# District of Columbia
# Risk-Based Corrective Action
# Technical Guidance
# (Risk-Based Decision Making)

## District Department of the Environment
### Toxic Substances Division
### Underground Storage Tanks Branch

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AST | Aboveground Storage Tank |
| ASTM | American Society for Testing and Materials |
| BTEX | Benzene, Toluene, Ethylbenzene, and Xylenes (total) |
| bgs | Below Ground Surface |
| CAP | Corrective Action Plan |
| COC | Chemical of Concern |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| DAFs | Dilution Attenuation Factors |
| DC | District of Columbia |
| DCRBCA | District of Columbia's Risk Based Corrective Action |
| DCRBDM | District of Columbia Risk Based Decision Making |
| DDOE | District Department of the Environment |
| DRO | Diesel Range Organics |
| DW | Demonstration Well |
| ECF | Equilibrium Conversion Factor |
| EPA | Environmental Protection Agency |
| FID | Flame Ionization Detector |
| ft | Feet |
| GRO | Gasoline Range Organics |
| IAR | Initial Abatement Report |
| IELCR | Individual Excess Lifetime Cancer Risk |
| IRIS | Integrated Risk Information System |
| ITRC | Interstate Technology Regulatory Council |

| | |
|---|---|
| IUR | Inhalation Unit Risk |
| LEL | Lower Explosive Level |
| LNAPL | Light Non-Aqueous Phase Liquid |
| MADEP | Massachusetts Department of Environmental Protection |
| MCC | Mandatory Cleanup Criteria |
| MCL | Maximum Contaminant Level |
| MTBE | Methyl Tert-Butyl Ether |
| NAPL | Non-Aqueous Phase Liquid |
| NFA | No Further Action |
| PAH | Polycyclic Aromatic Hydrocarbons |
| PID | Photo Ionization Detector |
| POD | Point of Demonstration |
| POE | Point of Exposure |
| QA/QC | Quality Assurance and Quality Control |
| RBCA | Risk-Based Corrective Action |
| RBSLs | Risk-Based Screening Levels |
| RCRA | Resource Conservation and Recovery Act |
| RFC | Reference Concentration |
| $RFD_o$ | Reference Dose |
| RNA | Remediation by Natural Attenuation |
| RP | Responsible Party |
| RSL | Regional Screening Level |
| SCES | Site Conceptual Exposure Scenario |
| $SF_o$ | Slope Factor |
| SSTLs | Site-Specific Target Levels |
| TCEQ | Texas Commission on Environmental Quality |
| TPH | Total Petroleum Hydrocarbons |
| USGS | United States Geological Survey |
| UST | Underground Storage Tank |
| VOC | Volatile Organic Compounds |

# 1.0
# INTRODUCTION AND BACKGROUND

## 1.1 INTRODUCTION

In an effort to streamline the management of releases and spills from underground storage tanks, in the late 1990's the District of Columbia (DC) formed a Stakeholders' Task Force comprised of 21 members. The Task Force was formed based on 63 responses received to an invitation sent earlier to a broad range of potential stakeholders. Based, in part, on the efforts of the Task Force, the first notice of the proposed rule making was published on June 4, 1999 for public comments to be submitted by July 5, 1999. The final notice of rulemaking was published on October 1, 1999, DC Register 4640, 20 DCMR chapter 55 through 70.

This final rulemaking entitled *District of Columbia Underground Storage Tank Regulations* consists of 14 Chapters. These new regulations include the **District of Columbia Risk-Based Corrective Action (DCRBCA) or Risk-Based Decision Making (DCRBDM)** process. This process can be used to develop site-specific risk-based screening levels (RBSLs) and site-specific target levels (SSTLs) for remediation. This approach is supported by the **United States Environmental Protection Agency (USEPA)**.

The DCRBCA process recognizes and balances (i) the need to protect public health, water resources, and the environment of the District, (ii) the variations in site-specific land use and hydrogeological characteristics, (iii) the existing laws and regulations of the District, and (iv) resource limitations. Appropriate risk and exposure assessment practices suggested by the USEPA and the American Society for Testing and Materials (ASTM) E1739-95 Standard have been integrated into this process.

This process is also consistent with the District of Columbia's overall objective of protecting public health, safety and welfare, the environment, and natural resources for present and future use. The process was developed and is administered by the District Department of the Environment (DDOE) **Underground Storage Tanks Branch (USTB) within the Toxic Substances Division**.

Conceptually, the risk-based approach presented in this guidance document could apply to all contaminated sites. However, currently its application is limited to sites contaminated with petroleum products released from UST systems, under the jurisdiction of the USTB. For other contaminants or petroleum releases from other sources, please consult with the division.

The guidance document to support the above referenced rule was first developed and published in 2002. Since then the environmental community has obtained valuable experience in the application of this process. Further, several technical changes have occurred in this process. In 2010, the USTB solicited comments from the consulting community to revise the guidance document. This revised document includes their recommendations as well as the technical changes mentioned above.

As the DCRBCA process is implemented, the USTB anticipates modifications and/or enhancements due to change in environmental policy and procedure. These modifications and/or amendments will be published as appropriate.

## 1.2 APPLICABILITY

The intent of the DCRBCA process for USTs is to develop site-specific target levels protective of current and potential future (i) human health, (ii) environment, (iii) nuisance conditions, and (iv) explosive type situations. This guidance focuses on petroleum releases from USTs. However, it can be used for a variety of other chemicals.

It may be appropriate to apply this procedure to petroleum releases from other sources (pipelines, terminals, above ground storage tanks, etc.), if there are no other circumstances at the site that would require application of a different process, e.g., under the Resource Conservation and Recovery Act (RCRA) C, D, or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) programs.

This document has been developed for environmental professionals with working knowledge and experience in the areas of site assessment, site investigation, risk assessment, and remedial actions. Technical information is included that describes the DCRBCA program and its elements, including data collection, risk assessment, and corrective action. Since the development of site-specific risk-based target levels is an integral part of the overall process of risk management and has not been described earlier in other guidance documents, it is described at length in this manual (Section 5.0). **<u>However, this guidance document is not intended as a general guide to every aspect of the risk assessment practice</u>.** Prior experience or training will be necessary for an individual to correctly implement risk assessment as part of the overall site management process.

# 2.0
# OVERVIEW OF DCRBCA PROCESS

## 2.1 INTRODUCTION

The DCRBCA process (Figure 2-1) includes a range of site-specific activities that begin with the first notice of a suspected or confirmed release. The process continues until the USTB determines that the residual site-specific concentrations are protective of human health and the environment. Upon completion of this process, the USTB will issue a **No Further Action (NFA)** letter provided that all the conditions identified in ***Section 6211 of the District of Columbia Underground Storage Tank Regulations*** have been met.

The DCRBCA process integrates the elements of initial release determination, site characterization, exposure assessment, risk calculations, and risk management activities (including corrective action and risk communication) to determine site-specific chemical concentrations protective of human health and the environment. Each element of the process is important and has to be correctly implemented to ensure adequate protection of human health and the environment.

The DCRBCA process is applicable at all petroleum UST sites irrespective of whether (i) the release has just been detected, (ii) the site is currently under investigation, or (iii) the site is in corrective action. Since the DCRBCA process can begin at any point subsequent to the confirmation of the release, sites currently under assessment should be carefully evaluated to ensure that sufficient quality and quantity of data are available.

Risk management is an important part of the DCRBCA process. Risk management activities may include active or passive corrective action systems as well as the consideration of owner-imposed institutional controls after the target levels have been established. Institutional controls include but are not limited to land use restrictions, receptor removal or relocation, and communication with potentially affected parties.

As appropriate, based on site conditions, DCRBCA process may use **remediation by natural attenuation (RNA)** as an element of the corrective action process. RNA can be used as the sole corrective action at sites where immediate threats to human health, safety, and the environment do not exist or have been mitigated, and are unlikely to occur. RNA may have to be used in conjunction with other remedial techniques. The case will still be open until the completion of such corrective action process.

## 2.2 STEP-BY-STEP DESCRIPTION OF THE DCRBCA PROCESS

The DCRBCA process consists of seven (7) steps shown in Figure 2-1 each of which includes several activities. Details of the required actions are described in the ***Chapters 55 to 70 of the District of Columbia Underground Storage Tank Regulations.*** Each of the seven steps is briefly described below. The reporting requirements are presented in Table 2-1. Details of the key steps are presented in subsequent sections of this document.

### 2.2.1 Step 1: Release Detection

The first step of the DCRBCA process requires the prevention of uncontrolled releases from the existing UST systems, which are in service. To achieve this goal, each UST system must have a method of release detection that complies with the requirements of ***Chapter 60 of the District of Columbia Underground Storage Tank Regulations.*** The release detection system shall be installed, calibrated, operated, and maintained in accordance with the manufacturer's instructions. The record keeping and reporting requirements are discussed in ***Section 5602 of the District of Columbia Underground Storage Tank Regulations.***

### 2.2.2 Step 2: Release Notification, Abatement, and Reporting

This step of the DCRBCA process requires a responsible party (RP) or a voluntary RP to take immediate action to contain, abate, and cleanup any spill, overfill or release of a regulated substance from a UST. Additionally, the RP must provide timely information to the USTB related to the release and any abatement actions taken within 24 hours of the occurrence or suspicion of a release. The specific requirements are presented in ***Chapter 62 of the District of Columbia Underground Storage Tank Regulations.*** When a release is suspected, the RP shall conduct appropriate tests to confirm the presence or absence of the leak. If the leak is confirmed, the RP shall take appropriate steps to repair the leak and initiate appropriate corrective action and notify the USTB.

### 2.2.3 Step 3: Initial Site Assessment

The objective of the initial site assessment is to collect soil and or groundwater samples to either confirm a release or to confirm that a release has not occurred. The RP should evaluate the on-site conditions as well as all the information related to the suspected release to select the location and type of samples to be collected. As appropriate the RP should comply with any directions provided by the USTB. The samples should be located and analyzed in a manner that maximizes the chances of detecting a release if it has occurred. This initial investigation should, at a minimum, be designed to measure the maximum soil and groundwater concentrations at the source, i.e., location of spill, leak, or release.

The data collected during the initial investigation should be used to determine whether the mandatory cleanup conditions have been met. These include:

1. Removal of the primary leaking source (UST, pipeline, etc.),
2. Removal of free product (light non-aqueous phase liquid, LNAPL) to the maximum extent practicable, and
3. Benzene concentration in groundwater does not exceed 15 milligrams per liter (mg/L).

If the above conditions have been met, an initial screening level evaluation should be conducted. This evaluation involves the comparison of maximum site concentrations with Tier 0 or Tier 1 levels as discussed in Section 2.3.

### 2.2.4 Step 4: Comprehensive Site Investigation

The objective of this step is to collect adequate quality and quantity of data to perform a site-specific risk evaluation and to develop media-specific target concentrations (Step 5). Specific requirements of a comprehensive site assessment are included in ***Section 6205 of the District of Columbia Underground Storage Tank Regulations.*** Details of the data that should be collected are presented in Section 4.0 of this guidance document. This step is necessary only if the initial site assessment identifies the need for further action. Prior to performing the comprehensive site assessment, the RP should prepare a work plan and get the work plan approved by the USTB.

### 2.2.5 Step 5: Selection or Development of Target Levels

The objective of this step is to select Tier 1 RBSLs from look up tables or develop Tier 2A or 2B SSTLs for each complete route of exposure. The identification of the complete routes of exposure will require the development of site conceptual exposure scenarios for current and potential future conditions. This step is described in detail in Section 5.0 of this guidance document and ***Section 6206 under Risk-Based Corrective Action Program of the District of Columbia Underground Storage Tank Regulations.***

As a part of this step, the soil and groundwater target levels must be compared with the pathway-specific representative concentrations. If the representative concentrations are exceeded, risk management activities are required at the site, and the process moves to Step 6. However, if the representative concentrations do not exceed the target levels, the RP may request a NFA from the USTB. In this case, the process moves to Step 7.

### 2.2.6 Step 6: Development and Implementation of the Corrective Action Plan

The objective of this step is to develop and implement an active or passive Corrective Action Plan (CAP) to achieve the target levels determined in Step 5 and also referred to as the risk management plan. The regulatory requirements for the corrective action plan are discussed in ***Section 6207 of the District of Columbia Underground Storage Tank Regulations.*** Additional discussion is included in Section 6.0 of this guidance document.

### 2.2.7 Step 7: Closure Request

After successful completion of the CAP, if necessary, or after the completion of the DCRBCA evaluation (Step 3 or 6), the RP may request a NFA. Prior to issuing a NFA letter, the USTB will confirm that the conditions identified in ***Section 6211 of the District of Columbia Underground Storage Tank Regulations*** have been met and all monitoring wells have been properly abandoned.

## 2.3 TARGET LEVELS

To streamline the evaluation of impacted UST sites in the DC, the RP may use any of the following four (4) target levels to achieve case closure:

**Tier 0 Screening Levels:** As per ***Section 6208 of the District of Columbia Underground Storage Tank Regulations,*** Tier 0 standards are empirical standards that consist of the following;

- Total petroleum hydrocarbons (TPH) gasoline range organics (GRO) or diesel range organics (DRO) concentrations in soil shall be no greater than one hundred milligrams per kilogram (100 mg/kg);
- Individual constituent concentrations of BTEX in soil shall not exceed benzene (0.005 mg/kg), toluene (9.6 mg/kg), ethylbenzene (0.04 mg/kg), and total xylenes (3.86 mg/kg).

For groundwater, the Tier 0 standards are the maximum contaminant levels (MCLs). If the maximum site concentrations meet these levels, the RP may request case closure. If these standards are not met, a tiered risk evaluation is appropriate.

**Tier 1 Risk-Based Screening Levels (RBSLs):** These are conservative risk based levels developed for different human receptors and different pathways. The site-specific application of RBSLs will require the development of a site conceptual exposure scenario and the selection of target levels for only those pathways that are complete.

**Tier 2A Site-Specific Target Levels (Tier 2A SSTLs):** These are conservative SSTLs that are developed using the same models, equations and input parameters used to develop Tier 1 RBSLs, except for site-specific fate and transport factors. Tier 2A SSTLs have to be established for each complete pathway.

**Tier 2B Site-Specific Target Levels (Tier 2B SSTLs):** These are SSTLs that provide flexibility to the RP in terms of using any technically defensible approach. To ensure that the approach is acceptable to the USTB, the RP should develop a detailed work plan, and have it approved by USTB prior to performing a Tier 2B evaluation. It is anticipated that very few sites if any will require a Tier 2B evaluation.

It is important to note that Tier 1, Tier 2A, and Tier 2B target concentrations are based on an acceptable individual excess lifetime cancer risk (IELCR) of $1 \times 10^{-6}$ for carcinogens and a hazard quotient (HQ) of 1 for non-carcinogens. Thus, the RP could adopt any of the tiered target concentrations as the cleanup levels.

## 2.4 REPORTING REQUIREMENTS

The site-specific implementation of the DCRBCA process requires the RP to prepare and submit several reports to the USTB. These reporting requirements are tabulated in Table 2-1 and presented below:

**Failure of the release detection system report:** If the release detection system does not perform according to the manufacturer's requirements, the RP must repair the system within 45 days. If the release detection system is not fixed or repaired, the RP must report the situation to the USTB within 24 hours of the expiration of the 45 days.

**Reporting of spills:** For spills less than 25 gallons, a RP must contain and cleanup the spill within 24 hours. If the cleanup cannot be completed within 24 hours, the RP must notify the

USTB. Spills exceeding 25 gallons, or spills that cause sheen in a surface water body, must be reported to the USTB within 24 hours and appropriate corrective action initiated.

**Reporting of releases:** Any owner, operator, RP, or their authorized agent must notify the USTB of a release or a suspected release within 24 hours. This initiates a 7-day investigation period during which the RP must confirm to the USTB whether a release has occurred. Additionally, the RP must immediately conduct initial abatement and leak detection system tests, if necessary.

**An initial site assessment:** Within 60 days after confirmation of a release, a RP shall submit to the USTB an Initial Site Assessment Report and a work plan for future site activities. The contents of the Initial Site Assessment Report are discussed in Section 4.0.

**Free product removal report:** Within 45 days of the confirmation of free product (LNAPL) at a site and **quarterly** thereafter, the RP must submit a free product removal status report. Note free product removal must continue on a **monthly** basis although the reporting is performed on a quarterly basis. Refer to Section 6.0 for additional discussions about LNAPL.

**Comprehensive site assessment report:** Within 60 days of the submission of the work plan accompanying the Initial Site Assessment Report, the RP shall submit a Comprehensive Site Assessment Report to the USTB. The specific contents and activities to be conducted as part of the Comprehensive Site Investigation are discussed in Section 4.0 of this guidance document.

**Risk-based evaluation report:** Following the completion of the comprehensive site characterization report, the RP will perform a tiered evaluation to develop the SSTLs and propose a CAP, if required. Within 60 days of receipt of the CAP, the USTB will either approve or disapprove the plan. Implementation of the plan shall begin within 30 days of receipt of the approval of the CAP. The effectiveness of the plan shall be evaluated at the end of each year.

**Groundwater monitoring report:** The USTB will require the submission of periodic monitoring reports as requested by the USTB.

To facilitate the preparation and review of the above deliverables, the USTB has developed DCRBCA software that consists of a series of forms that should be completed by the RP and submitted to the USTB. A hard copy of these forms is included in Appendix A and can be downloaded from DDOE's website www.ddoe.dc.gov.

A companion software to perform the calculations to develop SSTLs is available by contacting the RAM Group of Gannett Fleming, Inc. For additional information, send an e-mail to admin@ramgp.com.

# 3.0
# RELEASE NOTIFICATION, INITIAL ABATEMENT, AND CLOSURE REQUIREMENTS

## 3.1 INTRODUCTION

The DCRBCA process starts when a release or spill is suspected or confirmed at a site. The occurrence or confirmation of a release or spill may be based on either environmental or non-environmental factors. Environmental factors include, but are not limited to (i) identification of hydrocarbon vapors or stains in utility trenches, (ii) the occurrence of vapors in basements, or (iii) identification of sheen on a water body. Non-environmental factors include, but are not limited to (i) shortfall in the inventory, (ii) holes identified in a tank or piping during tank replacement activities, or (iii) failure of a tank test.

The DCRBCA process requires that any person involved in the management, maintenance, or ownership of a UST must notify the USTB of any release or suspected release within 24 hours. Specific release detection record keeping and notification requirements are presented in ***Sections 6001 and 6201 of the District of Columbia Underground Storage Tank Regulations.***

## 3.2 RELEASE NOTIFICATION

Within the DCRBCA process, a release may be (i) a known spill or overfill, or (ii) a suspected release.

The notification requirements for a spill are as follows:

- Any spill or overfill must be reported immediately to the USTB and Fire Department if there is any danger of fire or explosion.
- If the volume spilled is less than 25 gallons, the RP should take immediate action to contain and cleanup the spill. The USTB should be notified if the cleanup cannot be completed within 24 hours.
- If the volume spilled is greater than 25 gallons, or if the spill causes a sheen on a surface water body, the USTB must be informed within 24 hours and corrective action should be initiated.

The USTB should be notified immediately (within 24 hours) of a suspected release when the following occur:

- Failure of tank tightness test;
- Presence of LNAPL in excavation zone, basement, utility lines, dewatering wells, or a sump;
- Oozing of petroleum product from ground;
- Odors during tanks replacement or construction activities;
- Sudden loss of product from a UST;
- Unusual behavior of dispensing equipment;
- Unexplained presence of water in a tank;

- Results from a release detection method indicate a release; and
- Any other situation that may lead someone to suspect a hydrocarbon release.

For each of the above conditions, a written or oral (no voice message) report should be submitted that includes:

- How the release was discovered or suspected;
- The name and telephone number of the release reporter and his/her relationship to the site;
- The site address, contact name, phone number, position, and address;
- The name and phone number of the owner operator of the site and any known responsible parties;
- The location, date, time, and volume of release, capacity of the tank, and the substance released;
- Any initial abatement measures, and
- A qualitative evaluation of the human and environmental risks.

Within 7 days of the confirmation of a release, a written report must be submitted to the USTB, along with the initial report signed by the RP. The disposition of any material (soil, groundwater, etc.) recovered from the incident should also be included in the report.

## 3.3 INITIAL ABATEMENT

The primary objective of the initial abatement measures is to take appropriate steps to safeguard human health and the environment and to prevent further release of the hydrocarbons to the environment. Initial abatement may require the following actions:

- Empty the petroleum product from the UST system to prevent any further releases;
- Identify and mitigate any fire, explosion, or vapor hazards by controlling the release or evacuating the area affected by the release;
- Carefully handle any excavated materials or other contaminated media to avoid human contact as well as to avoid contamination of uncontaminated areas;
- Identify the product released;
- Begin removing any free product floating on groundwater or in excavations as soon as possible; and
- Initiate any other measures that may help safeguard human health and the environment and prevent further spreading of the hydrocarbons.

Within 20 days after release confirmation, the Initial Abatement Report (IAR) must be submitted to the USTB and Fire Department.

## 3.4 UST CLOSURE REQUIREMENTS

The reporting requirements for a temporary or permanent closure of a UST system are presented in ***Section 6100 of the District of Columbia Underground Storage Tank Regulations.*** These requirements relate to notification of the USTB, permit requirements, safety precautions to be observed during tank removal and closure activities, soil sampling and analysis requirements, disposal of any excavated material, and contents of a tank closure report.

As discussed in ***Section 6105.15 of the District of Columbia Underground Storage Tank Regulations***, depending on the results of the soil and groundwater concentrations, the USTB may grant a NFA status or require further site assessment. For the latter, the RP should initiate activities to collect the data discussed in Section 4.0.

## 3.5 LNAPL REMOVAL

LNAPL (free product) present at a site either as floating on the water table or in the soil represents a potential ongoing source of hydrocarbons that may result in unacceptable risk to human health and the environment or an expanding groundwater plume of hydrocarbon constituents. Thus, the DCRBCA requires the removal of LNAPL to the maximum extent practicable as discussed further in Section 4.9.1.

## 3.6 MANDATORY CLEANUP CRITERIA

The DCRBCA process requires that certain mandatory cleanup criteria (MCC) be satisfied at a site prior to submitting the request for case closure:

- Removal of the primary source (leaking tank, pipe, saturated soil, etc., if known);
- Removal of LNAPL to the extent practicable (historically a 0.1 inch thickness measured in a well is defined as free product); and,
- Maximum concentration of benzene in groundwater should not exceed 15 mg/L as per ***Section 6210 of the District of Columbia Underground Storage Tank Regulations***.

Typically the information gathered during the initial site investigation is used to determine whether the MCC have been met and to perform a Tier 0 evaluation.

# DATA REQUIREMENTS FOR DCRBCA PROCESS

## 4.1 INTRODUCTION

This section presents the data necessary to implement the DCRBCA process and a brief discussion of the techniques used to collect the data. This data would typically be collected subsequent to the confirmation of a release as part of the initial and comprehensive site characterization. The specific requirements of the initial and comprehensive site investigation are discussed in ***Sections 6203 to 6305 of the District of Columbia Underground Storage Tank Regulations***.

The objective of the data collection effort is to ensure that sufficient quality and quantity of data are available to (i) develop a site exposure model, (ii) compare maximum site concentrations with the Tier 1 RBSLs, if necessary (iii) develop Tier 2A and Tier 2B SSTLs, (iv) compare the target levels with representative concentrations, and (v) develop a feasible corrective action plan, if necessary.

To accomplish the above objectives, following categories of data are required:

- Nature and magnitude of the spill or release;
- Site information;
- Adjacent land use and receptor information including storm drains, utility lines, and any ecological receptors;
- Vadose zone soil characteristics;
- Saturated zone and groundwater characteristics;
- Distribution of the chemicals of concern in soil;
- Distribution of the chemicals of concern in groundwater; and
- Information about corrective action measures.

The data collected above should be used to complete the DCRBCA report forms (1, 2 and 4 through 15). As new data becomes available, these reports should be updated.

At most known leaking UST sites, portions or all of the necessary data may have been previously collected over an extended period of time, perhaps over several years. As part of the DCRBCA evaluation, the RP must carefully review the available data and identify any data gaps. As appropriate, a work plan to fill-in the data gaps should be prepared and implemented with the concurrence of the USTB. Only after all the necessary data has been collected, the RP should proceed with the development of target levels and the preparation of a corrective action plan, if necessary.

As a part of the DCRBCA evaluation and to understand the soil and groundwater impacts at the site, a comprehensive chronology of events related to site characteristics, remediation, tank removal activity, reported releases, etc. must be developed. The chronology of events must be documented using DCRBCA Report Form 6.

## 4.2 NATURE AND MAGNITUDE OF THE SPILL OR RELEASE

Knowledge about the nature and magnitude of the spill or release is necessary to identify the soil and/or the groundwater source at the site as well as to identify the chemicals of concern (COCs). The following information regarding a spill or release is necessary:

- Location of the spill or release,
- Quantity of the spill or release,
- Product spilled or released, and
- Any interim corrective action measures already performed.

The spill-related information can be obtained by (i) a review of the inventory records, (ii) interview of past employees, (iii) interviews with current on-site workers, and (iv) any spill incident reports filed with the USTB.

### 4.2.1 Location of Spill or Release

Location of spill or release defines the soil and groundwater source area. Likely spill/release locations at petroleum UST sites include (i) corroded or damaged tanks, (ii) piping especially at pipe bends, (iii) joints in pipes, (iv) dispenser islands, and (iv) accidental releases while filling the USTs. A spill or release may occur within the surficial soil (0 – 1 foot below the ground surface), subsurface soil (1 foot below ground surface to the water table), or below the water table, if the groundwater is shallow (up to 15 feet below ground surface).

The RP should review the operational history of the site to determine the location and timing of spill(s) or release(s). For most UST sites, the exact location and timing of the spill/source area may not be known. Moreover, the site may have had multiple spills/releases at different times and at different locations. In these cases, soil and groundwater sampling should be used to identify the likely location and extent (vertical and horizontal) of the residual soil and groundwater source. The exact number and location of samples have to be determined on a case-by-case basis using professional judgement and the concurrence of the USTB.

### 4.2.2 Quantity of Spill or Release

The DCRBCA does not necessarily require knowledge of the exact quantity of the spill or release. Often this information is not known. However, a general idea of the amount released may help evaluate the severity of the site conditions and the extent of contamination. Information on the amount released is typically based on inventory records.

### 4.2.3 Product Spilled and Chemicals of Concern

Identification of the specific product(s) spilled or released is important to identify the chemicals which are of real concern. The petroleum products regulated by the USTB include, but are not limited to:

- Gasoline,

- Diesel/light fuel oils,
- Product jet fuel,
- Kerosene,
- Heating oil, and
- Waste/used Oil.

Each of these products is composed of a number of hydrocarbon compounds and additives whose physical and chemical properties and percent composition in the product vary. Further, the environmental behavior (mobility, persistence, and inter-media transport) of the product and the adverse environmental and human health effects depend on (i) the properties of each constituent, and (ii) their concentration in the product.

While evaluating sites impacted by these products, the DCRBCA process focuses on a limited set of chemicals, specific to the product, that pose majority of the risk. These are known as the COCs. Table 4-1 lists the major products regulated by the USTB and the corresponding COCs for which the impacted soil and groundwater should be sampled and for which target levels should be developed.

Table 4-1 also lists the recommended analytical methods for the COCs. These methods should be used unless specific authorization to use alternative methods has been approved by the USTB.

If the spill or release at a site can be identified as a single product based on a reported spill or release, LNAPL analysis, or location of impacts (e.g., tank bottom of a particular product tank), COCs for that product only need be analyzed. If the product spilled or released cannot be conclusively identified, COCs corresponding to all the products suspected to have been stored at the site should be analyzed.

If data collected in the past did not include all the suspected COCs at a site, additional sampling may be necessary for the missing COCs before a DCRBCA evaluation can be performed.

### 4.2.4 Interim Remedial Actions

Typical interim remedial actions include the excavation and off-site disposal of contaminated soil, removal of LNAPL, soil vapor extraction, and pump and treat. Remedial actions performed at the site may have removed all or part of the product spilled or released. Soil and groundwater data collected prior to such activities may not be representative of current conditions and should not be used in risk evaluation. At such sites additional soil and groundwater concentration data should be collected after the completion of the corrective action. Data collected prior to the completion of corrective action, may be used to determine the locations where additional data should be collected.

***The nature and magnitude of the spill or release must be reported in DCRBCA Report Form 8.***

## 4.3 SITE INFORMATION

The following site information is necessary to complete the DCRBCA evaluation:

- Site map,
- Ground surface condition,
- Location of utilities on and adjacent to the site,
- On-site groundwater use,
- Location of stormwater drains and sumps, and
- Regional hydrogeology and aquifer characteristics.

Relevant site information can be obtained by (i) a site visit, (ii) review of engineering drawings showing the layout of the site, (iii) review of regional information, and (iv) review of files at the DDOE related to the site or adjacent sites.

### 4.3.1 Site Map

All maps should be made to scale, with a bar scale, and a north arrow. As appropriate, multiple site maps showing the locations of various structures on-site and the location of monitoring points should be prepared. A detailed site map of the facility showing the layout of the past and current USTs, ASTs, piping, dispenser islands, sumps, paved and unpaved areas, canopy, station building, storm drains, etc. should be prepared. A second map showing the locations of all (i) on-site monitoring wells including those that may have been abandoned, (ii) water use wells, (iii) soil borings, (iv) any soil vapor extraction wells, and (v) soil excavation areas should be prepared.

***Site information must be reported in DCRBCA Report Form 4.***

### 4.3.2 Ground Surface Conditions

Determine whether the site is paved. Also note the type, extent, and general condition of the pavement and determine the slope of the surface.

***Ground surface conditions must be reported in DCRBCA Report Form 4.***

### 4.3.3 Location of Utilities On and Adjacent to Site

Due to the potential for flow of contaminated groundwater and vapors into underground utility lines/conduits and preferential flow along the utility lines, a thorough evaluation of potential and real impacts to underground utilities must be performed. Utilities include phone lines, water lines, sanitary sewers, storm sewers, and natural gas lines. A combination of site observations, knowledge of buried utilities, and discussions with utility representatives and site owner should reveal the locations of site utilities. At a minimum perform the following:

- Locate all underground utility lines and conduits located within the area of known or likely soil and groundwater impact, both on-site and off-site where the release may have migrated, or may migrate in the future.

- Determine the direction of flow in the utilities (water, storm water, and sewage).
- Identify the utility lines/conduits on a base map which also show the extent and thickness of LNAPL, if any, and impacts to soil and groundwater.
- Determine depth of the utility lines/conduits relative to the depth of groundwater. Seasonal fluctuations of the groundwater levels should be carefully evaluated. As appropriate, a cross-sectional diagram should be provided illustrating the depth to groundwater and the locations and depths of the lines/conduits.
- Determine any past impacts to utilities and any complaints that may have been previously filed with the DDOE's Water Quality Division and Toxic Substances Division.
- As appropriate, sample the utilities and vaults using either explosimeters or by taking air samples especially if the site has measurable LNAPL in wells. If explosive conditions are encountered, immediately inform the USTB and the Fire Department.
- Where a utility is threatened, or where an explosive situation exists, appropriate measures to eliminate fire, explosive, and vapor hazards must be undertaken.

***Information about utilities must be reported in DCRBCA Report Form 4.***

### 4.3.4 On-Site Groundwater Use

The current and former owners and operators should be interviewed to determine whether a water use well is/was located on site. In case such a well is identified, construction details of the well should be obtained. At a minimum, the total depth of the well, screen interval, and the use of water should be determined. If such a well is identified and not currently in use or likely to be used in the future, it should be properly abandoned with the approval of the DDOE. Also any dewatering wells on or adjacent to the facility should be identified.

***Groundwater use and well construction details must be reported in DCRBCA Report Form 11.***

### 4.3.5 Regional Hydrogeology and Aquifer Characteristics

Published literature, especially United States Geological Survey (USGS) publications, and any investigations conducted on adjacent release sites should be reviewed to determine regional hydrogeology, soil types, and aquifer characteristics. Such information will help the RP in efficiently collecting site-specific soil and groundwater information as discussed in Section 4.5 and 4.6.

The survey should also locate surface water bodies located within 1000 feet of the site that could be potentially impacted by the site release. If a surface water body, that may potentially be impacted, is identified, collect information regarding the type (perennial vs. intermittent), water flow rate, flow direction, depth of water, width of the water body, and water use. The water body must be located on an area map.

***Hydrogeologic data must be reported in DCRBCA Report Form 10.***

## 4.4 ADJACENT LAND USE AND RECEPTOR INFORMATION

Land use information is used to identify the location and type of receptors, and the complete routes of exposure by which the receptors may be exposed to the COCs. This information is critical in developing a site conceptual exposure scenario. The following information should be collected:

- Current land use,
- Potential future land use,
- Water well survey, and
- Ecological receptor survey.

Several studies (Mace et al., 1997 and Rice et al., 1995) have shown that BTEX plumes from UST sites typically extend no more than 500 feet from the source, methyl tert-butyl ether (MTBE) plume may extend further. Thus, land use and receptor survey covering a radius of about 1,000 feet from the source is adequate. At sites where there is likelihood that the plume may be much longer, due to the magnitude of the spill or other site-specific conditions, a land use map covering the entire impacted and potentially impacted area is necessary.

### 4.4.1 Current Land Use

Land use of the site and its vicinity defines the on-site and off-site receptors that may be exposed to the COCs. There should be no ambiguity about the current land use. A walking land use survey within a 1,000 foot radius of the source should be conducted. The survey should clearly identify the following: schools, hospitals, residences (apartments, single-family homes), basements, day care centers, nursing homes, and nature of businesses. The map should also identify surface water bodies, parks, recreational areas, wildlife sanctuaries, wetlands, and agricultural areas. The results of such a survey should be documented on a land use map. It is not necessary to have a map drawn to an exact scale, rather an approximate scale would suffice in most cases.

***Land use must be reported in DCRBCA Report Form 5.***

### 4.4.2 Future Land Use

While it is easy to determine the current land use and receptors, future land use and receptors may not be certain. Unless the future land use is known it should be based on local zoning laws and surrounding land use patterns. As appropriate, aerial photographs, local planning offices, community master plans, changing land use patterns, interviews with current property owners, and commercial appraisals of a site can provide information for determining land use. Proximity to wetlands, critical habitat, and other environmentally sensitive areas are additional criteria that may help determine future land uses.

It may be appropriate to assume a land use that is conservative from an exposure consideration (i.e., residential) when the future land use cannot be determined. A risk evaluation assuming commercial land use will typically require a deed restriction or an Institutional Control to receive NFA.

***Land use must be reported in DCRBCA Report Form 5.***

### 4.4.3 Water Well Survey

A water well survey should be conducted to locate all public water supply wells within a mile radius of the site and all water use wells within a half-mile radius. Information sources include the USGS, water system operators, and interviews with local residents. In certain cases, a door-to-door survey of businesses and residents may have to be conducted as appropriate. The characteristics of the well including age, depth, water use, screen interval, and mode of operation (continuous vs. intermittent) should be documented. Additionally any dewatering wells located within a 1,000 ft radius of the site should be identified.

***Groundwater use and well construction details must be reported in DCRBCA Report Form 11.***

### 4.4.4 Ecological Receptor Survey

As appropriate, a 1,000 foot walking survey around the site to identify any ecological receptors is necessary. Ecological receptors include, but are not limited to, wetlands, surface water bodies, sensitive habitats, or the presence of endangered species. Any site where ecological receptors may be impacted will require consultation with the USTB.

***Ecological receptor survey results must be reported in DCRBCA Report Form 11.***

## 4.5 VADOSE ZONE SOIL CHARACTERISTICS

The vadose zone soil is the media through which COCs migrate to the groundwater and vapors move upwards to the surface or into an enclosed space. Thus, characteristics of the soils have considerable impact on the risk-based target levels. Relevant characteristics of soil include:

- Thickness of vadose zone and depth to groundwater,
- Porosity,
- Water content,
- Fractional organic carbon content, and
- Bulk density.

For the development of Tier 1 RBSLs, the USTB assumed conservative values of these parameters as presented in Table 5-5. For a Tier 2A or Tier 2B evaluation, site-specific values of these parameters, representative of (i) the source area, (ii) soils through which COCs migrate to reach groundwater, and (iii) soils through which vapors of the COCs migrate to reach the surface should be obtained.

Of the parameters mentioned above, organic carbon content must be determined using soil samples not impacted by the release. Since the organic carbon content varies with depth, wherever appropriate, samples representative of vadose and saturated zones should be collected. For measuring porosity and the bulk density of soil an undisturbed sample is necessary. Such a sample can be collected using a Shelby tube. Consideration must be given to collecting multiple samples if multiple lithologies are present which might affect transport of the COCs.

### 4.5.1 Thickness of Vadose Zone and Depth to Groundwater

The thickness of the vadose zone is determined based on the boring logs. It represents the distance from the ground surface to the depth at which the water table is encountered less the thickness of the capillary fringe.

Depth to groundwater is used in estimating the vapor emissions from groundwater. For outdoor inhalation, an average static depth to groundwater over the area can be used. For indoor inhalation, depth to groundwater below the "floor" of an existing structure of concern or at the most likely location of a future structure should be used. For sites with considerable seasonal fluctuation in water table level, a yearly average depth for each well may be used.

### 4.5.2 Dry Bulk Density

Dry bulk density (ASTM Method D2937-10, Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method) is the dry weight of soil sample divided by the field volume of the soil sample. An accurate measurement of bulk density requires weighing or determining the dry weight and volume of an undisturbed sample. This method involves collecting a core of known volume, using a thin-walled sampler to minimize disturbance of the soil sample, and transporting the core to the laboratory for analysis.

### 4.5.3 Porosity

Porosity is the ratio of the volume of voids to the volume of the soil sample. Many laboratories use dry bulk density and specific gravity data to determine porosity using the following:

$$n = 1 - \frac{\rho_b}{\rho_s} \tag{4-1}$$

where,

$n$ = Porosity ($cm^3/cm^3$)
$\rho_b$ = Dry bulk density ($g/cm^3$)
$\rho_s$ = Specific gravity or particle density ($g/cm^3$)

The "Standard Test Method for Specific Gravity of Soil" ASTM Method D854-10, may be used to determine specific gravity. If specific gravity is not available, a default value of 2.65 g/cc can be assumed for most mineral soils. If site-specific values of porosity are not available, it may be estimated from a literature source.

### 4.5.4 Volumetric Water Content/Moisture Content

Volumetric water content is the ratio of volume of water to the volume of soil. The ASTM Method D2216-10 (Standard Test Method for Laboratory Determination of Water [Moisture] Content of Soil and Rock) is a gravimetric oven drying method. The water content value used in most models is the volumetric water content. Hence, it may be necessary to use the following:

$$\theta_{wv} = \theta_{wg} \times \frac{\rho_b}{\rho_l} \qquad \text{(4-2)}$$

where,

$\theta_{wv}$ = Volumetric water content (cm$^3$ of water/cm$^3$ of soil)
$\theta_{wg}$ = Gravimetric water content, typically reported by the laboratory (g of water/g of soil)
$\rho_b$ = Dry bulk density (g of dry soil/cm$^3$ of soil)
$\rho_l$ = Density of water (g/cm$^3$)

### 4.5.5 Fractional Organic Carbon Content in Soil

Fractional organic carbon content is the weight of organic carbon in the soil divided by the weight of the soil and is expressed either as a ratio or as a percent. Typically fractional organic carbon content is estimated using ASTM Method D2974-07a (Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils). The results are usually reported as percent organic carbon content. The reported value can be converted to a fraction by dividing by 100.

If the fractional organic matter content is available, it has to be divided by 1.724 to estimate the fractional organic carbon content.

***The vadose zone characteristics must be reported in DCRBCA Report Form 10.***

## 4.6 SATURATED ZONE CHARACTERISTICS

COCs that reach the water table typically travel horizontally in the saturated zone. Characteristics of the saturated zone that determine the travel time for the COCs as well as the travel direction include:

- Horizontal hydraulic conductivity,
- Hydraulic gradient (magnitude and direction),
- Saturated zone soil characteristics (fractional organic carbon content, porosity, and dry bulk density), and
- Indicators of biodegradation.

Each of these is discussed below:

### 4.6.1 Hydraulic Conductivity

Hydraulic conductivity is the discharge of water per unit area per unit hydraulic gradient in a subsurface formation. Reliable estimates of site-specific hydraulic conductivity can be obtained by pump tests or slug tests. In the absence of these tests, literature value corresponding to the type of soil in the saturated zone may be used. When a literature value is used, adequate reference and justification for the value chosen should be provided. Hydraulic conductivity may also be estimated based on the grain size distribution of the porous formation (Shepherd, 1989).

### 4.6.2 Hydraulic Gradient

The magnitude and direction of the hydraulic gradient is estimated by comparing water levels measured in the monitoring wells. Typically, water level contour maps are prepared based on the measured data. These contour maps can be used to estimate both the direction and magnitude of the hydraulic gradient. When drawing the contour maps, care should be taken to ensure that measurements in monitoring wells screened in the same interval or hydrologic unit are used. For sites that have seasonal variation in hydraulic gradient, estimate the average hydraulic gradient for each season.

Consideration should also be given to determining any flow direction and vertical gradients at the site. Estimate of these requires a comparison of adjacent water levels in wells screened in different intervals.

***Saturated zone characteristics must be reported in DCRBCA Report Form 10.***

### 4.6.3 Saturated Zone Soil Characteristics

The saturated zone soil characteristics include the fractional organic carbon content, porosity, and bulk density. These parameters are required to quantify the movement of the COCs within the saturated zone. The laboratory methods to measure these parameters have been discussed in Section 4.5.

### 4.6.4 Indicators of Biodegradation

Several indicators (chemical concentrations, geo-chemical indicators, electron acceptors, microorganisms, and carbon dioxide) can be measured at a site to demonstrate the occurrence of natural attenuation. These indicators can be broadly classified into three groups: (i) primary, (ii) secondary, and (iii) the tertiary lines of evidence. Data collected under each line of evidence can be evaluated qualitatively or quantitatively to determine the occurrence of biodegradation.

- The primary line of evidence is to demonstrate a reduction in chemical concentration at a site by evaluating measured concentrations within monitoring wells.
- Secondary line of evidence refers to the measurement of geo-chemical indicators that include (i) dissolved oxygen, (ii) dissolved nitrates, (iii) manganese, (iv) ferrous iron, (v) sulfate, and (vi) methane. These indicators should be measured in at least three wells located along the flowline. Locations of these wells include (i) the background or

upgradient location, (ii) within the plume near the source, and (iii) within the plume in a downgradient well. Secondary line of evidence is necessary when (i) the primary line of evidence is not conclusive, or (ii) when such information is necessary to design a remedial system, e.g., by the addition of oxygen.

- Tertiary line of evidence involves the performance of microbiological studies such as the identification of the microorganisms present in the formation and their cell counts. Tertiary line of evidence is seldom used at petroleum hydrocarbon impacted sites.

The commonly used methods to estimate biodegradation include (i) mass balance analysis for expanding, stable, or shrinking plumes and (ii) plume concentration vs. distance plots. Under Tier 1, The DCRBCA program assumes no biodegration of hydrocarbons. Under higher tiers, the program allows the application of biodegradation for the evaluation of groundwater pathway.

***Natural attenuation parameters must be reported in DCRBCA Report Form 15.***

## 4.7 DISTRIBUTION OF COCs IN SOIL

Adequate soil concentration data are necessary to (i) compare representative concentrations for each complete pathway to the target levels and (ii) define the soil source dimensions. The assessment should be performed such that the Tier 1 RBSLs are considered throughout the assessment process to define the extent of investigation necessary to assess the horizontal and vertical extent of impacts. If it becomes apparent during the site investigation that the Tier 1 RBSLs will be met, then no additional information may be needed at the site. However, if the concentrations are likely to exceed the Tier 1 RBSLs, the site investigation should be performed such that all data necessary to perform a Tier 2A evaluation are obtained as expeditiously as possible.

The soil investigation(s) should be geared toward collecting the following data/information:

- Identification of the area impacted by COCs appropriate to the type of product released (see Table 4-1); and
- Identification of the horizontal and vertical extent of soil impacts. Unless otherwise directed by the USTB, the extent of impact should be defined to either non-detect or Tier 1 RBSLs.

The DCRBCA evaluation requires that a thorough assessment of source areas be performed to ensure that maximum concentrations of chemicals are detected at the site. To determine the spatial extent of the contamination, soil borings should be drilled starting from the known or suspected source area and drilling outwards until borings with non-detect or Tier 1 RBSLs are reached in all directions. To determine the vertical extent of the contamination, soil borings should be extended up to and possibly below the water table.

### 4.7.1 Surficial Soil Sampling

Within the DCRBCA program a distinction is made between surficial soil and subsurface soil. Surficial soil is defined as the soil up to 1 foot below the ground surface.

Evaluation of surficial soil pathways requires representative concentrations in surficial soil. Therefore, adequate number of soil samples should be collected and analyzed for potential COCs from surficial soils. When sampling from boreholes, collect one soil sample for laboratory analysis at a depth of one foot below the surface or 2 inches below the impervious (concrete or asphalt) pavement, whichever is shallower. Note that in some cases, very permeable material may be located 2 inches below the pavement, care should be taken to collect a representative sample.

For sites where the soil assessment has been completed,

- Do not take surficial soil samples when the site is paved and likely to remain so.
- For sites where the only COCs are volatile (e.g., BTEX), neglect the exposure pathways associated with surficial soil.
- For unpaved sites where the COCs are non-volatile (polycyclic aromatic hydrocarbons (PAHs) or metals), and there is evidence of a surficial spill or a shallow piping leak, collect surficial soil samples.
- For sites where the COCs are non-volatile (PAHs or metals), and there is evidence of a surficial spill or a shallow piping leak, and the site is paved, collect surficial soil samples only if the pavement is likely to be removed.

***Surficial soil data must be reported in DCRBCA Report Form 12.***

### 4.7.2 Subsurface Soil Sampling

Subsurface soil is the soil below the surficial soil. Since surficial soil extends from the surface to 1 foot below ground surface, subsurface soil extends from greater than 1 foot bgs up to the average static water table. Most receptors may not have direct exposure to this soil, except the construction worker, who may be involved in excavation activities below the surficial soil zone. Representative concentration in subsurface soil varies depending on the pathway and therefore, the soil sampling for subsurface soil is pathway-specific as described below:

1. For outdoor inhalation of vapor emissions from subsurface soil, representative concentrations of COCs over the entire soil source area are required.

2. For indoor inhalation of vapors from subsurface soils, for the current scenario, soil samples should be collected from a boring(s) adjacent to the existing structure of concern. In certain cases, sub-slab soil vapors may be necessary. For the future scenario, samples should be collected within the footprint of a planned structure. The DDOE plans to develop additional guidance related to indoor vapor intrusion pathway.

3. For exposure to a construction or utility worker during excavation activities, representative concentrations in the zone, where construction-related activities are likely to occur, should be estimated.

4. For leaching of COCs from soil to groundwater, the following parameters are critical: (i)

thickness of the contaminated soil zone, (ii) distance from the bottom of the contaminated zone to the water table, if any, and (iii) the representative concentration of COCs within the contaminated zone.

Soil sampling must be done in accordance with the following guidelines and procedures:

- Samples must be collected from the source area(s). If the source area(s) has not been identified, soil samples must be collected near the UST system, dispenser islands, and piping.
- Samples must be collected to determine the horizontal and vertical extent of soil contamination. At a minimum, four (4) soil borings must be installed at a site.
- Soil borings must be extended at least five feet beyond the depth of impact. The depth of impact can be approximately estimated based on the screening data collected during the soil borings.
- Samples should be collected at either 2 ft or 5 ft intervals (no more than 5 ft) down to the depth of impacts even if they extend below the water table and field screened. At least two samples corresponding to the highest field screening readings above the water table should be sent to the laboratory for analysis. If the thickness of the impact below the water table is more than 5 ft, a soil sample may be collected from below the water table for laboratory analysis.
- If the depth to water table is greater than 20 ft bgs, soil below subsurface soil (20 feet bgs) extending up to the water table should be sampled. As with vadose zone soil, samples should be collected at either 2 ft or 5 ft intervals. A sample must always be collected from the capillary fringe and preserved for laboratory analyses. The number of samples (other than the capillary fringe sample) preserved for laboratory analyses can vary depending on the thickness of the vadose zone. The samples should be selected based on photo-ionization detector (PID) readings.
- Soil borings should be logged and samples for laboratory evaluation collected in accordance with the methods approved by the USTB.
- All samples must be adequately preserved according to the requirements of the laboratory and analyzed within the holding times of each particular analysis.
- Sample analyses must be conducted in accordance with current DDOE analytical requirements and USEPA Office of Solid Waste and Emergency Response (OSWER) SW846 Methods.
- Adequate quality assurance and quality control (QA/QC) procedures must be utilized to ensure sample quality and integrity. QA/QC of samples should include surrogate and spike recovery and trip blanks whenever possible. The samples must not be cross-contaminated by drilling fluid or by the drilling and sampling procedures. All sampling equipment must be decontaminated utilizing the DDOE, USEPA, and industry standard protocol.

The appropriate methodology for abandoning boreholes is described in detail in the ASTM Guidance D 5299-99 (2005). The borehole is to be sealed from total depth to the surface with a bentonite/cement grout (6% to 8% bentonite powder). For borings of less than fifty (50) feet total depth, grout placement by tremmie pipe or grout pump should be considered.

***Subsurface soil data must be reported in DCRBCA Report Form 13.***

### 4.7.3 Soil Source Data

The soil analytical data, along with the historical use of the site should delineate the soil source area. If more than one source area is identified at a site, each source area should be evaluated separately. Once the soil source(s) is identified, source dimensions can be estimated. Length of source parallel to wind is used to estimate concentrations in ambient air. Since the wind directions fluctuate, conservatively the largest dimension (length instead of width for a rectangular source) of the source may be used. Depth to subsurface soil source should be the depth, in the source area, from surface to the zone where concentrations are above quantitation limits. Professional judgment should be used in choosing the depth.

### 4.7.4 Logging of Soil Boreholes

Each soil boring must be logged, by a qualified professional, to indicate depths correlating with changes in lithology (with lithologic descriptions), soil vapor (e.g., flame ionization detector (FID)) analyses, occurrence of groundwater, total depth, visual and olfactory observations, and any other pertinent data. When a monitoring well is installed, as built diagrams with depth to groundwater must be submitted for each well. A continuous soil profile from at least one boring should be developed with detailed lithologic descriptions. Particular emphasis should be placed on characteristics that control chemical migration and distribution such as zones of higher or lesser permeability, changes in lithology, correlation between soil vapor concentrations and different lithologic zones, obvious areas of soil discoloration, organic content, fractures, and other lithologic characteristics.

