE acute toxicity data base, which precluded calculating a Tier I CMC. **Attachment 4** indicates that one additional data point would have been required to calculate a Tier I ACR.

- **Attachment 5** shows that five taxonomic groups were missing from the diCE acute toxicity data base. No chronic data were found for this chemical.

Due to these data shortcomings, the Tier II methodology described in the Water Quality Guidance was used to derive aquatic life values for triCE and diCE.

3.3.2 Secondary Maximum Concentration (SMC)

All available acute toxicity data which conformed to the general requirements outlined in §3.2.1.2 of this technical memorandum are presented in **Attachments 3 and 5** for triCE and diCE, respectively. The available data for vinyl chloride was too incomplete for use in a Tier II calculation. As specified in the Water Quality Guidance, in order to calculate a SMC, the data base must contain at least a GMAV for one of three genera in the family Daphnidae, namely *Ceriodaphnia sp.*, *Daphnia sp.*, or *Simocephalus sp.* No such data were found for vinyl chloride. As a result, Tier II criteria could not be calculated for this chemical.

3.3.2.1 Calculating a Species Mean Acute Value (SMAV)

The SMAV was calculated as the geometric mean of the results of all acceptable tests for each species for which at least one acceptable acute data point was available. **Attachment 3 and 5** show the SMAVs for TriCE and DiCE, respectively.

3.3.2.2 Calculating a Genus Mean Acute Value (GMAV)

For each genus with one or more SMAVs, the GMAV was calculated as the geometric mean of the available SMAVs. **Attachment 3 and 5** present the GMAVs for triCE and diCE, respectively. Note that in general the GMAVs and SMAVs were the same because each genus shown in **Attachments 3 and 5** consisted of a single species. The one exception was for the genus *Daphnia* in **Attachment 3** which was represented by three separate species.

3.3.2.3 Calculating a Secondary Acute Value (SAV)

Given the data limitations inherent in a Tier II calculation, a secondary acute factor (SAF) must be used to calculate a SAV. **Table 2** provides the SAFs presented in the Water Quality Guidance. The SAFs are correction factors which reflect the minimum number of satisfied taxonomic group requirements listed in the Tier I methodology (see also Section 3.2.1.1 in this technical memorandum).

Table 2: Adjustment factors required to calculate Tier II SAFs

Number of minimum taxonomic requirements satisfied	Adjustment factor
1	21.9
2	13.0
3	8.0
4	7.0
5	6.1
6	5.2
7	4.3

Table 2 indicates that the adjustment factor decreases (i.e., becomes less conservative) with an increasing number of taxonomic groups which satisfy the minimum data requirements listed in Tier I.

The Water Quality Guidance provided the following equation for calculating a SAV:

SAV = lowest GMAV / SAF (equation 3)

where SAV = secondary acute value (mg/l)
GMAV = the lowest genus mean acute value (mg/l)
SAF = secondary acute factor (unitless)

- SAV for triCE

Attachment 3 shows that the acute toxicity data base for triCE contains seven of the eight minimum required taxonomic groups. As a result, the SAF for this compound equaled 4.3 (see **Table 2**). The lowest GMAV was equal to 17.1 mg/l (*C. Dubia;* see **Attachment 3**).

Based on this information, and using equation 3, the SAV for triCE was obtained as follows:

SAV_{triCE} = 17.1 mg/l / 4.3 = 3.98 mg/l

- SAV for diCE:

Attachment 5 shows that the acute toxicity data base for diCE contained three of the eight minimum required taxonomic groups. As a result, the SAF for this compound equaled 8.0 (see **Table 2**). The lowest GMAV was equal to 56.8 mg/l (*Daphnia magna*; see **Attachment 5**).

Based on this information, and using equation 3, the SAV for diCE was calculated as follows:

SAV_{diCE} = 56.8 mg/l / 8.0 = 7.1 mg/l

3.3.2.4 Calculating a Secondary Acute-to-Chronic Ratio (SACR)

The Water Quality Guidance described three approaches for calculating a SACR, depending on data availability:

(a) If three or more experimentally determined ACRs are available for the chemical, determine a FACR by calculating the geometric mean of the available ACRs (identical to §3.2.2.5).
(b) If at least one but less than three experimentally determined ACRs are available for the chemical, use enough default ACRs of 18.0 so that the total number of ACRs equals three. Calculate the SACR as the geometric mean of the three ACRs.
(c) If no experimentally determined ACRs are available for the chemical, assume a default SACR of 18.0 for use in the calculations.

The following SACRs were calculated using the approach outlined above:

- triCE:

Two experimental ACRs were obtained using the available data (see **Attachments 3 and 4**).

- The acute toxicity for flagfish was reported as 28.3 mg/l (Smith et al., 1991). An early life stage chronic toxicity test using the same species in the same laboratory resulted in a chronic value of 14.9 mg/l (Smith et al., 1991). Therefore, the ACR for this species equaled 1.9 (i.e., 28.3 ÷ 14.9).

- The acute toxicity for *C. dubia* was reported as 17.1 mg/l (Niederlehner et al., 1998). A three-brood chronic toxicity test using the same species in the same laboratory resulted in a chronic value of 9.16 mg/l (Niederlehner et al., 1998). Therefore, the ACR for this species

equaled 1.87 (i.e., 17.1 ÷ 9.16)

One default ACR of 18.0 was included in order to complete the set. Taking the geometric mean of these three values resulted in a SACR of 4.0 for triCE.

- diCE:

No experimental ACRs could be derived due to a lack of published chronic data for diCE. Hence a default SACR of 18 was assigned to this compound.

3.3.2.5 Calculating a Secondary Maximum Concentration (SMC)

Although not explicitly stated in the Water Quality Guidance, the SMC should be viewed as an estimate of the highest concentration of a material in the water column to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.

The Water Quality Guidance provided the following equation to calculate a SMC:

$$SMC = SAV / 2 \quad \text{(equation 5)}$$

where SMC = secondary maximum concentration (mg/l)
SAV = secondary acute value (mg/l)

Using equation 5, the following SMCs were calculated for triCE and diCE:

SMC_{triCE} = 3.98 mg/l / 2 = 1.99 mg/l

SMC_{diCE} = 7.10 mg/l / 2 = 3.55 mg/l

3.3.3 Secondary continuous concentration (SCC)

3.3.3.1 Calculating a secondary chronic value (SCV)

The Water Quality Guidance provided the following equation for calculating a SCV:

$$SCV = SAV / SACR \quad \text{(equation 6)}$$

where SCV = secondary chronic value (mg/l)
SAV = secondary acute value (mg/l)
SACR = secondary acute-to-chronic ratio (unitless)

- triCE:

Based on the available information, and using equation 6, the SCV for triCE was calculated as follows:

SCV_{triCE} = 3.98 mg/l / 4.0 = 1.0 mg/l

- diCE:

Based on the available information, and using equation 6, the SCV for diCE was calculated as follows:

SCV_{diCE} = 7.10 mg/l / 18.0 = 0.39 mg/l

3.3.3.2 Calculating a SCC

Although not explicitly stated in the Water Quality Guidance, the SCC should be viewed as an estimate of the highest concentration of a material in the water column to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

The SCC is defined by the Water Quality Guidance as being equal to the SCV (note that the Water Quality Guidance specified that the SCC was equal to the lowest of the SCV or the Final Plant Value [FPV] if plant toxicity data were available. Since plant toxicity data for were not found during the in-depth literature survey, FPVs could not be calculated and the SCCs equaled the SCVs).

Hence, the SCCs for triCE and diCE were obtained as follows:

$$SCC_{triCE} = SCV_{triCE} = 1.0 \text{ mg/l}$$
$$SCC_{diCE} = SCV_{diCE} = 0.39 \text{ mg/l}$$

3.3.4 Water quality criteria for triCE and diCE

The calculations outlined in Sections 3.2.2 and 3.2.3 produced the following results:

- SMC_{triCE} = 1.99 mg/l and SMC_{diCE} = 3.55 mg/l
- SCC_{triCE} = 1.0 mg/l and SCC_{diCE} = 0.39 mg/l

Based on these results, and the wording provided in the Water Quality Guidance, the Tier II water quality criterion for triCE should be stated as follows:

"The procedures described in the Tier II methodology indicate that, except possibly where a locally important species is very sensitive, aquatic organisms should not be affected unacceptably if the four-day average concentration of trichloroethylene does not exceed the 1.0 mg/l more than once every three years on the average and if the one-hour average concentration does not exceed 1.99 mg/l more than once every three years on the average".

Based on these results and the wording provided in the Water Quality Guidance, the Tier II water quality criterion for diCE should be stated as follows:

"The procedures described in the Tier II methodology indicate that, except possibly where a locally important species is very sensitive, aquatic organisms should not be affected unacceptably if the four-day average concentration of dichloroethylene does not exceed 0.39 mg/l more than once every three years on the average and if the one-hour average concentration does not exceed 3.55 mg/l more than once every three years on the average".

4.0 SUMMARY AND CONCLUSIONS

On November 13, 2002, EPA issued TDF No. 762 requesting ESAT to calculate Tier II SAVs and SCVs for tetraCE, triCE, diCE, and vinyl chloride. On December 13, 2002, EPA issued a modification to TDF No. 762, extending the completion date to January 10, 2003. On December 27, 2002, EPA issued a second modification (TDF No. 762B) to request calculations of Tier I Ambient Water Quality Criteria (AWQC) for those chemicals with sufficient data to support such calculations. On January 7, 2003, ESAT varianced the completion date to January 17, 2003 to allow for more time for peer review.

ESAT began with a quick search of the AQUIRE data base. This effort generated draft toxicity tables for use by EPA. This preliminary search was complemented by an in-depth search of the literature using the on-line data bases TOXNET, Environmental Abstracts, and Science Direct. Potentially interesting papers and reports were obtained from the regional EPA library. All references were reviewed to determine if the data

would be useful to this project. The available acute and chronic data were summarized in chemical-specific toxicity tables for use in the criteria calculations.

The data base available for tetraCE met the minimum requirements to calculate water quality criteria using the Tier I methodology. The data bases available for triCE and diCE had sufficient data only to calculate water quality criteria using the Tier II methodology. The data base for vinyl chloride lacked the minimum required data for Tier II calculations. This chemical was dropped from further consideration.

The results of the calculations described in this technical memorandum are shown in **Attachment 6** and can be summarized as follows:

- TetraCE was the most acutely toxic, followed by triCE and diCe. This pattern indicates that aquatic toxicity is mitigated with reduced chlorination. It also suggests that vinyl chloride should be the least toxic of the four compounds.

- For tetraCE and triCE, the results of this study compared favorably with the Tier II criteria published by Sutter (1996). The less conservative FCV (tetraCE) and SCV (triCE) probably reflect a more complete chronic data base than the one used by Sutter (1996).

- The SCV for diCE is quite conservative because no measured chronic data were available. As a result, a default ACR of 18.0 had to be used to calculate a chronic value.

- Vinyl chloride did not meet the minimum data requirements to calculate Tier II criteria.

5.0 ACRONYMS

If an acronym was used in criteria calculations, the parentheses indicate whether the term was used in Tier I and/or Tier II.

ACR	= acute-to-chronic ratio (Tier I and II)
AQUIRE	= AQUatic Toxicity Information Retrieval
AWQC	= ambient water quality criteria
CAS	= Chemical Abstract Service
CCC	= criterion continuous concentration (Tier I)
CMC	= criterion maximum concentration (Tier I)
diCE	= dichloroethylene
CMC	= criterion maximum concentration (Tier I)
FACR	= final acute-to-chronic ratio (Tier I)
FAV	= final acute value (Tier I)
FCV	= final chronic value (Tier I)
FPV	= final plant value (Tier I and II)
LOEC	= lowest observed effect concentration
MATC	= maximum allowable toxicant concentration
NOEC	= no observed effect concentration
GMAV	= genus mean acute value (Tier I and II)
SACR	= secondary acute-to-chronic ratio (Tier II)
SAF	= secondary acute factor (Tier II)
SAV	= secondary acute value (Tier II)
SCC	= secondary continuous concentration (Tier II)
SCV	= secondary chronic value (Tier II)
SMAV	= species mean acute value (Tier I and II)
SMC	= secondary maximum concentration (Tier II)
SMCV	= species mean chronic value (Tier I and II)

TDF	= technical direction form
tetraCE	= tetrachloroethylene
triCE	= trichloroethylene

6.0 REFERENCES

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Attachment 1: Summary of toxicity data on tetrachloroethylene for use in developing a Tier I acute ambient water quality criterion										
Species	Taxonomic Group	Age, Size, Stage	Test Condition	Exposure Duration	Toxicity Endpoint	Analytical Chemistry	Effects Conc.	Species Mean Acute Value[a] (SMAV)	Genus Mean Acute Value[b] (GMAV)	References
AQUATIC INVERTEBRATES										
pond snail *Physa heterostropha*	7	NA	static	96 h	LC50	NA	93.4 mg/l	93.4 mg/l	93.4 mg/l	Horne et al., 1983
midge *Tanytarsus dissimilis*	8	3rd or 4th instar	static	48 h	LC50	measured	30.8 mg/l	30.8 mg/l	30.8 mg/l	U.S. EPA, 1983
scud *Gammarus minus*	5	NA	static	96 h	LC50	NA	28.6 mg/l	28.6 mg/l	28.6 mg/l	Horne et al., 1983
water flea *Daphnia magna*	4	≤24 hr old	static	48 h	LC50	nominal	18.0 mg/l	12.4 mg/l	12.4 mg/l	Leblanc, 1980
		<24 hr old	static	48 h	EC50	measured	8.5 mg/l			Richter et al., 1983
stonefly *Tallaperia maria*	6	NA	static	96 h	LC50	NA	3.6 mg/l	3.6 mg/l	3.6 mg/l	Horne et al., 1983
Ceriodaphnia Dubia	4	<24 hr old	static renewal	48 h	LC50	measured	2.48 mg/l	2.48 mg/l	2.48 mg/l	Niederlehner et al., 1998
FISH, AMPHIBIANS										
fathead minnow *Pimephales promelas*	2, 3	28-34 d old juveniles	flow through	96 h	LC50	measured	23.8 mg/l	18.0 mg/l	18.0 mg/l	Broderius and Kahl, 1985
		adults (1.0 g; 4.9 cm)	flow through	96 h	LC50	measured	18.4 mg/l			Alexander et al., 1978
		30-35 d old juveniles	flow through	96 h	LC50	measured	13.4 mg/l			U.S. EPA, 1984
bluegill sunfish *Lepomis macrochirus*	2, 3	juveniles (0.32-1.2 g)	static	96 h	LC50	nominal	13.0 mg/l	13.0 mg/l	13.0 mg/l	Buccafusco et al., 1981
American flagfish *Jordanella floridae*	2, 3	2 to 4 mo old juveniles	flow through	96 h	LC50	measured	8.4 mg/l	8.4 mg/l	8.4 mg/l	Smith et al., 1991
rainbow trout *Oncorhynchus mykiss*	1	NA	flow through	96 h	EC50 (mortality)	NA	4.68 mg/l	4.84 mg/l	4.84 mg/l	Call et al, 1979
		juveniles (6.1±1.0 cm)	flow through	96 h	LC50	measured	5.0 mg/l			U.S. EPA, 1983

NA = not available

[a] the SMAV is calculated as the geometric mean of the data points when two or more values are available for a given species

[b] the GMAV is calculated as the geometric mean of the data points when two or more values are available for a given genus

Attachment 2: Summary of chronic toxicity data on tetrahloroethylene for use in developing a Tier I chronic ambient water quality criterion									
Species	Taxonomic Group[a]	Age, Size, Stage	Test Condition	Exposure Duration	Toxicity Endpoint	Analytical Chemistry	Effects Conc.	Species Mean Chronic Value[b] (SMAV)	Reference
CHRONIC TOXICITY									
American flagfish *Jordanella floridae*	1	1 wk old fry	flow through	28 d	MATC[c] (survival)	measured	3.69 mg/l	3.69 mg/l	Smith et al., 1991
fathead minnow *Pimephales promelas*	1	embryos	flow through	32 d	MATC (growth)	measured	0.84 mg/l	0.84 mg/l	U.S. EPA, 1984
water flea *Daphnia magna*	2	<24 hr old	static renewal	28 d	MATC (reprod.)	measured	0.75 mg/l	0.75 mg/l	Richter et al., 1983
water flea *Ceriodaphnia dubia*	3	<24 hr old	static renewal	7 d	MATC (reprod.)	measured	0.47 mg/l	0.47 mg/l	Niederlehner et al., 1998

