Delaware Risk-Based Corrective Action Protocol (DERBCAP)

For Petroleum Underground (UST) and Aboveground Storage Tank (AST) Sites

Delaware Department of Natural Resources and Environmental Control (DNREC)

DWHS
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Delaware's Risk Based Corrective Action Protocol (DERBCAP)

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1. STATEMENT OF PURPOSE

The Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Waste and Hazardous Substances (DWHS) has developed this updated protocol to supplement current guidelines provided in its various technical guidance documents including the *Hydrogeologic Investigation Guide (HIG)* regarding Site Assessments, petroleum releases and their associated corrective actions. DERBCAP provides for quantitative risk-based decision-making at leaking tank system sites.

This guidance is based on the American Society for Testing and Materials (ASTM) E 1739-95(2015) Standard Guide for Risk-Based Corrective Action (RBCA) at Petroleum Release Sites and meets the requirements in Delaware's *Regulations Governing Underground Storage Tank Systems*. Delaware's policy decisions are listed in **Error! Reference source not found.**. The Department acknowledges the assistance of the ASTM, the Partners in RBCA Implementation (PIRI), hazardous Substance Cleanup Act Advisory Committee (HAC), and Underground Storage Tank Advisory Council (USTAC), in the formulation of this guidance.

Many states have adopted the ASTM RBCA standard in varying degrees to establish their own risk based corrective action protocols. Delaware referred to the ASTM standard and risk-based protocols from several states including Oklahoma, Idaho, Pennsylvania, Utah, and Texas in the formulation of the Delaware RBCA standard.

1.1 Risk Glossary, Terms and Definitions

Action Level	Generic term applied to the level of concentration of a substance or contaminant that when exceeded is considered sufficient to warrant regulatory action.
Acceptable Risk	For purposes of DERBCAP, acceptable risk is set at 1 x 10^{-5} or one person in 100,000 or less for carcinogens and a Hazard Quotient of one (1) for non-carcinogenic compounds. For exposure calculations in DERBCAP, the target carcinogenic risk of 1 x 10^{-5} is the cumulative site risk. Individual compounds can also be calculated at 1 x 10^{-5} as long as the cumulative site target risk also does not exceed 1 x 10^{-5}.
AST	Aboveground storage tank.
AST System	An **Aboveground Storage Tank**, connected Underground or aboveground product, vent, and vapor recovery piping and its associated Ancillary Equipment, containment systems, and all appurtenances including but not limited to spill containment systems, overfill prevention systems, and release detection systems.

ASTM	The **American Society for Testing and Materials** is the body that standardized risk based corrective action, or RBCA. ASTM is a not-for- profit organization that writes standard test methods, specifications, practices, terminologies, guides and classifications for materials, products, systems and services that encompass metals, paints, plastics, textiles, petroleum, construction, energy, the environment, consumer products, medical services and devices, computerized systems, electronics and other areas.
Aesthetic Impact	An occurrence of COCs at a point of exposure, which is not a potential risk to human health, but may necessitate corrective action because of objectionable odors, taste, vapors or appearance.
Coastal Plain	A physiographic province consisting of a broad plain of usually unconsolidated sediment with an oceanic margin that slopes gently toward the water.
COC	**Chemical of Concern**. Specific chemical or constituent that is identified for evaluation in the risk assessment process. COCs may include products or constituents of products released to soil and/or groundwater.
Core	The region or regions within the soil and groundwater plume containing the highest and most mobile COCs and the lowest concentrations of dissolved oxygen, which, over time, can serve as a long-term source of groundwater contamination.
Cumulative Risk	The combined risks from aggregate exposures to multiple chemicals of concern for a completed pathway**.** For purposes of DERBCAP, acceptable risk is set at 1 x 10^{-5} or one person in 100,000 or less for carcinogens and a Hazard Quotient of one (1) for non-carcinogenic compounds. For exposure calculations in DERBCAP, the target carcinogenic risk of 1 x 10^{-5} is the cumulative site risk
Department	See DNREC
DERBCAP	Delaware's RBCA protocol

DNREC	Delaware's Department of Natural Resources and Environmental Control; the Department.
Dose	A specified amount; a measure of exposure usually expressed as an amount per unit body weight.
Engineering Control	A physical means of reducing the potential impacts of a release at a site. An engineering control can be used to eliminate a pathway to reduce future risk. Engineering controls can be, but are not limited to: caps, liners, slurry walls, or vapor barriers.
Environmentally Sensitive Area	Environmentally sensitive areas can be but are not limited to: surface waters, wetlands, excellent aquifer recharge areas, areas within a Well Head Protection Area (WHPA) for public or domestic water supply wells, and habitats of threatened or endangered species.
Exposure	Contact of a human or other ecological organism with COCs.
Fill	Man-made deposits of natural soils or rock product and waste materials.
Hazard Index	In the case of non-carcinogens, the sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. The hazard index is calculated separately for chronic, subchronic, and shorter duration exposures.
Hazard Quotient	For a particular chemical and mechanism of intake (e.g., oral, dermal, inhalation), is the ratio of the estimated receptor dose divided by the published reference dose for a particular chemical and mechanism of intake. The reference dose values are determined using the U. S. EPA
Institutional Control	"**Institutional Controls**" means non-engineered instruments, such as administrative and legal controls including but not limited to an Environmental Covenant (EC) as described in 7 Del. C. §§7907-7920, the Uniform Environmental Covenants Act (UECA), that help minimize the potential for human exposure to contamination and protect the integrity of the remedy.

	Light Non-Aqueous Phase Liquid having a specific gravity less than one (1) and composed of one or more organic compounds that are immiscible or sparingly soluble in water. The term encompasses all potential occurrences of LNAPL including free, mobile, and residual.
LNAPL	"**Mobile LNAPL**" means LNAPL that is hydraulically connected in the pore space, exceeds residual saturation, and has the potential to migrate both vertically and laterally. "**LNAPL Body**" means the 3- dimensional form and distribution of LNAPL in the subsurface existing in any phase. "**LNAPL Conceptual Site Model**" or "**LCSM**" means a model describing the physical properties, chemical composition, occurrence, and geologic setting of the LNAPL Body from which estimates of flux, risk and potential Remedial Action can be generated. The LCSM may be a dynamic, living model that changes through time as a function of natural attenuation or engineered Remedial Action processes, or additional site knowledge. "**Migrating LNAPL**" means Mobile LNAPL that is moving laterally and/or vertically in the environment under prevailing hydraulic conditions. (The result of the LNAPL movement is a net mass flux from one point to another. Not all Mobile LNAPL is Migrating, but all Migrating LNAPL must be Mobile LNAPL. "**Residual LNAPL**" means LNAPL that is hydraulically discontinuous and immobile under prevailing conditions. Residual LNAPL cannot move, but is a source for chemicals of concern dissolved in groundwater or in the vapor phase in soil gas. The Residual LNAPL saturation is a function of the initial or maximum LNAPL saturation and the porous medium.
LUST	Leaking Underground Storage Tank

LAST	Leaking Above Ground Storage Tank
MCL	**Maximum Contaminant Level**. A standard for drinking water established by EPA under the Safe Drinking Water Act. The State of Delaware can set more protective MCLs at its discretion. The MCL is the maximum permissible level of COCs in water that is used as a drinking water supply. MCLs are recognized in Delaware by the Division of Public Health and DNREC.
NFA	A **No Further Action** letter is issued by the Department based upon a determination that no further risk is posed to human health or the environment from a contaminant source in its current state. A standard NFA letter has no conditions and is issued when the Department has determined that COC levels pose no risk to human health or the environment. "**Conditional NFA**" letter may be issued for other situations and requires notification to the Department prior to any earth disturbing activities. A No Further Action letter is not a statutory release from future liability.
Exposure Pathway	A pathway is one of three risk elements. The pathway provides the route for an exposure. The exposure pathway is the course or route COCs take from a contaminant source to a receptor. An exposure pathway describes a unique mechanism by which an individual or population is exposed to COCs. Each exposure pathway includes a source or release from a source, an exposure route, and a point of exposure. If the exposure point is at a different location from the source, a transport/exposure media (e.g., groundwater) is included. Exposure pathways involve transport of contamination through exposure media (air, groundwater, and soil). DERBCAP recognizes three (3) pathways for risk: combined direct contact, ground water ingestion, and soil to groundwater leaching. The petroleum vapor intrusion pathway will be addressed per Department Policy.
Piedmont	A physiographic province typically formed at the base of a mountain range consisting of a bedrock surface overlain by a thin veneer of un- consolidated material and shaped by running water.

POC	A **Point of Compliance** can be any point between a contaminant source and a point of exposure where a regulatory standard must be met as determined by the Remediation Section.
POE	A **Point of Exposure** can be a well, body of water, soil pile, basement, excellent recharge area, property boundary, or any environmentally sensitive area as determined by the Department. It is the point at which an individual, population, or any environmentally sensitive area may come in contact with a COC originating from a site. For the purposes of this document regarding risk management, the terms "receptor" and "Point of Exposure" may be used interchangeably.
PVI	Petroleum Vapor Intrusion
RBCA	Risk Based Corrective Action
RBEL	A **Risk Based Exposure Level** is the risk-based concentration for a COC permitted at a Point of Exposure based on a level of cancer risk of 1×10^{-5} or less and a Hazard Quotient of 1 for non-carcinogenic compounds. In Tier 2 modeling, RBCA Toolkit uses these RBEL default values for site specific target level (SSTL) calculations. In demonstrating plume stability in Bioscreen, the RBEL concentration must be zero (i.e., COCs will never reach the POE).
RBSL	A **Risk Based Screening Level** is a Tier 1 risk-based concentration for a COC determined using conservative non-site-specific (generic) assumptions and default parameters. The RBSL is the concentration of COCs in soils or groundwater in the source or core that will assure an acceptable risk at the POE, based on the assumptions made. An RBSL can also be a site-specific cleanup goal.
Receptor	An organism or physical point of exposure that receives, may receive, or has received exposure to a COC as a result of a release. Under DERBCAP objects such as utilities, wetlands and surface water bodies are also considered receptors.

Release	Means any spilling, overfilling, leaking, emitting, discharging, escaping, leaching, or disposing of a Regulated Substance into groundwater, surface water, air, or soils.
Responsible Party	any Person who: (a) Owns or has a legal or equitable interest in a Facility or a Tank System; (b) Operates or otherwise controls activities at a Facility; (c) At the time of storage of Regulated Substances in a Tank System, operated or otherwise controlled activities at the Facility or Tank System, or owned or held a legal or equitable interest therein; (d) Arranged for or agreed to the placement of a Tank System by contract, agreement or otherwise; (e) Caused or contributed to a Release from a Tank System; or (f) Caused a Release as a result of transfer of a Regulated Substance to or from a Tank System.
Risk	For purposes of DERBCAP, acceptable risk is set at 1 x 10^{-5} or one person in 100,000 or less for carcinogens and a Hazard Quotient of one (1) for non-carcinogenic compounds. For exposure calculations in DERBCAP, the target carcinogenic risk of 1 x 10^{-5} is the cumulative site risk. Individual compounds can also be calculated at 1 x 10^{-5} as long as the cumulative site target risk also does not exceed 1 x 10^{-5}.
Risk Assessment	An analysis of the potential for adverse human health effects or effects on ecological receptors caused by a COC. It is used to determine the need for remedial action and to develop target levels and clean up goals where remedial action is required.
Risk Management	Measures or actions taken to ensure that the level of risk to human health or the environment as a result of possible exposure to COCs does not exceed 1 x 10^{-5}.

Route of Exposure	The course and manner in which COCs come in Contact with an organism through ingestion, inhalation, or dermal contact.
Sentinel Well	A groundwater-monitoring well located between a known area of groundwater contamination and a point of exposure.
Site Assessment	Investigation and report that measure for the Presence of a Release where contamination is most likely to be present at a petroleum impacted site. Selection of sample types, sample locations, and measurement methods shall be based on the nature of the stored substance, the type of backfill, the depth to groundwater, and other factors appropriate for identifying the presence of a Release. A Site Assessment is not restricted to the property boundary.
Soil	Sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks, which may or may not contain organic matter.
Source	Source of contamination can be a leaking tank, tank field, tank system, a spill, or residual contaminated soil or groundwater.
SSTL	A **Site Specific Target Level** (SSTL) is a Tier 2 risk-based concentration for a COC at the source that will be protective of receptors at some distance away from the source, based on site-specific data. It can also be a cleanup goal.
Tank System Activity	Tank System Activities can include: Retrofits, Repairs, Upgrades, Change in Service, Change in Product, Removal or Closure in Place
Tank System	A **Tank System** applies to **both AST System or an UST system.**

Tier	Refers to the amount of COC-specific and site-specific information that is required to assess potential risks to human health and the environment at a site. Each successive tier requires a greater amount of site-specific data but allows for cleanup goals that are less conservative. DERBCAP recognizes four (4) tiers, 0 to 3.
UST	Underground Storage Tank.
UST System	An **Underground Storage Tank**, connected underground product, vent, and vapor recovery piping and its associated Ancillary Equipment, containment systems, and all appurtenances including but not limited to spill containment systems, overfill prevention systems, and Release detection systems.
Used Oil	A petroleum based or synthetic oil used as an engine lubricant, engine oil, motor oil or lubricating oil for use in an internal combustion engine, or a lubricant for motor vehicle transmissions, gears, or axles, which through use or handling has become unsuitable for its original purpose due to the presence of impurities or loss of original properties.
Vapor Intrusion	The process by which volatile vapors partition from contaminated groundwater or other subsurface sources and migrate upward through vadose zone soils and into overlying buildings.

1.2 Basic Risk Concepts

1.2.1 Dose

Any substance can be considered a toxic agent. A toxic agent at a specific concentration exposed over a given duration is a dose. Gasoline is a toxic agent. Gasoline; however, is a complex mixture of over 100 constituents, many of which do not pose a human health risk. Some of these constituents are toxic, however. Individual constituents of complex petroleum mixtures, like gasoline, are considered chemicals of concern (COCs) based on factors such as carcinogenicity and mobility in the environment.

1.2.2 Exposure Pathway

There are three exposure routes: 1) dermal or direct contact, 2) inhalation and 3) ingestion. Within each exposure route are multiple exposure pathways that can contribute a dose to a given receptor. For example, within the inhalation route, there are the following inhalation pathways: volatilization from

surface soils, volatilization from groundwater, from LNAPL vapor migration into buildings, and shower off-gassing (particularly for benzene and naphthalene). Direct contact may be encountered through soil contact or through bathing in impacted groundwater. Contact through an ingestion route may involve soil ingestion, groundwater ingestion, or volatilization from groundwater and LNAPL.

1.2.3 Receptor

Receptors are considered to be human, ecological, or physical. Human receptors are often broken down by age group, usually child, adult, and senior and/or type of exposure resident, commercial, construction worker, etc. An ecological receptor is identified as a sensitive animal or plant population. And physical receptors are identified as a well, basement, property line, groundwater protection area, or other natural resources such as protected recharge areas. There are other ecological and physical receptors.

1.2.4 Risk

For risk to occur, all three elements: dose, pathway, and receptor must be present (Figure 1). If any of these elements is missing, a risk does not exist. Calculating risk involves the use of mathematical equations relating a variety of factors such as concentration of contaminants, duration of exposure, body weight, and exposure (ingestion, inhalation, and contact rate). Once quantified, risk can be used to determine the need for further action at a site.

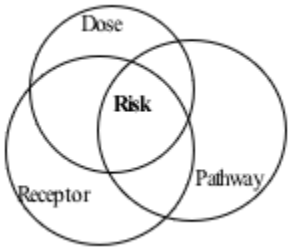


Figure 1. The Risk Concept

If chemical of concern (COC) concentrations fall below prescribed risk based concentrations, no further action may be required. However, in some cases, aesthetic concerns from an odor, taste, or visual evidence may require further action such as removal of surface soils for treatment or disposal, or capping.

Aesthetics often arise when dealing with groundwater used for drinking or bathing, particularly when dealing with compounds like methyl tertiary butyl ether (MTBE) which have low odor and taste thresholds. Although concentrations present may not pose a health risk, they may make drinking water unpalatable or malodorous; and therefore, require further action.

1.3 Risk Based Corrective Action Concepts

The concept of risk based corrective action, or RBCA, standardized by the American Society for Testing and Materials (ASTM) in *"Standard Guide E 1739-95(2015) for risk-based corrective action applied at petroleum release sites,"* provides the basis for Delaware's risk based corrective action protocol. The ASTM standard was formulated by federal, state, local, and industry officials.

The ASTM standard is a tiered quantitative approach to risk assessment that utilizes chemicals of concern rather than the total petroleum hydro-carbon analysis method. A three-tiered risk assessment method is used to evaluate the risk to human health posed by constituents in petroleum- contaminated soil, groundwater, and air at impacted sites. As the tier level increases from one to three, the level of site specificity and data sufficiency increases. The responsible party (RP) may remediate at any tier to cleanup levels specified at each tier or move to the next tier where more site-specific data must be collected and analyzed: and where consequently, remediation may not be required based upon fate and transport modeling-derived risk.

ASTM RBCA determines RBSLs and SSTLs for soil and groundwater using a backward mode of calculation. The standard mathematical exposure equations are used to calculate COC concentrations for a specified level of risk. The RBSLs and SSTLs are compared to site-specific data to identify the need for further action. RBCA also utilizes a site-specific risk characterization process that includes identification of complete exposure pathways, estimation of receptor dose, and calculation of associated risk levels. Following evaluation, a project may require: No Further Action; may require clean up to the current tier's RBSLs or SSTLs; or move on to the next higher tier.

1.4 Delaware's RBCA Background

Prior to DERBCAP, Delaware's tanks program incorporated risk into decision-making through qualitative evaluation. In this former process, site characterization and prioritization were based on three risk categories (A, B, and C). These categories were based on proximity of sensitive receptors and land use and assured that sites demanding a higher level of concern received the level of attention necessary to protect human health and the environment. Adding RBCA concepts to the former evaluation process has enabled the Department to include a quantitative component to the evaluation. This quantitative framework allows Delaware's established site-specific approach, while ensuring a high level of protection for human health and the environment.

DERBCAP is a multi-tiered risk based corrective action process. While the ASTM standard specifies three (3) tiers, DERBCAP includes an additional tier, Tier 0. Tier 0 covers Tank System Activities where the potential for a release from a Tank System must be assessed. An existing leaking tank system site may enter at Tiers 1, 2, or 3 depending on the amount of site-specific data gathered. The DERBCAP Tier structure is further explained in Section 1.6 below.

To remain consistent with other Delaware programs, a cancer risk of 1×10^{-5} is applied in all calculations. All numerical risks are based on human exposure, but environmental and ecological factors have been integrated into DERBCAP as points of exposure or POEs, as well. Additionally, an unacceptable risk is presumed to exist as a starting point until proper investigation has been conducted at the site and proves otherwise. DERBCAP's multi-tier structure, like ASTM RBCA, requires increasingly more comprehensive site-specific COC and site characteristic data as a site progresses through the tiers. Tier 0 action levels and Tier 1 RBSLs are based on the following statewide generic assumptions:

- grab soil samples are assumed to be collected at the top of the water table,
- groundwater is assumed to be used for drinking water,
- current land use is assumed to be residential, and
- Soils are assumed to be well sorted, permeable, fine-to medium-grained sand.

The DERBCAP Tier 1 RBSLs are determined by distance from source to a POE or POC for each COC (See Table 9).

At Tiers 2 and 3, Tier 1 RBSLs (as derived by generic statewide assumptions) are replaced with site specific target levels. SSTLs are developed by evaluating site specific characteristics through complex contaminant fate and transport modeling to evaluate risks to receptors. The DERBCAP tier structure is further explained in Section 1.6.

In addition, the DERBCAP generic exposure assessment is based on three potential exposure pathways:

- direct contact with impacted soils, whether by dermal contact, particulate ingestion, or inhalation of dust,
- ingestion of impacted groundwater, and
- Chemicals adsorbed to soil particles in the unsaturated zone above the water table, which can be remobilized by downward-infiltrating surface water from precipitation. Groundwater impacted by this remobilization processes is then ingested.

Vapor pathways are not included in a DERBCAP site assessment. However, the potential for vapor intrusion should be evaluated with the Department's *Vapor Intrusion Guidance*. This exposure pathway must be addressed on a track parallel to a DERBCAP assessment, following current Department policy and guidance. The DERBCAP conceptual exposure pathways are further explained in Section 3.1. The policy decisions that are the basis of DERBCAP are listed in **Error! Reference source not found.**.

1.5 DERBCAP Applicability

DERBCAP applies to Tank System sites that are regulated under Title 7, Delaware Code, Chapter 74, the *Underground Storage Tank Act*, Title 7 Delaware Code, Chapter 74A, *The Jeffrey Davis Aboveground Storage Tank Act* and other petroleum related sites that may be referred to the Remediation Section for follow-up remedial action. It remains the responsibility of the RP to achieve compliance with all other applicable environmental programs.

DERBCAP provides quantitative performance standards for the management of potential risks to human health at leaking storage Tank System sites in Delaware. It also provides the means to address potential risks to human safety, environmental and aesthetic impacts.

Before potential risks to human health may be assessed at a leaking tank system site, immediate risks to human safety and environmental impacts must be addressed and resolved. These include:

- eliminate any direct impacts caused by a release (e.g., impact to water supply wells),
- mitigation of vapor impacts caused by the release, especially by ventilation of enclosed locations such as utility conduits and basements,
- Remove mobile or migrating LNAPL to the extent practicable, wherever it occurs.

Aesthetic impacts occur when soils visibly stained by petroleum or soils that are the source of petroleum odors are either encountered at the surface or are brought to the surface by excavation. Aesthetic impacts are addressed by requiring that such soils be managed as though they exceed Tier 1 RBSLs,

whether or not they actually do. If transported off-site for any purpose, they are considered solid waste and must be transported by a Delaware-licensed solid waste hauler. They may not be reused as "clean fill" unless laboratory analyses confirm that all contaminants are Non-Detectable (ND) or meet clean fill criteria per the Department's Soil/Material Reuse Policy.

1.5.1 Alternative drinking water supplies

If potable water supply wells are rendered unusable because of a release from a leaking Tank System, alternative supplies must be provided. Carbon filters may be installed on the existing, impacted supply as a short-term step providing immediate protection. The emphasis is on permanent alternatives, however, which include:

- replacing impacted wells with non-impacted wells,
- connecting impacted users to public water-supply systems, and
- Remediating the groundwater until the impacted supply wells are once again usable.

Fate and transport segments of DERBCAP can be used to back-calculate soil and groundwater contaminant concentrations that are acceptable at the source area and which will be protective of receptors at various distances from the source area.

1.5.2 Removal of Light Non-Aqueous Phase Liquid (LNAPL)

In accordance with both Federal and State regulations, LNAPL must be removed to the maximum extent practicable. Some examples of LNAPL removal are: hand-bailing; use of sorbent materials; by pumping recovery wells; by installing passive sumps or constructing interception trenches; by implementing soil vapor extraction (which can cause LNAPL to volatilize for removal); or by other means.

1.5.3 Vapor Intrusion

Vapors emanating from contaminated soil or groundwater that enter buildings may result in indoor air concentrations that pose a risk to occupants. Accumulated vapors may pose an immediate risk of fire or explosion and may create adverse health effects from inhalation of toxic chemicals. Adequate ventilation is a short-term step to provide immediate relief and may be part of an engineered long-term solution. The potential for vapor intrusion will be evaluated with the Department's *Vapor Intrusion Guidance.*

1.5.4 Site Evaluation under DERBCAP

When the immediate impacts described above have been successfully addressed, then a leaking Tank System site can be assessed under DERBCAP. Under Tier 0, 1, 2 or 3 a specific clean up criteria can be defined for the RP or the tank owner or operator.

1.6 DERBCAP Process Overview

DERBCAP is a one-way process through each successive Tier (Figure 2). At each Tier a decision must be made to either clean up and close to that Tier's risk-based level or move on to the next Tier (Table 1).

Table 1. Tier Structure of DERBCAP

Tier	Chemistry	Site Characteristics
0	Generic chemicals	Generic statewide assumptions
1	Chemical specific Statewide RBSLs	Generic statewide assumptions
2	Chemical and site specific SSTLs	Site specific characteristics
3	More specific	More specific
Statewide assumptions include: grab soil samples are collected at the water table, groundwater is used for drinking water, current land use is residential, and soil is well sorted sand.		

DERBCAP Tier 0 applies to a project site at the time of Tank System Activities where the potential for a release from a Tank System must be assessed. Tier 0 soil action levels are conservative and assume there is a receptor in the immediate area of the Tank System. If Tier 0 action levels are exceeded, the RP has the option to clean up to the Tier 0 levels or move on to Tier 1. Tier 0 is discussed in Section 2.

DERBCAP Tier 1 applies to both new sites where Tier 0 levels were exceeded and also for existing leaking Tank System sites. Tier 1 RBSLs are based on conservative generic site assumptions along with a site-specific distance exposure assessment. The RP may achieve clean up at the Tier 1 RBSLs established for the site if the Department also determines an absence of cumulative risk. Otherwise, the project may move up to Tier 2. Upon Department approval COCs or pathways of concern may be eliminated at Tier 1 prior to the necessity for analysis at Tier 2. For example, if the Tier 1 soil limits are not exceeded, there is no need for further soil evaluation. Or, if only the groundwater benzene limit is exceeded, then Tier 2 need only address benzene. In this manner, the Tier 1 evaluation can help to focus the investigation or remediation plan. Tier 1 is discussed in Section 3.

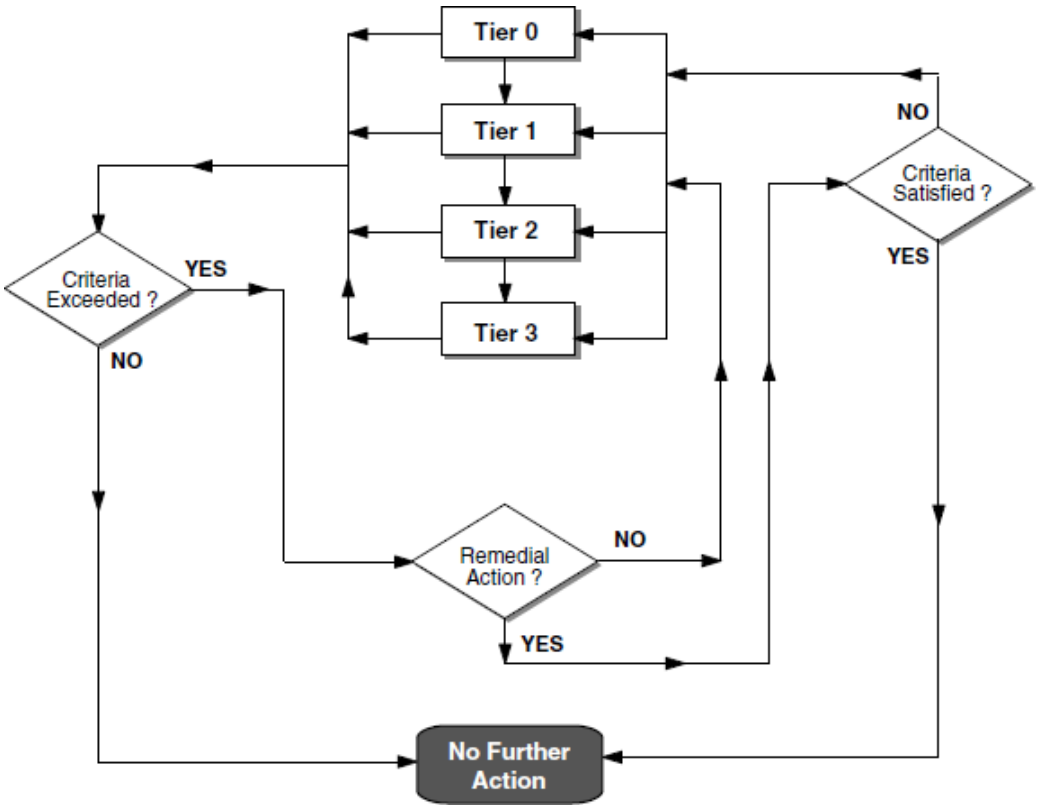


Figure 2. DERBCAP Process Flowchart

DERBCAP Tier 2 and Tier 3 SSTLs are based on progressive amounts of site-specific data and complex fate and transport modeling to achieve a more pointed risk evaluation. This assures that the acceptable level of risk is maintained with certainty based on greater site-specific data and not conservative assumptions as applied in Tiers 0 and 1. Tier 2 is discussed in Section 4, Tier 3 is discussed in Section 5. COCs or pathways of concern may also be eliminated through Tier 2 evaluation prior to the more detailed analysis at Tier 3.

2. TIER 0

2.1 Tier 0 Applicability

Tier 0 applies to all regulated Tank Systems that undertake Tank System Activities and where soil is disturbed and the potential for a release must be evaluated through a Site Assessment. This section also applies to other sites where a petroleum release has occurred in absence of a tank. The Tier 0 procedures as outlined in this document or other methods as approved by the Department shall be followed to ensure no releases to the environment.

Error! Reference source not found. presented below includes the generalized flow chart for the Tier 0 Tank System Activities process.