***All bore logs must be included as an attachment to the DCRBCA Report Form 10.***

## 4.8 DISTRIBUTION OF COCs IN GROUNDWATER

Adequate groundwater samples should be collected to delineate the extent of dissolved contaminant plumes in all directions and to provide representative concentrations for the complete routes of exposure. Soil source delineation can serve as a guide in choosing the location of monitoring wells.

### 4.8.1 Groundwater Sampling

If groundwater has been impacted, temporary sampling points may be used to screen the levels of groundwater impacts and to assist in determining the optimal location of permanent monitoring wells. A sufficient number of monitoring wells should be installed (a minimum of three for a Tier 1 evaluation) to document COC migration and groundwater flow. The monitoring wells must be installed in accordance with the following guidelines and procedures:

- Adequate number of monitoring wells must be installed to sufficiently delineate the horizontal and the vertical extent of the groundwater plume. At a minimum, one monitoring well must be installed in the source, one upgradient, and another downgradient of the source.

- Well placement and design should consider the concentration of COCs in the source area, and the occurrence of LNAPL at the site.
- Wells must be installed in accordance with DC Regulations, 21 DCMR 1900.1 and USEPA protocols.
- Well casing and screen materials must be properly selected. The screen interval must be set at least 2 – 3 feet above the shallowest expected depth of water table.
- Wells must be properly developed and gauged after installation.
- A site survey must be conducted to establish well elevations. Based on the groundwater elevations, groundwater flow direction and gradient should be determined and plotted on a map.

The groundwater samples must be collected in accordance with the following guidelines and procedures:

- Monitoring wells must be purged an adequate number of well volumes prior to collecting a sample, unless the DDOE accepts data collected using the no-purge or low purge or passive sampling technique.
- Samples must be collected utilizing USEPA approved methods and equipment.
- Samples must be adequately preserved according to the requirements of the laboratory analyses and extracted within the holding times of each particular analysis.
- Sample analyses must be conducted in accordance with current analytical requirements and USEPA OSWER SW846 Methods.
- Adequate QA/QC procedures must be utilized to ensure sample quality and integrity. QA/QC of samples should include surrogate and spike recovery and trip blanks whenever possible. All sampling equipment must be decontaminated utilizing the USTB, USEPA, and industry standard protocol.

If the plume is not delineated in all directions, location of new monitoring wells should be chosen based on the groundwater flow direction and the location of the soil source area.

### 4.8.2 Groundwater Protection

For potential use of groundwater in the future at a point (downgradient) from the source, the length, width and thickness of groundwater source will be required. Although the source length and width can be estimated from the groundwater analytical data and soil source dimensions, groundwater source thickness is not measured at the site. A thickness of 200 cm is conservatively assumed.

### 4.8.3 Surface Water and Sediment Sampling

As requested by the DDOE, surface water samples should be collected when COCs migration is known or suspected to affect a surface water body, in accordance with 21 DCMR 1900.1. Water samples should be collected from both upstream and downstream of a groundwater discharge point. In addition, sediment samples may be collected if the site conditions warrant.

***Groundwater data must be summarized in DCRBCA Report Form 14.***

## 4.9 EVALUATION OF LIGHT NON-AQUEOUS PHASE LIQUID

The detection of measurable LNAPL in a well or vadose zone must trigger a response to achieve the following objectives:

1. LNAPL should not be present at levels that could cause explosive conditions to occur at or near the site.
2. The LNAPL plume shall be fully delineated.
3. Dissolution of and volatilization from LNAPL should not generate dissolved phase or vapor phase concentrations that result in unacceptable human or ecological risk, under current or reasonable future conditions.
4. Both the LNAPL and its associated dissolved phase plume must be stable or shrinking.
5. LNAPL should reach asymptotic recovery rates or the LNAPL removal is demonstrably impracticable.

When data indicate that these goals have been sustainably achieved, no further evaluation or removal of LNAPL will be required. In some cases, provided all other relevant site conditions are acceptable and satisfy DCRBCA closure requirement, the DDOE may issue a NFA letter even though measurable LNAPL remains in one or more of the monitoring wells. The presence of measurable LNAPL in a well does not preclude the RP to perform a RBCA evaluation or request a NFA from the DDOE if the above five goals have been met.

### 4.9.1 Removal of LNAPL

At sites where investigation reveals the presence of measurable LNAPL in monitoring wells, the entity performing the investigation shall remove as much LNAPL as practicable based on “best available technologies” and as determined and approved by the DDOE. The primary objective of LNAPL removal is to meet the five objectives listed in Section 4.9.

The DDOE shall evaluate the practicability of LNAPL removal as proposed by the RP in LNAPL removal work plan. The work plan will include consideration of (i) the methods commonly available for such removal, (ii) removal rates over time using appropriate removal methods based on site-specific conditions, (iii) site-specific geology, (iv) the characteristics of the LNAPL and its constituents, (v) the extent to which the LNAPL is contributing to the expansion of a dissolved phase contaminant plume, (vi) the risks associated with the dissolved phase plume, and (vii) any other pertinent factor. An evaluation of the impracticability of LNAPL removal shall be undertaken only after reasonable attempts have been made to remove the measurable LNAPL from a monitoring well and the surrounding acquifer.

LNAPL removal activities at a site may be terminated with the approval of the DDOE when all the five objectives in Section 4.9 have been met.

The evaluator must prepare and submit to the DDOE an LNAPL removal report within 45 days of the initiation of LNAPL recovery and at periodic intervals as requested by the DDOE. Note:

the recovery must begin within 10 days of the measurement of LNAPL in a well.

A brief discussion of each of the five objectives is presented below.

### 4.9.2 Protection against Explosive Risk

In certain circumstances, the presence of LNAPL can pose a risk of explosion due to vapor migration and accumulation. At sites where LNAPL is present, vapor monitoring must be conducted in any confined space located to an area within about 50 feet of the known extent of LNAPL. Such monitoring must use monitoring equipment capable of detecting contaminants, associated with the specific type of LNAPL found at a site, at concentrations equal to or less than 25 percent of the lower explosive limit (LEL) of each volatile component of the LNAPL. Examples of confined spaces include utilities, manways, subsurface structures, and any other enclosed spaces within 50 feet of the known extent of the LNAPL plume where vapors may accumulate.

The detection of vapors at concentrations equal to or greater than 25 percent of the LEL of any one or more of the volatile components of the LNAPL shall constitute a potential explosion hazard and shall require abatement. Table 4-2 presents the LELs and 25% LELs for several volatile petroleum components. In the above discussion, the distance of 50 feet is approximate. Depending on site specific considerations (e.g. migration of LNAPL along preferential pathway (e.g., a utility)) LEL monitoring beyond 50 feet may be required by the DDOE.

### 4.9.3 Delineation of LNAPL Plume

The occurrence of measurable LNAPL must be documented and investigations must be conducted as a part of the site characterization activities, to determine the extent of the LNAPL. Data must be evaluated to determine if LNAPL is migrating, either as LNAPL or via dissolution into groundwater. This determination will require the installation and monitoring of wells, sufficient to fully define the LNAPL and dissolved-phase plume. Further, periodic measurement of LNAPL thickness and dissolved-phase contamination in these wells will be required. The resulting data must be sufficient to demonstrate spatial and temporal trends in LNAPL thickness and dissolved phase concentrations. Note that LNAPL thickness is critically affected by water table fluctuations. Therefore, the collection of sufficient data, especially at sites where there are strong seasonal and long-term water table fluctuations, is very important to ensure accurate LNAPL delineation and characterization.

For further discussion regarding the delineation of LNAPL plume, refer to USEPA, 1996; American Petroleum Institute (API), 2002; Interstate Technology & Regulatory Council (ITRC), 2009; and ASTM, 2010.

### 4.9.4 LNAPL Tiered Risk Assessment

LNAPL can pose a long term risk to human health due to generation of vapors, dissolution in groundwater, and migration to a point of exposure. To estimate the risk it is necessary to first calculate the dissolved and vapor phase concentrations in equilibrium with the LNAPL. These concentrations are used as explained in Section 5.0 to perform the tiered evaluation. The dissolved and vapor concentrations in equilibrium with LNAPL can be calculated using Raoult's law (Prausnitz, 1969). The concentration of a gasoline constituent in dissolved phase is equal to the mole fraction of the constituent in the LNAPL multiplied by the aqueous solubility of the pure compound, i.e.,

$$C_i^l = X_i \times S_i \tag{4-3}$$

where,

$C_i^l$ = Dissolved phase concentration of constituent *i* (mg/L),
$X_i$ = Mole fraction of the constituent *i*, and
$S_i$ = Solubility of the constituent *i* in pure water (mg/L).

Mole fraction of the constituent *i* can be estimated as:

$$X_i = \frac{0.01 \times w_i \times MW_{avg}}{MW_i} \tag{4-4}$$

where,

$w_i$ = Weight percent of the constituent *i* (%),
$MW_{avg}$ = Average molecular weight of the mixture (g/mol), and
$MW_i$ = Molecular weight of the constituent *i* (g/mol).

The vapor pressure of the constituent *i* is estimated as:

$$P_i^v = X_i \times P_i^s \tag{4-5}$$

where,

$P_i^v$ = Vapor pressure of constituent *i* (atm), and
$P_i^s$ = Saturated vapor pressure of constituent *i* (atm).

Vapor pressure can be converted to vapor concentration as:

$$C_i^v = \frac{X_i \times P_i^s \times MW_i}{R \times T} \times 10^6 \tag{4-6}$$

where,

$C_i^v$ = Vapor phase concentration of constituent *i* (mg/m$^3$), and
$R$ = Ideal gas constant (0.0821 L-atm/mol-K),
$T$ = Temperature (°K), and
$10^6$ = Unit conversion factor from g/L to mg/m$^3$.

Based on the above equations, the phase (dissolved or vapor) concentrations of the constituents depend on the mole fraction of the LNAPL not the amount of LNAPL. Thus, whether the thickness of LNAPL in a well is 1 foot or 1 inch, the phase concentrations would be identical.

The composition of the product (gasoline, dirt, etc.) varies over time due to weathering. The default LNAPL composition relative to the COCs for several products is shown in Table 4-3. Table 4-3 also presents the average molecular weight of products. These defaults can be used to estimate the effective dissolved and effective vapor phase concentrations associated with LNAPL at a site using the equations included in Appendix B. These dissolved and vapor concentrations are necessary to estimate the risk.

As appropriate, the RP may collect a representative sample of the LNAPL and use laboratory analysis to estimate the mole fraction of various COCs. In the absence of such site-specific data, default values from Table 4-3 may be used with adequate justification.

At Tier 3 evaluation, alternate technically defensible methods and models to evaluate LNAPL, composition, fate and transport, or plume stability, may be proposed in the work plan and used upon approval by the DDOE.

### 4.9.5 Plume Stability

One of the objectives of a RBCA evaluation is to collect sufficient data to delineate the extent of the LNAPL plume. In addition to the stability of the LNAPL plume, the stability of the associated dissolved-phase plume must be evaluated. The outcome of such an evaluation will, in part, determine whether and to what extent continued LNAPL recovery is required.

For further discussion regarding the plume stability, refer to USEPA (1996), API (2002), ITRC, (2009), and ASTM (2010).

### 4.9.6 Practicability of LNAPL Removal

LNAPL must be removed from the environment to the maximum extent practicable. The degree of removal constituting the “maximum extent practicable” is a site-specific determination and does not equate to a generic “LNAPL thickness in well” that can be uniformly applied to all sites regardless of site and LNAPL characteristics. The LNAPL removal workplan must discuss the mobility of LNAPL taking into consideration the site specific stratigraphy; density, and viscosity of the LNAPL; and water table fluctuations. For further discussion regarding the mobility of LNAPL, refer to USEPA (1996), API (2002), ITRC (2009), and ASTM (2010).

### 4.9.7 LNAPL Removal Work Plan

At sites where LNAPL is discovered such that, LNAPL removal is warranted, an LNAPL removal work plan must be submitted within 45 days of the discovery of the LNAPL. However, interim LNAPL removal must occur within 10 days of discovery. If LNAPL removal activities are to be conducted on an ongoing basis, a LNAPL removal report must be submitted to the DDOE quarterly unless a different reporting schedule is approved by the DDOE.

Following items are to be included in the LNAPL removal work plan:

- **Schedule**: As stipulated by the DDOE.

- **Intent of work plan**: The LNAPL Removal Work Plan should propose one or more methods to remove LNAPL to the extent warranted to satisfy the five objectives.

- **Contents to include, but not necessarily be limited to, the following**:

  - A brief history of the site and the occurrence of LNAPL,
  - An explanation of the methods to be used to remove LNAPL and to manage LNAPL once removed,
  - As necessary, schematics or diagrams showing the proposed LNAPL recovery method,
  - A monitoring plan to track LNAPL occurrence and distribution at the site,
  - A discussion of the proposed endpoint for removal activities,
  - A site map identifying the extent of LNAPL and identifying all LNAPL removal points,
  - A schedule for LNAPL removal activities, and
  - Other information, tables, graphs, maps, etc. as warranted.

### 4.9.8 LNAPL Removal Report

Following items are to be included in the LNAPL removal report:

- **Schedule**: As proposed in the work plan and agreed to, or stipulated by the DDOE.

- **Intent of report**: A LNAPL Removal Report is intended to document the LNAPL removal activities conducted at a site to address unacceptable risks associated with the LNAPL.

- **Contents to include, but not necessarily be limited to, the following**:

  - Site history, including release discovery and initial abatement activities (including initial LNAPL removal activities),
  - A discussion of LNAPL location and extent, including maps illustrating location and extent and identifying existing and historical monitoring points,
  - A discussion of the composition of the LNAPL (e.g., gasoline, diesel, etc.),
  - All applicable laboratory analytical data sheets, QA/QC data, and chain of custody forms (must be submitted as received from the laboratory),
  - A discussion of removal activities conducted and the practicability of further removal given consideration of all available removal methods,
  - A table listing each LNAPL removal event, the method of removal, the volume of LNAPL removed during each event, and the total volume removed (the volume removed should be differentiated from the total volume of fluid removed),
  - Text describing the expected duration of LNAPL recovery activities and any

proposed changes
- A discussion of planned future removal activities and a corresponding schedule, and
- Other maps, figures, tables, graphs, diagrams, etc. as warranted.

# 5.0
# SELECTION AND DEVELOPMENT OF RISK BASED LEVELS

## 5.1 INTRODUCTION

The DCRBCA process starts when a release is suspected or confirmed at a site and ends when the USTB approves a NFA letter for the site. Thus, the DCRBCA process includes all activities that have to be conducted at the site until the USTB determines that the COCs do not pose an unacceptable current or future risk to the public health, safety and welfare, or the environment. As presented in Section 2.0 of this guidance document, the DCRBCA process consists of seven (7) steps. This chapter discusses Step 5 of the process related to the development of risk-based target levels (RBSLs and SSTLs). Figure 5-1 shows the flowchart for this step.

The DCRBCA process allows calculation of site-specific target concentrations for soil, groundwater, and air primarily based on the protection of human health due to chronic exposure. These calculations do not take into account non-risk type conditions that may be identified during the investigation, such as excessive odor or staining of soils. Prior to requesting a NFA letter, the RP may be required to mitigate such nuisance conditions. The seriousness of the nuisance conditions will be determined as part of site investigation conducted by the RP and approved by the USTB.

Further, as a part of the site assessment, the RP is required to identify and evaluate impacts, if any, to sensitive environmental receptors such as wetlands, surface water bodies, endangered species, etc. The USTB, on a case-by-case basis, will identify the specific requirements for evaluating impacts to ecological receptors and any associated corrective action.

## 5.2 DEVELOPMENT OF SITE CONCEPTUAL EXPOSURE SCENARIO

The development of risk based levels starts with the development of **a site conceptual exposure scenario (SCES)**. A SCES identifies the source of COC, the COC release mechanisms, the media of concern, the pathways, and the receptors. It presents a working hypothesis of the manner by which COCs migrate from the source or the point of release to the **points of exposure (POEs)** where COCs come in contact with the receptors. If migration of the COCs from the source to the receptors is not possible, or if completion of the pathway is not possible under current or most likely future land use conditions, for example, due to engineering controls, the COCs will not pose any risk. Any pathways that are not complete will not pose any risk. Thus, for risk to be present at a site, at least one exposure pathway must be complete. Note for the groundwater pathway, even if there is no ingestion of groundwater and hence no complete pathway, it is still necessary to protect the groundwater resource as discussed in Section 5.4.

A SCES is a qualitative evaluation based on the information collected during site investigations (refer to Section 4.0). Typically, SCESs for three different time periods will be developed for each site: (i) the current land use, (ii) short-term future land use, such as a period of construction, and (iii) long-term future land use. Consideration of current and anticipated future land use ensures that the site-specific decisions will be protective of not only current but also future site use. At sites where the current and future land uses are likely to be the same, the current and future SCES would be identical.

A SCES may be presented in a graphical or a tabular format as shown in Figure 5-2 and Table 5-1 respectively. For each complete pathway and route of exposure identified in the SCES, risk-based target levels must be developed for each COC (see Table 4-1 for a list of the COCs). Key elements of the SCES include (i) land use, (ii) receptors, (iii) pathways, and (iv) routes of exposure. Each of these elements is discussed in the following sections.

***The SCES must be documented in DCRBCA Report Form 16.***

### 5.2.1 Land Use

Knowledge about the current and anticipated future land use is critical to identify (i) the type of activities occurring on or near the site, and (ii) the type of human and ecological receptors.

A determination of current and anticipated future land use must be made for an area currently or likely to be contaminated by site-specific COCs. This determination may include on-site as well as off-site areas.

- **On-site**: Includes the area within the legal boundaries of the property on which the source is/was located. This includes soil, groundwater, surface water, and air within those boundaries.

- **Off-site**: Includes the area outside the legal boundaries of the property on which the source is/was located or impacted from an on-site source. This includes soil, groundwater, surface water, and air located off-site.

Within each area (on-site/off-site) there may be multiple land uses, for example, a plume may have migrated off-site below a residential and a commercial area.

Within the DCRBCA process, land use is categorized as either residential or commercial. Residential land use generally results in lower risk-based target levels and cleanup to residential standards will usually allow unrestricted land use. Commercial land use includes industrial uses. Examples of residential and commercial land use are presented below:

- **Residential**: Typically a location where someone is present for an average of more than 8 hours a day. Residential land use includes, but is not limited to, schools, dwellings, residences, parks, playgrounds, hospitals, childcare centers, nursing homes, and any other sensitive human activity areas.

- **Commercial**: Typically a location where someone is on-site less than an average of 8 hours a day. Commercial land use includes, but is not limited to, gas stations, industrial operations, stores, businesses, and offices other than home offices, where employees work but do not reside on a continuing basis. Hotels, motels, and other structures with other transient activities may be included in the commercial definition.

The two categories of land use, commercial or residential, within a 1000-ft radius of the site should be clearly illustrated on maps included with the DCRBCA report. Care should be taken to ensure that the maps represent the current land use and are not reproductions of outdated maps of the area. A discussion of the current and potential future land use is presented in Section 4.4.

### 5.2.2 Receptors (On-Site and Off-Site)

The objective of DCRBCA process is to make decisions protective of the current as well as the most likely future on-site and off-site receptors. A typical DCRBCA evaluation should consider the human receptors, both children and adults, who live or work within at least 1,000 feet of the site. Additional receptors beyond 1,000 feet should also be identified and their risk evaluated for sites where COC plumes extend or are likely to extend beyond 1,000 feet of the site property boundary.

The human receptors considered in the DCRBCA evaluation include:

Residential – Child
Residential – Adult
Commercial Worker – Adult
Construction Worker – Adult

The primary difference between the construction worker and the commercial worker is the exposure duration. It is anticipated that the above human receptors will be the most exposed. Other human receptors, such as visitors or maintenance workers, will generally have less exposure and, if so, need not be considered further. For residential conditions, risk-based target levels for both an adult and a child have to be considered and the lower of the two values used for conservative health risk evaluation.

There are certain sites, such as conservation areas, sensitive resource areas, and agricultural areas, where livestock or wildlife may be potential receptors. In these areas, ecological exposures to wetlands, sensitive environments, or threatened and/or endangered species should be evaluated. Section 5.7 briefly addresses concerns regarding ecological risk evaluation. Sites that have ecological receptors should be evaluated on a case by case basis in consultation with the Natural Resources Administration and USTB of DDOE.

Surface water bodies should be evaluated to determine the potential effect of contaminated groundwater or surface water runoff from the site. Estimation of soil and groundwater target levels may be established by accounting for mixing of groundwater discharge with the stream-flow, with the approval of the DDOE.

On-site and off-site underground utilities must be identified. Environmental concerns related to utilities include: (i) their ability to serve as preferential pathways resulting in vapors in utilities e.g., storm and sanitary sewers, and (ii) potential adverse effects of COCs to property, including degradation of water lines, degradation of sewer lines, damage to outer coatings of gas lines, and damage to buried phone and electrical lines.

Generally acceptable quantitative methods to evaluate adverse effects on utilities are not available; therefore, a qualitative evaluation is appropriate in most cases. Soil vapor surveys along utility corridors or in manholes may be appropriate when quantitative information is essential, as for human exposure issues.

### 5.2.3 Pathways and Routes of Exposure

A receptor comes in contact with a COC through a completed exposure pathway. For a pathway to be complete there must be (i) a source of COCs, (ii) a mechanism by which the COCs are released, (iii) a medium through which the COCs travel from the point of release to the receptor location, and (iv) a route of exposure by which a COC enters the receptor's body and may cause an adverse health effect. This section identifies most commonly encountered exposure pathways at a contaminated site that must be evaluated to determine whether they are complete.

#### 5.2.3.1 Pathways for Inhalation

Intake of COCs can occur by the inhalation of vapors indoors or outdoors. Depending on the toxicity and odor threshold of the COC, unacceptable exposures may occur at concentrations below the odor threshold. Situations where indoor inhalation pathways are not complete include (i) no enclosed structures adjacent to or on top of contaminated (media) soil or groundwater, (ii) the structure is protected by a vapor barrier, or (iii) any other factor that makes the indoor inhalation exposure pathway incomplete.

COCs may volatilize from the soil or groundwater and diffuse through the overlying unsaturated zone to indoor or outdoor air where inhalation exposure occurs. The DDOE intends to develop Vapor Intrusion Guidance, which will be a companion document to evaluate this pathway.

#### 5.2.3.2 Pathways for Surficial Soils (0 – 1 foot)

Surficial soils are defined as soils extending from the surface to 1 foot bgs in unpaved areas. The exposure pathways associated with contaminated surficial soil include:

- Leaching and potential ingestion of contaminated groundwater,
- Leaching and potential migration to a surface water body, and
- Ingestion of soil, outdoor inhalation of vapors and particulates, and dermal contact with soil.

To evaluate these pathways, a sufficient number of surficial soil samples must be collected and analyzed for the COCs from the contaminated area. These sample concentrations are used to estimate the pathway-specific and chemical-specific, representative concentrations that are compared to the RBSLs or SSTLs for the complete pathways for each COC. The estimation of representative concentrations is discussed in Section 5.6.

For the construction worker, surficial soil refers to soil from the surface to the typical depth of construction. Soil within this depth may be brought to the surface during construction activities and result in exposures to the construction worker.

#### 5.2.3.3 Pathways for Subsurface Soils (1 foot bgs to the Water Table)

Subsurface soils are defined as native soils extending from 1-foot bgs to the water table. The exposure pathways associated with subsurface soils include:

- Indoor inhalation of vapor emissions,
- Outdoor inhalation of vapor emissions (typically not a critical pathway and hence it is not necessary to quantitatively evaluate this pathway),
- Leaching to groundwater and potential ingestion of groundwater, and
- Leaching to groundwater and potential migration to a surface water body.

To evaluate these pathways, a sufficient number of subsurface soil samples must be taken in the impacted area. The sample concentrations are used to estimate the site-specific, representative subsurface soil concentrations for all COCs that are compared to the RBSLs or SSTLs. The estimation of representative concentrations is discussed in Section 5.6.

#### 5.2.3.4 Pathways for Groundwater

Potentially complete exposure pathways for the contaminated groundwater include:

- Indoor inhalation of vapor emissions from groundwater,
- Outdoor inhalation of vapor emissions (typically not a critical pathway and hence do not have to be quantitatively evaluated),
- Dermal contact with groundwater,
- Domestic use of groundwater (this pathway includes ingestion of water and inhalation of vapors due to indoor water use), and
- Migration and discharge into a surface water body.

To evaluate these pathways, a sufficient number of groundwater samples must be obtained to adequately delineate the plume. The site-specific representative groundwater concentrations are then compared with the RBSLs or SSTLs. The estimation of representative concentrations is discussed in Section 5.6.

#### 5.2.3.5 Other Pathways

Each of the above exposure pathways must be considered when developing the SCES. In some cases it may be determined that one or more of these routes of exposure are incomplete, such as indoor inhalation of vapor emissions from groundwater if the building is located upgradient of the plume. In such cases the pathway will be eliminated from further consideration.

The professional developing the SCES must evaluate and consider all other pathways and routes of exposure that may be significant at a site, for which the USTB has not developed risk-based target levels. The RP should contact the USTB for further guidance regarding the evaluation of such pathways and routes of exposure.

## 5.3 CALCULATION OF RISK-BASED TARGET LEVELS

This section presents the development of target levels and the default data used to develop Tier 1 RBSLs. Appendix C presents a discussion on the development of target levels for TPH groups.

### 5.3.1 Target Risk Level

As per the DC's regulations, a risk-based decision making process requires the specification of a target or acceptable risk level for both carcinogenic and non-carcinogenic adverse health effects. The target risk levels are used to estimate the target exposure point concentrations. For carcinogenic effects, the DDOE will use an **individual excess lifetime cancer risk (IELCR)** of $1 \times 10^{-6}$ as the target risk for both current and future receptors. For non-carcinogenic effects, the acceptable risk level is a **hazard quotient (HQ)** of one (1) for current and future receptors. These target risk levels are used for all tiers.

The estimation of cumulative risk or the hazard index (HI, sum of HQs) is not required for the following reasons:

- There are a limited number of COCs at most regulated UST release sites and the COC's affect different organs;

- The DCRBCA process uses conservative exposure factors and target risk levels; and

- The models used to estimate the RBSLs and SSTLs include numerous conservative assumptions.

Thus, the risk and HQ from multiple COCs and multiple routes of exposure will not be added except for the routes of exposure associated with the surficial soil. The surficial soil RBSLs and SSTLs assume the cumulative effect of ingestion, inhalation, and dermal contact with a chemical.

### 5.3.2 Chemical-Specific Physical and Chemical Properties

The development of risk-based target levels, requires selected physical and chemical properties of the COCs. The values of these parameters are listed in Table 5-2. Several of these values are experimentally determined. Thus, their values in different references may differ. The DDOE requires the use of values tabulated in Table 5-2 for all DCRBCA evaluations unless there are justifiable reasons to modify these values. If such reasons exist, the RP must provide sufficient justification to the USTB to utilize a different value before performing the evaluation. The DDOE may update the data in Table 5-2 if new information becomes available.

### 5.3.3 Quantitative Toxicity Factors

The toxicity of chemicals is quantified using slope factors (or potency value) for chemicals with carcinogenic adverse health effects. For chemicals that cause non-carcinogenic adverse health effects, toxicity is typically quantified by reference dose or reference concentrations.

Toxicity values for the COCs are presented in Table 5-3(a). The DDOE requires that the most recent toxicity values recommended by the USEPA be used for the evaluations. As of the publication of this document, the values listed in Table 5-3(a) represent the most recent values and should be used for both Tier 1 and Tier 2A evaluations.

The availability of a more current, technically defensible toxicity value would be a justifiable reason to use an alternative value. To check the current toxicity values for COCs, the following sources may be contacted in the order listed:

(i) USEPA's Regional Screening Levels (RSLs),
(ii) USEPA's Integrated Risk Information System (IRIS),
(iii) Direct communication with the appropriate DDOE and USEPA personnel, and
(iv) Review of peer reviewed literature by qualified professionals to develop toxicity factors.

Additional chemical specific factors required to evaluate the dermal contact pathway are included in Table 5-3(b).

### 5.3.4 Exposure Factors

Exposure factors describe the physiological and behavioral characteristics of the receptor. These include factors such as the body weight, body surface area, air inhalation rates, water ingestion rate, etc. A list of default exposure factors to be used for Tier 1 and Tier 2A evaluations are presented in Table 5-4. The exposure factors are typically estimated based on literature and site-specific measurements are not conducted. For a Tier 2B evaluation, site-specific values of the exposure factors, other than default values, may be used if they can be justified. An excellent source of information is the USEPA's *Exposure Factors Handbook* (August 1997).

***Justification for the Tier 2A exposure parameters if different from Tier 1 should be included in DCRBCA Report Form 26.***

### 5.3.5 Fate and Transport Parameters

Fate and transport parameters are necessary to estimate the target levels for the indirect routes of exposure. These factors characterize the soil, groundwater, ambient air, and typical enclosed space. For a Tier 1 evaluation, the USTB has selected generic conservative default values that are listed in Table 5-5. For Tier 2A and 2B evaluation, a combination of site-specific and generic values for these parameters may be used. However, the value of each parameter used must be justified based on site-specific conditions.

***Justification for the Tier 2A fate and transport values must be provided in DCRBCA Report Form 24.***

A brief discussion of some of these parameters is presented below:

#### 5.3.5.1 Indoor and Outdoor Inhalation

The fate and transport models typically used to estimate volatile emissions from soil and groundwater require information about the soils in the vadose zone. The specific parameters required include:

- Soil bulk density,
- Organic carbon content,
- Porosity,
- Water content, and
- Air content.

The method used to measure these parameters is discussed in Section 4.5. Note that the sum of the water content and the air content must equal porosity.

Several other parameters are required to estimate the target levels for indoor and outdoor inhalation. These include:

- Air exchange rate in the building that depends on the construction of the building. Default values, listed in Table 5-5, may be used for Tier 2A as well as Tier 2B evaluation. Literature values may be obtained by researching architectural and building design publications.
- Height of the enclosed space is typically equal to the height of the first floor of the building,
- Areal fraction of cracks in the foundation of the building,
- Wind speed in the breathing zone,
- Height of the outdoor breathing space, typically estimated as 200 cm,
- Length of soil source parallel to the wind direction. This parameter is estimated based on the area of the contaminated soil identified during site characterization,
- Depth to COCs in subsurface soil, and
- Depth to groundwater.

These may be modified when the DDOE develops the companion Vapor Intrusion Guidance document focused on the indoor inhalation pathway.

#### 5.3.5.2 Protection of Groundwater

Several fate and transport parameters are required to estimate (i) the soil source concentration protective of the groundwater, (ii) the concentration in point of demonstration (POD) wells, and (iii) source well(s) concentrations. These include:

**The areal dimensions of the soil source:** Including the length and width of the soil source, as shown in Figure 5-3. These dimensions are estimated based on the site characterization data and should represent the most contaminated portion of the site. At sites where there are multiple sources, it may be appropriate to define more than one soil source. In the DCRBCA process, it is conservatively assumed that the COCs travel vertically downwards to the water table without any lateral dispersion. Therefore, the areal dimensions of the groundwater source are the same as the dimensions of the soil source. For Tier 1 evaluation, the thickness of the groundwater source is assumed to be 305 cm. Analytical equations to estimate the thickness are available in Salhotra et al. (1990) and the USEPA (1996).

**Soil properties representative of the soil source:** Including organic carbon content, porosity, water content, and air content. The soil properties in the soil source zone may differ from those of the vadose zone. For calculating Tier 1 RBSLs, it was assumed that values representative of the vadose zone are also representative of the soil source zone.

**Soil properties representative of the saturated zone:** Including organic carbon content, hydraulic conductivity, and hydraulic gradient. For Tier 1 evaluation (calculation of RBSLs), the organic carbon contents of the vadose zone and the saturated zone were assumed identical.

**Infiltration rate through the soil source:** For Tier 1 evaluation the infiltration rate may be assumed equal to 10% of the annual rainfall. In the absence of site-specific infiltration rate, this value may also be used for Tier 2A evaluation.

The evaluation of the groundwater protection pathway requires additional parameters that are included in Table 5-5. These parameters include distances to the POE and POD and have been discussed in Sections 5.4.1 and 5.4.2 of this guidance document.

### 5.3.6 Mathematical Models

Two types of models or equations, namely (i) the uptake equations, and (ii) the fate and transport models are required to calculate the risk based levels. For Tier 1 and Tier 2A evaluations, the DDOE has selected the models and equations presented in Appendix B. These models have been programmed in the DCRBCA Computational Software and were used to develop the Tier 1 RBSLs presented in Section 5.9. For Tier 2A evaluations, the DDOE recommends the use of these equations and models. For Tier 2B evaluations if the RP intends to use alternative models, their application must be pre-approved by the USTB. A guide to selection of an appropriate fate and transport model is *ASTM (1999) RBCA Fate and Transport Models: Compendium and Selection Guide or USEPA (1990) 625/6-90/016a; Groundwater Volume I; Groundwater and Contamination.*

## 5.4 PROTECTION OF GROUNDWATER

At all sites, the RBCA process requires the protection of groundwater. This pathway involves the following four elements:

- Selection of the most critical groundwater POE,
- Selection of the target level at the POE,
- Selection of one or more POD wells located between the source and the POE well,
- Back-calculation of acceptable concentrations at the (i) POD wells, (ii) soil source, and (iii) groundwater source.

Figure 5-4 shows a schematic of the leaching of COCs from the soil source to the POD and POE. As the COCs migrate from the soil source to the point of exposure, their concentrations decrease in three zones:

- In the unsaturated zone, due to natural attenuation processes occurring between the point of release and the groundwater table (represented by an unsaturated zone dilution attenuation factor, $DAF_{unsat}$),
- At the groundwater table due to mixing with the regional, uncontaminated groundwater flow (represented by a mixing zone dilution attenuation factor, $DAF_{mix}$), and
- In the saturated zone, due to natural attenuation processes occurring between the mixing zone and the point of exposure (represented by a saturated zone dilution attenuation factor, $DAF_{sat}$).

Each of the four elements is discussed below.

### 5.4.1 Location of Exposure Wells

The groundwater ingestion POE will be established at the nearest point where a water use well currently exists, or is most likely to exist in the foreseeable future. If no such well exists or is unlikely to be installed, then the POE, for Tier 1 evaluation, will be located at the closest downgradient private property boundary.

For Tier 2A and Tier 2B evaluations, the POE may be located at a distance lesser of (i) the nearest downgradient location of a drinking water well, (ii) 500 feet from the property boundary, or (iii) 1,000 feet from the contamination source.

The above guidance for the location of the POEs has been developed based on the very low likelihood of the current and potential future shallow groundwater use in the DC area. The RP should be able to demonstrate that (i) groundwater between the source and the POE is not likely to be used in the foreseeable future, and (ii) the plume is stable prior to receiving a NFA determination.

At sites where the flow is radial or the flow direction fluctuates significantly, multiple POEs, one in each flow direction, may have to be established. It is important to note that at many sites POE is not necessarily a real well, but may be a hypothetical well located specifically for evaluation of this pathway only.

### 5.4.2 Target Level at POE

The target level at the POE will be the groundwater standards listed in Table 5-6. These standards are equivalent to the MCLs. For chemicals that do not have MCLs, equivalent standards have been developed based on the ingestion of water and emissions of vapors due to indoor water use and the subsequent inhalation of these vapors.

### 5.4.3 Location of Point of Demonstration Wells

The RP and the DDOE will identify one or more POD wells. At most sites, existing monitoring wells would be used as POD wells. These are wells located between the source and the POE where (i) the groundwater concentrations will be measured; (ii) target levels at the POD wells will be calculated, as discussed in 5.4.4.2; (iii) the measured concentrations will be used to confirm that the concentrations at the POE will not exceed the target levels, and (iii) the plume is stable or decreasing in size and concentration. Note that multiple POD wells may be associated with a source and a POE.

### 5.4.4 Calculation of Acceptable Concentrations Protective of Groundwater

This section presents the methodology used to develop the various acceptable concentrations protective of groundwater. The methodology used for all tiers are identical except that in Tier 1 default values of fate and transport parameters (soil source dimensions, organic carbon content, porosity, water content, soil bulk density, hydraulic conductivity, hydraulic gradient, and distances to the POE) are used (refer to Table 5-5) whereas in Tier 2A and 2B evaluations site-specific values of these parameters may be used. Further, in a Tier 1 evaluation it is assumed that the COCs do not biodegrade, whereas in Tier 2A and Tier 2B the biodegradation of COCs may be considered based on site-specific considerations.

#### 5.4.4.1 Back-Calculation of Soil Source Concentrations

Based on the process described above, soil source concentration protective of groundwater can be calculated using the following equation:

$$C_{leachate} = DAF_{unsat} \times DAF_{mix} \times DAF_{sat} \times C_{POE} \qquad (5\text{-}1a)$$

$$C_{soil} = C_{leachate} \times ECF \qquad (5\text{-}1b)$$

In Equation 5-1, the equilibrium conversion factor (ECF) converts the leachate concentration to soil concentration. The dilution and attenuation factors (DAFs) represent the reduction in concentration as the COCs (i) travel from the soil source to the water table ($DAF_{unsat}$), (ii) mix with the groundwater ($DAF_{mix}$), and (iii) travel from the groundwater source to the POE ($DAF_{sat}$). This reduction in concentration is a result of the combined effect of several physical, chemical, and biological factors including advection, diffusion, dispersion, dilution, adsorption, and biodegradation processes (Tier 2A and 2B only).

In general, there are two ways to estimate the DAFs (i) using a fate and transport model, or (ii) by calculating the ratio of the concentrations measured at the source well and the POE. The second method can be used only at sites where the plume is stable or decreasing in size and concentration and sufficient groundwater monitoring data are available.

For Tier 1 evaluation, the $DAF_{unsat}$ was assumed to be unity, i.e., attenuation within the unsaturated zone was neglected. This is reasonable and conservative due to the relatively shallow depth to contamination at most UST sites in the DC. The Summer's model and the

Domenico's model were used to estimate $DAF_{mix}$ and $DAF_{sat}$, respectively. The specific equations for each of the DAFs are presented in Appendix B.

For a Tier 1 evaluation, Table 5-7 lists the DAFs that should be used to estimate the POD target concentration. These DAF's conservatively assume that the COCs do not degrade. For Tier 2B evaluations, DAFs may be calculated using site-specific monitoring data or an alternative fate and transport model implemented using site-specific data.

### 5.4.4.2 Calculation of POD Target Level

A step-by-step procedure to develop POD well target level is presented below:

**Step 1:** Identify POE(s) and the distance between the downgradient edge of the source and the POE. Refer to Section 5.4.1 for guidelines on location of POE(s).

**Step 2:** Establish target levels for the POE. The groundwater quality standards that have to be met at the POE are discussed in Section 5.4.2 and presented in Table 5-6.

**Step 3:** Identify POD wells and the distance between the edge of the source and the POE. Refer to Section 5.4.3 for guidance to select PODs.

**Step 4:** Calculate target concentration in the POD wells. Since the PODs are located between the source and the POE, the POD target levels would be higher than the POE target concentration. The difference reflects the reduction in concentration of the COCs as they migrate from the POD to the POE.

Specifically, the target concentration at the POD is estimated using:

$$C_{\text{target}}^{\text{POD}} = C_{\text{target}}^{\text{POE}} \frac{DAF_{\text{POE}}}{DAF_{\text{POD}}} \tag{5-2}$$

where,

$C_{target}^{POD}$ = Target concentration in the POD [mg/L]

$C_{target}^{POE}$ = Target concentration at the POE (groundwater standard) [mg/L]

$DAF_{POE}$ = Dilution attenuation factor between the POE and the source [(mg/L)/(mg/L)]

$DAF_{POD}$ = Dilution attenuation factor between the POD and the source [(mg/L)/(mg/L)]

## 5.5 PROTECTION OF SURFACE WATER

The DCRBCA process requires the protection of surface water to the standards listed in Table 5-6. For a Tier 1 evaluation, the surface water target levels have to be met at the location where the groundwater plume seeps into the surface water body. For Tier 2A and 2B evaluations, dilution due to the mixing of the groundwater plume with the surface water may be allowed by the DDOE, on a case-by-case basis. Thus, in this case, the surface water standards of Table 5-6 would be applicable at the downstream edge of the mixing zone.

The procedure presented in Section 5.4.3 can be used to develop POD well target levels for the protection of surface waters. The POD will be established at the nearest downgradient surface water body (Tier 1) or the edge of the mixing zone within the stream (Tier 2A and 2B). At sites where the POD well concentrations are exceeded, the USTB will require active or passive remediation until the concentrations stabilize below the calculated target levels.

## 5.6 ESTIMATION OF REPRESENTATIVE CONCENTRATIONS FOR SOIL AND GROUNDWATER PATHWAYS

A key aspect of the DCRBCA process is the calculation of representative concentration for each COC, in each medium, and for each pathway. The representative concentrations are compared with the relevant RBSLs (in Tier 1) and SSTLs (in Tier 2A and 2B) to make site-specific decisions. **Thus, the outcome of the risk management decision critically depends on the definition of the representative concentration**. The representative concentration as defined below will always be less than or at most equal to the maximum concentration. Thus, if the maximum soil and groundwater concentrations do not exceed the risk-based target levels, it is not necessary to calculate the representative concentrations. In no case should the maximum concentration exceed the representative concentration by a factor of 10.

### 5.6.1 Representative Groundwater Concentrations

For this pathway, at least three target levels are relevant and include (i) concentration at the POE, (ii) concentration at the POD well(s), and (iii) soil source concentration. Details of these concentrations are presented in Section 5.4. To evaluate whether the site concentrations are protective of this pathway, representative concentrations have to be estimated for the POE well, POD well, and the soil source concentration. Note at several sites POE well may not exist (refer Section 5.4). In all cases representative concentrations of the POD well and soil source are necessary.

The representative concentration in the POE well (if one exists) and the POD well is the average of the recent 2 years of concentration in the well, unless the concentrations in these wells show an increasing trend, in which case the most recent concentration must be used. Note that the USTB will not issue a NFA until concentrations in these and any other site related wells show a decreasing or stable concentration.

To estimate the representative soil source concentration, it is first necessary to identify the soil source zone on a site map. Note for a Tier 2A and 2B evaluation, the dimensions of the soil source zone are also used for the calculation of the target levels. The representative soil source concentration is the average of soil concentrations measured within the source zone. For borings with multiple concentrations measured at different depths, first estimate the average concentration in each boring and then average the concentrations in the various borings within the source. Concentrations reported as below laboratory reporting limit within the source zone may be replaced by half the laboratory reporting limit.

### 5.6.2 Representative Soil Concentrations

A representative concentration should always be tied to the route of exposure and the exposure domain, which is the area over which exposure can occur. The following steps are necessary to determine the representative surficial and subsurface soil concentration.

**Step 1**: Evaluate whether the spatial resolution of the data is sufficient. Whereas the exact number of samples cannot be specified, samples should be collected and data should be available from the areas of known or likely sources. Also, both surficial and subsurface soil data are necessary.

**Step 2**: If the data are old and not representative of current site conditions, (e.g., if a new spill is suspected or site remediation has occurred since the data was collected), the USTB may require the collection of current data. However, if the available data are old but below RBSLs or SSTLs and no release is suspected since the data were collected, it may not be necessary to collect new data. If sufficient new data are collected, they may be used for risk evaluation and the old data may be disregarded. In all cases, a new release will require the collection of additional data.

**Step 3**: After it has been determined that sufficient data are available to define the horizontal and vertical extent, magnitude, and character of COCs, the representative concentration should be calculated by using the arithmetic mean. While calculating these concentrations, note the following:

(i) Soil samples with concentrations below laboratory reporting limits and located **at the periphery of the impacted area** should not be used. The impacted area is defined based on visual or olfactory evidence of contamination and/or by laboratory data above reporting limits.

(ii) Typically, soil samples with concentrations below the reporting limit and **within the impacted area** are considered contaminated at concentrations half the applicable reporting limit. In certain cases where the reporting limits are elevated due to matrix effects or laboratory methods, an alternative procedure or possible re-sampling may be appropriate.

(iii) **Hotspots** and discrete areas of contamination may require additional evaluation. A hotspot is defined as an area where the maximum concentration is greater than ten times the average concentration.

### 5.6.3 Representative Soil Concentrations (For Subsurface Releases, Indoor Inhalation Pathway)

For calculating a representative concentration in soil for comparison to the target level for the indoor inhalation pathway, follow the procedures as described in Section 5.6.2 and obtain the average concentration from subsurface samples collected adjacent to an existing building or within the potential footprint of a future building.

## 5.7 ECOLOGICAL EXPOSURE

An ecological risk evaluation should be performed for sites on or adjacent to wetlands, sensitive environments, or habitat for threatened or endangered species. Where an ecological threat may exist due to a release, an ecological evaluation must be performed. The RP should follow USEPA or DDOE's guidelines for this evaluation.

## 5.8 DOCUMENTATION OF THE DCRBCA EVALUATION

The USTB requires that all Tier 1 and Tier 2 evaluations use the DCRBCA report forms (Appendix A). For Tier 1 evaluation it is not mandatory to use the computational software, however, for Tier 2 evaluation, use of DCRBCA software is mandatory.

Further, details regarding the computational software can be obtained by sending an E-mail to the developers at admin@ramgp.com.

## 5.9 TIER 1 EVALUATION

Tier 1 evaluation requires the comparison of site-specific representative soil and groundwater concentrations with the Tier 1 RBSLs established by the USTB for the complete routes of exposure. Before performing a Tier 1 evaluation, the RP must satisfy the mandatory cleanup criteria identified in Section 3.6.

A Tier 1 evaluation requires the following steps:

Step 1: Development of SCES
Step 2: Selection of relevant Tier 1 RBSLs
Step 3: Comparison of RBSLs selected in Step 2 with representative site-specific concentrations
Step 4: Selection of the next course of action

Each of these steps is discussed below:

### 5.9.1 Step 1: Development of a Site Conceptual Exposure Scenario

The development of a SCES has been described in Section 5.2. This step includes the location of the POE for each complete route of exposure.

### 5.9.2 Step 2: Selection of Relevant Tier 1 Risk-Based Screening Levels

For each complete exposure pathway identified in Step 1, RBSLs should be selected for each COC (refer Table 4-1 for the COCs for the product releases) and TPH group (TPH-GRO, TPH-DRO, and TPH-oil range organic (ORO)) from the appropriate Tier 1 RBSLs table. The USTB has developed RBSLs for commonly encountered routes of exposure and receptors as discussed in Section 5.3. The RBSLs for the various receptors and routes of exposure are presented in Tables 5-8 through 5-11.

To select the appropriate Tier 1 RBSLs protective of groundwater from Table 5-12, the locations of the nearest POE and POD have to be determined as described in Section 5.4.

### 5.9.3 Step 3: Comparison of RBSLs Selected in Step 2 with Representative Site-Specific Concentrations

After the Tier 1 RBSLs have been identified, they are compared with the representative concentrations to identify the next course of action presented in Section 5.9.4. The representative concentrations should be determined as discussed in Section 5.6.

### 5.9.4 Step 4: Selection of the Next Course of Action

Comparison of Tier 1 RBSLs with the representative concentrations will result in one of the following situations:

If the representative concentrations do not exceed the RBSLs and the site satisfies the requirements of ***Section 6211 of the District of Columbia Underground Storage Tank Regulations***, the USTB may approve NFA status. These requirements include, but are not limited to:

- The site does not and is not likely to pose a threat to human health or the environment as demonstrated by a comparison of the RBSLs with the site concentrations,
- No nuisance conditions exist at the site,
- LNAPL has been removed to the extent practicable per Section 3.5, and
- As applicable, the approved remedial plans have been implemented.

If the site concentrations exceed the Tier 1 RBSLs, the following three alternatives are available.

**Alternative 1: Remediation of Localized Exceedences**. If site concentrations exceed the Tier 1 RBSLs in a discrete, limited portion of the site, the RP, with the USTB approval, may choose to conduct interim remediation to meet Tier 1 RBSLs. An example of this scenario is the presence of a small quantity of soil that exceeds the Tier 1 RBSLs. Removal or treatment of this small area of soil may be sufficient to allow the site to meet the Tier 1 RBSLs and achieve NFA status without preparing a full fledged corrective action plan. Another example is excavation for complying with approved remedial plans to meet Tier 1 RBSLs for real property transactions. This action is different from an initial response action in that the latter focuses on the abatement of potential or emergency conditions.

**Alternative 2: Selection of Tier 2A Evaluation**. The RP may conduct a Tier 2A evaluation that may require the acquisition of additional site data.

**Alternative 3: Remediation to Tier 1 Levels**. With approval of the USTB, the RP may elect to develop a remediation plan to remediate the site to Tier 1 levels. Under this alternative the Tier 1 RBSLs become the cleanup levels. The plan would have to meet the requirements approved and supervised by the USTB.

The RP should carefully review the site conditions and propose one of the three alternatives listed above. The selection of Alternative 1, 2, or 3 will most likely be based on technical feasibility and economic considerations. For example, where the cost of cleanup is low (relative to the cost of additional data collection and analysis under a Tier 2 evaluation), it may be cost-effective to adopt the Tier 1 RBSLs as the cleanup levels.

## 5.10 TIER 2A EVALUATION

This section provides guidance for a Tier 2A evaluation that will be conducted when Tier 1 RBSLs are exceeded and it is not appropriate to adopt those three alternatives, to remediate the site to Tier 1 RBSLs. The Tier 2A evaluation is very similar to the Tier 1 evaluation in that it (i) is conservative; (ii) is broadly defined by the USTB but allows for some flexibility; (iii) uses relatively simple fate and transport algorithms (models); and (iv) uses default exposure factors.

The Tier 2A evaluation requires the following steps:

Step 1: Development of SCES,
Step 2: Selection of input parameters,
Step 3: Calculation of Tier 2A SSTLs,
Step 4: Comparison of SSTLs calculated in Step 3 with representative site-specific concentrations, and
Step 5: Selection of the next course of action.