[a] the minimum taxonomic groups required to calculate a Tier I criterion continuos concentration (CCC) are defined as follows:
1 = at least one species is a fish;
2 = at least one species is an invertebrate;
3 = at least one species is an acutely sensitive freshwater species

[b] the SMAV is calculated as the geometric mean of the data points when two or more values are available for a given species

[c] MATC = maximum allowable toxicant concentration

Attachment 3: Summary of acute toxicity data on trichloroethylene for use in developing a Tier II water quality criterion										
Species	Taxonomic Group	Age, Size, Stage	Test Condition	Exposure Duration	Toxicity Endpoint	Analytical Chemisrty	Effects Conc.	Species Mean Acute Value[a] (SMAV)	Genus Mean Acute Value[b] (GMAV)	Reference
AQUATIC INVERTEBRATES										
oligochaete worm *Tubificidae*	7	NR	static	48 h	LC50	nominal	132 mg/l	132 mg/l	132 mg/l	Slooff, 1983
water boatman *Corixa punctata*	6	NR (field collected)	static	48 h	LC50	nominal	110 mg/l	110 mg/l	110 mg/l	Slooff, 1983
leech *Erpobdella octoculata*	7	NR (field collected)	static	48 h	LC50	nominal	75 mg/l	75 mg/l	75 mg/l	Slooff, 1983
hydra *Hydra oligactis*	7	NR (lab culture)	static	48 h	LC50	nominal	75 mg/l	75 mg/l	75 mg/l	Slooff, 1983
stonefly *Nemoura cinera*	6	NR (field collected)	static	48 h	LC50	nominal	70 mg/l	75 mg/l	70 mg/l	Slooff, 1983
midge (fly) *Chironomus thummi*	6	NR	static	48 h	LC50	nominal	64 mg/l	75 mg/l	64 mg/l	Slooff, 1983
snail *Lymnaea stagnalis*	8	NR (lab culture)	static	48 h	LC50	nominal	56 mg/l	56 mg/l	56 mg/l	Slooff, 1983
damselfly *Ischnura elegans*	6	NR (field collected)	static	48 h	LC50	nominal	49 mg/l	49 mg/l	49 mg/l	Slooff, 1983
mayfly *Cloeon dipterum*	6	NR (field collected)	static	48 h	LC50	nominal	42 mg/l	42 mg/l	42 mg/l	Slooff, 1983
lanarian worm *Dugesia lugubris*	8	NR (field collected)	static	48 h	LC50	nominal	42 mg/l	42 mg/l	42 mg/l	Slooff, 1983
water flea *Daphnia cucullata*	4	11±1 d	static	48 h	LC50	nominal	57 mg/l	57 mg/l	37.4 mg/l	Canton and Adema, 1978
water flea *Daphnia pulex*	4	<24 hr old	static	48 h	LC50	nominal	45 mg/l	45 mg/l		Canton and Adema, 1978
water flea *Daphnia magna*	4	<24 hr old	static	48 h	LC50	nominal	60.9 mg/l	20.4 mg/l		Canton and Adema, 1978
										LeBlanc, 1980
		≤24 hr old	static	48 h	LC50	nominal	18 mg/l			
		4-6 d old	static	48 h	LC50	nominal	7.75 mg/l			Abernethy et al., 1986
aquatic sowbug *Asellus aquaticus*	NA	NR (field collected)	static	48 h	LC50	nominal	30 mg/l	30 mg/l	30 mg/l	Slooff, 1983

scud (amphipod) *Gammarus pulex*	5	NR (field collected)	static	48 h	LC50	nominal	24 mg/l	24 mg/l	24 mg/l	Slooff, 1983
water flea *Ceriodaphnia dubia*	4	<24 hr old	static renewal	48 h	LC50	measured	17.1 mg/l	17.1 mg/l	17.1 mg/l	Niederlehner et al., 1998
FISH, AMPHIBIANS										
Mexican axolotl *Ambystoma mexicanum*	3, 8	larvae (3-4 wks post-hatch)	static	48 h	LC50	NR	48 mg/l	48 mg/l	48 mg/l	Slooff and Baerselman, 1980
bluegill sunfish *Lepomis macrochirus*	2, 3	young-of-year (0.32-1.2 g)	static	96 h	LC50	nominal	45 mg/l	45 mg/l	45 mg/l	Buccafusco et al., 1981
fathead minnow *Pimephales promelas*	2, 3	adults (1g; 4.9 cm)	flow through	96 h	LC50	measured	40.7 mg/l	42.4 mg/l	42.4 mg/l	Alexander et al., 1978
		larvae (31 d old)	flow through	96 h	LC50	measured	44.1 mg/l			Geiger et al., 1985
clawed toad *Xenopus laevis*	3.8	larvae (3-4 wks post-hatch)	static	48 h	LC50	NR	45 mg/l	19.9 mg/l	19.8 mg/l	Sloof and Baerselman, 1980
		embryos	static renewal	96 h	EC50 (terato-genesis)	nominal	36 mg/l			Fort et al., 1993
		embryos	static renewal	96 h	EC50 (mal-formation)	nominal	4.82 mg/l			Rayburn et al., 1991
flagfish *Jordanella floridae*	2, 3	2 to 4 mo old juveniles	flow through	96 h	LC50	measured	28.3 mg/l	28.3 mg/l	28.3 mg/l	Smith et al., 1991

NA = not available
NR = not reported

[a] the SMAV is calculated as the geometric mean of the data points when two or more values are available for a given species

[b] the GMAV is calculated as the geometric mean of the data points when two or more values are available for a given genus

Attachment 4: Summary of chronic toxicity data on trichloroethylene for use in developing a Tier II water quality criterion									
Species	Taxonomic Group[a]	Age, Size, Stage	Test Condition	Exposure Duration	Toxicity Endpoint	Analytical Chemisrty	Effects Conc.	Species Mean Chronic Value[b] (SMAV)	Reference
flagfish *Jordanella floridae*	1	1 wk old fry	flow through	28 d	MATC[c] (survival)	measured	14.9 mg/l	14.9 mg/l	Smith et al., 1991
daphnid *Ceriodaphnia Dubia*	2	<24 hr old	static renewal	7 d	MATC (reprod.)	measured	9.16 mg/l	9.16 mg/l	Niederlehner et al., 1998

[a] the minimum taxonomic groups required to calculate a Tier I criterion continuos concentration (CCC) are defined as follows:
1 = at least one species is a fish;
2 = at least one species is an invertebrate;
3 = at least one species is an acutely sensitive freshwater species

[b] the SMAV is calculated as the geometric mean of the data points when two or more values are available for a given species

[c] MATC = maximum allowable toxicant concentration

Note: a Tier I CCC could not be calculated for trichloroethylene because chronic data were missing for one additional taxonomic group

Attachment 5: Summary of acute toxicity data on dichloroethylene (all isomers) for use in developing a Tier II water quality criterion										
SPECIES	Taxonomic Group	Age, Size, Stage	Test Condition	Exposure Duration	Toxicity Endpoint	Analytical Chemistry	Efects Conc.	Species Mean Acute Value[a] (SMAV)	Genus Mean Acute Value[b] (GMAV)	Reference
AQUATIC INVERTEBRATES										
water flea *Daphnia magna*	4	≤24 h old	static	48 h	LC50	nominal	200 mg/l	56.8 mg/l	56.8 mg/l	Leblanc, 1980
		≤24 h old	static	48 h	LC50	nominal	79 mg/l			Leblanc, 1980
		<24 h old	static	48 h	LC50	NR	11.6 mg/l			U.S. EPA, 1980
FISH, AMPHIBIANS										
bluegill sunfish *Lepomis macrochirus*	2, 3	young-of-year (0.32-1.2 g)	static	96 h	LC50	nominal	140 mg/l	140 mg/l	140 mg/l	Buccafusco et al., 1981
fathead minnow *Pimephales promelas*	2, 3	adults	flow-through	96 h	LC50	measured	108 mg/l	108 mg/l	108 mg/l	U.S. EPA, 1980

NR = not reported

[a] the SMAV is calculated as the geometric mean of the data points when two or more values are available for a given species

[b] the GMAV is calculated as the geometric mean of the data points when two or more values are available for a given genus

Attachment 6: Comparison of criteria developed for TDF No. 762B and by Suter (1996)						
Compound	**Tier 1 (mg/l)**		**Tier 2 (mg/l)**		**Suter, 1996 (mg/l)**	
	FAV	**FCV**	**SAV**	**SCV**	**SAV**	**SCV**
tetrachloroethylene	1.69	0.25	-	-	1.0	0.13
trichloroethylene	-	-	3.98	1.0	3.29	0.35
dichloroethylene	-	-	7.10	0.39	-	-
vinyl chloride	-	-	-	-	1.57	0.088

Appendix 1: Calculating a FAV for tetraCE based on the Tier I methodology					
Species	**Toxicity Value (mg/l)**	**Rank (R)**	**Cumulative Probability[a]**	**ln GMAV[b]**	**(ln GMAV)^2**
pond snail	93.4	10	0.91	-	-
midge	30.8	9	0.82	-	-
scud	28.6	8	0.73	-	-
fathead minnow	18.0	7	0.64	-	-
bluegill	13.0	6	0.55	-	-
waterflea	12.4	5	0.45		
flagfish	*8.4*	*4*	*0.36*	*2.128*	*4.529*
rainbow trout	*4.84*	*3*	*0.27*	*1.577*	*2.487*
stonefly	*3.6*	*2*	*0.18*	*1.281*	*1.641*
C. dubia	*2.48*	*1*	*0.09*	*0.908*	*0.825*
n = 10	-	-	*Σ = 0.9*	*Σ = 5.894*	*Σ = 9.482*

note: toxicity values are from Attachment 1
[a] cumulative probability = R/(n+1)
[b] GMAV = genus mean acute value

The calculations shown below are based on the formulae presented on p. 15396 of 40 CFR Part 132 - Water Quality Guidance for the Great Lakes System, March 23, 1995.

- **Calculating S^2 and S**

Σ ((ln GMAV)^2) = 9.482

(Σ (ln GMAV))^2/4 = 5.894^2/4 = 8.685

Σ (P) = 0.9

(Σ ($\sqrt{P}$))^2/4 = 1.844^2/4 = 0.850

S^2 = (9.482 - 8.685)/(0.9 - 0.850) = 15.940, and therefore S = $\sqrt{15.940}$ = 3.992

- **Calculating L**

Σ (ln GMAV) = 5.894

S ($\sum(\sqrt{P})$) = (3.992)(1.844) = 7.362

L = (5.894 - 7.362)/4 = - 0.367

- **Calculating A**

$A = S(\sqrt{0.05}) + L = (3.992)(0.224) + (-0.367) = 0.527$

- **Calculating FAV**

$FAV = e^{A} = e^{0.527} = 1.69$ mg/l

ATTACHMENT 2

Superfund Records Center
SITE: Commerce Street
BREAK: 03.02
OTHER: 550207

Aquatic Invertebrate, Sediment, and Surface Water Sampling in Unnamed Stream
Commerce Street Plume Superfund Site
Williston, VT
Final Technical Memo

TDF No. 2559A,B,C
Task Order No. 86
Task No. 04

Submitted to the:

Task Order Project Officer
Office of Environmental Measurement and Evaluation
USEPA - New England Regional Laboratory
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North Chelmsford, MA 01863-2431

Submitted by:

ESAT - Region I

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October 4, 2012

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1.0 PROJECT OBJECTIVES

The main objectives of this project were to determine if: (a) the invertebrate community structure and function in Unnamed Stream at different sampling stations was affected by groundwater-impacted discharges from the Commerce Street Plume Superfund Site in Williston, VT, and if (b) any observed differences in the invertebrate community could be attributed directly to the presence of Site-related contaminants (particularly, Volatile Organic Compounds [VOCs]) in surface water and/or sediment. This information will serve in future ecological risk-based decision making.

The following steps were undertaken to meet the project's objectives:

1. Conduct a site visit on March 30, 2012 with EPA Regional Project Manager (RPM) Karen Lumino and EPA risk assessor Rick Sugatt.
2. Prepare a Quality Assurance Project Plan (QAPP) Addendum for use in the field sampling effort.
3. During September 10, 2012 – September 13, 2012, collect surface water chemistry information using a YSI sonde and sample aquatic invertebrates, sediment, and surface water at previously staked sampling stations (i.e. PW-2, PW-11, PW-17, PW-20 and an off-site reference location).
4. Record the GPS coordinates of each sampling station.
5. Take pictures of the stream and riparian habitat, record observations and fill out habitat worksheets.
6. Write a technical memorandum to summarize the sampling procedures used; include copies of habitat worksheets, field notes, and a table summarizing the field surface water chemistry data.

This technical memorandum is organized as follows: Section 2.0 provides an introduction; Section 3.0 describes the field sampling procedures; Section 4.0 describes the sample processing and analyses, and Section 5.0 summarizes the deviations from the QAPP addendum.

2.0 INTRODUCTION

Unnamed Stream was visited by ESAT, EPA Regional Project Manager (RPM) Karen Lumino and EPA risk assessor Rick Sugatt on March 30, 2012 to determine the overall conditions of the stream and to identify possible sampling stations.

A field sampling plan was then developed (i.e. the QAPP Addendum to a Nobis Engineering prepared QAPP). The plan was to collect aquatic invertebrates, sediment samples, and surface water samples from Unnamed Stream for analysis of the following parameters:

- Surface water: VOCs and chlorides
- Sediment: Total Organic Carbon (TOC), Target Analytes List (TAL) metals, mercury, VOCs, and Semi-Volatile Organic Compounds (SVOCs)
- Epifaunal and infaunal aquatic invertebrates: community structure and function

The QAPP Addendum represented an attachment to the April 18, 2012 draft QAPP Amendment 2 prepared by Nobis Engineering (an EPA contractor) to support the spring 2012 groundwater and soil sampling and analysis program at the Site. The spring 2012 samples collected by Nobis were analyzed at EPA's New England Regional Laboratory (NERL) in North Chelmsford, MA for VOCs, SVOCs, and TAL metals using the same Standard Operating Procedures (SOPs) as were used for the surface water and sediment samples collected from Unnamed Stream. All of the analytical requirements pertaining to these three chemical analyses (such as the data quality objectives, detection limits, measurement performance criteria, quality control acceptance limits, corrective actions, acceptance criteria, etc.) were identical to those summarized in the April 18, 2012 document.

3.0 FIELD SAMPLING PROCEDURES

3.1 Standard operating procedures and other support documents

New England Regional Laboratory (NERL) SOPs were followed during field sampling efforts as described in the QAPP Addendum and are referred to in Table 2 of the Addendum.

3.2 Field notes

Real-time field notes were taken to provide detailed records of all the field activities (see **Appendix A**). All notebook entries were made using a ballpoint pen. All pages were dated with the initials of all personnel present. When necessary, corrections were made by striking a line through the text, dating and initialing the correction(s).