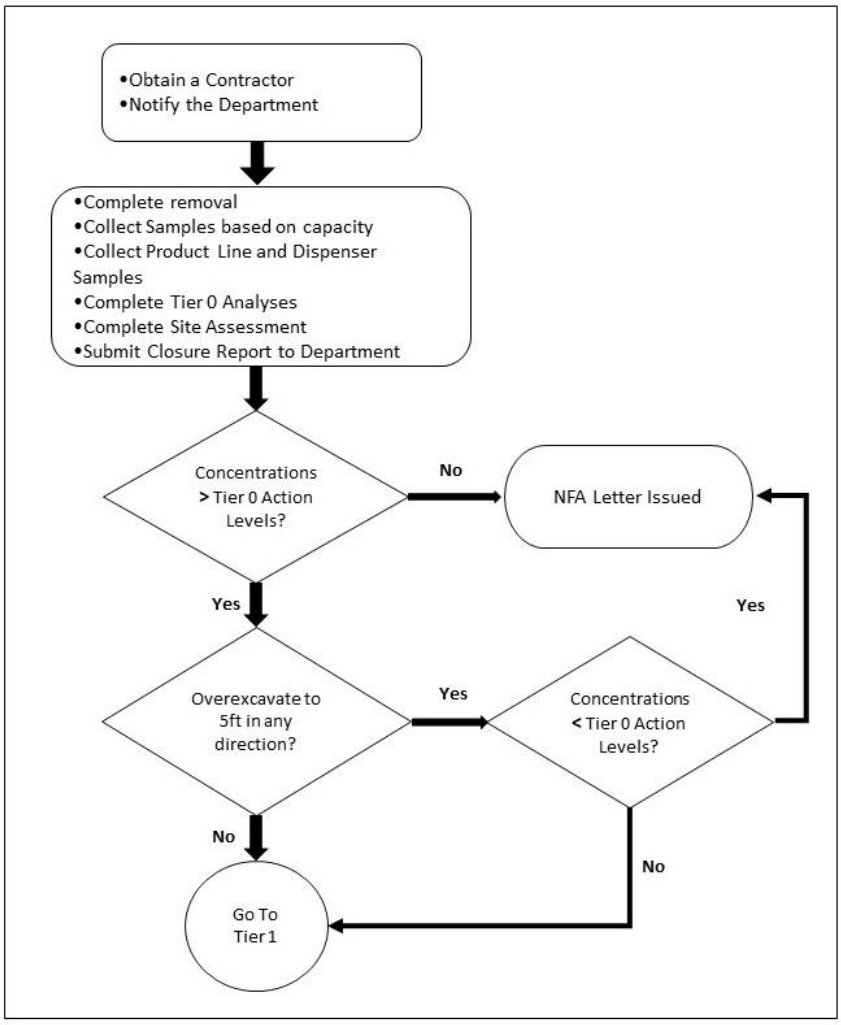


Figure 3. Tier 0 Tank System Activities

2.2 Tier 0 Site Assessment Requirements

2.2.1 Requirements for Tier 0 Soil Sampling and Analysis

2.2.1.1 Soil Sampling Protocol

Soil samples should be field screened and samples collected from the area where the contamination appears to be the greatest (presence of contamination, i.e. staining). To prevent volatilization of any contamination, samples should be collected as soon as the sample locations become accessible. The number of required soil samples per tank is described in the respective sections: Activity 1: Retrofits, Upgrades and Repairs of UST Systems/ Repairs and Modifications of ASTs; Activity 2 Tank Removals/ AST Relocations and Removals ; Activity 3 Closure in Place, Change in Service, Change in Product; Activity 4 Overexcavation; Activity 5 Dispenser Sampling at Tank Closures

All Tier 0 soil samples obtained from sites with Tanks containing Regulated Substances shall be analyzed according to the parameters outlined in Table 2.

Each soil analytical result must be less than the applicable Tier 0 limit, according to Table 2 in DERBCAP or additional investigation will be required at the discretion of the Department.

2.2.1.2 Tier 0 Analytical Requirements and Concentration Limits

Under the Tier 0 process, analysis for gasoline and diesel range organics (GRO and DRO) by Gas Chromatography Flame Ionization Detector (GC FID) or Gas Chromatography Mass Spectrometer (GC MS) replaces all prior TPH analytical methods. General chemicals of concern (COCs) found in petroleum products are chosen for a variety of factors including, but not limited to, carcinogenicity or other health effects, persistence in the environment, mobility, solubility, vapor pressure, or aesthetic factors.

To assure a constant level of protection for human health and the environment, Tier 0 uses a generic site conceptual model with the following assumptions to calculate Action Levels:

1. Groundwater is assumed to be used for drinking water.
2. Soils are assumed to be well sorted, permeable, fine to medium grained sand.
3. Current land use is assumed to be residential.

Laboratory Method Detection Limits (MDLs) must be less than applicable DERBCAP Action Level. Table 2 specifies the analytical requirements by substance stored and associated action levels. Footnotes outline specific requirements based on Tank System service dates, substance stored, and type of analysis.

Table 2. DERBCAP Tier 0 Soil Sample Analytes, Action Levels and EPA Lab Methods by Substance Stored for ASTs and USTs

Analyte	Tier 0 Action Level in Soil	Soil Sample Collection & Analytical Methods	Gasoline/ Av Gas	Kerosene / Jet Fuels	Diesel/ Heating Fuels	Used Oil [1,2, 9]	Heavy Oils	New Oil[8]	Other
GRO C6 - C10	100 mg/kg	EPA Method 5035/8015B	X	X		X			
DRO C10 - C28	1,000 mg/kg	EPA Method 8015B		X	X	X		X	
HRO ≥C28	1,000 mg/kg					X	X	X	
LEAD[4]	400 mg/kg	EPA Method 6010B or 7420	X			X			
Benzene	48 µg/kg	EPA Method 5035/8021B or 5035/8260D[6]	X	X		X			
Toluene	11,000 µg/kg		X	X		X			
Ethylbenzene	680 µg/kg		X	X		X			
Xylenes	45,000 µg/kg		X	X		X			
Ethanol[7]	NA		X						
EDB[4]	1.1 µg/kg		X			X			
EDC[4]	9.6 µg/kg		X			X			
MTBE[3]	190 µg/kg		X	X		X			
Other[5]									X

Notes:

1. Used oil as defined in Part A, Section 2 of the Delaware Regulations Governing Underground Storage Tank Systems and the Delaware Regulations Governing Hazardous Waste.
2. Used oil tanks may also be required to analyze for metals, volatiles, semi-volatiles, (EPA Method 5035/8021B or 5035/8260) or any other analyte as required (EPA Method 8270C, 8310 or 6010) on a site-specific basis depending on the tank contents. Contact DNREC for a determination on analytical requirements.
3. MTBE analysis is required, unless conclusive documentation is presented and pre-approved by DNREC confirming that the Tank System was not in service after January 1, 1978.
4. For gasoline Tank System only, Lead, EDB and EDC analysis is required unless conclusive documentation is presented and pre-approved by DNREC that the Tank System was installed after January 1, 1996. Lead, EDB and EDC analysis is always required for aviation gas Tank System.
5. If the Tank System contained anything other than petroleum products or if the tank system contained Racing Fuel, contact DNREC for information on sampling procedures and analytical requirements prior to any site activities.
6. Samples collected for the analysis of volatile organic compounds must be preserved with methanol. En Core™®samples are acceptable
7. Ethanol analysis is required, unless conclusive documentation is submitted and pre-approved by DNREC that no portion of the Tanks System was in service after April 1, 2006.
8. New Oil parameters may be modified with DNREC approval.
9. For Tank System where the substance is unknown, analysis for the used oil parameters is required.

Note: Encore™® Samplers should not be used when sampling pea gravel. When sampling pea gravel, methanol preservation of the sample in the field is required.

2.2.2 Quality Assurance/Quality Control Sampling Protocol

Owners and Operators or Responsible Parties are required to implement the following quality assurance/quality control protocols during collection as described below:

All samples must be submitted in clean sealed containers provided by the analytical laboratory and kept at ≤ 6°C until delivered to the laboratory for analysis. The laboratory must receive samples within

twenty-four (24) hours of collection. If sample delivery within twenty-four (24) hours is not possible (for example, samples are collected late on a Friday after the laboratory is closed) proper storage of the samples must be documented on the chain of custody form. A chain of custody form must be maintained at all times for all samples and submitted to the DNREC.

For sampling events where volatile organic compounds (BTEX, GRO, EDB, EDC, MTBE, etc.) are to be analyzed, a trip blank must accompany the cooler from pickup to delivery. The trip blank must be analyzed for the same volatile organic compounds as the collected soil samples.

For soil sampling events where volatile organic compounds are to be analyzed, methanol preservation or unpreserved such as Encore™® sampling must be conducted. NOTE: Unpreserved **should not** be used when sampling pea gravel. When sampling pea gravel, methanol preservation of the sample in the field is required. Coordinate with your laboratory in advance to determine best sample volume and appropriate bottleware size for representative samples and ease of sample collection.

The use of disposable or dedicated sampling equipment is preferred to non-disposable or non-dedicated sampling equipment to minimize the risk of cross-contamination; If non-disposable or non-dedicated sampling equipment is used to collect soil samples, the collection of an equipment blank is then required. All sampling equipment that is not dedicated or is not disposable shall be required to comply with decontaminated practices found in ASTM International, D5088-20, *standard Practice for Decontamination of Field Equipment Used at Waste Sites*.

2.2.3 Reporting Requirements

Responsible Parties shall submit soil sample reports that at a minimum include the following:

1. Site Map noting the sample locations.
2. Results of the soil sample analyses with chain-of-custody. The sample results must be labeled with the Facility ID Number, full site name, address, and sample dates.
3. Custody seal chain-of-custody, if applicable.
4. All appropriate disposal documentation (tank and contents, e.g. disposal of product, sludge, contaminated water)
5. Field notes if applicable.

2.2.4 Tier 0 Data Evaluation and Response Options

Upon receipt of a Tier 0 Site Assessment package, the Department will compare the appropriate Tier 0 action levels shown in **Error! Reference source not found.** to determine the need for further action at the site. Each soil sample will be evaluated to determine if the applicable Tier 0 action level has been exceeded. The RP will be issued either a No Further Action (NFA) letter or given the option to remediate either to Tier 0 levels or move to a Tier 1 site assessment.

Each soil analytical result must be less than the applicable Tier 0 limit or additional investigation will be required, at the discretion of the Department. Analytical results may not be averaged for comparison to the Tier 0 action levels.

2.3 Underground Storage Tank Tier 0 Investigations

2.3.1 Tier 0 UST Soil Sampling Protocols

2.3.1.1 Composite Soil Sampling

At least one composite soil sample per tank must be collected by taking several discrete samples from soil in each soil boring/test pit and mixing them together. (Figure 4)

2.3.1.2 Grab Soil Sampling

Grab soil samples must be collected from specific spots along the sides or bottom of the tank excavation and below the product dispensers per the diagram below (Figure 4). The location of the grab samples depends on the elevation of the water table.

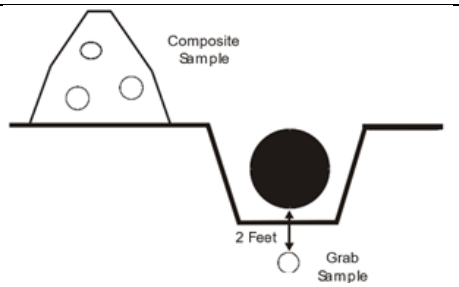
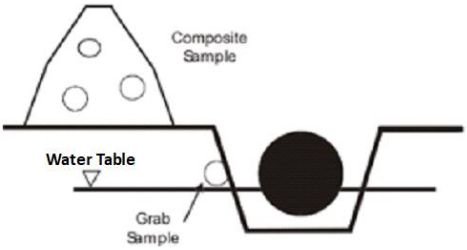
TANKS ABOVE THE WATER TABLE Collect grab samples at a depth equal in elevation to two (2) feet below the bottom of the tank. Composite soil samples shall be collected by taking several discrete samples from the soil in each boring/test pit and then mixed together.	
TANKS BELOW THE WATER TABLE Collect grab samples from the sidewall of the excavation immediately above the water table level in the pit. Composite soil samples shall be collected by taking several discrete samples from the soil in each boring/test pit and then mixed together.	

Figure 4. Sampling Method

2.3.1.3 Piping Run Sampling – Piping includes product, vent, vapor recovery and remote fill piping.

For Piping ***installed prior to January 1, 1999*** where closure-in-place of a piping run is performed, sampling is required for every 20 feet of piping. For piping runs removed from the ground via trenching so that soil conditions beneath the piping can be evaluated, sampling will only be required from areas of the piping trench with observable staining or evidence of a release.

For Piping ***installed after January 1, 1999*** sampling is <u>not</u> required unless there is observable staining or evidence of a release.

2.3.2 Activity 1 –Retrofits, Upgrades and Repairs of UST Systems

2.3.2.1 Dispenser Sump Installation or replacement, including product piping

If the retrofit includes replacement of the sump, or replacement of piping to the dispenser, then one grab sample per dispenser must be collected from an elevation of five (5) feet below each dispenser or at the top of the water table, whichever is encountered first. (Figure 5).

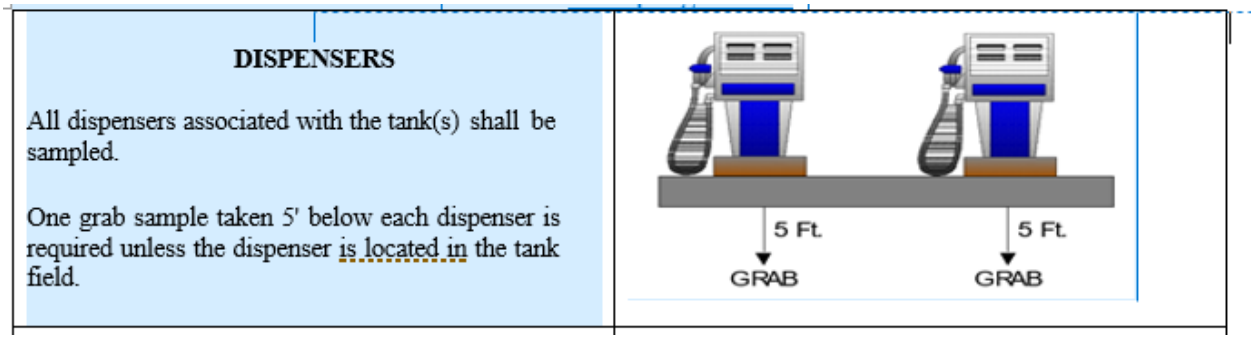


Figure 5. Dispenser Sampling Requirements

2.3.2.2 Spill Containment Replacement

Soil samples must be collected when concrete is broken or backfill is exposed to install spill containment buckets. One grab sample must be collected at the bottom of the excavation for each spill containment device installed.

2.3.2.3 Tank-top Sump Installation or Replacement

Soil samples must be collected when concrete is broken or backfill is exposed to install new or replace existing tank-top sumps. At least one composite sample must be collected by taking several discrete samples from the excavated material. In the event that no material is excavated in order to install the new sump, one composite sample must be collected from the walls of the excavation in the locations where contamination is visible or most likely to be present.

2.3.3 Activity 2 - UST System Removals

2.3.3.1 Soil Sampling Requirements Specific to UST System Removals

Responsible Parties shall comply with the following soil sample requirements according to each Tank capacity as illustrated in

Figure **6** and as described below (Table 3) for UST System Removals.

Table 3. Required Number of Soil Samples by Tank Capacity

UST Capacity (gallons)	# of Samples per Tank
0 – 1,100	1 grab & 1 composite/tank Dispenser & Piping Run samples
1,101 – 30,000	2 grabs & 1 composite/tank Dispenser & Piping Run samples
Compartmentalized USTs- Each compartment is treated as a standalone tank unless all compartments contain the same product.	2 grabs & 1 composite Dispenser & Piping Run samples for each compartment.

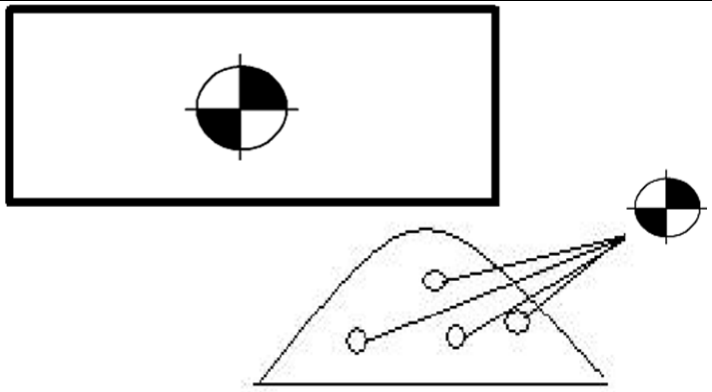
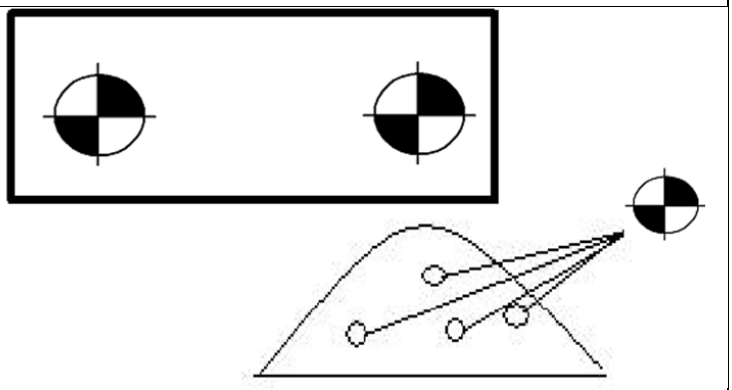
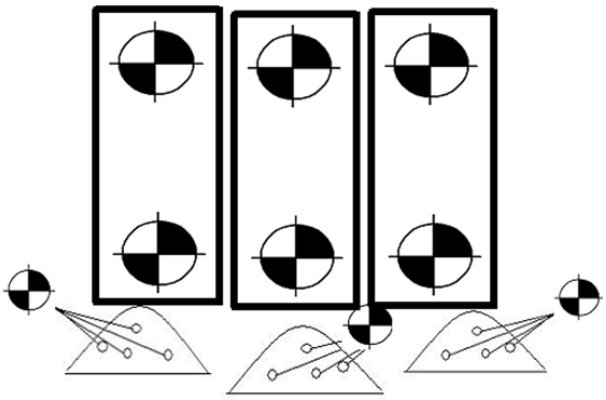
UST Capacity (gallons)	# Of Samples per Tank	Illustrations
0– 1,100	1 grab soil sample and 1 composite soil sample per tank	
1,101 – 30,000	2 grab soil samples and 1 composite soil sample per tank	
Multiple Tanks	Follow protocol for single tank based on capacity. Include one (1) composite soil sample per tank in the pit	Example: (3) 15,000 gallon USTs: 

Figure 6. UST Removal Soil Sample Locations and Quantity - by Capacity

2.3.4 Activity 3 - UST Closure in Place; Change In Service and Change in Substance Stored

Responsible Parties shall comply with the required number and location of soil samples according to each Tank capacity as illustrated in Figure 7 and as described below (Table 4) for UST Closure in Place; Change in Service and Change in Substance Stored:

Table 4. Required Number of Soil Samples by Tank Capacity

UST Capacity (gallons)	# of Samples per Tank
0 – 1,100	2 Borings (4 samples) 1grab & 1 composite from each boring Plus Dispenser samples
1,101 – 15,000	4 Borings (8 samples) 1 grab & 1 composite from each boring plus Dispenser samples
15,001 – above	6 borings (12 samples) 1 grab & 1 composite from each boring plus Dispenser samples

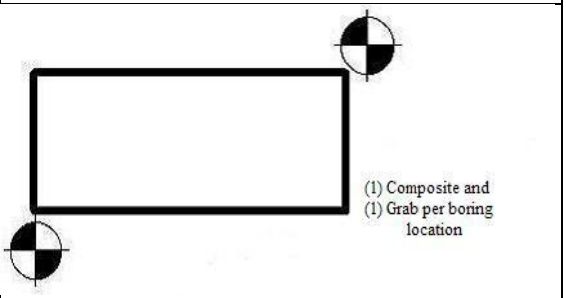
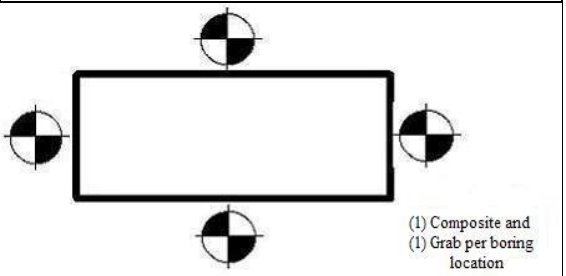
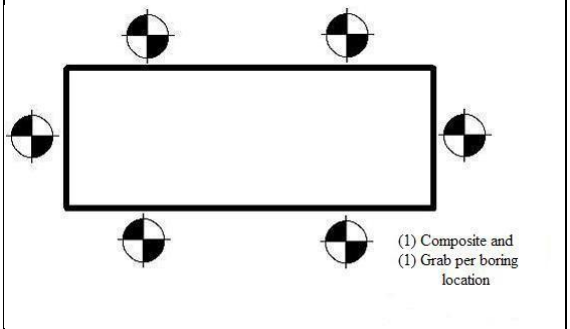
UST Capacity (gallons)	Number of Samples per Tank	Illustration
0 – 1,100	Install soil borings at opposite corners of the tank to a depth equal in elevation to two (2) feet below the bottom of the tank. Collect a grab sample from soils at the bottom of each boring or just above the soil/groundwater interface. Collect a composite sample by taking several discrete samples from the backfill materials generated during installation of the boring. (**Total: 4 soil samples**)	
1,101 – 15,000	Install one soil boring along each side to a depth equal in elevation to two (2) feet below the bottom of the tank to be closed in place. Collect a grab sample from soils at the bottom of each boring or just above the soil/groundwater interface. Collect a composite sample by taking several discrete samples from the backfill materials generated during installation of the boring. (**Total: 8 soil samples**)	
15,001-above	Install two soil borings along each long side and one soil boring along each short side to a depth equal in elevation to two (2) feet below the bottom of the tank to be closed in place. Collect a grab sample from soils at the bottom of each boring or just above the soil/groundwater interface Collect a composite sample by taking several discrete samples from the backfill materials generated during installation of the boring. (**Total: 12 soil samples**)	

Figure 7. UST Closure in Place - Soil Sample Locations and Quantity- by Capacity

2.3.5 UST Activity 4 –Overexcavation

During a removal, an RP has the option to over-excavate up to five (5) feet in all directions to attempt an immediate cleanup to Tier 0 action levels, provided that bedrock, a physical barrier, or the water table is not encountered. If any of these conditions are encountered or if soil contamination extends beyond the allowable five (5) foot maximum, then the RP must move to Tier 1 or contact the Department for approval to perform a larger overexcavation.-Additional excavation is permissible, following notification and approval from the Department. Following the excavation procedures, confirmatory soil samples are collected from each wall and the bottom of the excavation as describe in Table 4. .

2.3.5.1 Overexcavation Composite Samples

Composite soil samples should be collected by sampling the soils along the pit wall that are representative of subsurface conditions. The number of required composite soil samples per tank is described in Table 4. 5.

2.3.5.2 Overexcavation Grab Samples

If no contamination is apparent, grab samples should be collected from the center of each pit wall. The number of required grab soil samples per tank is described in

.

Table 5. Overexcavation - Required Number of Soil Samples by Tank Capacity

Capacity (gallons)	# of Samples per Tank
0 – 1,100	Composite Samples (5 samples) – 1 from each sidewall and 1 pit bottom
1,101 – 20,000	Composite Samples (5 samples) - 1 from each sidewall and 1 pit bottom Grab Samples (5 samples) – 1 from each sidewall and 1 pit bottom
20,000-above	Composite Samples – 1 per 20 feet each wall or bottom being overexcavated Grab Samples – 1 per 20 feet each wall or bottom being overexcavated

2.3.6 Activity 5 Soil Sampling Requirements for UST System Closures involving Dispensers

Responsible Parties performing UST closures involving dispensers shall comply with the soil sampling requirements as described below and as illustrated in Figure 5.

For UST System Closures involving dispensers, a collection of one (1) soil grab sample per dispenser is required and shall be taken from an elevation of five (5) feet below each dispenser or at the top of the water table, whichever is first encountered. See Figure 5.

2.4 Aboveground Storage Tank Tier 0 Investigations

2.4.1 AST Site Assessments

Site assessments shall not commence without prior written approval by the Department. Analysis shall be selected based upon any and all regulated substances stored in the AST over its lifetime.

2.4.1.1 Tier 0 AST Soil Sampling Protocol

- Soil and groundwater samples shall be obtained from the ground surface immediately beneath the AST, at the location of any visual staining or regulated substance accumulation, and beneath the ancillary piping.
- All leak detection devices or subsurface monitoring locations shall be sampled.
- Test pits shall be excavated, or soil borings advanced in the immediate vicinity of the AST, and representative soil and groundwater samples shall be obtained.

2.4.1.2 Grab Soil Sampling

Grab soil samples must be collected from specific spots along the perimeter of the tank per the diagram below (Figure 8). The number of grab samples depends on the size of the tank. The location of the grab samples depends on the elevation of the water table.

*Samples shall be obtained from the locations with the suspected highest concentration of contaminants of concern. Grab samples at the three (3) foot interval should be field screened. If there are indicators of contamination at the three (3) foot interval, sample to the depth where contamination

appears to be greatest and also immediately above the water table.

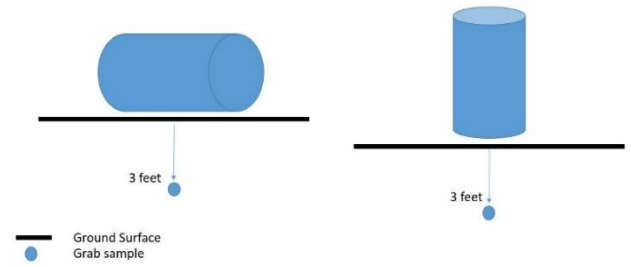
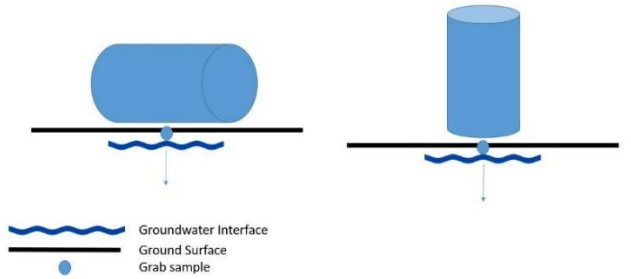
Sampling Above the Water Table* Shallow samples shall be discrete "grab" samples collected three (3) feet below the ground surface (bgs) or three (3) feet below the bottom of the AST, whichever is deeper.	
Sampling When Groundwater is Encountered Samples shall be collected immediately above the water table level.	

Figure 8. Grab Soil Sampling Locations

2.4.2 Activity 1: AST Repairs and Modifications

Responsible Parties performing AST activities involving AST repairs or modifications shall comply with the soil sampling requirements as described below.

2.4.2.1 Piping and Ancillary Equipment, Repairs, and Modifications

- At least one (1) discrete grab sample shall be collected from native soil two (2) feet below each underground swing joint, connector, or elbow.
- When elbows, connectors or swing joints are not known or available, collect at least one (1) grab soil sample two (2) feet below every twenty (20) linear feet of underground piping.
- Collect a minimum of one (1) grab sample three (3) feet below ground surface (bgs) grab at the first isolation valve for each run of aboveground piping.

2.4.2.2 AST System and Secondary Containment , Repairs, and Modifications

At least one (1) grab sample must be collected during AST system repairs or modifications where soil is excavated or if there is evidence of a release or at the bottom of the excavation for each containment device (dikes, berms or retaining walls; curbing; diversion ponds, holding tanks, sumps; vaults; double-walled tanks; liners external to the tanks).

2.4.3 Activity 2: AST Relocations & Removals

Responsible Parties performing AST Removals shall comply with the soil sampling requirements as described in Table 6 and Figure 9:

Table 6. Required Number of Soil Samples by Tank Size

Tank Diameter (feet)	Shallow 3' Perimeter Soil Samples	Shallow 3' Tank Bottom Soil Samples
<25	4	1
25-60	5	2
61-90	6	4
>90	Site Specific –Submit Work Plan for DNREC-WHS Approval	

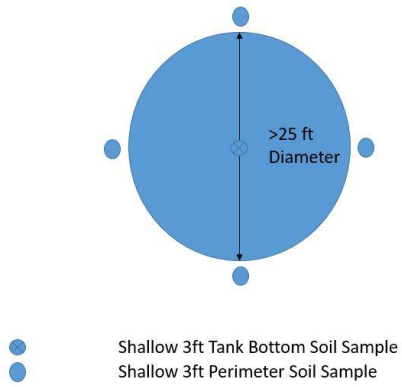
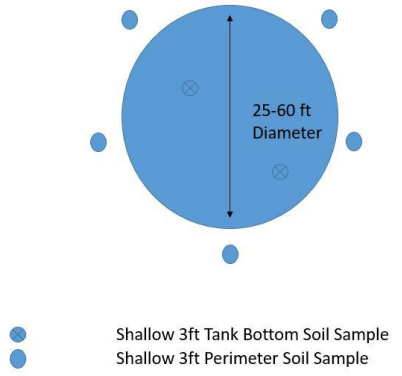
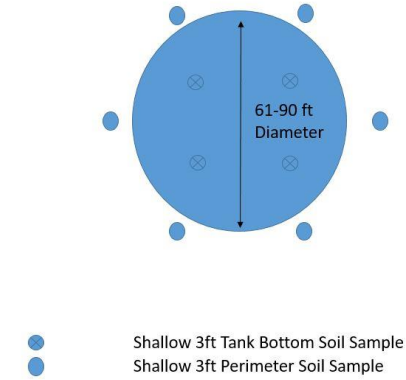
Tank Diameter (feet)	Illustration
<25	
25-60	
61-90	

Figure 9. Tank Removal Soil Sample Locations by Aboveground Tank Size

2.4.4 Activity 3: AST Closure in Place; Change In Service and Change in Substance Stored

Responsible Parties performing AST Activities involving Closure in Place, Change in Service or Change in Substance Stored shall comply with the soil sampling requirements as described in Table 7 and Figure 10:

Table 7. Required Number of Soil Samples by Above Ground Tank Size

Tank Diameter (feet)	Shallow 3' Perimeter Soil Samples	Deep Perimeter Soil Samples at water table
<25	4	4
25-60	5	5
61-90	6	6
>90	Site Specific - Submit Work Plan for DNREC-WHS Approval	

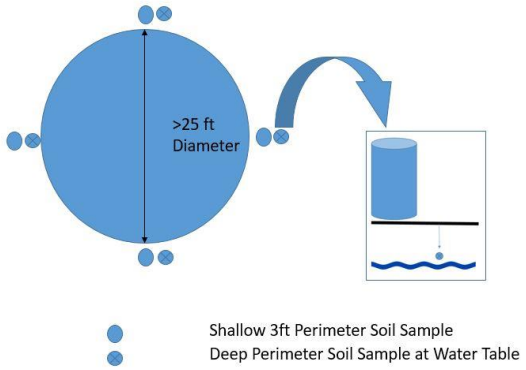
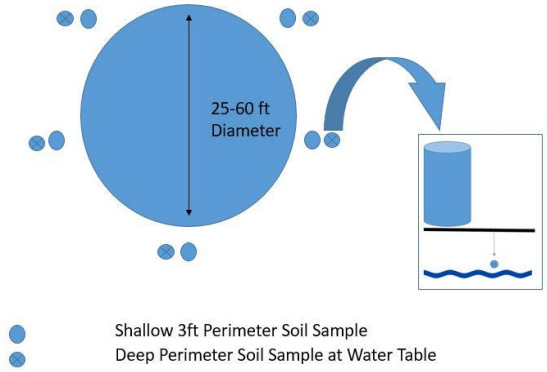
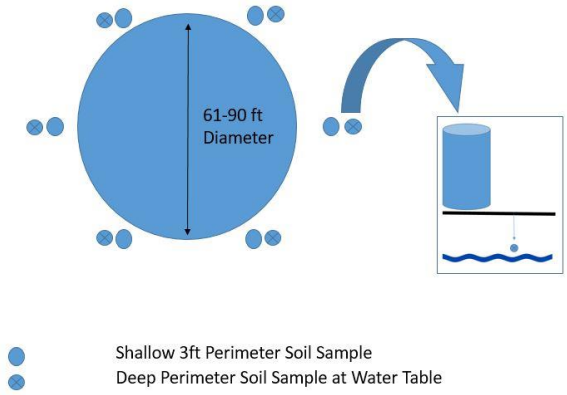
Tank Diameter (feet)	# of Samples per Tank	Illustration
<25	Collect samples at four (4) evenly spaced locations around tank perimeter. At each location, collect one (1) shallow 3' grab sample, and one (1) deep perimeter soil sample at the groundwater interface. Collect a grab sample from soils at the bottom of each boring or just above the soil/groundwater interface **(Total: 8 soil samples)**	
25-60	Collect samples at five (5) evenly spaced locations around tank perimeter. At each location, collect one (1) shallow 3' grab sample, and one (1) deep perimeter soil sample at the groundwater interface. Collect a grab sample from soils at the bottom of each boring or just above the soil/groundwater interface **(Total: 10 soil samples)**	
61-90	Collect samples at six (6) evenly spaced locations around tank perimeter. At each location, collect one (1) shallow 3' grab sample, and one (1) deep perimeter soil sample at the groundwater interface. Collect a grab sample from soils at the bottom of each boring or just above the soil/groundwater interface (**Total: 12 soil samples**)	

Figure 10. Closure In Place Soil Sample Locations by Aboveground Tank Size

2.4.5 Activity 4: AST Overexcavation

If a release is identified, the tank area may be overexcavated five (5) feet farther than any one side of the original tank location or to the extent of observable staining and evidence of a release. Additional excavation may be permissible following notification and approval from the Department. All excavations greater than one hundred (100) cubic yards shall be approved in advanced by the Department and a sampling plan shall be approved by the Department prior to commencing excavation.