### 5.10.1 Step 1: Development of a Site Conceptual Exposure Scenario

The RP should develop the SCES if it has not already been developed and identify the complete exposure routes and pathways. In most cases, the SCES for Tier 2A evaluation would be the same as the SCES developed for a Tier 1 evaluation. Tier 2A SSTLs should be calculated for all COCs and all complete pathways and routes of exposure even if the representative concentrations did not exceed the Tier 1 RBSLs.

### 5.10.2 Step 2: Input Parameters

Typically for a Tier 2A evaluation, the same models and algorithms used to develop the Tier 1 RBSLs, will be used. Thus, the Tier 2A input parameter requirements will be the same as for Tier 1. The specific values to be used for these parameters are discussed below. The USTB intends to regularly review and update the referenced tables to reflect the most current information for all four categories of parameters.

**Exposure Factors:** The USTB requires that the default Tier 1 exposure factors (Table 5-4) be used unless the RP can justify alternative values based on site-specific considerations.

**Physical and Chemical Properties:** The USTB requires the physical and chemical properties used for Tier 1 evaluation (Table 5-2) be used unless the RP can justify alternative values.

**Toxicity Values:** The USTB requires that the current toxicity values promulgated by USEPA be used. These are same as the values used for Tier 1 evaluation, listed in Table 5-3.

**Fate and Transport Parameters:** The USTB allows the owner and operator to use a combination of default and representative site-specific fate and transport parameters for a Tier 2A evaluation. The parameters identified with two asterisks in Table 5-5 must be replaced by site-specific values. Where site-specific values are not available due to access or other considerations, professional judgment has to be used to determine whether to collect additional data, use estimates from adjacent sites, literature values, or Tier 1default values. If additional data is necessary, a data acquisition work plan should be developed and approved by the USTB prior to performing the Tier 2A evaluation.

For the Tier 2A evaluation, the USTB will allow the use of chemical-specific biological decay rates based on an evaluation of the site-specific monitoring well data. A biodecay rate will be allowed only when the groundwater concentration data indicate a clear decreasing trend and the site-specific natural attenuation parameters indicate the occurrence of biodecay. Appendix D presents a method that can be used to estimate site-specific biodegradation rates. In cases where literature values are used, the half-life for any COC must not be less than 5 years, i.e., the first order decay rate should not exceed (ln 0.5)/5 = 0.139 $\text{yr}^{-1}$. Note the DAFs presented in Table 5-7 were estimated assuming no bio-decay.

**Target Risk:** The target risk for all tiers is the same, in accordance with ***Section 6206.4(c) of the District of Columbia Underground Storage Tank Regulations***. A discussion of the target risk levels is presented in Section 5.3.1 of this guidance.

### 5.10.3 Step 3: Calculation of Tier 2A SSTLs

The calculation of Tier 2A SSTLs should be performed by using the models and equations presented in Appendix B and the input parameter values discussed above. For computational ease, the USTB has sponsored the development of a software, which may be used for the calculations. Also refer to Section 5.8.

The USTB is not disallowing the use of other appropriate computational tools, but it requires that the USTB approve models and input parameters before they are used. If a RBCA evaluator uses alternative tools, the USTB may require verification, including submission of a copy of the software.

### 5.10.4 Step 4: Comparison of SSTLs Calculated with Representative Site-Specific Concentrations

The representative soil and groundwater concentrations for each complete route of exposure are calculated as for Tier 1 evaluation. See Section 5.6 for the calculation of representative concentrations. These representative concentrations are then compared with the Tier 2A SSTLs.

### 5.10.5 Step 5: Selection of the Next Course of Action

After the completion of a Tier 2A evaluation, the USTB may approve NFA letter if the site concentrations satisfy the requirements of ***Section 6211 of the District of Columbia Underground Storage Tank Regulations***. These requirements include, but are not limited to:

- The representative site concentrations do not exceed the Tier 2A SSTLs and the maximum concentration in each medium does not exceed the representative concentration by a factor of 10;
- No nuisance conditions exist at the site;
- LNAPL has been removed to the extent practicable as per Section 3.5;
- The USTB agrees with the Tier 2A evaluation and determines that additional confirmatory monitoring is not necessary; and
- As applicable, the approved remedial plans have been met.

If any representative site concentration exceeds the Tier 2A SSTLs for any COC, the following three alternatives are available.

**Alternative 1: Remediation of localized exceedences to Tier 2A SSTLs**. This alternative applies when there is a localized exceedence of Tier 2A SSTLs. With the USTB concurrence, the RP may select to perform interim remediation measures to achieve the Tier 2A SSTLs without writing a complete corrective action plan which would be necessary if Alternative 3 were selected.

**Alternative 2: Selection of Tier 2B Evaluation**. The RP may conduct a Tier 2B evaluation that may require the acquisition of additional site data.

**Alternative 3: Remediation to Tier 2A SSTLs**. With USTB approval, the RP may elect to develop a remediation plan to remediate the site to Tier 2A SSTLs. The plan would have to meet the requirements of ***Section 6207 of the District of Columbia Underground Storage Tank Regulations*** to be approved by the USTB.

## 5.11 TIER 2B EVALUATION

Within the DCRBCA process, Tier 2B evaluation is the most complex and detailed site-specific evaluation that may be conducted. Tier 2B allows the use of different fate and transport models with sufficient documentation of the models used. It is anticipated that very few sites if any will require a Tier 2B evaluation. Tier 2B evaluation provides the most flexibility for developing SSTLs but requires the RP to prepare a detailed work plan. The work plan has to be approved by the USTB prior to initiating the work. Hydrologically complex sites, sites with ecological impacts, and sites with other unique characteristics or land uses may be appropriate for a Tier 2B evaluation. For an ecological evaluation, the owner should follow USEPA’s guidelines for ecological risk evaluation.

## 5.12 CHARACTERISTICS OF THE TIERED EVALUATION

As a site moves through the DCRBCA tiered process, the following may occur:

- Collection of additional site-specific data, which would increase the cost of data collection, analysis, and labor cost, but reduce the overall uncertainty about the site.
- The need for additional analysis to develop SSTLs, which would involve additional cost over the use of Tier 1 RBSLs.
- In general, the calculated Tier 2B SSTLs will be higher than the Tier 2A SSTLs because lower tier levels are designed to be more conservative than higher tier levels. Thus, the cost of corrective action to achieve the target levels should be lower.
- The need for and the extent of regulatory oversight and review of the site-specific target levels will increase due to the added evaluation efforts.
- The level of uncertainty and conservatism will decrease due to the availability of more site-specific data.
- In general, the cost of assessments may increase, but the overall cost to achieve NFA should decrease.

Note that all complete routes of exposure and chemicals of concern have to be evaluated in Tier 2A and Tier 2B. Despite the above differences among the three tiers, there is one very significant similarity. Each tier will result in an equally acceptable level of protection for the site-specific human and environmental receptors, where the acceptable level of protection is defined as per ***Section 6204 (c) of the District of Columbia Underground Storage Tank Regulations***.

# 6.0
# RISK MANAGEMENT PLAN

Subsequent to the confirmation of a release, the DDOE may request the RP to develop and submit a corrective action plan (CAP). Alternatively, the RP may voluntarily submit a CAP. The overall objective of a CAP or risk management plan is to ensure that:

- Site conditions are protective of human health and the environment under current and reasonable anticipated future conditions; and
- Recoverable non-aqueous phase hydrocarbons are not present in the soil or groundwater.

Note protection of human health and the environment is based on achieving any of the tiered target levels discussed in Section 2.3 and approved by the DDOE.

A CAP may consist of a combination of active and/or passive remedial options as well as institutional controls acceptable to the DDOE. Specific requirements of the CAP are discussed in ***Section 6207 of the District of Columbia Underground Storage Tank Regulations.***

The following subsections provide information regarding a few risk management issues.

## 6.1 GROUNDWATER MONITORING

Within the DCRBCA process, there are two objectives of groundwater monitoring, namely (i) confirmatory monitoring and (ii) compliance monitoring.

The objective of confirmatory monitoring is to adequately understand the nature and extent of groundwater impacts and to confirm plume stability. Confirmatory monitoring may be required even when the concentrations do not exceed the tier specific target levels.

The objective of compliance monitoring is to confirm that concentrations in an exposure or demonstration well do not exceed the target levels established and approved by the DDOE. Thus compliance monitoring is performed only after SSTLs have been established and approved by the DDOE.

Typically one or more wells may be selected as the POD wells. Monitoring of POD wells should continue until concentrations in these wells do not exceed the POD target levels and the overall trend of concentrations in these wells is decreasing. Additional monitoring may be necessary to confirm plume stability. Note the POD target levels are established such that concentrations at the POE do not exceed the groundwater standards.

The number of wells, their location, frequency of sampling, and duration of sampling will vary from site to site and will require the DDOE’s concurrence. As a general rule, monitoring wells should be sampled quarterly for the first year after installation beyond which semi-annual, and in some cases, annual monitoring may be sufficient.

## 6.2 CORRECTIVE ACTION PLAN

The RP should prepare the CAP in accordance with the requirements of ***Section 6207 of the District of Columbia Underground Storage Tank Regulations.*** The CAP should be submitted in accordance with the schedule and format established by the DDOE. Within 60 days of the receipt of the CAP, the DDOE shall approve or disapprove the CAP. Upon approval, the RP should begin implementing the plan within 30 days. During the implementation phase, the RP should periodically evaluate the effectiveness of the CAP and propose modifications as appropriate.

## 6.3 OWNER IMPOSED INSTITUTIONAL CONTROLS

Institutional controls are administrative and legal means by which land-use assumptions used to develop the target levels remain valid for the necessary duration. Institutional controls often limit human exposure and can be used to eliminate exposure pathways, which might otherwise require consideration under a future scenario.

The DCRBCA process will recognize the presence of existing controls in the development of the SCES. Existing implicit or explicit institutional controls help determine the future land use. For example, existing right of ways, highways, commercial complexes, will be considered in developing the SCES prior to the selection of Tier 1 and higher target levels.

After the completion of tiered evaluation, the DDOE may accept owner imposed institutional controls, on a case-by-case basis as a way to eliminate certain pathways. The specific controls will be site-specific and it will be the owner/operators responsibility to convince the DDOE about the effectiveness and permanence of the control.

## 6.4 NOTIFICATION OF THE RELEASE

Under ***Section 6212 of the District of Columbia Underground Storage Tank Regulations*** for all confirmed releases which require a CAP, the DDOE shall provide a notice to the public directly affected by the release and the planned corrective actions.

The above notification should be made using any of the following procedures:

- Publication of the notices in local newspapers,
- Publication of the notices in the DC Register,
- Block advertisements,
- Public service announcements,
- Letters to individuals,
- Personal contacts by field staff, or
- Notice to Advisory Neighborhood Commissioners.

Any individual directly impacted by the release that may have migrated onto their property may request copy of relevant information pertaining to the site and if requested shall have the opportunity to comment on the CAP.

## 6.5 NO FURTHER ACTION PROCEDURE

When the DCRBCA evaluation has been performed and approved by the DDOE and the site has been remediated to the established levels, the owner operator may submit a request for "**No Further Action and Case Closure Determination"** to the DDOE**.** This request should be accompanied by a brief site summary containing the following information:

1. Site Name,
2. DOH LUST Case #,
3. Date DCRBCA report submitted,
4. Date DCRBCA report approved,
5. Date CAP submitted,
6. Date CAP approved,
7. Site location,
8. Site history,
9. Key issues,
10. Site investigation summary,
11. Field survey (if applicable), and
12. Remedial activities completed (if applicable).

Typically this would be the last report submitted to the USTB. The DDOE shall review the request and issue the letter if the site satisfies all the requirements for case closure. The letter would indicate that, based on the information submitted, the concentrations of COCs on or adjacent to the site do not pose an unacceptable level of risk to the public.

The NFA with conditions letter may specify some of the assumptions and site characteristics utilized in the DCRBCA evaluation. For example, the letter may indicate that the site was evaluated under the commercial land use scenario and that future site activities should be compatible with this land use.

# 7.0
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ASTM, Standard Test Method for Specific Gravity of Soil, D854-10.

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# TABLES

## Table 2-1
## Reporting Requirements under the DCRBCA Process

| Description | Deliverables |
|---|---|
| Failure of Release Detection System | If release detection is not repaired within 45 days, report to Division within 24 hours after the expiration of 45 days. |
| Spill Reports | Spills exceeding 25 gallons or those not cleaned within 24 hours must be reported within 24 hours. |
| Release Report | Notify within 24 hours of suspicion or confirmation of release. |
| Initial Site Assessment | To be submitted within 60 days after confirmation of release. |
| Free Product (LNAPL) Removal | Free product (LNAPL) removal report within 45 days. |
| Comprehensive Site Assessment Report | Within 60 days of submission of the Workplan. |
| Groundwater Monitoring Report | Data to be submitted within 30 days of receipt from laboratory. Semi-Annual or an Annual Comprehensive report. |
| DCRBCA Report | As requested by the Division. |
| Risk Management Plan | As requested by the approved DCRBCA report |

# Table 4-1
# Chemicals of Concern for Different Product Releases and Commonly Used Analytical Methods

| **Chemical** | **Gasoline** | **Diesel/** | **Kerosene** | **Heavy Fuel Oils** | **Waste/ Used Oil** | **Analytical Methods** | |
|---|---|---|---|---|---|---|---|
| | | **Light Fuel Oils** | **Jet Fuel** | | | **Groundwater** | **Soil** |
| Benzene | X | NC | NC | NC | X | SW-846 8260B | SW-846 8260B |
| Toluene | X | NC | NC | NC | X | SW-846 8260B | SW-846 8260B |
| Ethylbenzene | X | NC | NC | NC | X | SW-846 8260B | SW-846 8260B |
| Xylenes (total) | X | NC | NC | NC | X | SW-846 8260B | SW-846 8260B |
| Ethylene dibromide (EDB) | X** | NC | NC | NC | NC | SW-846 8260B or 8011[1] | SW-846 8260B |
| Ethylene dichloride (EDC (1,2-DCA)) | X** | NC | NC | NC | NC | SW-846 8260B | SW-846 8260B |
| Methyl-tert-butyl-ether (MTBE) | X | NC | NC | NC | X | SW-846 8260B | SW-846 8260B |
| Tertiary butyl alcohol (TBA) | X | X | NC | NC | X | SW-846 8260B | SW-846 8260B |
| Ethanol | X | X | NC | NC | NC | SW-846 8015B | SW-846 8015B |
| Acenaphthene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| Anthracene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| Benzo(a)anthracene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| Benzo(a)pyrene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| Benzo(b)fluoranthene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| Benzo(g,h,i)perylene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| Benzo(k)fluoranthene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| Chrysene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| Fluoranthene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| Fluorene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| Naphthalene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| Phenanthrene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| Pyrene | NC | X | X | X | X | SW-846 8270C | SW-846 8270C |
| **TPH GRO** | | | | | | | 8015M |
| >C6-C8 Aliphatics | X | NC | X | NC | X | * | * |
| >C8-C10 Aliphatics | X | X | X | NC | X | * | * |
| >C8-C10 Aromatics | X | X | X | NC | X | * | * |

## Table 4-1
## Chemicals of Concern for Different Product Releases and Commonly Used Analytical Methods

| Chemical | Gasoline | Diesel/ | Kerosene | Heavy Fuel Oils | Waste/ Used Oil | Analytical Methods | |
|---|---|---|---|---|---|---|---|
| | | Light Fuel Oils | Jet Fuel | | | Groundwater | Soil |
| **TPH DRO** | | | | | | | 8015M |
| >C10-C12 Aliphatics | X | X | X | NC | X | * | * |
| >C12-C16 Aliphatics | NC | X | X | NC | X | * | * |
| >C16-C21 Aliphatics | NC | X | NC | X | X | * | * |
| >C10-C12 Aromatics | X | X | X | NC | X | * | * |
| >C12-C16 Aromatics | X | X | X | NC | X | * | * |
| >C16-C21 Aromatics | NC | X | NC | NC | X | * | * |
| **TPH ORO** | | | | | | | 8015M |
| >C21-C35 Aliphatics | NC | X | NC | X | X | * | * |
| >C21-C35 Aromatics | NC | X | NC | X | X | * | * |

Notes:

X: Chemical of concern to be analyzed

NC: Not a chemical of concern

[1] Groundwater samples may be analyzed by SW-846 8011 to achieve a lower limit for EDB.

*: Contact laboratory for an appropriate GC/FID method. Available methods include the Massachusetts Method and the TPH Criteria Working Group Method. Fractionation is recommended only for Tier 2B evaluation.

**: Chemical of concern for leaded gasoline.

## Table 4-2
## Vapor Concentrations Protective of Explosive Hazards

| Compound | LEL (%) | UEL (%) | Action Levels (%)* |
|---|---|---|---|
| Gasoline | 1.4 | 7.4 | 0.35 (3,500 ppm) |
| JP-4 | 1.3 | 8 | 0.325 (3,250 ppm) |
| Diesel Fuel | 1.3 | 6 | 0.325 (3,250 ppm) |
| Fuel Oils | 1 | 5 | 0.25 (2,500 ppm) |
| Kerosene | 0.7 | 5 | 0.175 (1,750 ppm) |
| Benzene | 1.2 | 7.8 | 0.3 (3,000 ppm) |
| Ethylbenzene | 0.8 | 6.7 | 0.2 (2,000 ppm) |
| Toluene | 1.2 | 7.1 | 0.3 (3,000 ppm) |
| Xylenes | 1 | 7 | 0.25 (2,500 ppm) |
| MTBE | 1.65 | 8.4 | 0.41 (4,100 ppm) |

* Action levels are equal to 25 % of the LEL.

**Source:**
Chemical and Physical Information of Chemical Profiles in Agency for Toxic Substances and Disease Registry (ATSDR). http://www.atsdr.cdc.gov/.

## Table 4-3
## Typical Weight Percents for COCs in Different Products

| COCs | Weight Percent (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gasoline | | Diesel | | Jet Fuel (JP-4 & JP-5) | | Kerosene | | Fuel Oil No. 6 | |
| | Range | Average | Range | Average | Range | Average | Range | Average | Range | Average |
| **Average Molecular Weight (g/mol)** | **105** | | **230** | | **165** | | **105** | | **230** | |
| **VOLATILES** | | | | | | | | | | |
| Benzene | 1.6 - 2.3 | 1.90 | 0.0026 - 0.1 | 0.029 | 0.47 - 0.5 | 0.47 | --- | --- | --- | --- |
| Toluene | 6.4 - 10 | 8.10 | 0.0069 - 0.7 | 0.180 | 1.3 - 1.6 | 1.6 | --- | --- | --- | --- |
| Ethylbenzene | 1.4 - 2 | 1.70 | 0.007 - 0.2 | 0.068 | 0.37 - 0.69 | 0.66 | --- | --- | --- | --- |
| o-Xylene | 2.1 - 3.1 | 2.50 | 0.0012 - 0.085 | 0.043 | --- | 0.545 | --- | --- | --- | --- |
| m-Xylene | 3.9 - 5.4 | 4.60 | 0.009 - 0.255 | 0.110 | --- | 0.545 | --- | --- | --- | --- |
| p-Xylene | 1.6 - 2.3 | 1.90 | 0.009 - 0.255 | 0.110 | --- | 0.35 | --- | --- | --- | --- |
| Xylenes (total) | --- | --- | --- | 0.5 | --- | --- | --- | --- | --- | --- |
| **PAHs** | | | | | | | | | | |
| Acenaphthene | --- | --- | --- | --- | --- | --- | --- | 0.0047 | --- | --- |
| Anthracene | --- | --- | 3.0E-6 - 0.02 | 5.80E-03 | --- | --- | --- | 0.00012 | --- | 0.005 |
| Benzo(a)anthracene | --- | --- | 2.0E-6 - 6.7E-4 | 9.60E-05 | --- | --- | --- | --- | 0.0029 - 0.15 | 0.055 |
| Benzo(a)pyrene | | | 5.0E-6 - 8.4E-4 | 2.20E-04 | --- | --- | --- | --- | --- | 0.0044 |
| Benzo(b)fluoranthene | --- | --- | 1.55E-07 - 9.5E-05 | 1.55E-04 | --- | --- | --- | --- | --- | 0.022 |
| Benzo(k)fluoranthene | --- | --- | 1.55E-07 - 9.5E-06 | 1.55E-04 | --- | --- | --- | --- | --- | 0.022 |
| Chrysene | --- | --- | --- | 4.50E-05 | --- | --- | --- | --- | 0.0029 - 0.31 | 0.069 |
| Dibenz(a,h)anthracene | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fluoranthene | --- | --- | 6.8E-7 - 0.02 | 0.0059 | --- | --- | --- | 0.00086 | --- | 0.024 |
| Fluorene | --- | --- | 0.034 - 0.15 | 0.086 | --- | --- | --- | --- | --- | --- |
| Naphthalene | 0.15 - 0.36 | 0.25 | 0.01 - 0.8 | 0.26 | 0.25 - 0.5 | 0.41 | 0.15 - 0.46 | 0.31 | 0.00021 - 0.015 | 0.0042 |
| Pyrene | --- | --- | 0.000018 - 0.015 | 0.0046 | --- | --- | --- | 0.00024 | --- | 0.0023 |

Notes:

Data from Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG), May 1998. TPHCWG Series Volume 2: Composition of Petroleum Mixtures.

Average molecular weight: Values for gasoline, diesel, jet fuel were obtained from EPA On-line Tools for Site Assessment Calculation at http://www.epa.gov/athens/learn2model/part-two/onsite/es.htm. Value of gasoline was used for kerosene and value of di

1. ---: For these COCs pure product solubilites and saturated vapor concentrations were used.
2. Jet Fuel: Average values of JP-4 and JP-5 are taken.
3. Diesel: Values were available for m+p-Xylene. Each was considered 50% composition.
4. Diesel and Fuel Oil No. 6: Values were available for Benzo(b+k)fluoranthene. Each was considered 50% composition.

## Table 5-3(a)
## Toxicity Values of Chemicals of Concern

| Chemicals | CAS # | Oral Slope Factor SF$_o$ (mg/kg-day)$^{-1}$ | | Inhalation Unit Risk IUR (ug/m$^3$)$^{-1}$ | | Dermal Slope Factor SF$_{ABS}$ (mg/kg-day)$^{-1}$ | Oral Reference Dose RfD$_o$ (mg/kg-day) | | Inhalation Reference Concentration RfC (mg/m$^3$) | | Dermal Reference Dose RfD$_{ABS}$ (mg/kg-day) | Absorption Fraction | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Dermal, ABS$_d$ (unitless) | | Oral, ABS$_{GI}$ (unitless) | |
| Benzene | 71-43-2 | 5.5E-02 | r | 7.8E-06 | r | 5.5E-02 | 4.0E-03 | r | 3.0E-02 | r | 4.0E-03 | NA | | 1 | r |
| Toluene | 108-88-3 | NA | | NA | | NA | 8.0E-02 | r | 5.0E+00 | r | 8.0E-02 | NA | | 1 | r |
| Ethylbenzene | 100-41-4 | 1.1E-02 | r | 2.5E-06 | r | 1.1E-02 | 1.0E-01 | r | 1.0E+00 | r | 1.0E-01 | NA | | 1 | r |
| Xylenes (total) | 1330-20-7 | NA | | NA | | NA | 2.0E-01 | r | 1.0E-01 | r | 2.0E-01 | NA | | 1 | r |
| Ethylene dibromide (EDB) | 106-93-4 | 2.0E+00 | r | 6.0E-04 | r | 2.0E+00 | 9.0E-03 | r | 9.0E-03 | r | 9.0E-03 | NA | | 1 | r |
| Ethylene dichloride (EDC (1,2-DCA)) | 107-06-2 | 9.1E-02 | r | 2.6E-05 | r | 9.1E-02 | 6.0E-03 | r | 7.0E-03 | r | 2.0E-02 | NA | | 1 | r |
| Methyl tertiary butyl ether (MTBE) | 1634-04-4 | 1.8E-03 | r | 2.6E-07 | r | 1.8E-03 | 1.0E-02 | tr | 3.0E+00 | r | 1.0E-02 | NA | | 1 | r |
| Tertiary butyl alcohol (TBA) | 75-65-0 | NA | | NA | | NA | 9.0E-02 | tr | NA | tr | 9.0E-02 | NA | | 0.8 | tr |
| Ethanol | 64-17-5 | NA | | NA | | NA | 3.3E+01 | tr | NA | tr | 3.3E+01 | NA | | 0.8 | tr |
| Acenaphthene | 83-32-9 | NA | | NA | | NA | 6.0E-02 | r | NA | | 6.0E-02 | 0.13 | r | 1 | r |
| Anthracene | 120-12-7 | NA | | NA | | NA | 3.0E-01 | r | NA | | 3.0E-01 | 0.13 | r | 1 | r |
| Benzo(a)anthracene | 56-55-3 | 7.3E-01 | r | 1.1E-04 | r | 7.3E-01 | NA | | NA | | NA | 0.13 | r | 1 | r |
| Benzo(a)pyrene | 50-32-8 | 7.3E+00 | r | 1.1E-03 | r | 7.3E+00 | NA | | NA | | NA | 0.13 | r | 1 | r |
| Benzo(b)fluoranthene | 205-99-2 | 7.3E-01 | r | 1.1E-04 | r | 7.3E-01 | NA | | NA | | NA | 0.13 | r | 1 | r |
| Benzo(g,h,i)perylene | 191-24-2 | NA | | NA | | NA | 3.0E-02 | tr | NA | | 3.0E-02 | 0.13 | tr | 0.89 | tr |
| Benzo(k)fluoranthene | 207-08-9 | 7.3E-02 | r | 1.1E-04 | r | 7.3E-02 | NA | | NA | | NA | 0.13 | r | 1 | r |
| Chrysene | 218-01-9 | 7.3E-03 | r | 1.1E-05 | r | 7.3E-03 | NA | | NA | | NA | 0.13 | r | 1 | r |
| Fluoranthene | 206-44-0 | NA | | NA | | NA | 4.0E-02 | r | NA | | 4.0E-02 | 0.13 | r | 1 | r |
| Fluorene | 86-73-7 | NA | | NA | | NA | 4.0E-02 | r | NA | | 4.0E-02 | 0.13 | r | 1 | r |
| Naphthalene | 91-20-3 | NA | | 3.4E-05 | r | NA | 2.0E-02 | r | 3.0E-03 | r | 2.0E-02 | 0.13 | r | 1 | r |
| Phenanthrene | 85-01-8 | NA | | NA | | NA | 3.0E-02 | | NA | | 3.0E-02 | 0.13 | tr | 0.89 | tr |
| Pyrene | 129-00-0 | NA | | NA | | NA | 3.0E-02 | r | NA | | 3.0E-02 | 0.13 | r | 1 | r |
| **TPH-GRO** | NA | NA | | NA | | NA | NA | | NA | | NA | NA | | NA | |
| Aliphatics - > C6-C8 | NA | NA | | NA | | NA | 5.0E+00 | t | 1.8E+01 | t | 5.0E+00 | NA | | 0.8 | tr |
| Aliphatics - > C8-C10 | NA | NA | | NA | | NA | 1.0E-01 | t | 1.0E+00 | t | 1.0E-01 | NA | | 0.8 | tr |
| Aromatics - >C8-C10 | NA | NA | | NA | | NA | 4.0E-02 | t | 2.0E-01 | t | 4.0E-02 | NA | | 0.8 | tr |
| **TPH-DRO** | NA | NA | | NA | | NA | NA | | NA | | NA | NA | | NA | |
| Aliphatics - >C10-C12 | NA | NA | | NA | | NA | 1.0E-01 | t | 1.0E+00 | t | 5.0E-02 | 0.1 | tr | 0.5 | tr |
| Aliphatics - >C12-C16 | NA | NA | | NA | | NA | 1.0E-01 | t | 1.0E+00 | t | 5.0E-02 | 0.1 | tr | 0.5 | tr |
| Aliphatics - >C16-C21 | NA | NA | | NA | | NA | 2.0E+00 | t | NA | | 1.0E+00 | 0.1 | tr | 0.5 | tr |
| Aromatics - >C10-C12 | NA | NA | | NA | | NA | 4.0E-02 | t | 2.0E-01 | t | 2.0E-02 | 0.1 | tr | 0.5 | tr |
| Aromatics - >C12-C16 | NA | NA | | NA | | NA | 4.0E-02 | t | 2.0E-01 | t | 2.0E-02 | 0.1 | tr | 0.5 | tr |
| Aromatics - >C16-C21 | NA | NA | | NA | | NA | 3.0E-02 | t | NA | | 3.0E-02 | 0.13 | tr | 0.89 | tr |

## Table 5-3(a)
## Toxicity Values of Chemicals of Concern

| Chemicals | CAS # | Oral Slope Factor SF$_o$ (mg/kg-day)$^{-1}$ | | Inhalation Unit Risk IUR (ug/m$^3$)$^{-1}$ | | Dermal Slope Factor SF$_{ABS}$ (mg/kg-day)$^{-1}$ | Oral Reference Dose RfD$_o$ (mg/kg-day) | | Inhalation Reference Concentration RfC (mg/m$^3$) | | Dermal Reference Dose RfD$_{ABS}$ (mg/kg-day) | Absorption Fraction | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Dermal, ABS$_d$ (unitless) | | Oral, ABS$_{GI}$ (unitless) | |
| **TPH-ORO** | NA | NA | | NA | | NA | NA | | NA | | NA | NA | | NA | |
| Aliphatics - >C21-C35 | NA | NA | | NA | | NA | 2.0E+00 | t | NA | | 1.0E+00 | 0.1 | tr | 0.5 | tr |
| Aromatics - >C21-C35 | NA | NA | | NA | | NA | 3.0E-02 | t | NA | | 3.0E-02 | 0.13 | tr | 0.89 | tr |

Sources:

r - Regional Screening Level (RSL) Summary Table, May 2011 (USEPA, May 2011).

t -Total Petroleum Hydrocarbon Criteria Working Group, Series Volume 4 (TPHCWG, June 1997).

tr - Texas Risk Reduction Program (TRRP) Toxicity Factors and ABS$_{GI}$ and ABS$_d$ Values Tables (TCEQ, May 2011).

## Table 5-3(b)
## Parameters for Dermal Contact Pathway for Chemicals of Concern

| **Chemicals** | **CAS #** | **Permeability Coefficient, $K_p$ (cm/hr)** | | **Relative Contribution of Permeability Coefficient, B (unitless)** | | **Lag Time, $\tau_{event}$ (hr/event)** | | **Time to Reach Steady-Stae, t* (hr)** | | **Fraction Absorbed Water, FA (unitless)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Benzene | 71-43-2 | 1.49E-02 | *RE* | 0.05 | *RE* | 0.29 | *RE* | 0.70 | *RE* | 1.0 | *RE* |
| Toluene | 108-88-3 | 3.11E-02 | *RE* | 0.11 | *RE* | 0.35 | *RE* | 0.84 | *RE* | 1.0 | *RE* |
| Ethylbenzene | 100-41-4 | 4.93E-02 | *RE* | 0.20 | *RE* | 0.42 | *RE* | 1.01 | *RE* | 1.0 | *RE* |
| Xylenes (total) | 1330-20-7 | 5.32E-02 | *RE* | 0.21 | *RE* | 0.42 | *RE* | 1.01 | *RE* | 1.0 | *RE* |
| Ethylene dibromide (EDB) | 106-93-4 | 2.77E-03 | *RE* | 0.01 | *RE* | 1.21 | *RE* | 2.90 | *RE* | 1.0 | *RE* |
| Ethylene dichloride (EDC (1,2-DCA)) | 107-06-2 | 4.20E-03 | *RE* | 0.02 | *RE* | 0.38 | *RE* | 0.92 | *RE* | 1.0 | *RE* |
| Methyl tertiary butyl ether (MTBE) | 1634-04-4 | 4.47E-03 | *e* | 0.016 | *e* | 0.33 | *e* | 0.79 | *e* | 1.0 | *e* |
| Tertiary butyl alcohol (TBA) | 75-65-0 | 1.74E-03 | *e* | 0.006 | *e* | 0.27 | *e* | 0.66 | *e* | 1.0 | *e* |
| Ethanol | 64-17-5 | 5.38E-04 | *RE* | 0.001 | *RE* | 0.19 | *RE* | 0.46 | *RE* | 1.0 | *RE* |
| Acenaphthene | 83-32-9 | 1.19E-01 | *e* | 0.57 | *e* | 0.77 | *e* | 1.84 | *e* | 0.98 | *e* |
| Anthracene | 120-12-7 | 1.16E-02 | *e* | 0.60 | *e* | 1.05 | *e* | 2.51 | *e* | 0.97 | *e* |
| Benzo(a)anthracene | 56-55-3 | 4.74E-01 | *RE* | 2.75 | *RE* | 2.03 | *RE* | 8.53 | *RE* | 1.0 | *RE* |
| Benzo(a)pyrene | 50-32-8 | 7.01E-01 | *RE* | 4.27 | *RE* | 2.69 | *RE* | 11.67 | *RE* | 1.0 | *RE* |
| Benzo(b)fluoranthene | 205-99-2 | 7.02E-01 | *RE* | 4.29 | *RE* | 2.77 | *RE* | 12.03 | *RE* | 1.0 | *RE* |
| Benzo(g,h,i)perylene | 191-24-2 | 1.19E+00 | *e* | 7.62 | *e* | 3.69 | *e* | 16.55 | *e* | 0.65 | *e* |
| Benzo(k)fluoranthene | 207-08-9 | 6.60E-01 | *e* | 4.03 | *e* | 2.72 | *e* | 11.76 | *e* | 0.75 | *e* |
| Chrysene | 218-01-9 | 4.74E-01 | *RE* | 2.75 | *RE* | 2.03 | *RE* | 8.53 | *RE* | 1.0 | *RE* |
| Fluoranthene | 206-44-0 | 2.24E-01 | *RE* | 1.22 | *RE* | 1.45 | *RE* | 5.68 | *RE* | 1.0 | *RE* |
| Fluorene | 86-73-7 | 8.36E-02 | *e* | 0.41 | *e* | 0.90 | *e* | 2.15 | *e* | 0.97 | *e* |
| Naphthalene | 91-20-3 | 4.66E-02 | *RE* | 0.20 | *RE* | 0.56 | *RE* | 1.34 | *RE* | 1.0 | *RE* |
| Phenanthrene | 85-01-8 | 1.44E-01 | *RE* | 0.74 | *RE* | 1.06 | *RE* | 4.11 | *RE* | 1.0 | *RE* |
| Pyrene | 129-00-0 | 2.09E-01 | *e* | 1.15 | *e* | 1.43 | *e* | 5.55 | *e* | 0.95 | *e* |
| **TPH-GRO** | NA | NA | | NA | | NA | | NA | | NA | |
| Aliphatics - > C6-C8 | NA | NA | | NA | | NA | | NA | | NA | |
| Aliphatics - > C8-C10 | NA | NA | | NA | | NA | | NA | | NA | |
| Aromatics - >C8-C10 | NA | NA | | NA | | NA | | NA | | NA | |

## Table 5-3(b)
## Parameters for Dermal Contact Pathway for Chemicals of Concern

| Chemicals | CAS # | Permeability Coefficient, $K_p$ (cm/hr) | | Relative Contribution of Permeability Coefficient, B (unitless) | | Lag Time, $\tau_{event}$ (hr/event) | | Time to Reach Steady-Stae, t* (hr) | | Fraction Absorbed Water, FA (unitless) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **TPH-DRO** | NA | NA | | NA | | NA | | NA | | NA | |
| Aliphatics - >C10-C12 | NA | NA | | NA | | NA | | NA | | NA | |
| Aliphatics - >C12-C16 | NA | NA | | NA | | NA | | NA | | NA | |
| Aliphatics - >C16-C21 | NA | NA | | NA | | NA | | NA | | NA | |
| Aromatics - >C10-C12 | NA | NA | | NA | | NA | | NA | | NA | |
| Aromatics - >C12-C16 | NA | NA | | NA | | NA | | NA | | NA | |
| Aromatics - >C16-C21 | NA | NA | | NA | | NA | | NA | | NA | |
| **TPH-ORO** | NA | NA | | NA | | NA | | NA | | NA | |
| Aliphatics - >C21-C35 | NA | NA | | NA | | NA | | NA | | NA | |
| Aromatics - >C21-C35 | NA | NA | | NA | | NA | | NA | | NA | |

Sources:

RE - RAGS Part E. e - Estimated by RAGS Part E.

RE - Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual. Part E Supplimental Guidance for Dermal Risk Assessment (RAGS Part E), (USEPA, 2004).

## Table 5-4
## Default Exposure Factors

| Parameter | Symbol | Unit | Default Value | Source |
|---|---|---|---|---|
| **Averaging Time - Carcinogen** | $AT_c$ | years | 70 | USEPA, 2010 |
| **Averaging Time - Noncarcinogen** | $AT_{nc}$ | years | = ED | USEPA, 2010 |
| **Body Weight:** | | | | |
| Adult Receptors | BW | kg | 70 | USEPA, 2010 |
| Child Receptors | BW | kg | 15 | USEPA, 2010 |
| **Exposure Duration:** | | | | |
| Resident Child | ED | years | 6 | USEPA, 2010 |
| Resident Adult | ED | years | 24 | USEPA, 2010 |
| Commercial Worker | ED | years | 25 | USEPA, 2010 |
| Construction Worker | ED | years | 1 | PJ |
| **Exposure Frequency:** | | | | |
| Residents | EF | days/yr | 350 | USEPA, 2010 |
| Commercial Worker | EF | days/yr | 250 | USEPA, 2010 |
| Construction Worker | EF | days/yr | 90 | PJ |
| **Soil Ingestion Rate:** | | | | |
| Resident Child | $IR_{soil}$ | mg/day | 200 | USPEA, 2010 |
| Resident Adult | $IR_{soil}$ | mg/day | 100 | USEPA, 2010 |
| Commercial Worker | $IR_{soil}$ | mg/day | 100 | USEPA, 2010 |
| Construction Worker | $IR_{soil}$ | mg/day | 330 | USEPA, 2002 |
| **Daily Water Ingestion Rate:** | | | | |
| Resident Child | $IR_w$ | L/day | 1 | USEPA, 2010 |
| Resident Adult | $IR_w$ | L/day | 2 | USEPA, 2010 |
| **Exposure Time for Indoor Inhalation:** | | | | |
| Resident Child | $ET_{in}$ | hr/day | 16 | PJ |
| Resident Adult | $ET_{in}$ | hr/day | 16 | PJ |
| Commercial | $ET_{in}$ | hr/day | 8 | USEPA, 2010 |
| **Exposure Time for Outdoor Inhalation:** | | | | |
| Resident Child and Adult | $ET_{out}$ | hr/day | 8 | PJ |
| Commercial Worker | $ET_{out}$ | hr/day | 8 | USEPA, 2010 |
| Construction Worker | $ET_{out}$ | hr/day | 8 | PJ |
| **Skin Surface Area for Incidental Dermal Contact with Soil:** | | | | |
| Resident Child | $SA_{soil}$ | $cm^2/day$ | 2800 | USEPA, 2010 |
| Resident Adult | $SA_{soil}$ | $cm^2/day$ | 5700 | USEPA, 2010 |
| Commercial Worker | $SA_{soil}$ | $cm^2/day$ | 3300 | USEPA, 2010 |
| Construction Worker | $SA_{soil}$ | $cm^2/day$ | 3300 | USEPA, 2004 |
| **Soil to Skin Adherence Factor:** | | | | |
| Resident Child | AF | $mg/cm^2$ | 0.2 | USEPA, 2010 |
| Resident Adult | AF | $mg/cm^2$ | 0.07 | USEPA, 2010 |
| Commercial Worker | AF | $mg/cm^2$ | 0.2 | USEPA, 2010 |
| Construction Worker | AF | $mg/cm^2$ | 0.3 | USEPA, 2004 |
| **Event Frequency for Incidental Dermal Contact with Soil:** | | | | |
| Resident Child | $EV_{soil}$ | event/day | 1 | USEPA, 2002 |
| Resident Adult | $EV_{soil}$ | event/day | 1 | USEPA, 2002 |
| Commercial Worker | $EV_{soil}$ | event/day | 1 | USEPA, 2002 |
| Construction Worker | $EV_{soil}$ | event/day | 1 | USEPA, 2002 |

## Table 5-4
## Default Exposure Factors

| Parameter | Symbol | Unit | Default Value | Source |
|---|---|---|---|---|
| **Skin Surface Area for Incidental Dermal Contact with Water:** | | | | |
| Resident Child | $SA_{gw}$ | $cm^2$/day | 2800 | USEPA, 2004 |
| Resident Adult | $SA_{gw}$ | $cm^2$/day | 5700 | USEPA, 2004 |
| Commercial Worker | $SA_{gw}$ | $cm^2$/day | 3300 | USEPA, 2004 |
| Construction Worker | $SA_{gw}$ | $cm^2$/day | 3300 | USEPA, 2004 |
| **Event Frequency for Incidental Dermal Contact with Water:** | | | | |
| Resident Child | $EV_{gw}$ | event/day | 1 | PJ |
| Resident Adult | $EV_{gw}$ | event/day | 1 | PJ |
| Commercial Worker | $EV_{gw}$ | event/day | 1 | PJ |
| Construction Worker | $EV_{gw}$ | event/day | 1 | PJ |
| **Event Duration for Incidental Dermal Contact with Water:** | | | | |
| Resident Child | $t_{event}$ | hr/event | 1 | PJ |
| Resident Adult | $t_{event}$ | hr/event | 1 | PJ |
| Commercial Worker | $t_{event}$ | hr/event | 1 | PJ |
| Construction Worker | $t_{event}$ | hr/event | 1 | PJ |

**Notes:**
NR: Not required
PJ: Professional judgment

**Sources:**
US EPA, 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.
USEPA, 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part E Supplemental Guidance for Dermal Risk Assessment.
USEPA, 2010. Regional Screening Table - User's Guide, May 2010.

## Table 5-5(a)
## Tier 1 Default Fate and Transport Parameters

| Parameter | Symbol | Unit | Tier 1 Values |
|---|---|---|---|
| **SOIL PARAMETERS:** | | | |
| Length of Soil Source Area Parallel to Wind Direction** | $W_a$ | cm | 1500 |
| Depth to Subsurface Soil Sources** | $L_s$ | cm | 30.48 |
| Lower Depth of Surficial Soil Zone** | d | cm | 30.48 |
| Depth to Soil Vapor Measurement** | $d_v$ | cm | 30.48 |
| Thickness of Capillary Fringe** | $h_{cap}$ | cm | 5 |
| Thickness of Vadose Zone* | $h_v$ | cm | 295 |
| Dry Soil Bulk Density** | $\rho_s$ | g/cm$^3$ | 1.8 |
| Fractional Organic Carbon Content in the Vadose Zone** | foc | g-C/g-soil | 0.01 |
| Total Porosity in the Vadose Zone** | $\theta_T$ | cm$^3$/cm$^3$-soil | 0.3 |
| Volumetric Water Content in Capillary Fringe* | $\theta_{wcap}$ | cm$^3$/cm$^3$ | 0.27 |
| Volumetric Water Content in Vadose Zone** | $\theta_{ws}$ | cm$^3$/cm$^3$ | 0.2 |
| Volumetric Water Content in Foundation or Wall Cracks** | $\theta_{wcrack}$ | cm$^3$/cm$^3$ | 0.2 |
| Volumetric Air Content in Capillary Fringe* | $\theta_{acap}$ | cm$^3$/cm$^3$ | 0.03 |
| Volumetric Air Content in Vadose Zone* | $\theta_{as}$ | cm$^3$/cm$^3$ | 0.1 |
| Volumetric Air Content in Foundation/Wall Cracks* | $\theta_{acrack}$ | cm$^3$/cm$^3$ | 0.1 |
| **GROUNDWATER PARAMETERS:** | | | |
| Depth to Groundwater** | $L_{gw}$ | cm | 300 |
| Length of Groundwater Source Area Parallel to Wind Direction** | $W_{ga}$ | cm | 1500 |
| Width of GW Source Perpendicular to the GW Flow Direction** | Y | cm | 1500 |
| Length of the GW Source Parallel to the GW Flow Direction** | W | cm | 1500 |
| Total Porosity in the Saturated Zone** | $\theta_{TS}$ | cm$^3$/cm$^3$-soil | 0.3 |
| Saturated Zone Dry Soil Bulk Density** | $\rho_{ss}$ | g/cm$^3$ | 1.8 |
| Fractional Organic Carbon Content in the Saturated Zone** | $foc_s$ | g/g | 0.01 |
| Groundwater Mixing Zone Thickness** | $\delta_{gw}$ | cm | 200 |
| Hydraulic Conductivity in the Saturated Zone** | K | cm/year | 76000 |
| Hydraulic Gradient in the Saturated Zone** | i | -- | 0.004 |
| Groundwater Darcy Velocity* | $U_{gw}$ | cm/year | 304.1 |
| Infiltration Rate** | I | cm/year | 14 |
| **STREAM PARAMETERS:** | | | |
| Stream Flow Rate Upstream of the Point of Groundwater Discharge** | $Q_{sw}$ | ft$^3$/day | Variable |
| Impacted Groundwater Discharge into the Stream* | $Q_{gw}$ | ft$^3$/day | Calculated |
| COCs Concentration Upstream of the Groundwater Plume Discharge** | $C_{su}$ | mg/L | 0 |
| **AMBIENT AIR PARAMETERS:** | | | |
| Breathing Zone Height | $\delta_a$ | cm | 200 |
| Wind Speed within the Breathing Zone** | $U_a$ | cm/s | 225 |
| **PARTICULATE EMISSION RATE:** | | | |
| Residential and Commercial | Pe | g/cm$^2$sec | 6.90E-14 |
| Construction Worker | Pe | g/cm$^2$sec | 6.90E-09 |
| **GROUNDWATER RESOURCE PROTECTION PARAMETERS:** | | | |
| Distance from the Downgradient Edge of the Groundwater Source to the Point of Exposure** | $X_{poe}$ | ft | Variable |
| Longitudinal Dispersivity* | $\alpha_x$ | ft | Xpoe/10 |
| Transverse Dispersivity* | $\alpha_y$ | ft | Xpoe/30 |
| Vertical Dispersivity* | $\alpha_z$ | ft | Xpoe/200 |
| Distance from the Downgradient Edge of the Groundwater Source to the Point of Demonstration** | $X_{poc}$ | ft | Variable |
| Longitudinal Dispersivity* | $\alpha_x$ | ft | Xpoc/10 |
| Transverse Dispersivity* | $\alpha_y$ | ft | Xpoc/30 |
| Vertical Dispersivity* | $\alpha_z$ | ft | Xpoc/200 |

## Table 5-5(a)
## Tier 1 Default Fate and Transport Parameters

| Parameter | Symbol | Unit | Tier 1 Values |
|---|---|---|---|
| **STREAM PROTECTION PARAMETERS:** | | | |
| Distance from the Downgradient Edge of the Groundwater Source to the Stream** | $X_s$ | ft | Variable |
| Longitudinal Dispersivity* | $\alpha_x$ | ft | Xs/10 |
| Transverse Dispersivity* | $\alpha_y$ | ft | Xs/30 |
| Vertical Dispersivity* | $\alpha_z$ | ft | Xs/200 |
| Distance from the Downgradient Edge of the Groundwater Source to the Point of Demonstration** | $X_{spoc}$ | ft | Variable |
| Longitudinal Dispersivity* | $\alpha_x$ | ft | Xspoc/10 |
| Transverse Dispersivity* | $\alpha_y$ | ft | Xspoc/30 |
| Vertical Dispersivity* | $\alpha_z$ | ft | Xspoc/200 |

**Notes:**

*: Calculated value

**: These parameters must be replaced with site-specific values for Tier 2A evaluation.

## Table 5-5(b)
## Building/Advective Vapor Flux Parameters For Vapor Intrusion Pathway

| Parameter | Symbol | Units | Tier 1 Value |
|---|---|---|---|
| **Residential Structure** | | | |
| Surface Area of Building at or Below Grade* | $A_B$ | $cm^2$ | 1.00E+06 |
| Building Ventilation Rate* | $Q_{bldg}$ | $cm^3/s$ | 2.80E+04 |
| Distance from Bottom of Slab to Top of Contamination in Sub-Soil* | $L_T$ | cm | 15.48 |
| Distance from Bottom of Slab to Soil Vapor Measurement* | | | 15.48 |
| Distance from Bottom of Slab to Top of Groundwater Table* | | | 285 |
| Volumetric Flow Rate of Soil Gas into the Buidling** | $Q_{soil}$ | $cm^3/s$ | 83.33 |
| **$Q_{soil}$ is either a user-input above, or calculated below if $Q_{soil}$ above is "NA".** | | | |
| Volumetric Flow Rate of Soil Gas into the Building* | $Q_{soil}$ | $cm^3/s$ | |
| Buidling Foundation or Slab Thickness** | $L_{crack}$ | cm | 15 |
| Total Area of Cracks* | $A_{crack}$ | $cm^2$ | 400 |
| Soil-Building Pressure Difference** | $\Delta P$ | $gm/cm\text{-}s^2$ | 40 |
| Viscosity of Air* | $\mu$ | gm/cm-s | 1.80E-04 |
| Vapor Permeability for Soils below Building** | $k_v$ | $cm^2$ | 1.00E-08 |
| Air Exchange Rate ** | ER | l/24 hr | 12.1 |
| Building Height** | $H_B$ | cm | 200 |
| Building Width** | $W_B$ | cm | 1000 |
| Building Length** | $L_B$ | cm | 1000 |
| Depth below Grade to Bottom of Building Floor** | $L_F$ | cm | 15 |
| Floor-Wall Seam Gap** | w | cm | 0.1 |
| Equivalent Crack Radius* | $r_{crack}$ | cm | 0.1 |
| Floor-Wall Seam Perimeter* | $X_{crack}$ | cm | 4000 |
| **Commercial Structure** | | | |
| Surface Area of Building at or Below Grade* | $A_B$ | $cm^2$ | 1.00E+06 |
| Building Ventilation Rate* | $Q_{bldg}$ | $cm^3/s$ | 6.91E+04 |
| Distance from Bottom of Slab to Top of Contamination in Sub-Soil* | $L_T$ | cm | 15.48 |
| Distance from Bottom of Slab to Soil Vapor Measurement* | | | 15.48 |
| Distance from Bottom of Slab to Top of Groundwater Table* | | | 285 |
| Volumetric Flow Rate of Soil Gas into the Building** | $Q_{soil}$ | $cm^3/s$ | 83.33 |
| **Qsoil is either a user-input above, or calculated below if Qsoil above is "NA".** | | | |
| Volumetric Flow Rate of Soil Gas into the Building* | $Q_{soil}$ | $cm^3/s$ | |
| Building Foundation or Slab Thickness** | $L_{crack}$ | cm | 15 |
| Total Area of Cracks* | $A_{crack}$ | $cm^2$ | 400 |
| Soil-Building Pressure Difference** | $\Delta P$ | $gm/cm\text{-}s^2$ | 40 |
| Viscosity of Air* | $\mu$ | gm/cm-s | 1.80E-04 |
| Vapor Permeability for Soils below Building** | $k_v$ | $cm^2$ | 1.00E-08 |
| Air Exchange Rate** | ER | l/24 hr | 19.9 |
| Building Height** | $H_B$ | cm | 300 |
| Building Width ** | $W_B$ | cm | 1000 |
| Building Length** | $L_B$ | cm | 1000 |
| Depth below Grade to Bottom of Building Floor** | $L_F$ | cm | 15 |
| Floor-Wall Seam Gap** | w | cm | 0.1 |
| Equivalent Crack Radius* | $r_{crack}$ | cm | 0.1 |
| Floor-Wall Seam Perimeter* | $X_{crack}$ | cm | 4000 |

**Notes:**

*: Calculated value

**: These parameters may change when the Division develops the vapor intrusion pathway.

## Table 5-6
## Groundwater and Surface Water Standards at the Point of Exposure (POE) Well

| Chemicals of Concern | Groundwater [mg/L] | | Surface water [mg/L] | |
|---|---|---|---|---|
| | | | Class C | Class D |
| | | | CCC 4-Day Avg | 30-Day Avg |
| Benzene | 5.00E-03 | M | 1000 | 51 |
| Toluene | 1.00E+00 | M | 600 | 15000 |
| Ethylbenzene | 7.00E-01 | M | 40 | 2100 |
| Xylenes (total) | 1.00E+01 | M | | |
| Ethylene dibromide (EDB) | 1.18E-05 | | | |
| Ethylene dichloride (EDC (1,2-DCA)) | 5.00E-03 | M | | |
| Methyl tertiary butyl ether (MTBE) | 2.20E-02 | | | |
| Tertiary butyl alcohol (TBA) | 1.41E+00 | | | |
| Ethanol | 5.16E+02 | | | |
| Acenaphthene | 9.39E-01 | | 50 | 990 |
| Anthracene | 4.69E+00 | | | 40000 |
| Benzo(a)anthracene | 5.29E-05 | | | 0.018 |
| Benzo(a)pyrene | 2.00E-04 | M | | 0.018 |
| Benzo(b)fluoranthene | 5.29E-05 | | | 0.018 |
| Benzo(g,h,i)perylene | 4.69E-01 | | | |
| Benzo(k)fluoranthene | 7.85E-05 | | | 0.018 |
| Chrysene | 7.85E-04 | | | 0.018 |
| Fluoranthene | 6.26E-01 | | 400 | 140 |
| Fluorene | 6.26E-01 | | | 5300 |
| Naphthalene | 2.68E-04 | | 600 | |
| Phenanthrene | 4.69E-01 | | | |
| Pyrene | 4.69E-01 | | | 4000 |
| **TPH-GRO** | 3.45E+01 | | | |
| Aliphatics - > C6-C8 | 3.32E+01 | | | |
| Aliphatics - > C8-C10 | 1.04E+00 | | | |
| Aromatics - >C8-C10 | 3.13E-01 | | | |
| **TPH-DRO** | 3.45E+01 | | | |
| Aliphatics - >C10-C12 | 1.04E+00 | | | |
| Aliphatics - >C12-C16 | 1.04E+00 | | | |
| Aliphatics - >C16-C21 | 3.13E+01 | | | |
| Aromatics - >C10-C12 | 3.13E-01 | | | |
| Aromatics - >C12-C16 | 3.13E-01 | | | |
| Aromatics - >C16-C21 | 4.69E-01 | | | |
| **TPH-ORO** | 3.18E+01 | | | |
| Aliphatics - >C21-C35 | 3.13E+01 | | | |
| Aromatics - >C21-C35 | 4.69E-01 | | | |

Notes:
CCC: Criterion continuous concentration
CMC: Criterion maximum concentration
M: Values with a superscript are MCLs, all others are calculated values. (Refer Section 5.4.2).
Surfacewater Standards: 21 DCMR 1100 DDOE District of Columbia's Water Quality Standards.