Records included in the field notebook include the following types of information, as applicable:

- the date and time when each activity started and ended
- the weather conditions at the start of the day and significant changes in weather during the day
- a summary of equipment maintenance or decontamination activities, when applicable
- a description of sample collection and processing activities, such as:
    - sampling locations
    - recording of Global Positioning System (GPS) coordinates, if applicable
    - number and type(s) of samples collected
    - records of photographs taken, if applicable
    - field measurements and observations
- descriptions of problems encountered while in the field and corrective actions taken (if any)
    - including when deviations were made from the QAPP and why

3.3 Sampling stations

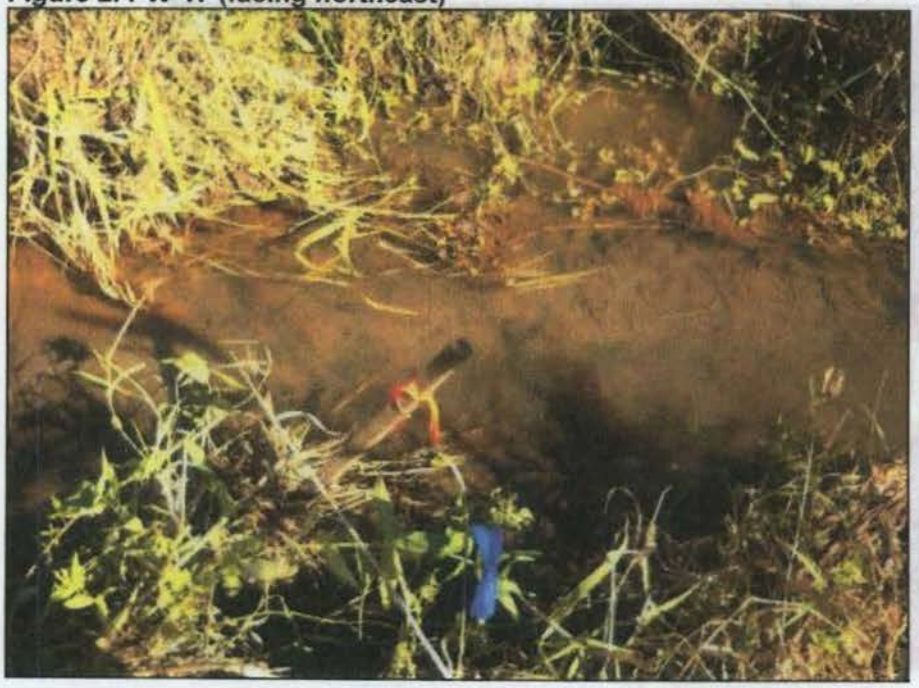
All the field activities took place at five specific sampling stations in Unnamed Stream, four of which coincide with pore water sample stations used by Nobis Engineering in July 2010. These sampling stations are listed below from furthest downstream to furthest upstream. Note that PW-2 was not mentioned in the Addendum. It was determined in the field, with the approval of Rick Sugatt (EPA technical lead), to sample PW-2 instead of PW-1 because of a lack of suitable habitat. The reference location was determined in the field as well. Both instances are discussed further below. The five sampling stations were as follows:

- PW-20: Recovery (far); located about 1,000 ft downstream from PW-17.
- PW-17: Recovery (near); located about 900 ft downstream from PW-11.
- PW 11: site-impacted area; this location had the highest levels of trichloroethylene and dichloroethylene during the July 2010 pore water sampling event.
- PW-2: study area reference, located above the Site just downstream from PW-1, not far from the culvert underneath Route 2
- Off-site reference: located upstream from PW-1, north of Route 2 in a small wetland fed by urban runoff (just West of 209 Blair Park Rd. in Williston, VT)

Sampling stations PW-20 and PW-17 were sampled on Tuesday September 11, 2012 (see **Figure 1** and **Figure 2** for lotic habitat pictures).

Figure 1. PW-20 (facing east)

Figure 2. PW-17 (facing northeast)



Sampling Stations PW-11 and PW-2 were sampled on Wednesday September 12, 2012, (see **Figure 3** and **Figure 4**).

Figure 3. PW-11 (facing southeast)

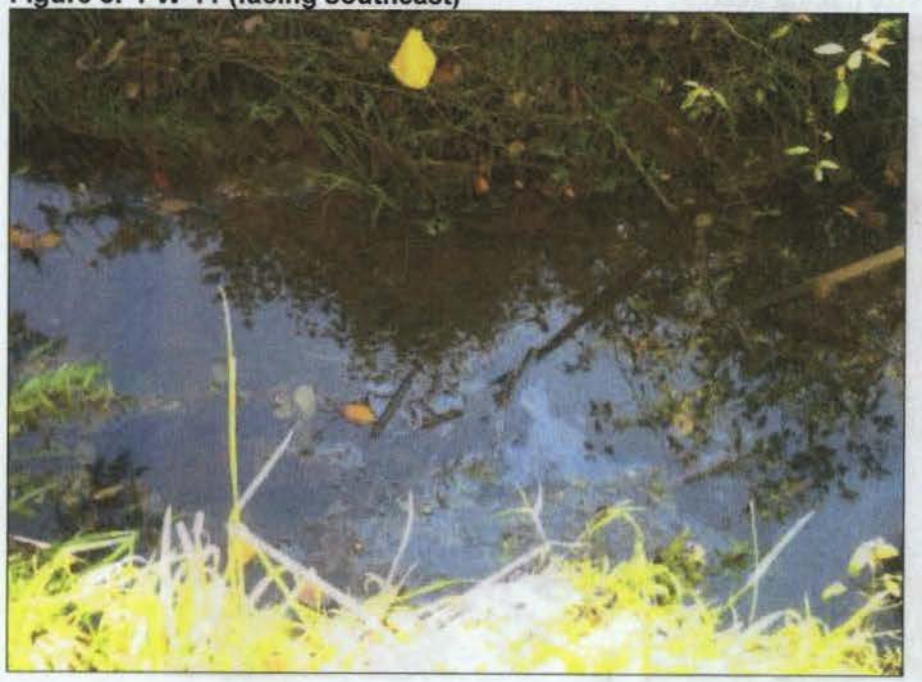
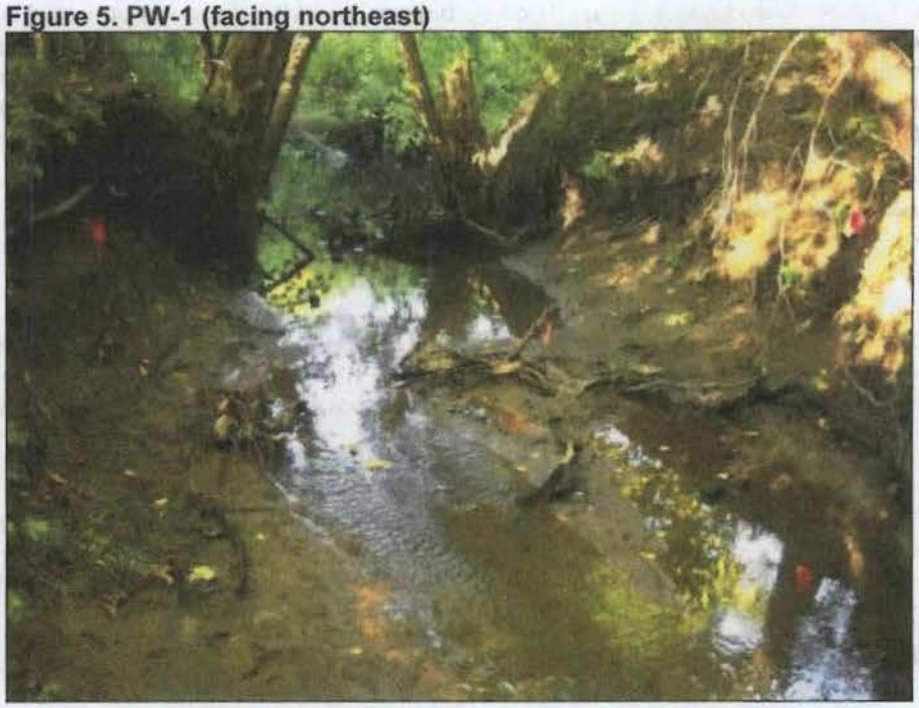


Figure 4. PW-2 (facing east)

Rick Sugatt (EPA) and Michael Ferrier (ESAT) decided not to sample PW-1, the on-site reference, as originally planned. PW-1 could not be properly sampled because the stream at this location was only a couple of inches deep and quite narrow, which made it difficult to collect a surface water sample without disturbing the sediment. In addition, the substrate consisted mostly of fine sediment (as seen in **Figure 5**).

Figure 5. PW-1 (facing northeast)



The off-site reference location was sampled on Thursday September 13, 2012, (See **Figure 6**). The sampling team received permission from Rich Watson to park in the Vermont Plastic Specialists, Inc. parking lot at 209 Blair Park Road. The stream was accessed via the Western side of the Vermont Plastics building near the loading dock. This area of the stream consisted of a small wetland fed by urban runoff. The sampling team had difficulty finding a more suitable reference location upstream of the groundwater plume without getting into more industrialized areas.

Figure 6. off-site reference (facing southwest)

Table 1 provides the Global Positioning System (GPS) coordinates of all five sampling stations. These were recorded the day they were sampled. PW-20, PW-17 and PW-11 GPS coordinates match

those provided by Nobis (see QAPP Addendum). The coordinates for PW-2 were not provided in the QAPP addendum but the PW-2 Nobis stake was located just downstream of PW-1, confirming the team was at the correct location. It should be noted that PW-11 is located in close proximity to two buildings and is at a bend in the stream. Although it may look detached from Unnamed Stream, it is not (see **Attachment 1** for the Nobis map and **Attachment 2** for the September 2012 sampling locations map).

Table 1: GPS coordinates for the sampling stations in Unnamed Stream

Station number	Sampling station	North	West
1	PW-20	44.44658066	-73.12380091
2	PW-17	44.44745849	-73.12147299
3	PW-11	44.44938290	-73.12188230
4	PW-2	44.45264118	-73.11935145
5	Upstream, off-Site reference	44.45478218	-73.11757334

3.4 Field sampling and data collection procedures

3.4.1 Introduction

The sampling effort started at the most downstream station (PW-20) on Unnamed Stream and proceeded sequentially upstream from there. On Monday September 10, 2012, an ESAT member used a Trimble GPS unit and the coordinates presented in Table 3 of the QAPP addendum to find the exact sampling stations prior to sampling. All of the Nobis stakes from the 2010 pore water sampling were found and their locations matched the coordinates provided. The off-site reference location was determined to be upstream of the plume, north of the Route 2 culvert in a small wetland fed by urban runoff. New flagging was placed on either side of the stream at each sampling station to clearly mark the banks. Steve Fiske (VT Department of Environmental Conservation) was present on Monday September 10, 2012 to show the sampling team how to use the VT method for collecting aquatic macroinvertebrates. He mentioned that Unnamed Stream was part of what VT calls Muddy Brook Tributary 4. The stream will continue to be referred to as Unnamed Stream in this report.

The YSI sonde was calibrated every morning before the start of field work. The sonde was taken to the first field sampling location of that day once all of the internal acceptability criteria were met. Sampling at each station proceeded in the following order: (1) surface water parameters were collected using the YSI sonde; (2) surface water samples were collected for VOC and chloride analysis; (3) sediment samples were collected for analysis of VOCs, SVOCs, TAL metals, mercury, and TOC; (5) benthic invertebrates were collected by two different methods; and (5) habitat assessment worksheets were filled out based on EPA's Rapid Bioassessment Protocols and the VT DEC lotic habitat assessment protocol.

The QAPP addendum noted that Unnamed Stream was quite narrow (2-4 ft) and stated that it might be necessary to collect sediment and invertebrate samples not just at the sampling station itself but also up to 15-20 ft upstream and downstream from it in order to get representative samples. The upstream and downstream portions were sampled for macroinvertebrates only at PW-2 and the reference station, both of which were located upstream from the contaminated groundwater recharge areas. On the other hand, only the downstream portions of stations PW-20, PW-17 and PW-11 were sampled for macroinvertebrates in order to follow the decreasing trend in VOC concentration and to more accurately capture where VOC-contaminated groundwater might have an effect on benthic invertebrates. Duplicate samples for all analyses were taken at sampling station PW-11, which represented the "hot spot" for the VOC-contaminated groundwater plume.

3.4.2 Surface water parameters

The temperature (°C), pH (standard units), dissolved oxygen (mg/L and % saturation), and specific conductance (microsiemens per cm [mS/cm]) of the surface water at each sampling station were measured using the YSI Model 556 Data Logger. One set of readings was taken in the center of Unnamed Stream at each sampling station, with the probe placed halfway down the water column. All readings were recorded in the field logbook and are summarized in **Attachment 3**.

3.4.3 Surface water sampling

A set of trip blanks were prepared for VOC analysis before the sampling team left the NERL on Monday September 10, 2012. These blanks consisted of 4 Volatile Organic Analysis (VOA) vials completely filled with deionized water (no headspace), placed on ice, and kept in the field cooler until the end of the trip. Trip blanks were not mentioned in the QAPP Addendum but are standard protocol for VOA sample collection.

A surface water pH test sample was prepared in a VOA vial in the field by filling the sample bottle almost to the top with stream water and counting the number of drops of HCl it took to acidify the water to a pH < 2.0. The number of drops needed to reach a pH < 2.0 was recorded and used to quickly and accurately acidify subsequent surface water samples. The pH test sample was then properly discarded. This process was repeated as needed at other sampling stations.

Two surface water samples were collected from each sampling station. The first sample was collected in four 40 mL VOA vials for VOC analysis, while the second sample was collected in one 250 mL plastic bottle for chloride analysis. Both samples were obtained by carefully immersing the sample bottles under the surface of the water. The four VOA vials were completely filled to remove any head space and limit evaporation during transport and storage. Great care was taken to avoid touching the soft substrate while filling the bottles to avoid suspending the sediment and contaminating the samples.

The four VOA vials were acidified in the field to pH < 2 using HCl, and stored on ice for return to the laboratory. The chloride sample was stored on ice without additional preservation. A duplicate VOC and chloride surface water sample were collected at PW-11. Note that the VOC duplicate consisted of another four VOA vials filled to the rim with surface water and acidified to pH < 2.

3.4.4 Sediment sampling

Two separate sediment samples were collected at each sampling station for VOC analysis. One composite sediment sample consisting of three subsamples was also collected from each sampling station for analysis of SVOCs, TAL metals, and TOC. All samples were collected from low-energy depositional areas around each sampling station to maximize the possibility of detecting contaminants.

The two samples for VOC analysis were collected first, as follows:

- VOC sample 1: A 10 mL sediment plug was collected by inserting a clean, 10 mL syringe with its tip cut off directly into the sediment bed and then carefully transferring the sample into a 40 mL Teflon-lined septum vial containing 10 mL of methanol (see Table 4 in QAPP Addendum for details). The vial was then tightly closed and placed on ice.

- VOC sample 2: A second sediment sample was collected in the same way and placed in a separate 40 mL VOC vial (this one without methanol) to determine the % moisture of the VOC sample. This sample was collected using a clean syringe, closed and placed on ice.

An Eckman dredge was then used to collect sediment for the last set of analyses (i.e. SVOCs, TAL metals, and TOC). Three 6" deep sediment samples were collected with the dredge and placed into a clean 20 L cubitainer with the top cut off. Coarse debris such as leaves, sticks, pebbles, or vegetation were removed from the cubitainer and discarded. Extra overlying water was poured off after settling to avoid losing fines. The sediment was then thoroughly homogenized with a clean plastic scoop and

distributed into labeled sample containers. Every effort was made to ensure that all of the sediment grabs had similar composition and were all collected in water < 1 ft deep. A duplicate composite sediment sample for SVOC, TAL metals, and TOC analyses was collected at station PW-11.

At location PW-11, the Eckman dredge was impractical to use because of excess woody debris. Instead, a clean plastic scoop was used to collect sediment within an area and depth equivalent to the Eckman dredge. This method was replicated with the duplicate sample as well.

The Eckman dredge was decontaminated between sampling stations but not between subsample collections at a given sampling station. The dredge was scrubbed with a brush and laboratory grade, non-phosphate detergent and tap water, rinsed 3 times with distilled deionized water and shook dry

The used soapy water and rinse water were captured and containerized for proper disposal at the NERL in North Chelmsford, MA.

A rinsate blank sample was collected at location PW-11 after the sediment sampling equipment was decontaminated. This sample was obtained by pouring 1 L of distilled deionized water over the cleaned equipment and collecting the runoff in a pre-labeled sample container. The rinsate blank was stored in the same cooler as all of the other samples. It will be analyzed for total metals and mercury at the NERL.

3.4.5 Invertebrate sampling

ESAT recorded the major habitat characteristics at each sample station on standardized habitat worksheets (see **Appendix B**). Additional descriptions were also recorded in the field logbook (see **Appendix A**). Several pictures of the habitats and sampling activities were also taken and can be viewed at G:\\ALLSHARE\ESATBIO\Commerce Street (VT).

3.4.5.1 Collecting infaunal invertebrates by sifting sediment samples

The VT DEC noted that silt, sand or gravel substrate should not be sampled as part of their standard protocol. As outlined in the next section, however, substrate was sampled around each sampling station in an effort to link sediment contamination to benthic invertebrate community composition. This method allows for a volumetric population comparison between sample stations because each subsample (i.e. core) has a definitive volume (3" high, 2 ½" diameter cylindrical dimension = 4.73 in^3 of sediment).

Four replicate sediment samples were collected in the vicinity of each sampling station using a percussion sediment corer. Each replicate sample consisted of four subsample cores collected near each other (making sure not to remove sediment from previous sediment grab sample holes). The benthic invertebrates collected from each set of four cores was combined into one replicate sample and preserved with 70% ethanol.