Following excavation, confirmatory composite soil samples are collected from each wall and bottom of the excavation. Confirmatory sampling of the excavated material will be a function of the size of the excavation. In general, at least one (1) grab sample shall be collected from every "face" (or sidewall) of the excavation cavity for a total of five (5) samples. One (1) additional "composite" sample shall be collected from the bottom of the excavation and one (1) additional "composite" sample shall be collected from the sidewalls. This is the general sampling plan for any excavation that does not exceed twenty (20) feet of run in any direction.

2.4.6 Activity 5: AST Closures involving dispensers

see Section 2.3.6 Activity 5 Soil Sampling Requirements for UST System Closures involving Dispensers.

3. TIER 1

3.1 Tier 1 Applicability

Tier 1 is the next level in DERBCAP. An RP may choose to enter the RBCA process at Tier 1 with any currently active LUST/LAST site or will move up to Tier 1 from Tier 0 if tank Site Assessment soil analytical results exceed applicable Tier 0 action levels.

To assure a consistent level of protection for human health and the environment, Tier 1 uses a generic site conceptual model with the following assumptions to calculate RBSLs:

1. Grab soil samples are assumed to be collected at the top of the water table.
2. Groundwater is assumed to be used for drinking water.
3. Soils are assumed to be well sorted, permeable, fine to medium grained sand.
4. Current land use is assumed to be residential.

In Tier 1, specific chemicals of concern (COCs) found in petroleum products are chosen for a variety of factors including, but not limited to, carcinogenicity or other health effects, persistence in the environment, mobility, solubility, vapor pressure, or aesthetic factors. RBSLs are then calculated for each COC for surface soil (direct contact exposure pathway), subsurface soil (soil leaching or partitioning to groundwater), and groundwater (groundwater ingestion exposure pathway.) Vapor pathways are not part of the RBSL calculations. However, vapor intrusion risk is evaluated per the Department's Vapor Intrusion Guidance. Figure 11 summarizes the exposure pathways used to calculate DERBCAP RBSLs. See Appendix 5 for formulas used in RBSL calculations.

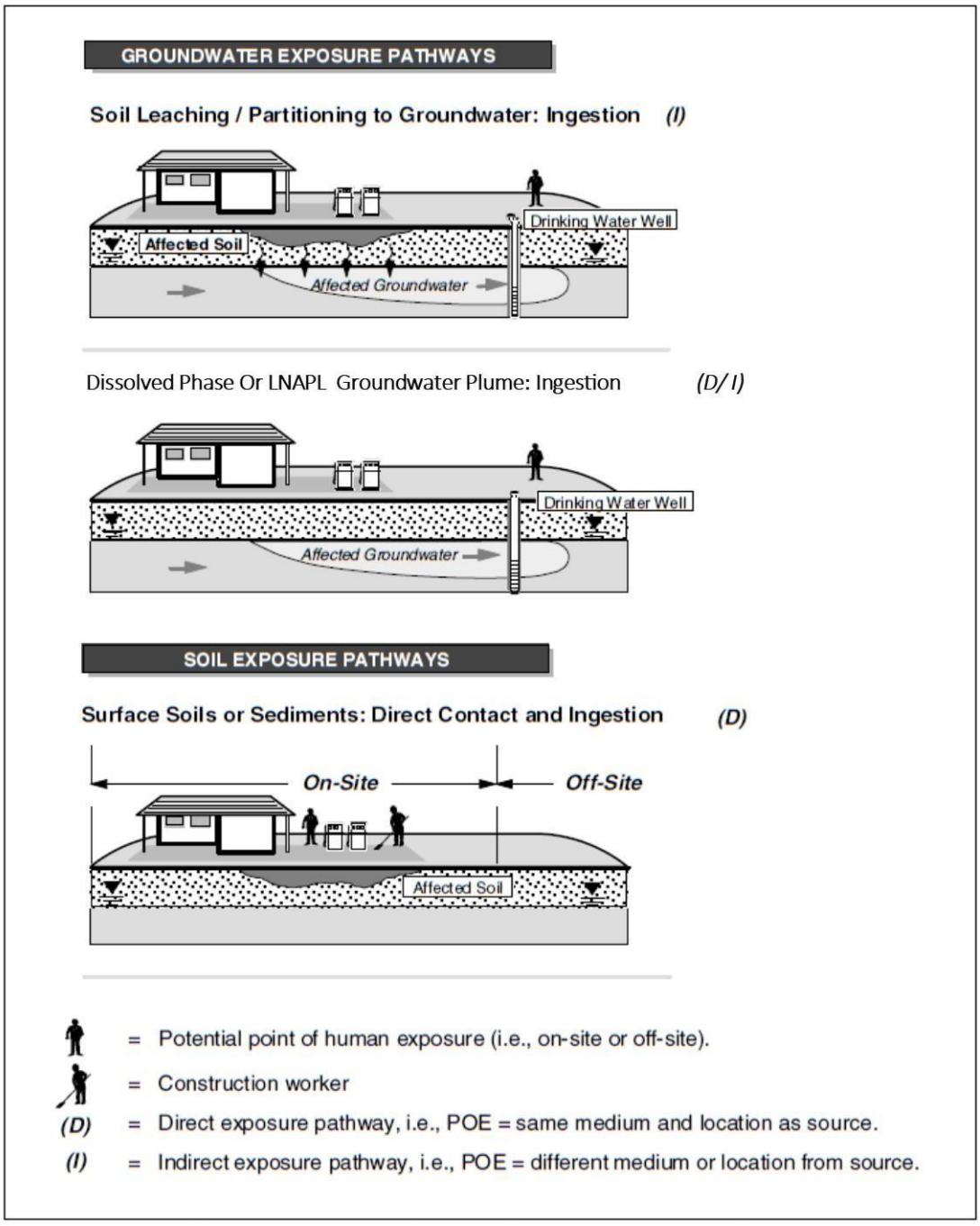


Figure 11. DERBCAP Exposure Pathways Chosen from the ASTM Standard

The target risk limit for both individual chemicals and cumulative site risk for carcinogens is 1 x 10^{-5}; for non-carcinogens the hazard quotient (HQ) is less than or equal to 1.

It should be noted that the Tier 1 RBSLs outlined in Table 9 do not account for cumulative risk associated with the chemicals of concern for each media. A cumulative Risk Assessment may be required for detect- ed chemicals of concern in each media where a complete exposure pathway exists.

3.2 Tier 1 Site Investigation Requirements

A Tier 1 DERBCAP Hydrogeologic Investigation requires that all samples be analyzed for all specified COCs based on substance stored and media sampled. If a tank field holds multiple tanks containing more than one type of stored petroleum product, then all samples must be analyzed for all COCs for all substances stored. Additionally, a DERBCAP Tier 1 Hydrogeologic Investigation requires the collection of groundwater samples and analysis for the same COCs, unless otherwise approved by the Department.

Groundwater sampling may not be required at the Department's discretion when contamination is proven to be limited to the unsaturated zone through field screening and confirmatory sampling, or when bedrock is encountered above the water table. This option will apply primarily to sites located in the Piedmont region.

The submittal of a DERBCAP Tier 1 Hydrogeologic Investigation workplan is not required. However, responsible parties and/or their consultants may contact the Department for a teleconference or meeting to discuss the proposed scope of the investigation.

The Hydrogeologic Investigation Guide should be consulted for a thorough description of the requirements and expectations for a Hydrogeologic Investigation.

In general, a Hydrogeologic Investigation must include the following:

- Complete delineation of all contaminant phases that exist both on and off site and whether the source is moving through soils, via groundwater, or along manmade conduits (e.g., utility trenches);
- Determination of groundwater flow direction;
- Location of all area points of exposure (receptors);
- Interpretation of the data provided;
- Risk Assessment; and
- Recommendations for further activity at the site.

Laboratory Method Detection Limits (MDLs) must be less than applicable DERBCAP RBSLs.

A Tier 1 Hydrogeologic Investigation may be completed in phases at the responsible party's discretion, provided that all regulatory timeframes are met. The initial investigation phase may use a direct push technology to determine the extent of the release and facilitate the placement of monitoring wells. No Further Action may be granted at any time during an investigation at the Department's discretion based on an analysis of the data provided. To meet the criteria and warrant no further action at a project site, the data must demonstrate that contamination is localized in extent and not mobile. In addition, sample concentrations must be less than RBSLs and have met a cumulative risk for carcinogens less than 1×10^{-5}; for noncarcinogens the hazard quotient (HQ) is less than or equal to 1 for completed exposure pathways.

3.3 Tier 1 Concentration Limits

Tier 1 fate and transport default parameters used to calculate the RBSLs are located in Appendix 2, exposure assumptions are located in Appendix 3. The calculation sheets for each exposure pathway by distance to the POE on which Table 9 RBSLs are located in Appendix 4. The equations and methodology used to calculate the Tier 1 RBSLs are located in Appendix 5. Table 8 lists DERBCAP COCs and Table 9 lists the Tier 1 RBSLs.

Due to the physical and chemical properties of lead, the RBSL concentration value for less than 50 feet (<50') is applied in all situations at all distances.

It should be noted that the Tier 1 RBSLs outlined in Table 9 do not account for cumulative risk associated with the chemicals of concern for each media.

The Department may require a Cumulative Risk Assessment when more than one chemical of concern is reported by laboratory analysis in a given media with a completed exposure pathway. It has been the Department's experience at petroleum cleanup sites that constituent risk tends to be driven by one or two components, such as benzene or naphthalene. A large number of petroleum constituents may be detected in soil or groundwater; however, only one or two of those constituents may actually approach or exceed risk-based concentrations. A majority of risk-based decisions related to petroleum constituents will be directly compared to the established RBSLs or, when applicable, to the SSTLs generated at the Tier 2 level. In cases where several constituents are detected at levels close to or above the risk-based concentrations, the Department may require a determination of cumulative risk to ensure that the overall site risk does not exceed acceptable levels.

Risk from the PVI pathway should be evaluated using indoor air data, the most recent version of the Vapor Intrusion Screening Level calculator (VISL), or the Johnson & Ettinger (J&E) model with updated toxicity values. Refer to the Department Vapor Guidance for details on vapor intrusion risk assessment, including use of models as approved by the Department, such as but not limited to the ITRC Petroleum Vapor Intrusion Guidance and the EPA Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Tank System Sites.

3.3.1 Exposure Point Concentrations

The Exposure Point Concentrations (EPCs) are the concentrations of chemicals of concern in the environmental media at the point of human exposure.

The Department recommends the use of EPA's most current version of the ProUCL software to calculate the EPC due to its wide availability, ease of use, and the regular updates provided by US EPA. Statistical software other than ProUCL should be preapproved by the Department prior to use on a site-by-site basis. ProUCL is available as a free download from the US EPA.

For soil sample sets with less than 10 samples, the maximum observed concentration (MOC) must be utilized in the risk assessment. When 10 or more soil samples have been collected and laboratory analyzed, the 95% Upper Confidence Limit (UCL) may be utilized as determined by ProUCL or other approved statistical program. The Department may, at its discretion, allow a lower number of samples; however, an appropriate statistical method as recommended by ProUCL including non-parametric analysis (i.e. average for lead) is required to determine Exposure Point Concentrations.

The EPCs to be used in risk calculations for soil should be the 95% UCL of the COC mean of the analytical data set. The ProUCL software accounts for non-detects and calculates the 95% UCL using

various methods and recommends the most appropriate UCL to use based on the data. A minimum of 10 soil samples is recommended to calculate a more reliable UCL but the minimum number of samples may vary depending on site conditions and as determined by the Department. In addition, the calculated average of the parent and duplicate sample should be used for any 95% UCL calculations within ProUCL. Any variation will be on a site-specific basis and pre-approved by the Department. Please note that this applies to all media (soil, groundwater, and vapor).

For groundwater, the MOC must be utilized as the EPC unless otherwise approved by the Department.

It is preferred that EPCs for vapor intrusion be based upon indoor air samples. However, EPCs for vapor intrusion can be based on the maximum soil gas or sub-slab results if there are background issues related to indoor air samples. In these cases, the use of indoor air data is problematic due to the high likelihood of indoor sources or outdoor ambient sources of VOCs. Note, if indoor air concentrations are determined to be from a sub-surface source, indoor air data is the preferred source of data to calculate risk. Soil gas data is preferred when there is a suspected indoor air source. Due to the high variability of the sample data on a monthly, daily, or hourly basis, the maximum concentration in soil gas, sub-slab or indoor air should be used as the exposure point concentration. However, if adequate data is available for each sample type, such as soil-gas or sub-slab, to calculate a 95% UCL then that value can be used for the EPC.

3.4 Tier 1 Data Evaluation and Response Options

A detailed site map must be included with the Tier 1 Hydrogeologic Investigation Report submitted to the Department (see the Hydrogeologic Investigation Guide). All decisions regarding potential risk and cleanup levels center on the distance from the source to all POEs. The responsible party should determine the distance from the source to all POEs and propose applicable RBSLs for Department approval using Table 9 in this document. All measured COC concentrations will be compared to applicable RBSLs based on distance to a POE. See Scenarios in Section 3.5.

It should be noted that the Tier 1 RBSLs outlined in Table 9 do not account for cumulative risk associated with the chemicals of concern for each media. A determination of cumulative Risk Assessment may be required when more than one chemical of concern is reported by laboratory analysis in a given media and a completed exposure pathway exists.

Upon submittal of a Tier 1 Hydrogeologic Investigation Report, the Department will apply the appropriate RBSLs and evaluate cumulative risk for completed exposure pathways to determine the need for further action at the site. The RP will be issued an NFA letter, a conditional NFA letter, be given the option to cleanup to the appropriate RBSLs or proceed to Tier 2.

Figure 12 shows the Tier 1 process. Refer to the Tier 1 scenarios in Section 3.5 for determining distance components for RBSLs and Corrective Action workplans. Any point within a plume (such as a monitor well) where COC concentrations are greater than Tier 1 RBSLs must be remediated, or the responsible party may request proceeding to a Tier 2.

The Tier 1 evaluation may be used to screen certain pathways from further consideration. The Department may require a determination of cumulative risk to ensure that the overall site risk does not exceed acceptable levels.

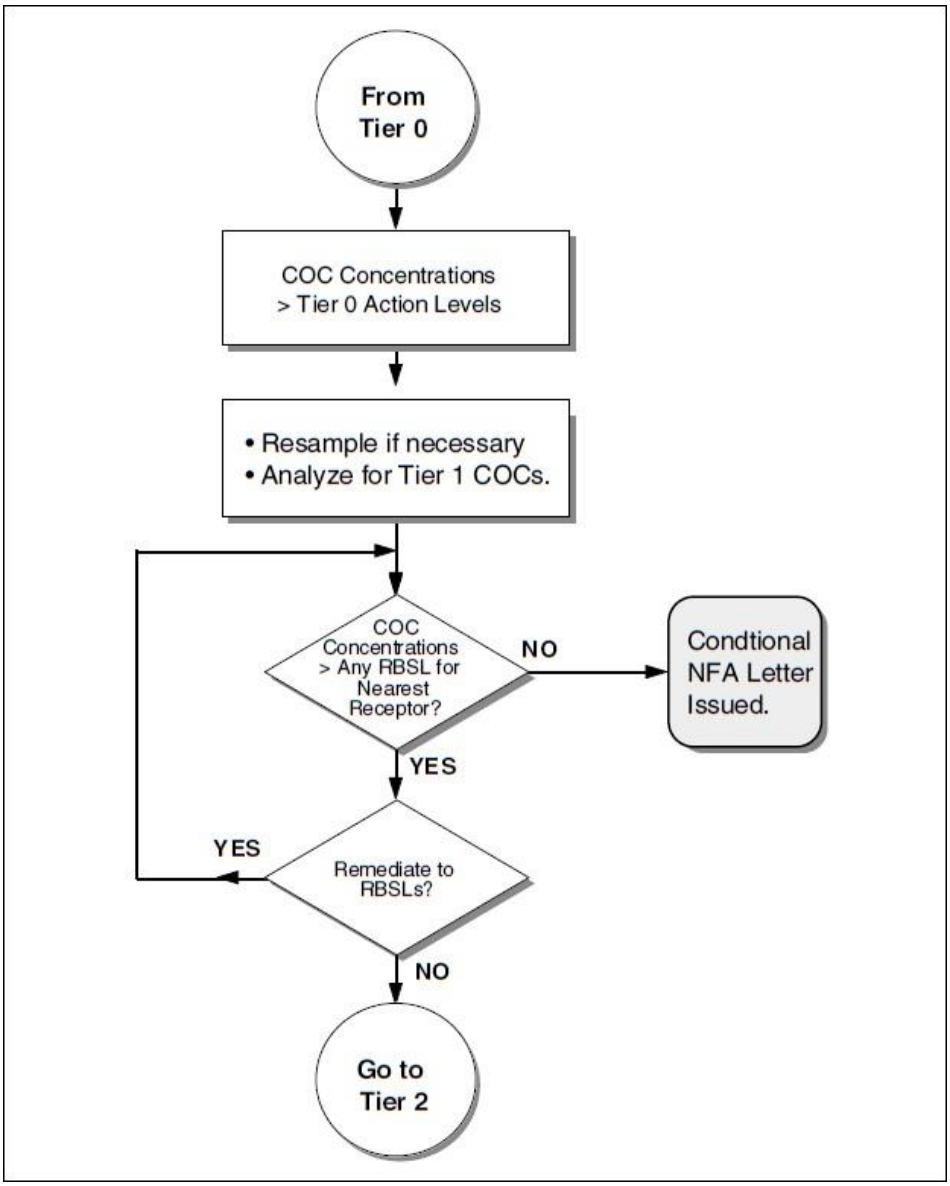


Figure 12. Tier 1 Flowchart

Table 8. DERBCAP Chemicals of Concern

Chemical of Concern (COC)	Product									
	Gasoline/Av-Gas		Jet Fuel/Kero		Diesel		Heating Fuel		Used Oil	
	SOIL	GW	SOIL	GW	SOIL	GW	SOIL	GW	SOIL	GW
VOLATILES										
Benzene	X	X	X	X		X		X	X	X
Toluene	X	X	X	X		X		X	X	X
Ethylbenzene	X	X	X	X		X		X	X	X
Xylene (mixed isomers)	X	X	X	X		X		X	X	X
Isopropylbenzene (Cumene)	X	X		X*						
ADDITIVES										
Methyl t-butyl ether (MTBE)[2]	X	X	X	X					X	X
Lead[1,3]	X**(T)	X**(D)							X(T)	X(D)
1,2-Dichloroethane (EDC)[3]	X**	X**	X**	X**					X	X
1,2 Dibromoethane (EDB)[3]	X**	X**							X	X
1,2,4 Trimethylbenzene (TMB)	X	X								
1,3,5 Trimethylbenzene (TMB)	X	X								
Tert-butyl ether (TBA)	X	X	X	X						
PAH-CARCINOGENIC										
Benzo(a)Anthracene			X		X		X		X	
Benzo(a)Pyrene			X		X		X		X	
Benzo(b)Fluoranthene					X		X		X	
Benzo(k)Fluoranthene					X		X		X	
Chrysene					X	X	X	X	X	X
Ideno(1,2,3-cd)Pyrene					X		X		X	
PAH-NON-CARCINOGENIC										
Acenaphthene					X	X	X	X	X	X
Anthracene					X		X		X	
Fluoranthene					X		X		X	
Fluorene			X		X		X		X	
Napthalene	X	X	X	X	X	X	X	X	X	X
Phenanthrene			X	X	X	X	X	X	X	X
Pyrene					X		X		X	
OTHER										
PCBs									X	X
Semi-volatiles									X	X
Volatiles									X	X

Notes:
*Jet fuel only.
**If leaded gasoline, aviation gasoline, or jet fuel
(D) Dissolved Lead
(T) Total Lead
[1] Samples collected from point of use must be analyzed for Total Lead; samples collected from the aquifer must be analyzed for Dissolved lead.
[2] MTBE analysis is required, unless conclusive documentation is presented and pre-approved by DNREC confirming that the Tank System was not in service after January 1, 1978.
[3] For gasoline Tank Systems only, lead, EDB and EDC analysis is required unless conclusive documentation is presented and pre-approved by DNREC that the gasoline Tank was installed after January 1, 1996. Lead, EDB and EDC analysis is always required for aviation gasoline.

Table 9. DERBCAP Risk-Based Screening Levels (RBSLs)

Chemicals of Concern (COC) Units: mg/Kg or mg/L	DISTANCE TO POINT OF EXPOSURE (POE) OR POINT OF COMPLIANCE (POC)								
	< 50 ft			51-100 ft	101-200 ft	201-300 ft	301-400 ft	401-500 ft	> 500 ft
	$SOIL_{DC}$	$SOIL_{GW}$	GW	GW	GW	GW	GW	GW	GW
VOLATILES									
Benzene	1.2	0.048	0.014	0.025	0.078	0.44	1.5	4.1	9.5
Toluene	490	11	1.6	>530	>530	>530	>530	>530	>530
Ethylbenzene	5.8	0.68	0.7*	0.7*	2.1	40	>170	>170	>170
Xylene (mixed isomers)	58	45	10*	13	65	>200	>200	>200	>200
Isopropylbenzene (Cumene)	190	310	2	>50	>50	>50	>50	>50	>50
Naphthalene	3.8	0.14	0.002	0.12	3.6	>31	>31	>31	>31
1,2,4 Trimethylbenzene (TMB)	5.8	8.5	0.2	>57	>57	>57	>57	>57	>57
1,3,5 Trimethylbenzene (TMB)	220	46	1	1.300	3.2	11	23	41	51
ADDITIVES									
Methyl t-butyl ether (MTBE)	47	0.19	0.2	0.42	1.5	11	47	150	430
Lead	400	400	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1,2-Dichloroethane (EDC)	0.46	0.0096	0.0086	0.018	0.066	0.47	2	6.8	19
1,2-Dibromoethane (EDB)	0.036	0.0011	0.00039	0.002	0.018	0.4	4.4	32	180
TBA		0.12	0.24	0.48	1.7	12	50	160	440
PAH-CARCINOGENIC									
Benz(a)Anthracene	0.82	>35	0.0078	>0.01	>0.01	>0.01	>0.01	>0.01	>0.01
Benzo(a)Pyrene	0.24	>15	0.00078	>0.0016	>0.0016	>0.0016	>0.0016	>0.0016	>0.0016
Benzo(b)Fluoranthene	1.11	>18	>0.0015	>0.0015	>0.0015	>0.0015	>0.0015	>0.0015	>0.0015
Benzo(k)Fluoranthene	1.6	>6.8	>0.00055	>0.00055	>0.00055	>0.00055	>0.00055	>0.00055	>0.00055
Chrysene	16	>6.2	>0.002	>0.002	>0.002	>0.002	>0.002	>0.002	>0.002
Indeno(1,2,3-cd)Pyrene	1.3	>130	>0.0038	>0.0038	>0.0038	>0.0038	>0.0038	>0.0038	>0.0038
PAH-NON-CARCINOGENIC									
Acenaphthene	360	>170	1.2	>4.2	>4.2	>4.2	>4.2	>4.2	>4.2
Anthracene	1800	>10	>.043	>.043	>.043	>.043	>.043	>.043	>.043
Fluoranthene	240	>130	>0.26	>0.26	>0.26	>0.26	>0.26	>0.26	>0.26
Fluorene	240	>150	0.8	>2	>2	>2	>2	>2	>2
Phenanthrene	180	>140	0.6	>0.99	>0.99	>0.99	>0.99	>0.99	>0.99
Pyrene	180	>51	>0.14	>0.14	>0.14	>0.14	>0.14	>0.14	>0.14

Notes**:**

SOILGW=RBSL for soil partitioning/leaching to groundwater ingestion pathway. SOILDC=RBSL for soil direct contact (ingestion, inhalation, and dermal contact) pathway; applies for on-site exposure only. GW=RBSL for groundwater ingestion pathway.

1) ">" indicates that the groundwater cleanup standard is greater than the constituent's aqueous solubility or the soil cleanup standard is greater than the soil residual saturation.

2) Values established by RBCA Toolkit for DERBCAP, Version 2.53de--see Appendices for supporting documentation

3) "*"=Most stringent RBSL set to EPA Maximum Contaminant Levels

3.5 DERBCAP Tier 1 RBSL and Tier 2 SSTL Scenarios

The following scenarios illustrate the application of DERBCAP procedures to various conditions that may be encountered on-site. In all cases, the goals are to:

- minimize potential risks to human health and the environment, and
- Prevent further environmental degradation.

Under this section, source is further defined as any point within a plume, such as at a monitoring well, where COC concentrations are greater than either Tier 1 RBSLs or Tier 2 SSTLs. In the scenarios described in this section, substitute SSTLs for RBSLs at Tier 2. The application of these scenarios as an integral part of DERBCAP is to determine groundwater plume stability and assess whether further degradation of groundwater is occurring. Assessment under these scenarios enables the Department to evaluate the potential for future risk.

Table 10 below describes the scenario for a site with a groundwater plume that has not spread beyond the property boundary for site-specific COC concentrations and distance to the closest POE.

Table 10. Scenario Lookup Table for On-Site Plumes

POE < 500 ft.		**No POE < 500 ft.**	
COC concentrations exceed RBSLs	COC concentrations do not exceed RBSLs	COC concentrations exceed > 500 ft. RBSLs	COC concentrations do not exceed > 500 ft. RBSLs
Go to Scenario 1	Go to Scenario 3A	Go to Scenario 2	Go to Scenario 3B
Note: This table does not apply for lead. See Section 3.3.			

Table 11 below describes the applicable scenario for a site with a ground-water plume that has spread beyond the property boundary for site-specific COC concentrations and distance to the closest POE. The scenarios are described following Table 11.

Table 11. Scenario Lookup Table for Off-Site Plumes

POE < 500 ft.		**No POE <500 ft.**	
COC concentrations in the source and/or the off-site portion exceed RBSLs	COC concentrations in the source and the off- site portion do not exceed RBSLs	COC concentrations in the source exceed the source to POC distance derived RBSLs	COC concentrations in the source do not exceed the source to POC distance derived RBSLs
Go to Scenario 4	Go to Scenario 6A	Go to Scenario 5	Go to Scenario 6B
Note: This table does not apply for lead. See Section 3.3.			

3.5.1 Scenario 1: On-Site Plume, POE less than 500 ft. from Downgradient Property Line

If the groundwater plume is located in its entirety within the boundaries of the property, a minimum of three (3) monitoring wells, including at least one (1) Point of Compliance (POC) monitoring well, must be in- stalled. The POC well(s) must be located on the most down-gradient property line. If a point of exposure (POE) located within 500 feet down gradient of the site is identified, groundwater cleanup goals in each monitor well will be a function of the distance from the source to the POE. For example, if a monitor well is installed 75 feet from a POE in a groundwater plume contaminated with gasoline COCs, cleanup goals for the COCs in the monitor well will be the 51-100 foot Risk Based Screening Levels (RBSLs). If the concentrations of the COCs in any or all of the monitor wells exceed the RBSLs, remediation must be performed. Cleanup goals for each monitor well will be the RBSLs assigned to each monitor well within the plume.

However, if at any time COC contaminants are identified in the POC well(s), the Department may assign new cleanup goals. The new goals will be a function of the distance from each monitor well to the closest POC well. Upon termination of all remedial activities at least one (1) year of quarterly groundwater monitoring must be performed, during which the concentrations of the COCs in all monitoring wells must remain at or below the cleanup goals established for the site.