# Table 5-7
# Tier 1 Default Dilution Attenuation Factors for Saturated Zone ($DAF_{sat}$)

| **Distance from the Downgradient Edge of the Grondwater Source to Point of Exposure** [ft] | **$DAF_{sat}$** [(mg/L)/(mg/L)] |
|---|---|
| 0 | 1 |
| 50 | 1.31 |
| 100 | 3.11 |
| 150 | 6.23 |
| 200 | 10.6 |
| 250 | 16.3 |
| 300 | 23.2 |
| 350 | 31.3 |
| 400 | 40.8 |
| 450 | 51.4 |
| 500 | 63.4 |
| 600 | 91 |
| 700 | 124 |
| 800 | 161 |
| 900 | 204 |
| 1000 | 252 |

**Notes:**

Calculated using Domenico's Model and the following assumptions:
- Infinite source
- No chemical biodegradation
- Source width of 49.2 feet (1500 cm)
- Source thickness of 6.6 feet (200 cm)

## Table 5-8
## Risk-Based Screening Levels for a Resident Child

| Chemicals of Concern | Air | | Surficial Soil | Sub-surface Soil | | Soil Vapor | | Groundwater | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Indoor** | Outdoor | Ingestion, Inhalation (Vapor Emissions and Particulates), and Dermal Contact | Indoor Inhalation** | Outdoor Inhalation | Indoor Inhalation** | Outdoor Inhalation | Indoor Inhalation** | Outdoor Inhalation | Incidental Dermal Contact | Domestic Use of Water (Ingestion and Inhalation) |
| | [mg/m$^3$-air] | | [mg/kg] | | | [mg/m$^3$-air] | | [mg/L] | | | |
| Benzene | 2.34E-03 | 4.68E-03 | 1.60E+01 | 2.03E-02 | 6.26E+01 | 2.94E+00 | 9.10E+03 | 2.70E-01 | 5.91E+02 | 5.09E-02 | 5.00E-03 M |
| Toluene | 7.82E+00 | 1.56E+01 | 6.23E+03 * | 1.00E+02 | 3.21E+05 * | 1.10E+04 | 3.51E+07 + | 9.00E+02 # | 1.97E+06 # | 8.57E+00 | 1.00E+00 M |
| Ethylbenzene | 7.30E-03 | 1.46E-02 | 7.86E+01 | 1.63E-01 | 5.40E+02 | 1.14E+01 | 3.76E+04 | 8.26E-01 | 1.81E+03 # | 6.71E-02 | 7.00E-01 M |
| Xylenes (total) | 1.56E-01 | 3.13E-01 | 1.05E+04 * | 3.86E+00 | 1.21E+04 * | 2.05E+02 | 6.44E+05 + | 2.05E+01 | 4.49E+04 # | 1.17E+01 | 1.00E+01 M |
| Ethylene dibromide (EDB) | 3.04E-05 | 6.08E-05 | 4.25E-01 | 1.22E-03 | 4.32E+00 | 6.45E-02 | 2.29E+02 | 3.95E-02 | 8.81E+01 | 3.87E-03 | 3.65E-05 |
| Ethylene dichloride (EDC (1,2-DCA)) | 7.02E-04 | 1.40E-03 | 9.38E+00 | 9.55E-03 | 2.97E+01 | 8.99E-01 | 2.80E+03 | 3.05E-01 | 6.72E+02 | 9.71E-02 | 5.00E-03 M |
| Methyl tertiary butyl ether (MTBE) | 7.02E-02 | 1.40E-01 | 4.90E+02 | 9.32E-01 | 2.99E+03 | 9.81E+01 | 3.14E+05 | 6.42E+01 | 1.42E+05 # | 4.90E+00 | 5.89E-02 |
| Tertiary butyl alcohol (TBA) | NA | NA | 8.80E+03 | NA | NA | NA | NA | NA | NA | 1.88E+02 | 1.41E+00 |
| Ethanol | NA | NA | 3.23E+06 * | NA | NA | NA | NA | NA | NA | 2.48E+05 | 5.16E+02 |
| Acenaphthene | NA | NA | 3.44E+03 * | NA | NA | NA | NA | NA | NA | 1.19E+00 | 9.39E-01 |
| Anthracene | NA | NA | 1.72E+04 * | NA | NA | NA | NA | NA | NA | 5.26E+01 # | 4.69E+00 # |
| Benzo(a)anthracene | 1.66E-04 | 3.32E-04 | 9.16E-01 | 4.13E+02 * | 8.94E+05 * | 1.14E-01 + | 2.48E+02 + | 2.30E+00 # | 4.93E+03 # | 4.78E-05 | 1.43E-04 |
| Benzo(a)pyrene | 1.66E-05 | 3.32E-05 | 9.16E-02 | 1.81E+03 * | 3.76E+05 * | 5.86E-03 + | 1.21E+00 + | 5.69E-01 # | 6.23E+02 # | 2.81E-06 | 2.00E-04 M |
| Benzo(b)fluoranthene | 1.66E-04 | 3.32E-04 | 9.16E-01 | 1.38E+04 * | 6.19E+06 * | 6.24E-02 + | 2.79E+01 + | 6.52E+00 # | 1.01E+04 # | 2.76E-05 | 1.43E-04 |
| Benzo(g,h,i)perylene | NA | NA | 1.87E+03 * | NA | NA | NA | NA | NA | NA | 4.08E-02 # | 4.69E-01 # |
| Benzo(k)fluoranthene | 1.66E-04 | 3.32E-04 | 9.16E+00 * | 1.51E+04 * | 6.07E+06 * | 6.17E-02 + | 2.48E+01 + | 6.79E+00 # | 1.01E+04 # | 3.96E-04 | 2.93E-04 |
| Chrysene | 1.66E-03 | 3.32E-03 | 9.15E+01 * | 8.49E+03 * | 1.56E+07 * | 9.87E-01 + | 1.81E+03 + | 3.99E+01 # | 8.41E+04 # | 4.78E-03 # | 2.93E-03 # |
| Fluoranthene | NA | NA | 2.29E+03 * | NA | NA | NA | NA | NA | NA | 3.00E-01 # | 6.26E-01 # |
| Fluorene | NA | NA | 2.29E+03 * | NA | NA | NA | NA | NA | NA | 1.05E+00 | 6.26E-01 |
| Naphthalene | 5.37E-04 | 1.07E-03 | 4.69E+02 | 7.54E-01 | 2.52E+03 * | 8.73E-01 | 2.92E+03 + | 7.64E-01 | 1.69E+03 # | 1.16E+00 | 1.07E-03 |
| Phenanthrene | NA | NA | 1.87E+03 * | NA | NA | NA | NA | NA | NA | 4.09E-01 | 4.69E-01 |
| Pyrene | NA | NA | 1.72E+03 * | NA | NA | NA | NA | NA | NA | 2.55E-01 # | 4.69E-01 # |
| **TPH-GRO** | 3.07E+01 | 6.13E+01 | 4.65E+05 * | 5.44E+01 | 1.63E+05 * | 3.59E+04 | 1.08E+08 + | 3.88E+01 | 8.54E+04 # | NA | 3.45E+01 |
| Aliphatics - > C6-C8 | 2.88E+01 | 5.76E+01 | 4.52E+05 * | 2.88E+01 | 8.65E+04 * | 3.37E+04 | 1.01E+08 + | 1.74E+01 # | 3.79E+04 # | NA | 3.32E+01 # |
| Aliphatics - > C8-C10 | 1.56E+00 | 3.13E+00 | 9.49E+03 * | 1.06E+01 | 3.20E+04 * | 1.83E+03 | 5.50E+06 + | 8.60E-01 # | 1.87E+03 # | NA | 1.04E+00 # |
| Aromatics - >C8-C10 | 3.13E-01 | 6.26E-01 | 3.69E+03 * | 1.50E+01 | 4.50E+04 * | 3.66E+02 | 1.10E+06 + | 2.05E+01 | 4.57E+04 # | NA | 3.13E-01 |
| **TPH-DRO** | 3.75E+00 | 7.51E+00 | 2.30E+05 * | 2.12E+03 * | 6.35E+06 * | 4.38E+03 | 1.32E+07 + | 2.45E+02 # | 5.43E+05 # | NA | 3.45E+01 # |
| Aliphatics - >C10-C12 | 1.56E+00 | 3.13E+00 | 9.73E+03 * | 7.68E+01 | 2.31E+05 * | 1.83E+03 | 5.50E+06 + | 7.69E-01 # | 1.72E+03 # | NA | 1.04E+00 # |
| Aliphatics - >C12-C16 | 1.56E+00 | 3.13E+00 | 9.93E+03 * | 1.33E+03 * | 4.00E+06 * | 1.83E+03 + | 5.50E+06 + | 6.69E-01 # | 1.49E+03 # | NA | 1.04E+00 # |
| Aliphatics - >C16-C21 | NA | NA | 2.01E+05 * | NA | NA | NA | NA | NA | NA | NA | 3.13E+01 # |
| Aromatics - >C10-C12 | 3.13E-01 | 6.26E-01 | 3.86E+03 * | 7.07E+01 | 2.12E+05 * | 3.64E+02 | 1.09E+06 + | 5.26E+01 # | 1.17E+05 # | NA | 3.13E-01 |
| Aromatics - >C12-C16 | 3.13E-01 | 6.26E-01 | 3.96E+03 * | 6.41E+02 * | 1.91E+06 * | 3.57E+02 + | 1.06E+06 + | 1.91E+02 # | 4.23E+05 # | NA | 3.13E-01 |
| Aromatics - >C16-C21 | NA | NA | 1.87E+03 * | NA | NA | NA | NA | NA | NA | NA | 4.69E-01 |
| **TPH-ORO** | NA | NA | 2.02E+05 * | NA | NA | NA | NA | NA | NA | NA | 3.18E+01 # |
| Aliphatics - >C21-C35 | NA | NA | 2.01E+05 * | NA | NA | NA | NA | NA | NA | NA | 3.13E+01 # |
| Aromatics - >C21-C35 | NA | NA | 1.87E+03 * | NA | NA | NA | NA | NA | NA | NA | 4.69E-01 # |

**Notes:**

***:** Calculated RBSL exceeded saturated soil concentration and calculated value is shown.

**#:** Calculated RBSL exceeded pure component water solubility and calculated value is shown.

+: Calculated RBSL exceeded saturated soil vapor concentration and calculated value is shown.
Soil concentrations are presented on a dry weight basis.

**: These values may change when the Division develops the vapor intrusion pathway.

NA: Not available due to lack of an input parameter.

M: MCL

## Table 5-9
## Risk-Based Screening Levels for a Resident Adult

| **Chemicals of Concern** | **Air** |  | **Surficial Soil** | **Sub-surface Soil** |  | **Soil Vapor** |  | **Groundwater** |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Indoor** | Outdoor | Ingestion, Inhalation (Vapor Emissions and Particulates), and Dermal Contact | Indoor Inhalation** | Outdoor Inhalation | Indoor Inhalation** | Outdoor Inhalation | Indoor Inhalation** | Outdoor Inhalation | Incidental Dermal Contact | Domestic Use of Water (Ingestion and Inhalation) |
|  | [mg/m$^3$-air] |  | [mg/kg] |  |  | [mg/m$^3$-air] |  | [mg/L] |  |  |  |
| Benzene | 5.85E-04 | 1.17E-03 | 3.64E+01 | 5.06E-03 | 1.57E+01 | 7.36E-01 | 2.28E+03 | 6.76E-02 | 1.48E+02 | 2.92E-02 | 5.00E-03 M |
| Toluene | 7.82E+00 | 1.56E+01 | 5.80E+04 * | 1.00E+02 | 3.21E+05 * | 1.10E+04 | 3.51E+07 + | 9.00E+02 # | 1.97E+06 # | 1.96E+01 | 1.00E+00 M |
| Ethylbenzene | 1.83E-03 | 3.65E-03 | 1.76E+02 | 4.08E-02 | 1.35E+02 | 2.84E+00 | 9.41E+03 | 2.06E-01 | 4.53E+02 # | 3.85E-02 | 7.00E-01 M |
| Xylenes (total) | 1.56E-01 | 3.13E-01 | 7.68E+04 * | 3.86E+00 | 1.21E+04 * | 2.05E+02 | 6.44E+05 + | 2.05E+01 | 4.49E+04 # | 2.69E+01 | 1.00E+01 M |
| Ethylene dibromide (EDB) | 7.60E-06 | 1.52E-05 | 9.38E-01 | 3.04E-04 | 1.08E+00 | 1.61E-02 | 5.73E+01 | 9.89E-03 | 2.20E+01 | 2.22E-03 | 1.18E-05 |
| Ethylene dichloride (EDC (1,2-DCA)) | 1.75E-04 | 3.51E-04 | 2.07E+01 | 2.39E-03 | 7.43E+00 | 2.25E-01 | 6.99E+02 | 7.63E-02 | 1.68E+02 | 5.57E-02 | 5.00E-03 M |
| Methyl tertiary butyl ether (MTBE) | 1.75E-02 | 3.51E-02 | 1.11E+03 | 2.33E-01 | 7.46E+02 | 2.45E+01 | 7.86E+04 | 1.61E+01 | 3.55E+04 | 2.81E+00 | 2.20E-02 |
| Tertiary butyl alcohol (TBA) | NA | NA | 8.21E+04 * | NA | NA | NA | NA | NA | NA | 4.31E+02 | 3.29E+00 |
| Ethanol | NA | NA | 3.01E+07 * | NA | NA | NA | NA | NA | NA | 5.70E+05 # | 1.20E+03 |
| Acenaphthene | NA | NA | 2.88E+04 * | NA | NA | NA | NA | NA | NA | 2.72E+00 | 2.19E+00 |
| Anthracene | NA | NA | 1.44E+05 * | NA | NA | NA | NA | NA | NA | 1.21E+02 # | 1.10E+01 # |
| Benzo(a)anthracene | 4.15E-05 | 8.30E-05 | 1.92E+00 | 1.03E+02 * | 2.24E+05 * | 2.86E-02 + | 6.19E+01 + | 5.75E-01 # | 1.23E+03 # | 2.74E-05 | 5.29E-05 |
| Benzo(a)pyrene | 4.15E-06 | 8.30E-06 | 1.92E-01 | 4.53E+02 * | 9.39E+04 * | 1.47E-03 + | 3.04E-01 + | 1.42E-01 # | 1.56E+02 # | 1.61E-06 | 2.00E-04 M |
| Benzo(b)fluoranthene | 4.15E-05 | 8.30E-05 | 1.92E+00 | 3.46E+03 * | 1.55E+06 * | 1.56E-02 + | 6.97E+00 + | 1.63E+00 # | 2.52E+03 # | 1.58E-05 | 5.29E-05 |
| Benzo(g,h,i)perylene | NA | NA | 1.55E+04 * | NA | NA | NA | NA | NA | NA | 9.36E-02 # | 1.10E+00 # |
| Benzo(k)fluoranthene | 4.15E-05 | 8.30E-05 | 1.92E+01 * | 3.77E+03 * | 1.52E+06 * | 1.54E-02 + | 6.20E+00 + | 1.70E+00 # | 2.52E+03 # | 2.27E-04 | 7.85E-05 |
| Chrysene | 4.15E-04 | 8.30E-04 | 1.91E+02 * | 2.12E+03 * | 3.89E+06 * | 2.47E-01 + | 4.53E+02 + | 9.98E+00 # | 2.10E+04 # | 2.74E-03 # | 7.85E-04 |
| Fluoranthene | NA | NA | 1.92E+04 * | NA | NA | NA | NA | NA | NA | 6.87E-01 # | 1.46E+00 # |
| Fluorene | NA | NA | 1.92E+04 * | NA | NA | NA | NA | NA | NA | 2.41E+00 # | 1.46E+00 |
| Naphthalene | 1.34E-04 | 2.68E-04 | 2.62E+02 | 1.88E-01 | 6.31E+02 * | 2.18E-01 | 7.30E+02 + | 1.91E-01 | 4.24E+02 # | 2.66E+00 | 2.68E-04 |
| Phenanthrene | NA | NA | 1.55E+04 * | NA | NA | NA | NA | NA | NA | 9.38E-01 | 1.10E+00 # |
| Pyrene | NA | NA | 1.44E+04 * | NA | NA | NA | NA | NA | NA | 5.85E-01 # | 1.10E+00 # |
| **TPH-GRO** | 3.07E+01 | 6.13E+01 | 4.08E+06 * | 5.44E+01 | 1.63E+05 * | 3.59E+04 | 1.08E+08 + | 3.88E+01 | 8.54E+04 # | NA | 4.59E+01 |
| Aliphatics - > C6-C8 | 2.88E+01 | 5.76E+01 | 3.96E+06 * | 2.88E+01 | 8.65E+04 * | 3.37E+04 | 1.01E+08 + | 1.74E+01 # | 3.79E+04 # | NA | 4.38E+01 # |
| Aliphatics - > C8-C10 | 1.56E+00 | 3.13E+00 | 8.64E+04 * | 1.06E+01 | 3.20E+04 * | 1.83E+03 | 5.50E+06 + | 8.60E-01 # | 1.87E+03 # | NA | 1.68E+00 # |
| Aromatics - >C8-C10 | 3.13E-01 | 6.26E-01 | 3.28E+04 * | 1.50E+01 | 4.50E+04 * | 3.66E+02 | 1.10E+06 + | 2.05E+01 | 4.57E+04 # | NA | 4.38E-01 |
| **TPH-DRO** | 3.75E+00 | 7.51E+00 | 1.86E+06 * | 2.12E+03 * | 6.35E+06 * | 4.38E+03 | 1.32E+07 + | 2.45E+02 # | 5.43E+05 # | NA | 7.83E+01 # |
| Aliphatics - >C10-C12 | 1.56E+00 | 3.13E+00 | 7.73E+04 * | 7.68E+01 | 2.31E+05 * | 1.83E+03 | 5.50E+06 + | 7.69E-01 # | 1.72E+03 # | NA | 1.68E+00 # |
| Aliphatics - >C12-C16 | 1.56E+00 | 3.13E+00 | 7.84E+04 * | 1.33E+03 * | 4.00E+06 * | 1.83E+03 + | 5.50E+06 + | 6.69E-01 # | 1.49E+03 # | NA | 1.68E+00 # |
| Aliphatics - >C16-C21 | NA | NA | 1.62E+06 * | NA | NA | NA | NA | NA | NA | NA | 7.30E+01 # |
| Aromatics - >C10-C12 | 3.13E-01 | 6.26E-01 | 2.95E+04 * | 7.07E+01 | 2.12E+05 * | 3.64E+02 | 1.09E+06 + | 5.26E+01 # | 1.17E+05 # | NA | 4.38E-01 |
| Aromatics - >C12-C16 | 3.13E-01 | 6.26E-01 | 3.10E+04 * | 6.41E+02 * | 1.91E+06 * | 3.57E+02 + | 1.06E+06 + | 1.91E+02 # | 4.23E+05 # | NA | 4.38E-01 |
| Aromatics - >C16-C21 | NA | NA | 1.55E+04 * | NA | NA | NA | NA | NA | NA | NA | 1.10E+00 # |
| **TPH-ORO** | NA | NA | 1.64E+06 * | NA | NA | NA | NA | NA | NA | NA | 7.41E+01 # |
| Aliphatics - >C21-C35 | NA | NA | 1.62E+06 * | NA | NA | NA | NA | NA | NA | NA | 7.30E+01 # |
| Aromatics - >C21-C35 | NA | NA | 1.55E+04 * | NA | NA | NA | NA | NA | NA | NA | 1.10E+00 # |

**Notes:**

***:** Calculated RBSL exceeded saturated soil concentration and calculated value is shown.

**#:** Calculated RBSL exceeded pure component water solubility and calculated value is shown.

+: Calculated RBSL exceeded saturated soil vapor concentration and calculated value is shown.
Soil concentrations are presented on a dry weight basis.

**: These values may change when the Division develops the vapor intrusion pathway.

NA: Not available due to lack of an input parameter.

M: MCL

## Table 5-10
## Risk-Based Screening Levels for a Commercial Worker

| **Chemicals of Concern** | **Air** | | **Surficial Soil** | **Sub-surface Soil** | | **Soil Vapor** | | **Groundwater** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Indoor** | Outdoor | Ingestion, Inhalation (Vapor Emissions and Particulates), and Dermal Contact | Indoor Inhalation** | Outdoor Inhalation | Indoor Inhalation** | Outdoor Inhalation | Indoor Inhalation** | Outdoor Inhalation | Incidental Dermal Contact |
| | [mg/m$^3$-air] | | [mg/kg] | | | [mg/m$^3$-air] | | [mg/L] | | |
| Benzene | 1.57E-03 | 1.57E-03 | 4.83E+01 | 3.36E-02 | 2.10E+01 | 4.88E+00 | 3.06E+03 | 4.48E-01 | 1.99E+02 | 6.78E-02 |
| Toluene | 2.19E+01 | 2.19E+01 | 8.11E+04 * | 6.91E+02 | 4.49E+05 * | 7.57E+04 | 4.92E+07 + | 6.22E+03 # | 2.76E+06 # | 4.75E+01 |
| Ethylbenzene | 4.91E-03 | 4.91E-03 | 2.32E+02 | 2.70E-01 | 1.81E+02 | 1.89E+01 | 1.26E+04 | 1.37E+00 | 6.08E+02 # | 8.93E-02 |
| Xylenes (total) | 4.38E-01 | 4.38E-01 | 9.82E+04 * | 2.67E+01 | 1.70E+04 * | 1.42E+03 | 9.02E+05 + | 1.42E+02 # | 6.28E+04 # | 6.50E+01 |
| Ethylene dibromide (EDB) | 2.04E-05 | 2.04E-05 | 1.23E+00 | 2.02E-03 | 1.45E+00 | 1.07E-01 | 7.70E+01 | 6.56E-02 | 2.96E+01 | 5.15E-03 |
| Ethylene dichloride (EDC (1,2-DCA)) | 4.72E-04 | 4.72E-04 | 2.72E+01 | 1.58E-02 | 9.98E+00 | 1.49E+00 | 9.40E+02 | 5.06E-01 | 2.26E+02 | 1.29E-01 |
| Methyl tertiary butyl ether (MTBE) | 4.72E-02 | 4.72E-02 | 1.47E+03 | 1.55E+00 | 1.00E+03 | 1.63E+02 | 1.06E+05 | 1.06E+02 | 4.77E+04 | 6.51E+00 |
| Tertiary butyl alcohol (TBA) | NA | NA | 1.15E+05 * | NA | NA | NA | NA | NA | NA | 1.04E+03 |
| Ethanol | NA | NA | 4.22E+07 * | NA | NA | NA | NA | NA | NA | 1.38E+06 # |
| Acenaphthene | NA | NA | 3.30E+04 * | NA | NA | NA | NA | NA | NA | 6.57E+00 # |
| Anthracene | NA | NA | 1.65E+05 * | NA | NA | NA | NA | NA | NA | 2.92E+02 # |
| Benzo(a)anthracene | 1.11E-04 | 1.11E-04 | 2.11E+00 | 6.85E+02 * | 3.00E+05 * | 1.90E-01 + | 8.32E+01 + | 3.81E+00 # | 1.66E+03 # | 6.36E-05 |
| Benzo(a)pyrene | 1.11E-05 | 1.11E-05 | 2.11E-01 | 3.01E+03 * | 1.26E+05 * | 9.72E-03 + | 4.08E-01 + | 9.44E-01 # | 2.09E+02 # | 3.74E-06 |
| Benzo(b)fluoranthene | 1.11E-04 | 1.11E-04 | 2.11E+00 | 2.30E+04 * | 2.08E+06 * | 1.03E-01 + | 9.37E+00 + | 1.08E+01 # | 3.38E+03 # | 3.68E-05 |
| Benzo(g,h,i)perylene | NA | NA | 1.75E+04 * | NA | NA | NA | NA | NA | NA | 2.26E-01 # |
| Benzo(k)fluoranthene | 1.11E-04 | 1.11E-04 | 2.10E+01 * | 2.50E+04 * | 2.04E+06 * | 1.02E-01 + | 8.34E+00 + | 1.13E+01 # | 3.38E+03 # | 5.26E-04 |
| Chrysene | 1.11E-03 | 1.11E-03 | 2.10E+02 * | 1.41E+04 * | 5.23E+06 * | 1.64E+00 + | 6.09E+02 + | 6.62E+01 # | 2.83E+04 # | 6.36E-03 # |
| Fluoranthene | NA | NA | 2.20E+04 * | NA | NA | NA | NA | NA | NA | 1.66E+00 # |
| Fluorene | NA | NA | 2.20E+04 * | NA | NA | NA | NA | NA | NA | 5.83E+00 # |
| Naphthalene | 3.61E-04 | 3.61E-04 | 3.22E+02 | 1.25E+00 | 8.48E+02 * | 1.45E+00 | 9.81E+02 + | 1.27E+00 | 5.69E+02 # | 6.43E+00 |
| Phenanthrene | NA | NA | 1.75E+04 * | NA | NA | NA | NA | NA | NA | 2.27E+00 # |
| Pyrene | NA | NA | 1.65E+04 * | NA | NA | NA | NA | NA | NA | 1.42E+00 # |
| **TPH-GRO** | 8.58E+01 | 8.58E+01 | 5.56E+06 * | 3.76E+02 | 2.29E+05 * | 2.48E+05 | 1.51E+08 + | 2.71E+02 # | 1.20E+05 # | NA |
| Aliphatics - > C6-C8 | 8.06E+01 | 8.06E+01 | 5.40E+06 * | 1.99E+02 | 1.21E+05 * | 2.33E+05 | 1.42E+08 + | 1.20E+02 # | 5.30E+04 # | NA |
| Aliphatics - > C8-C10 | 4.38E+00 | 4.38E+00 | 1.20E+05 * | 7.34E+01 | 4.48E+04 * | 1.26E+04 | 7.71E+06 + | 5.94E+00 # | 2.62E+03 # | NA |
| Aromatics - >C8-C10 | 8.76E-01 | 8.76E-01 | 4.50E+04 * | 1.03E+02 | 6.30E+04 * | 2.52E+03 | 1.54E+06 + | 1.45E+02 # | 6.39E+04 # | NA |
| **TPH-DRO** | 1.05E+01 | 1.05E+01 | 2.02E+06 * | 1.46E+04 * | 8.89E+06 * | 3.03E+04 + | 1.84E+07 + | 1.71E+03 # | 7.60E+05 # | NA |
| Aliphatics - >C10-C12 | 4.38E+00 | 4.38E+00 | 8.42E+04 * | 5.30E+02 * | 3.23E+05 * | 1.26E+04 + | 7.71E+06 + | 5.45E+00 # | 2.40E+03 # | NA |
| Aliphatics - >C12-C16 | 4.38E+00 | 4.38E+00 | 8.55E+04 * | 9.19E+03 * | 5.60E+06 * | 1.26E+04 + | 7.71E+06 + | 4.74E+00 # | 2.09E+03 # | NA |
| Aliphatics - >C16-C21 | NA | NA | 1.76E+06 * | NA | NA | NA | NA | NA | NA | NA |
| Aromatics - >C10-C12 | 8.76E-01 | 8.76E-01 | 3.22E+04 * | 4.88E+02 | 2.97E+05 * | 2.52E+03 | 1.53E+06 + | 3.69E+02 # | 1.64E+05 # | NA |
| Aromatics - >C12-C16 | 8.76E-01 | 8.76E-01 | 3.39E+04 * | 4.43E+03 * | 2.67E+06 * | 2.47E+03 + | 1.49E+06 + | 1.33E+03 # | 5.92E+05 # | NA |
| Aromatics - >C16-C21 | NA | NA | 1.75E+04 * | NA | NA | NA | NA | NA | NA | NA |
| **TPH-ORO** | NA | NA | 1.78E+06 * | NA | NA | NA | NA | NA | NA | NA |
| Aliphatics - >C21-C35 | NA | NA | 1.76E+06 * | NA | NA | NA | NA | NA | NA | NA |
| Aromatics - >C21-C35 | NA | NA | 1.75E+04 * | NA | NA | NA | NA | NA | NA | NA |

**Notes:**

***:** Calculated RBSL exceeded saturated soil concentration and calculated value is shown
**#:** Calculated RBSL exceeded pure component water solubility and calculated value is shown
+: Calculated RBSL exceeded saturated soil vapor concentration and calculated value is shown.
Soil concentrations are presented on a dry weight basis.
**: These values may change when the Division develops the vapor intrusion pathway.
NA: Not available due to lack of an input parameter.

## Table 5-11
## Risk-Based Screening Levels for a Constrcuction Worker

| Chemicals of Concern | Air | Soil Upto Depth of Construction | Groundwater | |
|---|---|---|---|---|
| | Outdoor | Ingestion, Inhalation (Vapor Emissions and Particulates), and Dermal Contact | Outdoor Inhalation | Incidental Dermal Contact |
| | $[mg/m^3$-air] | [mg/kg] | [mg/L] | |
| Benzene | 1.09E-01 | 6.91E+02 | 1.38E+04 # | 4.71E+00 |
| Toluene | 6.08E+01 | 6.46E+04 * | 7.67E+06 # | 1.32E+02 |
| Ethylbenzene | 3.41E-01 | 3.18E+03 * | 4.22E+04 # | 6.20E+00 |
| Xylenes (total) | 1.22E+00 | 2.39E+04 * | 1.75E+05 # | 1.81E+02 # |
| Ethylene dibromide (EDB) | 1.42E-03 | 1.78E+01 | 2.06E+03 | 3.58E-01 |
| Ethylene dichloride (EDC (1,2-DCA)) | 3.28E-02 | 3.04E+02 | 1.57E+04 # | 8.97E+00 |
| Methyl tertiary butyl ether (MTBE) | 3.28E+00 | 8.49E+03 | 3.31E+06 # | 1.16E+02 |
| Tertiary butyl alcohol (TBA) | NA | 9.68E+04 * | NA | 2.89E+03 |
| Ethanol | NA | 3.55E+07 * | NA | 3.83E+06 # |
| Acenaphthene | NA | 3.71E+04 * | NA | 1.82E+01 # |
| Anthracene | NA | 1.86E+05 * | NA | 8.10E+02 # |
| Benzo(a)anthracene | 7.74E-03 | 5.92E+01 * | 1.15E+05 # | 4.42E-03 |
| Benzo(a)pyrene | 7.74E-04 | 5.92E+00 | 1.45E+04 # | 2.60E-04 |
| Benzo(b)fluoranthene | 7.74E-03 | 5.92E+01 * | 2.35E+05 # | 2.55E-03 # |
| Benzo(g,h,i)perylene | NA | 2.02E+04 * | NA | 6.28E-01 # |
| Benzo(k)fluoranthene | 7.74E-03 | 5.80E+02 * | 2.35E+05 # | 3.66E-02 # |
| Chrysene | 7.74E-02 | 5.78E+03 * | 1.96E+06 # | 4.42E-01 # |
| Fluoranthene | NA | 2.48E+04 * | NA | 4.62E+00 # |
| Fluorene | NA | 2.48E+04 * | NA | 1.62E+01 # |
| Naphthalene | 2.50E-02 | 4.16E+03 * | 3.95E+04 # | 1.79E+01 |
| Phenanthrene | NA | 2.02E+04 * | NA | 6.30E+00 # |
| Pyrene | NA | 1.86E+04 * | NA | 3.93E+00 # |
| **TPH-GRO** | NA | 1.04E+09 * | NA | 3.32E+05 # |
| Aliphatics - > C6-C8 | 2.24E+02 | 2.24E+06 * | 1.47E+05 # | NA |
| Aliphatics - > C8-C10 | 1.22E+01 | 7.10E+04 * | 7.28E+03 # | NA |
| Aromatics - >C8-C10 | 2.43E+00 | 2.74E+04 * | 1.78E+05 # | NA |
| **TPH-DRO** | NA | 1.27E+08 * | NA | 2.11E+06 # |
| Aliphatics - >C10-C12 | 1.22E+01 | 8.39E+04 * | 6.67E+03 # | NA |
| Aliphatics - >C12-C16 | 1.22E+01 | 1.01E+05 * | 5.80E+03 # | NA |
| Aliphatics - >C16-C21 | NA | 2.15E+06 * | NA | NA |
| Aromatics - >C10-C12 | 2.43E+00 | 3.40E+04 * | 4.54E+05 # | NA |
| Aromatics - >C12-C16 | 2.43E+00 | 3.94E+04 * | 1.65E+06 # | NA |
| Aromatics - >C16-C21 | NA | 2.02E+04 * | NA | NA |
| **TPH-ORO** | NA | NA | NA | NA |
| Aliphatics - >C21-C35 | NA | 2.15E+06 * | NA | NA |
| Aromatics - >C21-C35 | NA | 2.02E+04 * | NA | NA |

**Notes:**

***:** Calculated RBSL exceeded saturated soil concentration and calculated value is shown.
**#:** Calculated RBSL exceeded pure component water solubility and calculated value is shown.
+: Calculated RBSL exceeded saturated soil vapor concentration and calculated value is shown.
Soil concentrations are presented on a dry weight basis.
**: These values may change when the Division develops the vapor intrusion pathway.
NA: Not available due to lack of an input parameter.

## Table 5-12
## Tier 1 RBSLs for Soil Concentrations (for Leaching to Groundwater) for Different Distances to the Groundwater Exposure Point

| Chemicals of Concern | Water Standard† [mg/L] | Tiier 1 RBTLs for Soil Concentration at the Source for Different Distances to the Exposure Point | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 ft. [mg/kg] | 50 ft. [mg/kg] | 100 ft. [mg/kg] | 150 ft. [mg/kg] | 200 ft. [mg/kg] | 250 ft. [mg/kg] | 300 ft. [mg/kg] | 350 ft. [mg/kg] | 400 ft. [mg/kg] | 450 ft. [mg/kg] | 500 ft. [mg/kg] | 1000 ft. [mg/kg] |
| Benzene | 5.00E-03 | 3.08E-02 | 4.03E-02 | 9.57E-02 | 1.92E-01 | 3.27E-01 | 5.01E-01 | 7.14E-01 | 9.65E-01 | 1.26E+00 | 1.58E+00 | 1.95E+00 | 7.76E+00 |
| Toluene | 1.00E+00 | 9.60E+00 | 1.26E+01 | 2.98E+01 | 5.98E+01 | 1.02E+02 | 1.56E+02 | 2.23E+02 | 3.01E+02 | 3.91E+02 | 4.94E+02 | 6.08E+02 | 2.42E+03 * |
| Ethylbenzene | 7.00E-01 | 1.25E+01 | 1.64E+01 | 3.89E+01 | 7.79E+01 | 1.33E+02 | 2.04E+02 | 2.90E+02 | 3.92E+02 | 5.10E+02 | 6.44E+02 | 7.93E+02 * | 3.15E+03 * |
| Xylenes (total) | 1.00E+01 | 1.54E+02 | 2.01E+02 | 4.78E+02 * | 9.59E+02 * | 1.63E+03 * | 2.50E+03 * | 3.57E+03 * | 4.82E+03 * | 6.27E+03 * | 7.92E+03 * | 9.75E+03 * | 3.88E+04 * |
| Ethylene dibromide (EDB) | 1.18E-05 | 2.34E-05 | 3.06E-05 | 7.28E-05 | 1.46E-04 | 2.49E-04 | 3.81E-04 | 5.43E-04 | 7.34E-04 | 9.55E-04 | 1.21E-03 | 1.48E-03 | 5.90E-03 |
| Ethylene dichloride (EDC (1,2-DCA)) | 5.00E-03 | 9.93E-03 | 1.30E-02 | 3.08E-02 | 6.18E-02 | 1.05E-01 | 1.61E-01 | 2.30E-01 | 3.11E-01 | 4.05E-01 | 5.11E-01 | 6.29E-01 | 2.50E+00 |
| Methyl tertiary butyl ether (MTBE) | 2.20E-02 | 1.96E-02 | 2.56E-02 | 6.08E-02 | 1.22E-01 | 2.08E-01 | 3.18E-01 | 4.53E-01 | 6.13E-01 | 7.97E-01 | 1.01E+00 | 1.24E+00 | 4.93E+00 |
| Tertiary butyl alcohol (TBA) | 1.41E+00 | 8.40E-01 | 1.10E+00 | 2.61E+00 | 5.23E+00 | 8.92E+00 | 1.37E+01 | 1.95E+01 | 2.63E+01 | 3.42E+01 | 4.32E+01 | 5.32E+01 | 2.12E+02 |
| Ethanol | 5.16E+02 | 2.47E+02 | 3.24E+02 | 7.68E+02 | 1.54E+03 | 2.63E+03 | 4.02E+03 | 5.73E+03 | 7.75E+03 | 1.01E+04 | 1.27E+04 | 1.57E+04 | 6.23E+04 * |
| Acenaphthene | 9.39E-01 | 1.84E+02 | 2.41E+02 * | 5.72E+02 * | 1.15E+03 * | 1.96E+03 * | 3.00E+03 * | 4.27E+03 * | 5.77E+03 * | 7.51E+03 * | 9.47E+03 * | 1.17E+04 * | 4.64E+04 * |
| Anthracene | 4.69E+00 | 2.99E+03 * | 3.91E+03 * | 9.29E+03 * | 1.86E+04 * | 3.18E+04 * | 4.87E+04 * | 6.93E+04 * | 9.38E+04 * | 1.22E+05 * | 1.54E+05 * | 1.90E+05 * | 7.53E+05 * |
| Benzo(a)anthracene | 5.29E-05 | 3.64E-01 | 4.77E-01 | 1.13E+00 | 2.27E+00 | 3.87E+00 | 5.93E+00 | 8.44E+00 | 1.14E+01 | 1.48E+01 | 1.87E+01 * | 2.31E+01 * | 9.17E+01 * |
| Benzo(a)pyrene | 2.00E-04 | 4.58E+00 | 5.98E+00 | 1.42E+01 * | 2.85E+01 * | 4.86E+01 * | 7.44E+01 * | 1.06E+02 * | 1.43E+02 * | 1.86E+02 * | 2.35E+02 * | 2.90E+02 * | 1.15E+03 * |
| Benzo(b)fluoranthene | 5.29E-05 | 1.23E+00 | 1.61E+00 | 3.83E+00 | 7.69E+00 | 1.31E+01 * | 2.01E+01 * | 2.86E+01 * | 3.87E+01 * | 5.03E+01 * | 6.35E+01 * | 7.82E+01 * | 3.11E+02 * |
| Benzo(g,h,i)perylene | 4.69E-01 | 2.90E+04 * | 3.79E+04 * | 9.00E+04 * | 1.80E+05 * | 3.08E+05 * | 4.71E+05 * | 6.71E+05 * | 9.08E+05 * | 1.18E+06 * | 1.49E+06 * | 1.84E+06 * | 7.29E+06 * |
| Benzo(k)fluoranthene | 7.85E-05 | 1.80E+00 | 2.35E+00 | 5.58E+00 * | 1.12E+01 * | 1.91E+01 * | 2.92E+01 * | 4.16E+01 * | 5.63E+01 * | 7.32E+01 * | 9.24E+01 * | 1.14E+02 * | 4.52E+02 * |
| Chrysene | 7.85E-04 | 5.52E+00 * | 7.22E+00 * | 1.71E+01 * | 3.44E+01 * | 5.86E+01 * | 8.98E+01 * | 1.28E+02 * | 1.73E+02 * | 2.25E+02 * | 2.84E+02 * | 3.50E+02 * | 1.39E+03 * |
| Fluoranthene | 6.26E-01 | 1.35E+03 * | 1.77E+03 * | 4.20E+03 * | 8.42E+03 * | 1.44E+04 * | 2.20E+04 * | 3.13E+04 * | 4.24E+04 * | 5.51E+04 * | 6.95E+04 * | 8.56E+04 * | 3.40E+05 * |
| Fluorene | 6.26E-01 | 2.24E+02 * | 2.92E+02 * | 6.94E+02 * | 1.39E+03 * | 2.37E+03 * | 3.64E+03 * | 5.18E+03 * | 7.00E+03 * | 9.11E+03 * | 1.15E+04 * | 1.42E+04 * | 5.63E+04 * |
| Naphthalene | 2.68E-04 | 1.63E-02 | 2.13E-02 | 5.05E-02 | 1.01E-01 | 1.73E-01 | 2.64E-01 | 3.77E-01 | 5.09E-01 | 6.63E-01 | 8.36E-01 | 1.03E+00 | 4.09E+00 |
| Phenanthrene | 4.69E-01 | 2.58E+02 * | 3.38E+02 * | 8.03E+02 * | 1.61E+03 * | 2.74E+03 * | 4.20E+03 * | 5.99E+03 * | 8.10E+03 * | 1.05E+04 * | 1.33E+04 * | 1.64E+04 * | 6.51E+04 * |
| Pyrene | 4.69E-01 | 9.94E+02 * | 1.30E+03 * | 3.09E+03 * | 6.19E+03 * | 1.05E+04 * | 1.62E+04 * | 2.30E+04 * | 3.11E+04 * | 4.05E+04 * | 5.11E+04 * | 6.30E+04 * | 2.50E+05 * |
| **TPH-GRO** | 3.45E+01 | 6.83E+03 * | 8.93E+03 * | 2.12E+04 * | 4.25E+04 * | 7.25E+04 * | 1.11E+05 * | 1.58E+05 * | 2.14E+05 * | 2.78E+05 * | 3.51E+05 * | 4.33E+05 * | 1.72E+06 * |
| Aliphatics - > C6-C8 | 3.32E+01 | 5.52E+03 * | 7.21E+03 * | 1.71E+04 * | 3.43E+04 * | 5.86E+04 * | 8.97E+04 * | 1.28E+05 * | 1.73E+05 * | 2.25E+05 * | 2.84E+05 * | 3.49E+05 * | 1.39E+06 * |
| Aliphatics - > C8-C10 | 1.04E+00 | 1.30E+03 * | 1.70E+03 * | 4.03E+03 * | 8.08E+03 * | 1.38E+04 * | 2.11E+04 * | 3.01E+04 * | 4.07E+04 * | 5.29E+04 * | 6.67E+04 * | 8.22E+04 * | 3.27E+05 * |
| Aromatics - >C8-C10 | 3.13E-01 | 1.95E+01 | 2.55E+01 | 6.05E+01 | 1.21E+02 | 2.07E+02 | 3.17E+02 | 4.51E+02 | 6.10E+02 | 7.94E+02 | 1.00E+03 | 1.23E+03 * | 4.90E+03 * |
| **TPH-DRO** | 3.45E+01 | 7.69E+08 * | 1.01E+09 * | 2.39E+09 * | 4.79E+09 * | 8.17E+09 * | 1.25E+10 * | 1.78E+10 * | 2.41E+10 * | 3.13E+10 * | 3.96E+10 * | 4.87E+10 * | 1.94E+11 * |
| Aliphatics - >C10-C12 | 1.04E+00 | 1.02E+04 | 1.34E+04 | 3.17E+04 | 6.36E+04 | 1.08E+05 | 1.66E+05 | 2.37E+05 | 3.20E+05 | 4.16E+05 | 5.25E+05 | 6.47E+05 | 2.57E+06 |
| Aliphatics - >C12-C16 | 1.04E+00 | 2.04E+05 * | 2.66E+05 * | 6.32E+05 * | 1.27E+06 * | 2.16E+06 * | 3.31E+06 * | 4.72E+06 * | 6.38E+06 * | 8.30E+06 * | 1.05E+07 * | 1.29E+07 * | 5.13E+07 * |
| Aliphatics - >C16-C21 | 3.13E+01 | 7.69E+08 * | 1.01E+09 * | 2.39E+09 * | 4.79E+09 * | 8.16E+09 * | 1.25E+10 * | 1.78E+10 * | 2.41E+10 * | 3.13E+10 * | 3.95E+10 * | 4.87E+10 * | 1.94E+11 * |
| Aromatics - >C10-C12 | 3.13E-01 | 3.08E+01 | 4.02E+01 | 9.55E+01 | 1.92E+02 | 3.27E+02 | 5.00E+02 | 7.13E+02 * | 9.64E+02 * | 1.25E+03 * | 1.58E+03 * | 1.95E+03 * | 7.74E+03 * |
| Aromatics - >C12-C16 | 3.13E-01 | 6.12E+01 | 8.01E+01 | 1.90E+02 | 3.81E+02 * | 6.50E+02 * | 9.96E+02 * | 1.42E+03 * | 1.92E+03 * | 2.49E+03 * | 3.15E+03 * | 3.88E+03 * | 1.54E+04 * |
| Aromatics - >C16-C21 | 4.69E-01 | 2.90E+02 * | 3.79E+02 * | 9.00E+02 * | 1.81E+03 * | 3.08E+03 * | 4.72E+03 * | 6.72E+03 * | 9.08E+03 * | 1.18E+04 * | 1.49E+04 * | 1.84E+04 * | 7.30E+04 * |
| **TPH-ORO** | 3.18E+01 | 7.69E+08 * | 1.01E+09 * | 2.39E+09 * | 4.79E+09 * | 8.16E+09 * | 1.25E+10 * | 1.78E+10 * | 2.41E+10 * | 3.13E+10 * | 3.95E+10 * | 4.87E+10 * | 1.94E+11 * |
| Aliphatics - >C21-C35 | 3.13E+01 | 7.69E+08 | 1.01E+09 | 2.39E+09 | 4.79E+09 | 8.16E+09 | 1.25E+10 | 1.78E+10 | 2.41E+10 | 3.13E+10 | 3.95E+10 | 4.87E+10 | 1.94E+11 |
| Aromatics - >C21-C35 | 4.69E-01 | 2.30E+03 * | 3.01E+03 * | 7.15E+03 * | 1.43E+04 * | 2.44E+04 * | 3.74E+04 * | 5.33E+04 * | 7.21E+04 * | 9.38E+04 * | 1.18E+05 * | 1.46E+05 * | 5.79E+05 * |

**Notes:**

*: Calculated Tier 1 RBSLs for soil concentrations exceeded saturated soil concentration and calculated values are shown.