A 2 ½" diameter clear plastic core tube was placed into the sediment 3" deep, carefully pulled out and then emptied into a no. 30 sieve bucket. This was done four times for one replicate and all subsamples were placed into the same sieve bucket. The sieve bucket was then placed in the stream, making sure not to completely submerge it, and swirled around to rinse fines, such as clay, out of the sample. Leaf detritus was discarded. Any remaining sediment and organisms were placed into a labeled 1L plastic jar and preserved with 70% ethanol

In summary, four cores were collected from four locations per sampling station (16 cores per sampling station), resulting in at least 20 composite benthic invertebrate samples from Unnamed Stream (four composites per sampling station from five different sampling stations).

PW-11 underwent a full re-sample using the method described above in order to generate a duplicate infaunal invertebrate sample.

3.4.5.1 Collecting epifaunal invertebrates by sweep bottom kick net sampling

A kick net was used to collect a total of four jabs from representative habitats as described in the QAPP Addendum. Sampling was performed by jabbing the net into debris dams, vegetation, or root mats, pulling back rapidly to dislodge invertebrates, then sweeping forward again into the same area to scoop up the dislodged invertebrates. This jabbing and sweeping motion was repeated several times at the same point and considered one of four jabs. Each jab was taken in a general upstream direction from each subsequent point. All four jabs (from different points around the sample station) were combined into a single composite sample. Excess debris was first removed, and leaves and sticks were thoroughly rinsed off to prevent losing any attached bugs. The total contents were transferred to labeled sample bottle(s) and preserved in 70% - 80% ethanol. Two replicates were collected at each sample station and two replicates were collected at PW-11 as a duplicate sample.

The following habitats were sampled when present, as mentioned in the QAPP Addendum (see **Appendix A** field log notes for details of samples taken at each station):

- Vegetated margins – consist of overhanging bank vegetation and submerged root mats. Sampled by jabbing vigorously, with an upward motion, brushing the net against the vegetation and roots along the bank. The entire jab was taken place underwater as much as possible to avoid collecting terrestrial organisms.

- Snags and logs – consist of submerged wood, primarily dead trees, logs, branches, roots and leaf packs lodged between rocks or logs. Sampled by holding the net under the submerged wood, rubbing and shaking the area above the net and scooping organisms, bark, twigs and other dislodged organic matter into the net.

- Aquatic vegetation beds and decaying organic matter – consist of beds of submerged, green/leafy plants that are attached to the stream bottom. Sampled by jabbing vigorously, with an upward motion, against or through the plant bed. The net was kept under water as much as possible to avoid collecting terrestrial organisms.

3.4.6 Habitat assessment

The stream habitat at each sampling station was photographed and then described using the Habitat Assessment Field Data Sheet – Low Gradient Streams (see **Appendix C** for completed forms) using the descriptions and definitions provided in Chapter 5 (Habitat assessment and physicochemical parameters) of the Rapid Bioassessment Protocols (see QAPP Addendum). Note that the catchment area was not estimated for each sample location.

The habitat assessment field data sheet contains ten habitat parameters that were scored between a low of 1 (poorest condition) and a high of 20 (best possible condition). The data sheets were completed based on reaching a consensus between all of the field biologists participating in the sampling event.

4.0 SAMPLE PROCESSING AND ANALYSES

Proper paperwork, including labels and chain-of-custody forms, were maintained at all times during the project and follow the requirements outlined in Attachment 8 of the QAPP addendum.

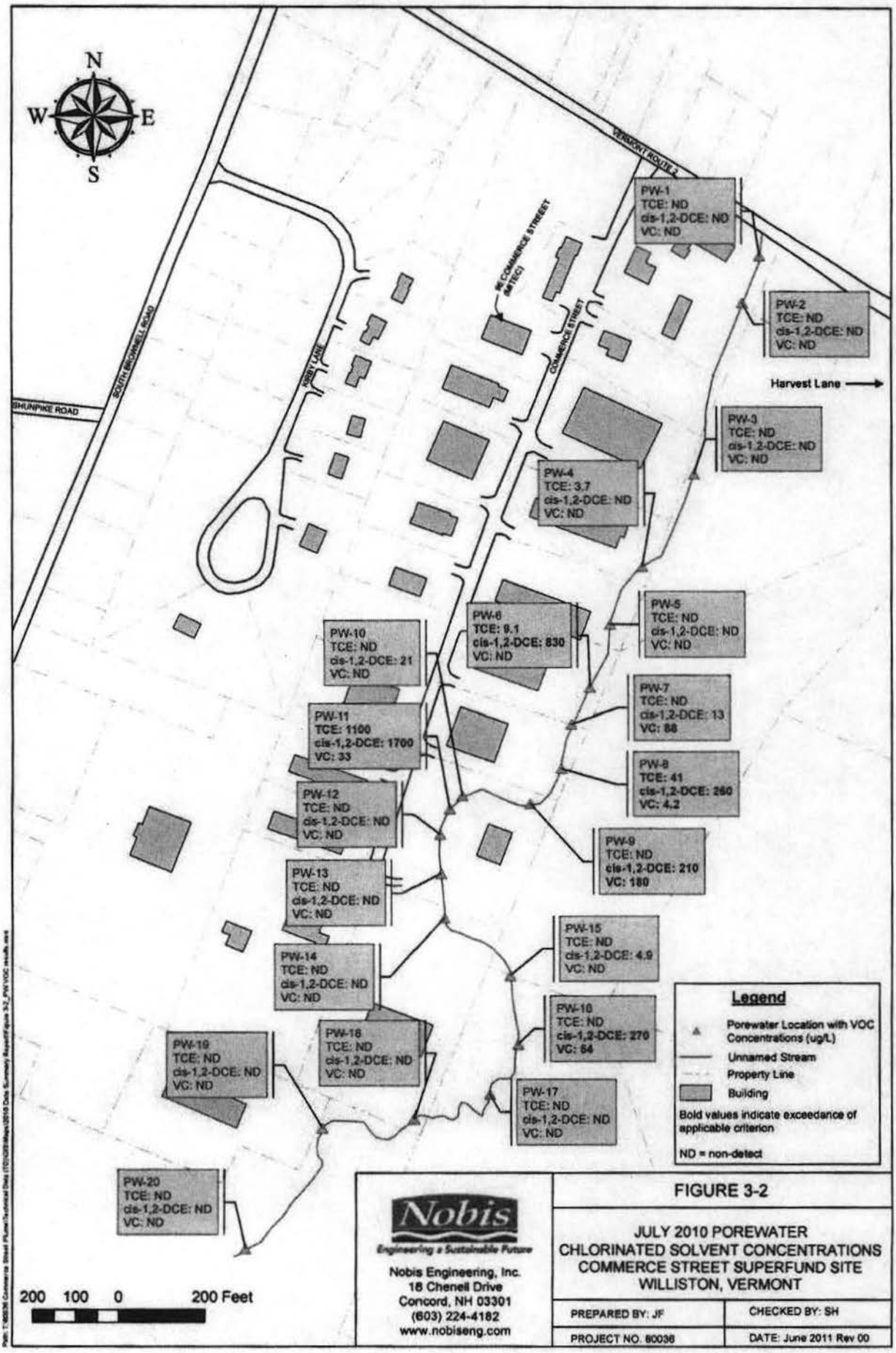
Labels were completed with the initials of the person collecting the sample, the date, and the jar number, when applicable. Labels were then wrapped in clear packing tape to protect them from water or ethanol damage and to prevent the label from accidentally detaching during transport and storage. Invertebrate samples were preserved with between 70%-80% ethanol, tightly closed, then sealed with electrical tape. Sediment and water samples were placed on ice in a cooler shortly after being collected. Ice was refreshed as necessary.

5.0 DEVIATIONS FROM THE QAPP

The following table summarizes the deviations from the QAPP or QAPP Addendum that occurred during the field sampling effort:

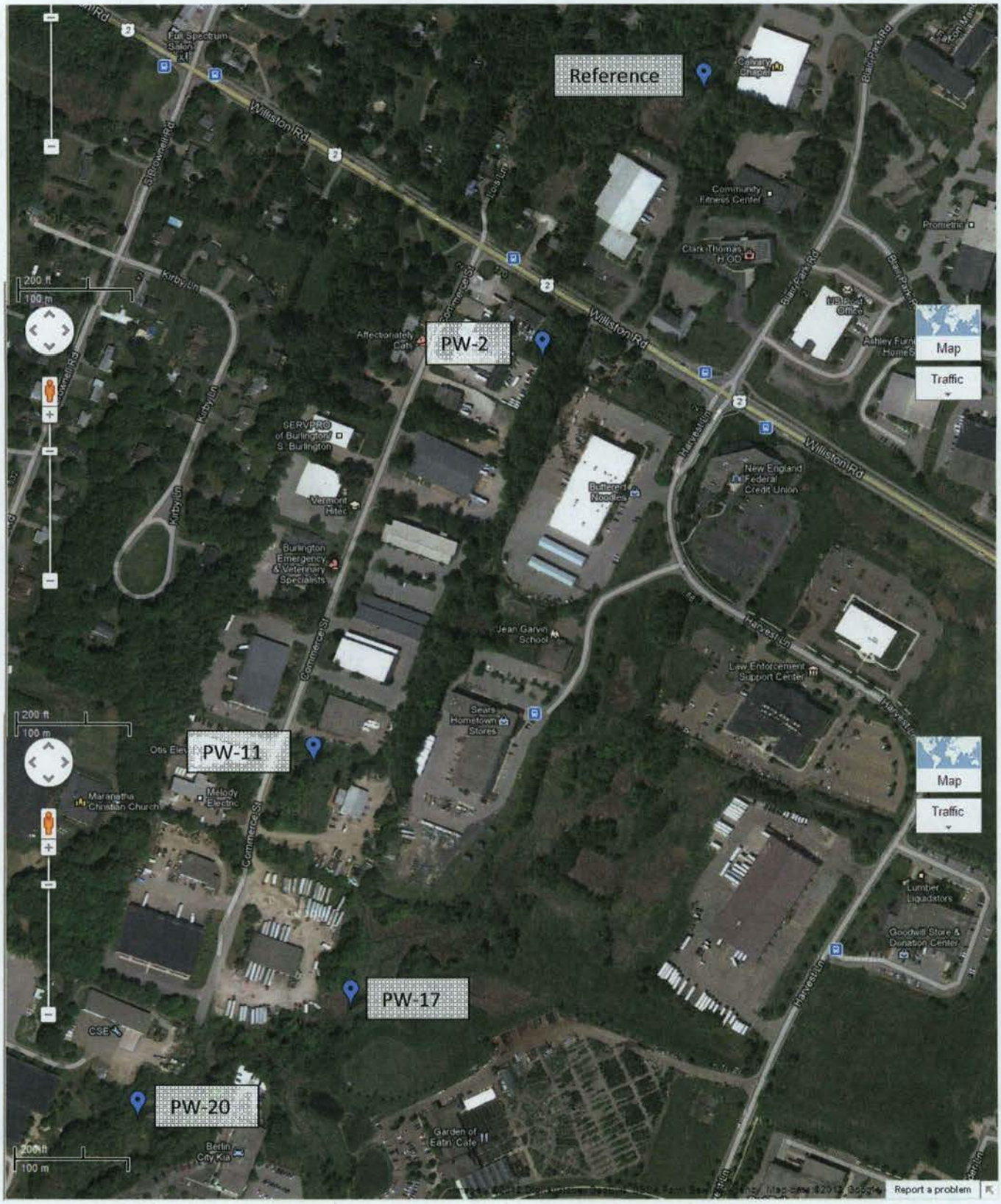
QAPP protocol	Deviation	Reason for deviation
1. Sample PW-1 as on-site reference	Sampled PW-2 in place of PW-1	PW-1 was not sampled because the stream was only a couple of inches deep and a about a foot wide, making it difficult to sample the surface water without disturbing the sediment.
2. Use 3" diameter core tube for infauna macroinvertebrate sample collection	Used a 2 ½" diameter core tube	Only 2 ½" diameter plastic core tubes were available. This does not impact the sample collection method other than changing the overall volume of the samples collected. Regardless of the change in core tube diameter, the same volume was collected across replicates.
3. No mention of collecting VOC trip blanks	Collected VOC trip blanks (deionized water from the lab)	This step was included because it is standard protocol according to the NERL SOP (EIASOP-VOAGCMS9 Rev.9 3/31/10)
4. Collect sediment VOC samples from the Eckman grab	Collected sediment VOC samples directly from the sediment bed	Removing the VOC sediment sample directly from the sediment bed insured less loss of VOCs upon extraction as the sediment was not as disturbed initially by the Eckman dredge. The water was only up to a foot deep at each location so it was easy to insert the syringe directly into the sediment bed.
5. Use Eckman or plastic sediment core tube for sediment collection	Used a clean plastic scoop at location PW-11 and it's duplicate	This was necessary because PW-11 was covered in woody debris. The Eckman may not have been able to penetrate the soil or close completely upon retrieval if a stick was in the way. Using a clean plastic scoop enabled the sampler to work around woody debris

Attachment 1. Nobis 2010 porewater sampling locations



Attachment 2. September 2012 sampling locations (as seen on Google maps)

*Note this is a combination of 3 maps placed together to show the full extent of sampling.



Attachment 3: Commerce Street: Field Surface Water Chemistry Results

Station	Analysis Date	Temperature (°C)	Conductivity (us/cm)	pH	D.O. (%)	D.O. (mg/L)
PW-20	9/11/2012	12.14	1916	7.42	73.5	7.82
PW-17	9/11/2012	15.52	2475	7.58	78.4	7.75
PW-11	9/12/2012	13.4	1004	7.57	76	7.92
PW-2	9/12/2012	16.83	916	7.85	88.2	8.51
Reference	9/13/2012	17.53	965	8.21	100.9	9.62

D.O. = dissolved oxygen

Qced: MCM 10·4·12

APPENDIX A

Field Logbook Notes

9/10/12 BGK, MCM, LB, MF, ~~Steve~~ Rick Sougat BGK 9.10.12

Commerce St. arrival @ 1240
part cloudy, cool, no rain.
→ Met Rick (EPA) upon arrival.

~~PW-20~~ ~~44.44655522~~ MCM
~~-73.12387937~~ 9.10.12
~~Taken right @ Nobis loc.~~
~~Stake found ~20ft~~
~~upstream (unmarked~~
~~wooden)~~
~~Photos: #810, #811~~
~~(red Nikon)~~

(±1m)
PW-20: 44.44658066 N
-73.12380091 W
- Flagging moved up to location with unmarked wooden stake
- Entered stream near old wooden steps

Met with Steve Fisk of VT DEC @ 1400 showed VT method of sampling

9.10.12 MCM, BGK, MF, LB, RS

PW-17: placed flags at stake
N: ~~44.44476745907~~ mcm 9.10.12
mcm 9.10.12 ~~N~~ N: 44.44745849
W: -73.12147299
(± 65 cm)
walked in by trucks

PW-11: placed flag at stake
N: 44.4493829
W: -73.12188230
walked in by large tree and woodchips

PW-01: placed flag at stake
N: 44.45291114
W: -73.11912540
walked in behind house

Left @ 1700

(Ted Delong met crew around 11:00)
↳ Avatar

9.11.12 MF, BGK, MCM, LB, RS
Commerce Street Arrival @0814
Sunny ~45°F, No rain

YSI Sonde 556 calibration:
pH: 4.0 std.: 4.0
10.0 std.: 10.0
7.0 check: 7.00 ✓
conductivity: 100 µS/cm (chk): ✓
(cal) 1000 µS/cm: 1000 µS/cm
DO: 103.1% ✓ calibrated at 100%

At PW-20: 9:40 am partly cloudy no rain

Temp: 12.14°C VOA (SW) @ 0950 AM
Cond: 1916 µS/cm
PH: 7.42
DO: 73.5% 7.82 mg/L (not calibrated)

photos: #596 + 597
(2728.JPG + 2729.JPG)
- facing East

sediment VOCs collected @ 1020
sediment grabs (3) taken
@ 1025 - Sample jars filled (3)

All samples taken to cooler after sed ~~core~~ grabs sampled
BGK 9.11.12

9.11.12 BGK, MCM, LB, RS, Tod Delong (Avatar)

PW-20 (Rep1)

Macroinverts (sediment) taken @ 10:42. Took 4 plugs, 3" deep, 2½" diameter. Placed in 500 µm sieve bucket. Sediment noted to plug sieve so slow to drain sample.
- C. tentan larvae, small clam noted. Not much else. + decaying leaf matter. Fines rinsed out.