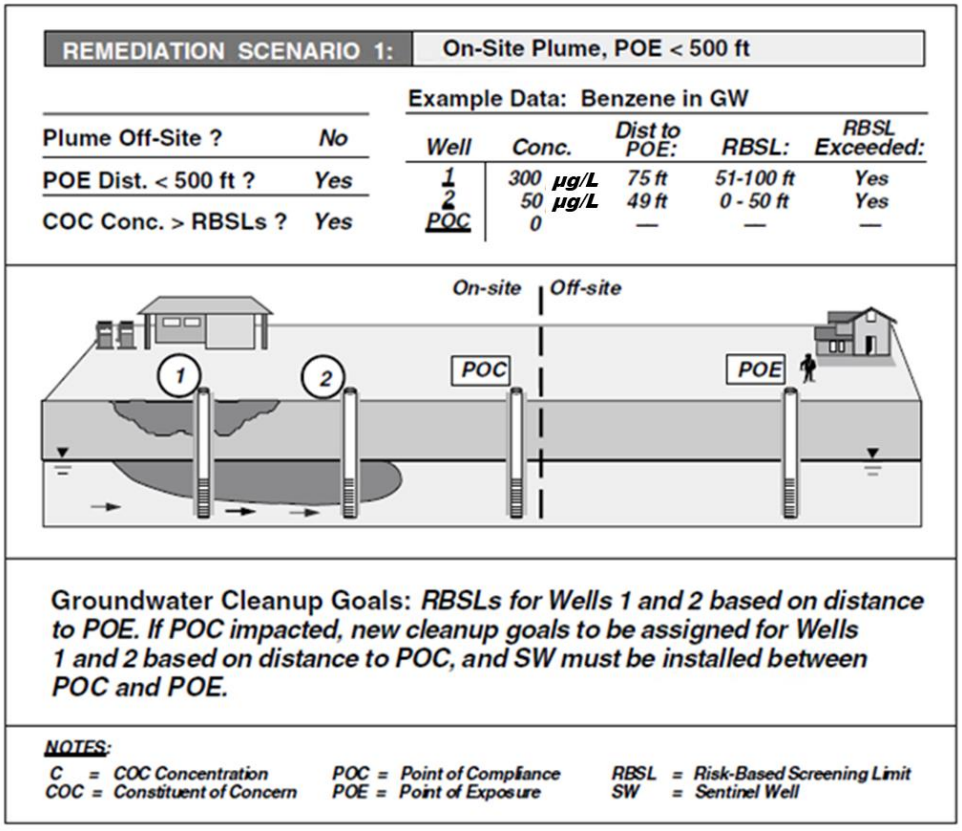


Figure 13. Remediation Scenario 1

3.5.2 Scenario 2: On-Site Plume, POE greater than 500 ft. from Downgradient Property Line

If the groundwater plume is located in its entirety within the boundaries of the site and no POEs located within 500 feet down gradient of the site are identified, cleanup goals will be the >500' RBSLs for soil and groundwater. A minimum of three (3) monitoring wells, including one POC well must be installed. The POC well(s) must be located on the most down gradient property line. If the concentrations of the COCs in any or all of the monitor wells exceed the >500 feet RBSLs, remediation must be performed. Cleanup goals will be the >500 feet RBSLs.

However, if at any time COC contaminants are identified in the POC well(s), the Department may assign new cleanup goals. The new goals for each monitor well will be a function of the distance from each monitor well to the closest POC well. Upon termination of all remedial activities at least one (1) year of quarterly groundwater monitoring must be performed, during which the concentrations of the COCs in all monitoring wells must remain at or below the cleanup goals established for the site.

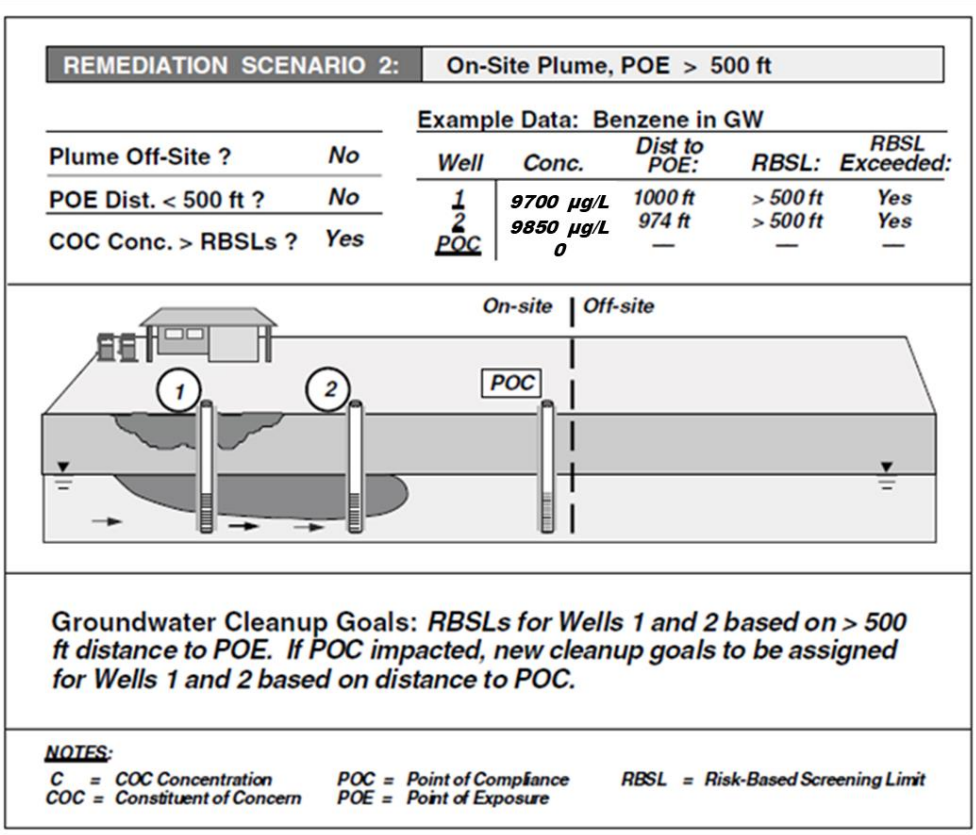


Figure 14. Remediation Scenario 2

3.5.3 Scenarios 3A and 3B: On-Site Plume, COC Concentrations less than RBSLs

If the groundwater plume is located in its entirety within the boundaries of the site and the

concentrations of the COCs in the soil and groundwater are already less than the RBSLs determined at the site (as described in Scenarios 1 or 2) options include:

1. Petition the Department for No Further Action as supported by site data, or
2. Monitor the site quarterly for one (1) year to show that the groundwater concentrations are stable or decreasing, or
3. Perform DERBCAP Tier 2 modeling with site specific data to show that the plume is stable or decreasing.

A minimum of three (3) monitoring wells, including one POC well must be installed. The POC well(s) must be located on the most down-gradient property line.

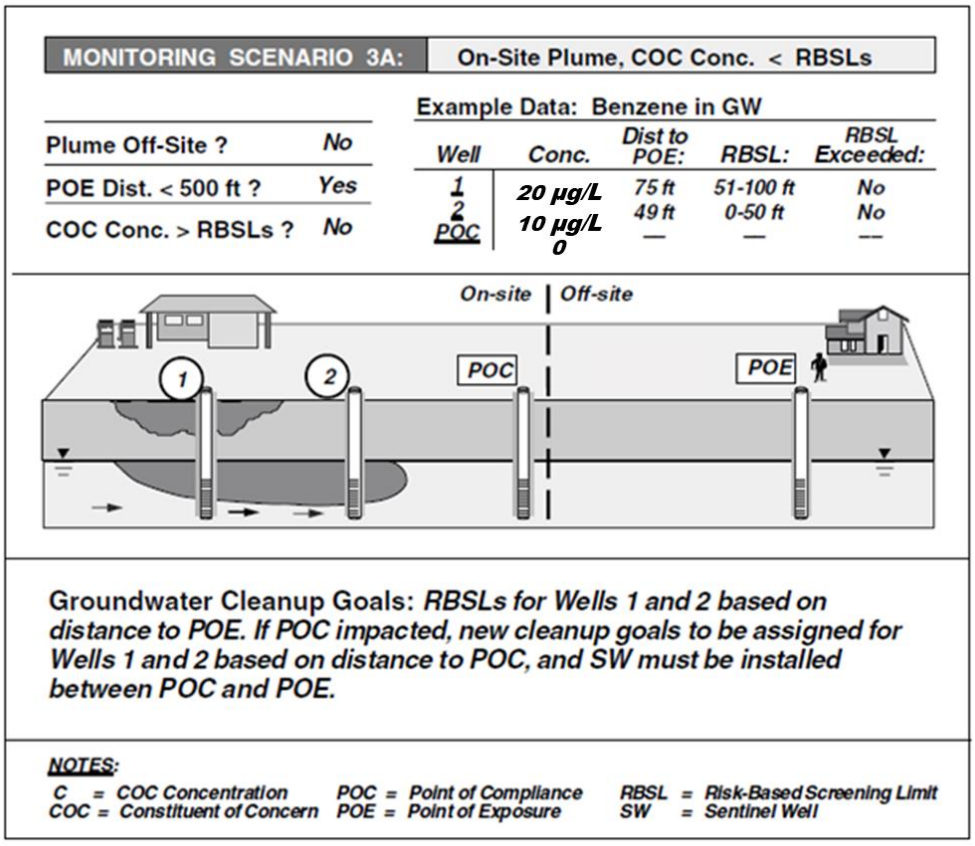


Figure 15. Monitoring Scenario 3A

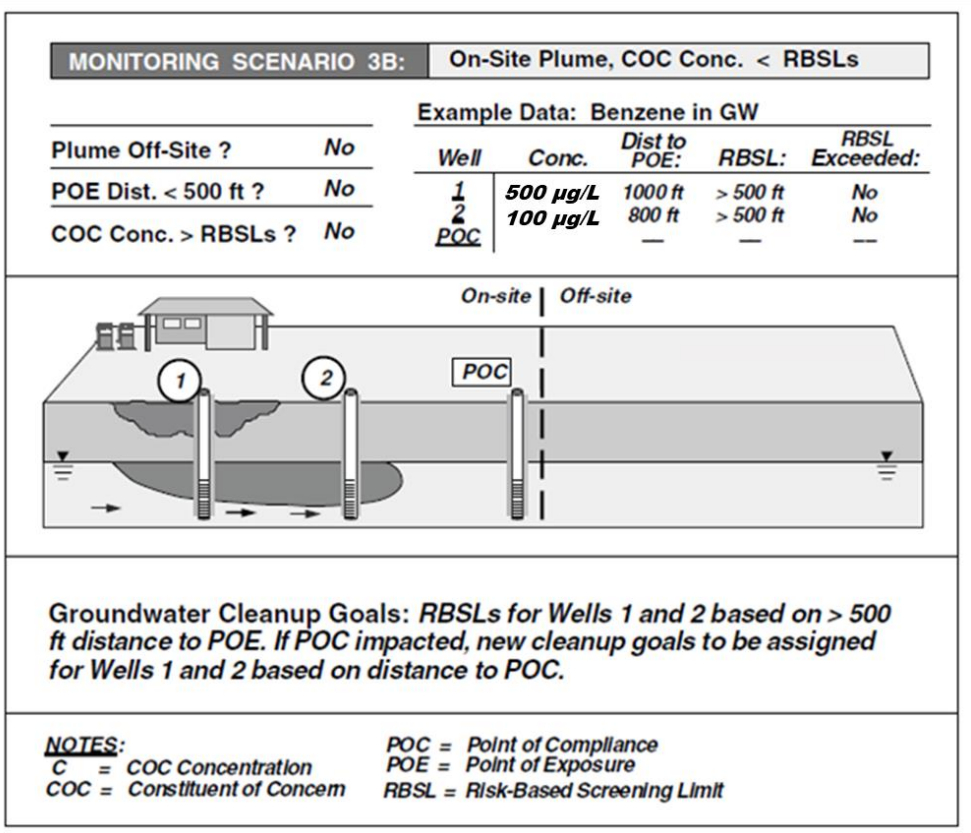


Figure 16. Monitoring Scenario 3B

However, if at any time COC contaminants are identified in the POC well(s), the Department may assign new cleanup goals. The new goals will be a function of the distance of the source of the plume to the closest POC well. In addition, if at any time during the course of one year of groundwater monitoring the concentrations of the groundwater or soil COCs exceed the RBSLs assigned to the site, remediation, or Tier 2 modeling may be required. *Indefinite groundwater monitoring will not be permitted.*

3.5.4 Scenario 4: Off-Site Plume, POE less than 500 ft. from Downgradient Property Line

If the groundwater plume has spread off-site, a minimum of three (3) monitoring wells, including at least one (1) Point of Compliance (POC) well, must be installed. The POC well(s) must be located on the most down-gradient property line. If a POE located within 500 feet down-gradient of the site is identified, a sentinel monitoring well must also be installed. The sentinel well must be placed between the leading edge of the plume and the POE. Cleanup goals for the monitor wells within the plume will be a function of the distance from each monitor well to the closest POC well. If the concentrations of any of the COCs in the monitor wells exceed the RBSLs assigned to each monitor well, remediation may be required. The RBSLs assigned to each monitor well will be the cleanup goals for each monitor well.

However, if at any time contaminants are discovered in the sentinel well, cleanup goals for the off-site portion of the plume will become a function of either the distance from the POC well to the

sentinel well or from the sentinel well to the POE. The Department will use the shortest distance when establishing off-site cleanup goals. If the concentrations of the COCs in the off-site portion of the plume exceed the assigned RBSLs, remediation may be required. Cleanup goals for the COCs in the off-site portion of the plume (i.e., from the POC well to the sentinel well) will be the RBSLs assigned to the off-site portion of the plume. In addition, the Department will require the installation of a new sentinel well between the old sentinel well and the POE. Upon termination of all remedial activities at least one (1) year of quarterly groundwater monitoring must be performed, during which the concentrations of the COCs in all monitoring wells must remain at or below the cleanup goals established for the site

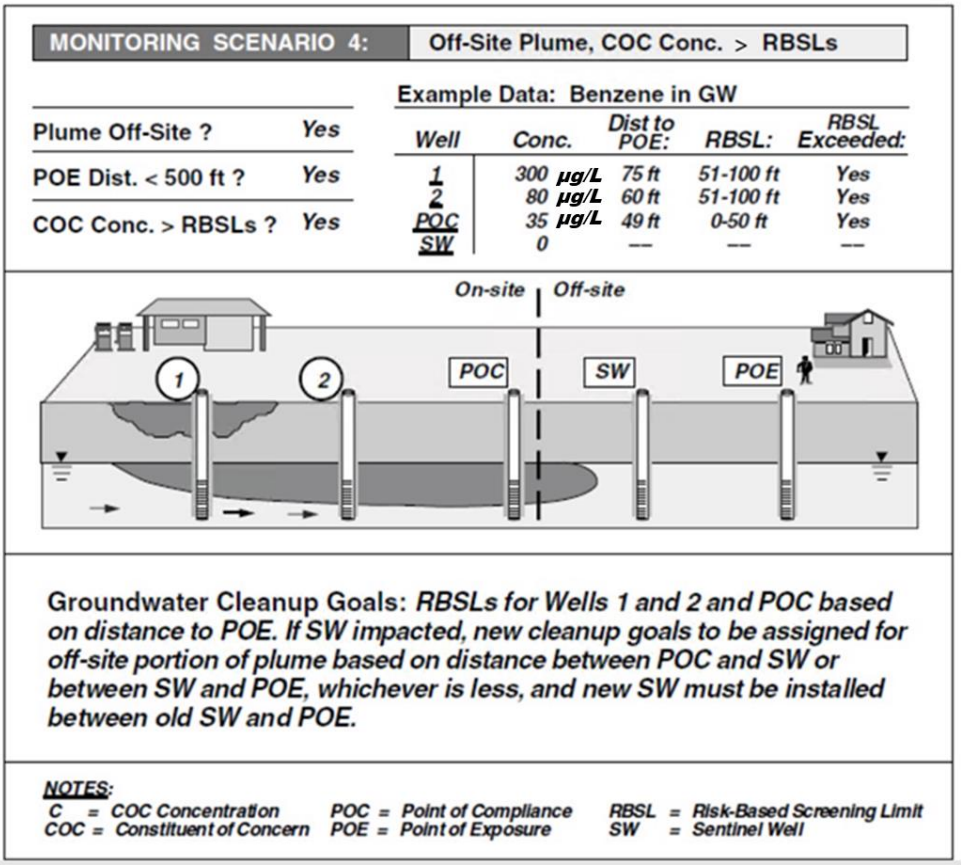


Figure 17. Monitoring Scenario 4

3.5.5 Scenario 5: Off-Site Plume, POE greater than 500 ft. from Downgradient Property Line

If the groundwater plume has spread off-site and no POEs located within 500 feet downgradient of the site are identified, cleanup goals for the monitor wells in the plume will be a function of the distance from each monitor well to the closest POC well. A minimum of three (3) monitoring wells, including at least one (1) Point of Compliance (POC) monitoring well must be installed. The POC well(s) must be located on the most down-gradient property line. If the concentrations of the COCs in any monitor well exceed the RBSLs assigned to that monitor well, remediation may be required.

The RBSLs assigned to the monitoring wells will be the strictest RBSLs or calculated by the distance

from the monitoring wells to the POC. RBSLs for the off-site portion of the plume will be addressed on a site-specific basis. Upon termination of all remedial activities at least one (1) year of quarterly groundwater monitoring must be performed, during which the concentrations of the COCs in all monitoring wells must remain at or below the cleanup goals established for the site.

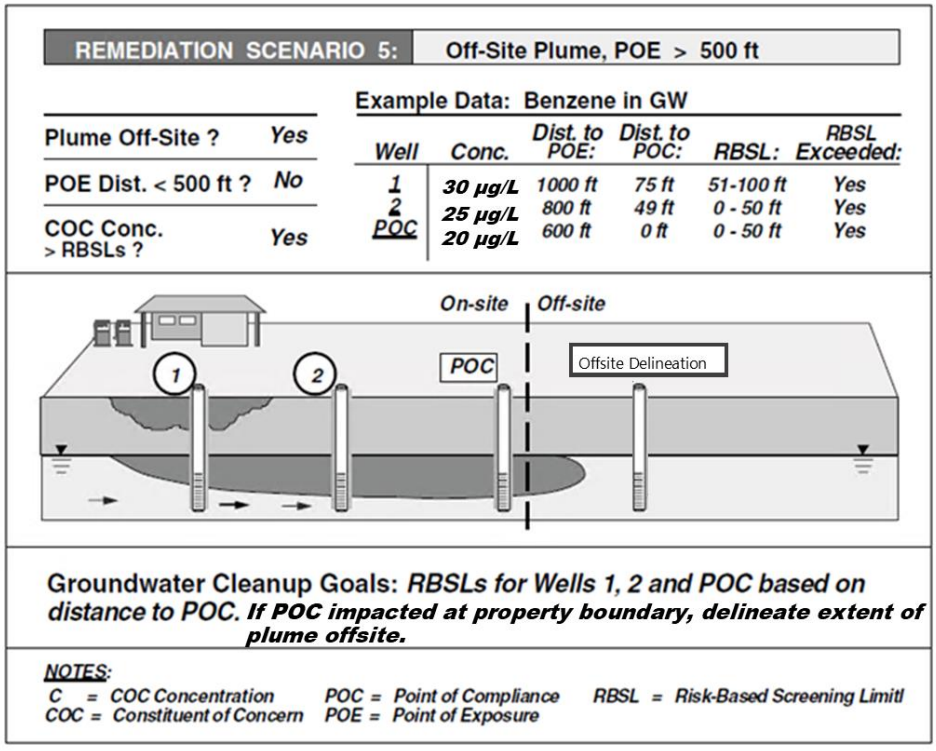


Figure 18. Remediation Scenario 5

3.5.6 Scenarios 6A and 6B: Off-Site Plume, COC Concentrations, less than RBSLs

If the groundwater plume has spread off-site and the concentrations of the COCs in the soil and groundwater are less than the RBSLs assigned to the site (as described in either Scenario 4 or Scenario 5) you must either:

1. Monitor the site quarterly for no less than one (1) year to show that the COC concentrations in the groundwater are stable or decreasing, or
2. Perform DERBCAP Tier 2 modeling with site specific data to show that the plume is stable or decreasing.

However, if at any time during the course of one year of groundwater monitoring the concentrations of the soil or groundwater COCs exceed the RBSLs assigned to your site, remediation or Tier 2 modeling will be required. Indefinite groundwater monitoring will not be permitted.

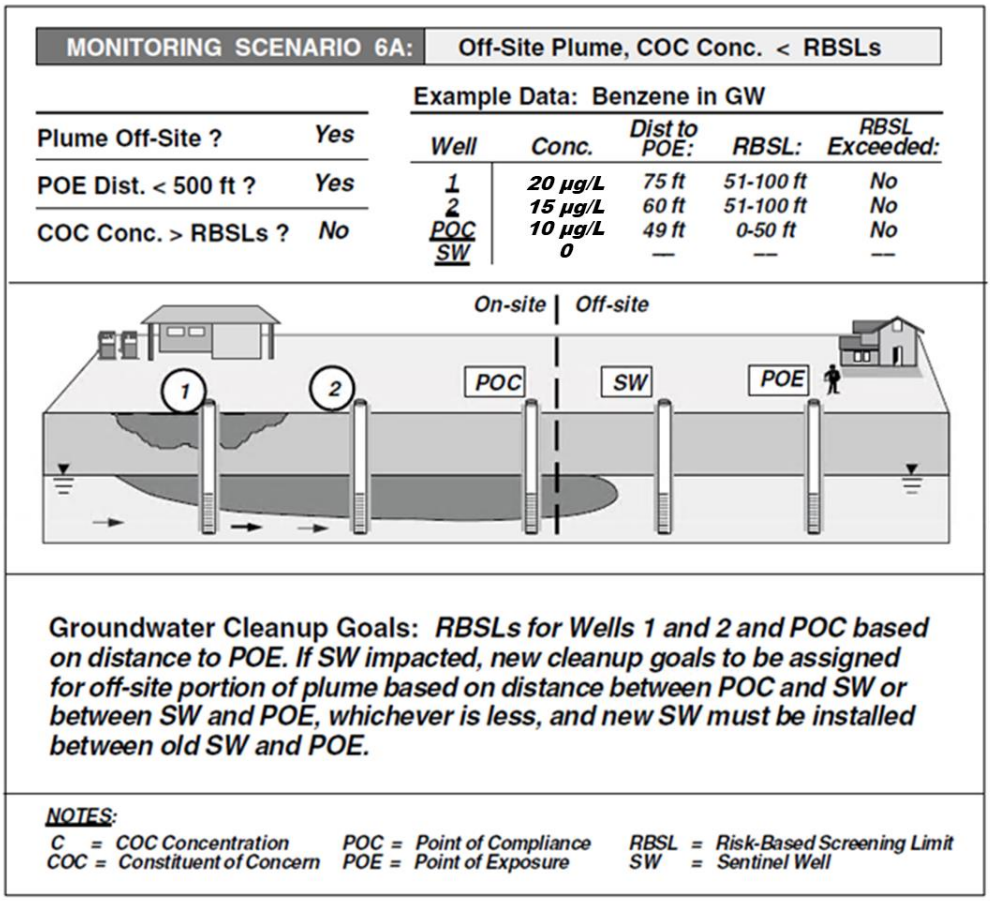


Figure 19. Monitoring Scenario 6A

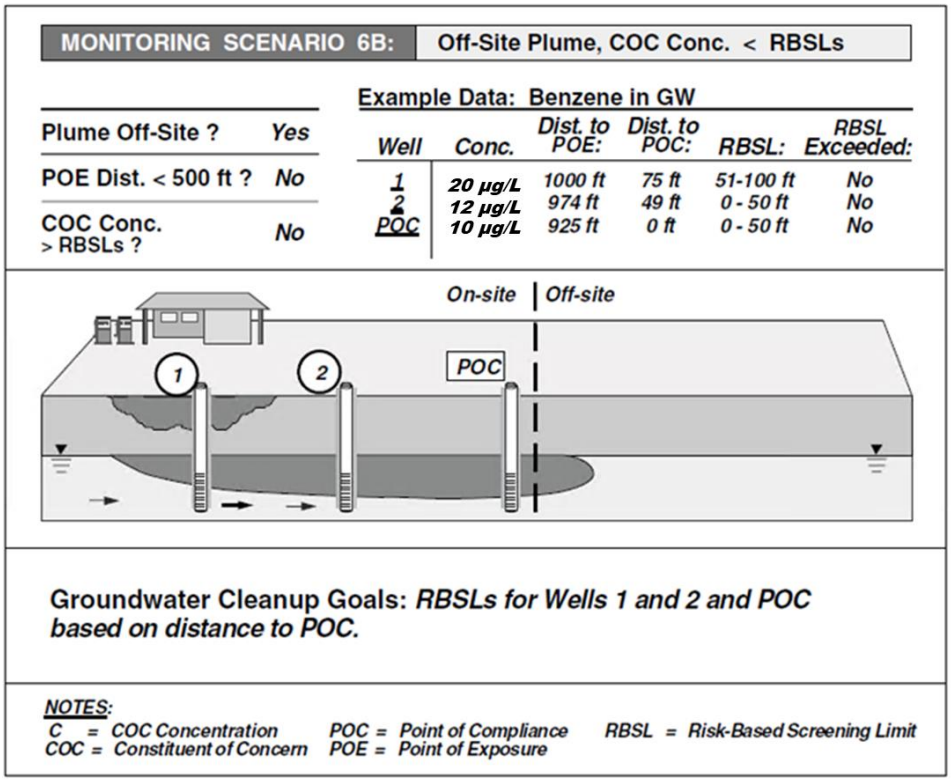


Figure 20. Monitoring Scenario 6B

4. TIER 2

4.1 Tier 2 Applicability

Under Tier 2, the RP may derive Site-Specific Target Levels (SSTLs) based on site-specific receptor locations and other site-specific soil and groundwater input parameters. The Tier 2 evaluation only applies to those exposure pathways (i.e., soil direct contact, soil leaching to groundwater, and groundwater ingestion) and those constituents that fail Tier 1 (Figure 21).

If concentrations of COCs exceed Tier 1 RBSLs, then a Tier 2 site assessment can be conducted as an alternative to remediating contamination to the level of Tier 1 RBSLs. At Tier 2, site-specific hydrogeologic parameters are substituted for corresponding Tier 1 assumptions and are used to calculate SSTLs for the chemicals of concern. SSTLs become the new cleanup goals for the site provided cumulative risk for carcinogens is less than 1×10^{-5}; for non-carcinogens the hazard quotient (HQ) is less than or equal to 1 for completed exposure pathways.

A Tier 2 site assessment may not be conducted without prior written approval from the Department.

4.2 Tier 2 Site Investigation Requirements

A Tier 2 site assessment includes:

- Site-specific geologic characterization.
- Measurement or calculation of site-specific physical characteristics.
- Calculation of SSTLs, using Department-approved models.

Appendix 2 lists the site-specific Tier 2 parameters that must be substituted for the Tier 1 generic assumptions in calculating SSTLs.

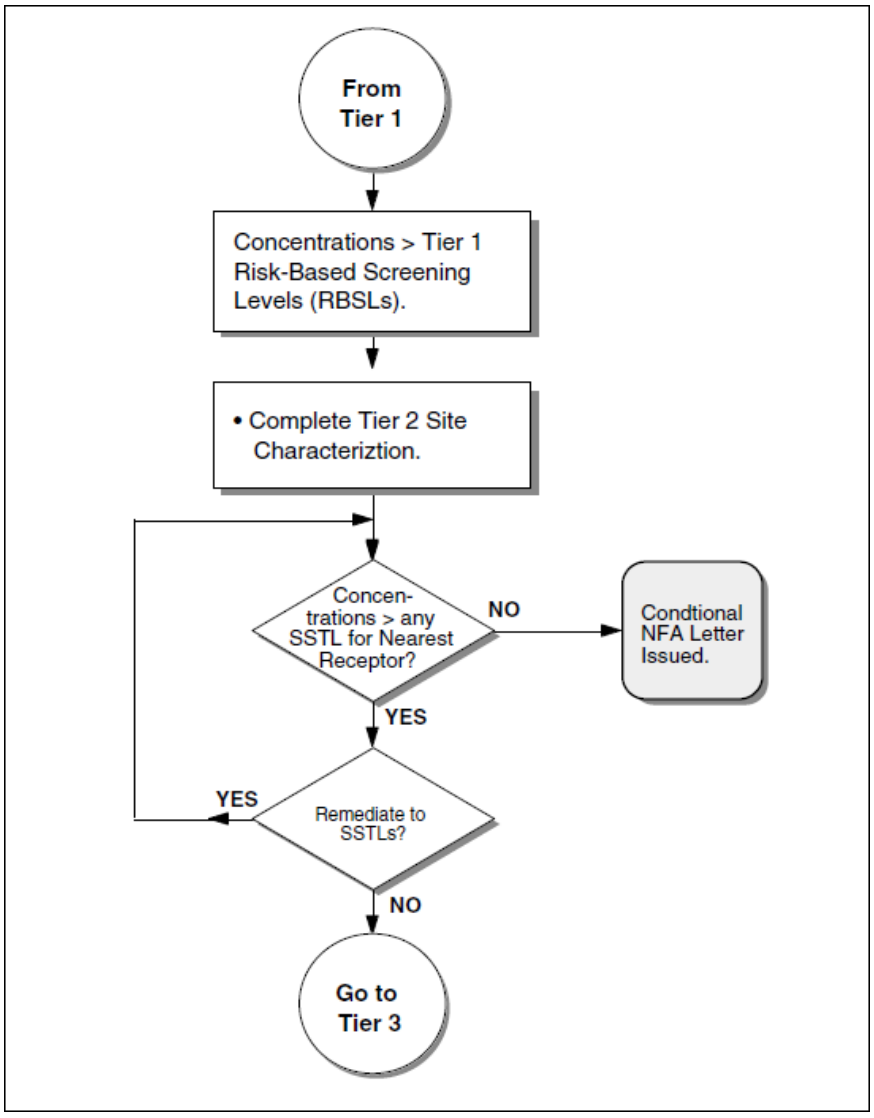


Figure 21. Tier 2 Flowchart

4.3 Risk and Concentration Limits

All individual chemical of concern concentration limits shown by SSTLs are calculated based on a risk of 1 x 10^{-5} for carcinogenic effects and a hazard quotient of 1.0 for non-carcinogenic effects. This is the same as for Tier 0 and Tier 1. It is for this reason that the exposure parameters (average volume of drinking water ingested per day, average length of exposure, etc.) used in DERBCAP, adopted from values determined by the U.S. EPA, may not be altered. Site-specific geologic inputs and specific distance to a POE are also factors used to develop SSTLs.