†: MCL, health advisory, or domestic water use Tier 1 RBSL for a resident (minimum of child and adult
Soil concentrations are presented on a dry weight basis

# FIGURES

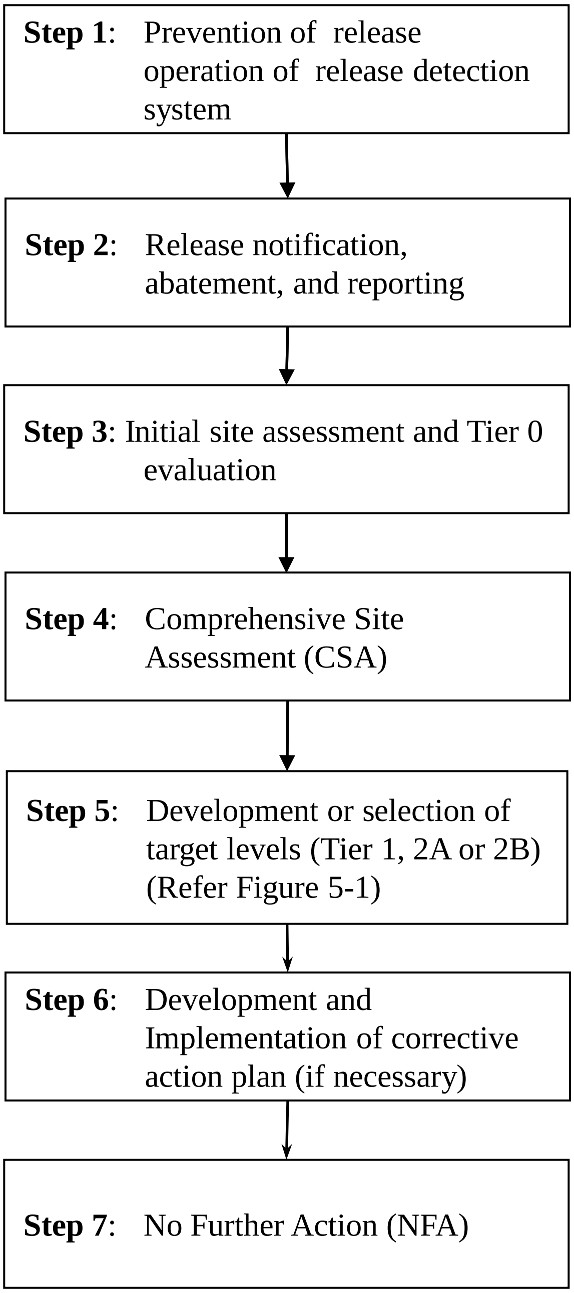


**Figure 2-1 Key Steps in DCRBCA Process**

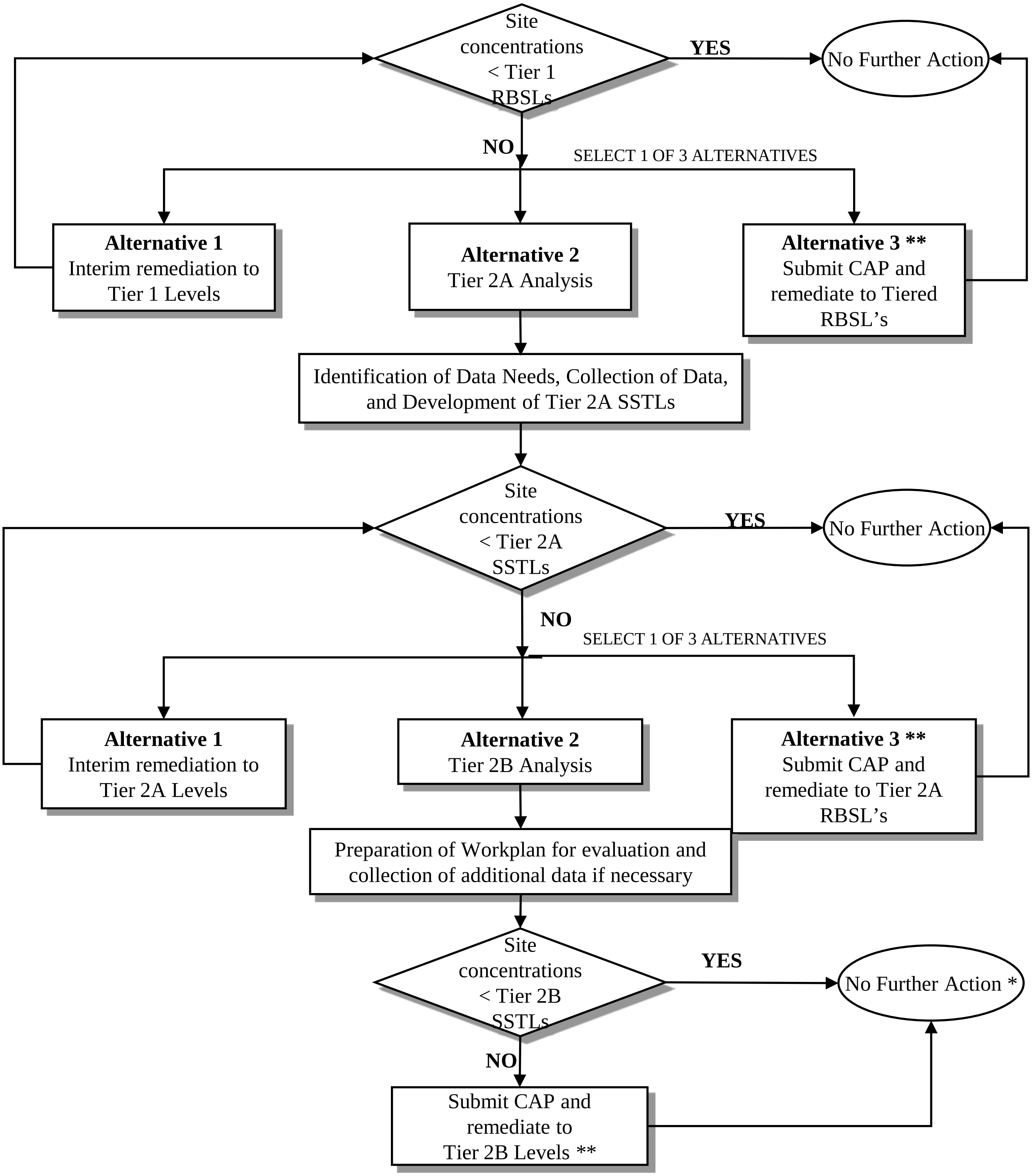


**Figure 5-1: SELECTION AND DEVELOPMENT OF TARGET LEVELS IN DCRBCA PROCESS**

* Additionally requires the Groundwater plume to be stable or decreasing, and no nuisance conditions

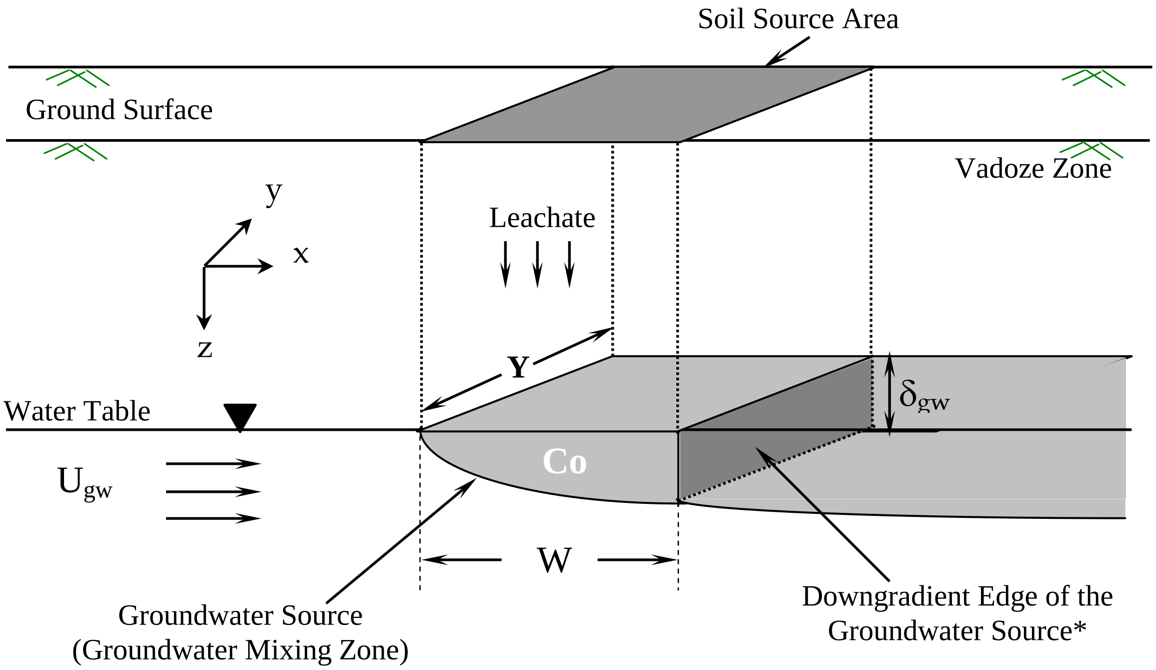
** Requires a corrective action plan

| CONTAMINATED MEDIA | PATHWAYS/TRANSPORT MECHANISMS | EXPOSURE ROUTES | POTENTIAL RECEPTORS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CURRENT LAND USE | | | | | | | | FUTURE LAND USE | | | | | | | |
| | | | ON-SITE | | | | OFF-SITE | | | | ON-SITE | | | | OFF-SITE | | | |
| | | | Residents-Child | Residents - Adult | Commercial Workers | Construction Workers | Residents-Child | Residents - Adult | Commercial Workers | Construction Workers | Residents-Child | Residents - Adult | Commercial Workers | Construction Workers | Residents-Child | Residents - Adult | Commercial Workers | Construction Workers |
| Air Vapors | | Inhalation (Indoors) | | | | NA | | | | NA | | | | NA | | | | NA |
| | | Inhalation (Outdoors)* | | | | | | | | | | | | | | | | |
| Surficial Soil | Wind Erosion/Dispersion/ Volatilization/Vapor Migration | Inhalation (vapors & particulates) and Dermal Contact and Ingestion | | | | | | | | | | | | | | | | |
| Subsurface Soils | Volatilization/Vapor Migration | Inhalation (Indoors) | | | | NA | | | | NA | | | | NA | | | | NA |
| | | Inhalation (Outdoors)* | | | | | | | | | | | | | | | | |
| | | Dermal Contact and Ingestion | NA | NA | NA | | NA | NA | NA | | NA | NA | NA | | NA | NA | NA | |
| Groundwater | Volatilization/Vapor Migration | Inhalation (Indoors) | | | | NA | | | | NA | | | | NA | | | | NA |
| | | Inhalation (Outdoors)* | | | | | | | | | | | | | | | | |
| | Drinking Water | Ingestion | | | | NA | | | | NA | | | | NA | | | | NA |

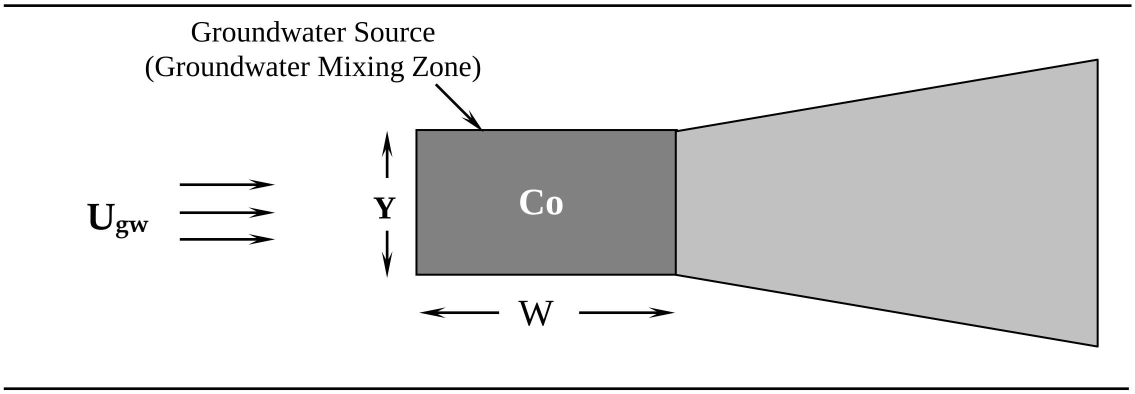
| | YES | NO |
|---|---|---|
| Contaminant-saturated soil present? | ☐ | ☐ |
| LNAPL phase liquid present? | ☐ | ☐ |
| Utilities Threatened? | ☐ | ☐ |
| Surface Waters within a 500 foot radius? | ☐ | ☐ |
| Ecological Receptors? | ☐ | ☐ |
| Potential Leaching to groundwater? | ☐ | ☐ |

C Indicates potentially completed pathways
NA Not applicable as per the DCRBDM policy
* Typically not a critical pathway

**Figure 5-2**
**Graphical Display of a Site Conceptual Exposure Scenario**
**(For Illustration Only)**



**SECTION**



**PLAN**

$U_{gw}$ = Groundwater velocity
$\delta_{gw}$ = Thickness of the mixing zone
$C_o$ = Source concentration

**Note:**
Assumes only vertical leaching, i.e., there is no horizontal spreading in the unsaturated zone.

Figure 5-3
Areal Dimensions of Soil Source

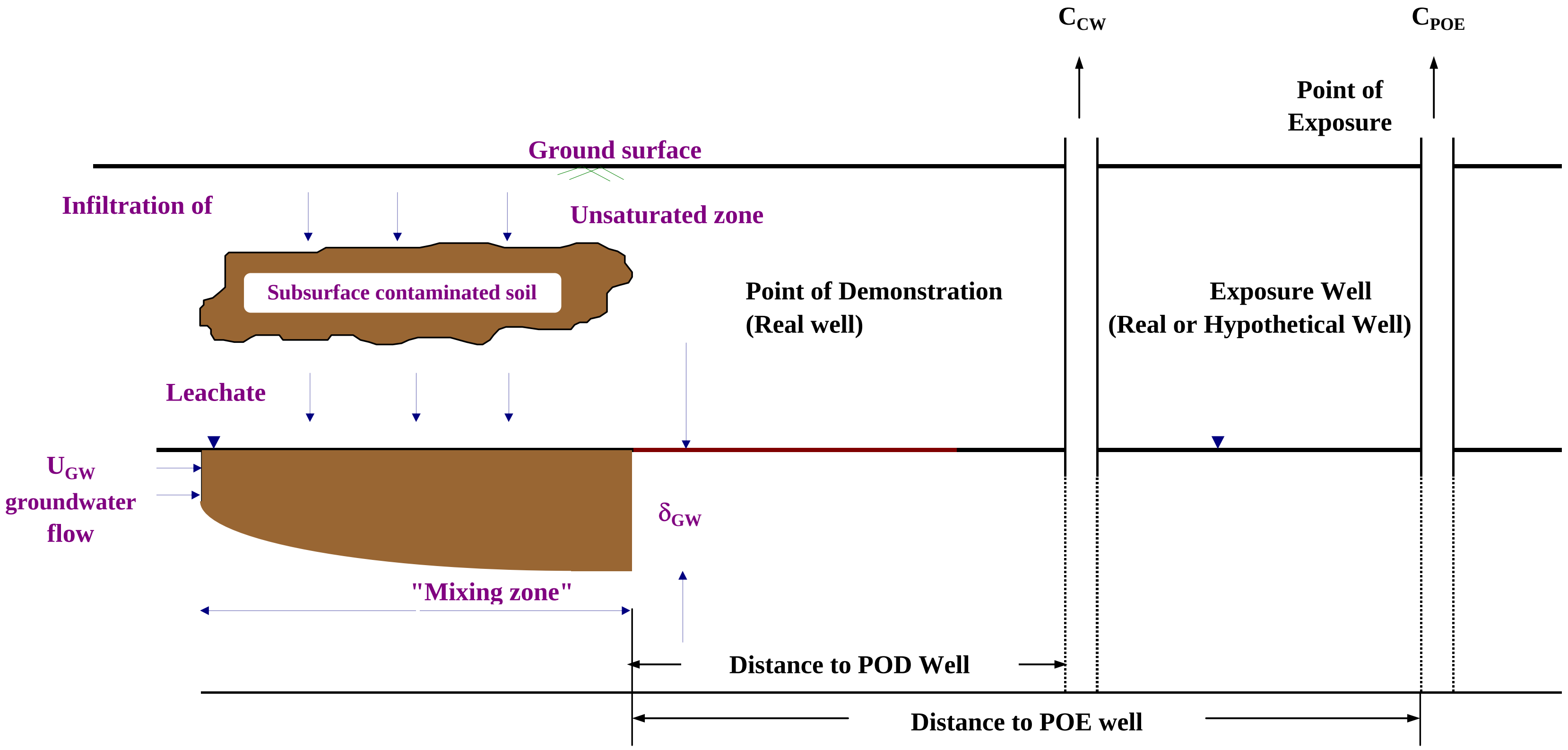


**Figure 5-4**
Schematic of the Source, Point of Demonstration Well, and Exposure Well

# APPENDIX A
# DCRBCA REPORT FORMS AND USER'S GUIDE FOR REPORT FORMS

TABLE OF CONTENTS

A.1 TIER 1 REPORT FORMS

A.2 TIER 2 REPORT FORMS

A.3 USER'S GUIDE FOR REPORT FORMS

# APPENDIX A.1
# TIER 1 REPORT FORMS

# Risk-Based Corrective Action For Petroleum Releases At Underground Storage Tank Sites

(DCRBCA TIER 1 REPORT FORMS)

June 2011

| | |
|---|---|
| FACILITY NAME: | |
| WARD NAME: | |
| LUST CASE NO.: | |
| FACILITY ID NO.: | |
| SUBMITTAL DATE: | |
| PREPARED BY: | |
| REVIEWED BY: | |

# DCRBCA REPORT

## TABLE OF CONTENTS *(Page 1 of 3)*

## TIER 1 FORMS

| **Form No.** | **Description** | **Check box if included** |
|---|---|---|
| 1. | Executive Summary | ☐ |
| 2. | Facility Information | ☐ |
| 3. | Site Classification Scenarios (Intentionally left blank) | ☐ |
| 4. | Site Description | ☐ |
| 5. | Land Use | ☐ |
| 6. | Chronology of Events | ☐ |
| 7. | Underground Storage Tank Type | ☐ |
| 8. | Release Characterization | ☐ |
| 9. | Free Product | ☐ |
| 10. | Site Stratigraphy and Hydrogeology | ☐ |
| 11. | Groundwater and Surface Water Use | ☐ |
| 12. | Analytical Data Summary for Surficial Soil | ☐ |
| 13. | Analytical Data Summary for Subsurface Soil | ☐ |
| 14. | Analytical Data Summary for Groundwater | ☐ |
| 15 | Natural Attenuation Parameters | ☐ |
| 16. | Site Conceptual Exposure Scenario | |
| | On-site Receptors | |
| | On-site Resident (Child and Adult) | ☐ |
| | On-site Commercial Worker | ☐ |
| | On-site Construction Worker | ☐ |
| | Off-site Receptors | |
| | Off-site Resident (Child and Adult) | ☐ |
| | Off-site Commercial Worker | ☐ |
| | Off-site Construction Worker | ☐ |
| 17. | Comparison of Tier 1 RBSLs with Representative Site Concentrations | ☐ |
| | On-site Receptors | ☐ |
| | On-site Resident Child | ☐ |
| | On-site Resident Adult | ☐ |
| | On-site Commercial Worker | ☐ |
| | On-site Construction Worker | ☐ |
| | Off-site Receptors | ☐ |
| | Off-site Resident Child | ☐ |
| | Off-site Resident Adult | ☐ |
| | Off-site Commercial Worker | ☐ |
| | Off-site Construction Worker | ☐ |

# DCRBCA REPORT

## TABLE OF CONTENTS *(Page 2 of 3)*

### TIER 1 FORMS (Continued)

| Form No. | Description | Check box if included |
|---|---|---|
| 18. | Tier 1 Groundwater Resource Protection Target Concentrations | ☐ |
| 19. | Tier 1 Stream Protection Target Concentrations | ☐ |
| 20. | Tier 1 Applicable Target Levels for Various Media | ☐ |
| 21. | Tier 1 Conclusions and Recommendations | ☐ |
| 22. | References and Protocols | ☐ |

### TIER 2A FORMS

| | | |
|---|---|---|
| 23. | Tier 2A Fate and Transport Parameters | ☐ |
| 24. | Justification for Changing Tier 2A Fate and Transport Parameters | ☐ |
| 25. | Tier 2A Exposure Factors | ☐ |
| 26. | Justification for Changing Tier 2A Exposure Factors | ☐ |
| 27. | Comparison of Tier 2A SSTLs with Representative Site Concentrations | |
| | On-site Receptors | |
| | On-site Resident Child | ☐ |
| | On-site Resident Adult | ☐ |
| | On-site Commercial Worker | ☐ |
| | On-site Construction Worker | ☐ |
| | Off-site Receptors | |
| | Off-site Resident Child | ☐ |
| | Off-site Resident Adult | ☐ |
| | Off-site Commercial Worker | ☐ |
| | Off-site Construction Worker | ☐ |
| 28. | Tier 2A Groundwater Resource Protection Target Concentrations | ☐ |
| 29. | Tier 2A Stream Protection Target Concentrations | ☐ |
| 30. | Tier 2A Applicable Target Levels for Various Media | ☐ |
| 31. | Tier 2A Conclusions and Recommendations | ☐ |

## DCRBCA REPORT

## TABLE OF CONTENTS *(Page 3 of 3)*

*All maps submitted to the Division must include a bar scale, legend, north arrow, location of all known soil boring and monitoring wells, and date of map, where appropriate.*

## ATTACHMENTS

| **Attachment No.** | **Description** | **Check box if included** |
|---|---|---|
| 1. | Topographic Map | ☐ |
| 2. | Site Map with Utility Locations | ☐ |
| 3. | Land Use Map (Radius of 500 feet) | ☐ |
| 4. | Area Map: with detailed land use in the vicinity of the site (at least 500 feet in the downgradient direction and one property deep on all other sides including across the street) | ☐ |
| 5. | Site Map with UST Location(s) | ☐ |
| 6. | Representative Soil Boring Logs: with monitoring well screen interval, size, and depth (also indicate sample depths, field screening results, and initial water level) | ☐ |
| 7. | Representative Soil Boring Logs: cross-section showing the stratigraphy of the site | ☐ |
| 8. | Area Geologic Map | ☐ |
| 9. | Area Map with Well Locations: within one-half mile radius of the site (the wells on the map must be labeled). Maps must also indicate the location of streams, lakes, etc., within a 500 foot radius of the site. | ☐ |
| 10. | Groundwater Gradient Map: contoured map with the predominant flow direction from the most recent sampling event (add multiple maps if the flow direction fluctuates) | ☐ |
| 11. | Soil and Groundwater Concentration Maps: for benzene, MTBE, total BTEX, and Total PAHs from the most recent sampling event | ☐ |
| 12. | Soil and Groundwater Contour Maps: for benzene, MTBE, total BTEX, and Total PAHs from the most recent sampling event | ☐ |
| 13. | Time vs. Concentration Trend Maps: for benzene, MTBE, and total BTEX if four or more sampling events have occurred per well | ☐ |
| 14. | Map Identifying Point(s) of Exposure: for both current and future conditions | ☐ |
| 15. | Historical Groundwater Analytical and Gauging Data | ☐ |
| 16. | Representative Concentrations | ☐ |

**OTHER ATTACHMENTS:**

**DCRBCA REPORT** **FORM NO. 1**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## EXECUTIVE SUMMARY

|  |  |
|---|---|
| Facility name: |  |
| Facility address: |  |
| Status of facility: | ☐ Active ☐ Inactive |
| Ground surface condition: |  |
| Estimated volume of product released: |  |
| Is native soil impacted? | ☐ On-site ☐ Off-site |
| Is groundwater impacted? | ☐ On-site ☐ Off-site |
| Has the source of release been identified? |  |
| Has free product ever been detected? | ☐ YES ☐ NO |
| Was free product removed? | ☐ YES ☐ NO |
| Was free product detected in the most recent sampling event? | ☐ YES ☐ NO |
| Has surface water been impacted by the release? | ☐ YES ☐ NO |
| Shallowest depth to groundwater: |  |
| Average depth to groundwater: |  |
| Has a drinking water supply well been impacted by this release? | ☐ YES ☐ NO ☐ UNKNOWN |

## RECOMMENDATIONS

| **TIER 1** | **TIER 2A** |
|---|---|
| ☐ No further action under Tier 1 | ☐ No further action under Tier 2A |
| ☐ Compliance Monitoring | ☐ Compliance Monitoring |
| ☐ Remediate to Tier 1 RBSLs to achieve no further action | ☐ Remediate to Tier 2A SSTLs to achieve no further action |
| ☐ Perform interim remedial action and then re-evaluate | ☐ Perform interim remedial action and then re-evaluate |
| ☐ Perform Tier 2A Evaluation | ☐ Perform Tier 2B Evaluation |

## ADDITIONAL NOTES

**Recommended attachments**: None.

**DCRBCA REPORT** **FORM NO. 2**

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## FACILITY INFORMATION

Facility name:

Facility address:

Facility phone number:

Tank owner:

Tank owner's address:

Tank owner's phone number:

Property owner:

Property owner's address:

Property owner's phone number:

## REPORT PREPARED BY

*I certify that the DCRBCA evaluation as stated in this report was prepared under my supervision. I am experienced in the concepts and procedures of risk assessment and risk management as they relate to the DCRBCA evaluation.*

| | |
|---|---|
| *DCRBCA Evaluator* | *Date* |
| *Printed Name* | *Company Name and Telephone Number* |

## ADDITIONAL NOTES

**Recommended attachments**: Topographic map

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 3** |

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## SITE CLASSIFICATION SCENARIOS

***Intentionally left blank***

**DCRBCA REPORT** **FORM NO. 4**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## SITE DESCRIPTION

**Site Status:**

☐ Operating as a gasoline station

☐ Not operating, with tanks in place

☐ Temporarily out of service from to

☐ Permanently out of service. Tanks permanently closed in Currently site used as

**Ground Surface Condition:**

☐ Unpaved

☐ Paved % area paved Materials

Any visible cracks in the pavement? ☐ YES ☐ NO

**Subsurface Utilities:**

In the space provided for additional notes, please indicate the location and distance to the nearest utility access point (manhole).

Have the utilities been screened for vapor levels? ☐ YES ☐ NO If YES, attach documentation of vapor monitoring results.

In the space provided for additional notes, please indicate the location of the nearest sump and dewatering well.

*Indicate which of the following utilities currently act as conduits or are potentially liable to become conduits under the columns entitled "Impacted by release," and "Potentially Impacted by Release," respectively.*

| | **Depth [feet]** | **Type of material** | **Flow direction** | **Impacted by release** | **Potentially impacted by release** |
|---|---|---|---|---|---|
| ☐ Sanitary sewer | | | | | |
| ☐ Covered storm sewer | | | | | |
| ☐ Open ditch | | | | | |
| ☐ Water line | | | | | |
| ☐ Gas line | | | | | |
| ☐ Electric line | | | | | |
| ☐ Telephone line | | | | | |

**Current Status of Excavated Soil:**

*If any USTs or ASTs were over-excavated, discuss the status of the excavated soil.*

| | **Date** | **Quantity** | **Location** |
|---|---|---|---|
| ☐ Stockpiled On-site | | | |
| ☐ Disposed Off-site | | | |
| ☐ Used (as fill material, etc.) On-site | | | |
| ☐ Used as Road Base | | | |
| ☐ Land Farm | | | |
| ☐ Stockpiled Off-site | | | |

## ADDITIONAL NOTES

**Recommended attachments**: Site map with locations of utilities and USTs.

**DCRBCA REPORT** **FORM NO. 5**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## LAND USE

| **Current On-site Land Use** | **Current** | **Future On-site Land Use** | **Future** |
|---|---|---|---|
| Residential | ☐ | Residential | ☐ |
| Commercial | ☐ | Commercial | ☐ |
| Industrial | ☐ | Industrial | ☐ |
| Other | ☐ | Other | ☐ |

**Comments**: *Justify the choice for future land use.*

Immediate Off-site Land Use (within 1,000 feet - at a minimum, state whether residential, agricultural, commercial, or sensitive)

North:
Northeast:
Northwest:
South:
Southeast:
Southwest:
West:
East:

## ADDITIONAL RECEPTOR SURVEY

*List the distance and direction (downgradient, upgradient, or crossgradient) to these facilities (generally 1 mile radius is sufficient).*

| | **Distance (feet)** | **Direction** |
|---|---|---|
| Nearest residential site: | | |
| Nearest commercial site: | | |
| Nearest industrial site: | | |
| If site vacant, nearest inhabited building: | | |
| Nearest ecologically sensitive area: | | |
| Nearest school, hospital, day care, retirement home, etc.: | | |

## ADDITIONAL NOTES

**Recommended attachments**: Land use map (1,000 foot radius), Area map - with detailed land use in the vicinity of the site.

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 6** |

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## CHRONOLOGY OF EVENTS

| ***Date*** | ***Instructions*:** *Describe site activities related to spill events, including location, type, and estimated volume of materials stored or released, tank pulls, time and duration of release, and affected media (e.g. soil, groundwater, etc.). Describe monitoring well installation, soil boring activities, and slug tests. Also discuss past corrective action efforts as appropriate. (Use additional sheets as necessary)* |
|---|---|
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**Page 1 of**

**Recommended attachments**: None.

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 6** |

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## CHRONOLOGY OF EVENTS

| | |
|---|---|
| ***Date*** | ***Instructions :*** *Describe site activities related to spill events, including location, type, and estimated volume of materials stored or released, tank pulls, time and duration of release, and affected media (e.g. soil, groundwater, etc.). Describe monitoring well installation, soil boring activities, and slug tests. Also discuss past corrective action efforts as appropriate. (Use additional sheets as necessary)* |
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**Recommended attachments**: None.

**DCRBCA REPORT** **FORM NO. 6**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## CHRONOLOGY OF EVENTS

| | |
|---|---|
| ***Date*** | ***Instructions*** **:** *Describe site activities related to spill events, including location, type, and estimated volume of materials stored or released, tank pulls, time and duration of release, and affected media (e.g. soil, groundwater, etc.). Describe monitoring well installation, soil boring activities, and slug tests. Also discuss past corrective action efforts as appropriate. (Use additional sheets as necessary)* |
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**Recommended attachments**: None.

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 6** |

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## CHRONOLOGY OF EVENTS

| ***Date*** | ***Instructions :*** *Describe site activities related to spill events, including location, type, and estimated volume of materials stored or released, tank pulls, time and duration of release, and affected media (e.g. soil, groundwater, etc.). Describe monitoring well installation, soil boring activities, and slug tests. Also discuss past corrective action efforts as appropriate. (Use additional sheets as necessary)* |
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**Recommended attachments** : None.

**DCRBCA REPORT** **FORM NO. 6**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## CHRONOLOGY OF EVENTS

| | |
|---|---|
| ***Date*** | ***Instructions*** **:** *Describe site activities related to spill events, including location, type, and estimated volume of materials stored or released, tank pulls, time and duration of release, and affected media (e.g. soil, groundwater, etc.). Describe monitoring well installation, soil boring activities, and slug tests. Also discuss past corrective action efforts as appropriate. (Use additional sheets as necessary)* |
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**Recommended attachments** : None.

**DCRBCA REPORT** **FORM NO. 7**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## UNDERGROUND STORAGE TANK TYPE

*Provide the installation dates for all tanks and removal dates for inactive tanks. A site map denoting Tank Number(s) is required.*

| Tank Number(s) | Product | Capacity | Active | | Installation Date | Removal Date | Closure in Place Date | Temporarily Out of Use Since |
|---|---|---|---|---|---|---|---|---|
| | | | Yes | No | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |
| | | | ☐ | ☐ | | | | |

## ADDITIONAL NOTES

**Recommended attachments**: A site map with tank location(s).

**DCRBCA REPORT** **FORM NO. 8**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## RELEASE CHARACTERIZATION

*Release discovered during/by:*

☐ UST Removal
☐ Failed System Tightness Test
☐ Inventory Control
☐ Facility Remodeling/Construction Activity
☐ Unknown
☐ Other (specify)

☐ Closure in Place
☐ Environmental Assessment
☐ Citizen Complaint
☐ Known Spill Incident

### SOURCE(S) OF RELEASE

☐ Spills/Overfills
☐ Piping
☐ Dispenser Islands
☐ Tanks
☐ Unknown
☐ Other (specify)

### SUBSTANCE(S) RELEASED

☐ Gasoline
☐ Diesel
☐ Used Oil
☐ AV Gas
☐ Jet Fuel
☐ Hydraulic Fluid
☐ Kerosene
☐ Other (specify)

## SUMMARY OF SPILL

| | | | |
|---|---|---|---|
| Has the source of release been identified? | ☐ YES | ☐ NO | |
| Has the release been abated? | ☐ YES | ☐ NO | |
| Is native soil impacted? | ☐ YES | ☐ NO | |
| Is groundwater impacted? | ☐ YES | ☐ NO | |
| Is surface water impacted? | ☐ YES | ☐ NO | |

## DETAILS OF KNOWN SPILLS (if any)

| **Date Released** | **Location** | **Quantity/Type** |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

## ADDITIONAL NOTES

**Recommended attachments**: None.

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 9** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## FREE PRODUCT

Has free product been found at the site? ☐ YES ☐ NO

*(Note if NO, proceed to the next report form)*

Date free product was released (if known):

Type of free product released:

Estimated quantity of free product released:

Number of monitoring wells currently at the site:

List the monitoring wells historically containing free product:

List the monitoring wells currently containing free product:

Specify the well ID maximum thickness:

Well ID: Feet; Date:

## RECOMMENDATIONS

Has free product removal been initiated? ☐ YES ☐ NO

If YES, specify method of removal (bailer, pump, etc.)?

If NO, cite reason:

Frequency of removal (weekly, monthly, etc.):

Total number of recovery events to date:

Total amount of purge-water recovered:

Total amount of free product recovered:

Date of latest free product report submittal:

## ADDITIONAL NOTES

**Recommended attachments**: Free product thickness maps as appropriate.

**DCRBCA REPORT** **FORM NO. 10**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## SITE STRATIGRAPHY AND HYDROGEOLOGY

### STRATIGRAPHY OF THE SITE

| **Depth** [feet] | **Unified Soil Classification** | **Type of Soil** |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

Predominant soil type:

| **Depth**<br>[feet] | **Type of Bedrock & Geological Formation**<br>(discuss rock properties and features) |
|---|---|
| | |
| | |
| | |
| | |
| | |

### HYDROGEOLOGY OF THE SATURATED IMPACTED ZONE

Type of aquifer? ☐ Confined ☐ Unconfined ☐ Perched

Underlying predominant aquifer name:

Aquifer classification (if applicable):

Range of groundwater level fluctuations [ft bgs]:

Average depth to water table/static water level:

Flow direction:

Hydraulic gradient (i) [--]:

Hydraulic conductivity (K) [cm/year]:

Hydraulic conductivity test method (Select from below):

☐ Grain size/Sieve analysis ☐ Slug test ☑ Pump test Duration (hrs):

☐ Other (*specify and attach literature* )

Darcy velocity (K x i) [cm/year - calculated]:

Annual precipitation (average for last 30 years) [inches/year]:

### VADOSE ZONE CHARACTERISTICS

| | **Values/Range** | | | **Method** |
|---|---|---|---|---|
| Dry bulk density [g/cm$^3$] | | ☐ Estimated | ☐ Measured | |
| Estimated porosity (θ) [cm$^3$/cm$^3$]: | | ☐ Estimated | ☐ Measured | |
| Water content [cm$^3$/cm$^3$]: | | ☐ Estimated | ☐ Measured | |
| Fractional organic carbon content [g-C/g-soil]: | | ☐ Estimated | ☐ Measured | |

### ADDITIONAL NOTES

**Recommended attachments**: Area geologic map/relevant cross-sections and soil boring logs.

**DCRBCA REPORT** **FORM NO. 11**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## GROUNDWATER USE

### Current

| | YES | NO | IN USE | NOT USED |
|---|---|---|---|---|
| Potable domestic water use: | ☐ | ☐ | ☐ | ☐ |
| Non-potable water use: | ☐ | ☐ | ☐ | ☐ |
| Public/Municipal supply: | ☐ | ☐ | ☐ | ☐ |
| Industrial supply: | ☐ | ☐ | ☐ | ☐ |
| Agriculture: | ☐ | ☐ | ☐ | ☐ |
| Other (explain in Notes): | ☐ | ☐ | ☐ | ☐ |

### Future

| | YES | NO |
|---|---|---|
| Potable domestic water use: | ☐ | ☐ |
| Non-potable water use: | ☐ | ☐ |
| Public/Municipal supply: | ☐ | ☐ |
| Industrial supply: | ☐ | ☐ |
| Agriculture: | ☐ | ☐ |
| Other (explain in Notes): | ☐ | ☐ |

## NOTES (Justify choice for future use)

## SURFACEWATER USE

### Current

| | YES | NO | IN USE | NOT USED |
|---|---|---|---|---|
| Potable domestic water use: | ☐ | ☐ | ☐ | ☐ |
| Non-potable water use: | ☐ | ☐ | ☐ | ☐ |
| Public/Municipal supply: | ☐ | ☐ | ☐ | ☐ |
| Industrial supply: | ☐ | ☐ | ☐ | ☐ |
| Agriculture: | ☐ | ☐ | ☐ | ☐ |
| Other (explain in Notes): | ☐ | ☐ | ☐ | ☐ |

### Future

| | YES | NO |
|---|---|---|
| Potable domestic water use: | ☐ | ☐ |
| Non-potable water use: | ☐ | ☐ |
| Public/Municipal supply: | ☐ | ☐ |
| Industrial supply: | ☐ | ☐ |
| Agriculture: | ☐ | ☐ |
| Other (explain in Notes): | ☐ | ☐ |

## NOTES (Justify choice for future use)

## ECOLOGICAL RECEPTORS AND HABITATS

| | | YES | NO |
|---|---|---|---|
| 1. | Are there any ecological receptors or habitats present within a 1000 foot radius from the facility? | ☐ | ☐ |
| 2. | Is there a complete pathway at the site for an ecological impact beyond what is considered under the surface water impacts evaluation? | ☐ | ☐ |
| 3. | Are there visible indications of stressed receptors or habitats on or near the site that may be a result of a chemical release? | ☐ | ☐ |
| | Other (explain in Notes): | ☐ | ☐ |

***If the answer to questions 2 & 3 is YES, contact the Division before proceeding any further.***

## ADDITIONAL NOTES

**Recommended attachments**: Area map with well locations within a one-half mile radius of the site.

**DCRBCA REPORT** **FORM NO. 12**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## ANALYTICAL DATA SUMMARY FOR SURFICIAL SOIL

| **MW / SB No.** | | | | | | | | | | | | | **Arithmetic Average** | **Maximum** | **Ratio (Maximum/ Arithmetic Average) *** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sampling Date** | | | | | | | | | | | | | | | |
| **Sample Depth (ft)** | | | | | | | | | | | | | | | |
| **ORGANIC CHEMICALS** | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | |

**NOTE:**

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**Non-detects can be expressed as ND, BDL, etc. All concentrations in mg/kg.**

*** : If the ratio is high (for example >10) there may be a hot spot and additional investigation/evaluation is warranted. In such circumstances, contact the Division.**

**Page 1 of**

**Recommended Attachments:** Site map showing location(s) of surficial soil sample(s), and chemical concentration maps.

## DCRBCA REPORT

**FORM NO. 12**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## ANALYTICAL DATA SUMMARY FOR SURFICIAL SOIL

| **MW / SB No.** | | | | | | | | | | | | | **Arithmetic Average** | **Maximum** | **Ratio (Maximum/ Arithmetic Average) *** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sampling Date** | | | | | | | | | | | | | | | |
| **Sample Depth (ft)** | | | | | | | | | | | | | | | |
| **ORGANIC CHEMICALS** | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | |

**NOTE:**

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**Non-detects can be expressed as ND, BDL, etc. All concentrations in mg/kg.**

*** : If the ratio is high (for example >10) there may be a hot spot and additional investigation/evaluation is warranted. In such circumstances, contact the Division.**

**Recommended Attachments:** Site map showing location(s) of surficial soil sample(s), and chemical concentration maps.

# DCRBCA REPORT

**FORM NO. 13**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## ANALYTICAL DATA SUMMARY FOR SUBSURFACE SOIL

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MW / SB No.** | | | | | | | | | | | | | | | | | | | **Arithmetic Average** | **Maximum** | **Ratio (Maximum/ Arithmetic Average) *** |
| **Sampling Date** | | | | | | | | | | | | | | | | | | | | | |
| **Sample Depth (ft)** | | | | | | | | | | | | | | | | | | | | | |
| **ORGANIC CHEMICALS** | | | | | | | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | | | | | | | |

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**Recommended Attachments**: Site map showing location(s) of sub-surface soil sample(s), and chemical concentration maps.

**DCRBCA REPORT** **FORM NO. 13**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## ANALYTICAL DATA SUMMARY FOR SUBSURFACE SOIL

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MW / SB No.** | | | | | | | | | | | | | | | | | | | **Arithmetic Average** | **Maximum** | **Ratio (Maximum/Arithmetic Average) *** |
| **Sampling Date** | | | | | | | | | | | | | | | | | | | | | |
| **Sample Depth (ft)** | | | | | | | | | | | | | | | | | | | | | |
| **ORGANIC CHEMICALS** | | | | | | | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | | | | | | | |

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**DCRBCA REPORT** **FORM NO. 13**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## ANALYTICAL DATA SUMMARY FOR SUBSURFACE SOIL

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MW / SB No.** | | | | | | | | | | | | | | | | | | | **Arithmetic Average** | **Maximum** | **Ratio (Maximum/Arithmetic Average) *** |
| **Sampling Date** | | | | | | | | | | | | | | | | | | | | | |
| **Sample Depth (ft)** | | | | | | | | | | | | | | | | | | | | | |
| **ORGANIC CHEMICALS** | | | | | | | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | | | | | | | |

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# DCRBCA REPORT

**FORM NO. 13**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## ANALYTICAL DATA SUMMARY FOR SUBSURFACE SOIL

| **MW / SB No.** | | | | | | | | | | | | | | | | | | | **Arithmetic Average** | **Maximum** | **Ratio (Maximum/Arithmetic Average) *** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sampling Date** | | | | | | | | | | | | | | | | | | | | | |
| **Sample Depth (ft)** | | | | | | | | | | | | | | | | | | | | | |
| **ORGANIC CHEMICALS** | | | | | | | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | | | | | | | |

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**Recommended Attachments**: Site map showing location(s) of sub-surface soil sample(s), and chemical concentration maps.

# DCRBCA REPORT

**FORM NO. 14**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## ANALYTICAL DATA SUMMARY FOR GROUNDWATER

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Number | | | | | | | | | | | | | |
| Screen Interval (feet below datum) | | | | | | | | | | | | | |
| Water Level (feet below datum) | | | | | | | | | | | | | |
| Installation Date | | | | | | | | | | | | | |
| Number of Times Sampled | | | | | | | | | | | | | |
| Benzene<br>MCL = 0.005 mg/L | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Toluene<br>MCL = 1.0 mg/L | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Ethylbenzene<br>MCL = 0.7 mg/L | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Xylenes<br>MCL = 10 mg/L | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |

**NOTE: Provide any laboratory analytical datasheets not previously submitted to the Division. Add additional sheets as needed.**
**For "Range", use historical data (i.e., all data), for "Maximum" and "Mean", use the past two (2) years of data.**

**Recommended Attachment**: Historical GW data and site map showing location(s) of monitoring well(s), and chemical concentration maps.

# DCRBCA REPORT

**FORM NO. 14**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## ANALYTICAL DATA SUMMARY FOR GROUNDWATER

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Number | | | | | | | | | | | | | |
| Screen Interval (feet below datum) | | | | | | | | | | | | | |
| Water Level (feet below datum) | | | | | | | | | | | | | |
| Installation Date | | | | | | | | | | | | | |
| Number of Times Sampled | | | | | | | | | | | | | |
| Benzene | No. of Detects | | | | | | | | | | | | |
| MCL = 0.005 mg/L | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Toluene | No. of Detects | | | | | | | | | | | | |
| MCL = 1.0 mg/L | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Ethylbenzene | No. of Detects | | | | | | | | | | | | |
| MCL = 0.7 mg/L | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Xylenes | No. of Detects | | | | | | | | | | | | |
| MCL = 10 mg/L | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |

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**For "Range", use historical data (i.e., all data), for "Maximum" and "Mean", use the past two (2) years of data.**

**Page 2 of**

**Recommended Attachment**: Historical GW data and site map showing location(s) of monitoring well(s), and chemical concentration maps.

# DCRBCA REPORT

**FORM NO. 14**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## ANALYTICAL DATA SUMMARY FOR GROUNDWATER

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Number | | | | | | | | | | | | | |
| Screen Interval (feet below datum) | | | | | | | | | | | | | |
| Water Level (feet below datum) | | | | | | | | | | | | | |
| Installation Date | | | | | | | | | | | | | |
| Number of Times Sampled | | | | | | | | | | | | | |
| Benzene<br>MCL = 0.005 mg/L | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Toluene<br>MCL = 1.0 mg/L | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Ethylbenzene<br>MCL = 0.7 mg/L | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Xylenes<br>MCL = 10 mg/L | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |

**NOTE: Provide any laboratory analytical datasheets not previously submitted to the Division. Add additional sheets as needed.**
**For "Range", use historical data (i.e., all data), for "Maximum" and "Mean", use the past two (2) years of data.**

**Recommended Attachment**: Historical GW data and site map showing location(s) of monitoring well(s), and chemical concentration maps.

**DCRBCA REPORT** **FORM NO. 14**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## ANALYTICAL DATA SUMMARY FOR GROUNDWATER

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Number | | | | | | | | | | | | | |
| Screen Interval (feet below datum) | | | | | | | | | | | | | |
| Water Level (feet below datum) | | | | | | | | | | | | | |
| Installation Date | | | | | | | | | | | | | |
| Number of Times Sampled | | | | | | | | | | | | | |
| MTBE | No. of Detects | | | | | | | | | | | | |
| MCL = NA | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Naphthalene | No. of Detects | | | | | | | | | | | | |
| MCL = NA | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | No. of Detects | | | | | | | | | | | | |
| MCL = NA | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | No. of Detects | | | | | | | | | | | | |
| MCL = 0.005 mg/L | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |

**NOTE: Provide any laboratory analytical datasheets not previously submitted to the Division. Add additional sheets as needed.**
**For "Range", use historical data (i.e., all data), for "Maximum" and "Mean", use the past two (2) years of data.**

**Recommended Attachment**: Historical GW data and site map showing location(s) of monitoring well(s), and chemical concentration maps.

| **DCRBCA REPORT** | **FORM NO. 14** |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## ANALYTICAL DATA SUMMARY FOR GROUNDWATER

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Number | | | | | | | | | | | | | |
| Screen Interval (feet below datum) | | | | | | | | | | | | | |
| Water Level (feet below datum) | | | | | | | | | | | | | |
| Installation Date | | | | | | | | | | | | | |
| Number of Times Sampled | | | | | | | | | | | | | |
| MTBE<br>MCL = NA | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Naphthalene<br>MCL = NA | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Ethylene dibromide (EDB)<br>MCL = NA | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Ethylene dichloride (EDC)<br>MCL = 0.005 mg/L | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |

**NOTE: Provide any laboratory analytical datasheets not previously submitted to the Division. Add additional sheets as needed.**

**For "Range", use historical data (i.e., all data), for "Maximum" and "Mean", use the past two (2) years of data.**

**Recommended Attachment**: Historical GW data and site map showing location(s) of monitoring well(s), and chemical concentration maps.

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 14** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## ANALYTICAL DATA SUMMARY FOR GROUNDWATER

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Number | | | | | | | | | | | | | |
| Screen Interval (feet below datum) | | | | | | | | | | | | | |
| Water Level (feet below datum) | | | | | | | | | | | | | |
| Installation Date | | | | | | | | | | | | | |
| Number of Times Sampled | | | | | | | | | | | | | |
| MTBE | No. of Detects | | | | | | | | | | | | |
| MCL = NA | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Naphthalene | No. of Detects | | | | | | | | | | | | |
| MCL = NA | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | No. of Detects | | | | | | | | | | | | |
| MCL = NA | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | No. of Detects | | | | | | | | | | | | |
| MCL = 0.005 mg/L | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |

**NOTE: Provide any laboratory analytical datasheets not previously submitted to the Division. Add additional sheets as needed.**

**For "Range", use historical data (i.e., all data), for "Maximum" and "Mean", use the past two (2) years of data.**

**Recommended Attachment**: Historical GW data and site map showing location(s) of monitoring well(s), and chemical concentration maps.

## DCRBCA REPORT

**FORM NO. 14**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

### ANALYTICAL DATA SUMMARY FOR GROUNDWATER

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Number | | | | | | | | | | | | | |
| Screen Interval (feet below datum) | | | | | | | | | | | | | |
| Water Level (feet below datum) | | | | | | | | | | | | | |
| Installation Date | | | | | | | | | | | | | |
| Number of Times Sampled | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TB | No. of Detects | | | | | | | | | | | | |
| MCL = NA | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Ethanol | No. of Detects | | | | | | | | | | | | |
| MCL = NA | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |

**NOTE: Provide any laboratory analytical datasheets not previously submitted to the Division. Add additional sheets as needed.**
**For "Range", use historical data (i.e., all data), for "Maximum" and "Mean", use the past two (2) years of data.**

**Recommended Attachment**: Historical GW data and site map showing location(s) of monitoring well(s), and chemical concentration maps.

**DCRBCA REPORT** **FORM NO. 14**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## ANALYTICAL DATA SUMMARY FOR GROUNDWATER

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Number | | | | | | | | | | | | | |
| Screen Interval (feet below datum) | | | | | | | | | | | | | |
| Water Level (feet below datum) | | | | | | | | | | | | | |
| Installation Date | | | | | | | | | | | | | |
| Number of Times Sampled | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TB | No. of Detects | | | | | | | | | | | | |
| MCL = NA | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Ethanol | No. of Detects | | | | | | | | | | | | |
| MCL = NA | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |

**NOTE: Provide any laboratory analytical datasheets not previously submitted to the Division. Add additional sheets as needed.**
**For "Range", use historical data (i.e., all data), for "Maximum" and "Mean", use the past two (2) years of data.**

**Recommended Attachment**: Historical GW data and site map showing location(s) of monitoring well(s), and chemical concentration maps.