Rep2 @ 11:00 (4 plugs) 3" deep, 2½" diam.
- a few clams

Rep3 @ 11:05 (4 plugs)
- gas bubbles released on insertion
- a few clams, not much else

Rep4 @ 11:10 (4 plugs)
- slight bubbling upon insertion

Habitat (Ben inverts) - overhanging vegetation on most banks. [alders = shade, nightshade, grasses, jewelweed all over, sensitive fern] muddy, decaying vegetation. some ~~logs~~ sticks

9.11.12 BGK, MCM, LB, RS, TD PW-20

Rep 1

Aquatic macros @ 11:22 (PW-20) → MF sampled
- Jabbed bank w/roots + some overhanging veg x2
- let salamander go.
- Jabbed overhanging veg
- Jabbed log jam w/leaf pack (downstream of PW-20) up to 15m downstream after starting @ sampling location for sed/sw/Ben. macros.
- let small fish (unidentifiable) go.
- couple small crayfish noted.

1 Jar

Rep2 Aquatic macros @ 11:34 (PW-20) - MF sampled.

2 Jars

- overhanging veg/root mat
- undercut root mat
- noted water striders
- log jam. no leaf pack x2
- noted longnose dace + odonates
- noted crayfish, odonates
- sampled a little past where rep1 was taken. (~16/17m?)

→

9.11.12 BGK, MCM, LB, MF, TD

PW-17 @ 1426:

YSI Sonde
pH: 7.58
Temp: 15.52°C
Cond: 2475 µS/cm
DO: 78.4%, 7.75 mg/L

-VOA (SW) sample (4) taken at 2:30pm

Chloride (SW) taken @ 1435

Sediment (VOA) taken @ 1439

Sediment grab w/ Eckman for 3 analyses taken @ 1436
-3 grabs. Composited in cut out cubitainer w/ clean plastic scoop. Distributed into amber glass jars.
All H_2O + Sed samples taken to cooler w/ ice @ 1540

AQ Inv Rep1:
Jab #1: undercut rootmat
Jab #2: undercut (overhanging veg) with rootmat
Jab #3: undercut with rootmat + overhanging veg
Jab #4: overhanging veg + root mat
→ All along same bank.

sediment plug 1 @ 1500
~~5~~ 8 plugs MCM 9.11.12

9.11.12 BGK, MCM, LB, MF

sediment plugs (3rd set of 4) = much finer (clay) @ 1530

observed 4 spine? stickleback in ~~trt team~~ AQ Inv Jab Rep1 BGK 9.11.12

AQ Inv Rep2:
-Jab #1
-Jab #2
-Jab #3
} undercut rootmat with overhanging vegetation
-Jab #4: macrophyte

Left site @ 1644

~~9.12.12 MCM, BGK, LB, MF~~
~~YSI sonde 556 calibration~~
MCM 9.12.12

9.12.12 MCM, BGK, LB, MF, RS
Commerce Street Arrival @ 0834 sunny ~55°F
Parked in Aquatec parking lot with permission

YSI 556 Sonde Calibration 0851
pH: 4.0 cal: 4.00 ✓
10.0 cal: 10.00 ✓
7.0 check: 7.04 ✓
conductivity: 1000 µm/cm c cal ✓
100 µm/cm c chk: 1092
D.O.: 102.1% ✓ cal @ 100%

PW-11 @ 1010
YSI sonde
pH: 7.57
cond: 1004 µ1/cm c
DO%: 76
DO mg/L: 7.92
Temp: 13.40°C
Surface water VOCs collected @ 1023 - MF
- Dups also collected for surface water VOCs @ PW-11 @ 1025

9.12.12 MF, BGK, LB, MCM, RS

Sediment VOCs + Dup collected @ 1036 - MF @ 1038

Eckman Grabs taken @ 1043
- too much woody debris, scoop used instead (within area equivalent to Eckman and depth of 6 in)
Dup also @ 1043

Sediment plugs taken @ 1106 Rep 1
~~Dups @ 1113~~ mcm 9.12.12 Dup 1 @ 1146
Rep 2 @ 1113 Dup 2 @ 1152
Rep 3 @ 1128 Dup 3 @ ~~1159~~ 1214 mcm 9.12.12
Rep 4 @ 1129 Dup 4 @ 1216

AQ Inv Rep 1: 2 jars ~~(1 of 2)~~
Jab #1: Undercut rootmat, overhanging veg, immergent aquatic macrophytes @ 1239
Jab #2: leaf pack, stick jam @ 1241
Jab #3: woody debris
→ crayfish found
→ stickelback
Jab #4: veg rootmat

9 12 12 MCM BGK, LB, MF, RS
~~Dup~~ Aq Inv Rep ~~#2~~ #2: ~~2 jars~~ 2 jars ~~2 jars~~ ~~(2 of 2)~~
JAB #1 - submergent, emergent aquatic veg
- 2 stickleback
- crawfish
JAB #2 - woody debris
JAB #3 - woody debris
JAB #4 - aquatic veg
@ 1:30

Dup Aq Inv Rep #1: ~~(1 of 2 jars)~~ ~~2 jars~~
JAB #1 - overhanging veg
JAB #2 - emergent macrophyte
JAB #3 - root mat
JAB #4 - overhanging veg
@ 1:38

Dup Aq Inv Rep #2: ~~(2 of 2 jars)~~ 2 jars
JAB #1 - root mat
JAB #2 - overhanging veg: root mat
JAB #3 - undercut with root mat
JAB #4 -

9.12.12 MCM, LB, BGK, MF
PW2 @ 1551
Sonde YSI Data @ 1551
pH: 7.85
Cond: 916 µs/cm
DO% 88.2
DO mg/L 8.51
Temp (°C): 16.83
Site switched from PW1 to PW2 to provide better sampling conditions. Decision confirmed with Rick Sugat of EPA

Rinsate blank on deconed Eckman + scoop @ 1415 after PW-11 and placed in cooler.

New VOC pH blank
- 4 drops of HCl added to make sure pH still less than 2 done because of higher pH @ this site pH @ 2 use 5 drops to preserve.

Surface H_2O VOCs collected @ 1557 (4 VOCs)

9.12.12 MF, LB, BGK, MCM

Chloride sample taken @ 1601

Sediment VOCs collected @ 1602
(and sample for % solids)

3 Eckman Grabs taken @ 1606
(Rctr, ctr, Lctr across station)

Photos: 2755.jpg - PW02 transect
2756.jpg - PW2 full transect
(both taken to East)

GPS point @ PW2 (taken by stake w/flagging left by Nobis for Pore water sample)
N: 44.45264118
W: -73.11935145
(±) 1.2 m

Sediment plugs taken @ 1629
(4 plugs) Rep 1
replicate 2 plugs taken @ 1630
(4 plugs) Rep 2
replicate 3 plug taken @ 1647
(4 plugs) Rep 3
replicate 4 plug taken @ 1653
(4 plugs) Rep 4

9.12.12 MF, LB, BGK, MCM

Rep 1 Jabs: @ 1702
~10 m up 1: 2758.jpg NW
~~15~~ 12 m up 2: 2760.jpg NW
~~17~~ 13 m up 3: 2761.jpg SE
~~20~~ 14 m up 4: 2762.jpg NE
All @ Log jams upstream of transect
crayfish + odonate in 1st rep

Rep 2 Jabs @ 1704
~10 m 1: undercut hanging roots
~12 m 2: woody debris, crayfish, fish
~~MCM 9.12.12 3~~ (small stickleback)
3: sticks and leafpack
4: submerged woody debris and leafpack

PW1
2763.jpg } (NE)
2764.jpg }
Photos of transect PW1 to verify reason for moving to PW2

Deconed Eckman and preserved samples with 80% EtOH

Left site @ 1800

9.13.12 BGK, MCM, LB, MF, RS

Reference location:

Arrival @ 0820. Parked in parking lot of Vermont Plastic Specialists, Inc. Rick S. got permission from Rich Watson (802-879-0072) @ 209 Blair Park in Williston, VT

YSI Sonde Calibration:

pH: 4.00 Cal
10.00 Cal
7.00 Cal check: 6.99 ✓
Conductivity: 1000 um/cm Cal
1000 us/cm 1095 ✓
DO Cal % @ 100% ✓
DO Cal Check: 100.8%, 9.65 mg/L

walked down to reference location @ 0951

Reference

Sonde YSI 556 Data
pH: ~~8.17~~ 8.21 MCM 9.13.12
cond (µs/cm²): ~~960~~ 965 MCM 9.13.12
DO%: 100.9
DO mg/L: 9.62
Temp (°C): ~~17.45~~ 17.53 MCM 9.13.12

9.13.12 BGK, MCM, LB, MF, RS

Ref GPS coord
N: 44.45478218
W: -73.11757334
(in back of plastics building past loading dock)

New pH blank done due to high pH @ 1037
5 drops HCl into blank = 1.5 on pH paper
will continue to add 5 drops to VOC samples

Surface H_2O VOCs taken @ 1040

sediment Eckman grabs @ 1044 - 3 grabs down center channel

Rep 1 sediment plugs @ 1058
Rep 2 sediment plugs @ 1058
Rep 3 sediment plugs @ 1111
Rep 4 sediment plugs @ 1115

Rep 2 plugs 1 in thick organic layer with sand. Dark gray

9.13.12 MCM, BGK, MF, LB
silt sand mix as well. Tentan larvae

Rep 1 sed plug - chunks of clay

Rep 3 sed. plug - silt, sand, clay

water column invert samp

Rep 1:

Jab 1: Damselfly, Dragonfly larvae, other odonates, snails. Macrophytes, submerged rootmat with overhanging vegetation. @ 1116 ~5m upstr.
Mollusca + arthropoda represented phyla

Jab 2: submerged woody debris ~6m upstream submerged woody debris and overhanging vegetation @ 1122
~~submerged rootpack with detritus~~ mcm 9.13.12

~7m up Jab 3: submerged rootmat with detritus. @ 1123

~8m up Jab 4: small leafpack in small wood jam @ 1125

9.13.12 MCM, BGK, LB, MF

Rep 2:

Jab 1: exposed aquatic rootmat and overlying vegetation @ 1130
Some litter found in net. (Plastic bag and styrofoam, bubblewrap) ~6m up

Jab 2: some woody debris exposed aquatic rootmat and overlying veg ~7m up
plastic bag + metal post found submerged @ 1132
metal can set in bank

Jab 3: leaf mat with woody debris @ 1135 ~9m up

Jab 4: exposed aquatic rootmat. Leaf litter and woody debris @ 1136 ~10m upstream

Dace found in rep 2 jabs
Caddisfly found in rep 1 jabs

Stream not channelized but @ overflow conditions will become march.
* Left site @ 1250

APPENDIX B

Lotic Benthos Field Sheets

(ESAT & Steve Fiske copies)

LOTIC BENTHOS FIELD SHEET
(2011 edition)

BioLab ID _____
Chem LabID _____

Site Name Muddy Brook (Unnamed Stream) River Mile _____
Site ID PW-20 Trib4
Date 9·11·12 Time 11:08 Crew MF, BGK, LB, MCM
Site Description Large riparian width

Town: Williston, VT Stream Order: _____ Drainage Area: _____ Km^2 Elevation: _____ ft
D.D° Latitude: 44.44658066 Longitude: -73.12380091 Lat/Long source (GPS – set to NAD83:) _____
Weather: partly cloudy Flow/Weather Previous (2 weeks/2days): Heavy rain/partly cloudy
Surrounding Land Use: commercial + industrial

SAMPLING INFORMATION chest
Sampler: MF Gear: waders
Effort Time: ____ min Mesh: 500 um
Area: _____ m^2 Quantitative: Y / N
#Reps: _____ Comp/rep: ____

Qual. PERIPHYTON COVER for each type 0-100% (*See back for Periphyton Cover Form*)
Diatom _____% Filamentous Green _____% and length _____in
Blue Green _____% Moss _____% Green _____% Other _____%

General Trophic Rating: _____ (0=oligo, 5=Eutroph)

EMBEDDEDNESS
(5) 0-5% Excel (4) 5-25% V Good (3) 25-50% Good (2) 50-75% Fair (1) > 75% Poor Estimate 100 %
Silt Rating: 3 (0=none, 5= chocolate) CPOM Rating (leaf packs): 1 (0= none,5=high)
Lg Woody Debris (>4"dia) #: ~~15~~ <5% /100m (reach)
~~<50%~~ MCM 9.11.12

GENERAL WATER TYPE Riffle, Winder, or Other _____ Warm, Cold, or Mixed Channelized: Y / N Upstream Dam: Y / N ____mi
B.F.Width: 2.55 (m) Wetted Width: 2.25 (m) Riffle Depth: 0.5 (m) Pool Depth: _____(m) and Obs: _____
Bank Stability: EX VG G F Velocity estimate (circle): (S) <0.4 ft/sec, (M) 0.4-2 ft/sec, (F) >2 ft/sec Measured: _____ ft/sec

Riparian VEGETATION (both sides, does not need to add up to 100%) Riparian Width (facing upstream) L 718 m, R 718 m
Overstory: Softwood 0 % Hardwood 30 % Understory: Shrub (brush) 25 % Grass 0 % Herbaceous 75 %
Canopy %: 100 90 80 70 60 50 40 30 20 10 0 Overhead: Open, Partly Open, or Closed

WATER QUALITY PARAMETERS Sampler: BGK Meter (type, #) YSI 556 sonde
Baseflow or Freshet Flow Present Flow: H - M – L Annotate? Y / N
Temp Air ~16 °C °F Temp Water 12.14 °C fpH 7.42 lab pH _____ fCond 1916 D.O.% 73.5 D.Omg/l 7.82 Color slightly Milky
Cond pH Alk TP DP Cl ICAnions Turb TN N02-3 Ca Mg Na K Hardness Metals, TNH3, TSS Other _____, _____,
_____, _____, _____, _____, _____, _____, _____

SITE SKETCH & GENERAL OBSERVATIONS (circle those that apply) Overall Aesthetic Rating 0 (poor) – 5 (exc.) 4

A – Pollution: Sludge | Sawdust | Paper Fiber | Sand | Silt | Sewage | Oily Sheen | Trash | Iron | Scum | None
B – Water Clarity: Clear | Slightly Turbid | Moderately Turbid | Very Turbid | Secci Tube_____mm
C – Water Color: Clear | Green Milky | Brown (Tannic) L M H | Gray | Metallic | Reddish
D – Odors: None | Musty | Fishy | Sewage | Manure | Sulfur(eggs) | Oily/gas
Aquatic Biota Observed: Mussels, Crayfish, Gastropods, Fish, Other

small fish, crayfish, salamander, clams
see field log book

(ESAT)

Field Sheet Complete: MCM (initial)
Photos: Y / N
Fish Survey Conducted: Y / N

LOTIC BENTHOS FIELD SHEET
(2011 edition)

BioLab ID _____
Chem LabID _____

(Unnamed Stream)

Site Name Muddy Brook Tributary #4 River Mile _____
Site ID PW-17
Date 09-11-12 Time 1440 Crew MF, BGK, LB, MCM
Site Description Large riparian zone

Town: Williston, VT Stream Order: _____ Drainage Area: _____ Km^2 Elevation: _____ ft
D.D° Latitude: 44.44745849 Longitude: -73.12147299 Lat/Long source (GPS – set to NAD83:) _____
Weather: Sunny ~75°F Flow/Weather Previous (2 weeks/2days): heavy rain / partly cloudy
Surrounding Land Use: _____

SAMPLING INFORMATION **Qual. PERIPHYTON COVER** for each type 0-100% (*See back for Periphyton Cover Form*)
Sampler: BGK/MF Gear: Chestwader VT method Diatom _____% Filamentous Green _____% and length _____in
Effort Time: ____ min Mesh: 500 um Blue Green _____% Moss _____% Green _____% Other _____%
Area: _____ m^2 Quantitative: Y / N
#Reps: _____ Comp/rep: ____ General Trophic Rating: _____ (0=oligo, 5=Eutroph)

EMBEDDEDNESS
(5) 0-5% Excel (4) 5-25% V Good (3) 25-50% Good (2) 50-75% Fair (1) > 75% Poor Estimate 100 %
Silt Rating: 4 (0=none, 5= chocolate) CPOM Rating (leaf packs): 0 (0= none,5=high)
Lg Woody Debris (>4"dia) #: 0 /100m (reach)