It should be noted that the as with the Tier 1 RBSLs, SSTLs do not account for cumulative risk associated with the chemicals of concern for each media. A cumulative Risk Assessment will be required for detected chemicals of concern in each media where a complete exposure pathway exists.

4.4 Data Evaluation and Response Options

SSTLs differ from RBSLs in that:

- site-specific soil and groundwater parameters may be used in place of Tier 1 defaults, and
- the POE type and location may be matched to actual site conditions.

In calculating SSTLs, site-specific data is substituted for the conservative generic assumptions of Tier 0 and Tier 1. This allows the margin of safety to decrease, while maintaining a constant level of protection against potential risks to public health. The Delaware module of the RBCA Toolkit (available from Groundwater Services, Inc., Houston, Texas, www.gsi-net.com, Phone: 713-522-6300 or rbcainfo@gsi-net.com) may be used to calculate SSTLs under DERBCAP. The Tier 1 assessment may screen out some COCs or pathways of concern prior to conducting the more detailed Tier 2 analysis.

Having performed a Tier 2 site assessment and scenario examination, a Responsible Party may:

- Not have to perform any further remediation if the concentrations of the COCs are less than the applicable SSTLs.
- Have to perform further remediation if the concentrations of the COCs are greater than the applicable SSTLs.
- Request permission from the Department to proceed with a Tier 3 site assessment.

Any point within a plume (such as a monitor well) where COC concentrations are greater than either Tier 1 RBSLs or Tier 2 SSTLs must be remediated.

For non-residential sites exposure factors in Appendix 3 may be used instead of the Tier 1 residential default values.

4.4.1 Tier 2 Modeling Options

In the risk assessment process, a model is used to predict the transport of specific chemicals of concern through a groundwater system using detailed, site-specific, hydrogeological information. Tier 2 modeling in DERBCAP may be appropriate for those chemicals of concern that have concentrations that exceed Tier 1 RBSLs. By demonstrating, through modeling, that a contaminant plume is stable or shrinking and will never reach a POE, a Conditional No Further Action letter may be issued. If, however, the modeling provides insufficient evidence of plume stability and concentrations are above the SSTLs calculated in Tier 2, the site may be remediated to Tier 2 SSTLs or it may enter Tier 3, which involves detailed, three-dimensional, numerical modeling.

The purpose of modeling in Tier 2 of the RBCA process is to derive a conservative estimate of the natural reduction in COC concentrations occurring between the source and POE. This estimated "natural attenuation factor" can then be used to derive an SSTL value (RBCA Tool Kit) at the source location, which will prevent exceeding the applicable RBEL (Risk Based Exposure Level) limits at the POE. The natural attenuation factor for each applicable exposure pathway and COC may be estimated using appropriate fate-and-transport models.

Alternatively, empirical measurements may be used to show that the contaminants will never reach

the POE. For example, time-series groundwater monitoring data may demonstrate that the affected groundwater plume is in a stable or shrinking condition, in which case, POEs outside the current plume area will not be impacted. When available, such time-series data regarding plume stability is considered more reliable than fate-and-transport modeling. The quality of the field data is essential to the validity of the modeling effort. Unrepresentative data will result in unreliable modeling results.

There are several models available, some more involved than others, that all solve specific equations that form the basis of the model. Fate and transport models are the most prevalent and practical of the groundwater models. In hydrogeology, they are used to predict the distribution of chemicals, such as the Tier 1 COCs, through the sub-surface. Fate and transport models can be analytical or numerical. Analytical fate and transport models use mathematical solutions to governing equations that are continuous in space and time and are based on assumptions of uniform properties and regular geometry (ASTM, 1999). They require specific inputs and provide unique answers. Analytical models are generally fast and easy to solve, require less field data and therefore are usually good for quick field screening. Numerical models, on the other hand, can provide non-unique answers using various input data sets that require geological interpretation. They require more site-specific information and can take hours to solve more representative field conditions. Numerical models allow field conditions to vary in space and time, thus resulting in a better representation of the complex geology. Generally, in the RBCA process, more complex models require much more field data.

At Tier 2, the RP is afforded modeling options including but not limited to RBCA Toolkit (which is used to derive Site Specific Target Levels (SSTLs)), BIOSCREEN (which can be used to show that the contaminated plume is shrinking and will not reach a POE), or an equivalent model as approved by the Department. The models may be used individually or together to accomplish the goals set out prior to modeling. The Tier 2 evaluation only applies to those exposure pathways (i.e., soil direct contact, soil leaching to groundwater, and groundwater ingestion) and those constituents that failed Tier 1.

The DERBCAP module of the RBCA Toolkit software (Ground Water Services, Inc.) is an analytical fate and transport model that allows the user to calculate site specific target levels or SSTLs. SSTLs are Tier 2 cleanup levels for the proper COCs and are based upon site-specific measurements, not the site conceptual model assumptions used in Tier 1.

BIOSCREEN is a two-dimensional, analytical, fate and transport model that models in the forward direction, that is, contaminant concentrations are predicted based on concentrations of a source. BIOSCREEN is most frequently used to simulate Remediation through Natural Attenuation (RNA). It predicts the migration of a contaminated plume if no engineering controls are implemented and answers how long the plume will last. BIOSCREEN can be downloaded at no charge from the following EPA website:

https://www.epa.gov/water-research/bioscreen-natural-attenuation-decision-support-system

After the additional Tier 2 site-specific data is gathered, a consultant will model the data and submit a report that includes the following:

- Purpose of the model
- Data input used in modeling
- Parameters changed during calibration runs

- Sensitivity analyses that were performed
- Any maps that may be useful
- Conclusion and recommendations to the Department

The Department will consider additional modeling options that are publicly available on a site-specific basis. Prior to Tier 2 modeling, Departmental approval must be obtained to use such models.

The Department may require a Cumulative Risk Assessment when more than one chemical of concern is reported by laboratory analysis in a given media with a completed exposure pathway. It has been the Department's experience at petroleum cleanup sites that constituent risk tends to be driven by one or two components, such as benzene or naphthalene. A large number of petroleum constituents may be detected in soil or groundwater; however, only one or two of those constituents may actually approach or exceed risk-based concentrations. A majority of risk-based decisions related to petroleum constituents will be directly compared to the established RBSLs or, when applicable, to the SSTLs generated at the Tier 2 level. In cases where several constituents are detected at levels close to or above the risk-based concentrations, the Department may require a determination of cumulative risk to ensure that the overall site risk does not exceed acceptable levels.

5. TIER 3

Tier 3 offers an additional level of evaluation for projects not adequately assessed under the previous tiers due to extreme complexity of the site. Difficulty in assessment may be derived from a variability of the site's geology, an extensive or unusual suite of contaminants with complex interactions, which may require a cooperative approach with other environmental programs within the Department, or unusual temporal considerations.

A DERBCAP Tier 3 site assessment may not be performed without prior approval from the Department. The RP is responsible for developing the entire site investigation, assessment, data analysis and remediation workplan, including definition of all decision point criteria. Exposure factors may only be selected from those already defined by the U. S. EPA.

It is expected that a DERBCAP Tier 3 site assessment will include numerical computer modeling based on extensive site investigation, sampling, testing and analysis conducted under strict QA/QC and data validation procedures. Proprietary computer models may not be used.

Tier 3 may be applied to a project site after receiving approval from the Department to utilize an alternative means for evaluation. It involves modeling and additional data collection in excess of what is required at the Tier 2 level in order to refine the process for SSTL calculation and develop a CSM that is acutely specific to the site.

6. TIER 1 LABORATORY METHODS

Analyses of soils and groundwater samples collected for a DERBCAP site assessment must be performed in accordance with the methods listed below unless the acceptability of alternate methodologies can be established to the satisfaction of DNREC.

Table 12. Analytical Laboratory Methods

Tier 1 Analysis

PRODUCT STORED	PARAMETERS TO BE TESTED IN SOIL	ANALYTICAL METHOD (reported on dry weight basis)	PARAMETERS TO BE TESTED IN GROUNDWATER	ANALYTICAL METHOD
Gasoline,	Benzene	EPA Method 5035/8021B or 5035/8260	Benzene	EPA Method 5030B/8021B, 5030B/8260B or 524.2
Aviation Gas	Toluene		Toluene	
	Ethylbenzene		Ethylbenzene	
	Xylenes		Xylenes	
	Isopropylbenzene (Cumene)		Isopropylbenzene (Cumene)	
	Naphthalene		Naphthalene	
	Methyl tert-Butyl Ether (MTBE)[3]		Methyl tert-Butyl Ether (MTBE)[3]	
	Tert-Butyl Alcohol (TBA)		Tert-Butyl Alcohol (TBA)	
	Dibromoethane, 1,2- (EDB)[4]		Dichloroethane, 1, 2- (EDC)[4]	
	Dichloroethane, 1, 2- (EDC)[4]		1,2,4 Trimethylbenzene	
	1,2,4 Trimethylbenzene		1,3,5 Trymethylbenzene	
	1,3,5 Trimethylbenzene		Dibromoethane, 1,2- (EDB)[4]	EPA Method 8011 or 504.1
	Lead[4]	EPA Method 6010B or 7420	Dissolved Lead	EPA Method 6020 or 7421
Kerosene,	Benzene	EPA Method 5035/8021B or 5035/8260	Benzene	EPA Method 5030B/8021B, 5030B/8260B or 524.2
Jet Fuel	Toluene		Toluene	
	Ethylbenzene		Ethylbenzene	
	Xylenes		Xylenes	
	Methyl tert-Butyl Ether (MTBE)[3]		Methyl tert-Butyl Ether (MTBE)[3]	
	Tert-Butyl Alcohol (TBA)		Tert-Butyl Alcohol (TBA)	
	Dichloroethane, 1, 2- (EDC)[4]		Dichloroethane, 1, 2- (EDC)[4]	
	Naphthalene		Isopropylbenzene (Cumene)	
	Benzo(a)Anthracene	EPA Method 8270C or 8310	Naphthalene	
	Benzo(a) Pyrene			
	Fluorene		Phenanthrene	EPA Method 8270C, 8310 or 525.2
	Phenanthrene			
Diesel,	Benzo(a)Anthracene	EPA Method 8270C or 8310	Benzene	EPA Method 5030B/8021B,

PRODUCT STORED	PARAMETERS TO BE TESTED IN SOIL	ANALYTICAL METHOD (reported on dry weight basis)	PARAMETERS TO BE TESTED IN GROUNDWATER	ANALYTICAL METHOD
Heating Fuel	Benzo(a)Pyrene Benzo(b)Fluoranthene Benzo(k)Fluoranthene Chrysene		Toluene Ethylbenzene Xylenes	5030B/8260B or 524.2
	Indeno(1,2,3-cd)Pyrene Acenaphthene Anthracene Fluoranthene Fluorene Naphthalene Phenanthrene Pyrene		Chrysene Acenaphthene Naphthalene Phenanthrene	EPA Method 8270C, 8310 or 525.2
Used Oil[1,2], New Oil[8]	Benzene Toluene Ethylbenzene Xylenes Methyl tert-Butyl Ether (MTBE)[3] Dibromoethane, 1,2- (EDB)[4]	EPA Method 5035/8021B or 5035/8260	Benzene Toluene Ethylbenzene Xylenes Methyl tert-Butyl Ether (MTBE) Dichloroethane, 1, 2- (EDC)[4]	EPA Method 5030B/8021B, 5030B/8260B or 524.2
	Dichloroethane, 1, 2- (EDC)[4]		Dibromoethane, 1,2- (EDB)[4]	EPA Method 8011 or 504.1
	Lead[4]	EPA Method 6010B or 7420	Lead	EPA Method 6020 or 7421
	Benzo(a)Anthracene Benzo(a)Pyrene Benzo(b)Fluoranthene Benzo(k)Fluoranthene Chrysene Indeno(1,2,3-cd)Pyrene Acenaphthene Anthracene Fluoranthene Fluorene Naphthalene Phenanthrene Pyrene	EPA Method 8270C or 8310	Chrysene Acenaphthene Naphthalene Phenanthrene	EPA Method 8270C, 8310 or 525.2
	Other [2] (as required-VOC,SVOCs,Metals, or other analyte on site-specific basis)	EPA Method 5035/8021B or 5035/8260 EPA Method 8270C or 8310 EPA Method 6010	Other [2] (as required-VOC,SVOCs,Metals, or other analyte on site-specific basis)	EPA Method 5030B/8021B, 5030B/8260B or 524.2 EPA Method 8270C, 8310 or 525.2 EPA Method 6010

PRODUCT STORED	PARAMETERS TO BE TESTED IN SOIL	ANALYTICAL METHOD (reported on dry weight basis)	PARAMETERS TO BE TESTED IN GROUNDWATER	ANALYTICAL METHOD
Other[5]	Other[5] (Site Specific)	To Be Determined	Other[5] (Site Specific)	To Be Determined

1. Used oil as defined in the Delaware Regulations Governing Underground Storage Tank Systems, Part A, Section 2. and the Delaware Regulations Governing Hazardous Waste.
2. Used oil Tank Systems may also be required to analyze for metals, volatiles, semi-volatiles or any other analyte as required on a site specific basis depending on the tank contents. Contact DNREC for determination.
3. MTBE analysis is required, unless conclusive documentation is submitted and pre-approved by DNREC that no portion of the tank system was in service after January 1, 1978.
4. For gasoline Tank Systems only, Lead, EDB and EDC analysis is required, unless conclusive documentation is submitted and pre-approved by DNREC documenting that all portions of the tank system were installed after January 1, 1996.
5. If the tank system contained anything other than petroleum products or if the tank system contained Racing Fuel, contact DNREC for information on sampling procedures and analytical requirements prior to any on site activities.
6. Samples collected for the analysis of volatile organic compounds must be preserved with methanol. Encore™® samplers are acceptable provided the preservative is methanol.
7. EPA 524.2 may be used for drinking water analysis only.
   Note: Encore™® Samplers should not be used when sampling pea gravel. When sampling pea gravel, methanol preservation of the sample in the field is required.
8. New Oil parameters may be modified with DNREC approval.

7. MANAGING FUTURE ENVIRONMENTAL AND HEALTH IMPACTS

Residual petroleum contamination at project sites may be considered a solid waste.

When it has been determined that contamination does not pose a threat to human health, safety and the environment, a No Further Action letter will be issued to document the site closure. In some cases, although a limited amount of residual contamination may remain on site, it does not pose a direct threat to human health and the environment as long as it remains undisturbed. These sites receive a Conditional No Further Action letter that documents site closure as long as the land use does not change. At sites with contaminated soils and groundwater, that meet the definition of solid waste, when disturbed by digging or excavating in the case of soil, or withdrawal of groundwater, the: (1) excavated soil, (2) groundwater, (3) future land use changes, must be managed as solid waste. In addition, a contaminated materials management plan (CMMP) must be approved by the Department prior to the beginning of work. Future changes to land use, parcel delineation may change the risk-based assumptions and corresponding clean up level under which the site was originally closed. Reassessment of clean up levels and management of residual contamination may be required when land use changes.

Future site owners must be notified of restrictions and requirements placed on soil and groundwater to ensure protection of human health and the environment.

7.1 Institutional Controls

Institutional controls include such Department actions as:

- Issuing a conditional NFA that limits or controls future activity in the area of residual petroleum contamination at a site;
- Notifying anyone proposing work at a site with a previous LUST or LAST history of the potential need for a CMMP through the MISS UTILITY program;
- Managing future groundwater use in an area in or near residual groundwater contamination by issuing water well permits with conditions on location, well construction and water use;
- Facilitating private party transactions through Freedom of Information Act Requests; and
- Maintaining a Geographic Information System (GIS) database with Tank site positions accessible to public view through Department Internet links.

Environmental Covenants may be used to address residual contamination on a property by limiting potential exposure pathways to contaminated soil or groundwater. Covenants are filed with the Registrar of Deeds in each county; a tax parcel number for the property is required.

Appendix 1.
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Appendix 2.
Fate and Transport Parameters

PARAMETER	UNITS	TIER 1 DEFAULT VAULE		TIER 2 VALUE[1]
		ASTM	DERBCAP	
Site Parameters				
Lower depth of surficial soil zone	cm	100	60 (2 ft) [3]	D
Width of soil source area parallel to wind	cm	1500 (50 ft)	ASTM	SS
Width of soil source area parallel to groundwater flow	cm	1500 (50 ft)	ASTM	SS
Distance from plume "core" to POE	ft	0	0 - 50 ft 51 – 100 ft 101 – 200 ft 201-300 ft 301– 400 ft 401-500 ft > 500 ft	SS
Ambient air mixing zone height	cm	200	ASTM	D
Wind speed above ground surface in ambient air mixing zone	cm/s	225	ASTM	D
Averaging time for vapor flux: -Resident and commercial worker -Construction worker	 s s	 9.46×10^8 (30 yr) 3.15×10^7 (1 yr)	ASTM ASTM	 D D
Particulate emission factor (PEF): -Resident and commercial worker -Construction worker	 $g/cm^2/s$ $g/cm^2/s$	 6.0×10^{-14} 6.1×10^{-9}	ASTM ASTM	 D D
Hydrogeologic Parameters				
Total soil porosity	cm^3/cm^3	0.38 [4]	ASTM	E
Volumetric air content in vadose zone soil	cm^3/cm^3	0.26	ASTM	E
Volumetric water content in vadose zone soil	cm^3/cm^3	0.12	ASTM	E
Soil bulk density	gm/cm^3	1.7	1.78 [5]	D
Fraction organic carbon in vadose zone soil	g/g	0.01	ASTM	D/SS
Infiltration rate of water in vadose zone	cm/yr	30	35 [6]	D

PARAMETER	UNITS	TIER 1 DEFAULT VAULE		TIER 2 VALUE[1]
		ASTM	DERBCAP	
Groundwater mixing zone height	cm	200 (6.5ft)	ASTM	D
Groundwater Darcy velocity -Hydraulic conductivity -Hydraulic gradient	cm/yr cm/s cm/cm	2500 (82ft/yr) (8×10^{-3}) (0.01)	915 (30ft/yr) (7) (2.9×10^{-3}) (ASTM)	- E SS
Effective soil porosity	cm^3/cm^3	0.38	ASTM	E
Fraction organic carbon in groundwater zone	g/g	NA	0.001	D
Longitudinal dispersivity	cm	NA	0.1 x dist. to POE	D
Transverse dispersivity	cm	NA	0.33 x long. disp.	D
Vertical dispersivity	cm	NA	0.05 x long. disp.	D
Chemical-Specific Parameters				
Organic carbon partition coefficient	g/g	CS	CS	CS
First-order degradation rate	day^{-1}	CS	CS	CS

Notes:

1) Recommended sources for Tier 2 values:

   D = Use of DERBCAS Tier 1 default value is recommended for parameters which i) exhibit only a moderate degree of site-specific variability and ii) cannot be easily obtained on a site-specific basis;

   E = Use of default estimate based on soil type is recommended for parameters which i) exhibit only a moderate degree of variability within a particular soil type and ii) methods available to measure site-specific values are unlikely to be significantly more accurate than soil type estimates (Table 8 can be used to estimate these parameter values);

   SS = Use of site-specific measured values is recommended for parameters which i) exhibit a wide range of site-specific variability that may significantly impact model predictions and ii) are amenable to characterization based on limited site-specific measurements;

   CS = Parameter value is chemical-specific and should be taken from appropriate literature sources.

2) POE = Point of Exposure; NA = Not applicable.

3) DERBCAS Tier 1 default for lower depth of surfical soil zone based on SIRB remediation standard guidance.

4) ASTM Tier 1 default for total soil porosity based on 150 ft/day permeability of clean sand.

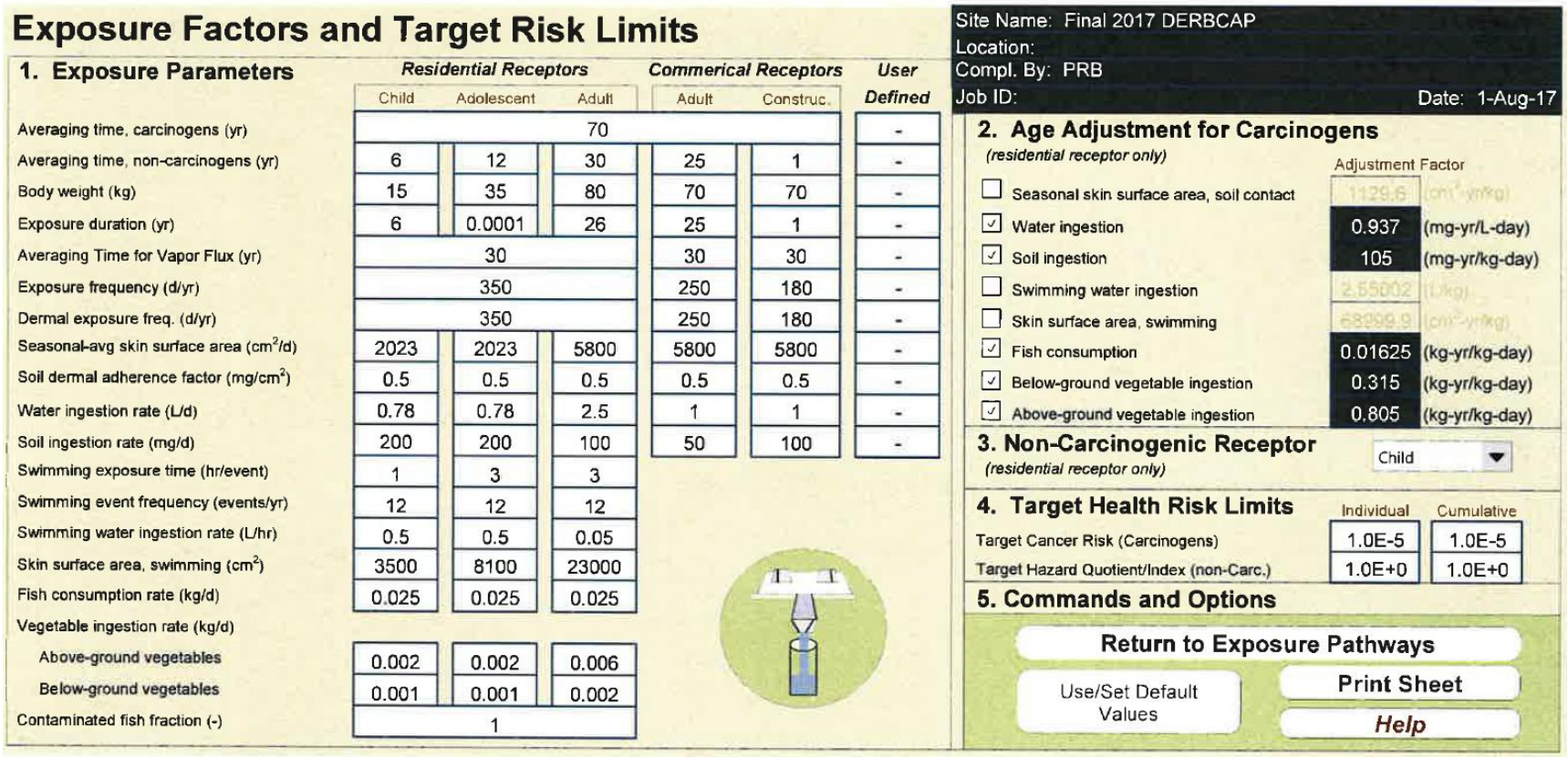
5) DERBCAS Tier 1 default for soil bulk density based on 1.5 tons/yd3.

6) DERBCAS Tier 1 default for infiltration rate of water through vadose zone based on DGS state average of 14 inches infiltration and 44 inches total precipitation.

7) DERBCAS Tier 1 default for groundwater Darcy velocity based on groundwater seepage velocity of 79 ft/yr.

Appendix 3.
Standard Exposure Assumptions

Exposure Factors and Target Risk Limits



Exposure Factors and Target Risk Limits

1. Exposure Parameters

	Residential Receptors			Commerical Receptors		User
	Child	Adolescent	Adult	Adult	Construc.	Defined
Averaging time, carcinogens (yr)	70					-
Averaging time, non-carcinogens (yr)	6	12	30	25	1	-
Body weight (kg)	15	35	80	70	70	-
Exposure duration (yr)	6	0.0001	26	25	1	-
Averaging Time for Vapor Flux (yr)	30			30	30	-
Exposure frequency (d/yr)	350			250	180	-
Dermal exposure freq. (d/yr)	350			250	180	-
Seasonal-avg skin surface area (cm^2/d)	2023	2023	5800	5800	5800	-
Soil dermal adherence factor (mg/cm^2)	0.5	0.5	0.5	0.5	0.5	-
Water ingestion rate (L/d)	0.78	0.78	2.5	1	1	-
Soil ingestion rate (mg/d)	200	200	100	50	100	-
Swimming exposure time (hr/event)	1	3	3			
Swimming event frequency (events/yr)	12	12	12			
Swimming water ingestion rate (L/hr)	0.5	0.5	0.05			
Skin surface area, swimming (cm^2)	3500	8100	23000			
Fish consumption rate (kg/d)	0.025	0.025	0.025			
Vegetable ingestion rate (kg/d)						
Above-ground vegetables	0.002	0.002	0.006			
Below-ground vegetables	0.001	0.001	0.002			
Contaminated fish fraction (-)	1					

Site Name: Final 2017 DERBCAP
Location:
Compl. By: PRB
Job ID: Date: 1-Aug-17

2. Age Adjustment for Carcinogens
(residential receptor only)

	Adjustment Factor	
☐ Seasonal skin surface area, soil contact	1129.6	(cm^2-yr/kg)
☑ Water ingestion	0.937	(mg-yr/L-day)
☑ Soil ingestion	105	(mg-yr/kg-day)
☐ Swimming water ingestion	2.55002	(L/kg)
☐ Skin surface area, swimming	6899.9	(cm^2-yr/kg)
☑ Fish consumption	0.01625	(kg-yr/kg-day)
☑ Below-ground vegetable ingestion	0.315	(kg-yr/kg-day)
☑ Above-ground vegetable ingestion	0.805	(kg-yr/kg-day)

3. Non-Carcinogenic Receptor *(residential receptor only)*: Child

4. Target Health Risk Limits

	Individual	Cumulative
Target Cancer Risk (Carcinogens)	1.0E-5	1.0E-5
Target Hazard Quotient/Index (non-Carc.)	1.0E+0	1.0E+0

5. Commands and Options

Return to Exposure Pathways
Use/Set Default Values
Print Sheet
Help

Appendix 4.
Exposure Pathway Calculation Sheets

- 0-50' RBSLs
- 51-100' RBSLs
- 101-200' RBSLs
- Soil to Groundwater for <50' RBSLs

RBSL CALCULATION FOOTNOTES

1. BW of adult changed to 80 kg
2. Exposure duration of adolescent changed to 0.0001 yr- age group specifically not targeted
3. Exposure duration of adult changed to 26yrs-this allows for 6 years as child and 26-6yrs (20yrs) as an adult
4. Water ingestion rate for child and adolescent changed from 1L/d to 0.781/d
5. Water ingestion rate for adult changed from 21/d to 2.5 1/d
6. New for 2017-we are age adjusting for carcinogens
7. New for 2017-we are focusing on child receptors
8. Slope factor for Benzo-a-pyrene changed from 7.3 to 1
9. Slope factor for benz-a-anthracene changed from 0.73 to 0.1
10. Slope factor for benzo-b-fluoranthene changed from 0.73 to 0.1
11. Slope factor for benzo-k-fluoranthene changed from 0.073 to 0.01
12. Slope factor for chrysene changed from 0.0073 to 0.001
13. Slope factor for indeno-1,2,3-cd-pyrene changed from 0.73 to 0.1
14. Slope factor for ethylbenzene added, 0.011
15. Slope factor for TBA added,

    0.0033(11tt ps:/ / oehha.ca.gov/media/ downlo ads/ water/ chemlcals/ nl/ paltba risk02.pdf)
16. 1,3,5-trimethlbenzene does not have half-lives-will be run with identical values to TBA and 1,2,4-trimethylbenzene, respectively and then again without first order decay
    a. Due to lack of data, no decay option was input into chart
17. Add inhalation unit risk for naphthalene, 0.000034-Due to this inhalation risk Toolkit severely underestimates the risk from naphthalene in groundwater for residential use. Inhalation risk is calculated by the following formula:

    $$\text{Risk} = \frac{[\text{concentration } \mu g/l) \times \text{slope factor} \times 350 \text{ days} \times 26 \text{ years} \times (0.SL/\ m^3}{365 \text{ days} \times 70 \text{ years}}$$

    By substituting naphthalene's inhalation slope factor and solving for concentration we get 1.65 µg/L. I have rounded to 2 µg/1.
18. Soil to groundwater concentration were based off of the ASTM model rather than the DE submergence model
19. Soil to groundwater concentrations were only calculated for the <50 RBSL, risk-based screening level
20. Adjustments were made in the RBSL calculation (or toolkit modeling) for naphthalene due to the carcinogenic nature of the inhalation risk. The inhalation risk for naphthalene poses a significantly higher threat than the ingestion risk as calculated by the DERBCAP Toolkit.