# DCRBCA REPORT

**FORM NO. 14**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## ANALYTICAL DATA SUMMARY FOR GROUNDWATER

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Number | | | | | | | | | | | | | |
| Screen Interval (feet below datum) | | | | | | | | | | | | | |
| Water Level (feet below datum) | | | | | | | | | | | | | |
| Installation Date | | | | | | | | | | | | | |
| Number of Times Sampled | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | No. of Detects | | | | | | | | | | | | |
| MCL = NA | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| Ethanol | No. of Detects | | | | | | | | | | | | |
| MCL = NA | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |
| | No. of Detects | | | | | | | | | | | | |
| | Range (high - low) | | | | | | | | | | | | |
| | Maximum (mg/L) | | | | | | | | | | | | |
| | Mean (mg/L) | | | | | | | | | | | | |
| | Recent Trend | | | | | | | | | | | | |

**NOTE: Provide any laboratory analytical datasheets not previously submitted to the Division. Add additional sheets as needed.**

**For "Range", use historical data (i.e., all data), for "Maximum" and "Mean", use the past two (2) years of data.**

**Recommended Attachment**: Historical GW data and site map showing location(s) of monitoring well(s), and chemical concentration maps.

## DCRBCA REPORT

**FORM NO. 15**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

### NATURAL ATTENUATION PARAMETERS

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MW / SB No.** | | | | | | | | | | | | | | | |
| **Sampling Date** | | | | | | | | | | | | | | | |
| **PARAMETERS** | | | | | | | | | | | | | | | |
| Dissolved Oxygen | | | | | | | | | | | | | | | |
| Nitrate | | | | | | | | | | | | | | | |
| Sulfate | | | | | | | | | | | | | | | |
| Manganese | | | | | | | | | | | | | | | |
| Methane | | | | | | | | | | | | | | | |
| Ferrous Iron | | | | | | | | | | | | | | | |
| Carbon dioxide | | | | | | | | | | | | | | | |
| Oxidation Reduction Potential | | | | | | | | | | | | | | | |
| **OTHER PARAMETERS** | | | | | | | | | | | | | | | |
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**NOTE:**

**Provide any laboratory analytical datasheets not previously submitted to the Division.**
**Add additional sheets if data for more than 3 sampling events and 5 monitoring wells are available.**
**Non-detects can be expressed as ND, BDL, etc.**

**Page 1 of** ____

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**Recommended Attachment**: Site map showing location(s) of monitoring well(s), and chemical concentration maps.

# DCRBCA REPORT FORM NO. 15

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## NATURAL ATTENUATION PARAMETERS

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MW / SB No.** | | | | | | | | | | | | | | | |
| **Sampling Date** | | | | | | | | | | | | | | | |
| **PARAMETERS** | | | | | | | | | | | | | | | |
| Dissolved Oxygen | | | | | | | | | | | | | | | |
| Nitrate | | | | | | | | | | | | | | | |
| Sulfate | | | | | | | | | | | | | | | |
| Manganese | | | | | | | | | | | | | | | |
| Methane | | | | | | | | | | | | | | | |
| Ferrous Iron | | | | | | | | | | | | | | | |
| Carbon dioxide | | | | | | | | | | | | | | | |
| Oxidation Reduction Potential | | | | | | | | | | | | | | | |
| **OTHER PARAMETERS** | | | | | | | | | | | | | | | |
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**NOTE:**

**Provide any laboratory analytical datasheets not previously submitted to the Division. Add additional sheets as needed.**

**Add additional sheets if data for more than 3 sampling events and 5 monitoring wells are available.**

**Non-detects can be expressed as ND, BDL, etc.**

**Page 2 of**

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**Recommended Attachment**: Site map showing location(s) of monitoring well(s), and chemical concentration maps.

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 16 - RESIDENT** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## SITE CONCEPTUAL EXPOSURE SCENARIO - ON-SITE RESIDENT (CHILD AND ADULT)

| ROUTES OF EXPOSURE | CURRENT CONDITIONS | | FUTURE CONDITIONS | |
|---|---|---|---|---|
| | C/ NC* | JUSTIFICATION | C/ NC* | JUSTIFICATION |
| **SURFICIAL SOIL** | | | | |
| Outdoor inhalation of vapors and particulate matter, ingestion, and dermal contact | | | | |
| **SUBSURFACE SOIL** | | | | |
| Indoor inhalation of vapors | | | | |
| **GROUNDWATER** | | | | |
| Indoor inhalation of vapors | | | | |
| Dermal contact | | | | |
| Ingestion of groundwater and inhalation of vapors from indoor water use (It is assumed water is supplied by on-site water supply well) | | | | |

**NOTE:**

*** C** : Complete Pathway, **NC** : Not Complete

**Recommended Attachment**: Map identifying all points of exposure (for both current and future conditions).

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 16-COMMERCIAL WORKER** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## SITE CONCEPTUAL EXPOSURE SCENARIO - ON-SITE COMMERCIAL WORKER

| **ROUTES OF EXPOSURE** | **CURRENT CONDITIONS** | | **FUTURE CONDITIONS** | |
|---|---|---|---|---|
| | **C/ NC*** | **JUSTIFICATION** | **C/ NC*** | **JUSTIFICATION** |
| **SURFICIAL SOIL** | | | | |
| Outdoor inhalation of vapors and particulate matter, ingestion, and dermal contact | | | | |
| **SUBSURFACE SOIL** | | | | |
| Indoor inhalation of vapors | | | | |
| **GROUNDWATER** | | | | |
| Indoor inhalation of vapors | | | | |
| Dermal contact | | | | |
| Ingestion of groundwater from an on-site water supply well | | | | |

**NOTE:**
*** C** : Complete Pathway, **NC** : Not Complete

**Recommended Attachment**: Map identifying all points of exposure (for both current and future conditions).

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 16-CONSTRUCTION WORKER** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## SITE CONCEPTUAL EXPOSURE SCENARIO - ON-SITE CONSTRUCTION WORKER

| **ROUTES OF EXPOSURE** | **CURRENT CONDITIONS** | | **FUTURE CONDITIONS** | |
|---|---|---|---|---|
| | **C/ NC*** | **JUSTIFICATION** | **C/ NC*** | **JUSTIFICATION** |
| **SOIL TO TYPICAL DEPTH OF CONSTRUCTION** | | | | |
| Outdoor inhalation of vapors and particulate matter, ingestion, and dermal contact | *C* | | *C* | |
| **GROUNDWATER** | | | | |
| Dermal contact | *C* | | *C* | |
| Outdoor inhalation of vapors | ***Not Applicable*** | | | |
| Ingestion of groundwater from an on-site water supply well | ***Not Applicable*** | | | |

**NOTE:**

*** C** : Complete Pathway, **NC** : Not Complete

**Recommended Attachment**: Map identifying all points of exposure (for both current and future conditions).

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 16 - RESIDENT** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## SITE CONCEPTUAL EXPOSURE SCENARIO - OFF-SITE RESIDENT (CHILD AND ADULT)

| ROUTES OF EXPOSURE | CURRENT CONDITIONS | | FUTURE CONDITIONS | |
|---|---|---|---|---|
| | C/ NC* | JUSTIFICATION | C/ NC* | JUSTIFICATION |
| **SURFICIAL SOIL** | | | | |
| Outdoor inhalation of vapors and particulate matter, ingestion, and dermal contact | | | | |
| **SUBSURFACE SOIL** | | | | |
| Indoor inhalation of vapors | | | | |
| **GROUNDWATER** | | | | |
| Indoor inhalation of vapors | | | | |
| Dermal contact | | | | |
| Ingestion of groundwater and inhalation of vapors from indoor water use (It is assumed water is supplied by on-site water supply well) | | | | |

**NOTE:**
*** C** : Complete Pathway, **NC** : Not Complete

**Recommended Attachment**: Map identifying all points of exposure (for both current and future conditions).

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 16-COMMERCIAL WORKER** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## SITE CONCEPTUAL EXPOSURE SCENARIO - OFF-SITE COMMERCIAL WORKER

| **ROUTES OF EXPOSURE** | **CURRENT CONDITIONS** | | **FUTURE CONDITIONS** | |
|---|---|---|---|---|
| | **C/ NC*** | **JUSTIFICATION** | **C/ NC*** | **JUSTIFICATION** |
| **SURFICIAL SOIL** | | | | |
| Outdoor inhalation of vapors and particulate matter, ingestion, and dermal contact | | | | |
| **SUBSURFACE SOIL** | | | | |
| Indoor inhalation of vapors | | | | |
| **GROUNDWATER** | | | | |
| Indoor inhalation of vapors | | | | |
| Dermal contact | | | | |
| Ingestion of groundwater from an off-site water supply well | | | | |

**NOTE:**

*** C** : Complete Pathway, **NC** : Not Complete

**Recommended Attachment**: Map identifying all points of exposure (for both current and future conditions).

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 16-CONSTRUCTION WORKER** |

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## SITE CONCEPTUAL EXPOSURE SCENARIO - OFF-SITE CONSTRUCTION WORKER

| **ROUTES OF EXPOSURE** | **CURRENT CONDITIONS** | | **FUTURE CONDITIONS** | |
|---|---|---|---|---|
| | **C/ NC*** | **JUSTIFICATION** | **C/ NC*** | **JUSTIFICATION** |
| **SOIL TO TYPICAL DEPTH OF CONSTRUCTION** | | | | |
| Outdoor inhalation of vapors and particulate matter, ingestion, and dermal contact | *C* | | *C* | |
| **GROUNDWATER** | | | | |
| Dermal contact | *C* | | *C* | |
| Outdoor inhalation of vapors | ***Not Applicable*** | | | |
| Ingestion of groundwater from an off-site water supply well | ***Not Applicable*** | | | |

**NOTE:**

*** C** : Complete Pathway, **NC** : Not Complete

**Recommended Attachment**: Map identifying all points of exposure (for both current and future conditions).

**DCRBCA REPORT** **FORM NO. 17 - RESIDENT CHILD**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## COMPARISON OF TIER 1 RBSLs WITH REPRESENTATIVE CONCENTRATIONS - ON-SITE RESIDENT CHILD

| **CHEMICALS OF CONCERN** | **SURFICIAL SOIL** | | | **SUB-SURFACE SOIL** | | | **GROUNDWATER** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors anc particulate matter, and dermal contact | | | Indoor inhalation of vapors | | | Indoor inhalation of vapors | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | **E/NE** | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | **E/NE** | Rep. Conc. [mg/L] | RBSLs [mg/L] | **E/NE** | Rep. Conc. [mg/L] | RBSLs [mg/L] | **E/NE** |
| **ORGANICS** | For Rep. Conc., refer Attachment 16, Table xx | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum
☐ Arithmetic Average
☐ Other

**NA**: Not Applicable
**E**: Representative on-site concentration exceeds Tier 1 RBSL
**NE**: Representative on-site concentration does not exceed Tier 1 RBSL

*****: Calculated RBSL exceeded saturated soil concentration and calcualted RBSL is shown.
**#**: Calculated RBSL exceeded pure component water solubility and calculated RBSL is shown.

**Recommended Attachment**: Representative concentrations.

**DCRBCA REPORT** **FORM NO. 17 - RESIDENT ADULT**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## COMPARISON OF TIER 1 RBSLs WITH REPRESENTATIVE CONCENTRATIONS - ON-SITE RESIDENT ADULT

| **CHEMICALS OF CONCERN** | **SURFICIAL SOIL** | | | **SUB-SURFACE SOIL** | | | **GROUNDWATER** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Indoor inhalation of vapors | | | Indoor inhalation of vapors | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | **E/NE** | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | **E/NE** | Rep. Conc. [mg/L] | RBSLs [mg/L] | **E/NE** | Rep. Conc. [mg/L] | RBSLs [mg/L] | **E/NE** |
| **ORGANICS** | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum

☐ Arithmetic Average

☐ Other

**NA**: Not Applicable

**E**: Representative on-site concentration exceeds Tier 1 RBSl

**NE**: Representative on-site concentration does not exceed Tier 1 RBSl

***:** Calculated RBSL exceeded saturated soil concentration and calcualted RBSL is shown.

**#:** Calculated RBSL exceeded pure component water solubility and calculated RBSL is shown.

**Recommended Attachment**: Representative concentrations

**DCRBCA REPORT** **FORM NO. 17 - COMMERCIAL WORKER**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## COMPARISON OF TIER 1 RBSLs WITH REPRESENTATIVE CONCENTRATIONS - ON-SITE COMMERCIAL WORKER

| CHEMICALS OF CONCERN | SURFICIAL SOIL | | | SUB-SURFACE SOIL | | | GROUNDWATER | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Indoor inhalation of vapors | | | Indoor inhalation of vapors | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | E/NE | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | E/NE | Rep. Conc. [mg/L] | RBSLs [mg/L] | E/NE | Rep. Conc. [mg/L] | RBSLs [mg/L] | E/NE |
| **ORGANICS** | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum
☐ Arithmetic Average
☐ Other

**NA**: Not Applicable
**E**: Representative on-site concentration exceeds Tier 1 RBSI
**NE**: Representative on-site concentration does not exceed Tier 1 RBSI

***:** Calculated RBSL exceeded saturated soil concentration and calcualted RBSL is shown.
**#:** Calculated RBSL exceeded pure component water solubility and calculated RBSL is shown.

**Page 3 of**

**Recommended Attachment**: Representative concentrations

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 17 - CONSTRUCTION WORKER** |

| | | |
|---|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** | |
| **SUBMITTAL DATE:** | **PREPARED BY:** | |

## COMPARISON OF TIER 1 RBSLs WITH REPRESENTATIVE CONCENTRATIONS - ON-SITE CONSTRUCTION WORKER

| **CHEMICALS OF CONCERN** | **SOIL TO TYPICAL DEPTH OF CONST.** | | | | | |
|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | **C** | Dermal contact | | **C** |
| | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | **E/NE** | Rep. Conc. [mg/L] | RBSLs [mg/L] | **E/NE** |
| **ORGANICS** | | | | | | |
| Benzene | | | | | | |
| Toluene | | | | | | |
| Ethylbenzene | | | | | | |
| Xylenes (mixed) | | | | | | |
| Ethylene dibromide (EDB) | | | | | | |
| Ethylene dichloride (EDC) | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | |
| Ethanol | | | | | | |
| Acenaphthene | | | | | | |
| Anthracene | | | | | | |
| Benzo(a)anthracene | | | | | | |
| Benzo(a)pyrene | | | | | | |
| Benzo(b)fluoranthene | | | | | | |
| Benzo(g,h,i)perylene | | | | | | |
| Benzo(k)fluoranthene | | | | | | |
| Chrysene | | | | | | |
| Fluoranthene | | | | | | |
| Fluorene | | | | | | |
| Naphthalene | | | | | | |
| Phenanthrene | | | | | | |
| Pyrene | | | | | | |
| **TPH** | | | | | | |
| TPH-GRO | | | | | | |
| TPH-DRO | | | | | | |
| TPH-ORO | | | | | | |

**NOTE:**

**NA**: Not Applicable

**E**: Representative on-site concentration exceeds Tier 1 RBSL.

**NE**: Representative on-site concentration does not exceed Tier 1 RBSL.

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

- ☐ Maximum
- ☐ Arithmetic Average
- ☐ Other

***:** Calculated RBSL exceeded saturated soil concentration and calcualted RBSL is shown.

**#:** Calculated RBSL exceeded pure component water solubility and calculated RBSL is shown.

**Recommended Attachment** Representative concentrations

**DCRBCA REPORT** **FORM NO. 17 - RESIDENT CHILD**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## COMPARISON OF TIER 1 RBSLs WITH REPRESENTATIVE CONCENTRATIONS - OFF-SITE RESIDENT CHILD

| CHEMICALS OF CONCERN | SURFICIAL SOIL | | | SUB-SURFACE SOIL | | | GROUNDWATER | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Indoor inhalation of vapors | | | Indoor inhalation of vapors | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | **E/NE** | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | **E/NE** | Rep. Conc. [mg/L] | RBSLs [mg/L] | **E/NE** | Rep. Conc. [mg/L] | RBSLs [mg/L] | **E/NE** |
| **ORGANICS** | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum
☐ Arithmetic Average
☐ Other

**NA**: Not Applicable
**E**: Representative on-site concentration exceeds Tier 1 RBSL.
**NE**: Representative on-site concentration does not exceed Tier 1 RBSL.

*****: Calculated RBSL exceeded saturated soil concentration and calcualted RBSL is shown.
**#**: Calculated RBSL exceeded pure component water solubility and calculated RBSL is shown.

---

**Recommended Attachment**: Representative concentrations.

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 17 - RESIDENT ADULT** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## COMPARISON OF TIER 1 RBSLs WITH REPRESENTATIVE CONCENTRATIONS - OFF-SITE RESIDENT ADULT

| CHEMICALS OF CONCERN | SURFICIAL SOIL | | | SUB-SURFACE SOIL | | | GROUNDWATER | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Indoor inhalation of vapors | | | Indoor inhalation of vapors | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | E/NE | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | E/NE | Rep. Conc. [mg/L] | RBSLs [mg/L] | E/NE | Rep. Conc. [mg/L] | RBSLs [mg/L] | E/NE |
| **ORGANICS** | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum
☐ Arithmetic Average
☐ Other

**NA**: Not Applicable
**E**: Representative on-site concentration exceeds Tier 1 RBSI
**NE**: Representative on-site concentration does not exceed Tier 1 RBSI

***:** Calculated RBSL exceeded saturated soil concentration and calcualted RBSL is shown.
**#:** Calculated RBSL exceeded pure component water solubility and calculated RBSL is shown.

**Recommended Attachment**: Representative concentrations

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 17 - COMMERCIAL WORKER** |

| | | | |
|---|---|---|---|
| **LUST CASE NO.:** | | **FACILITY ID NO.:** | |
| **SUBMITTAL DATE:** | | **PREPARED BY:** | |

## COMPARISON OF TIER 1 RBSLs WITH REPRESENTATIVE CONCENTRATIONS - OFF-SITE COMMERCIAL WORKER

| **CHEMICALS OF CONCERN** | **SURFICIAL SOIL** | | | **SUB-SURFACE SOIL** | | **GROUNDWATER** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Indoor inhalation of vapors | | Indoor inhalation of vapors | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | **E/NE** | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | Rep. Conc. [mg/L] | RBSLs [mg/L] | **E/NE** | Rep. Conc. [mg/L] | RBSLs [mg/L] | **E/NE** |
| **ORGANICS** | | | | | | | | | | | |
| Benzene | | | | | | | | | | | |
| Toluene | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum

☐ Arithmetic Average

☐ Other ____________________

**NA**: Not Applicable

**E**: Representative on-site concentration exceeds Tier 1 RBSL

**NE**: Representative on-site concentration does not exceed Tier 1 RBSI

*****: Calculated RBSL exceeded saturated soil concentration and calcualted RBSL is shown.

**#**: Calculated RBSL exceeded pure component water solubility and calculated RBSL is shown.

**Recommended Attachment**: Representative concentrations

| | | |
|---|---|---|
| **DCRBCA REPORT** | | **FORM NO. 17 - CONSTRUCTION WORKER** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** | |
| **SUBMITTAL DATE:** | **PREPARED BY:** | |

## COMPARISON OF TIER 1 RBSLs WITH REPRESENTATIVE CONCENTRATIONS - OFF-SITE CONSTRUCTION WORKER

| **CHEMICALS OF CONCERN** | **SOIL TO TYPICAL DEPTH OF CONST.** | | | | | |
|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | **C** | Dermal contact | | **C** |
| | Rep. Conc. [mg/kg] | RBSLs [mg/kg] | **E/NE** | Rep. Conc. [mg/L] | RBSLs [mg/L] | **E/NE** |
| **ORGANICS** | | | | | | |
| Benzene | | | | | | |
| Toluene | | | | | | |
| Ethylbenzene | | | | | | |
| Xylenes (mixed) | | | | | | |
| Ethylene dibromide (EDB) | | | | | | |
| Ethylene dichloride (EDC) | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | |
| Ethanol | | | | | | |
| Acenaphthene | | | | | | |
| Anthracene | | | | | | |
| Benzo(a)anthracene | | | | | | |
| Benzo(a)pyrene | | | | | | |
| Benzo(b)fluoranthene | | | | | | |
| Benzo(g,h,i)perylene | | | | | | |
| Benzo(k)fluoranthene | | | | | | |
| Chrysene | | | | | | |
| Fluoranthene | | | | | | |
| Fluorene | | | | | | |
| Naphthalene | | | | | | |
| Phenanthrene | | | | | | |
| Pyrene | | | | | | |
| **TPH** | | | | | | |
| TPH-GRO | | | | | | |
| TPH-DRO | | | | | | |
| TPH-ORO | | | | | | |

**NOTE:**

**Page 8 of**

**NA**: Not Applicable

**E**: Representative on-site concentration exceeds Tier 1 RBSL.

**NE**: Representative on-site concentration does not exceed Tier 1 RBSL.

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

- ☐ Maximum
- ☐ Arithmetic Average
- ☐ Other

*****: Calculated RBSL exceeded saturated soil concentration and calcualted RBSL is shown.

**#**: Calculated RBSL exceeded pure component water solubility and calculated RBSL is shown.

**Recommended Attachment**: Representative concentrations.

**DCRBCA REPORT** **FORM NO. 18**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## TIER 1 GROUNDWATER RESOURCE PROTECTION TARGET CONCENTRATIONS

Distance from source to the point of exposure (POE):

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **COMPARISON FOR SOURCE SOIL** | | | **COMPARISON FOR SOURCE GROUNDWATER** | | | **COMPARISON FOR POINT OF DEMONSTRATION WELLS** | | | | | | | | |
| **CHEMICALS OF CONCERN** | Soil Source Rep. Conc. [1] [mg/kg] | Allowable Soil Conc. [2] [mg/kg] | **E/ NE** | GW Source Rep. Conc. [3] [mg/L] | Allowable GW Conc. at the Source [4] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** |
| **POD WELL NO.** | | | | | | | | | | | | | | | |
| **DISTANCE FROM SOURCE** | | | | | | | | | | | | | | | |
| **RECENT TREND** | | | | | | | | | | | | | | | |
| **ORGANICS** | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | |

**NOTE**: Use the ***DCRBCA Computational Software*** to calculate the (i) soil source conc., (ii) GW source conc., and (iii) the point of demonstration (POD) well conc.

**Page 1 of**

1: The soil source representative concentrations have to be calculated and entered here.

2: Allowable soil concentrations at the source protective of groundwater at the POE.

3: The groundwater source representative concentrations have to be calculated and entered here.

4: Allowable groundwater concentrations at the source protective of groundwater at the POE.

5: Represents the representative concentrations in the POD well

6: Represents the allowable groundwater concentrations at a POD protective of a POE.

For representative concentrations, refer **Attachment 16**:

**E**: Representative on-site concentration exceeds calculated POD well concentration.

**NE**: Representative on-site concentration does not exceed calculated POD well concentration.

**Recommended Attachment:** (i) A map showing the location(s) of the soil source(s), location of POE, and location(s) of POD. (ii) Representative Concentrations.

**DCRBCA REPORT** **FORM NO. 18**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## TIER 1 GROUNDWATER RESOURCE PROTECTION TARGET CONCENTRATIONS

Distance from source to the point of exposure (POE):

| **CHEMICALS OF CONCERN** | **COMPARISON FOR POINT OF DEMONSTRATION WELLS** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | CW Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** |
| **POD WELL NO.** | | | | | | | | | | | | | | | |
| **DISTANCE FROM SOURCE** | | | | | | | | | | | | | | | |
| **RECENT TREND** | | | | | | | | | | | | | | | |
| **ORGANICS** | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | |

**NOTE**: Use the ***DCRBCA Computational Software*** to calculate the (i) soil source conc., (ii) GW source conc., and (iii) the point of demonstration (POD) well conc. **Page 2 of**

5: Represents the representative concentrations in the POD well

6: Represents the allowable groundwater concentrations at a POD protective of a POE.

For representative concentrations, refer **Attachment 16**:

**E**: Representative on-site concentration exceeds calculated POD well concentration.

**NE**: Representative on-site concentration does not exceed calculated POD well concentration.

**Recommended Attachment:**(i) A map showing the location(s) of the soil source(s), location of POE, and location(s) of POD. (ii) Representative Concentrations.

**DCRBCA REPORT** **FORM NO. 19**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## TIER 1 STREAM PROTECTION TARGET CONCENTRATIONS

Distance from source to the stream:

| CHEMICALS OF CONCERN | COMPARISON FOR SOURCE SOIL | | | COMPARISON FOR SOURCE GROUNDWATER | | | COMPARISON FOR POD WELL AT THE STREAM BANK | | | COMPARISON FOR POD WELLS BETWEEN THE SOURCE AND THE STREAM BANK | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soil Source Rep. Conc. [1] [mg/kg] | Allowable Soil Conc. [2] [mg/kg] | E/ NE | GW Source Rep. Conc. [3] [mg/L] | Allowable GW Conc. at the Source [4] [mg/L] | E/ NE | POD Rep. Conc.[5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | E/ NE | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | E/ NE | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | E/ NE |
| **POD WELL NO.** | | | | | | | | | | | | | | | |
| **DISTANCE FROM SOURCE** | | | | | | | | | | | | | | | |
| **RECENT TREND** | | | | | | | | | | | | | | | |
| **ORGANICS** | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | |

**NOTE:** Use the ***DCRBCA Computational Software*** to calculate the (i) soil source conc., (ii) GW source conc., and (iii) the point of demonstration (POD) well conc.

1: The soil source representative concentrations have to be calculated and entered here.

2: Allowable soil concentrations at the source protective of groundwater at the POE.

3: The groundwater source representative concentrations have to be calculated and entered here.

4: Allowable groundwater concentrations at the source protective of groundwater at the POE.

5: Represents the representative concentrations in POD well

6: Represents the allowable groundwater concentrations at a POD protective of a POE.

For representative concentrations, refer **Attachment 16**:

**E**: Representative on-site concentration exceeds allowable concentration.

**NE**: Representative on-site concentration does not exceed allowable concentration.

**Recommended Attachment:** (i) A map showing the location(s) of the soil source(s), location of stream, and location(s) of POD. (ii) Representative Concentrations.

**DCRBCA REPORT** **FORM NO. 19**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## TIER 1 STREAM PROTECTION TARGET CONCENTRATIONS

Distance from source to the stream:

| CHEMICALS OF CONCERN | COMPARISON FOR POINT OF DEMOSNTRATION WELLS BETWEEN THE SOURCE AND THE STREAM BANK | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | E/ NE | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | E/ NE | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | E/ NE | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | E/ NE | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | E/ NE |
| **POD WELL NO.** | | | | | | | | | | | | | | | |
| **DISTANCE FROM SOURCE** | | | | | | | | | | | | | | | |
| **RECENT TREND** | | | | | | | | | | | | | | | |
| **ORGANICS** | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | |

**NOTE:** Use the ***DCRBCA Computational Software*** to calculate the (i) soil source conc., (ii) GW source conc., and (iii) the point of demonstration (POD) well conc.

5: Represents the representative concentrations in the POD well

6: Represents the allowable groundwater concentrations at POD protective of a POE.

For representative concentrations, refer **Attachment 16**:

**E**: Representative on-site concentration exceeds allowable concentration.

**NE**: Representative on-site concentration does not exceed allowable concentration.

**Recommended Attachment:**(i) A map showing the location(s) of the soil source(s), location of stream, and location(s) of POD. (ii) Representative Concentrations.

DCRBCA REPORT **FORM NO. 20**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## TIER 1 APPLICABLE TARGET LEVELS FOR VARIOUS MEDIA

**NOTE**: The RBSLs listed for each route of exposure are the minimum RBSL for all the receptors for that particular route of exposure. The applicable target levels are the minimum RBSLs of all the routes of exposures within each media

| **CHEMICALS OF CONCERN** | **SURFICIAL SOIL** | **SUBSURFACE SOIL** | **GROUNDWATER** | | **Soil Concentrations Protective of Groundwater** [mg/kg] | **Soil Concentrations Protective of Stream** [mg/kg] |
|---|---|---|---|---|---|---|
| | Ingestion, outdoor Inhalation of vapors and particulates, and dermal contact [mg/kg] | Indoor Inhalation [mg/kg] | Indoor Inhalation [mg/L] | Dermal contact [mg/L] | | |
| **ORGANICS** | | | | | | |
| Benzene | | | | | | |
| Toluene | | | | | | |
| Ethylbenzene | | | | | | |
| Xylenes (mixed) | | | | | | |
| Ethylene dibromide (EDB) | | | | | | |
| Ethylene dichloride (EDC) | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | |
| Ethanol | | | | | | |
| Acenaphthene | | | | | | |
| Anthracene | | | | | | |
| Benzo(a)anthracene | | | | | | |
| Benzo(a)pyrene | | | | | | |
| Benzo(b)fluoranthene | | | | | | |
| Benzo(g,h,i)perylene | | | | | | |
| Benzo(k)fluoranthene | | | | | | |
| Chrysene | | | | | | |
| Fluoranthene | | | | | | |
| Fluorene | | | | | | |
| Naphthalene | | | | | | |
| Phenanthrene | | | | | | |
| Pyrene | | | | | | |
| **TPH** | | | | | | |
| TPH-GRO | | | | | | |
| TPH-DRO | | | | | | |
| TPH-ORO | | | | | | |

**NOTE:**
N/A: Not Applicable

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 21** |

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## TIER 1 CONCLUSIONS AND RECOMMENDATIONS

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DCRBCA REPORT **FORM NO. 21**

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|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## TIER 1 CONCLUSIONS AND RECOMMENDATIONS

| | |
|---|---|
| DCRBCA REPORT | FORM NO. 22 |

| | |
|---|---|
| LUST CASE NO.: | FACILITY ID NO.: |
| SUBMITTAL DATE: | PREPARED BY: |

## REFERENCES AND PROTOCOLS

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**DCRBCA REPORT** **FORM NO. 22**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## REFERENCES AND PROTOCOLS

# APPENDIX A.2
# TIER 2 REPORT FORMS

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 23** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## TIER 2A FATE AND TRANSPORT PARAMETERS *(Page 1 of 3)*

| Parameter | Symbol | Unit | Tier 1 Default Value | Tier 2A Value | Comment |
|---|---|---|---|---|---|
| **SOIL PARAMETERS:** | | | | | |
| Length of Soil Source Area Parallel to Wind Direction | $W_a$ | cm | 1500 | | |
| Depth to Subsurface Soil Source | $L_s$ | cm | 30.48 | | |
| Lower Depth of Surficial Soil Zone | d | cm | 30.48 | | |
| Depth to Soil Vapor Measurement | $d_v$ | cm | 30.48 | | |
| Thickness of Capillary Fringe | $h_{cap}$ | cm | 5 | | |
| Thickness of Vadose Zone* | $h_v$ | cm | 295 | | |
| Unsaturated Zone Dry Soil Bulk Density | $\rho_s$ | $g/cm^3$ | 1.8 | | |
| Fractional Organic Carbon Content in Vadose Zone | $f_{oc}$ | g-C/g-soil | 0.01 | | |
| Total Soil Porosity in Vadose Zone | $\theta_T$ | $cm^3/cm^3$-soil | 0.3 | | |
| Volumetric Water Content in Capillary Fringe* | $\theta_{wcap}$ | $cm^3/cm^3$ | 0.27 | | |
| Volumetric Water Content in Vadose Zone | $\theta_{ws}$ | $cm^3/cm^3$ | 0.2 | | |
| Volumetric Water Content in Foundation/Wall Cracks | $\theta_{wcrack}$ | $cm^3/cm^3$ | 0.2 | | |
| Volumetric Air Content in Capillary Fringe* | $\theta_{acap}$ | $cm^3/cm^3$ | 0.03 | | |
| Volumetric Air Content in Vadose Zone* | $\theta_{as}$ | $cm^3/cm^3$ | 0.1 | | |
| Volumetric Air Content in Foundation/Wall Cracks* | $\theta_{acrack}$ | $cm^3/cm^3$ | 0.1 | | |
| **GROUNDWATER PARAMETERS:** | | | | | |
| Depth to Groundwater | $L_{gw}$ | cm | 300 | | |
| Length of Groundwater Source Area Parallel to Wind Direction | $W_{ga}$ | cm | 1500 | | |
| Width of GW Source Perpendicular to the GW Flow Direction | Y | cm | 1500 | | |
| Length of the GW Source Parallel to the GW Flow Direction | W | cm | 1500 | | |
| Total Porosity in the Saturated Zone | $\theta_{TS}$ | $cm^3/cm^3$-soil | 0.3 | | |
| Saturated Zone Dry Soil Bulk Density | $\rho_{ss}$ | $g/cm^3$ | 1.8 | | |
| Fractional Organic Carbon Content in the Saturated Zone | $foc_s$ | g/g | 0.01 | | |
| Groundwater Mixing Zone Thickness | $\delta_{gw}$ | cm | 200 | | |
| Hydraulic Conductivity in the Saturated Zone | K | cm/year | 76000 | | |
| Hydraulic Gradient | i | -- | 0.004 | | |
| Groundwater Darcy Velocity* | $U_{gw}$ | cm/year | 304.1 | | |
| Infiltration Rate | I | cm/year | 14 | | |
| **STREAM PARAMETERS:** | | | | | |
| Stream Flow Rate Upstream of the Point of Groundwater Discharge | $Q_{sw}$ | $ft^3/day$ | Variable | | |
| Impacted Groundwater Discharge into the Stream* | $Q_{gw}$ | $ft^3/day$ | Calculated | | |
| COCs Concentration Upstream of the Groundwater Plume Discharge | $C_{su}$ | mg/L | 0 | | |
| **AMBIENT AIR PARAMETERS:** | | | | | |
| Breathing Zone Height | $\delta_a$ | cm | 200 | | |
| Wind Speed within the Breathing Zone | $U_a$ | cm/s | 225 | | |

**DCRBCA REPORT** **FORM NO. 23**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## TIER 2A FATE AND TRANSPORT PARAMETERS *(Page 2 of 3)*

| Parameter | Symbol | Unit | Tier 1 Default Value | Tier 2A Value | Comment |
|---|---|---|---|---|---|
| **PARTICULATE EMISSION RATE:** | | | | | |
| Residential and Commercial | $P_e$ | $g/cm^2sec$ | 6.9E-14 | | |
| Construction Worker | $P_e$ | $g/cm^2sec$ | 6.9E-09 | | |
| **GROUNDWATER RESOURCE PROTECTION:** | | | | | |
| Distance from the Downgradient Edge of the Groundwater Source to the Point of Exposure | $X_{poe}$ | ft | Varialble | | |
| Longitudinal Dispersivity* | $\alpha_x$ | ft | $X_{poe}/10$ | | |
| Transverse Dispersivity* | $\alpha_y$ | ft | $X_{poe}/30$ | | |
| Vertical Dispersivity* | $\alpha_z$ | ft | $X_{poe}/200$ | | |
| Distance from the Downgradient Edge of the Groundwater Source to the Point of Demonstration | $X_{poc}$ | ft | Variable | | |
| Longitudinal Dispersivity* | $\alpha_x$ | ft | $X_{poc}/10$ | | |
| Transverse Dispersivity* | $\alpha_y$ | ft | $X_{poc}/30$ | | |
| Vertical Dispersivity* | $\alpha_z$ | ft | $X_{poc}/200$ | | |
| **STREAM PROTECTION:** | | | | | |
| Distance from the Downgradient Edge of the Groundwater Source to the Stream | $X_s$ | ft | Varialble | | |
| Longitudinal Dispersivity* | $a_x$ | ft | $X_s/10$ | | |
| Transverse Dispersivity* | $a_y$ | ft | $X_s/30$ | | |
| Vertical Dispersivity* | $a_z$ | ft | $X_s/200$ | | |
| Distance from the Downgradient Edge of the Groundwater Source | $X_{spoc}$ | ft | Variable | | |
| Longitudinal Dispersivity* | $a_x$ | ft | $X_{spoc}/10$ | | |
| Transverse Dispersivity* | $a_y$ | ft | $X_{spoc}/30$ | | |
| Vertical Dispersivity* | $a_z$ | ft | $X_{spoc}/200$ | | |

*: Calculated value.

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 23** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## TIER 2A BUILDING/ADVECTIVE VAPOR FLUX PARAMETERS FOR VAPOR INTRUSION *(Page 3 of 3)*

| **Parameter** | **Symbol** | **Unit** | **Tier 1 Default Value** | **Tier 2A Value** | **Comment** |
|---|---|---|---|---|---|
| **BUILDING/ADVECTIVE VAPOR FLUX PARAMETERS FOR VAPOR INTRUSION:** | | | | | |
| Volumetric Flow Rate of Soil Gas into the Building: | | | | | |
| Residential | $Q_{soil}$ | 1/sec | 83.33 | | |
| Commercial/Construction Worker | $Q_{soil}$ | 1/sec | 83.33 | | |
| Soil-Buidling Pressure Difference: | | | | | |
| Residential | $\Delta P$ | $gm/cm\text{-}s^2$ | 40 | | |
| Commercial/Construction Worker | $\Delta P$ | $gm/cm\text{-}s^2$ | 40 | | |
| Vapor Permeability for Soils Below Building: | | | | | |
| Residential | $k_v$ | $cm^2$ | 1.00E-08 | | |
| Commercial/Construction Worker | $k_v$ | $cm^2$ | 1.00E-08 | | |
| Buidling Foundation or Slab Thickness: | | | | | |
| Residential | $L_{crack}$ | cm | 15 | | |
| Commercial/Construction Worker | $L_{crack}$ | cm | 15 | | |
| Air Exchange Rate: | | | | | |
| Residential | ER | 1/24hr | 12.1 | | |
| Commercial/Construction Worker | ER | 1/24hr | 19.9 | | |
| Building Height: | | | | | |
| Residential | $H_B$ | cm | 200 | | |
| Commercial/Construction Worker | $H_B$ | cm | 300 | | |
| Building Width: | | | | | |
| Residential | $W_B$ | cm | 1,000 | | |
| Commercial/Construction Worker | $W_B$ | cm | 1,000 | | |
| Building Length: | | | | | |
| Residential | $L_B$ | cm | 1,000 | | |
| Commercial/Construction Worker | $L_B$ | cm | 1,000 | | |
| Depth Below Grade to Bottom of Building: | | | | | |
| Residential | $L_F$ | cm | 15 | | |
| Commercial/Construction Worker | $L_F$ | cm | 15 | | |
| Floor-Wall Seam Gap | | | | | |
| Residential | w | cm | 0.1 | | |
| Commercial/Construction Worker | w | cm | 0.1 | | |

The above parameters may change when the Division develops the vapor intrusion pathway.

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 24** |

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## JUSTIFICATION FOR CHANGING TIER 2A FATE AND TRANSPORT PARAMETERS

| ***Tier 2A Fate and Transport Parameter*** | ***Justification*** |
|---|---|
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| **DCRBCA REPORT** | **FORM NO. 24** |

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## JUSTIFICATION FOR CHANGING TIER 2A FATE AND TRANSPORT PARAMETERS

| ***Tier 2A Fate and Transport Parameter*** | ***Justification*** |
|---|---|
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| **DCRBCA REPORT** | **FORM NO. 25** |

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## TIER 2A EXPOSURE FACTORS *(Page 1 of 2)*

| **Parameter** | **Symbol** | **Unit** | **Tier 1 Default Value** | **Tier 2A Value** | **Comment** |
|---|---|---|---|---|---|
| Averaging Time for Carcinogens | ATc | year | 70 | | |
| Averaging Time for Non-Carcinogens | ATn | year | =ED | | |
| **Body Weight** | | | | | |
| Resident Child | BW | kg | 15 | | |
| Resident Adult | BW | kg | 70 | | |
| Commercial Worker | BW | kg | 70 | | |
| Construction Worker | BW | kg | 70 | | |
| **Exposure Duration:** | | | | | |
| Resident Child | ED | year | 6 | | |
| Resident Adult | ED | year | 24 | | |
| Commercial Worker | ED | year | 25 | | |
| Construction Worker | ED | year | 1 | | |
| **Exposure Frequency:** | | | | | |
| Resident Child | EF | day/year | 350 | | |
| Resident Adult | EF | day/year | 350 | | |
| Commercial Worker | EF | day/year | 250 | | |
| Construction Worker | EF | day/year | 90 | | |
| **Soil Ingestion Rate:** | | | | | |
| Resident Child | IRsoil | mg/day | 200 | | |
| Resident Adult | IRsoil | mg/day | 100 | | |
| Commercial Worker | IRsoil | mg/day | 100 | | |
| Construction Worker | IRsoil | mg/day | 330 | | |
| **Daily Water Ingestion Rate:** | | | | | |
| Resident Child | IRw | L/day | 1 | | |
| Resident Adult | IRw | L/day | 2 | | |
| **Exposure Time for Indoor Inhalation:** | | | | | |
| Resident Child | ETin | hr/day | 16 | | |
| Resident Adult | ETin | hr/day | 16 | | |
| Commercial Worker | ETin | hr/day | 8 | | |
| **Exposure Time for Outdoor Inhalation:** | | | | | |
| Resident Child | ETout | hr/day | 8 | | |
| Resident Adult | ETout | hr/day | 8 | | |
| Commercial Worker | ETout | hr/day | 8 | | |
| Construction Worker | ETout | hr/day | 8 | | |
| **Skin Surface Area for Incidental Dermal Contact with Soil:** | | | | | |
| Resident Child | SAsoil | $cm^2$/day | 2800 | | |
| Resident Adult | SAsoil | $cm^2$/day | 5700 | | |
| Commercial Worker | SAsoil | $cm^2$/day | 3300 | | |
| Construction Worker | SAsoil | $cm^2$/day | 3300 | | |

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 25** |

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## TIER 2A EXPOSURE FACTORS *(Page 2 of 2)*

| Parameter | Symbol | Unit | Tier 1 Default Value | Tier 2A Value | Comment |
|---|---|---|---|---|---|
| **Soil skin adherence factor** | | | | | |
| Resident Child | M | mg/cm$^2$ | 0.2 | | |
| Resident Adult | M | mg/cm$^2$ | 0.07 | | |
| Commercial Worker | M | mg/cm$^2$ | 0.2 | | |
| Construction Worker | M | mg/cm$^2$ | 0.3 | | |
| **Event Frequency for Incidental Dermal Contact with Soil:** | | | | | |
| Resident Child | EVsoil | event/day | 1 | | |
| Resident Adult | EVsoil | event/day | 1 | | |
| Commercial Worker | EVsoil | event/day | 1 | | |
| Construction Worker | EVsoil | event/day | 1 | | |
| **Skin Surface Area for Incidental Dermal Contact with Water:** | | | | | |
| Resident Child | SAgw | cm$^2$/day | 2800 | | |
| Resident Adult | SAgw | cm$^2$/day | 5700 | | |
| Commercial Worker | SAgw | cm$^2$/day | 3300 | | |
| Construction Worker | SAgw | cm$^2$/day | 3300 | | |
| **Event Frequency for Incidental Dermal Contact with Water:** | | | | | |
| Resident Child | EVgw | event/day | 1 | | |
| Resident Adult | EVgw | event/day | 1 | | |
| Commercial Worker | EVgw | event/day | 1 | | |
| Construction Worker | EVgw | event/day | 1 | | |
| **Event Duration for Incidental Dermal Contact with Water:** | | | | | |
| Resident Child | tevent | hr/event | 1 | | |
| Resident Adult | tevent | hr/event | 1 | | |
| Commercial Worker | tevent | hr/event | 1 | | |
| Construction Worker | tevent | hr/event | 1 | | |
| **Target Risk** | TR | -- | 0.000001 | | |
| **Target Hazard Quotient** | THQ | -- | 1 | | |

**Note:**

ED = Exposure duration

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 26** |

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## JUSTIFICATION FOR CHANGING TIER 2A EXPOSURE FACTORS

| *Tier 2A Exposure Factors* | *Justification* |
|---|---|
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**DCRBCA REPORT** **FORM NO. 26**

| | |
|---|---|
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## JUSTIFICATION FOR CHANGING TIER 2A EXPOSURE FACTORS

| *Tier 2A Exposure Factors* | *Justification* |
|---|---|
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**DCRBCA REPORT** **FORM NO. 27 - RESIDENT CHILD**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## COMPARISON OF TIER 2A SSTLs WITH REPRESENTATIVE CONCENTRATIONS - ON-SITE RESIDENT CHILD

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CHEMICALS OF CONCERN** | **SURFICIAL SOIL** | | | **SUB-SURFACE SOIL** | | | **GROUNDWATER** | | | | | |
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Indoor inhalation of vapors | | | Indoor inhalation of vapors | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | **E/NE** | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | **E/NE** | Rep. Conc. [mg/L] | SSTLs [mg/L] | **E/NE** | Rep. Conc. [mg/L] | SSTLs [mg/L] | **E/NE** |
| **ORGANICS** | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum

☐ Arithmetic Average

☐ Other

**E:** Representative on-site concentration exceeds Tier 2A SSTL.

**NE:** Representative on-site concentration does not exceed Tier 2A SSTL.

**N/A:** Not Applicable

Indicate complete pathways by typing in a "C" in the box provided besides the title for each pathway. Type "NC" for incomplete pathways. Enter the calculated Site-Specific Target Levels (SSTLs) for all complete pathways. Use the DCRBCA Computational Software to calculate the SSTLs.

**Page 1 of**

**Recommended Attachment**: Output tables from the DCRBCA Computational Software and Representative Concentrations

| DCRBCA REPORT | FORM NO. 27 - RESIDENT ADULT |
|---|---|
| LUST CASE NO.: | FACILITY ID NO.: |
| SUBMITTAL DATE: | PREPARED BY: |

## COMPARISON OF TIER 2A SSTLs WITH REPRESENTATIVE CONCENTRATIONS - ON-SITE RESIDENT ADULT

| CHEMICALS OF CONCERN | SURFICIAL SOIL | | | SUB-SURFACE SOIL | | | GROUNDWATER | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Indoor inhalation of vapors | | | Indoor inhalation of vapors | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | E/NE | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | E/NE | Rep. Conc. [mg/L] | SSTLs [mg/L] | E/NE | Rep. Conc. [mg/L] | SSTLs [mg/L] | E/NE |
| **ORGANICS** | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | |
| TP-GRO | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum
☐ Arithmetic Average
☐ Other

**E:** Representative on-site concentration exceeds Tier 2A SSTL.
**NE:** Representative on-site concentration does not exceed Tier 2A SSTL.
**N/A:** Not Applicable

Indicate complete pathways by typing in a "C" in the box provided besides the title for each pathway. Type "NC" for incomplete pathways. Enter the calculated Site-Specific Target Levels (SSTLs) for all complete pathways. Use the DCRBCA Computational Software to calculate the SSTLs.

**Recommended Attachment**: Output tables from the DCRBCA Computational Software and Representative Concentrations.

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 27 - COMMERCIAL WORKER** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## COMPARISON OF TIER 2A SSTLs WITH REPRESENTATIVE CONCENTRATIONS - ON-SITE COMMERCIAL WORKER

| **CHEMICALS OF CONCERN** | **SURFICIAL SOIL** | | | **SUB-SURFACE SOIL** | | | **GROUNDWATER** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Indoor inhalation of vapors | | | Indoor inhalation of vapors | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | **E/NE** | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | **E/NE** | Rep. Conc. [mg/L] | SSTLs [mg/L] | **E/NE** | Rep. Conc. [mg/L] | SSTLs [mg/L] | **E/NE** |
| **ORGANICS** | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | |
| TP-GRO | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum

☐ Arithmetic Average

☐ Other

**E:** Representative on-site concentration exceeds Tier 2A SSTL.

**NE:** Representative on-site concentration does not exceed Tier 2A SSTL.

**N/A:** Not Applicable

Indicate complete pathways by typing in a "C" in the box provided besides the title for each pathway. Type "NC" for incomplete pathways. Enter the calculated Site-Specific Target Levels (SSTLs) for all complete pathways. Use the DCRBCA Computational Software to calculate the SSTLs.

**Recommended Attachment**: Output tables from the DCRBCA Computational Software and Representative Concentrations.

**DCRBCA REPORT** **FORM NO. 27 - CONSTRUCTION WORKER**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## COMPARISON OF TIER 2A SSTLs WITH REPRESENTATIVE CONCENTRATIONS - ON-SITE CONSTRUCTION WORKER

| **CHEMICALS OF CONCERN** | **SOIL** | | | **GROUNDWATER** | | |
|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | **E/NE** | Rep. Conc. [mg/L] | SSTLs [mg/L] | **E/NE** |
| **ORGANICS** | | | | | | |
| Benzene | | | | | | |
| Toluene | | | | | | |
| Ethylbenzene | | | | | | |
| Xylenes (mixed) | | | | | | |
| Ethylene dibromide (EDB) | | | | | | |
| Ethylene dichloride (EDC) | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | |
| Ethanol | | | | | | |
| Acenaphthene | | | | | | |
| Anthracene | | | | | | |
| Benzo(a)anthracene | | | | | | |
| Benzo(a)pyrene | | | | | | |
| Benzo(b)fluoranthene | | | | | | |
| Benzo(g,h,i)perylene | | | | | | |
| Benzo(k)fluoranthene | | | | | | |
| Chrysene | | | | | | |
| Fluoranthene | | | | | | |
| Fluorene | | | | | | |
| Naphthalene | | | | | | |
| Phenanthrene | | | | | | |
| Pyrene | | | | | | |
| **TPH** | | | | | | |
| TPH-GRO | | | | | | |
| TPH-DRO | | | | | | |
| TPH-ORO | | | | | | |

**NOTE:**

**Page 4 of**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum

☐ Arithmetic Average

☐ Other

**E:** Representative on-site concentration exceeds Tier 2 SSTL.

**NE:** Representative on-site concentration does not exceed Tier 2 SSTL.

**N/A:** Not Applicable

Indicate complete pathways by typing in a "C" in the box provided besides the title for each pathway. Type "NC" for incomplete pathways. Enter the calculated Site-Specific Target Levels (SSTLs) for all complete pathways. Use the DCRBCA Computational Software to calculate the SSTLs.