GENERAL WATER TYPE Riffle, Winder, or Other _____ Warm, Cold, or Mixed Channelized: Y / N Upstream Dam: Y / N ____mi
*B.F.Width: 1.7 (m) Wetted Width: 1.8 (m) Riffle Depth: 0.2 (m) Pool Depth: _____(m) and Obs: _____
Bank Stability: EX VG G F Velocity estimate (circle): (S) <0.4 ft/sec, (M) 0.4-2 ft/sec, (F) >2 ft/sec Measured: _____ ft/sec

Riparian VEGETATION (both sides, does not need to add up to 100%) Riparian Width (facing upstream) L 718 m, R >18 m
Overstory: Softwood 0 % Hardwood 0 % Understory: Shrub (brush) 0 % Grass 0 % Herbaceous 100 %
Canopy %: 100 90 80 70 60 50 40 30 20 10 0 Overhead: Open, Partly Open, or Closed

WATER QUALITY PARAMETERS Sampler: MF Meter (type, #) YSI 556 Sonde
Baseflow or Freshet Flow Present Flow: H - M – L Annotate? Y / N
Temp Air ~75 °C/°F Temp Water 15.52 °C fpH 7.58 lab pH _____ fCond 2475 D.O.% 78.4 D.Omg/l 7.75 Color clear
Cond pH Alk TP DP Cl ICAnions Turb TN N02-3 Ca Mg Na K Hardness Metals, TNH3, TSS Other _____, _____,
_____, _____, _____, _____, _____, _____, _____

SITE SKETCH & GENERAL OBSERVATIONS (circle those that apply) Overall Aesthetic Rating 0 (poor) – 5 (exc.) 3

A – Pollution: Sludge | Sawdust | Paper Fiber | Sand | Silt | Sewage | Oily Sheen | Trash | Iron | Scum | None
B – Water Clarity: Clear | Slightly Turbid | Moderately Turbid | Very Turbid | Secci Tube_____mm
C – Water Color: Clear | Green Milky | Brown (Tannic) L M H | Gray | Metallic | Reddish
D – Odors: None | Musty | Fishy | Sewage | Manure | Sulfur(eggs) | Oily/gas
Aquatic Biota Observed: Mussels, Crayfish, Gastropods, Fish, Other Stickleback see ~~attached~~ field log book

mcm 9.11.12

*BF width shorter because of undercut

(ESAT)

Field Sheet Complete: _____ (initial)
Photos: Y / N
Fish Survey Conducted: Y / N

LOTIC BENTHOS FIELD SHEET
(2011 edition)

BioLab ID _____
Chem LabID _____

(Unnamed Stream)

Site Name Muddy Brook Tributary 4 River Mile _____
Site ID PW-11
Date 9.12.12 Time 1113 Crew MF, BGK, mcm, LB
Site Description Near street and parking lot of Aquatec

Town: Williston, VT Stream Order: _____ Drainage Area: _____ Km^2 Elevation: _____ ft
D.D° Latitude: 44.4493829 Longitude: -73.12188230 Lat/Long source (GPS – set to NAD83:) _____
Weather: sunny, clear Flow/Weather Previous (2 weeks/2days): clear/sunny
Surrounding Land Use: commercial/industrial partly cloudy at times/ Heavy rain past 2 wks

SAMPLING INFORMATION Chest waders
Sampler: MF Gear: waders
Effort Time: ____ min Mesh: 500 um
Area: _____ m^2 Quantitative: Y / N
#Reps: _____ Comp/rep: ____

Qual. PERIPHYTON COVER for each type 0-100% (*See back for Periphyton Cover Form*)
Diatom _____% Filamentous Green _____% and length _____in
Blue Green _____% Moss _____% Green _____% Other _____%
General Trophic Rating: _____ (0=oligo, 5=Eutroph)

EMBEDDEDNESS
(5) 0-5% Excel (4) 5-25% V Good (3) 25-50% Good (2) 50-75% Fair (1) > 75%Poor Estimate 100 %
Silt Rating: 2 (0=none, 5= chocolate) CPOM Rating (leaf packs): X3 (0= none,5=high)
mcm 9.12.12
Lg Woody Debris (>4"dia) #: 4 /~~100m~~ (reach) 11.3 m

GENERAL WATER TYPE Riffle, Winder, or Other _____ Warm, Cold, or Mixed Channelized ~~Y~~ / N Upstream Dam: Y / N ____mi
B.F.Width: 1.8 (m) Wetted Width: 1.0 (m) Riffle Depth: 0.2 (m) Pool Depth: _____(m) and Obs: _____
Bank Stability: EX VG G F Velocity estimate (circle): (S) <0.4 ft/sec, (M) 0.4-2 ft/sec, (F) >2 ft/sec Measured: _____ ft/sec

Riparian VEGETATION (both sides, does not need to add up to 100%) Riparian Width (facing upstream) L ~~5~~ 18 m, R ~~5~~ ~12 m mcm 1.12.12
Overstory: Softwood 0 % Hardwood 55 % Understory: Shrub (brush) 20 % Grass 0 % Herbaceous 80 %
Canopy %: 100 90 80 70 60 50 40 30 20 10 0 Overhead: Open, Partly Open, or Closed

WATER QUALITY PARAMETERS Sampler: MF + BGK Meter (type, #) YSI Sonde 556
Baseflow or Freshet Flow Present Flow: H M – L Annotate? Y / N
Temp Air ~82 °C/°F Temp Water 13.40 °C fpH 7.57 lab pH _____ fCond 1004 D.O.% 76 D.Omg/l 7.92 Color clear
Cond pH Alk TP DP Cl ICAnions Turb TN N02-3 Ca Mg Na K Hardness Metals, TNH3, TSS Other _____, _____,
_____, _____, _____, _____, _____, _____, _____

SITE SKETCH & GENERAL OBSERVATIONS (circle those that apply) Overall Aesthetic Rating 0 (poor) – 5 (exc.) 3

A – Pollution: Sludge | Sawdust | Paper Fiber | Sand | Silt | Sewage | Oily Sheen | Trash | Iron | Scum | None
B – Water Clarity: Clear | Slightly Turbid | Moderately Turbid | Very Turbid | Secci Tube_____mm
C – Water Color: Clear | Green Milky | Brown (Tannic) L M H | Gray | Metallic | Reddish
D – Odors: None | Musty | Fishy | Sewage | Manure | Sulfur(eggs) | Oily/gas
Aquatic Biota Observed: Mussels, Crayfish, Gastropods, Fish, Other

crayfish, stickleback

see field log book

(ESAT)

Field Sheet Complete: MCM (initial)
Photos: Y / N
Fish Survey Conducted: Y / N

LOTIC BENTHOS FIELD SHEET
(2011 edition)

BioLab ID _____
Chem LabID _____

(Unnamed Stream)

Site Name Muddy Brook Tributary 4 River Mile _____
Site ID PW2
Date 9.12.12 Time 1710 Crew MCM, MF, LB, BGK
Site Description behind building

Town: Williston, VT Stream Order: _____ Drainage Area: _____ Km^2 Elevation: _____ ft
D.D° Latitude: 44.45264118 Longitude: -73.11935145 Lat/Long source (GPS – set to NAD83:) _____
Weather: Clear/sunny Flow/Weather Previous (2 weeks/2days): Heavy rain/partly cloudy
Surrounding Land Use: commercial + industrial ~50%

SAMPLING INFORMATION Chest waders
Sampler: MF Gear: Net
Effort Time: ____ min Mesh: 500 um
Area: _____ m^2 Quantitative: Y / N
#Reps: _____ Comp/rep: ____

Qual. PERIPHYTON COVER for each type 0-100% (*See back for Periphyton Cover Form*)
Diatom _____% Filamentous Green _____% and length _____in
Blue Green _____% Moss _____% Green _____% Other _____%
General Trophic Rating: _____ (0=oligo, 5=Eutroph)

EMBEDDEDNESS
(5) 0-5% Excel (4) 5-25% V Good (3) 25-50% Good (2) 50-75% Fair (1) > 75%Poor Estimate 100 %
Silt Rating: 2 (0=none, 5= chocolate) CPOM Rating (leaf packs): 1 (0= none,5=high)
Lg Woody Debris (>4"dia) #: 5 ~~/100m~~ (reach) MCM 9.12.12 14.6 m
All sand/silt

GENERAL WATER TYPE Riffle, Winder, or Other _____ Warm, Cold, or Mixed Channelized: Y / N Upstream Dam: Y / N ____mi
B.F.Width: 2.7 (m) Wetted Width: 1.7 (m) Riffle Depth: 0.17 (m) Pool Depth: _____(m) and Obs: _____
Bank Stability: EX VG G F Velocity estimate (circle): (S) <0.4 ft/sec, (M) 0.4-2 ft/sec, (F) >2 ft/sec Measured: _____ ft/sec

Riparian VEGETATION (both sides, does not need to add up to 100%) Riparian Width (facing upstream) L ~6 m, R >18 m
Overstory: Softwood 0 % Hardwood 90 % Understory: Shrub (brush) 0 % Grass 10 % Herbaceous 90 %
Canopy %: 100 90 80 70 60 50 40 30 20 10 0 Overhead: Open, Partly Open, or Closed mostly closed

WATER QUALITY PARAMETERS Sampler: BGK Meter (type, #) YSI 556 Sonde
Baseflow or Freshet Flow Present Flow: H - M - L Annotate? Y / N
Temp Air 75 °C/°F Temp Water 16.83 °C fpH 7.85 lab pH _____ fCond 916 D.O.% 88.2 D.Omg/l 8.51 Color clear
Cond pH Alk TP DP Cl ICAnions Turb TN N02-3 Ca Mg Na K Hardness Metals, TNH3, TSS Other _____, _____,
_____, _____, _____, _____, _____, _____, _____

SITE SKETCH & GENERAL OBSERVATIONS (circle those that apply) Overall Aesthetic Rating 0 (poor) – 5 (exc.) 2

A – Pollution: Sludge | Sawdust | Paper Fiber | Sand | Silt | Sewage | Oily Sheen | Trash | Iron | Scum | None
B – Water Clarity: Clear | Slightly Turbid | Moderately Turbid | Very Turbid | Secci Tube_____mm
C – Water Color: Clear | Green Milky | Brown (Tannic) L M H | Gray | Metallic | Reddish
D – Odors: None | Musty | Fishy | Sewage | Manure | Sulfur(eggs) | Oily/gas
Aquatic Biota Observed: Mussels, Crayfish, Gastropods, Fish, Other

crayfish, fish (stickleback), odonates

see field log book

(ESAT)

Field Sheet Complete: MCM (initial)
Photos: Y / N
Fish Survey Conducted: Y / N

LOTIC BENTHOS FIELD SHEET
(2011 edition)

BioLab ID _____
Chem LabID _____

(Unnamed Stream)

Site Name Muddy Brook Trib 4 River Mile _____
Site ID Reference
Date 9.13.12 Time 0955 Crew MF BGK LB MCM
Site Description behind loading dock (@ Vermont Plastics, 209 Blair Park Rd)

Town: Williston, VT Stream Order: _____ Drainage Area: _____ Km^2 Elevation: _____ ft
D.D° Latitude: 44.45478218 Longitude: -73.11757334 Lat/Long source (GPS – set to NAD83:) _____
Weather: Clear/sunny Flow/Weather Previous (2 weeks/2days): sunny/~~no~~ heavy rain
Surrounding Land Use: industrial + commercial MCM 10.2.12

SAMPLING INFORMATION
Sampler: MF Gear: _____
Effort Time: ____ min Mesh: 500 um
Area: _____ m^2 Quantitative: Y / N
#Reps: _____ Comp/rep: ____

Qual. PERIPHYTON COVER for each type 0-100% (*See back for Periphyton Cover Form*)
Diatom _____% Filamentous Green _____% and length _____in
Blue Green _____% Moss _____% Green _____% Other _____%

General Trophic Rating: _____ (0=oligo, 5=Eutroph)

EMBEDDEDNESS
(5) 0-5% Excel (4) 5-25% V Good (3) 25-50% Good (2) 50-75% Fair (1) > 75%Poor Estimate 100 %
Silt Rating: 1 (0=none, 5= chocolate) CPOM Rating (leaf packs): 1 (0= none,5=high)
Lg Woody Debris (>4"dia) #: 2 /~~100m~~ (reach) MCM 9.13.12 14m

GENERAL WATER TYPE Riffle, Winder, or Other _____ Warm, Cold, or Mixed Channelized: Y / N Upstream Dam: Y / N ____mi
B.F.Width: 2.3 (m) Wetted Width: 1.7 (m) Riffle Depth: 0.26 (m) Pool Depth: _____(m) and Obs: _____
Bank Stability: EX VG G F Velocity estimate (circle): (S) <0.4 ft/sec, (M) 0.4-2 ft/sec, (F) >2 ft/sec Measured: _____ ft/sec

Riparian VEGETATION (both sides, does not need to add up to 100%) Riparian Width (facing upstream) L ~~16~~ 12 m, R 18 m MCM 9.13.12
Overstory: Softwood 0 % Hardwood 40 % Understory: Shrub (brush) 0 % Grass 40 % Herbaceous 60 %
Canopy %: 100 90 80 70 60 50 40 30 20 10 0 Overhead: Open, Partly Open, or Closed

WATER QUALITY PARAMETERS Sampler: BGK Meter (type, #) YSI 556 sonde
Baseflow or Freshet Flow Present Flow: H - M - L Annotate? Y / N
Temp Air ~70 °C, °F Temp Water 17.53 °C fpH 8.21 lab pH _____ fCond 965 D.O.% 100.9 D.Omg/l 9.62 Color Clear
Cond pH Alk TP DP Cl ICAnions Turb TN N02-3 Ca Mg Na K Hardness Metals, TNH3, TSS Other _____, _____,
_____, _____, _____, _____, _____, _____, _____

SITE SKETCH & GENERAL OBSERVATIONS (circle those that apply) Overall Aesthetic Rating 0 (poor) – 5 (exc.) 3
Loading Dock in view

A – Pollution: Sludge | Sawdust | Paper Fiber | Sand | Silt | Sewage | Oily Sheen | Trash | Iron | Scum | None
B – Water Clarity: Clear | Slightly Turbid | Moderately Turbid | Very Turbid | Secci Tube_____mm
C – Water Color: Clear | Green Milky | Brown (Tannic) L M H | Gray | Metallic | Reddish
D – Odors: None | Musty | Fishy | Sewage | Manure | Sulfur(eggs) | Oily/gas
Aquatic Biota Observed: Mussels, Crayfish, Gastropods, Fish, Other

odonates and snails
Dace species
see field log book

(ESAT)

Field Sheet Complete: MCM (initial)
Photos: Y / N
Fish Survey Conducted: Y / N

APPENDIX C

Habitat Assessment Field Datasheet – Low Gradient

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME Unnamed Stream	LOCATION PW-20
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT 44.4465866 LONG -73.1238091	RIVER BASIN
STORET #	AGENCY Techlaw Inc, ESAT
INVESTIGATORS MCM, MF, BGK, LB	
FORM COMPLETED BY Meaghan Macri	DATE 9.11.12 TIME 0940 (AM) PM / REASON FOR SURVEY commerce street plume

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 10	20 19 18 17 16	15 14 13 12 11	(10) 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 14	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE 2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 (2) 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 19	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 16	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

PW-20

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 20	(20) 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 15	20 19 18 17 16	(15) 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 9 (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1 0
SCORE 9 (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank (10) 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank (10) 9	8 7 6	5 4 3	2 1 0

Total Score 154

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

Muddy Brook (Unnamed Stream)

STREAM NAME Tributary #4	LOCATION PW-17
STATION # _____ RIVERMILE _____	STREAM CLASS
LAT 44.44745849 LONG -73.12147299	RIVER BASIN
STORET #	AGENCY Techlaw, Inc. ESAT
INVESTIGATORS MF, BGK, LB, MCM	
FORM COMPLETED BY Meaghan Macri	DATE 9-11-12 TIME 1435 AM PM / REASON FOR SURVEY Commerce Street plume

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE 2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 20	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

BGK 9-11-12

MCM 9-11-12 BGK 9-11-12

PW-17

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 20	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 7 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 7 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 10 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 10 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 152

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

Muddy Brook (Unnamed Stream)

STREAM NAME Trib 4	LOCATION PW-11
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT 44.4493829 LONG -73.12188239	RIVER BASIN
STORET #	AGENCY ESAT, Techlaw Inc.
INVESTIGATORS MF, BGK, MCM, LB	
FORM COMPLETED BY Meaghan Macri	DATE 9.12.12 TIME 1020 (AM) PM / REASON FOR SURVEY Commerce Street Plume