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Exposure Parameters		Residential				Commercial/Industrial		User Defined
		Child*	Adolescent	Adult	Age Adjusted**	Adult	Construct.	
ATc	Averaging time for carcinogens (yr)	70	70	70	NA	70	70	-
ATn	Averaging time for non-carcinogens (yr)	6	12	30	NA	25	1	-
BW	Body weight (kg)	15	35	80	NA	70	70	-
ED	Exposure duration (yr)	6	0.0001	26	NA	25	1	-
τ	Averaging time for vapor flux (yr)	30	30	30	NA	30	30	-
EF	Exposure frequency (days/yr)	350	350	350	NA	250	180	-
EFD	Exposure frequency for dermal exposure	350	350	350	NA	250	180	-
IRw	Ingestion rate of water (L/day)	0.78	0.78	2.5	2.9	1	NA	-
IRs	Ingestion rate of soil (mg/day)	200	200	100	323	50	100	-
SA	Skin surface area (dermal) (cm^2)	2023	2023	5800	NA	5800	5800	-
M	Soil to skin adherence factor	0.5	0.5	0.5	NA	0.5	0.5	-
ETswim	Swimming exposure time (hr/event)	1	3	3	NA	NA	NA	NA
EVswim	Swimming event frequency (events/yr)	12	12	12	NA	NA	NA	NA
IRswim	Water ingestion while swimming (L/hr)	0.5	0.5	0.05	NA	NA	NA	NA
SAswim	Skin surface area for swimming (cm^2)	3500	8100	23000	NA	NA	NA	NA
IRfish	Ingestion rate of fish (kg/yr)	0.025	0.025	0.025	0.050	NA	NA	NA
Ffish	Contaminated fish fraction (unitless)	1	1	1	NA	NA	NA	NA
IRbg	Below-ground vegetable ingestion	0.002	0.002	0.006	2.477	NA	NA	NA
IRabg	Above-ground vegetable ingestion	0.001	0.001	0.002	0.969	NA	NA	NA
VGbg	Above-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA
VGabg	Below-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA

* = Child Receptor used for Non-Carcinogens
** = NS= Age Adjustment not selected for this parameter. Age-adjusted rate is effective value corresponding to adult exposure factors.

Complete Exposure Pathways and Receptors	On-site	Off-site 1	Off-site 2
Groundwater:			
Groundwater Ingestion	Residential	Residential	Residential
Soil Leaching to Groundwater Ingestion	Residential	Residential	Residential
Apply MCL Values	No	No	No
Applicable Surface Water Exposure Routes:			
Swimming	NA	NA	None
Fish Consumption	NA	NA	None
Aquatic Life Protection	NA	NA	None
Soil:			
Direct Contact: direct combined pathways	None	NA	NA
Apply CLEA- UK SGV levels		No	
Outdoor Air:			
Particulates from Surface Soils	None	None	None
Volatilization from Soils	None	None	None
Volatilization from Groundwater	None	None	None
Indoor Air:			
Volatilization from Soils	None	NA	NA
Volatilization from Groundwater	None	None	None
Soil Leaching to Groundwater Volatilization	None	None	None

Receptor Distance from Source Media	On-site	Off-site 1	Off-site 2	(Units)
Groundwater receptor	0	51	101	(ft)
Outdoor air inhalation receptor	NA	NA	NA	(ft)
Indoor air inhalation receptor	NA	NA	NA	(ft)

Target Health Risk Values		Individual	Cumulative
TR	Target Risk (carcinogens)	1.0E-5	1.0E-5
THQ	Target Hazard Quotient (non-carcinogenic risk)	1.0E+0	1.0E+0

Modeling Options	
RBCA tier	Tier 2
Outdoor air volatilization model	NA
Indoor air volatilization model	NA
Soil leaching model	ASTM leaching model
Use soil attenuation model (SAM) for leachate?	No
Use dual equilibrium desorption model?	No
Apply Mass Balance Limit for Soil Volatilization?	No
Apply UK (CLEA) SGV as soil concentration limit	No
Vegetable calculation options	NA
Air dilution factor	NA
Groundwater dilution-attenuation factor	Domenico model w/ biodeg.

Delaware Soil Submergence Model Parameters		Value	(Units)
θ_N	Residual NAPL content in submerged soils	NA	(-)
f	Water table fluctuation cycles per year	NA	(1/yr)
t_{HU}	Duration of high water table condition	NA	(d)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	NA			(ft)
h_v	Vadose zone thickness	NA			(ft)
ρ_s	Soil bulk density	1.78			(g/cm^3)
f_{oc}	Fraction organic carbon	0.01			(-)
θ_T	Soil total porosity	0.38			(-)
		capillary	vadose	foundation	
θ_w	Volumetric water content	0.342	0.12	0.12	(-)
θ_a	Volumetric air content	0.038	0.26	0.26	(-)
K_{vs}	Vertical hydraulic conductivity	10353.54331			(ft/yr)
k_v	Vapor permeability	1.07639E-11			(ft^2)
L_{gw}	Depth to groundwater	9.842519685			(ft)
pH	Soil/groundwater pH	6.8			(-)
W	Length of source-zone area parallel to wind	NA			(ft)
W_{gw}	Length of source-zone area parallel to GW flow	49.21259843			(ft)
L_{ss}	Thickness of affected surface soils	NA			(ft)
A	Source zone area	NA			(ft^2)
L_s	Depth to top of affected soils	NA			(ft)
L_{base}	Depth to base of affected soils	NA			(ft)
L_{subs}	Thickness of affected soils	NA			(ft)

Outdoor Air Parameters		Value	(Units)
U_{air}	Ambient air velocity in mixing zone	NA	(ft/s)
δ_{air}	Air mixing zone height	NA	(ft)
Q/C	Inverse mean concentration at the center of source	NA	
P_a	Areal particulate emission rate	NA	(g/cm^2/s)
V	Fraction of vegetative cover	NA	
U_m	Mean annual airvelocity at 7m	NA	
U_t	Equivalent 7m air velocity threshold value	NA	
Γ(x)	Windspeed function dependant on Um/Ut	NA	
PEF	Particulate Emission Factor	NA	

Building Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	NA	(ft)
A_b	Foundation area	NA	NA	(ft^2)
X_{crk}	Foundation perimeter	NA	NA	(ft)
ER	Building air exchange rate	NA	NA	(1/s)
L_{crk}	Foundation thickness	NA	NA	(ft)
Z_{crk}	Depth to bottom of foundation slab	NA	NA	(ft)
η	Foundation crack fraction	NA	NA	(-)
dP	Indoor/outdoor differential pressure	NA	NA	(g/cm/s^2)
Q_s	Convective air flow through slab	NA	NA	(ft^3/s)
θ_{wcrack}	Volumetric water content of cracks	NA	NA	(-)
θ_{acrack}	Volumetric air content of cracks	NA	NA	(-)
BV	Building Volume	NA	NA	(ft^3)
w	Building Width Perpendicular to GW flow	NA	NA	(ft)
L	Building Length Parallel to GW flow	NA	NA	(ft)
v	Saturated Soil Zone Porosity	NA	NA	(-)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	6.56167979	(ft)
I_f	Net groundwater infiltration rate	35	(cm/yr)
U_{gw}	Groundwater Darcy velocity	30	(ft/yr)
V_{gw}	Groundwater seepage velocity	78.94736842	(ft/yr)
K_s	Saturated hydraulic conductivity	3000	(ft/yr)
i	Groundwater gradient	0.01	(-)
S_w	Width of groundwater source zone	49.21259843	(ft)
S_d	Depth of groundwater source zone	6.56167979	(ft)
θ_{eff}	Effective porosity in water-bearing unit	0.38	(-)
$f_{oc\text{-}sat}$	Fraction organic carbon in water-bearing unit	0.001	(-)
pH_{sat}	Groundwater pH	6.2	(-)
	Biodegradation considered?	1st Order	

Transport Parameters		Off-site 1	Off-site 2	Off-site 1	Off-site 2	(Units)
	Lateral Groundwater Transport	Groundwater Ingestion		Groundwater to Indoor Air		
α_x	Longitudinal dispersivity	5.1E+0	1.0E+1	NA	NA	(ft)
α_y	Transverse dispersivity	1.7E+0	3.3E+0	NA	NA	(ft)
α_z	Vertical dispersivity	2.6E-1	5.1E-1	NA	NA	(ft)
	Lateral Outdoor Air Transport	Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
σ_y	Transverse dispersion coefficient	NA	NA	NA	NA	(ft)
σ_z	Vertical dispersion coefficient	NA	NA	NA	NA	(ft)
ADF	Air dispersion factor	NA	NA	NA	NA	(-)

Surface Water Parameters		Off-site 2	(Units)
Q_{sw}	Surface water flowrate	NA	(ft^3/s)
W_{pl}	Width of GW plume at SW discharge	NA	(ft)
δ_{pl}	Thickness of GW plume at SW discharge	NA	(ft)
DF_{sw}	Groundwater-to-surface water dilution factor	NA	(-)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT

Site Name: 2018 DERBCAP
Site Location: Delaware
Completed By: PRB
Date Completed: 13-Dec-18
Job ID:

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-5
Target Hazard Quotient 1.0E+0
Groundwater DAF Option: Domenico - First Order (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways (Checked if Pathway is Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	■ Groundwater Ingestion			□ Groundwater Volatilization to Indoor Air			□ Groundwater Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/L)	On-site (0 ft) Residential	Off-site 1 (51 ft) Residential	Off-site 2 (101 ft) Residential	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	(mg/L)	"■" if yes	Only if "yes" left
71-43-2	Benzene		1.4E-2	2.5E-2	7.8E-2							1.4E-2	□	NA
108-88-3	Toluene		1.6E+0	>5.3E+2	>5.3E+2							1.6E+0	□	NA
100-41-4	Ethyl benzene *		7.1E-2	3.3E-1	2.1E+0							7.1E-2	□	NA
1330-20-7	Xylenes (mixed isomers)		4.0E+0	1.3E+1	6.5E+1							4.0E+0	□	NA
98-82-8	Cumene		2.0E+0	>5.0E+1	>5.0E+1							2.0E+0	□	NA
1634-04-4	Methyl t-Butyl ether (MTBE)		2.0E-1	4.2E-1	1.5E+0							2.0E-1	□	NA
56-55-3	Benz-a-anthracene *		7.8E-3	>1.0E-2	>1.0E-2							7.8E-3	□	NA
50-32-8	Benzo-a-pyrene *		7.8E-4	>1.6E-3	>1.6E-3							7.8E-4	□	NA
205-99-2	Benzo-b-fluoranthene *		>1.5E-3	>1.5E-3	>1.5E-3							>1.5E-3	□	NA
207-08-9	Benzo-k-fluoranthene *		>5.5E-4	>5.5E-4	>5.5E-4							>5.5E-4	□	NA
218-01-9	Chrysene *		>2.0E-3	>2.0E-3	>2.0E-3							>2.0E-3	□	NA
193-39-5	Indeno-1,2,3-cd-pyrene *		>3.8E-3	>3.8E-3	>3.8E-3							>3.8E-3	□	NA
83-32-9	Acenaphthene		1.2E+0	>4.2E+0	>4.2E+0							1.2E+0	□	NA
120-12-7	Anthracene		>4.3E-2	>4.3E-2	>4.3E-2							>4.3E-2	□	NA
206-44-0	Fluoranthene		>2.6E-1	>2.6E-1	>2.6E-1							>2.6E-1	□	NA
86-73-7	Fluorene		8.0E-1	>2.0E+0	>2.0E+0							8.0E-1	□	NA
85-01-8	Phenanthrene		6.0E-1	>9.9E-1	>9.9E-1							6.0E-1	□	NA
129-00-0	Pyrene		>1.4E-1	>1.4E-1	>1.4E-1							>1.4E-1	□	NA
106-93-4	Ethylene dibromide		3.9E-4	2.3E-3	1.8E-2							3.9E-4	□	NA
107-06-2	Dichloroethane, 1,2-		8.6E-3	1.8E-2	6.6E-2							8.6E-3	□	NA
95-63-6	Trimethylbenzene, 1,2,4-		2.0E-1	>5.7E+1	>5.7E+1							2.0E-1	□	NA

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent solubility value. NA = Not applicable. NC = Not calculated.

RBCA SITE ASSESSMENT

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Job ID:

1 OF 1

SUBSURFACE SOIL (2 - 9.8 ft) SSTL VALUES

Target Risk (Class A & B) 1.0E-5
Target Hazard Quotient 1.0E+0

Groundwater DAF Option: Domenico - First Order (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways (Checked if Pathway is Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	■ Soil Leaching to Groundwater Ingestion			☐ Soil Leaching to Groundwater/ Groundwater Volatilization to Indoor Air			☐ Soil Vol. to Indoor Air	☐ Soil Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/kg)	On-site (0 ft) Residential	Off-site 1 (51 ft) Residential	Off-site 2 (101 ft) Residential	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	On-site (0 ft) None	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	(mg/kg)	"■" if yes	Only if "yes" left
71-43-2	Benzene		4.8E-2	8.6E-2	2.7E-1								4.8E-2	☐	
108-88-3	Toluene		1.1E+1	>8.0E+2	>8.0E+2								1.1E+1	☐	
100-41-4	Ethyl benzene *		6.8E-1	3.2E+0	2.1E+1								6.8E-1	☐	
1330-20-7	Xylenes (mixed isomers)		4.5E+1	1.5E+2	>5.0E+2								4.5E+1	☐	
98-82-8	Cumene		3.1E+2	>1.7E+3	>1.7E+3								3.1E+2	☐	
1634-04-4	Methyl t-Butyl ether (MTBE)		1.9E-1	4.0E-1	1.4E+0								1.9E-1	☐	
56-55-3	Benz-a-anthracene *		>3.5E+1	>3.5E+1	>3.5E+1								>3.5E+1	☐	
50-32-8	Benzo-a-pyrene *		>1.5E+1	>1.5E+1	>1.5E+1								>1.5E+1	☐	
205-99-2	Benzo-b-fluoranthene *		>1.8E+1	>1.8E+1	>1.8E+1								>1.8E+1	☐	
207-08-9	Benzo-k-fluoranthene *		>6.8E+0	>6.8E+0	>6.8E+0								>6.8E+0	☐	
218-01-9	Chrysene *		>6.2E+0	>6.2E+0	>6.2E+0								>6.2E+0	☐	
193-39-5	Indeno-1,2,3-cd-pyrene *		>1.3E+2	>1.3E+2	>1.3E+2								>1.3E+2	☐	
83-32-9	Acenaphthene		>1.7E+2	>1.7E+2	>1.7E+2								>1.7E+2	☐	
120-12-7	Anthracene		>1.0E+1	>1.0E+1	>1.0E+1								>1.0E+1	☐	
206-44-0	Fluoranthene		>1.3E+2	>1.3E+2	>1.3E+2								>1.3E+2	☐	
86-73-7	Fluorene		>1.5E+2	>1.5E+2	>1.5E+2								>1.5E+2	☐	
85-01-8	Phenanthrene		>1.4E+2	>1.4E+2	>1.4E+2								>1.4E+2	☐	
129-00-0	Pyrene		>5.1E+1	>5.1E+1	>5.1E+1								>5.1E+1	☐	
106-93-4	Ethylene dibromide		1.1E-3	6.2E-3	4.8E-2								1.1E-3	☐	
107-06-2	Dichloroethane, 1,2-		9.6E-3	2.0E-2	7.3E-2								9.6E-3	☐	
95-63-6	Trimethylbenzene, 1,2,4-		8.5E+0	>5.4E+2	>5.4E+2								8.5E+0	☐	

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent residual saturation value. NA = Not applicable. NC = Not calculated.

Exposure Pathway Calculation Sheets (Continued)

- 201-300’ RBSLs
- 301-400' RBSLs

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Exposure Parameters		Residential				Commercial/Industrial		User Defined
		Child*	Adolescent	Adult	Age Adjusted**	Adult	Construct.	
ATc	Averaging time for carcinogens (yr)	70	70	70	NA	70	70	-
ATn	Averaging time for non-carcinogens (yr)	6	12	30	NA	25	1	-
BW	Body weight (kg)	15	35	80	NA	70	70	-
ED	Exposure duration (yr)	6	0.0001	26	NA	25	1	-
τ	Averaging time for vapor flux (yr)	30	30	30	NA	30	30	-
EF	Exposure frequency (days/yr)	350	350	350	NA	250	180	-
EFD	Exposure frequency for dermal exposure	350	350	350	NA	250	180	-
IRw	Ingestion rate of water (L/day)	0.78	0.78	2.5	2.9	1	NA	-
IRs	Ingestion rate of soil (mg/day)	200	200	100	323	50	100	-
SA	Skin surface area (dermal) (cm^2)	2023	2023	5800	NA	5800	5800	-
M	Soil to skin adherence factor	0.5	0.5	0.5	NA	0.5	0.5	-
ETswim	Swimming exposure time (hr/event)	1	3	3	NA	NA	NA	
EVswim	Swimming event frequency (events/yr)	12	12	12	NA	NA	NA	
IRswim	Water ingestion while swimming (L/hr)	0.5	0.5	0.05	NA	NA	NA	
SAswim	Skin surface area for swimming (cm^2)	3500	8100	23000	NA	NA	NA	
IRfish	Ingestion rate of fish (kg/yr)	0.025	0.025	0.025	0.050	NA	NA	
Flfish	Contaminated fish fraction (unitless)	1	1	1	NA	NA	NA	
IRbg	Below-ground vegetable ingestion	0.002	0.002	0.006	2.477	NA	NA	
IRabg	Above-ground vegetable ingestion	0.001	0.001	0.002	0.969	NA	NA	
VGbg	Above-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	
VGabg	Below-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	

* = Child Receptor used for Non-Carcinogens
** = NS= Age Adjustment not selected for this parameter. Age-adjusted rate is effective value corresponding to adult exposure factors.

Complete Exposure Pathways and Receptors	On-site	Off-site 1	Off-site 2
Groundwater:			
Groundwater Ingestion	Residential	Residential	Residential
Soil Leaching to Groundwater Ingestion	Residential	Residential	Residential
Apply MCL Values	No	No	No
Applicable Surface Water Exposure Routes:			
Swimming			None
Fish Consumption			None
Aquatic Life Protection			None
Soil:			
Direct Contact: direct combined pathways	None	NA	
Apply CLEA- UK SGV levels		No	
Outdoor Air:			
Particulates from Surface Soils	None	None	None
Volatilization from Soils	None	None	None
Volatilization from Groundwater	None	None	None
Indoor Air:			
Volatilization from Soils	None	NA	NA
Volatilization from Groundwater	None	None	None
Soil Leaching to Groundwater Volatilization	None	None	None

Receptor Distance from Source Media	On-site	Off-site 1	Off-site 2	(Units)
Groundwater receptor	0	201	301	(ft)
Outdoor air inhalation receptor	NA	NA	NA	(ft)
Indoor air inhalation receptor	NA	NA	NA	(ft)

Target Health Risk Values		Individual	Cumulative
TR	Target Risk (carcinogens)	1.0E-5	1.0E-5
THQ	Target Hazard Quotient (non-carcinogenic risk)	1.0E+0	1.0E+0

Modeling Options	
RBCA tier	Tier 2
Outdoor air volatilization model	NA
Indoor air volatilization model	NA
Soil leaching model	ASTM leaching model
Use soil attenuation model (SAM) for leachate?	No
Use dual equilibrium desorption model?	No
Apply Mass Balance Limit for Soil Volatilization?	No
Apply UK (CLEA) SGV as soil concentration limit	No
Vegetable calculation options	NA
Air dilution factor	NA
Groundwater dilution-attenuation factor	Domenico model w/ biodeg.

Delaware Soil Submergence Model Parameters		Value	(Units)
θ_N	Residual NAPL content in submerged soils	NA	(-)
f	Water table fluctuation cycles per year	NA	(1/yr)
t_{hu}	Duration of high water table condition	NA	(d)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	NA			(ft)
h_v	Vadose zone thickness	NA			(ft)
ρ_s	Soil bulk density	1.78			(g/cm^3)
f_{oc}	Fraction organic carbon	0.01			(-)
θ_T	Soil total porosity	0.38			(-)
		capillary	vadose	foundation	
θ_w	Volumetric water content	0.342	0.12	0.12	(-)
θ_a	Volumetric air content	0.038	0.26	0.26	(-)
K_{vs}	Vertical hydraulic conductivity	10353.54331			(ft/yr)
k_v	Vapor permeability	1.07639E-11			(ft^2)
L_{gw}	Depth to groundwater	9.842519685			(ft)
pH	Soil/groundwater pH	6.8			(-)
W	Length of source-zone area parallel to wind	NA			(ft)
W_{gw}	Length of source-zone area parallel to GW flow	49.21259843			(ft)
L_{ss}	Thickness of affected surface soils	NA			(ft)
A	Source zone area	NA			(ft^2)
L_s	Depth to top of affected soils	NA			(ft)
L_{base}	Depth to base of affected soils	NA			(ft)
L_{subs}	Thickness of affected soils	NA			(ft)

Outdoor Air Parameters		Value	(Units)
U_{air}	Ambient air velocity in mixing zone	NA	(ft/s)
δ_{air}	Air mixing zone height	NA	(ft)
Q/C	Inverse mean concentration at the center of source	NA	
P_e	Areal particulate emission rate	NA	(g/cm^2/s)
V	Fraction of vegetative cover	NA	
U_m	Mean annual airvelocity at 7m	NA	
U_t	Equivalent 7m air velocity threshold value	NA	
F(x)	Windspeed function dependant on Um/Ut	NA	
PEF	Partculate Emission Factor	NA	

Building Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	NA	(ft)
A_b	Foundation area	NA	NA	(ft^2)
X_{crk}	Foundation perimeter	NA	NA	(ft)
ER	Building air exchange rate	NA	NA	(1/s)
L_{crk}	Foundation thickness	NA	NA	(ft)
Z_{crk}	Depth to bottom of foundation slab	NA	NA	(ft)
η	Foundation crack fraction	NA	NA	(-)
dP	Indoor/outdoor differential pressure	NA	NA	(g/cm/s^2)
Q_s	Convective air flow through slab	NA	NA	(ft^3/s)
θ_{wcrack}	Volumetric water content of cracks	NA	NA	(-)
θ_{acrack}	Volumetric air content of cracks	NA	NA	(-)
BV	Building Volume	NA	NA	(ft^3)
w	Building Width Perpendicular to GW flow	NA	NA	(ft)
L	Building Length Parallel to GW flow	NA	NA	(ft)
v	Saturated Soil Zone Porosity	NA	NA	(-)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	6.56167979	(ft)
I_f	Net groundwater infiltration rate	35	(cm/yr)
U_{gw}	Groundwater Darcy velocity	30	(ft/yr)
V_{gw}	Groundwater seepage velocity	78.94736842	(ft/yr)
K_s	Saturated hydraulic conductivity	3000	(ft/yr)
i	Groundwater gradient	0.01	(-)
S_w	Width of groundwater source zone	49.21259843	(ft)
S_d	Depth of groundwater source zone	6.56167979	(ft)
θ_{eff}	Effective porosity in water-bearing unit	0.38	(-)
f_{oc-sat}	Fraction organic carbon in water-bearing unit	0.001	(-)
pH_{sat}	Groundwater pH	6.2	(-)
	Biodegradation considered?	1st Order	

Transport Parameters		Off-site 1	Off-site 2	Off-site 1	Off-site 2	(Units)
Lateral Groundwater Transport		Groundwater Ingestion		Groundwater to Indoor Air		
α_x	Longitudinal dispersivity	2.0E+1	3.0E+1	NA	NA	(ft)
α_y	Transverse dispersivity	6.8E+0	9.9E+0	NA	NA	(ft)
α_z	Vertical dispersivity	1.0E+0	1.5E+0	NA	NA	(ft)
Lateral Outdoor Air Transport		Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
σ_y	Transverse dispersion coefficient	NA	NA	NA	NA	(ft)
σ_z	Vertical dispersion coefficient	NA	NA	NA	NA	(ft)
ADF	Air dispersion factor	NA	NA	NA	NA	(-)

Surface Water Parameters		Off-site 2	(Units)
Q_{sw}	Surface water flowrate	NA	(ft^3/s)
W_{pl}	Width of GW plume at SW discharge	NA	(ft)
δ_{pl}	Thickness of GW plume at SW discharge	NA	(ft)
DF_{gw}	Groundwater-to-surface water dilution factor	NA	(-)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Job ID:

1 OF 1

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-5
Target Hazard Quotient 1.0E+0

Groundwater DAF Option: Domenico - First Order (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways (Checked if Pathway is Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	■ Groundwater Ingestion			□ Groundwater Volatilization to Indoor Air			□ Groundwater Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
			On-site (0 ft)	Off-site 1 (201 ft)	Off-site 2 (301 ft)	On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)	On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)			Only if "yes"
CAS No.	Name	(mg/L)	Residential	Residential	Residential	None	None	None	None	None	None	(mg/L)	"■" if yes	left
71-43-2	Benzene		1.4E-2	4.4E-1	1.5E+0							1.4E-2	☐	NA
108-88-3	Toluene		1.6E+0	>5.3E+2	>5.3E+2							1.6E+0	☐	NA
100-41-4	Ethyl benzene *		7.1E-2	4.0E+1	>1.7E+2							7.1E-2	☐	NA
1330-20-7	Xylenes (mixed isomers)		4.0E+0	>2.0E+2	>2.0E+2							4.0E+0	☐	NA
98-82-8	Cumene		2.0E+0	>5.0E+1	>5.0E+1							2.0E+0	☐	NA
1634-04-4	Methyl t-Butyl ether (MTBE)		2.0E-1	1.1E+1	4.7E+1							2.0E-1	☐	NA
56-55-3	Benz-a-anthracene *		7.8E-3	>1.0E-2	>1.0E-2							7.8E-3	☐	NA
50-32-8	Benzo-a-pyrene *		7.8E-4	>1.6E-3	>1.6E-3							7.8E-4	☐	NA
205-99-2	Benzo-b-fluoranthene *		>1.5E-3	>1.5E-3	>1.5E-3							>1.5E-3	☐	NA
207-08-9	Benzo-k-fluoranthene *		>5.5E-4	>5.5E-4	>5.5E-4							>5.5E-4	☐	NA
218-01-9	Chrysene *		>2.0E-3	>2.0E-3	>2.0E-3							>2.0E-3	☐	NA
193-39-5	Indeno-1,2,3-cd-pyrene *		>3.8E-3	>3.8E-3	>3.8E-3							>3.8E-3	☐	NA
83-32-9	Acenaphthene		1.2E+0	>4.2E+0	>4.2E+0							1.2E+0	☐	NA
120-12-7	Anthracene		>4.3E-2	>4.3E-2	>4.3E-2							>4.3E-2	☐	NA
206-44-0	Fluoranthene		>2.6E-1	>2.6E-1	>2.6E-1							>2.6E-1	☐	NA
86-73-7	Fluorene		8.0E-1	>2.0E+0	>2.0E+0							8.0E-1	☐	NA
85-01-8	Phenanthrene		6.0E-1	>9.9E-1	>9.9E-1							6.0E-1	☐	NA
129-00-0	Pyrene		>1.4E-1	>1.4E-1	>1.4E-1							>1.4E-1	☐	NA
106-93-4	Ethylene dibromide		3.9E-4	4.1E-1	4.5E+0							3.9E-4	☐	NA
107-06-2	Dichloroethane, 1,2-		8.6E-3	4.8E-1	2.1E+0							8.6E-3	☐	NA
95-63-6	Trimethylbenzene, 1,2,4-		2.0E-1	>5.7E+1	>5.7E+1							2.0E-1	☐	NA

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent solubility value. NA = Not applicable. NC = Not calculated.

Exposure Pathway Calculation Sheets (Continued)

- 401-500’ RBSLs
- >500' RBSLs

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Exposure Parameters		Residential				Commercial/Industrial		User Defined
		Child*	Adolescent	Adult	Age Adjusted**	Adult	Construct.	
ATc	Averaging time for carcinogens (yr)	70	70	70	NA	70	70	-
ATn	Averaging time for non-carcinogens (yr)	6	12	30	NA	25	1	-
BW	Body weight (kg)	15	35	80	NA	70	70	-
ED	Exposure duration (yr)	6	0.0001	26	NA	25	1	-
τ	Averaging time for vapor flux (yr)	30	30	30	NA	30	30	-
EF	Exposure frequency (days/yr)	350	350	350	NA	250	180	-
EFD	Exposure frequency for dermal exposure	350	350	350	NA	250	180	-
IRw	Ingestion rate of water (L/day)	0.78	0.78	2.5	2.9	1	NA	-
IRs	Ingestion rate of soil (mg/day)	200	200	100	323	50	100	-
SA	Skin surface area (dermal) (cm^2)	2023	2023	5800	NA	5800	5800	-
M	Soil to skin adherence factor	0.5	0.5	0.5	NA	0.5	0.5	-
ETswim	Swimming exposure time (hr/event)	1	3	3	NA	NA	NA	NA
EVswim	Swimming event frequency (events/yr)	12	12	12	NA	NA	NA	NA
IRswim	Water ingestion while swimming (L/hr)	0.5	0.5	0.05	NA	NA	NA	NA
SAswim	Skin surface area for swimming (cm^2)	3500	8100	23000	NA	NA	NA	NA
IRfish	Ingestion rate of fish (kg/yr)	0.025	0.025	0.025	0.050	NA	NA	NA
Flfish	Contaminated fish fraction (unitless)	1	1	1	NA	NA	NA	NA
IRbg	Below-ground vegetable ingestion	0.002	0.002	0.006	2.477	NA	NA	NA
IRabg	Above-ground vegetable ingestion	0.001	0.001	0.002	0.969	NA	NA	NA
VGbg	Above-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA
VGabg	Below-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA

* = Child Receptor used for Non-Carcinogens
** = NS= Age Adjustment not selected for this parameter. Age-adjusted rate is effective value corresponding to adult exposure factors.

Complete Exposure Pathways and Receptors	On-site	Off-site 1	Off-site 2
Groundwater:			
Groundwater Ingestion	Residential	Residential	Residential
Soil Leaching to Groundwater Ingestion	Residential	Residential	Residential
Apply MCL Values	No	No	No
Applicable Surface Water Exposure Routes:			
Swimming	NA	NA	None
Fish Consumption	NA	NA	None
Aquatic Life Protection	NA	NA	None
Soil:			
Direct Contact: direct combined pathways	None	NA	NA
Apply CLEA- UK SGV levels		No	
Outdoor Air:			
Particulates from Surface Soils	None	None	None
Volatilization from Soils	None	None	None
Volatilization from Groundwater	None	None	None
Indoor Air:			
Volatilization from Soils	None	NA	NA
Volatilization from Groundwater	None	None	None
Soil Leaching to Groundwater Volatilization	None	None	None

Receptor Distance from Source Media	On-site	Off-site 1	Off-site 2	(Units)
Groundwater receptor	0	401	501	(ft)
Outdoor air inhalation receptor	NA	NA	NA	(ft)
Indoor air inhalation receptor	NA	NA	NA	(ft)

Target Health Risk Values		Individual	Cumulative
TR	Target Risk (carcinogens)	1.0E-5	1.0E-5
THQ	Target Hazard Quotient (non-carcinogenic risk)	1.0E+0	1.0E+0

Modeling Options	
RBCA tier	Tier 2
Outdoor air volatilization model	NA
Indoor air volatilization model	NA
Soil leaching model	ASTM leaching model
Use soil attenuation model (SAM) for leachate?	No
Use dual equilibrium desorption model?	No
Apply Mass Balance Limit for Soil Volatilization?	No
Apply UK (CLEA) SGV as soil concentration limit	No
Vegetable calculation options	NA
Air dilution factor	NA
Groundwater dilution-attenuation factor	Domenico model w/ biodeg.