**Recommended Attachment**: Output tables from the DCRBCA Computational Software and Representative Concentrations.

**DCRBCA REPORT** **FORM NO. 27 - RESIDENT CHILD**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## COMPARISON OF TIER 2A SSTLs WITH REPRESENTATIVE CONCENTRATIONS - OFF-SITE RESIDENT CHILD

| **CHEMICALS OF CONCERN** | **SURFICIAL SOIL** | | | **SUB-SURFACE SOIL** | | | **GROUNDWATER** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Indoor inhalation of vapors | | | Indoor inhalation of vapors | | | Outdoor inhalation of vapors | | |
| | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | **E/NE** | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | **E/NE** | Rep. Conc. [mg/L] | SSTLs [mg/L] | **E/NE** | Rep. Conc. [mg/L] | SSTLs [mg/L] | **E/NE** |
| **ORGANICS** | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum

☐ Arithmetic Average

☐ Other

**E:**Representative on-site concentration exceeds Tier 2 SSTL.

**NE:**Representative on-site concentration does not exceed Tier 2 SSTL.

**N/A:** Not Applicable

Indicate complete pathways by typing in a "C" in the box provided besides the title for each pathway. Type "NC" for incomplete pathways. Enter the calculated Site-Specific Target Levels (SSTLs) for all complete pathways. Use the DCRBCA Computational Software to calculate the SSTLs.

**Recommended Attachment**: Output tables from the DCRBCA Computational Software and Representative Concentrations.

| | |
|---|---|
| **DCRBCA REPORT** | **FORM NO. 27 - RESIDENT ADULT** |
| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## COMPARISON OF TIER 2A SSTLs WITH REPRESENTATIVE CONCENTRATIONS - OFF-SITE RESIDENT ADULT

| **CHEMICALS OF CONCERN** | **SURFICIAL SOIL** | | | **SUB-SURFACE SOIL** | | | **GROUNDWATER** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Indoor inhalation of vapors | | | Indoor inhalation of vapors | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | **E/NE** | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | **E/NE** | Rep. Conc. [mg/L] | SSTLs [mg/L] | **E/NE** | Rep. Conc. [mg/L] | SSTLs [mg/L] | **E/NE** |
| **ORGANICS** | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum

☐ Arithmetic Average

☐ Other

**E:** Representative on-site concentration exceeds Tier 2 SSTL.

**NE:** Representative on-site concentration does not exceed Tier 2 SSTL.

**N/A:** Not Applicable

Indicate complete pathways by typing in a "C" in the box provided besides the title for each pathway. Type "NC" for incomplete pathways. Enter the calculated Site-Specific Target Levels (SSTLs) for all complete pathways. Use the DCRBCA Computational Software to calculate the SSTLs.

**Recommended Attachment**: Output tables from the DCRBCA Computational Software and Representative Concentrations.

**DCRBCA REPORT** **FORM NO. 27 - COMMERCIAL WORKER**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## COMPARISON OF TIER 2A SSTLs WITH REPRESENTATIVE CONCENTRATIONS - OFF-SITE COMMERCIAL WORKER

| CHEMICALS OF CONCERN | SURFICIAL SOIL | | | SUB-SURFACE SOIL | | | GROUNDWATER | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Indoor inhalation of vapors | | | Indoor inhalation of vapors | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | **E/NE** | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | **E/NE** | Rep. Conc. [mg/L] | SSTLs [mg/L] | **E/NE** | Rep. Conc. [mg/L] | SSTLs [mg/L] | **E/NE** |
| **ORGANICS** | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum

☐ Arithmetic Average

☐ Other

**E:**Representative on-site concentration exceeds Tier 2 SSTL.
**NE:**Representative on-site concentration does not exceed Tier 2 SSTL.
**N/A:** Not Applicable

Indicate complete pathways by typing in a "C" in the box provided besides the title for each pathway. Type "NC" for incomplete pathways. Enter the calculated Site-Specific Target Levels (SSTLs) for all complete pathways. Use the DCRBCA Computational Software to calculate the SSTLs.

**Recommended Attachment**: Output tables from the DCRBCA Computational Software and Representative Concentrations.

**DCRBCA REPORT** **FORM NO. 27 - CONSTRUCTION WORKER**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## COMPARISON OF TIER 2A SSTLs WITH REPRESENTATIVE CONCENTRATIONS - OFF-SITE CONSTRUCTION WORKER

| CHEMICALS OF CONCERN | SOIL TO TYPICAL DEPTH OF CONST. | | | GROUNDWATER | | |
|---|---|---|---|---|---|---|
| | Ingestion, outdoor inhalation of vapors and particulate matter, and dermal contact | | | Dermal contact | | |
| | Rep. Conc. [mg/kg] | SSTLs [mg/kg] | E/NE | Rep. Conc. [mg/L] | SSTLs [mg/L] | E/NE |
| **ORGANICS** | | | | | | |
| Benzene | | | | | | |
| Toluene | | | | | | |
| Ethylbenzene | | | | | | |
| Xylenes (mixed) | | | | | | |
| Ethylene dibromide (EDB) | | | | | | |
| Ethylene dichloride (EDC) | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | |
| Ethanol | | | | | | |
| Acenaphthene | | | | | | |
| Anthracene | | | | | | |
| Benzo(a)anthracene | | | | | | |
| Benzo(a)pyrene | | | | | | |
| Benzo(b)fluoranthene | | | | | | |
| Benzo(g,h,i)perylene | | | | | | |
| Benzo(k)fluoranthene | | | | | | |
| Chrysene | | | | | | |
| Fluoranthene | | | | | | |
| Fluorene | | | | | | |
| Naphthalene | | | | | | |
| Phenanthrene | | | | | | |
| Pyrene | | | | | | |
| **TPH** | | | | | | |
| TPH-GRO | | | | | | |
| TPH-DRO | | | | | | |
| TPH-ORO | | | | | | |

**NOTE:**

Enter the representative concentration (Rep. Conc.) and indicate (Select One):

☐ Maximum

☐ Arithmetic Average

☐ Other

**E:**Representative on-site concentration exceeds Tier 2 SSTL.

**NE:**Representative on-site concentration does

**N/A:** Not Applicable

Indicate complete pathways by typing in a "C" in the box provided besides the title for each pathway. Type "NC" for incomplete pathways. Enter the calculated Site-Specific Target Levels (SSTLs) for all complete pathways. Use the DCRBCA Computational Software to calculate the SSTLs.

**Recommended Attachment**: Output tables from the DCRBCA Computational Software and Representative Concentrations.

**DCRBCA REPORT** **FORM NO. 28**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## TIER 2A GROUNDWATER RESOURCE PROTECTION TARGET CONCENTRATIONS

Distance from source to the point of exposure (POE):

| CHEMICALS OF CONCERN | COMPARISON FOR SOURCE SOIL | | | COMPARISON FOR SOURCE GROUNDWATER | | | COMPARISON FOR POINT OF DEMONSTRATION WELLS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soil Source Rep. Conc. [1] [mg/kg] | Allowable Soil Conc. [2] [mg/kg] | **E/ NE** | GW Source Rep. Conc. [3] [mg/L] | Allowable GW Conc. at the Source [4] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** |
| **POD WELL NO.** | | | | | | | | | | | | | | | |
| **DISTANCE FROM SOURCE** | | | | | | | | | | | | | | | |
| **RECENT TREND** | | | | | | | | | | | | | | | |
| **ORGANICS** | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | |

**NOTE:** Use the ***DCRBCA Computational Software*** to calculate the (i) soil source conc., (ii) GW source conc., and (iii) the point of demonstration (POD) well conc.

1: The soil source representative concentrations have to be calculated and entered here.

2: Allowable soil concentrations at the source protective of groundwater at the POE.

3: The groundwater source representative concentrations have to be calculated and entered here.

4: Allowable groundwater concentrations at the source protective of groundwater at the POE.

5: Represents the representative concentrations in the point of demonstration (POD) well

6: Represents the allowable groundwater concentrations at a POD protective of a POE.

For representative concentrations, refer **Attachment 16**:

**E**: Representative on-site concentration exceeds calculated POD concentration.

**NE**: Representative on-site concentration does not exceed calculated compliance well concentration.

**Recommended Attachment:** (i) A map showing the location(s) of the soil source(s), location of POE, and location(s) of POD. (ii) Representative Concentrations.

**DCRBCA REPORT** **FORM NO. 28**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## TIER 2A GROUNDWATER RESOURCE PROTECTION TARGET CONCENTRATIONS

Distance from source to the point of exposure (POE):

| **CHEMICALS OF CONCERN** | **COMPARISON FOR POINT OF DEMONSTRATION WELLS** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** |
| **POD WELL NO.** | | | | | | | | | | | | | | | |
| **DISTANCE FROM SOURCE** | | | | | | | | | | | | | | | |
| **RECENT TREND** | | | | | | | | | | | | | | | |
| **ORGANICS** | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | |

**NOTE:** Use the ***DCRBCA Computational Software*** to calculate the (i) soil source conc., (ii) GW source conc., and (iii) the point of demonstration (POD) well conc.

5: Represents the representative concentrations in the POD well

6: Represents the allowable groundwater concentrations at a POD protective of a POE.

**E**: Representative on-site concentration exceeds calculated POD concentration.

**NE**: Representative on-site concentration does not exceed calculated POD concentration.

**Recommended Attachment:** (i) A map showing the location(s) of the soil source(s), location of POE, and location(s) of POD. (ii) Representative Concentrations.

**DCRBCA REPORT** **FORM NO. 29**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## TIER 2A STREAM PROTECTION TARGET CONCENTRATIONS

Distance from source to the stream:

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **COMPARISON FOR SOURCE SOIL** | | | **COMPARISON FOR SOURCE GROUNDWATER** | | | **COMPARISON FOR POD WELL AT THE STREAM BANK** | | | **COMPARISON FOR POD WELLS BETWEEN THE SOURCE AND THE STREAM BANK** | | | | | |
| **CHEMICALS OF CONCERN** | Soil Source Rep. Conc. [1] [mg/kg] | Allowable Soil Conc. [2] [mg/kg] | **E/ NE** | GW Source Rep. Conc. [3] [mg/L] | Allowable GW Conc. at the Source [4] [mg/L] | **E/ NE** | POD Rep. Conc.[5] [mg/L] | Allowable GW Conc. at a POD[6] [mg/L] | **E/ NE** | POD Rep. Conc.[5] [mg/L] | Allowable GW Conc. at a POD[6] [mg/L] | **E/ NE** | POD Rep. Conc.[5] [mg/L] | Allowable GW Conc. at a POD[6] [mg/L] | **E/ NE** |
| **POD WELL NO.** | | | | | | | | | | | | | | | |
| **DISTANCE FROM SOURCE** | | | | | | | | | | | | | | | |
| **RECENT TREND** | | | | | | | | | | | | | | | |
| **ORGANICS** | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | |

**NOTE**: Use the ***DCRBCA Computational Software*** to calculate the (i) soil source conc., (ii) GW source conc., and (iii) the point of demonstration (POD) well conc.

1: The soil source representative concentrations have to be calculated and entered here.

2: Allowable soil concentrations at the source protective of groundwater at the POE.

3: The groundwater source representative concentrations have to be calculated and entered here.

4: Allowable groundwater concentrations at the source protective of groundwater at the POE.

5: Represents the representative concentrations in the POD

6: Represents the allowable groundwater concentrations at a POD protective of a POE.

**E**: Representative on-site concentration exceeds calculated POD concentration.

**NE**: Representative on-site concentration does not exceed calculated POD concentration.

**Recommended Attachment:** (i) A map showing the location(s) of the soil source(s), location of stream, and location(s) of POD. (ii) Representative Concentrations.

**DCRBCA REPORT** **FORM NO. 29**

**LUST CASE NO.:** **FACILITY ID NO.:**

**SUBMITTAL DATE:** **PREPARED BY:**

## TIER 2A STREAM PROTECTION TARGET CONCENTRATIONS

Distance from source to the stream:

| **CHEMICALS OF CONCERN** | **COMPARISON FOR POINT OF DEMONSTRATION WELLS BETWEEN THE SOURCE AND THE STREAM BANK** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** | POD Rep. Conc. [5] [mg/L] | Allowable GW Conc. at a POD [6] [mg/L] | **E/ NE** |
| **POD WELL NO.** | | | | | | | | | | | | | | | |
| **DISTANCE FROM SOURCE** | | | | | | | | | | | | | | | |
| **RECENT TREND** | | | | | | | | | | | | | | | |
| **ORGANICS** | | | | | | | | | | | | | | | |
| Benzene | | | | | | | | | | | | | | | |
| Toluene | | | | | | | | | | | | | | | |
| Ethylbenzene | | | | | | | | | | | | | | | |
| Xylenes (mixed) | | | | | | | | | | | | | | | |
| Ethylene dibromide (EDB) | | | | | | | | | | | | | | | |
| Ethylene dichloride (EDC) | | | | | | | | | | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | | | | | | | | | | |
| Tertiary butyl alcohol (TBA) | | | | | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | | | | | |
| Acenaphthene | | | | | | | | | | | | | | | |
| Anthracene | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | | | | | | | | | | | | | | | |
| Chrysene | | | | | | | | | | | | | | | |
| Fluoranthene | | | | | | | | | | | | | | | |
| Fluorene | | | | | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | | | | | |
| Phenanthrene | | | | | | | | | | | | | | | |
| Pyrene | | | | | | | | | | | | | | | |
| **TPH** | | | | | | | | | | | | | | | |
| TPH-GRO | | | | | | | | | | | | | | | |
| TPH-DRO | | | | | | | | | | | | | | | |
| TPH-ORO | | | | | | | | | | | | | | | |

**NOTE:** Use the ***DCRBCA Computational Software*** to calculate the (i) soil source conc., (ii) GW source conc., and (iii) point of demonstration (POD) well conc.

**Page 2 of**

5: Represents the representative concentrations in the POD well

6: Represents the allowable groundwater concentrations at a POD protective of a POE.

**E**: Representative on-site concentration exceeds allowable concentration.

**NE**: Representative on-site concentration does not exceed allowable concentration.

**Recommended Attachment:** (i) A map showing the location(s) of the stream(s). (ii) Representative Concentrations.

**DCRBCA REPORT** **FORM NO. 30**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## TIER 2A APPLICABLE TARGET LEVELS FOR VARIOUS MEDIA

**NOTE**: The SSTLs listed for each route of exposure are the minimum SSTL for all the receptors for that particular route of exposure.
The applicable target levels are the minimum SSTLs of all the routes of exposures within each media.

| CHEMICALS OF CONCERN | SURFICIAL SOIL | SUBSURFACE SOIL | GROUNDWATER | | **Soil Concentrations Protective of Groundwater** | **Soil Concentrations Protective of Stream** |
|---|---|---|---|---|---|---|
| | Ingestion, outdoor Inhalation ofvapors and particulates, and dermal contact | Indoor Inhalation | Indoor Inhalation | Dermal contact | | |
| | [mg/kg] | [mg/kg] | [mg/L] | | [mg/kg] | [mg/kg] |
| **ORGANICS** | | | | | | |
| Benzene | | | | | | |
| Toluene | | | | | | |
| Ethylbenzene | | | | | | |
| Xylenes (mixed) | | | | | | |
| Ethylene dibromide (EDB) | | | | | | |
| Ethylene dichloride (EDC) | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | |
| Tertiary butylal cohol (TBA) | | | | | | |
| Ethanol | | | | | | |
| Acenaphthene | | | | | | |
| Anthracene | | | | | | |
| Benzo(a)anthracene | | | | | | |
| Benzo(a)pyrene | | | | | | |
| Benzo(b)fluoranthene | | | | | | |
| Benzo(g,h,i)perylene | | | | | | |
| Benzo(k)fluoranthene | | | | | | |
| Chrysene | | | | | | |
| Fluoranthene | | | | | | |
| Fluorene | | | | | | |
| Naphthalene | | | | | | |
| Phenanthrene | | | | | | |
| Pyrene | | | | | | |
| **TPH** | | | | | | |
| TPH-GRO | | | | | | |
| TPH-DRO | | | | | | |
| TPH-ORO | | | | | | |

**NOTE:**
N/A: Not Applicable

DCRBCA REPORT **FORM NO. 31**

**LUST CASE NO.:**

**FACILITY ID NO.:**

**SUBMITTAL DATE:**

**PREPARED BY:**

## TIER 2A CONCLUSIONS AND RECOMMENDATIONS

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| **DCRBCA REPORT** | **FORM NO. 31** |

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| **LUST CASE NO.:** | **FACILITY ID NO.:** |
| **SUBMITTAL DATE:** | **PREPARED BY:** |

## TIER 2A CONCLUSIONS AND RECOMMENDATIONS

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# APPENDIX A.3
# USER'S GUIDE FOR REPORT FORMS

## INTRODUCTION

The DCRBCA Report Forms are distributed in two high-density 3.5" floppy diskettes. The diskette contains 2 files (two Microsoft Excel files):

1. T1Forms.xls
2. T2Forms.xls

The MS Excel files (T1Forms.xls and T2Forms.xls) as the name implies contain forms for the two different tiers within the DCRBCA program.

## HARDWARE AND SOFTWARE REQUIREMENTS

To use the DCRBCA Forms, you need:

- An 80386-based computer or better.
- A monitor with VGA capabilities or better. An 800x600 resolution is highly recommended.
- A mouse.
- Microsoft (MS) Windows 3.1 or later version.
- Microsoft (MS) Excel 5.0 or later version.
- 8 megabytes of random access memory (RAM).
- 1 megabytes of disk space per worksheet module beyond the installation of MS Windows and MS Excel or MS Word.

## PREREQUISITES

Operating knowledge and intermediate level of experience of MS Excel.

## INSTALLATION

- Insert the diskette into the floppy drive.
- Create directory in your harddrive,
  e.g. *MD C:\DC if using MSDOS prompt. Window 3.1 users can create a directory in the File Manager and Windows 95 users in the Explorer.*
- Copy the files from the floppy drive to the directory,
  e.g. *COPY A:*.* C:\DC\*.**

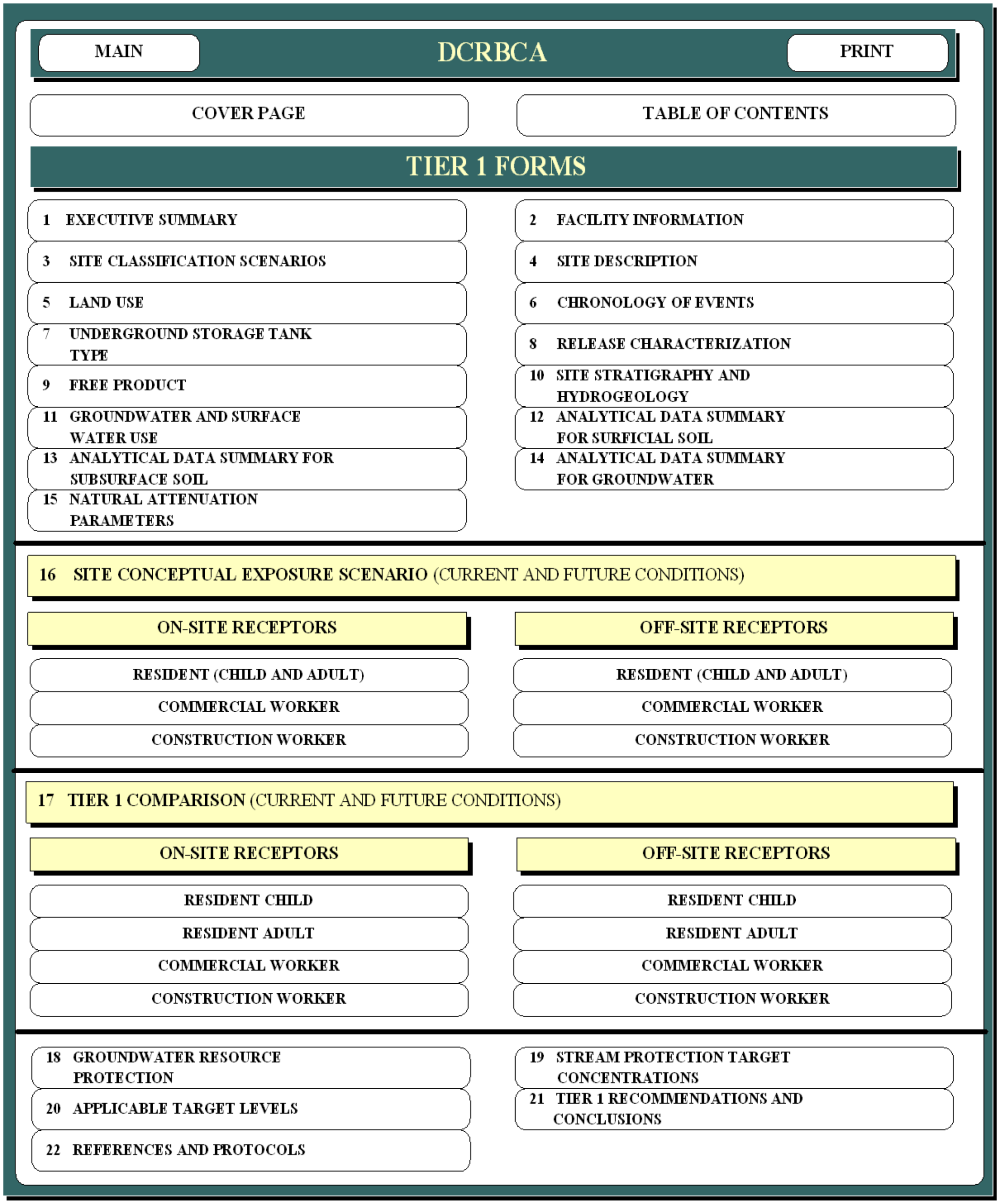
## USING THE FORMS

Note: Consult your Microsoft Excel manual for the basic spreadsheet operations.

## Tier 1 Forms

- Use ***"File"*** and ***"Open"*** command from MS Excel menu to open the file.

Use the ***"Main Menu"*** in the package to browse through the software. Once within the package, the MAIN MENU button, provided on all the forms enables the user to get to the Main Menu. The relationship of the button to the DCRBCA Forms is shown in the picture below.



- Enter your data in red-underlined spaces only. The package will not allow the user to (i) change the information originally present on the form, (ii) the formatting, and (iii) to enter data in spaces without red-underlined spaces.
- Each form has four options, **MAIN MENU** **PREVIOUS** **NEXT** **PRINT**. The first button takes you to the Main Menu, the second takes you to the previous form, the third takes you to the next form, and the fourth button prints the worksheet (other options for printing these forms are provided in the next section).
- **Hint:** Save the file under a different name. Use the "***File***" and "***Save As***" command from MS Excel menu.

## PRINTING THE FORMS

### MS Excel File

- Click on the ***PRINT*** button on the ***MAIN MENU***.
- Check the boxes besides the Forms you desire to print and click print.
- There are options for ***selecting*** or ***deselecting*** all the Forms simultaneously.
- The ***CANCEL*** button takes you back to the ***MAIN MENU***.

Alternatively, the user can print each form one at a time by using the ***PRINT icon*** in the MS Excel toolbar directly.

## TIER 1 FORMS

☐ COVER PAGE

☐ TABLE OF CONTENTS

☐ 1 EXECUTIVE SUMMARY

☐ 2 FACILITY INFORMATION

☐ 3 SITE CLASSIFICATION SCENARIOS

☐ 4 SITE DESCRIPTION

☐ 5 LAND USE

☐ 6 CHRONOLOGY OF EVENTS

☐ 7 UNDERGROUND STORAGE TANK TYPE

☐ 8 RELEASE CHARACTERIZATION

☐ 9 FREE PRODUCT

☐ 10 SITE STRATIGRAPHY AND HYDROGEOLOGY

☐ 11 GROUNDWATER AND SURFACE WATER USE

☐ 12 ANALYTICAL DATA SUMMARY FOR SURFICIAL SOIL

☐ 13 ANALYTICAL DATA SUMMARY FOR SUBSURFACE SOIL

☐ 14 ANALYTICAL DATA SUMMARY FOR GROUNDWATER

☐ 15 NATURAL ATTENUATION PARAMETERS

### 16 SITE CONCEPTUAL EXPOSURE SCENARIO (CURRENT AND FUTURE CONDITIONS)

| ON-SITE RECEPTORS | OFF-SITE RECEPTORS |
|---|---|
| ☐ RESIDENTIAL EXPOSURES | ☐ RESIDENTTIAL EXPOSURES |
| ☐ COMMERCIAL WORKER | ☐ COMMERCIAL WORKER |
| ☐ CONSTRUCTION WORKER | ☐ CONSTRUCTION WORKER |

### 17 TIER 1 COMPARISON (CURRENT AND FUTURE CONDITIONS)

| ON-SITE RECEPTORS | OFF-SITE RECEPTORS |
|---|---|
| ☐ RESIDENT CHILD | ☐ RESIDENT CHILD |
| ☐ RESIDENT ADULT | ☐ RESIDENT ADULT |
| ☐ COMMERCIAL WORKER | ☐ COMMERCIAL WORKER |
| ☐ CONSTRUCTION WORKER | ☐ CONSTRUCTION WORKER |

☐ 18 COMPLIANCE WELL CONCENTRATIONS

☐ 18 COMPLIANCE WELL CONCENTRATIONS

☐ 19 APPLICABLE TARGET LEVELS

☐ 20 TIER 1 RECOMMENDATIONS AND CONCLUSIONS

☐ 21 REFERENCES AND PROTOCOLS

## SPECIAL INSTRUCTIONS

## TIER 1 REPORT FORMS

### Cover

The information on the cover page (site ID, address etc.) must be completed as this information is automatically entered at the top of all the forms.

### Form No. 10 – Hydrogeology of the Saturated Zone

The Darcy velocity is automatically calculated if the hydraulic gradient and hydraulic conductivity are entered on the same form.

### Form No. 12/13 – Analytical Data Summary for Surficial/Subsurface Soil

The arithmetic average, maximum, and ratio of the arithmetic average to maximum, are calculated automatically when data is entered into the form.

### Form No. 17 - Comparison of Representative Site Concentrations with Tier 1 RBSLs

This form compares the representative site concentrations with Tier 1 RBSLs. When representative concentrations are entered they will be compared automatically with the RBSLs previously calculated and an E/NE entered in the adjoining column. As mentioned in the footnote, "E" indicates that the representative site concentration "exceed" RBSL and "NE" indicates that the representative site concentration does not exceed RBSL. For a discussion on the representative concentration refer to the District of Columbia Risk-Based Corrective Action Technical Guidance document.

### Form No. 18/19 – Tier 1 Groundwater Resource Protection and Stream Protection Target Concentrations

When representative concentrations and RBSLs are entered the software automatically enters E/NE as appropriate. The user may run (i) the DCRBCA computational program, (ii) any other appropriate software, or (iii) the information in Table 5-7 to develop the RBSLs protective of GW or stream. These calculated values have to be entered by the user on this form.

### Form No. 20 – Tier 1 Applicable Target Levels for Various Media

The values in this table are entered automatically from Forms 17, 18, and 19, and require no additional input from the user.

## TIER 2A REPORT FORMS

Cover

Site information should be completed as for the Tier 1 report forms as they are entered automatically into each additional form.

Form No.23 – Tier 2A Fate and Transport Parameters

On these forms the user should justify all the fate and transport factors used for developing Tier 2A target levels. Even if default values are used, they have to be justified as being representative of current conditions.

Form No. 25 - Tier 2A Exposure Factors

This form is similar to Form 23 in that it requires justification for exposure factors used. Typically for Tier 2A evaluations the default exposure factors used for Tier 1 will be used.

Form Nos. 27/28/29 – Comparison of Tier 2A SSTLs with Representative concentrations and Tier 2A Groundwater Resource Protection and Stream Protection Target Concentrations

Representative concentrations and SSTLs should be entered here, see District of Columbia Risk-Based Corrective Action Technical Guidance document for calculation of the representative concentration. The user has to run the DCRBCA computational program or any other appropriate software to develop these SSTLs and enter the Tier 2A calculated SSTLs on this form. The software will automatically compare these values and enter E/NE as required.

Form No. 30 - Tier 1 Applicable Target Levels for Various Media

Data is automatically entered from forms 27, 28, and 29, and requires no inputs from the user.

# APPENDIX B
# MODEL/EQUATIONS FOR ESTIMATING TIER 1 AND TIER 2A TARGET LEVELS WITHIN THE DCRBCA PROCESS

# APPENDIX B
# MODEL/EQUATIONS FOR ESTIMATING TIER 1 AND TIER 2A TARGET LEVELS WITHIN THE DCRBCA PROCESS

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The symbols used in the equations are all defined with their units. Also, symbols are consistent with those used in Tables 5-4 and 5-5; the DCRBCA computational software and report forms.

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## Indoor Inhalation of Vapors
## (Child and Adult Resident, and Commercial Worker)

Carcinogenic Effects

$$RBTL_{ai} = \frac{TR \times AT_c \times 365}{ED \times EF \times ET_{in} \times IUR \times 1000}$$

Non-carcinogenic Effects

$$RBTL_{ai} = \frac{THQ \times AT_{nc} \times 365 \times RfC}{ED \times EF \times ET_{in}}$$

Source: RAGS Vol. I Part F, 2009

where,

$RBTL_{ai}$ = Risk-based target level in indoor air [mg/m$^3$]
$TR$ = Target risk or the increased chance of developing cancer over a lifetime due to exposure to a chemical [-]
$THQ$ = Target hazard quotient for a chemical [-]
$AT_c$ = Averaging time for carcinogens[year]
$AT_{nc}$ = Averaging time for non-carcinogens[year]
$ED$ = Exposure duration [year]
$EF$ = Exposure frequency [day/year]
$ET_{in}$ = Indoor Exposure time [(hr/day)×(1 day/24 hours)]
$IUR$ = Chemical-specific inhalation unit risk [(ug/m$^3$)$^{-1}$]
$RfC$ = Chemical-specific inhalation reference concentration [mg/m$^3$]
$365$ = Converts $AT_c$, $AT_{nc}$ in years to days [day/year]
$1000$ = Converts mg to ug [ug/mg]

## Outdoor Inhalation of Vapors
## (Child and Adult Resident, Commercial Worker, and Construction Worker)

Carcinogenic Effects

$$RBTL_{ao} = \frac{TR \times AT_c \times 365}{ED \times EF \times ET_{out} \times IUR \times 1000}$$

Non-carcinogenic Effects

$$RBTL_{ao} = \frac{THQ \times AT_{nc} \times 365 \times RfC}{ED \times EF \times ET_{out}}$$

Source: RAGS Vol. I Part F, 2009

where,

$RBTL_{ao}$ = Risk-based target level in outdoor air [mg/m$^3$]

$TR$ = Target risk or the increased chance of developing cancer over a lifetime due to exposure to a chemical [-]

$THQ$ = Target hazard quotient for a chemical [-]

$AT_c$ = Averaging time for carcinogens [year]

$AT_{nc}$ = Averaging time for non-carcinogens [year]

$ED$ = Exposure duration [year]

$EF$ = Exposure frequency [day/year]

$ET_{out}$ = Outdoor Exposure time [(hr/day)×(1 day/24 hours)]

$IUR$ = Chemical-specific inhalation unit risk [(ug/m$^3$)$^{-1}$]

$RfC$ = Chemical-specific inhalation reference dose [mg/m$^3$]

$365$ = Converts $AT_c$, $AT_{nc}$ in years to days [day/year]

$1000$ = Converts mg to ug [ug/mg]

## Ingestion of Water
## (Child and Adult Resident)

Carcinogenic Effects

$$RBTL_{ingw} = \frac{TR \times BW \times AT_c \times 365}{ED \times EF \times IR_w \times SF_o}$$

Non-carcinogenic Effects

$$RBTL_{ingw} = \frac{THQ \times BW \times AT_{nc} \times 365 \times RfD_o}{ED \times EF \times IR_w}$$

Source: RAGS Vol. I Part A, 1989

where,

$RBTL_{ingw}$ = Risk-based target level for ingestion of water [mg/L]
$TR$ = Target risk or the increased chance of developing cancer over a lifetime due to exposure to a chemical [-]
$THQ$ = Target hazard quotient for a chemical [-]
$BW$ = Body weight [kg]
$AT_c$ = Averaging time for carcinogens [year]
$AT_{nc}$ = Averaging time for non-carcinogens [year]
$ED$ = Exposure duration [year]
$EF$ = Exposure frequency [day/year]
$ET$ = Exposure time [hr/day]
$IR_w$ = Water ingestion rate [L/day]
$SF_o$ = Chemical-specific oral cancer slope or potency factor [(mg/kg-day)$^{-1}$]
$RfD_o$ = Chemical-specific oral reference dose [mg/kg-day]
$365$ = Converts $AT_c$, $AT_{nc}$ in years to days [day/year]

## Inhalation of Vapors from Groundwater During Domestic Water Use
## (Child and Adult Resident)

Carcinogenic Effects

$$RBTL_{inhdw} = \frac{TR \times AT_c \times 365}{ED \times EF \times ET_{in} \times K_f \times IUR \times 1000}$$

Non-carcinogenic Effects

$$RBTL_{inhdw} = \frac{THQ \times AT_{nc} \times 365 \times RfC}{ED \times EF \times ET_{in} \times K_f}$$

Source: USEPA User's Guide for Regional Screening Levels, May 2010.

where,

$RBTL_{inhdw}$ = Risk-based target level in indoor air during domestic water use [mg/m$^3$]

$TR$ = Target risk or the increased chance of developing cancer over a lifetime due to exposure to a chemical [-]

$THQ$ = Target hazard quotient for a chemical [-]

$AT_c$ = Averaging time for carcinogens[year]

$AT_{nc}$ = Averaging time for non-carcinogens[year]

$ED$ = Exposure duration [year]

$EF$ = Exposure frequency [day/year]

$ET_{in}$ = Indoor Exposure time [(hr/day)×(1 day/24 hours)]

$K_f$ = Volatilization factor for domestic water use [day/year]

$IUR$ = Chemical-specific inhalation unit risk [(ug/m$^3$)$^{-1}$]

$RfC$ = Chemical-specific inhalation reference concentration [mg/m$^3$]

$365$ = Converts $AT_c$, $AT_{nc}$ in years to days [day/year]

$1000$ = Converts mg to ug [ug/mg]

## Inhalation of Vapors from and Ingestion of Groundwater During Domestic Water Use
## (Child and Adult Resident)

Carcinogenic and Non-carcinogenic Effects

$$RBTL_{gwd} = \frac{1}{\frac{1}{RBSL_{ingw}} + \frac{1}{RBSL_{inhdw}}}$$

Source: USEPA User’s Guide for Regional Screening Levels, May 2010.

where,

$RBTL_{gwd}$ = Risk-based target level for groundwater used for domestic use [mg/L]

$RBTL_{ingw}$ = Risk-based target level for ingestion of groundwater[mg/L]

$RBTL_{inhdw}$ = Risk-based target level for inhalation of vapor from groundwater during domestic use [mg/L]

## Ingestion of Chemicals in Soil
## (Child and Adult Resident, Commercial Worker, and Construction Worker)

Carcinogenic Effects

$$RBTL_{ings} = \frac{TR \times BW \times AT_{c} \times 365}{ED \times EF \times IR_{soil} \times ABS_{GI} \times SF_{o} \times 10^{-6}}$$

Non-carcinogenic Effects

$$RBTL_{ings} = \frac{THQ \times BW \times AT_{nc} \times 365 \times RfD_{o}}{ED \times EF \times IR_{soil} \times ABS_{GI} \times 10^{-6}}$$

Source: RAGS Vol. I Part A, 1989

where,

$RBTL_{ings}$ = Risk-based target level for ingestion of soil [mg/kg]
$TR$ = Target risk or the increased chance of developing cancer over a lifetime due to exposure to a chemical [-]
$THQ$ = Target hazard quotient for a chemical [-]
$BW$ = Body weight [kg]
$AT_{c}$ = Averaging time for carcinogens [year]
$AT_{nc}$ = Averaging time for non-carcinogens [year]
$ED$ = Exposure duration [year]
$EF$ = Exposure frequency [day/year]
$IR_{soil}$ = Soil ingestion rate [mg/day]
$ABS_{GI}$ = Oral absorption fraction [-]
$SF_{o}$ = Chemical-specific oral cancer slope factor [(mg/kg-day)$^{-1}$]
$RfD_{o}$ = Chemical-specific oral reference dose [mg/kg-day]
$365$ = Converts $AT_{c}$, $AT_{nc}$ in years to days [day/year]
$10^{-6}$ = Converts mg to kg [mg/kg]

## Dermal Contact with Chemicals in Water
## (Child and Adult Resident, Commercial Worker, and Construction Worker)

Carcinogenic Effects

$$RBTL_{dcw} = \frac{TR \times BW \times AT_c \times 365 \times 1000}{ED \times EF \times SA_{gw} \times EV_{gw} \times Z \times SF_{ABS}}$$

Non-carcinogenic Effects

$$RBTL_{dcw} = \frac{THQ \times BW \times AT_{nc} \times 365 \times 1000 \times RfD_{ABS}}{ED \times EF \times SA_{gw} \times EV_{gw} \times Z}$$

For organic chemicals,

If $t_{event} < t^*$, then $Z = 2 \times FA \times K_p \sqrt{6\tau_{event} \frac{t_{event}}{\pi}}$

If $t_{event} > t^*$, then

$$Z = FA \times K_p \left[ \frac{t_{event}}{1+B} + 2\tau_{event} \left( \frac{1+3B+3B^2}{(1+B)^2} \right) \right]$$

For inorganic chemicals, $Z = K_p \times t_{event}$

where,

$RBTL_{dcw}$ = Risk-based target level for dermal contact with water [mg/L]
$TR$ = Target risk [-]
$THQ$ = Target hazard quotient for a chemical [-]
$BW$ = Body weight [kg]
$AT_c$ = Averaging time for carcinogens [year]
$AT_{nc}$ = Averaging time for non-carcinogens [year]
$SA_{gw}$ = Skin surface area available for contact with water [$cm^2$]
$EV_{gw}$ = Event frequency [event/day]
$ED$ = Exposure duration [year]
$EF$ = Exposure frequency [day/year]
$SF_{ABS}$ = Chemical-specific dermal cancer slope or potency factor [$(mg/kg\text{-}day)^{-1}$]
$RfD_{ABS}$ = Chemical-specific dermal reference dose [mg/kg-day]
$365$ = Converts $AT_c$, $AT_{nc}$ in years to days [day/year]
$1000$ = Conversion factor from $cm^3$ to L [$cm^3/L$]
$t_{event}$ = Event duration [hr/event]
$t^*$ = Chemical-specific time to reach steady-state [hr]
$Z$ = Chemical-specific dermal factor [cm/event]
$K_p$ = Chemical-specific dermal permeability coefficient [cm/hr]
$FA$ = Chemical-specific fraction absorbed in water [-]
$\tau$ = Chemical-specific lag time [hr/event]
$B$ = Chemical-specific relative contribution of permeability coefficient [-]

| | |
|---|---|
| $B = K_P \frac{\sqrt{MW}}{2.6}$<br>$\log K_P = -2.80 + 0.66 \log K_{OW} - 0.0056MW$<br>If B<0.6 or B=0.6, then, $t^* = 2.4\tau_{event}$<br>If B>0.6 then, $t^* = 6\tau_{event} \times (b - \sqrt{b^2 - c^2})$<br>where,<br>$c = \frac{1 + 3B + 3B^2}{3(1 + B)}$<br>$b = 2 \times \frac{(1 + B)^2}{\pi} - c$<br>$\tau_{event} = 0.105 \times 10^{(0.0056MW)}$<br>Source: RAGS Vol. I Part E, 2004 | where,<br>$MW$ = Molecular weight [g/mole]<br>$K_{ow}$ = Octanol-water partition coefficient [L/kg] |

## Dermal Contact with Chemicals in Soil
## (Child and Adult Resident, Commercial Worker, and Construction Worker)

Carcinogenic Effects

$$RBTL_{ds} = \frac{TR \times BW \times AT_c \times 365}{ED \times EF \times SA_{soil} \times EV_{soil} \times AF \times ABS_d \times SF_{ABS} \times 10^{-6}}$$

Non-carcinogenic Effects

$$RBTL_{ds} = \frac{THQ \times BW \times AT_{nc} \times 365 \times RfD_{ABS}}{ED \times EF \times SA_{soil} \times EV_{soil} \times AF \times ABS_d \times 10^{-6}}$$

Source: RAGS Vol. I Part E, 2004

where,

$RBTL_{ds}$ = Risk-based target level for dermal contact with soil [mg/kg]
$TR$ = Target risk or the increased chance of developing cancer over a lifetime due to exposure to a chemical [-]
$THQ$ = Target hazard quotient for a chemical [-]
$BW$ = Body weight [kg]
$AT_c$ = Averaging time for carcinogens [year]
$AT_{nc}$ = Averaging time for non-carcinogens [year]
$ED$ = Exposure duration [year]
$EF$ = Exposure frequency [day/year]
$SA_{soil}$ = Skin surface area available for contact with soil [$cm^2$]
$EV_{soil}$ = Event frequency [event/day]
$AF$ = Soil to skin adherence factor [$mg/cm^2$-event]
$ABS_d$ = Chemical-specific dermal absorption fraction [-]
$SF_{ABS}$ = Chemical-specific dermal cancer slope factor [$(mg/kg\text{-}day)^{-1}$]
$RfD_{ABS}$ = Chemical-specific oral reference dose [mg/kg-day]
$365$ = Converts $AT_c$, $AT_{nc}$ in years to days [day/year]
$10^{-6}$ = Converts mg to kg [kg/mg]

## Inhalation of Vapors and Particulates of Chemicals in Soil
## (Child and Adult Resident, Commercial Worker, and Construction Worker)

Carcinogenic Effects

$$RBTL_{inhs} = \frac{TR \times AT_c \times 365}{ED \times EF \times ET_{out} \times IUR \times (VF_s + VF_p) \times 1000}$$

Non-carcinogenic Effects

$$RBTL_{inhs} = \frac{THQ \times AT_c \times 365 \times RfC}{ED \times EF \times ET_{out} \times (VF_s + VF_p)}$$

where,

$RBTL_{inhs}$ = Risk-based target level of inhalation of vapors and particulates from soil [mg/kg]

$TR$ = Target risk or the increased chance of developing cancer over a lifetime due to exposure to a chemical [-]

$THQ$ = Target hazard quotient for a chemical [-]

$AT_c$ = Averaging time for carcinogens [year]

$AT_{nc}$ = Averaging time for non-carcinogens [year]

$ED$ = Exposure duration [year]

$EF$ = Exposure frequency [day/year]

$ET_{out}$ = Outdoor exposure time [(hr/day)×(1 day/24 hours)]

$IUR$ = Chemical-specific inhalation unit risk [$(\text{ug/m}^3)^{-1}$]

$RfC$ = Chemical-specific inhalation reference dose [$\text{mg/m}^3$]

$365$ = Converts $AT_c$, $AT_{nc}$ in years to days [day/year]

$1000$ = Converts mg to ug [ug/mg]

$VF_s$ = Volatilization factor for vapor emissions from soil [$(\text{mg/m}^3$-air)/(mg/kg-soil)]

$VF_p$ = Volatilization factor for particulate emissions from soil [$(\text{mg/m}^3$-air)/(mg/kg-soil)]

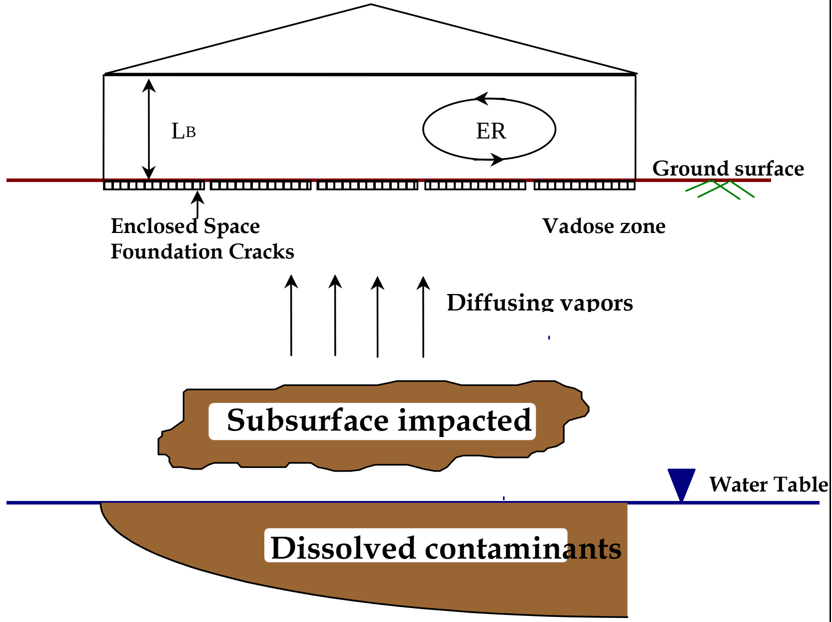
## Ingestion of, Dermal Contact with, and Inhalation of Vapors and Particulates from Soil
## (Child and Adult Resident, Commercial Worker, and Construction Worker)

$$RBTL_s = \frac{1}{\frac{1}{RBSL_{ings}} + \frac{1}{RBSL_{ds}} + \frac{1}{RBSL_{inhs}}}$$

where,

$RBTL_s$ = Risk-based target level of soil [mg/kg]
$RBTL_{ings}$ = Risk-based target level for ingestion of soil [mg/kg]
$RBTL_{ds}$ = Risk-based target level for dermal contact with soil [mg/kg]
$RBTL_{inhs}$ = Risk-based target level of inhalation of vapors and particulates from soil [mg/kg]

## Subsurface Soil Vapor Concentration Protective Indoor Vapor Inhalation



$$RBTL_{svi} = \frac{RBTL_{ai}}{\alpha_{sv}}$$

where,

$RBTL_{svi}$ = Risk-based target level for indoor inhalation of vapors from subsurface [mg/m$^3$-air]

$RBTL_{ai}$ = Risk-based target level for indoor inhalation of air [mg/m$^3$-air]

$\alpha_{sv}$ = Attenuation factor from subsurface soil vapor to indoor (enclosed space) air [-]

Note: $\alpha_{sv}$ is calculated using equation on pp-B30 with depth to soil vapor measurement.

Source: ASTM E1739-95

## Subsurface Soil Vapor Concentration Protective of Outdoor Vapor Inhalation

$$RBTL_{svo} = \frac{RBTL_{ao}}{VF_{svamb}}$$

where,

$RBTL_{svo}$ = Risk-based target level for outdoor inhalation of vapors from subsurface soil vapor [mg/m$^3$-air]

$RBTL_{ao}$ = Risk-based target level for outdoor inhalation of air [mg/m$^3$-air]

$VF_{svamb}$ = Volatilization factor from subsurface soil vapor to outdoor air [--]

Note: The above equation is equal to the sub-surface soil concentration protective of outdoor vapor inhalation ($VF_{samb}$) except where the (i) volatilization factor ($VF_{svamb}$) is estimated without the use of equilibrium conversion factors and (ii) depth ($d_{sv}$) used is up to the soil vapor measurement.