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 17	20 19 18 (17) 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 13	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE 3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 (3) 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 20	(20) 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 15	20 19 18 17 16	(15) 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

PW-11

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 19	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 10	20 19 18 17 16	15 14 13 12 11	(10) 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 9 (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1 0
SCORE 9 (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 9 (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 7 (RB)	Right Bank 10 9	8 (7) 6	5 4 3	2 1 0

Total Score 151

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

Muddy Brook (Unnamed Stream)

STREAM NAME Tributary 4	LOCATION PW2
STATION # _____ RIVERMILE _____	STREAM CLASS
LAT 44.45264118 LONG -73.11935145	RIVER BASIN
STORET #	AGENCY ESAT Techlaw Inc
INVESTIGATORS MF, BGK, LB, MCM	
FORM COMPLETED BY Meaghan Macri	DATE 9.12.12 TIME 1637 AM PM / REASON FOR SURVEY Commerce street plume

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 (7) 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 (7) 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE 0	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 (0)
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 19	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 10	20 19 18 17 16	15 14 13 12 11	(10) 9 8 7 6	5 4 3 2 1 0

PW-2

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 (6)	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 0	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 (0)
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 8 (LB)	Left Bank 10 9	(8) 7 6	5 4 3	2 1 0
SCORE 8 (RB)	Right Bank 10 9	(8) 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 8 (RB)	Right Bank 10 9	(8) 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 2 (RB)	Right Bank 10 9	8 7 6	5 4 3	(2) 1 0

Total Score 95

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME Trib 4 (unnamed stream) Muddy Brook	LOCATION Reference site
STATION # _____ RIVERMILE _____	STREAM CLASS
LAT 44.45478218 LONG -73.11757334	RIVER BASIN
STORET #	AGENCY ESAT Techlaw Inc
INVESTIGATORS MCM, BGK, LB, MF	
FORM COMPLETED BY Meaghan Macri	DATE 9.13.12 TIME 1102 AM PM / REASON FOR SURVEY commerce street plume

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 15	20 19 18 17 16	(15) 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 12	20 19 18 17 16	15 14 13 (12) 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 (7) 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 18	20 19 (18) 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 19	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Reference

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 20	(20) 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length ~~1 to 2~~ times longer than if it was in a straight line. 2 to 3 MCM 9.13.12	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 14	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank (10) 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank (10) 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 6 (LB)	Left Bank 10 9	8 7 (6)	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank (10) 9	8 7 (6)	5 4 3	2 1 0

Total Score 161

APPENDIX D

Physical Characterization/Water Quality Field Datasheets

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET
(FRONT)

Muddy Brook (Unnamed Stream)

STREAM NAME ~~UM~~ Trib 4	LOCATION PW-20
STATION # _____ RIVERMILE _____	STREAM CLASS
LAT 44.4465866 LONG -73.12380091	RIVER BASIN
STORET #	AGENCY ESAT Tecnlaw, Inc.
INVESTIGATORS MCM, MF, BGK, LB	
FORM COMPLETED BY Meaghan Macri	DATE 9-11-12 TIME 0940 AM ☒ PM / REASON FOR SURVEY Commerce Street Plume

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
20 % ☒	%cloud cover	☒ 50 %
☐	clear/sunny	☐

Has there been a heavy rain in the last 7 days? ☒ Yes ☐ No

Air Temperature ~16 °C

Other _____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

photos: (Red Nikon)

2728.jpg } Facing East
2729.jpg }
2730.jpg - East (sed. plug)

Benthos sampling Locations (VT)

2731.jpg - SE
2732.jpg - N
2733.jpg - S
2734.jpg - W

Available in: G:\ALLSHARE\ESATBIO\Commerce St (VT)

STREAM CHARACTERIZATION

Stream Subsystem
☒ Perennial ☐ Intermittent ☐ Tidal

Stream Type
☒ Coldwater ☐ Warmwater

Stream Origin
☐ Glacial
☐ Non-glacial montane
☐ Swamp and bog
☒ Spring-fed
☐ Mixture of origins
☒ Other urban runoff

Catchment Area _____ km²

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

PW-20

WATERSHED FEATURES	**Predominant Surrounding Landuse** ☐ Forest ☒ Commercial ☐ Field/Pasture ☒ Industrial ☐ Agricultural ☐ Other ☐ Residential **Local Watershed NPS Pollution** ☐ No evidence ☐ Some potential sources ☒ Obvious sources **Local Watershed Erosion** ☒ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ☒ Trees ☐ Shrubs ☒ Grasses ☒ Herbaceous **dominant species present** Alder/spotted jewlweed/sensitive fern various grass mcm 9.11.12
INSTREAM FEATURES	**Estimated Reach Length** 16 m **Estimated Stream Width** 2.25 m **Sampling Reach Area** 36 m² mcm 0.036 **Area in km² (m²x1000)** ~~36000~~ km² **Estimated Stream Depth** ~~0.6~~ m 0.5 mcm 9.11.12 **Surface Velocity (at thalweg)** <0.1 m/sec **Canopy Cover** ☐ Partly open ☒ Partly shaded ☐ Shaded **High Water Mark** 0.6 m **Proportion of Reach Represented by Stream Morphology Types** ☐ Riffle ___ % ☒ Run ~~100~~ % 80 ☒ Pool 20 % mcm 9.11.12 **Channelized** ☐ Yes ☒ No **Dam Present** ☐ Yes ☒ No
LARGE WOODY DEBRIS	**LWD** 1 m² 27.8 m²/km² **Density of LWD** <5% ~~m²/km²~~ (LWD/ reach area) mcm 9.13.12
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ☒ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating ☐ Floating Algae ☐ Attached Algae **dominant species present** ~~Alder~~ No living vegetation **Portion of the reach with aquatic vegetation** ~~30~~ % 0%
WATER QUALITY	**Temperature** 12.14 °C **Specific Conductance** 1916 µS/cm° **Dissolved Oxygen** 73.5%, 7.82 mg/L **pH** 7.42 **Turbidity** — **WQ Instrument Used** YSI 556 sonde **Water Odors** ☒ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other ___ **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☒ None ☐ Other ___ **Turbidity (if not measured)** ☐ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Stained ☒ Other Milky
SEDIMENT/ SUBSTRATE	**Odors** ☒ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other ___ **Oils** ☒ Absent ☐ Slight ☐ Moderate ☐ Profuse **Deposits** ☐ Sludge ☐ Sawdust ☐ Paper fiber ☒ Sand ☐ Relict shells ☒ Other No deposits **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No N/A

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock		0	Detritus	sticks, wood, coarse plant materials (CPOM)	20
Boulder	> 256 mm (10")	0			
Cobble	64-256 mm (2.5"-10")	0	Muck-Mud	black, very fine organic (FPOM)	0
Gravel	2-64 mm (0.1"-2.5")	0			
Sand	0.06-2mm (gritty)	50	Marl	grey, shell fragments	0
Silt	0.004-0.06 mm	50			
Clay	< 0.004 mm (slick)	0			

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET
(FRONT)

Muddy Brook (Unnamed Stream

STREAM NAME Tributary 4	LOCATION PW-17
STATION # _____ RIVERMILE _____	STREAM CLASS
LAT 44.44745849 LONG -73.12147299	RIVER BASIN
STORET #	AGENCY Techlaw Inc, ESAT
INVESTIGATORS MF, BGK, LB, MCM	
FORM COMPLETED BY Meaghan Macri	DATE 9.11.12 TIME 1430 AM PM / REASON FOR SURVEY Commerce street plume

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
___% ☐	%cloud cover	☒ 50%
☒	clear/sunny	☐

Has there been a heavy rain in the last 7 days? ☒ Yes ☐ No

Air Temperature ~25 °C

Other _____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

photos:

2735.jpg
2736.jpg
2737.jpg
2738.jpg
} NE → } Eckman grab

2739.jpg-NE -sed. grab (Eckman)
2740.jpg-NE -plug
2741.jpg- E - Jab #1
2742.jpg- E - Jab #2
2743.jpg- SE - Jab #3
2743.jpg - S - Jab #4
} Rep 1

Available in G:\ALLSHARE\ESATBIO\ Commerce St (VT)

STREAM CHARACTERIZATION

Stream Subsystem: ☒ Perennial ☐ Intermittent ☐ Tidal

Stream Type: ☒ Coldwater ☐ Warmwater

Stream Origin: ☐ Glacial ☐ Non-glacial montane ☐ Swamp and bog ☒ Spring-fed ☐ Mixture of origins ☒ Other urban runoff

Catchment Area _____ km²

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

PW-17

WATERSHED FEATURES	**Predominant Surrounding Landuse** ☐ Forest ☒ Commercial ☐ Field/Pasture ☒ Industrial ☐ Agricultural ☒ Other _____ ☐ Residential **Local Watershed NPS Pollution** ☐ No evidence ☐ Some potential sources ☒ Obvious sources **Local Watershed Erosion** ☒ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ☐ Trees ☐ Shrubs ☒ Grasses ☒ Herbaceous **dominant species present** cattail, spotted jewelweed, phragmites, purple loosestrife
INSTREAM FEATURES	**Estimated Reach Length** 14 ~~1.7~~ ~~because mcm undercut~~ m **Estimated Stream Width** 1.8 m **Sampling Reach Area** 25.2 m² **Area in km²** ~~(m²x1000)~~ mcm 9.11.12 0.0252 km² **Estimated Stream Depth** 0.2 m **Surface Velocity** <0.1 m/sec (at thalweg) **Canopy Cover** ☒ Partly open ☐ Partly shaded ☐ Shaded **High Water Mark** 0.45 m **Proportion of Reach Represented by Stream Morphology Types** ☐ Riffle ____% ☒ Run 100 % ☐ Pool ____% **Channelized** ☐ Yes ☒ No **Dam Present** ☐ Yes ☒ No
LARGE WOODY DEBRIS	**LWD** 0 m² **Density of LWD** 0 m²/km² (LWD/ reach area)
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ☐ Rooted emergent ☒ Rooted submergent ☐ Rooted floating ☐ Free floating ☐ Floating Algae ☐ Attached Algae **dominant species present** ~~N/A No aquatic vegetation~~ unknown macrophyte mcm 9.11.12 **Portion of the reach with aquatic vegetation** ~~0~~ 1 % mcm 9.11.12
WATER QUALITY	**Temperature** 15.52 °C **Specific Conductance** 2475 µS/cm **Dissolved Oxygen** 78.4%, 7.75 mg/L **pH** 7.58 **Turbidity** — **WQ Instrument Used** YSI 556 sonde **Water Odors** ☒ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other _____ **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☒ None ☐ Other _____ **Turbidity (if not measured)** ☒ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other _____
SEDIMENT/ SUBSTRATE	**Odors** ☒ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other _____ **Oils** ☒ Absent ☐ Slight ☐ Moderate ☐ Profuse **Deposits** ☐ Sludge ☐ Sawdust ☐ Paper fiber ☒ Sand ☐ Relict shells ☒ Other NO Deposits **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No N/A (NO stones)

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock		0	Detritus	sticks, wood, coarse plant materials (CPOM)	40
Boulder	> 256 mm (10")	0			
Cobble	64-256 mm (2.5"-10")	0	Muck-Mud	black, very fine organic (FPOM)	20
Gravel	2-64 mm (0.1"-2.5")	0			
Sand	0.06-2mm (gritty)	30	Marl	grey, shell fragments	0
Silt	0.004-0.06 mm	60			
Clay	< 0.004 mm (slick)	10			

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET
(FRONT)

Muddy Brook (Unnamed Stream)

STREAM NAME Tributary 4	LOCATION PW-11
STATION # _____ RIVERMILE _____	STREAM CLASS
LAT 44.4493829 LONG -73.12188230	RIVER BASIN
STORET #	AGENCY ESAT, Techlaw Inc.
INVESTIGATORS MF, MCM, BGK, LB	
FORM COMPLETED BY Meaghan Macri	DATE 9.12.12 TIME 1015 (AM) PM / REASON FOR SURVEY commerce street plume

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
___% ☐	%cloud cover	☒ ~20%
☒	clear/sunny	☐

Has there been a heavy rain in the last 7 days? ☒ Yes ☐ No

Air Temperature ~12 °C

Other _____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

Photographs:

2745.jpg (SE) @transect
2746.jpg (SE) Flecks of oil
2747.jpg (S) scoopr sediment
2748.jpg (SE) 1st Jab Rep 1
2749.jpg (SE) 2nd Jab Rep 1
2752.jpg (SE) 3rd Jab Rep 1
2753.jpg (E) 4th Jab Rep 1

Available in G:\\ALLSHARE\ESATBIO\Commerce St(VT)

STREAM CHARACTERIZATION

Stream Subsystem: ☒ Perennial ☐ Intermittent ☐ Tidal

Stream Type: ☒ Coldwater ☐ Warmwater

Stream Origin: ☐ Glacial ☐ Non-glacial montane ☐ Swamp and bog ☒ Spring-fed ☐ Mixture of origins ☒ Other urban runoff

Catchment Area _____ km²

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

PW-11

WATERSHED FEATURES	**Predominant Surrounding Landuse** ☐ Forest ☒ Commercial ☐ Field/Pasture ☒ Industrial ☐ Agricultural ☐ Other ☐ Residential **Local Watershed NPS Pollution** ☐ No evidence ☐ Some potential sources ☒ Obvious sources **Local Watershed Erosion** ☒ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ☒ Trees ☐ Shrubs ☒ Grasses ☒ Herbaceous various Grasses **dominant species present** spotted jewelweed, Alder, white birch, white pine, Ash (mixed decid uous)
INSTREAM FEATURES	**Estimated Reach Length** 11.3 m **Estimated Stream Width** 1.0 m **Sampling Reach Area** 11.3 m² **Area in km²** ~~(m²x1000)~~ 0.0113 km² MCM 9/12/12 **Estimated Stream Depth** 0.2 m **Surface Velocity (at thalweg)** <0.1 m/sec **Canopy Cover** ☐ Partly open ☒ Partly shaded ☐ Shaded **High Water Mark** 0.28 m **Proportion of Reach Represented by Stream Morphology Types** ☐ Riffle 1 % ☒ Run 90 % ☒ Pool 10 % **Channelized** ☐ Yes ☒ No **Dam Present** ☐ Yes ☒ No
LARGE WOODY DEBRIS	**LWD** 0.5 m² **Density of LWD** 44.25 m²/km² **(LWD/ reach area)**
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ☒ Rooted emergent ☒ Rooted submergent ☐ Rooted floating ☐ Free floating ☐ Floating Algae ☒ Attached Algae **dominant species present** submerged broadleaf **Portion of the reach with aquatic vegetation** 10 %
WATER QUALITY	**Temperature** 13.40 °C **Specific Conductance** 1004 µs/cm **Dissolved Oxygen** 76%, 7.92 mg/L **pH** 7.57 **Turbidity** — **WQ Instrument Used** YSI sonde 556 **Water Odors** ☒ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☒ Flecks <0.5 m² ☐ None ☐ Other **Turbidity (if not measured)** ☒ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other
SEDIMENT/ SUBSTRATE	**Odors** ☒ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other **Oils** ☒ Absent ☐ Slight ☐ Moderate ☐ Profuse **Deposits** ☐ Sludge ☐ Sawdust ☐ Paper fiber ☒ Sand ☐ Relict shells ☒ Other NO Deposits **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No N/A NO stones

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock		0	Detritus	sticks, wood, coarse plant materials (CPOM)	30
Boulder	> 256 mm (10")	0			
Cobble	64-256 mm (2.5"-10")	0	Muck-Mud	black, very fine organic (FPOM)	0
Gravel	2-64 mm (0.1"-2.5")	0			
Sand	0.06-2mm (gritty)	65	Marl	grey, shell fragments	0
Silt	0.004-0.06 mm	30			
Clay	< 0.004 mm (slick)	5			

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET
(FRONT)

Muddy Brook (Unnamed Stream)

STREAM NAME Tributary 4	LOCATION PW2	
STATION # _____ RIVERMILE _____	STREAM CLASS	
LAT 44.45264118 LONG -73.11935145	RIVER BASIN	
STORET #	AGENCY ESAT Techlaw inc	
INVESTIGATORS MF, BGK, LB, MCM		
FORM COMPLETED BY Meaghan Macri	DATE 9.12.12 TIME 1551 AM PM	REASON FOR SURVEY commerce street plume

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
___% ☐	%cloud cover	☒ 50%
☒	clear/sunny	☐