Delaware Soil Submergence Model Parameters		Value	(Units)
θ_N	Residual NAPL content in submerged soils	NA	(-)
f	Water table fluctuation cycles per year	NA	(1/yr)
t_{hU}	Duration of high water table condition	NA	(d)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	NA			(ft)
h_v	Vadose zone thickness	NA			(ft)
ρ_s	Soil bulk density	1.78			(g/cm^3)
f_{oc}	Fraction organic carbon	0.01			(-)
θ_T	Soil total porosity	0.38			(-)
		capillary	vadose	foundation	
θ_w	Volumetric water content	0.342	0.12	0.12	(-)
θ_a	Volumetric air content	0.038	0.26	0.26	(-)
K_{vs}	Vertical hydraulic conductivity	10353.54331			(ft/yr)
k_v	Vapor permeability	1.07639E-11			(ft^2)
L_{gw}	Depth to groundwater	9.842519685			(ft)
pH	Soil/groundwater pH	6.8			(-)
W	Length of source-zone area parallel to wind	NA			(ft)
W_{gw}	Length of source-zone area parallel to GW flow	49.21259843			(ft)
L_{ss}	Thickness of affected surface soils	NA			(ft)
A	Source zone area	NA			(ft^2)
L_s	Depth to top of affected soils	NA			(ft)
L_{base}	Depth to base of affected soils	NA			(ft)
L_{subs}	Thickness of affected soils	NA			(ft)

Outdoor Air Parameters		Value	(Units)
U_{air}	Ambient air velocity in mixing zone	NA	(ft/s)
δ_{air}	Air mixing zone height	NA	(ft)
Q/C	Inverse mean concentration at the center of source	NA	
P_a	Areal particulate emission rate	NA	(g/cm^2/s)
V	Fraction of vegetative cover	NA	
U_m	Mean annual airvelocity at 7m	NA	
U_t	Equivalent 7m air velocity threshold value	NA	
F(x)	Windspeed function dependant on Um/Ut	NA	
PEF	Partculate Emission Factor	NA	

Building Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	NA	(ft)
A_b	Foundation area	NA	NA	(ft^2)
X_{crk}	Foundation perimeter	NA	NA	(ft)
ER	Building air exchange rate	NA	NA	(1/s)
L_{crk}	Foundation thickness	NA	NA	(ft)
Z_{crk}	Depth to bottom of foundation slab	NA	NA	(ft)
η	Foundation crack fraction	NA	NA	(-)
dP	Indoor/outdoor differential pressure	NA	NA	(g/cm/s^2)
Q_s	Convective air flow through slab	NA	NA	(ft^3/s)
θ_{wcrack}	Volumetric water content of cracks	NA	NA	(-)
θ_{acrack}	Volumetric air content of cracks	NA	NA	(-)
BV	Building Volume	NA	NA	(ft^3)
w	Building Width Perpendicular to GW flow	NA	NA	(ft)
L	Building Length Parallel to GW flow	NA	NA	(ft)
v	Saturated Soil Zone Porosity	NA	NA	(-)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	6.56167979	(ft)
I_f	Net groundwater infiltration rate	35	(cm/yr)
U_{gw}	Groundwater Darcy velocity	30	(ft/yr)
V_{gw}	Groundwater seepage velocity	78.94736842	(ft/yr)
K_s	Saturated hydraulic conductivity	3000	(ft/yr)
i	Groundwater gradient	0.01	(-)
S_w	Width of groundwater source zone	49.21259843	(ft)
S_d	Depth of groundwater source zone	6.56167979	(ft)
θ_{eff}	Effective porosity in water-bearing unit	0.38	(-)
f_{oc-sat}	Fraction organic carbon in water-bearing unit	0.001	(-)
pH_{sat}	Groundwater pH	6.2	(-)
	Biodegradation considered?	1st Order	

Transport Parameters		Off-site 1	Off-site 2	Off-site 1	Off-site 2	(Units)
Lateral Groundwater Transport		Groundwater Ingestion		Groundwater to Indoor Air		
α_x	Longitudinal dispersivity	4.0E+1	5.0E+1	NA	NA	(ft)
α_y	Transverse dispersivity	1.3E+1	1.7E+1	NA	NA	(ft)
α_z	Vertical dispersivity	2.0E+0	2.5E+0	NA	NA	(ft)
Lateral Outdoor Air Transport		Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
σ_y	Transverse dispersion coefficient	NA	NA	NA	NA	(ft)
σ_z	Vertical dispersion coefficient	NA	NA	NA	NA	(ft)
ADF	Air dispersion factor	NA	NA	NA	NA	(-)

Surface Water Parameters		Off-site 2	(Units)
Q_{sw}	Surface water flowrate	NA	(ft^3/s)
W_{pl}	Width of GW plume at SW discharge	NA	(ft)
δ_{pl}	Thickness of GW plume at SW discharge	NA	(ft)
DF_{sw}	Groundwater-to-surface water dilution factor	NA	(-)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Job ID:

1 OF 1

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-5
Target Hazard Quotient 1.0E+0

Groundwater DAF Option: Domenico - First Order (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways (Checked if Pathway is Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	■ Groundwater Ingestion			☐ Groundwater Volatilization to Indoor Air			☐ Groundwater Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/L)	On-site (0 ft) Residential	Off-site 1 (401 ft) Residential	Off-site 2 (501 ft) Residential	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	(mg/L)	"■" if yes	Only if "yes" left
71-43-2	Benzene		1.4E-2	4.1E+0	9.5E+0							1.4E-2	☐	NA
108-88-3	Toluene		1.6E+0	>5.3E+2	>5.3E+2							1.6E+0	☐	NA
100-41-4	Ethyl benzene *		7.1E-2	>1.7E+2	>1.7E+2							7.1E-2	☐	NA
1330-20-7	Xylenes (mixed isomers)		4.0E+0	>2.0E+2	>2.0E+2							4.0E+0	☐	NA
98-82-8	Cumene		2.0E+0	>5.0E+1	>5.0E+1							2.0E+0	☐	NA
1634-04-4	Methyl t-Butyl ether (MTBE)		2.0E-1	1.5E+2	4.3E+2							2.0E-1	☐	NA
56-55-3	Benz-a-anthracene *		7.8E-3	>1.0E-2	>1.0E-2							7.8E-3	☐	NA
50-32-8	Benzo-a-pyrene *		7.8E-4	>1.6E-3	>1.6E-3							7.8E-4	☐	NA
205-99-2	Benzo-b-fluoranthene *		>1.5E-3	>1.5E-3	>1.5E-3							>1.5E-3	☐	NA
207-08-9	Benzo-k-fluoranthene *		>5.5E-4	>5.5E-4	>5.5E-4							>5.5E-4	☐	NA
218-01-9	Chrysene *		>2.0E-3	>2.0E-3	>2.0E-3							>2.0E-3	☐	NA
193-39-5	Indeno-1,2,3-cd-pyrene *		>3.8E-3	>3.8E-3	>3.8E-3							>3.8E-3	☐	NA
83-32-9	Acenaphthene		1.2E+0	>4.2E+0	>4.2E+0							1.2E+0	☐	NA
120-12-7	Anthracene		>4.3E-2	>4.3E-2	>4.3E-2							>4.3E-2	☐	NA
206-44-0	Fluoranthene		>2.6E-1	>2.6E-1	>2.6E-1							>2.6E-1	☐	NA
86-73-7	Fluorene		8.0E-1	>2.0E+0	>2.0E+0							8.0E-1	☐	NA
85-01-8	Phenanthrene		6.0E-1	>9.9E-1	>9.9E-1							6.0E-1	☐	NA
129-00-0	Pyrene		>1.4E-1	>1.4E-1	>1.4E-1							>1.4E-1	☐	NA
106-93-4	Ethylene dibromide		3.9E-4	3.2E+1	1.8E+2							3.9E-4	☐	NA
107-06-2	Dichloroethane, 1,2-		8.6E-3	6.8E+0	1.9E+1							8.6E-3	☐	NA
95-63-6	Trimethylbenzene, 1,2,4-		2.0E-1	>5.7E+1	>5.7E+1							2.0E-1	☐	NA

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent solubility value. NA = Not applicable. NC = Not calculated.

Exposure Pathway Calculation Sheets (Continued)

- Naphthalene

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Exposure Parameters		Residential				Commercial/Industrial		User Defined
		Child*	Adolescent	Adult	Age Adjusted**	Adult	Construct.	
ATc	Averaging time for carcinogens (yr)	70	70	70	NA	70	70	-
ATn	Averaging time for non-carcinogens (yr)	6	12	30	NA	25	1	-
BW	Body weight (kg)	15	35	80	NA	70	70	-
ED	Exposure duration (yr)	6	0.0001	26	NA	25	1	-
τ	Averaging time for vapor flux (yr)	30	30	30	NA	30	30	-
EF	Exposure frequency (days/yr)	350	350	350	NA	250	180	-
EFD	Exposure frequency for dermal exposure	350	350	350	NA	250	180	-
IRw	Ingestion rate of water (L/day)	0.78	0.78	2.5	2.9	1	NA	-
IRs	Ingestion rate of soil (mg/day)	200	200	100	323	50	100	-
SA	Skin surface area (dermal) (cm^2)	2023	2023	5800	NA	5800	5800	-
M	Soil to skin adherence factor	0.5	0.5	0.5	NA	0.5	0.5	-
ETswim	Swimming exposure time (hr/event)	1	3	3	NA	NA	NA	NA
EVswim	Swimming event frequency (events/yr)	12	12	12	NA	NA	NA	NA
IRswim	Water ingestion while swimming (L/hr)	0.5	0.5	0.05	NA	NA	NA	NA
SAswim	Skin surface area for swimming (cm^2)	3500	8100	23000	NA	NA	NA	NA
IRfish	Ingestion rate of fish (kg/yr)	0.025	0.025	0.025	0.050	NA	NA	NA
FIfish	Contaminated fish fraction (unitless)	1	1	1	NA	NA	NA	NA
IRbg	Below-ground vegetable ingestion	0.002	0.002	0.006	2.477	NA	NA	NA
IRabg	Above-ground vegetable ingestion	0.001	0.001	0.002	0.969	NA	NA	NA
VGbg	Above-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA
VGabg	Below-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA

* = Child Receptor used for Non-Carcinogens
** = NS= Age Adjustment not selected for this parameter. Age-adjusted rate is effective value corresponding to adult exposure factors.

Complete Exposure Pathways and Receptors	On-site	Off-site 1	Off-site 2
Groundwater:			
Groundwater Ingestion	Residential	MCL	MCL
Soil Leaching to Groundwater Ingestion	Residential	MCL	MCL
Apply MCL Values	Yes	Yes	Yes
Applicable Surface Water Exposure Routes:			
Swimming	NA	NA	None
Fish Consumption	NA	NA	None
Aquatic Life Protection	NA	NA	None
Soil:			
Direct Contact: direct combined pathways	None	NA	NA
Apply CLEA- UK SGV levels		No	
Outdoor Air:			
Particulates from Surface Soils	None	None	None
Volatilization from Soils	None	None	None
Volatilization from Groundwater	None	None	None
Indoor Air:			
Volatilization from Soils	None	NA	NA
Volatilization from Groundwater	None	None	None
Soil Leaching to Groundwater Volatilization	None	None	None

Receptor Distance from Source Media	On-site	Off-site 1	Off-site 2	(Units)
Groundwater receptor	0	51	101	(ft)
Outdoor air inhalation receptor	NA	NA	NA	(ft)
Indoor air inhalation receptor	NA	NA	NA	(ft)

Target Health Risk Values		Individual	Cumulative
TR	Target Risk (carcinogens)	1.0E-5	1.0E-5
THQ	Target Hazard Quotient (non-carcinogenic risk)	1.0E+0	1.0E+0

Modeling Options	
RBCA tier	Tier 2
Outdoor air volatilization model	NA
Indoor air volatilization model	NA
Soil leaching model	ASTM leaching model
Use soil attenuation model (SAM) for leachate?	No
Use dual equilibrium desorption model?	No
Apply Mass Balance Limit for Soil Volatilization?	No
Apply UK (CLEA) SGV as soil concentration limit	No
Vegetable calculation options	NA
Air dilution factor	NA
Groundwater dilution-attenuation factor	Domenico model w/ biodeg.

Delaware Soil Submergence Model Parameters		Value	(Units)
θ_N	Residual NAPL content in submerged soils	NA	(-)
f	Water table fluctuation cycles per year	NA	(1/yr)
t_{hu}	Duration of high water table condition	NA	(d)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	NA			(ft)
h_v	Vadose zone thickness	NA			(ft)
ρ_s	Soil bulk density	1.78			(g/cm^3)
f_{oc}	Fraction organic carbon	0.01			(-)
θ_T	Soil total porosity	0.38			(-)
		capillary	vadose	foundation	
θ_w	Volumetric water content	0.342	0.12	0.12	(-)
θ_a	Volumetric air content	0.038	0.26	0.26	(-)
K_{vs}	Vertical hydraulic conductivity	10353.54331			(ft/yr)
k_v	Vapor permeability	1.07639E-11			(ft^2)
L_{gw}	Depth to groundwater	9.842519685			(ft)
pH	Soil/groundwater pH	6.8			(-)
W	Length of source-zone area parallel to wind	NA			(ft)
W_{gw}	Length of source-zone area parallel to GW flow	49.21259843			(ft)
L_{ss}	Thickness of affected surface soils	NA			(ft)
A	Source zone area	NA			(ft^2)
L_s	Depth to top of affected soils	NA			(ft)
L_{base}	Depth to base of affected soils	NA			(ft)
L_{subs}	Thickness of affected soils	NA			(ft)

Outdoor Air Parameters		Value	(Units)
U_{air}	Ambient air velocity in mixing zone	NA	(ft/s)
δ_{air}	Air mixing zone height	NA	(ft)
Q/C	Inverse mean concentration at the center of source	NA	
P_a	Areal particulate emission rate	NA	(g/cm^2/s)
V	Fraction of vegetative cover	NA	
U_m	Mean annual airvelocity at 7m	NA	
U_t	Equivalent 7m air velocity threshold value	NA	
F(x)	Windspeed function dependant on Um/Ut	NA	
PEF	Particulate Emission Factor	NA	

Building Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	NA	(ft)
A_b	Foundation area	NA	NA	(ft^2)
X_{crk}	Foundation perimeter	NA	NA	(ft)
ER	Building air exchange rate	NA	NA	(1/s)
L_{crk}	Foundation thickness	NA	NA	(ft)
Z_{crk}	Depth to bottom of foundation slab	NA	NA	(ft)
η	Foundation crack fraction	NA	NA	(-)
dP	Indoor/outdoor differential pressure	NA	NA	(g/cm/s^2)
Q_s	Convective air flow through slab	NA	NA	(ft^3/s)
θ_{wcrack}	Volumetric water content of cracks	NA	NA	(-)
θ_{acrack}	Volumetric air content of cracks	NA	NA	(-)
BV	Building Volume	NA	NA	(ft^3)
w	Building Width Perpendicular to GW flow	NA	NA	(ft)
L	Building Length Parallel to GW flow	NA	NA	(ft)
v	Saturated Soil Zone Porosity	NA	NA	(-)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	6.56167979	(ft)
I_f	Net groundwater infiltration rate	35	(cm/yr)
U_{gw}	Groundwater Darcy velocity	30	(ft/yr)
V_{gw}	Groundwater seepage velocity	78.94736842	(ft/yr)
K_s	Saturated hydraulic conductivity	3000	(ft/yr)
i	Groundwater gradient	0.01	(-)
S_w	Width of groundwater source zone	49.21259843	(ft)
S_d	Depth of groundwater source zone	6.56167979	(ft)
θ_{eff}	Effective porosity in water-bearing unit	0.38	(-)
$f_{oc\text{-}sat}$	Fraction organic carbon in water-bearing unit	0.001	(-)
pH_{sat}	Groundwater pH	6.2	(-)
	Biodegradation considered?	1st Order	

Transport Parameters		Off-site 1	Off-site 2	Off-site 1	Off-site 2	(Units)
Lateral Groundwater Transport		Groundwater Ingestion		Groundwater to Indoor Air		
α_x	Longitudinal dispersivity	5.1E+0	1.0E+1	NA	NA	(ft)
α_y	Transverse dispersivity	1.7E+0	3.3E+0	NA	NA	(ft)
α_z	Vertical dispersivity	2.6E-1	5.1E-1	NA	NA	(ft)
Lateral Outdoor Air Transport		Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
α_y	Transverse dispersion coefficient	NA	NA	NA	NA	(ft)
α_z	Vertical dispersion coefficient	NA	NA	NA	NA	(ft)
ADF	Air dispersion factor	NA	NA	NA	NA	(-)

Surface Water Parameters		Off-site 2	(Units)
Q_{sw}	Surface water flowrate	NA	(ft^3/s)
W_{pi}	Width of GW plume at SW discharge	NA	(ft)
δ_{pi}	Thickness of GW plume at SW discharge	NA	(ft)
DF_{sw}	Groundwater-to-surface water dilution factor	NA	(-)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Job ID:

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-5
Target Hazard Quotient 1.0E+0

Groundwater DAF Option: Domenico - First Order (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways (Checked if Pathway is Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	■ Groundwater Ingestion			□ Groundwater Volatilization to Indoor Air			□ Groundwater Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/L)	On-site (0 ft)	Off-site 1 (51 ft)	Off-site 2 (101 ft)	On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)	On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)			Only if "yes" left
			Residential	MCL	MCL	None	None	None	None	None	None	(mg/L)	"■" if yes	
91-20-3	Naphthalene *		2.0E-3	1.2E-1	3.6E+0							2.0E-3	☐	NA

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent solubility value. NA = Not applicable. NC = Not calculated.

RBCA SITE ASSESSMENT

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Job ID:

1 OF 1

SUBSURFACE SOIL (2 - 9.8 ft)
SSTL VALUES

Target Risk (Class A & B) 1.0E-5
Target Hazard Quotient 1.0E+0

Groundwater DAF Option: Domenico - First Order (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways (Checked if Pathway is Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	■ Soil Leaching to Groundwater Ingestion			□ Soil Leaching to Groundwater/ Groundwater Volatilization to Indoor Air			□ Soil Vol. to Indoor Air	□ Soil Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/kg)	On-site (0 ft)	Off-site 1 (51 ft)	Off-site 2 (101 ft)	On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)	On-site (0 ft)	On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)			Only if "yes" left
			Residential	MCL	MCL	None	None	None	None	None	None	None	(mg/kg)	"■" if yes	
91-20-3	Naphthalene *		1.4E-1	8.2E+0	2.5E+2								1.4E-1	☐	

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent residual saturation value. NA = Not applicable. NC = Not calculated.

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Exposure Parameters		Residential				Commercial/Industrial		User Defined
		Child*	Adolescent	Adult	Age Adjusted**	Adult	Construct.	
ATc	Averaging time for carcinogens (yr)	70	70	70	NA	70	70	-
ATn	Averaging time for non-carcinogens (yr)	6	12	30	NA	25	1	-
BW	Body weight (kg)	15	35	80	NA	70	70	-
ED	Exposure duration (yr)	6	0.0001	26	NA	25	1	-
τ	Averaging time for vapor flux (yr)	30	30	30	NA	30	30	-
EF	Exposure frequency (days/yr)	350	350	350	NA	250	180	-
EFD	Exposure frequency for dermal exposure	350	350	350	NA	250	180	-
IRw	Ingestion rate of water (L/day)	0.78	0.78	2.5	2.9	1	NA	-
IRs	Ingestion rate of soil (mg/day)	200	200	100	323	50	100	-
SA	Skin surface area (dermal) (cm^2)	2023	2023	5800	NA	5800	5800	-
M	Soil to skin adherence factor	0.5	0.5	0.5	NA	0.5	0.5	-
ETswim	Swimming exposure time (hr/event)	1	3	3	NA	NA	NA	NA
EVswim	Swimming event frequency (events/yr)	12	12	12	NA	NA	NA	NA
IRswim	Water ingestion while swimming (L/hr)	0.5	0.5	0.05	NA	NA	NA	NA
SAswim	Skin surface area for swimming (cm^2)	3500	8100	23000	NA	NA	NA	NA
IRfish	Ingestion rate of fish (kg/yr)	0.025	0.025	0.025	0.050	NA	NA	NA
FIfish	Contaminated fish fraction (unitless)	1	1	1	NA	NA	NA	NA
IRbg	Below-ground vegetable ingestion	0.002	0.002	0.006	2.477	NA	NA	NA
IRabg	Above-ground vegetable ingestion	0.001	0.001	0.002	0.969	NA	NA	NA
VGbg	Above-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA
VGabg	Below-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA

* = Child Receptor used for Non-Carcinogens
** = NS= Age Adjustment not selected for this parameter. Age-adjusted rate is effective value corresponding to adult exposure factors.

Complete Exposure Pathways and Receptors	On-site	Off-site 1	Off-site 2
Groundwater:			
Groundwater Ingestion	Residential	MCL	MCL
Soil Leaching to Groundwater Ingestion	Residential	MCL	MCL
Apply MCL Values	Yes	Yes	Yes
Applicable Surface Water Exposure Routes:			
Swimming	NA	NA	None
Fish Consumption	NA	NA	None
Aquatic Life Protection	NA	NA	None
Soil:			
Direct Contact: direct combined pathways	None	NA	NA
Apply CLEA- UK SGV levels		No	
Outdoor Air:			
Particulates from Surface Soils	None	None	None
Volatilization from Soils	None	None	None
Volatilization from Groundwater	None	None	None
Indoor Air:			
Volatilization from Soils	None	NA	NA
Volatilization from Groundwater	None	None	None
Soil Leaching to Groundwater Volatilization	None	None	None

Receptor Distance from Source Media	On-site	Off-site 1	Off-site 2	(Units)
Groundwater receptor	0	201	301	(ft)
Outdoor air inhalation receptor	NA	NA	NA	(ft)
Indoor air inhalation receptor	NA	NA	NA	(ft)

Target Health Risk Values		Individual	Cumulative
TR	Target Risk (carcinogens)	1.0E-5	1.0E-5
THQ	Target Hazard Quotient (non-carcinogenic risk)	1.0E+0	1.0E+0

Modeling Options	
RBCA tier	Tier 2
Outdoor air volatilization model	NA
Indoor air volatilization model	NA
Soil leaching model	ASTM leaching model
Use soil attenuation model (SAM) for leachate?	No
Use dual equilibrium desorption model?	No
Apply Mass Balance Limit for Soil Volatilization?	No
Apply UK (CLEA) SGV as soil concentration limit	No
Vegetable calculation options	NA
Air dilution factor	NA
Groundwater dilution-attenuation factor	Domenico model w/ biodeg.

Delaware Soil Submergence Model Parameters		Value	(Units)
θ_N	Residual NAPL content in submerged soils	NA	(-)
f	Water table fluctuation cycles per year	NA	(1/yr)
t_{hU}	Duration of high water table condition	NA	(d)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	NA			(ft)
h_v	Vadose zone thickness	NA			(ft)
ρ_s	Soil bulk density	1.78			(g/cm^3)
f_{oc}	Fraction organic carbon	0.01			(-)
θ_T	Soil total porosity	0.38			(-)
		capillary	vadose	foundation	
θ_w	Volumetric water content	0.342	0.12	0.12	(-)
θ_a	Volumetric air content	0.038	0.26	0.26	(-)
K_{vs}	Vertical hydraulic conductivity	10353.54331			(ft/yr)
k_v	Vapor permeability	1.07639E-11			(ft^2)
L_{gw}	Depth to groundwater	9.842519685			(ft)
pH	Soil/groundwater pH	6.8			(-)
W	Length of source-zone area parallel to wind	NA			(ft)
W_{gw}	Length of source-zone area parallel to GW flow	49.21259843			(ft)
L_{ss}	Thickness of affected surface soils	NA			(ft)
A	Source zone area	NA			(ft^2)
L_s	Depth to top of affected soils	NA			(ft)
L_{base}	Depth to base of affected soils	NA			(ft)
L_{subs}	Thickness of affected soils	NA			(ft)

Outdoor Air Parameters		Value	(Units)
U_{air}	Ambient air velocity in mixing zone	NA	(ft/s)
δ_{air}	Air mixing zone height	NA	(ft)
Q/C	Inverse mean concentration at the center of source	NA	
P_a	Areal particulate emission rate	NA	(g/cm^2/s)
V	Fraction of vegetative cover	NA	
U_m	Mean annual airvelocity at 7m	NA	
U_t	Equivalent 7m air velocity threshold value	NA	
F(x)	Windspeed function dependant on Um/Ut	NA	
PEF	Particulate Emission Factor	NA	

Building Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	NA	(ft)
A_b	Foundation area	NA	NA	(ft^2)
X_{crk}	Foundation perimeter	NA	NA	(ft)
ER	Building air exchange rate	NA	NA	(1/s)
L_{crk}	Foundation thickness	NA	NA	(ft)
Z_{crk}	Depth to bottom of foundation slab	NA	NA	(ft)
η	Foundation crack fraction	NA	NA	(-)
dP	Indoor/outdoor differential pressure	NA	NA	(g/cm/s^2)
Q_s	Convective air flow through slab	NA	NA	(ft^3/s)
θ_{wcrack}	Volumetric water content of cracks	NA	NA	(-)
θ_{acrack}	Volumetric air content of cracks	NA	NA	(-)
BV	Building Volume	NA	NA	(ft^3)
w	Building Width Perpendicular to GW flow	NA	NA	(ft)
L	Building Length Parallel to GW flow	NA	NA	(ft)
v	Saturated Soil Zone Porosity	NA	NA	(-)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	6.56167979	(ft)
I_f	Net groundwater infiltration rate	35	(cm/yr)
U_{gw}	Groundwater Darcy velocity	30	(ft/yr)
V_{gw}	Groundwater seepage velocity	78.94736842	(ft/yr)
K_s	Saturated hydraulic conductivity	3000	(ft/yr)
i	Groundwater gradient	0.01	(-)
S_w	Width of groundwater source zone	49.21259843	(ft)
S_d	Depth of groundwater source zone	6.56167979	(ft)
θ_{eff}	Effective porosity in water-bearing unit	0.38	(-)
$f_{oc\text{-}sat}$	Fraction organic carbon in water-bearing unit	0.001	(-)
pH_{sat}	Groundwater pH	6.2	(-)
	Biodegradation considered?	1st Order	

Transport Parameters		Off-site 1	Off-site 2	Off-site 1	Off-site 2	(Units)
Lateral Groundwater Transport		Groundwater Ingestion		Groundwater to Indoor Air		
α_x	Longitudinal dispersivity	2.0E+1	3.0E+1	NA	NA	(ft)
α_y	Transverse dispersivity	6.6E+0	9.9E+0	NA	NA	(ft)
α_z	Vertical dispersivity	1.0E+0	1.5E+0	NA	NA	(ft)
Lateral Outdoor Air Transport		Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
σ_y	Transverse dispersion coefficient	NA	NA	NA	NA	(ft)
σ_z	Vertical dispersion coefficient	NA	NA	NA	NA	(ft)
ADF	Air dispersion factor	NA	NA	NA	NA	(-)

Surface Water Parameters		Off-site 2	(Units)
Q_{sw}	Surface water flowrate	NA	(ft^3/s)
W_{pl}	Width of GW plume at SW discharge	NA	(ft)
δ_{pl}	Thickness of GW plume at SW discharge	NA	(ft)
DF_{sw}	Groundwater-to-surface water dilution factor	NA	(-)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Job ID:

1 OF 1

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-5
Target Hazard Quotient 1.0E+0

Groundwater DAF Option: Domenico - First Order (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways (Checked if Pathway is Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	■ Groundwater Ingestion			□ Groundwater Volatilization to Indoor Air			□ Groundwater Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/L)	On-site (0 ft)	Off-site 1 (201 ft)	Off-site 2 (301 ft)	On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)	On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)			Only if "yes" left
			Residential	MCL	MCL	None	None	None	None	None	None	(mg/L)	"■" if yes	
91-20-3	Naphthalene *		2.0E-3	>3.1E+1	>3.1E+1							2.0E-3	☐	NA

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent solubility value. NA = Not applicable. NC = Not calculated.

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Exposure Parameters		Residential				Commercial/Industrial		User Defined
		Child*	Adolescent	Adult	Age Adjusted**	Adult	Construct.	
ATc	Averaging time for carcinogens (yr)	70	70	70	NA	70	70	-
ATn	Averaging time for non-carcinogens (yr)	6	12	30	NA	25	1	-
BW	Body weight (kg)	15	35	80	NA	70	70	-
ED	Exposure duration (yr)	6	0.0001	26	NA	25	1	-
τ	Averaging time for vapor flux (yr)	30	30	30	NA	30	30	-
EF	Exposure frequency (days/yr)	350	350	350	NA	250	180	-
EFD	Exposure frequency for dermal exposure	350	350	350	NA	250	180	-
IRw	Ingestion rate of water (L/day)	0.78	0.78	2.5	2.9	1	NA	-
IRs	Ingestion rate of soil (mg/day)	200	200	100	323	50	100	-
SA	Skin surface area (dermal) (cm^2)	2023	2023	5800	NA	5800	5800	-
M	Soil to skin adherence factor	0.5	0.5	0.5	NA	0.5	0.5	-
ETswim	Swimming exposure time (hr/event)	1	3	3	NA	NA	NA	NA
EVswim	Swimming event frequency (events/yr)	12	12	12	NA	NA	NA	NA
IRswim	Water ingestion while swimming (L/hr)	0.5	0.5	0.05	NA	NA	NA	NA
SAswim	Skin surface area for swimming (cm^2)	3500	8100	23000	NA	NA	NA	NA
IRfish	Ingestion rate of fish (kg/yr)	0.025	0.025	0.025	0.050	NA	NA	NA
FIfish	Contaminated fish fraction (unitless)	1	1	1	NA	NA	NA	NA
IRbg	Below-ground vegetable ingestion	0.002	0.002	0.006	2.477	NA	NA	NA
IRabg	Above-ground vegetable ingestion	0.001	0.001	0.002	0.969	NA	NA	NA
VGbg	Above-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA
VGabg	Below-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA

* = Child Receptor used for Non-Carcinogens
** = NS= Age Adjustment not selected for this parameter. Age-adjusted rate is effective value corresponding to adult exposure factors.