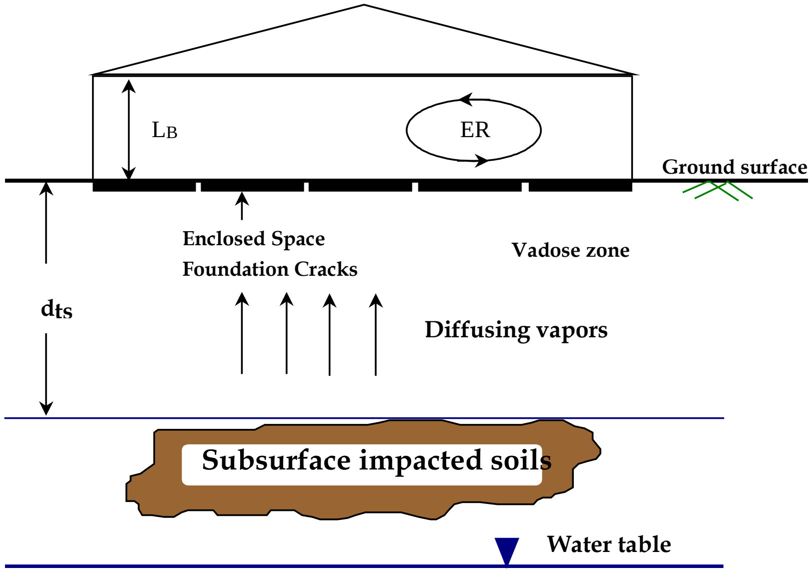
## Subsurface Soil Concentration Protective of Indoor Vapor Inhalation

$$RBTL_{si} = \frac{RBTL_{ai}}{VF_{sesp}}$$

where,

| | | |
|---|---|---|
| $RBTL_{si}$ | = | Risk-based target level for indoor inhalation of vapors from subsurface soils [mg/kg-soil] |
| $RBTL_{ai}$ | = | Risk-based target level for indoor inhalation of air [mg/m$^3$-air] |
| $VF_{sesp}$ | = | Volatilization factor from subsurface soil to indoor (enclosed space) air [(mg/m$^3$-air)/(mg/kg-soil)] |

Source: ASTM E1739-95



## Subsurface Soil Concentration Protective of Outdoor Vapor Inhalation

$$RBTL_{so} = \frac{RBTL_{ao}}{VF_{samb}}$$

where,

$RBTL_{so}$ = Risk-based target level for outdoor inhalation of vapors from subsurface soil [mg/kg-soil]
$RBTL_{ao}$ = Risk-based target level for outdoor inhalation of air [mg/m$^3$-air]
$VF_{samb}$ = Volatilization factor from subsurface soil to outdoor air [(mg/m$^3$-air)/(mg/kg-soil)]

Source: ASTM E1739-95

## Groundwater Concentration Protective of Indoor Vapor Inhalation

$$RBTL_{wi} = \frac{RBTL_{ai}}{VF_{wesp}}$$

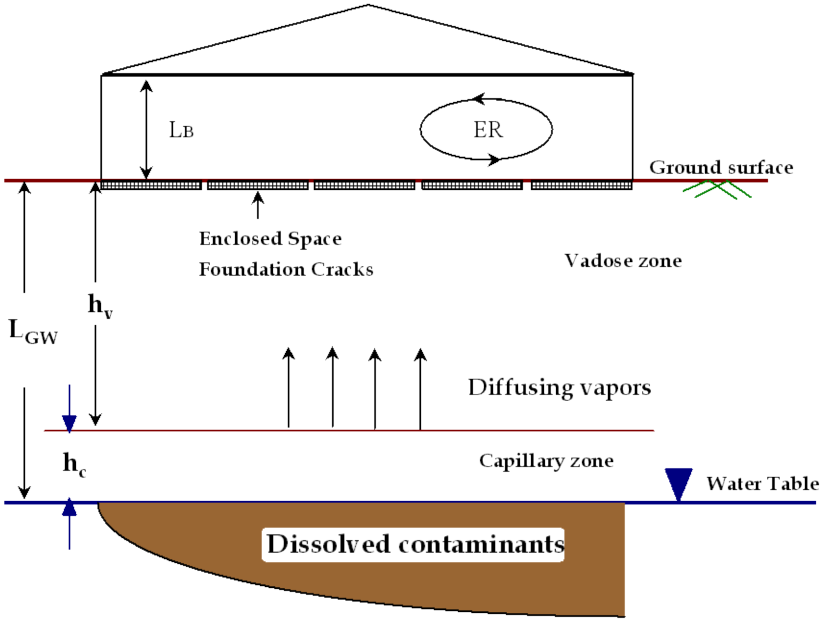
where,

$RBTL_{wi}$ = Risk-based target level for indoor inhalation of vapors from groundwater [mg/L-water]

$RBTL_{ai}$ = Risk-based target level for indoor inhalation of air [mg/m$^3$-air]

$VF_{wesp}$ = Volatilization factor from groundwater to indoor (enclosed space) air [(mg/m$^3$-air)/(mg/L-water)]

Source: ASTM E1739-95



## Groundwater Concentration Protective of Outdoor Vapor Inhalation

$$RBTL_{wo} = \frac{RBTL_{ao}}{VF_{wamb}}$$

where,

$RBTL_{wi}$ = Risk-based target level for outdoor inhalation of vapors from groundwater [mg/L-water]
$RBTL_{ao}$ = Risk-based target level for outdoor inhalation of air [mg/m$^3$-air]
$VF_{wamb}$ = Volatilization factor from groundwater to outdoor air [(mg/m$^3$-air)/(mg/L-water)]

Source: ASTM E1739-95

## Attenuation Factors
## (Subsurface Soil Vapor to Indoor Air)

For advection and diffusion,

$$\alpha_{sv} = \frac{\left[\left(\frac{D_T^{eff} \times A_B}{Q_{bldg} \times L_T}\right) \times \exp\left(\frac{Q_{soil} \times L_{crack}}{D_{crack}^{eff} \times A_{crack}}\right)\right]}{\left[\exp\left(\frac{Q_{soil} \times L_{crack}}{D_{crack}^{eff} \times A_{crack}}\right) + \left(\frac{D_T^{eff} \times A_B}{Q_{bldg} \times L_T}\right) + \left(\frac{D_T^{eff} \times A_B}{Q_{soil} \times L_T}\right)\left[\exp\left(\frac{Q_{soil} \times L_{crack}}{D_{crack}^{eff} \times A_{crack}}\right) - 1\right]\right]}$$

For diffusion only,

$$\alpha_{sv} = \frac{\left(\frac{D_T^{eff} \times A_B}{Q_{bldg} \times L_T}\right)}{\left[1 + \left(\frac{D_T^{eff} \times A_B}{Q_{bldg} \times L_T}\right) + \left(\frac{D_T^{eff} \times A_B \times L_{crack}}{L_T \times D_{crack}^{eff} \times A_{crack}}\right)\right]}$$

Source: User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings, 2004

where,

$\alpha_{sv}$ = Attenuation factor for soil vapor [-]
$D_T{}^{eff}$ = Total overall effective diffusion coefficient [$cm^2$/s]
$A_B$ = Area of enclosed space below grade [$cm^2$]
$Q_{bldg}$ = Building ventilation rate [$cm^3$/s]
$L_T$ = Source to building separation [cm]
$Q_{soil}$ = Volumetric flow rate of soil-vapor into the enclosed space [$cm^3$/s]
$L_{crack}$ = Slab thickness [cm]
$D_{crack}{}^{eff}$ = Effective diffusion coefficient through the cracks [$cm^2$/s]
$A_{crack}$ = Area of total cracks [$cm^2$]
$D_{source}$ = Depth below grade to top of contamination [cm]
$L_F$ = Depth below grade to bottom of enclosed space floor [cm]
$L_B$ = Length of building [cm]
$W_B$ = Width of building [cm]
$Q_{bldg}$ = Building ventilation rate [$cm^3$/s]
$H_B$ = Height of building [cm]
$ER$ = Air exchange rate [l/h]
$3600$ = Conversion factor [sec/h]
$\Delta P$ = Soil-building pressure differential [g/cm-$s^2$]
$k_v$ = Soil gas permeability[$cm^2$]
$X_{crack}$ = Floor-wall seam perimeter [cm]
$\mu$ = Viscosity of air at soil temperature [g/cm-s]
$r_{crack}$ = Equivalent crack radius [cm]
$Z_{crack}$ = Crack depth below grade [cm]

| | |
|---|---|
| where,<br>$L_T = D_{source} - L_F$<br>If $L_F > L_{crack}$, $A_B = \left(L_B \times W_B\right) + \left(2 \times L_F \times L_B\right) + \left(2 \times L_F \times W_B\right)$<br>If $L_F \leq L_{crack}$, $A_B = \left(L_B \times W_B\right)$<br>$Q_{bldg} = \left(\frac{L_B \times W_B \times H_B \times ER}{3600}\right)$<br>$A_{crack} = 2 \times \left(L_B + W_B\right) \times w$<br>$Q_{soil} = \frac{2\pi \times \Delta P \times k_v \times X_{crack}}{\mu \times \ln\left(\frac{2Z_{crack}}{r_{crack}}\right)}$<br>$X_{crack} = 2 \times \left(L_B + W_B\right)$<br>$r_{crack} = \left(\frac{A_{crack}}{X_{crack}}\right)$ | |

## Volatilization Factors (Surficial Soil to Outdoor Air)

$$VF_{ss} = \frac{2 \times W_a \times \rho_s}{U_m \times \delta_a} \times \sqrt{\frac{D_s^{eff} \times H}{\pi \times [\theta_{ws} + (K_s \times \rho_s) + (H \times \theta_{as})] \times \tau}} \times 10^3$$

or

$$VF_{ss} = \frac{W_a \times \rho_s \times d_s}{U_m \delta_a \times \tau} \times 10^3$$

Use smaller of the two $VF_{ss}$.

Source: ASTM E1739-95

where:

$W_a$ = Length of soil source area parallel to wind direction [cm]

$\rho_s$ = Dry soil bulk density [g-soil/cm$^3$-soil]

$U_m$ = Mean annual wind speed [cm/s]

$\delta_a$ = Breathing zone height [cm]

$d_s$ = Depth to base of surficial soil zone [cm]

$D_s^{eff}$ = Effective diffusion coefficient in soil based on vapor-phase concentration [cm$^2$/s]

$H$ = Chemical-specific Henry's Law constant [(mg/cm$^3$-air)/ (mg/cm$^3$-H$_2$O)]

$\theta_{ws}$ = Volumetric water content in vadose zone soils [cm$^3$-H$_2$O/cm$^3$- soil]

$K_{sv}$ = $f_{oc} \times K_{oc}$
= Chemical-specific soil-water sorption coefficient for the unsaturated zone [cm$^3$-H$_2$O/g-soil]

$\theta_{as}$ = Volumetric air content in the vadose zone soils [cm$^3$-air/cm$^3$-soil]

$\tau$ = Averaging time for vapor flux [s]
= *ED (yr)* × *365 (day/yr)* × *86400 (sec/day)*

$10^3$ = Conversion factor [(cm$^3$-kg)/(m$^3$-g)]

*Note: Surficial soil properties are assumed same as the vadose zone properties.*

## Volatilization Factors
## (Particulate Emissions from Surficial Soil)

$$VF_p = \frac{P_e \times W_a}{U_m \times \delta_a} \times 10^3$$

Source: ASTM E1739-95

where:

$P_e$ = Particulate emission rate [g-soil/cm$^2$-sec]
$W_a$ = Length of soil source area parallel to wind direction [cm]
$U_m$ = Mean annual wind speed [cm/s]
$\delta_a$ = Breathing zone height [cm]
$10^3$ = Conversion factor [(cm$^3$-kg)/(m$^3$-g)]

## Volatilization Factors
## (Subsurface Soil Vapor to Outdoor Air)

$$VF_{svamb} = \frac{1}{\left(1 + \frac{U_m \times 100 \times \delta_a \times d_{sv}}{D_s^{eff} \times W_a}\right)}$$

Note: The above equation is equal to the sub-surface soil concentration protective of outdoor vapor inhalation ($VF_{samb}$) except where the (i) volatilization factor ($VF_{svamb}$) is estimated without the use of equilibrium conversion factors and (ii) depth ($d_{sv}$) used is up to the soil vapor measurement.

where,

$VF_{svamb}$ = Volatilization factor from subsurface soil vapor to outdoor air [--]

$U_m$ = Mean annual wind speed [m/s]

$\delta_a$ = Breathing zone height [cm]

$d_{sv}$ = Depth to subsurface soil vapor source [cm]

$D_s^{eff}$ = Effective diffusion coefficient in soil based on vapor-phase concentration [$cm^2/s$]

$W_a$ = Dimension of soil source area parallel to wind direction [cm]

*100* = Converts wind speed in [m/s] to [cm/s]

## Volatilization Factors
## (Subsurface Soil to Indoor Air)

$$VF_{sesp} = \frac{H \times \rho_s}{[\theta_{ws} + (K_{sv} \times \rho_s) + (H \times \theta_{as})]} \times \alpha_s \times 10^3$$

Note: $\alpha_s$ is calculated using equation on pp-B30 with depth to soil source.

Source: ASTM 1739-95

where,

$VF_{sesp}$ = Volatilization factor from subsurface soil to indoor (enclosed space) air [$m^3$-air/(mg/kg-soil)]

$H$ = Chemical-specific Henry's Law constant [L-water/L-air]

$\rho_s$ = Dry soil bulk density [g-soil/$cm^3$-soil]

$\theta_{ws}$ = Volumetric water content in vadose zone soil [$cm^3$-water/$cm^3$-soil]

$\theta_{as}$ = Volumetric air content in vadose zone soil [$cm^3$-air/$cm^3$-soil]

$K_{sv}$ = $f_{ocv} \times K_{oc}$ = Chemical-specific soil-water sorption coefficient in vadose zone [$cm^3$/g]

$\alpha_s$ = Attenuation factor from subsurface soil to indoor

$10^3$ = Conversion factor [($cm^3$-kg)/($m^3$-g)]

## Volatilization Factors
## (Subsurface Soil to Outdoor Air)

$$VF_{samb} = \frac{H \times \rho_s}{\left(\theta_{ws} + K_{sv} \times \rho_s + H \times \theta_{as}\right)\left(1 + \frac{100 \times U_m \times \delta_a \times d_{ts}}{D_s^{eff} \times W_{ga}}\right)} \times 10^3$$

Source:  ASTM E1739-95

where,

$VF_{samb}$ = Volatilization factor from subsurface soil to outdoor air [(mg/m$^3$-air)/(mg/kg-soil)]

$H$ = Vadose zone chemical specific Henry's Law constant [L-water/L-air]

$\rho_s$ = Dry soil bulk density [g-soil/cm$^3$-soil]

$\theta_{ws}$ = Volumetric water content in vadose zone soil [cm$^3$-water/cm$^3$-soil]

$\theta_{as}$ = Volumetric air content in vadose zone soil [cm$^3$-air/cm$^3$-soil]

$K_{sv}$ = $f_{ocv} \times K_{oc}$ = Chemical-specific soil-water sorption coefficient in vadose zone [cm$^3$/g]

$U_m$ = Mean annual wind speed [m/s]

$\delta_a$ = Breathing zone height [cm]

$d_{ts}$ = Depth to subsurface soil source [cm]

$D_s^{eff}$ = Effective diffusion coefficient in soil based on vapor-phase concentration [cm$^2$/s]

$W_{ga}$ = Dimension of soil source area parallel to wind direction [cm]

$100$ = Conversion factor [cm/m]

$10^3$ = Conversion factor [cm$^3$-kg/m$^3$-g]

## Volatilization Factors
## (Groundwater to Indoor Air)

$$VF_{wesp} = H \times \alpha_{gw} \times 10^{3}$$

Note: $\alpha_{gw}$ is calculated using equation on pp-B30 with depth to groundwater.

Source: ASTM 1739-95

where,

$VF_{wesp}$ = Volatilization factor from groundwater to indoor (enclosed space) air [(mg/m$^3$-air)/(mg/L-water)]

$H$ = Vadose zone chemical specific Henry's Law constant [L-water/L-air]

$\alpha_{gw}$ = Attenuation factor from groundwater to indoor

$10^3$ = Conversion factor [L/m$^3$]

## Volatilization Factors
## (Groundwater to Outdoor Air)

$$VF_{wamb} = \frac{H}{1 + \left( \frac{100 \times U_m \times \delta_a \times L_{GW}}{W_{ga} \times D_{ws}^{eff}} \right)} \times 10^3$$

Source: ASTM E1739-95

where,

$VF_{wamb}$ = Volatilization factor from groundwater to outdoor air [(mg/m$^3$-air)/(mg/L-water)]

$H$ = Vadose zone chemical specific Henry's Law constant [L-water/L-air]

$U_m$ = Mean annual wind speed [m/s]

$\delta_a$ = Breathing zone height [cm]

$L_{GW}$ = Depth to groundwater [cm]

$D_{ws}^{eff}$ = Effective diffusion coefficient between groundwater and soil surface [cm$^2$/s]

$W_{ga}$ = Dimension of soil source area parallel to wind direction [cm]

$100$ = Conversion factor [cm/m]

$10^3$ = Conversion factor [L/m$^3$]

## Effective Diffusion Coefficient

$D_s^{eff}$ : Effective diffusion coefficient in soil based on vapor-phase concentration [cm$^2$/s]

$$D_s^{eff} = D^a \times \frac{\theta_{as}^{3.33}}{\theta_T^{2.0}} + D^w \times \frac{1}{H} \times \frac{\theta_{ws}^{3.33}}{\theta_T^{2.0}}$$

where,

$D^a$ = Chemical-specific diffusion coefficient in air [cm$^2$/s]
$D^w$ = Chemical-specific diffusion coefficient in water [cm$^2$/s]
$\theta_{as}$ = Volumetric air content in vadose zone soils [cm$^3$-air/cm$^3$-soil]
$\theta_{ws}$ = Volumetric water content in vadose zone soils [cm$^3$-water/cm$^3$-soil]
$\theta_T$ = Total soil porosity in the impacted zone [cm$^3$/cm$^3$-soil]
$H$ = Chemical-specific Henry's Law constant [L-water/L-air]

$D_{ws}^{eff}$ : Effective diffusion coefficient between groundwater and surface soil [cm$^2$/s]

$$D_{ws}^{eff} = (h_c + h_v) \times \left[ \frac{h_{cap}}{D_{cap}^{eff}} + \frac{h_v}{D_s^{eff}} \right]^{-1}$$

where,

$h_c$ = Thickness of capillary fringe [cm]
$h_v$ = Thickness of vadose zone [cm]
$D_{cap}^{eff}$ = Effective diffusion coefficient through capillary fringe [cm$^2$/s]
$D_s^{eff}$ = Effective diffusion coefficient in soil based on vapor-phase concentration [cm$^2$/s]
$L_{GW}$ = Depth to groundwater ($h_{c\,+}\, h_v$) [cm]

$D_{cap}^{eff}$ : Effective diffusion coefficient for the capillary fringe [cm$^2$/s]

$$D_{cap}^{eff} = D^a \times \frac{\theta_{acap}^{3.33}}{\theta_T^{2.0}} + D^w \times \frac{1}{H} \times \frac{\theta_{wcap}^{3.33}}{\theta_T^{2.0}}$$

where,

$D^a$ = Chemical-specific diffusion coefficient in air [cm$^2$/s]
$D^w$ = Chemical-specific diffusion coefficient in water [cm$^2$/s]
$\theta_{acap}$ = Volumetric air content in capillary fringe soils [cm$^3$-air/cm$^3$-soil]
$\theta_{wcap}$ = Volumetric water content in capillary fringe soils [cm$^3$-water/cm$^3$-soil]
$\theta_T$ = Total soil porosity [cm$^3$/cm$^3$-soil]
$H$ = Chemical-specific Henry's Law constant [L-water/L-air]

$D_{crack}^{eff}$ : Effective diffusion coefficient through foundation cracks [cm$^2$/s]

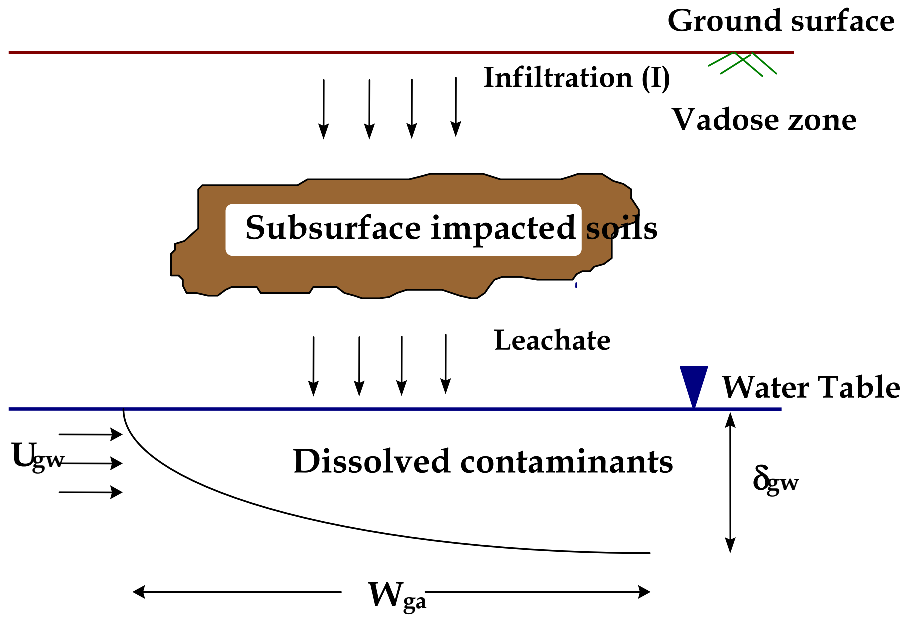
$$D_{crack}^{eff} = D^a \times \frac{\theta_{acrack}^{3.33}}{\theta_T^{2.0}} + D^w \times \frac{1}{H} \times \frac{\theta_{wcrack}^{3.33}}{\theta_T^{2.0}}$$

where,

$D^a$ = Chemical-specific diffusion coefficient in air [cm$^2$/s]
$D^w$ = Chemical-specific diffusion coefficient in water [cm$^2$/s]
$\theta_{acrack}$ = Volumetric air content in foundation/wall cracks [cm$^3$-air/cm$^3$-total volume]
$\theta_{wcrack}$ = Volumetric water content in foundation/wall cracks [cm$^3$-water/cm$^3$-total volume]
$\theta_T$ = Total soil porosity [cm$^3$/cm$^3$-soil]
$H$ = Chemical-specific Henry's Law constant [L-water/L-air]

Source: ASTM E1739-95

## Subsurface Soil Concentrations Protective of Leaching to Groundwater



$$RBTL_{SL} = \frac{RBTL_w}{LF_{SW}}$$

where,

$RBTL_{SL}$ = Risk-based target level for leaching to groundwater from subsurface soil [mg/kg-soil]

$RBTL_w$ = Risk-based target level for ingestion of groundwater [mg/L-water]

$LF_{SW}$ = Leaching Factor (from subsurface soil to groundwater) [(mg/L-water)/(mg/kg-soil)]

Source: ASTM E1739-95

## Leaching Factor from Subsurface Soil to Groundwater

$$LF_{SW} = \frac{\rho_s}{[\theta_{ws} + K_{sv} \times \rho_s + H \times \theta_{as}] \times \left(1 + \frac{U_{gw} \times \delta_{gw}}{I \times W_{ga}}\right)}$$

where,

$LF_{SW}$ = Leaching factor from subsurface soil to groundwater [(mg/L-water)/(mg/kg-soil)]  
$\rho_s$ = Vadose zone dry soil bulk density [g-soil/cm$^3$-soil]  
$\theta_{ws}$ = Volumetric water content in vadose zone soils [cm$^3$-water/cm$^3$- soil]  
$K_{sv}$ = $f_{ocv} \times K_{oc}$ = Chemical-specific soil-water sorption coefficient in vadose zone [cm$^3$-water/g-soil]  
$H$ = Chemical-specific Henry's Law constant [L-water/L-air]  
$\theta_{as}$ = Volumetric air content in the vadose zone soils [cm$^3$-air/cm$^3$-soil]  
$U_{gw}$ = $Ki$ = Groundwater Darcy Velocity [cm/year]  
$K$ = Hydraulic conductivity of saturated zone [cm/year]  
$i$ = Hydraulic gradient in saturated zone [-]  
$\delta_{gw}$ = Groundwater mixing zone thickness [cm]  
$I$ = Infiltration rate of water through vadose zone [cm/year]  
$W_{ga}$ = Groundwater dimension parallel to groundwater flow direction [cm]

This equation consists of two parts (i) the Summer’s model and (ii) equilibrium conversion of the leachate concentration to a soil concentration on a dry weight basis.

Source: ASTM E1739-95

## Soil Concentration at Which Dissolved Pore Water and Vapor Phases Become Saturated

Single Component

$$C_s^{SAT} = \frac{S}{\rho_s} \times [H \times \theta_{as} + \theta_{ws} + K_{sv} \rho_s]$$

Multiple Components

$$C_s^{SAT} = \frac{S_{ei}}{\rho_s} \times [H \times \theta_{as} + \theta_{ws} + K_{sv} \times \rho_s]$$

where,

$C_s^{SAT}$ = Soil concentration at which dissolved pore water and vapor phases become saturated [(mg/kg-soil)]

$S$ = Pure component solubility in water [mg/L-water]

$S_{ei}$ = Effective solubility of component *i* in water = $x_i \times S$ [mg/L-water]

$x_i$ = Mole fraction of component *i* = $(w_i \times MW_{\text{avg}})/MW_i$ [-]

$w_i$ = Weight fraction of component *i* [-]

$MW_{\text{avg}}$ = Average molecular weight of mixture [g/mole]

$MW_i$ = Molecular weight of component *i* [g/mole]

$\rho_s$ = Vadose zone dry soil bulk density [g-soil/cm$^3$-soil]

$H$ = Chemical-specific Henry's Law constant [L-water/L-air]

$\theta_{as}$ = Volumetric air content in the vadose zone soils [cm$^3$-air/cm$^3$-soil]

$\theta_{ws}$ = Volumetric water content in vadose zone soils [cm$^3$-water/cm$^3$- soil]

$K_{sv}$ = $f_{ocv} \times K_{oc}$ = Chemical-specific soil-water sorption coefficient in vadose zone [cm$^3$-water/g-soil]

$f_{ocv}$ = Fraction organic carbon in vadose zone [g-C/g-soil]

Source: ASTM E1739-95

## Soil Vapor Concentration at Which Vapor Phase Becomes Saturated

Single Component

$$C_v^{SAT} = \frac{P^s \times MW}{R \times T} \times 10^6$$

Multiple Components

$$C_v^{SAT} = \frac{x_i \times P_i^s \times MW_i}{R \times T} \times 10^6$$

where,

$C_v^{SAT}$ = Soil vapor concentration at which vapor phase become saturated [mg/m$^3$-air]
$P^s$ = Saturated vapor pressure [atm]
$P_i^s$ = Effective vapor pressure of component *i* in water = $x_i \times P^s$ [atm]
$R$ = Ideal gas constant [0.08206 atm•L/mol•K]
$T$ = Temperature [K]
$S_{ei}$ = Effective solubility of component *i* in water = $x_i \times S$ [mg/L-water]
$x_i$ = Mole fraction of component *i* = $(w_i \times MW_{avg})/MW_i$ [-]
$w_i$ = Weight fraction of component *i* [-]
$MW_{avg}$ = Average molecular weight of mixture [g/mole]
$MW_i$ = Molecular weight of component *i* [g/mole]
$\rho_s$ = Vadose zone dry soil bulk density [g-soil/cm$^3$-soil]
$10^6$ = Conversion factor [(g/L)/(mg/m$^3$)]

Source: ASTM E1739-95

## Domenico Model: Dilution Attenuation Factor in Saturated Zone

Domenico model for multi-dimensional transport with decay and continuous source:

$$\frac{C(x,y,z,t)}{C_o} = (1/8)\ exp\left[\frac{x}{2\,\alpha_x}\left[1 - \sqrt{1+\frac{4\,\lambda\,\alpha_x}{v}}\right]\right] \times erfc\left[\frac{\left[(x-vt)\sqrt{1+\frac{4\,\lambda\,\alpha_x}{v}}\right]}{2\sqrt{\alpha_x \times v \times t}}\right] \times$$

$$\left[erf\left[\frac{(y+Y/2)}{2\sqrt{\alpha_y\,x}}\right] - erf\left[\frac{(y-Y/2)}{2\sqrt{\alpha_y\,x}}\right]\right] \times \left[erf\left[\frac{(z+Z)}{2\sqrt{\alpha_z\,x}}\right] - erf\left[\frac{(z-Z)}{2\sqrt{\alpha_z\,x}}\right]\right]$$

where,

$C$ = Dissolved-phase concentration [mg/L]

$C_o$ = Dissolved-phase concentration at the source (at x=y=z=0) [mg/L]

$v$ = Retarded seepage velocity [m/sec]

$\lambda$ = Overall first order bio-decay rate [1/day]

$\alpha_x$ = Longitudinal dispersivity [m]

$\alpha_y$ = Lateral dispersivity [m]

$\alpha_z$ = Vertical dispersivity [m]

$x, y, z$ = Spatial coordinates [m]

$t$ = Time [day]

$x$ = Distance along the centerline measured from the downgradient edge of the groundwater source [m]

$Y$ = GW source dimension perpendicular to GW flow direction [m]

$Z$ = GW source (mixing zone) thickness [m]

DAF = $C_o/C(x)$

At the centerline, for steady-state (after a long time) the concentration can be obtained by setting $y = 0$, $z = 0$, and $x << v \times t$ as:

$$\frac{C(x)}{C_o} = exp\left[\frac{x}{2\,\alpha_x}\left[1 - \sqrt{1+\frac{4\,\lambda\,\alpha_x}{v}}\right]\right] \times$$

$$erf\left[\frac{Y}{4\sqrt{\alpha_y\,x}}\right] \times erf\left[\frac{Z}{2\sqrt{\alpha_z\,x}}\right]$$

At the centerline, for steady-state the concentration without decay can be obtained by setting y = 0, z = 0, x << vt, and $\lambda = 0$ as:

$$\frac{C(x)}{C_o} = erf\left[\frac{Y}{4\sqrt{\alpha_y\,x}}\right] \times erf\left[\frac{Z}{2\sqrt{\alpha_z\,x}}\right]$$

Note: Compare to ASTM E1739-95, p. 31, where, $Y = S_w$ $Z = S_d$, $v = u$, and $C_o = C_{source}$

Source: Domenico, P.A. and F.W. Schwartz, 1990, Physical and Chemical Hydrogeology. John Wiley and Sons, NY, 824 p. (Eqn. 17.21)

## Allowable Soil and Groundwater Concentration for Groundwater Resource Protection

$$\text{Allowable soil concentration at the source [mg/kg]} = \text{Target groundwater concentration at the POE} \times \frac{DAF_{POE}}{LF_{SW}} \times DAF_{unsat}$$

$$\text{Allowable groundwater concentration at the POD [mg/L]} = \text{Target groundwater concentration at the POE} \times \frac{DAF_{POE}}{DAF_{POD}}$$

where,

$POE$ = Point of exposure

$POD$ = Point of demonstration

$DAF_{POE}$ = Dilution attenuation factor between the point of exposure and source estimated using Domenico’s equation

$DAF_{POD}$ = Dilution attenuation factor between the point of demonstration and source estimated using Domenico’s equation

$DAF_{unsat}$ = Dilution attenuation factor in the unsaturated zone

$LF_{SW}$ = Dry soil leaching factor [(mg/L-water)/(mg/kg-soil)]

Additional relationships used in the calculation of allowable soil and groundwater concentration with chemical degradation:

$$\text{First order decay rate [1/day]} = \frac{0.693}{Half\ \ Life}; \qquad v = \frac{Ki}{\theta_{TS} R_s}$$

$$\text{Retardation factor for organics in the saturated zone } (R_s) = 1 + \left(\frac{\rho_{ss} \times K_{ss}}{\theta_{TS}}\right), \qquad K_{ss} = f_{ocs} \times K_{oc} \text{ (for organics only)}$$

where,

$v$ = Regarded seepage velocity [cm/year]

$K$ = Hydraulic conductivity in saturated zone [cm/year]

$i$ = Hydraulic gradient in saturated zone [-]

$\rho_{ss}$ = Saturated zone dry soil bulk density [g-soil/cm$^3$-soil]

$K_{ss}$ = Chemical-specific soil-water sorption coefficient in the saturated zone [cm$^3$-H$_2$O/g-soil]

$K_{oc}$ = Chemical-specific normalized partition coefficient [cm$^3$/g-C]

$\theta_{TS}$ = Total porosity in the saturated zone [cm$^3$/g-C]

$f_{ocs}$ = Fractional organic carbon content in the saturated zone [g-C/g-soil]

## Stream Protection: Allowable Groundwater Concentration at Point of Discharge

$$C_{gw} = \frac{C_{sw}\left(Q_{gw} + Q_{sw}\right)}{Q_{gw}} - C_{su}\left(\frac{Q_{sw}}{Q_{gw}}\right)$$

$$Q_{gw} = \left(Z + \sqrt{\alpha_z X_s}\right) \times \left(Y + 2\sqrt{\alpha_y X_s}\right) \times U_{gw}$$

where,
$Q_{gw}$ = Impacted groundwater discharge into the stream [ft$^3$/day]
$C_{gw}$ = Allowable concentration in groundwater at the point of discharge into the stream [mg/L]
$Q_{sw}$ = Stream flow upstream of the point of groundwater discharge (stream flow rate) [ft$^3$/day]
$C_{sw}$ = Allowable concentration at the downstream edge of the stream's mixing zone, i.e., the applicable stream water quality criteria [mg/L]
$C_{su}$ = COC concentration upstream of the groundwater plume discharge [mg/L]
$Y$ = GW source dimension perpendicular to GW flow direction [ft]
$Z$ = GW source (mixing zone) thickness [ft]
$\alpha_y$ = Lateral dispersivity [ft]
$\alpha_z$ = Vertical dispersivity [ft]
$X_s$ = Distance from the downgradient edge of the groundwater source to the stream [ft]
$U_{gw}$ = Darcy velocity [ft/day]

## Stream Protection: Allowable Soil and Groundwater Concentration at Source and Point of Demonstration

$$\text{Allowable soil concentration at the source [mg/kg]} = \text{Target concentration [mg/L] at the POE} \times \frac{DAF_{POE}}{LF_{SW}} \times DAF_{unsat}$$

$$\text{Allowable groundwater concentration at the POD [mg/L]} = \text{Target concentration [mg/L] at the POE} \times \frac{DAF_{POE}}{DAF_{POD}}$$

where,

$POE$ = Point of exposure
$POD$ = Point of demonstration
$DAF_{POE}$ = Dilution attenuation factor between the point of exposure and source estimated using Domenico's equation
$DAF_{POD}$ = Dilution attenuation factor between the point of demonstration and the source estimated using Domenico's equation
$DAF_{unsat}$ = Dilution attenuation factor in the unsaturated zone
$LF_{SW}$ = Dry soil leaching factor [(mg/L-water)/(mg/kg-soil)]

For calculation of $DAF_{POE}$ and $DAF_{POD}$, please refer to Domenico's model.

# APPENDIX C

# CONSIDERATION OF TOTAL PETROLEUM HYDROCARBONS WITHIN THE DCRBCA PROCESS

# APPENDIX C
# CONSIDERATON OF TOTAL PETROLEUM HYDROCARBONS WITHIN THE DCRBCA PROCESS

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# APPENDIX C

# CONSIDERATION OF TOTAL PETROLEUM HYDROCARBONS WITHIN THE DCRBCA PROCESS

## C.1 INTRODUCTION

Petroleum products including gasoline, diesel, heating oils, etc. contain hundreds or even thousands of individual constituents with a range of physical, chemical, and toxicological properties. The properties of several of these chemicals are not known and it is not possible to calculate their risk-based target levels. Further, it is impractical to analyze the concentration of each of these chemicals in the environmental media impacted by petroleum hydrocarbons. Thus, a variety of approaches have been developed to estimate media-specific target levels and to identify the key constituents for the management of petroleum, specifically heating oil, diesel impacted sites. These approaches include:

1. Target levels for total petroleum hydrocarbon (TPH) concentration,
2. Target levels for specified ranges of petroleum hydrocarbons, e.g., TPH-GRO (gasoline range organics), TPH-DRO (diesel range organics), and TPH-ORO (oil range organics),
3. Target levels for selected COCs (those considered most toxic and for which sufficient data is available), e.g., benzene, toluene, ethylbenzene, xylenes, ethanol, naphthalene, and PAHs,
4. Target levels for a specified size range of aromatic and aliphatic fractions, e.g., aliphatics >C6-C8, aliphatics C8-C10, aromatics C10 - C20, etc.,
5. A combination of the above approaches.

Each of the above approaches is approximate. However, in each case the field sampling and analysis approach should be consistent with the approach used to develop target levels. For example, if target levels are developed for specific aromatic and aliphatic fractions, (approach 4 above), soil and groundwater samples must be analyzed for the corresponding fractions. The laboratory analysis cost for measuring TPH concentration are significantly lower than for measuring individual fractions, thus the selection of a particular approach has significant cost implications. If cost were not an issue, measurement of individual fractions (Approach 4) would be the preferred approach.

Within the DCRBCA process, petroleum hydrocarbon impacts will be evaluated using the following approach:

- For Tier 1 and Tier 2A evaluations, develop target levels for the individual COCs identified in Table 4-1, and for TPH-GRO, TPH-DRO , and TPH-ORO. Thus, for the comparison of risk based levels with representative site concentrations, it will be necessary to analyze soil samples for the individual constituents as well as TPH-GRO, TPH-DRO, and TPH-ORO using method 8015 (modified). This is a combination of Approach 2 and 3 above. If available, analytical data for TPH fractions may be used for Tier 1 and Tier 2A evaluations.

- For Tier 2B evaluations, either use the above approach or develop target levels for the COCs and specified petroleum fractions using the TPH Criteria Working Group Method. This method is a modification of that used by Massachusetts Department of Environmental Protection (MADEP).

The TPH Criteria Working Group recommendations were based on a very exhaustive study of the petroleum products, their fate and transport properties, and toxicity. The Criteria TPH Working Group was established in 1993 and consisted of over 400 participants from numerous organizations including USEPA, industries, consulting companies, and trade organizations. The goal of this group was to develop scientifically defensible information for establishing soil cleanup levels protective of human health and the environment. The efforts of this group culminated in the publication of five volumes (see reference list).

## C.2 DEVELOPMENT OF TIER 1 AND TIER 2A TARGET LEVELS

As mentioned in Chapter 5 of this document, development of target levels requires the following information:

1. Target risk level for carcinogenic as well as non-carcinogenic adverse health effects. For specific discussion, refer to Section 5.3.1.

2. Fraction-Specific Physical and Chemical properties. These are discussed in Section 5.3.2 and Section C.3 below for the specific fractions.

3. Quantitative toxicity values. These are discussed in Section 5.3.3 and in Section C.4 below for the specific fractions.

4. Receptor specific exposure factors. For specific discussion refer to Section 5.3.4.

5. Fate and transport parameters. For specific discussion refer to Section 5.3.5.

6. Intake equations and fate and transport models. For specific discussion refer to Section 5.3.6 and Appendix B.

Thus the overall approach for developing Tier 1 and Tier 2A screening levels for the petroleum fractions is the same as that described in Section 5.0, except for the chemical specific properties discussed below.

## C.3 FRACTION-SPECIFIC PHYSICAL AND CHEMICAL PROPERTIES

Table D-1 lists the chemical-specific properties of the petroleum fractions used by several different entities, namely (Texas Commission on Environmental Quality (TCEQ), MADEP, and the TPH Criteria Working Group. As mentioned above the TPH Criteria Working Group data were used in the DCRBCA process.

## C.4 TOXICOLOGICAL PROPERTIES OF VARIOUS FRACTIONS

Table C-1 lists the toxicological properties of the petroleum fractions used by several entities. As mentioned above the TPH Criteria Working Group data were used in the DCRBCA process.

## C.5 DEVELOPMENT OF TIER 1 AND TIER 2A TARGET LEVELS FOR TPH-GRO, TPH-DRO, AND TPH-ORO

Table C-2 lists the aromatic and aliphatic fractions included in each of the three TPH groups namely: TPH-GRO, TPH-DRO, and TPH-ORO. These fractions are consistent with the SW846 analytical method 8015 (modified).

Risk-based screening levels for TPH-GRO, TPH-DRO, and TPH-ORO were developed using the following steps:

Step 1: Calculate target levels for individual TPH fractions (Each TPH fraction is treated as an individual chemical and the computational software calculates target levels for each fraction.)

Step 2: If the value obtained for a fraction in Step 1 exceeded the theoretical maximum concentration (soil saturation for soil and solubility for groundwater), the particular fraction is not of concern for the respective pathway. The computational software shows the calculated value with "*" for soil and "#" for groundwater indicating that the calculated value exceeds soil saturation or solubility.

Step 3: Add the target level, from Step 2, for each fraction within a TPH group (see Table C-2 for a list of fractions within each group) to obtain the target level for that particular TPH group. (Some fractions may not have a target level for a particular pathway because that particular fraction does not have any toxicity data.)

Step 4: In Step 2, if the target levels for all the fractions within a particular TPH group exceeded the theoretical maximum concentration (soil saturation for soil and solubility for groundwater), the particular TPH group is not of concern for the respective pathway. The computational software shows the calculated value with "*" for soil and "#" for groundwater indicating that the calculated value exceeds soil saturation or solubility.

The computational software performs the above steps.

## C.6 SITE-SPECIFIC IMPLEMENTATION OF THIS APPROACH

For the Tier 1 and Tier 2A implementation of the DCRBCA process, the RP should collect and analyze soil and groundwater concentration of the individual COCs and the three TPH groups using the methods indicated in Table 4-1. Since the measured value of TPH-GRO includes the contribution of BTEX concentration, it is necessary to subtract the total BTEX concentration from the measured TPH-GRO prior to comparing it with the Tier 1 and Tier 2A target levels. This correction to the measured TPH-GRO concentrations will ensure that the comparison of the measured and the target values is consistent with the assumptions used to estimate the tiered approach. If available, analytical data for TPH fractions may be used for Tier 1 and Tier 2A evaluations.

For a Tier 2B evaluation, the RP may use either the approach used for Tier 2A evaluation or use the TPH Criteria Working Group method to estimate the risk based levels for each of the TPH fractions. Note if the TPH Criteria Working Group Method is used, the RP must collect soil and ground water data for the individual fractions to estimate representative concentrations.

REFERENCES

Texas Commission on Environmental Quality; ***Texas Risk Reduction Program Protective Concentration Level Tables, March, 2010.***

Total Petroleum Hydrocarbon Criteria Working Group: ***Volume 1; Analysis of Petroleum Hydrocarbons in Environmental Media, Amherst Scientific Publishers, 1997.***

Total Petroleum Hydrocarbon Criteria Working Group: ***Volume 2; Composition of Petroleum Mixtures, Amherst Scientific Publishers, 1997.***

Total Petroleum Hydrocarbon Criteria Working Group: ***Volume 3; Selection of representative TPH Fractions Based on Fate and Transport Considerations, Amherst Scientific Publishers, 1997.***

Total Petroleum Hydrocarbon Criteria Working Group: ***Volume 4; Development of Fraction Specific Reference Doses (RfDs) and Reference Concentrations (RfCs) for Total Petroleum Hydrocarbons (TPH), Amherst Scientific Publishers, 1997.***

Total Petroleum Hydrocarbon Criteria Working Group: ***Volume 5 Human Health Risk-Based Evaluation of Petroleum Release Sites: Implementing the Working Group Approach, June 1999.***

Massachusetts Department of Environmental Protection; ***Characterizing Risks Posed by Petroleum Contaminated Sites – Implementation of MADEP VPH/EPH Approach, October 2002.***

## Table C-1
## Physical Chemical and Toxicological Properties Used by Indicated Groups for TPH Fractions

| TEXAS COMMISSION ON ENVIRONMENTAL QUALITY[A] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fraction | RfDo [mg/kg-day] | RfCi [mg/$m^3$] | MW [g/mole] | H [unitless] | Log $K_{oc}$ [unitless] | Dair [$cm^2$/s] | Dwater [$cm^2$/s] | Solubility [mg/L] | Vapor Pressure [mm Hg] |
| **Aliphatics** | | | | | | | | | |
| C6 | 0.06 | 2.0E-01/1.8E+01* | 81 | 33 | 2.9 | 0.1 | 1.00E-05 | 36 | 266 |
| >C6-C8 | 0.06 | 2.0E-01/1.8E+01* | 100 | 50 | 3.6 | 0.1 | 1.00E-05 | 5.4 | 47.9 |
| >C8-C10 | 0.1 | 1 | 130 | 80 | 4.5 | 0.1 | 1.00E-05 | 0.43 | 4.8 |
| >C10-C12 | 0.1 | 1 | 160 | 120 | 5.4 | 0.1 | 1.00E-05 | 0.034 | 4.79E-01 |
| >C12-C16 | 0.1 | 1 | 200 | 520 | 6.7 | 0.1 | 1.00E-05 | 7.60E-04 | 3.65E-02 |
| >C16-C21 | 2 | --- | 270 | 4900 | 8.8 | 0.1 | 1.00E-05 | 2.50E-06 | 8.40E-04 |
| **Aromatics** | | | | | | | | | |
| >C7-C8 | 0.1 | 1.0 | 92 | 0.3 | 2.1 | 0.087 | 8.60E-06 | 530 | 28.2 |
| >C8-C10 | 0.04 | 0.2 | 120 | 0.48 | 3.2 | 0.1 | 1.00E-05 | 65 | 4.788 |
| >C10-C12 | 0.04 | 0.2 | 130 | 0.14 | 3.4 | 0.1 | 1.00E-05 | 25 | 4.79E-01 |
| >C12-C16 | 0.04 | 0.2 | 150 | 0.053 | 3.7 | 0.1 | 1.00E-05 | 5.8 | 3.65E-02 |
| >C16-C21 | 0.03 | --- | 190 | 0.013 | 4.2 | 0.1 | 1.00E-05 | 0.65 | 8.40E-04 |

**Notes:**

*: The first value represents the toxicity value to be used for evaluating mixtures with greater than 53% n-hexane content; the second value represents the toxicity value to be used for evaluating mixtures with less than 53% n-hexane content.

| TOTAL PETROLEUM HYDROCARBON CRITERIA WORKING GROUP[B] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fraction | RfDo [mg/kg-day] | RfCi [mg/$m^3$] | MW [g/mole] | H [unitless] | Log $K_{oc}$ [unitless] | Dair [$cm^2$/s] | Dwater [$cm^2$/s] | Solubility [mg/L] | Vapor Pressure [mm Hg] |
| **Aliphatics** | | | | | | | | | |
| >C6-C8 | 5 | 18.4 | 100 | 50 | 3.6 | 0.1 | 1.00E-05 | 5.4 | 47.88 |
| >C8-C10 | 0.1 | 1 | 130 | 55 | 4.5 | 0.1 | 1.00E-05 | 0.43 | 4.79E+00 |
| >C10-C12 | 0.1 | 1 | 160 | 60 | 5.4 | 0.1 | 1.00E-05 | 0.034 | 4.79E-01 |
| >C12-C16 | 0.1 | 1 | 200 | 69 | 6.7 | 0.1 | 1.00E-05 | 7.60E-04 | 3.65E-02 |
| >C16-C21 | 2 | NA | 270 | 85 | 8.8 | 0.1 | 1.00E-05 | 2.50E-06 | 8.36E-04 |
| >C21-C35 | 2 | NA | NA | NA | NA | NA | NA | NA | NA |
| **Aromatics** | | | | | | | | | |
| >C8-C10 | 0.04 | 0.2 | 120 | 0.39 | 3.2 | 0.1 | 1.00E-05 | 65 | 4.79E+00 |
| >C10-C12 | 0.04 | 0.2 | 130 | 0.13 | 3.4 | 0.1 | 1.00E-05 | 25 | 4.79E-01 |
| >C12-C16 | 0.04 | 0.2 | 150 | 0.028 | 3.7 | 0.1 | 1.00E-05 | 5.8 | 3.65E-02 |
| >C16-C21 | 0.03 | NA | 190 | 0.0025 | 4.2 | 0.1 | 1.00E-05 | 0.65 | 8.36E-04 |
| >C21-C35 | 0.03 | NA | 240 | 1.70E-05 | 5.1 | 0.1 | 1.00E-05 | 6.60E-03 | 3.34E-07 |

| MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION[C] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fraction | RfDo [mg/kg-day] | RfCi [mg/$m^3$] | MW [g/mole] | H [unitless] | $K_{oc}$ [unitless] | Dair [$cm^2$/s] | Dwater [$cm^2$/s] | Solubility [mg/L] | Vapor Pressure [atm] |
| **Aliphatics** | | | | | | | | | |
| >C5-C8 | 0.04 | 0.2 | 93 | 54 | 2265 | 0.08 | 1.00E-05 | 11 | 0.1 |
| >C9-C12 | 0.1 | 0.2 | 149 | 65 | 157.5 | 0.07 | 1.00E-05 | 0.07 | 8.70E-04 |
| >C9-C18 | 0.1 | 0.2 | 170 | 69 | 714 | 0.07 | 5.00E-06 | 0.01 | 1.40E-04 |
| >C19-C36 | 2 | NA | Considered immobile | | | | | | |
| **Aromatics** | | | | | | | | | |
| >C9-C10 | 0.03 | 0.05 | 120 | 0.33 | 1778 | 0.07 | 1.00E-05 | 51 | 2.90E-03 |
| >C11-C22 | 0.03 | 0.05 | 150 | 0.03 | 5000 | 0.06 | 1.00E-05 | 5.8 | 3.20E-05 |

References:

A - TCEQ; Texas Risk Reduction Program (TRRP) Protective Concentration Level tables, March 201
B - Volumes 4 and 5 of Total Petroleum Hydrocarbon Criteria Working Group Serie
C - Characterizing Risks Posed by Petroleum Contaminated Sites – Implementation of MADEP VPH/EPH Approach, October 2002
NA: Not Available

# APPENDIX D
# DEVELOPMENT OF SITE-SPECIFIC BIODEGRADATION RATE

# APPENDIX D

# DEVELOPMENT OF A SITE-SPECIFIC BIODEGRADATION RATE

The following step-by-step procedure may be used to develop a site-specific biodegradation rate or half-life for use in the groundwater resource protection evaluation. The method follows the American Society for Testing and Materials guideline for remediation of groundwater by natural attenuation at petroleum-release sites (ASTM, 1998, pages 118-120).

Step 1: Determine the groundwater flow directions based on the water level measurements for each monitoring event.

Step 2: For each monitoring event, identify the wells located along the directions of flow, i.e. along the plume centerline(s). Note, since the flow direction may vary, different wells may be used for different monitoring events.

Step 3: Tabulate the concentrations of the chemicals of concern and calculate the natural log of the concentrations.

Step 4: Plot the natural log of the concentrations on the Y-axis and the distance from the downgradient face of the source area along the X-axis.

Step 5: For each plot, calculate the slope of the best-fit line and test whether or not the null hypothesis can be rejected at the .05 level of significance. The null hypothesis in this case is that the slope of the regression line is zero, indicating no relationship between the natural log of concentration and distance. An example of this type of calculation can be found in Miller and Freund (1985, p. 298).

Step 6: Estimate the groundwater seepage velocity and the longitudinal dispersivity using the formulas in Step 8.

Step 7: Multiply the slope of the best-fit line calculated in Step 5 by the seepage velocity to estimate *k*, the overall natural attenuation (NA) rate (see Buscheck and Alcantar, 1995).

The NA rate represents the reduction in concentration due to the combined influence of the various NA processes. Note that this overall NA rate (*k*) should not be confused with the biodegradation rate ($\lambda$) that is an input to Domenico model to estimate saturated zone Dilution Attenuation Factor (DAF) used in DCRBCA (see Equation 24 on page B-34).

Step 8: Estimate the biodegradation rate ($\lambda$) using the below equation derived by Buscheck and Alcantar (1995, equation 9) based on the solution of the one-dimensional transport equation with biodegradation.

$$\lambda = \frac{v}{4\alpha_x}\left\{\left[1 + 2\alpha_x\left(\frac{k}{v}\right)\right]^2 - 1\right\}$$

Where:

$\lambda$ = Biodegradation rate (1/yr)

$\alpha_x$ = Longitudinal dispersivity (Xpoe/10)(cm)

Xpoe = Distance from the source to the Point of Exposure (POE) (cm)

$k$ = Overall attenuation rate (1/yr)

$v$ = Seepage Velocity (Hydraulic gradient x Hydraulic conductivity/Porosity) (cm/yr)

Steps 1 through 8 should be completed for each relevant groundwater monitoring event, for example, all those within the period over which representative concentrations have been calculated. The results should be presented as a range of NA ($k$) and biodecay ($\lambda$) rates. The latter is used as an input to the Domenico model to estimate the saturated zone dilution attenuation factor. Due to confounding factors such as seasonal variations in groundwater velocity, water level fluctuations, errors in sampling and analysis methods, the NA and biodegradation rates may vary significantly between events. Therefore, it is best to present the range as well as the average rates.

Professional judgment must be used to determine the most representative $\lambda$ for use in the calculation of the chemical half-lives.

Step 9: Calculate a half-life for each chemical using the equation, $\lambda = .693/\text{half-life}$. $\lambda$ should be written as 1/days for this calculation.

Utilize the derived site-specific half-lives in the calculation of the soil and groundwater target levels. The half-lives for each chemical of concern for which a biodecay-based target level is proposed should be tabulated.

## REFERENCES

ASTM, 1998. *Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites*, Standard E1943-98 published by The American Society for Testing and Materials, Conshohocken, PA.

Buscheck, T. E., and C. M. Alcantar, 1995. Regression Techniques and Analytical Solutions to Demonstrate Intrinsic Bioremediation, in Hinchee, R. E., J. T. Wilson, and D. C. Downey, editors, 1995, *Intrinsic Bioremediation*, Battelle Press, Columbus, Ohio.

Miller, Irwin and Freund, John E. 1985, *Probability and Statistics for Engineers*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 07632.