Has there been a heavy rain in the last 7 days? ☒ Yes ☐ No

Air Temperature ~27° C

Other_____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

Photos: 2755.jpg - PW2 Transect (E)
2756.jpg - PW2 Full Transect (E)

Rep 1 Jabs:

2758.jpg (NW)
2760.jpg (NW)
2761.jpg (SE)
2762.jpg (NE)

All @ log jams (woody debris) within 20m of transect PW2

Available in G:\ALLSHARE\ESATBU\ Commerce St (VT)

STREAM CHARACTERIZATION

Stream Subsystem ☒ Perennial ☐ Intermittent ☐ Tidal

Stream Type ☒ Coldwater ☐ Warmwater

Stream Origin
☐ Glacial
☐ Non-glacial montane
☐ Swamp and bog
☒ Spring-fed
☐ Mixture of origins
☒ Other Urban Runoff

Catchment Area_____ km²

PW-2

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES	**Predominant Surrounding Landuse** ☐ Forest ☒ Commercial ☐ Field/Pasture ☒ Industrial ☐ Agricultural ☐ Other _____ ☐ Residential **Local Watershed NPS Pollution** ☐ No evidence ☐ Some potential sources ☒ Obvious sources **Local Watershed Erosion** ☒ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ☒ Trees ☐ Shrubs ☒ Grasses ☒ Herbaceous **dominant species present** _____
INSTREAM FEATURES	**Estimated Reach Length** 14.6 m **Estimated Stream Width** 1.7 m **Sampling Reach Area** 24.82 m² **Area in km² (m²x1000)** 0.02482 km² **Estimated Stream Depth** 0.17 m **Surface Velocity (at thalweg)** < 0.1 m/sec **Canopy Cover** ☐ Partly open ☒ Partly shaded ☐ Shaded mostly shaded **High Water Mark** 0.62 m **Proportion of Reach Represented by Stream Morphology Types** ☐ Riffle ___ % ☒ Run 90 % ☒ Pool 10 % **Channelized** ☒ Yes ☐ No **Dam Present** ☐ Yes ☒ No
LARGE WOODY DEBRIS	**LWD** 1 m² **Density of LWD** 40 m²/km² (LWD/ reach area)
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ☐ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating ☐ Floating Algae ☐ Attached Algae **dominant species present** None **Portion of the reach with aquatic vegetation** 0 %
WATER QUALITY	**Temperature** 16.83 °C **Specific Conductance** 916 **Dissolved Oxygen** 88.2% 8.51 mg/L **pH** 7.85 **Turbidity** — **WQ Instrument Used** YSI 556 sonde **Water Odors** ☒ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other _____ **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☒ None ☐ Other _____ **Turbidity (if not measured)** ☒ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other _____
SEDIMENT/ SUBSTRATE	**Odors** ☒ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other _____ **Oils** ☒ Absent ☐ Slight ☐ Moderate ☐ Profuse **Deposits** ☐ Sludge ☐ Sawdust ☐ Paper fiber ☒ Sand ☐ Relict shells ☒ Other NO DEPOSITS **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No N/A NO ROCKS

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock		0	Detritus	sticks, wood, coarse plant materials (CPOM)	40
Boulder	> 256 mm (10")	0			
Cobble	64-256 mm (2.5"-10")	0	Muck-Mud	black, very fine organic (FPOM)	0
Gravel	2-64 mm (0.1"-2.5")	0			
Sand	0.06-2mm (gritty)	50	Marl	grey, shell fragments	0
Silt	0.004-0.06 mm	45			
Clay	< 0.004 mm (slick)	5			

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

Muddy Brook (Unnamed Stream)

STREAM NAME Trib 4	LOCATION Reference
STATION # _____ RIVERMILE _____	STREAM CLASS
LAT 44.4547828 LONG -73.1757334	RIVER BASIN
STORET #	AGENCY ESAT Techlaw Inc.
INVESTIGATORS MF, BGK, LB, MCM	
FORM COMPLETED BY Meaghan Macri	DATE 9.13.12 TIME 0951 (AM) PM / REASON FOR SURVEY Commerce street plume

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
____%☐	%cloud cover	☐ ____%
☒	clear/sunny	☒

Has there been a heavy rain in the last 7 days? ☐ Yes ☒ No

Air Temperature ~21 °C

Other _____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

Photographs:

2765.jpg (SW) - Reference site

2766.jpg (SW) - Sampling H_2O VOCs

2767.jpg (NW) - benthic sampling

2768.jpg (W)
2769.jpg (W)
2770.jpg (W)
} Rep 1 Jabs 1-4 (in order)

2771 + 2772 (W) → both jab 4

2773 (E)
2774 (E)
} metal gas can set in bank @ 2nd jab of rep 2

Available in G:\ALLSHARE\ESATBIO\Commerce St (VT)

STREAM CHARACTERIZATION

Stream Subsystem
☒ Perennial ☐ Intermittent ☐ Tidal

Stream Type
☒ Coldwater ☐ Warmwater

Stream Origin
☐ Glacial
☐ Non-glacial montane
☐ Swamp and bog
☒ Spring-fed
☐ Mixture of origins
☒ Other urban runoff

Catchment Area _____ km²

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

Reference

WATERSHED FEATURES	**Predominant Surrounding Landuse** ☐ Forest ☒ Commercial ☒ Field/Pasture ☒ Industrial ☐ Agricultural ☐ Other ☐ Residential **Local Watershed NPS Pollution** ☐ No evidence ☒ Some potential sources ☐ Obvious sources **Local Watershed Erosion** ☒ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ☒ Trees ☐ Shrubs ☒ Grasses ☒ Herbaceous **dominant species present** spotted jewelweed, mixed deciduous nightshade grapevine, birch and hardwood white oak red maple various grasses
INSTREAM FEATURES	**Estimated Reach Length** 14 m **Estimated Stream Width** 1.7 m **Sampling Reach Area** 23.8 m² **Area in km²** ~~(m²x1000)~~ 0.0238 km² mcm 9.13.12 **Estimated Stream Depth** 0.26 m **Surface Velocity** < 0.1 m/sec (at thalweg) barely flowing **Canopy Cover** ☒ Partly open ☐ Partly shaded ☐ Shaded **High Water Mark** * m **Proportion of Reach Represented by Stream Morphology Types** ☐ Riffle ___ % ☒ Run 90 % ☒ Pool 10 % **Channelized** ☐ Yes ☒ No **Dam Present** ☐ Yes ☒ No road culverts
LARGE WOODY DEBRIS	**LWD** < 0.25 m² **Density of LWD** 10.5 m²/km² (LWD/ reach area)
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ☐ Rooted emergent ☒ Rooted submergent ☐ Rooted floating ☐ Free floating ☐ Floating Algae ☐ Attached Algae **dominant species present** various macrophytes **Portion of the reach with aquatic vegetation** 5 %
WATER QUALITY	**Temperature** 17.53 °C **Specific Conductance** 965 **Dissolved Oxygen** 100.9% 9.62 mg/L **pH** 8.21 **Turbidity** — **WQ Instrument Used** YSI 556 sonde **Water Odors** ☒ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other ___ **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☒ None ☐ Other ___ **Turbidity (if not measured)** ☒ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other ___
SEDIMENT/ SUBSTRATE	**Odors** ☒ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other ___ **Oils** ☒ Absent ☐ Slight ☐ Moderate ☐ Profuse **Deposits** ☐ Sludge ☐ Sawdust ☐ Paper fiber ☒ Sand ☐ Relict shells ☒ Other NO deposits **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No N/A NO ROCKS

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock		0	Detritus	sticks, wood, coarse plant materials (CPOM)	50
Boulder	> 256 mm (10")	0			
Cobble	64-256 mm (2.5"-10")	0	Muck-Mud	black, very fine organic (FPOM)	0
Gravel	2-64 mm (0.1"-2.5")	0			
Sand	0.06-2mm (gritty)	10	Marl	grey, shell fragments	0
Silt	0.004-0.06 mm	45			
Clay	< 0.004 mm (slick)	45			

* overflows to marsh @ overflow condition

APPENDIX E

Chain of Custodies

ENVIRONMENTAL PROTECTION AGENCY

REGION 1

To Alpha Lab, Call # 2023

CHAIN OF CUSTODY RECORD

PROJ. NO.: 12090019

PROJECT NAME: (Williston, VT) Commerce Street Sampling

SAMPLERS: (Signature)

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	TOC Lloyd Kahn Method						REMARKS
													To: Alpha Analytical
PW-20	9.11.12	1025	✓		PW20-SED	1	✓						Sediment Samples
PW-17	9.11.12	1436	✓		PW17-SED	1	✓						
PW-11	9.12.12	1043	✓		PW11-SED	1	✓						
PW-11(Dup)	9.12.12	1043	✓		PW11-DUP-SED	1	✓						
PW-2	9.12.12	1606	✓		PW2-SED	1	✓						
Reference	9.13.12	1044	✓		Reference-SED	1	✓						

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Bethany Kelley	9.14.12 11:18	EMT			
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

1- 19060

ENVIRONMENTAL PROTECTION AGENCY

REGION 1

CHAIN OF CUSTODY RECORD

PROJ. NO.: 12090019

PROJECT NAME: Commerce Street (Williston, VT) Sampling

SAMPLERS: (Signature)

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	#TCA	#VOAMW	#METW-PE	#MERCW			REMARKS
													To: Region 1 NERL
PW-17	9.11.12	1435		✓	PW17-SW	1	✓						
		1430		✓	PW17-SW	4		✓					Reps 1-4
Reference	9.13.12	1040		✓	Reference-SW	1	✓						
		1040		✓	Reference-SW	4		✓					Reps 1-4
PW20	9.11.12	0950		✓	PW20-SW	1	✓						
		0950		✓	PW20-SW	4		✓					Reps 1-4
PW2	9.12.12	1601		✓	PW2-SW	1	✓						
		1557		✓	PW2-SW	4		✓					Reps 1-4
PW11	9.12.12	1023		✓	PW11-SW	1	✓						
		1023		✓	PW11-SW	4		✓					Reps 1-4
PW11(Dup)	9.12.12	1025		✓	PW11-DUP-SW	1	✓						
		1025		✓	PW11-DUP-SW	4		✓					Reps 1-4
	9.12.12	1415		✓	Rinsate Blank	1			✓	✓			
	9.10.12	0900		✓	Trip Blanks	4		✓					

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Bethany Kelley	9.14.12 11:18				
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature) ESAT	Date / Time	Remarks	
			9/14/12 11:18		

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

4°C

1- 10070

ENVIRONMENTAL PROTECTION AGENCY

REGION 1

CHAIN OF CUSTODY RECORD

PROJ. NO.: 12090019

PROJECT NAME: ~~Commerce Street (Williston, VT) Sampling~~

SAMPLERS: (Signature)

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	$VOAHS	% Solids	$METHS-RE	MERCS	ABNAMS	REMARKS
												To: Region 1 NERL
	9.11.12	1439		✓	PW17-SED	1	✓	✓				~~Preservative in $VOAHS jar - MeOH (32.680~~
		1439	✓		PW17-SED	1			✓	✓	✓	
	9.13.12	~~1602~~ 1451		✓	Reference-SED	1	✓	✓				Preservative in $VOAHS jar = MeOH (27.6
		~~1602~~ 1451	✓		Reference-SED	1			✓	✓	✓	
	9.11.12	1020		✓	PW20-SED	1	✓	✓				Preservative in $VOAHS jar = MeOH
		1020	✓		PW20-SED	1			✓	✓	✓	
	9.12.12	1602		✓	PW2-SED	1	✓	✓				~~Preservative in $VOAHS jar - MeOH~~
		1602	✓		PW2-SED	1			✓	✓	✓	
	9.12.12	1036		✓	PW11-SED	1	✓	✓				Preservative in $VOAHS jar - MeOH
		1036	✓		PW11-SED	1			✓	✓	✓	
	9.12.12	1038		✓	PW11-DUP-SED	1	✓	✓				Preservative in $VOAHS jar = MeOH
		1038	✓		PW11-DUP-SED	1			✓	✓	✓	

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Bethany Kelley	9.14.12 11:18				
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature) ESAT	Date / Time	Remarks	
			9/14/12 11:18		

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

1- 10069

ENVIRONMENTAL PROTECTION AGENCY

REGION 1

CHAIN OF CUSTODY RECORD

PROJ. NO.

PROJECT NAME: ~~Commerce Street Sampling~~ (Williston, VT)

SAMPLERS: (Signature) Bethany Kelley

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	Taxonomy						REMARKS
~~PW-20~~	~~9-10-12~~ 9-11-12	1122	✓		PW-20-AQINV-REP1	1	✓						
~~PW-20~~	9-11-12	1134	✓		PW-20-AQINV-REP2	2	✓						
PW-20		1042	✓		PW-20-~~AQINV-REP3~~ BENINV-REP1 BEK 9-12-12	1	✓						
PW-20		1100	✓		PW-20-BENINV-REP2	1	✓						
PW-20		1105	✓		PW-20-BENINV-REP3	1	✓						
~~PW-20~~		1110	✓		PW-20-BENINV-REP4	1	✓						
PW-17		1600	✓		PW17-~~B~~AQINV-REP1 BEK 9-12-12	1	✓						
~~PW-17~~		1600	✓		PW17-AQINV-REP2	1	✓						
PW-17		1500	✓		PW17-BENINV-REP1	1	✓						
PW-17		1500	✓		PW17-BENINV-REP2	1	✓						
PW-17		1530	✓		PW17-BENINV-REP3	1	✓						
PW-17		1530	✓		PW17-BENINV-REP4	1	✓						
PW-11	9-12-12	~~1100~~ 1239	✓		PW11-AQINV-REP1	2	✓						
PW-11	1330	~~1115~~ 1244 9-18-12	✓		PW11-AQINV-REP2	2	✓						
PW-11		1106	✓		PW11-BENINV-REP1	2	✓						

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Bethany Kelley	9-13-12 1620				
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	
			9/13/12 1620		

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

ENVIRONMENTAL PROTECTION AGENCY

REGION 1

CHAIN OF CUSTODY RECORD

PROJ. NO.

PROJECT NAME: Commerce Street Sampling (Williston, VT)

SAMPLERS: (Signature) Bethany Kelley

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	Taxonomy						REMARKS
PW-2	9.12.12	1702 ~~1113~~	✓		PW2-AQINV-REP1	1	✓						
PW-2		1704 ~~1122~~	✓		PW2-AQINV-REP2 MCM 9-13-12	12	✓						
PW-2		1629	✓		PW2-BENINV-REP1	1	✓						
PW-2		1630	✓		PW2-BENINV-REP2	1	✓						
PW-2		1647	✓		PW2-BENINV-REP3	1	✓						
PW-2		1653	✓		PW2-BENINV-REP4	1	✓						
PW-11		1113	✓		PW11-BENINV-REP2	1	✓						
PW-11		1128	✓		PW11-BENINV-REP3	1	✓						
PW-11		1129	✓		PW11-BENINV-REP4	1	✓						
PW-11(DUP)		1338	✓		PW11DUP-AQINV-REP1	1	✓						
PW-11(DUP)		1345	✓		PW11DUP-AQINV-REP2	2	✓						
PW-11(DUP)		1146	✓		PW11DUP-BENINV-REP1	1	✓						
PW-11(DUP)		1152	✓		PW11DUP-BENINV-REP2	2	✓						
PW-11(DUP)		1214	✓		PW11DUP-BENINV-REP3	1	✓						
PW-11(DUP)		1216	✓		PW11DUP-BENINV-REP4	1	✓						

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Bethany Kelley	9.13.12 1620				
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	
			9/13/12 1620		

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

ENVIRONMENTAL PROTECTION AGENCY

REGION 1

CHAIN OF CUSTODY RECORD

PROJ. NO.

PROJECT NAME: commerce street sampling Williston, VT

SAMPLERS: (Signature) Bethany Kelley

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	Taxonomy						REMARKS
Ref	9.13.12	1116	✓		Reference-AQINV-REP1	2	✓						
Ref		1130	✓		Reference-AQINV-REP2	2	✓						
Ref		1058	✓		Reference-BENINV-REP1	1	✓						
Ref		1058	✓		Reference-BENINV-REP2	1	✓						
Ref		1111	✓		Reference-BENINV-REP3	1	✓						
Ref	↓	1115	✓		Reference-BENINV-REP4	1	✓						

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Bethany Kelley	9.13.12 1620				
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	
			7/13/12 1620		

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

1- 10624