Complete Exposure Pathways and Receptors	On-site	Off-site 1	Off-site 2
Groundwater:			
Groundwater Ingestion	Residential	MCL	MCL
Soil Leaching to Groundwater Ingestion	Residential	MCL	MCL
Apply MCL Values	Yes	Yes	Yes
Applicable Surface Water Exposure Routes:			
Swimming	NA	NA	None
Fish Consumption	NA	NA	None
Aquatic Life Protection	NA	NA	None
Soil:			
Direct Contact: direct combined pathways	None	NA	NA
Apply CLEA- UK SGV levels		No	
Outdoor Air:			
Particulates from Surface Soils	None	None	None
Volatilization from Soils	None	None	None
Volatilization from Groundwater	None	None	None
Indoor Air:			
Volatilization from Soils	None	NA	NA
Volatilization from Groundwater	None	None	None
Soil Leaching to Groundwater Volatilization	None	None	None

Receptor Distance from Source Media	On-site	Off-site 1	Off-site 2	(Units)
Groundwater receptor	0	401	501	(ft)
Outdoor air inhalation receptor	NA	NA	NA	(ft)
Indoor air inhalation receptor	NA	NA	NA	(ft)

Target Health Risk Values		Individual	Cumulative
TR	Target Risk (carcinogens)	1.0E-5	1.0E-5
THQ	Target Hazard Quotient (non-carcinogenic risk)	1.0E+0	1.0E+0

Modeling Options	
RBCA tier	Tier 2
Outdoor air volatilization model	NA
Indoor air volatilization model	NA
Soil leaching model	ASTM leaching model
Use soil attenuation model (SAM) for leachate?	No
Use dual equilibrium desorption model?	No
Apply Mass Balance Limit for Soil Volatilization?	No
Apply UK (CLEA) SGV as soil concentration limit	No
Vegetable calculation options	NA
Air dilution factor	NA
Groundwater dilution-attenuation factor	Domenico model w/ biodeg.

Delaware Soil Submergence Model Parameters		Value	(Units)
θ_N	Residual NAPL content in submerged soils	NA	(-)
f	Water table fluctuation cycles per year	NA	(1/yr)
t_{hU}	Duration of high water table condition	NA	(d)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	NA			(ft)
h_v	Vadose zone thickness	NA			(ft)
ρ_s	Soil bulk density	1.78			(g/cm^3)
f_{oc}	Fraction organic carbon	0.01			(-)
θ_T	Soil total porosity	0.38			(-)
		capillary	vadose	foundation	
θ_w	Volumetric water content	0.342	0.12	0.12	(-)
θ_a	Volumetric air content	0.038	0.26	0.26	(-)
K_{vs}	Vertical hydraulic conductivity	10353.54331			(ft/yr)
k_v	Vapor permeability	1.07639E-11			(ft^2)
L_{gw}	Depth to groundwater	9.842519685			(ft)
pH	Soil/groundwater pH	6.8			(-)
W	Length of source-zone area parallel to wind	NA			(ft)
W_{gw}	Length of source-zone area parallel to GW flow	49.21259843			(ft)
L_{ss}	Thickness of affected surface soils	NA			(ft)
A	Source zone area	NA			(ft^2)
L_s	Depth to top of affected soils	NA			(ft)
L_{base}	Depth to base of affected soils	NA			(ft)
L_{subs}	Thickness of affected soils	NA			(ft)

Outdoor Air Parameters		Value	(Units)
U_{air}	Ambient air velocity in mixing zone	NA	(ft/s)
δ_{air}	Air mixing zone height	NA	(ft)
Q/C	Inverse mean concentration at the center of source	NA	
P_a	Areal particulate emission rate	NA	(g/cm^2/s)
V	Fraction of vegetative cover	NA	
U_m	Mean annual airvelocity at 7m	NA	
U_t	Equivalent 7m air velocity threshold value	NA	
F(x)	Windspeed function dependant on Um/Ut	NA	
PEF	Partculate Emission Factor	NA	

Building Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	NA	(ft)
A_b	Foundation area	NA	NA	(ft^2)
X_{crk}	Foundation perimeter	NA	NA	(ft)
ER	Building air exchange rate	NA	NA	(1/s)
L_{crk}	Foundation thickness	NA	NA	(ft)
Z_{crk}	Depth to bottom of foundation slab	NA	NA	(ft)
η	Foundation crack fraction	NA	NA	(-)
dP	Indoor/outdoor differential pressure	NA	NA	(g/cm/s^2)
Q_s	Convective air flow through slab	NA	NA	(ft^3/s)
θ_{wcrack}	Volumetric water content of cracks	NA	NA	(-)
θ_{acrack}	Volumetric air content of cracks	NA	NA	(-)
BV	Building Volume	NA	NA	(ft^3)
w	Building Width Perpendicular to GW flow	NA	NA	(ft)
L	Building Length Parallel to GW flow	NA	NA	(ft)
v	Saturated Soil Zone Porosity	NA	NA	(-)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	6.56167979	(ft)
I_f	Net groundwater infiltration rate	35	(cm/yr)
U_{gw}	Groundwater Darcy velocity	30	(ft/yr)
V_{gw}	Groundwater seepage velocity	78.94736842	(ft/yr)
K_s	Saturated hydraulic conductivity	3000	(ft/yr)
i	Groundwater gradient	0.01	(-)
S_w	Width of groundwater source zone	49.21259843	(ft)
S_t	Depth of groundwater source zone	6.56167979	(ft)
θ_{eff}	Effective porosity in water-bearing unit	0.38	(-)
$f_{oc\text{-}sat}$	Fraction organic carbon in water-bearing unit	0.001	(-)
pH_{sat}	Groundwater pH	6.2	(-)
	Biodegradation considered?	1st Order	

Transport Parameters		Off-site 1	Off-site 2	Off-site 1	Off-site 2	(Units)
Lateral Groundwater Transport		Groundwater Ingestion		Groundwater to Indoor Air		
α_x	Longitudinal dispersivity	4.0E+1	5.0E+1	NA	NA	(ft)
α_y	Transverse dispersivity	1.3E+1	1.7E+1	NA	NA	(ft)
α_z	Vertical dispersivity	2.0E+0	2.5E+0	NA	NA	(ft)
Lateral Outdoor Air Transport		Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
σ_y	Transverse dispersion coefficient	NA	NA	NA	NA	(ft)
σ_z	Vertical dispersion coefficient	NA	NA	NA	NA	(ft)
ADF	Air dispersion factor	NA	NA	NA	NA	(-)

Surface Water Parameters		Off-site 2	(Units)
Q_{sw}	Surface water flowrate	NA	(ft^3/s)
W_{pl}	Width of GW plume at SW discharge	NA	(ft)
δ_{pl}	Thickness of GW plume at SW discharge	NA	(ft)
DF_{sw}	Groundwater-to-surface water dilution factor	NA	(-)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT

Site Name: 2018 DERBCAP
Site Location: Delaware

Completed By: PRB
Date Completed: 13-Dec-18

Job ID:

1 OF 1

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-5
Target Hazard Quotient 1.0E+0

Groundwater DAF Option: Domenico - First Order (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways (Checked if Pathway is Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	■ Groundwater Ingestion			☐ Groundwater Volatilization to Indoor Air			☐ Groundwater Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/L)	On-site (0 ft) Residential	Off-site 1 (401 ft) MCL	Off-site 2 (501 ft) MCL	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	(mg/L)	"■" if yes	Only if "yes" left
91-20-3	Naphthalene *		2.0E-3	>3.1E+1	>3.1E+1							2.0E-3	☐	NA

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent solubility value. NA = Not applicable. NC = Not calculated.

CHEMICAL DATA FOR SELECTED COCs

Physical Property Data

Orange = One or more parameter differs from User Chemical Database Constituent	CAS Number	Type	Molecular Weight (g/mole)		Aqueous Solubility (@ 20 - 25 C) (mg/L)		Soil Saturation Limit Calculated (mg/kg)	Vapor Pressure (@ 20 - 25 C) (mm Hg)		Henry's Constant (@ 20 - 25 C) (unitless)		log (Koc) or log (Kd) (@ 20 - 25 C) log(L/kg)		
Naphthalene	91-20-3	O	128.17352	TX09	31.4	TX09	4.89E+02	8.89E-02	TX09	2.00E-02	TX09	3.19E+00	Koc	TX09

Site Name: 2018 DERBCAP
Site Location: Delaware
Job ID:
Date Completed: 13-Dec-18
Completed By: PRB

CHEMICAL DATA FOR SELECTED COCs

Physical Property Data

Orange = One or more parameter differs from User Chemical Database	pH specific Kd for non-organics							log(Kow)		Diffusion Coefficients			
	Surface Soil Column			Water Bearing Unit									
Constituent	Slope	y-Intercept	logKd_pH (L/kg)	Slope	y-Intercept	logKd_pH (L/kg)		(@ 20 - 25 C) log(L/kg)		Air (cm^2/s)		Water (cm^2/s)	
Naphthalene	-	-	-	-	-	-	-	3.17E+00	TX09	5.90E-02	TX09	7.50E-06	TX09

Site Name: 2018 DERBCAP
Site Location: Delaware
Job ID:
Date Completed: 13-Dec-18
Completed By: PRB

CHEMICAL DATA FOR SELECTED COCs

Miscellaneous Parameters

Orange = One or more parameter differs from User Chemical Database	Analytical Detection Limits				Half Life (First-Order Decay)			Soil-to-Plant Biotransfer Factors			Relative Bioavailability Factor		Leaf Concen. Factor Calculated	Root Concen. Factor Calculated	Bioconcentration Factor	
Constituent	Groundwater (mg/L)		Soil (mg/kg)		Saturated (days)	Unsaturated (days)		Above-grd (unitless)	Below-grd (unitless)				(mg/kg)/(mg/L)	(mg/kg)/(mg/L)		
Naphthalene	1.00E-02	S2	1.00E-02	S2	2.58E+02	2.58E+02	H	-	-	-	1.00E+00	TX09	3.54E+00	9.14E+00	430	LY

Site Name: 2018 DERBCAP
Site Location: Delaware
Job ID:
Date Completed: 13-Dec-18
Completed By: PRB

CHEMICAL DATA FOR SELECTED COCs

Dermal Exposure

Orange = One or more parameter differs from User Chemical Database	Water Dermal Permeability Data					
Constituent	Dermal Permeability Coeff. (cm/hr)	Lag time for Dermal Exposure (hr)	Critical Exposure Time (hr)	Relative Contr of Derm Perm Coeff	Water/Skin Derm Ads. Fact Calculated	
Naphthalene	0.069	0.53	2.2	0.2	0.27002	D

Site Name: 2018 DERBCAP
Site Location: Delaware
Job ID:
Date Completed: 13-Dec-18
Completed By: PRB

CHEMICAL DATA FOR SELECTED COCs

Orange = One or more parameter differs from User Chemical Database	Dermal Relative Abs. Factor	Absorbtion Fraction		
Constituent	Calculated	Dermal (unitless)	Gastrointestinal (unitless)	
Naphthalene	0.146067416	0.13	0.89	TX09

Site Name: 2018 DERBCAP
Site Location: Delaware
Job ID:
Date Completed: 13-Dec-18
Completed By: PRB

CHEMICAL DATA FOR SELECTED COCs

Regulatory Standards

Orange = One or more parameter differs from User Chemical Database	Maximun Contaminant Level		Time-Weighted Average Workplace Criteria (mg/m^3)		UK Soil Guideline Values				
Constituent	(mg/L)				Residential/Plant mg/kg	Residential/No Plant mg/kg	Allotments mg/kg	Commercial/Ind. mg/kg	
Naphthalene	*0.002*	*Adjust*	50	OS	-	-	-	-	-

Site Name: 2018 DERBCAP
Site Location: Delaware
Job ID:
Date Completed: 13-Dec-18
Completed By: PRB

CHEMICAL DATA FOR SELECTED COCs

Regulatory Standards

Orange = One or more parameter differs from User Chemical Database	Surface Water Quality Criteria									
	Aquatic Life Protection				Human Health Protection					
	Freshwater (mg/L)		Marine (mg/L)		Drink & Freshwater Fish (mg/L)		Freshwater Fish (mg/L)		Saltwater Fish (mg/L)	
Constituent										
Naphthalene	-	-	-	-	-	-	-	-	-	-

Site Name: 2018 DERBCAP
Site Location: Delaware
Job ID:
Date Completed: 13-Dec-18
Completed By: PRB

CHEMICAL DATA FOR SELECTED COCs

Toxicity Parameters

Orange = One or more parameter differs from User Chemical Database Constituent	Oral RfD or TDSI (mg/kg/day)		Dermal RfD or TDSI (mg/kg/day)		Inhalation Equivalent RfC or TCA (mg/m^3)		Oral Equivalent Slope Factor 1/(mg/kg/day)		Dermal Equivalent Slope Factor 1/(mg/kg/day)		Inhalation Equivalent Unit Risk Factor $1/(\mu g/m^3)$	
Naphthalene	0.02	EPA-I	0.02	D2	0.003	EPA-I	-	-	-	-	-	-

Site Name: 2018 DERBCAP
Site Location: Delaware
Job ID:
Date Completed: 13-Dec-18
Completed By: PRB

Exposure Pathway Calculation Sheets (Continued)

- 1, 3, 5-TMB

RBCA SITE ASSESSMENT

Input Parameter Summary

Site Name: DERBCAP-2019-1,3,5-TMB
Site Location:

Completed By: Patrick Boettcher
Date Completed: 8-Jan-19

Exposure Parameters		Residential				Commercial/Industrial		User Defined
		Child*	Adolescent	Adult	Age Adjusted**	Adult	Construct.	
ATc	Averaging time for carcinogens (yr)	70	70	70	NA	70	70	-
ATn	Averaging time for non-carcinogens (yr)	6	12	30	NA	25	1	-
BW	Body weight (kg)	15	35	80	NA	70	70	-
ED	Exposure duration (yr)	6	0.0001	26	NA	25	1	-
τ	Averaging time for vapor flux (yr)	30	30	30	NA	30	30	-
EF	Exposure frequency (days/yr)	350	350	350	NA	250	180	-
EFD	Exposure frequency for dermal exposure	350	350	350	NA	250	180	-
IRw	Ingestion rate of water (L/day)	0.78	0.78	2.8	2.9	1	NA	-
IRs	Ingestion rate of soil (mg/day)	200	200	100	323	50	100	-
SA	Skin surface area (dermal) (cm^2)	2023	2023	5800	NA	5800	5800	-
M	Soil to skin adherence factor	0.5	0.5	0.5	NA	0.5	0.5	-
ETswim	Swimming exposure time (hr/event)	1	3	3	NA	NA	NA	NA
EVswim	Swimming event frequency (events/yr)	12	12	12	NA	NA	NA	NA
IRswim	Water ingestion while swimming (L/hr)	0.5	0.5	0.05	NA	NA	NA	NA
SAswim	Skin surface area for swimming (cm^2)	3500	8100	23000	NA	NA	NA	NA
IRfish	Ingestion rate of fish (kg/yr)	0.025	0.025	0.025	0.050	NA	NA	NA
FIfish	Contaminated fish fraction (unitless)	1	1	1	NA	NA	NA	NA
IRbg	Below-ground vegetable ingestion	0.002	0.002	0.006	2.477	NA	NA	NA
IRabg	Above-ground vegetable ingestion	0.001	0.001	0.002	0.969	NA	NA	NA
VGbg	Above-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA
VGabg	Below-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA

* = Child Receptor used for Non-Carcinogens
** = NS= Age Adjustment not selected for this parameter. Age-adjusted rate is effective value corresponding to adult exposure factors.

Complete Exposure Pathways and Receptors	On-site	Off-site 1	Off-site 2
Groundwater:			
Groundwater Ingestion	Residential	Residential	Residential
Soil Leaching to Groundwater Ingestion	Residential	Residential	Residential
Apply MCL Values	No	No	No
Applicable Surface Water Exposure Routes:			
Swimming	NA	NA	None
Fish Consumption	NA	NA	None
Aquatic Life Protection	NA	NA	None
Soil:			
Direct Contact: direct combined pathways	None	NA	NA
Apply CLEA- UK SGV levels		No	
Outdoor Air:			
Particulates from Surface Soils	None	None	None
Volatilization from Soils	None	None	None
Volatilization from Groundwater	None	None	None
Indoor Air:			
Volatilization from Soils	None	NA	NA
Volatilization from Groundwater	None	None	None
Soil Leaching to Groundwater Volatilization	None	None	None

Receptor Distance from Source Media	On-site	Off-site 1	Off-site 2	(Units)
Groundwater receptor	0	51	101	(ft)
Outdoor air inhalation receptor	NA	NA	NA	(ft)
Indoor air inhalation receptor	NA	NA	NA	(ft)

Target Health Risk Values		Individual	Cumulative
TR	Target Risk (carcinogens)	1.0E-5	1.0E-5
THQ	Target Hazard Quotient (non-carcinogenic risk)	1.0E+0	1.0E+0

Modeling Options	
RBCA tier	Tier 2
Outdoor air volatilization model	NA
Indoor air volatilization model	NA
Soil leaching model	ASTM leaching model
Use soil attenuation model (SAM) for leachate?	No
Use dual equilibrium desorption model?	No
Apply Mass Balance Limit for Soil Volatilization?	No
Apply UK (CLEA) SGV as soil concentration limit	No
Vegetable calculation options	NA
Air dilution factor	NA
Groundwater dilution-attenuation factor	Domenico model

Delaware Soil Submergence Model Parameters		Value	(Units)
θ_N	Residual NAPL content in submerged soils	NA	(-)
f	Water table fluctuation cycles per year	NA	(1/yr)
t_{HU}	Duration of high water table condition	NA	(d)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: DERBCAP-2019-1,3,5-TMB
Site Location:

Completed By: Patrick Boettcher
Date Completed: 8-Jan-19

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	NA			(ft)
h_v	Vadose zone thickness	NA			(ft)
ρ_s	Soil bulk density	1.78			(g/cm^3)
f_{oc}	Fraction organic carbon	0.01			(-)
θ_T	Soil total porosity	0.38			(-)
		capillary	vadose	foundation	
θ_w	Volumetric water content	0.342	0.12	0.12	(-)
θ_a	Volumetric air content	0.038	0.26	0.26	(-)
K_{vs}	Vertical hydraulic conductivity	10353.54331			(ft/yr)
k_v	Vapor permeability	1.07639E-11			(ft^2)
L_{gw}	Depth to groundwater	9.842519685			(ft)
pH	Soil/groundwater pH	6.8			(-)
W	Length of source-zone area parallel to wind	NA			(ft)
W_{gw}	Length of source-zone area parallel to GW flow	49.21259843			(ft)
L_{ss}	Thickness of affected surface soils	NA			(ft)
A	Source zone area	NA			(ft^2)
L_s	Depth to top of affected soils	NA			(ft)
L_{base}	Depth to base of affected soils	NA			(ft)
L_{subs}	Thickness of affected soils	NA			(ft)

Outdoor Air Parameters		Value	(Units)
U_{air}	Ambient air velocity in mixing zone	NA	(ft/s)
δ_{air}	Air mixing zone height	NA	(ft)
Q/C	Inverse mean concentration at the center of source	NA	
P_a	Areal particulate emission rate	NA	(g/cm^2/s)
V	Fraction of vegetative cover	NA	
U_m	Mean annual airvelocity at 7m	NA	
U_t	Equivalent 7m air velocity threshold value	NA	
F(x)	Windspeed function dependant on Um/Ut	NA	
PEF	Partculate Emission Factor	NA	

Building Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	NA	(ft)
A_b	Foundation area	NA	NA	(ft^2)
X_{crk}	Foundation perimeter	NA	NA	(ft)
ER	Building air exchange rate	NA	NA	(1/s)
L_{crk}	Foundation thickness	NA	NA	(ft)
Z_{crk}	Depth to bottom of foundation slab	NA	NA	(ft)
η	Foundation crack fraction	NA	NA	(-)
dP	Indoor/outdoor differential pressure	NA	NA	(g/cm/s^2)
Q_s	Convective air flow through slab	NA	NA	(ft^3/s)
θ_{wcrack}	Volumetric water content of cracks	NA	NA	(-)
θ_{acrack}	Volumetric air content of cracks	NA	NA	(-)
BV	Building Volume	NA	NA	(ft^3)
w	Building Width Perpendicular to GW flow	NA	NA	(ft)
L	Building Length Parallel to GW flow	NA	NA	(ft)
v	Saturated Soil Zone Porosity	NA	NA	(-)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	6.56167979	(ft)
I_f	Net groundwater infiltration rate	35	(cm/yr)
U_{gw}	Groundwater Darcy velocity	30	(ft/yr)
V_{gw}	Groundwater seepage velocity	78.94736842	(ft/yr)
K_s	Saturated hydraulic conductivity	3000	(ft/yr)
i	Groundwater gradient	0.01	(-)
S_w	Width of groundwater source zone	49.21259843	(ft)
S_d	Depth of groundwater source zone	6.56167979	(ft)
[illegible]	[illegible]	[illegible]	[illegible]
f_{oc-sat}	Fraction organic carbon in water-bearing unit	0.001	(-)
pH_{sat}	Groundwater pH	6.2	(-)
	Biodegradation considered?	No	

Transport Parameters		Off-site 1	Off-site 2	Off-site 1	Off-site 2	(Units)
Lateral Groundwater Transport		Groundwater Ingestion		Groundwater to Indoor Air		
α_x	Longitudinal dispersivity	5.1E+0	1.0E+1	NA	NA	(ft)
α_y	Transverse dispersivity	1.7E+0	3.3E+0	NA	NA	(ft)
α_z	Vertical dispersivity	2.6E-1	5.1E-1	NA	NA	(ft)
Lateral Outdoor Air Transport		Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
σ_y	Transverse dispersion coefficient	NA	NA	NA	NA	(ft)
σ_z	Vertical dispersion coefficient	NA	NA	NA	NA	(ft)
ADF	Air dispersion factor	NA	NA	NA	NA	(-)

Surface Water Parameters		Off-site 2	(Units)
Q_{sw}	Surface water flowrate	NA	(ft^3/s)
W_{pl}	Width of GW plume at SW discharge	NA	(ft)
δ_{pl}	Thickness of GW plume at SW discharge	NA	(ft)
DF_{sw}	Groundwater-to-surface water dilution factor	NA	(-)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT

Site Name: DERBCAP-2019-1,3,5-TMB
Site Location:

Completed By: Patrick Boetticher
Date Completed: 8-Jan-19

Job ID:

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-5
Target Hazard Quotient 1.0E+0

Groundwater DAF Option: Domenico - No Decay (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways (Checked if Pathway is Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	■ Groundwater Ingestion			☐ Groundwater Volatilization to Indoor Air			☐ Groundwater Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/L)	On-site (0 ft) Residential	Off-site 1 (51 ft) Residential	Off-site 2 (101 ft) Residential	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	(mg/L)	"■" if yes	Only if "yes" left
108-67-8	Trimethylbenzene, 1,3,5-		1.0E+0	1.3E+0	3.2E+0							1.0E+0	☐	NA

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent solubility value. NA = Not applicable. NC = Not calculated.

RBCA SITE ASSESSMENT

Site Name: DERBCAP-2019-1,3,5-TMB
Site Location:
Completed By: Patrick Boettcher
Date Completed: 8-Jan-19
Job ID:

SUBSURFACE SOIL (2 - 9.8 ft)
SSTL VALUES

Target Risk (Class A & B) 1.0E-5
Target Hazard Quotient 1.0E+0
Groundwater DAF Option: Domenico - No Decay (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways (Checked if Pathway is Complete)

			■ Soil Leaching to Groundwater Ingestion			□ Soil Leaching to Groundwater/ Groundwater Volatilization to Indoor Air			□ Soil Vol. to Indoor Air	□ Soil Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
CONSTITUENTS OF CONCERN		Representative Concentration	On-site (0 ft)	Off-site 1 (51 ft)	Off-site 2 (101 ft)	On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)	On-site (0 ft)	On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)			Only if "yes" left
CAS No.	**Name**	(mg/kg)	Residential	Residential	Residential	None	None	None	None	None	None	None	(mg/kg)	"■" if yes	
108-67-8	Trimethylbenzene, 1,3,5-		4.6E+1	6.2E+1	1.5E+2								4.6E+1	☐	

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent residual saturation value. NA = Not applicable. NC = Not calculated.

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: DERBCAP-2019-1,3,5-TMB
Site Location:

Completed By: Patrick Boettcher
Date Completed: 8-Jan-19

Exposure Parameters		Residential				Commercial/Industrial		User Defined
		Child*	Adolescent	Adult	Age Adjusted**	Adult	Construct.	
ATc	Averaging time for carcinogens (yr)	70	70	70	NA	70	70	-
ATn	Averaging time for non-carcinogens (yr)	6	12	30	NA	25	1	-
BW	Body weight (kg)	15	35	80	NA	70	70	-
ED	Exposure duration (yr)	6	0.0001	26	NA	25	1	-
τ	Averaging time for vapor flux (yr)	30	30	30	NA	30	30	-
EF	Exposure frequency (days/yr)	350	350	350	NA	250	180	-
EFD	Exposure frequency for dermal exposure	350	350	350	NA	250	180	-
IRw	Ingestion rate of water (L/day)	0.78	0.78	2.5	2.9	1	NA	-
IRs	Ingestion rate of soil (mg/day)	200	200	100	323	50	100	-
SA	Skin surface area (dermal) (cm^2)	2023	2023	5800	NA	5800	5800	-
M	Soil to skin adherence factor	0.5	0.5	0.5	NA	0.5	0.5	-
ETswim	Swimming exposure time (hr/event)	1	3	3	NA	NA	NA	NA
EVswim	Swimming event frequency (events/yr)	12	12	12	NA	NA	NA	NA
IRswim	Water ingestion while swimming (L/hr)	0.5	0.5	0.05	NA	NA	NA	NA
SAswim	Skin surface area for swimming (cm^2)	3500	8100	23000	NA	NA	NA	NA
IRfish	Ingestion rate of fish (kg/yr)	0.025	0.025	0.025	0.050	NA	NA	NA
Ffish	Contaminated fish fraction (unitless)	1	1	1	NA	NA	NA	NA
IRbg	Below-ground vegetable ingestion	0.002	0.002	0.006	2.477	NA	NA	NA
IRabg	Above-ground vegetable ingestion	0.001	0.001	0.002	0.969	NA	NA	NA
VGbg	Above-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA
VGabg	Below-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA

* = Child Receptor used for Non-Carcinogens

** = NS= Age Adjustment not selected for this parameter. Age-adjusted rate is effective value corresponding to adult exposure factors.

Complete Exposure Pathways and Receptors	On-site	Off-site 1	Off-site 2
Groundwater:			
Groundwater Ingestion	Residential	Residential	Residential
Soil Leaching to Groundwater Ingestion	Residential	Residential	Residential
Apply MCL Values	No	No	No
Applicable Surface Water Exposure Routes:			
Swimming	NA	NA	None
Fish Consumption	NA	NA	None
Aquatic Life Protection	NA	NA	None
Soil:			
Direct Contact: direct combined pathways	None	NA	NA
Apply CLEA- UK SGV levels		No	
Outdoor Air:			
Particulates from Surface Soils	None	None	None
Volatilization from Soils	None	None	None
Volatilization from Groundwater	None	None	None
Indoor Air:			
Volatilization from Soils	None	NA	NA
Volatilization from Groundwater	None	None	None
Soil Leaching to Groundwater Volatilization	None	None	None

Receptor Distance from Source Media	On-site	Off-site 1	Off-site 2	(Units)
Groundwater receptor	0	201	301	(ft)
Outdoor air inhalation receptor	NA	NA	NA	(ft)
Indoor air inhalation receptor	NA	NA	NA	(ft)

Target Health Risk Values		Individual	Cumulative
TR	Target Risk (carcinogens)	1.0E-5	1.0E-5
THQ	Target Hazard Quotient (non-carcinogenic risk)	1.0E+0	1.0E+0

Modeling Options	
RBCA tier	Tier 2
Outdoor air volatilization model	NA
Indoor air volatilization model	NA
Soil leaching model	ASTM leaching model
Use soil attenuation model (SAM) for leachate?	No
Use dual equilibrium desorption model?	No
Apply Mass Balance Limit for Soil Volatilization?	No
Apply UK (CLEA) SGV as soil concentration limit	No
Vegetable calculation options	NA
Air dilution factor	NA
Groundwater dilution-attenuation factor	Domenico model

Delaware Soil Submergence Model Parameters		Value	(Units)
θ_N	Residual NAPL content in submerged soils	NA	(-)
f	Water table fluctuation cycles per year	NA	(1/yr)
t_{hu}	Duration of high water table condition	NA	(d)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: DERBCAP-2019-1,3,5-TMB
Site Location:

Completed By: Patrick Boettcher
Date Completed: 8-Jan-19

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	NA			(ft)
h_v	Vadose zone thickness	NA			(ft)
ρ_s	Soil bulk density	1.78			(g/cm^3)
f_{oc}	Fraction organic carbon	0.01			(-)
θ_T	Soil total porosity	0.38			(-)
		capillary	vadose	foundation	
θ_w	Volumetric water content	0.342	0.12	0.12	(-)
θ_a	Volumetric air content	0.038	0.26	0.26	(-)
K_{vs}	Vertical hydraulic conductivity	10353.54331			(ft/yr)
k_v	Vapor permeability	1.07639E-11			(ft^2)
L_{gw}	Depth to groundwater	9.842519685			(ft)
pH	Soil/groundwater pH	6.8			(-)
W	Length of source-zone area parallel to wind	NA			(ft)
W_{gw}	Length of source-zone area parallel to GW flow	49.21259843			(ft)
L_{ss}	Thickness of affected surface soils	NA			(ft)
A	Source zone area	NA			(ft^2)
L_s	Depth to top of affected soils	NA			(ft)
L_{base}	Depth to base of affected soils	NA			(ft)
L_{subs}	Thickness of affected soils	NA			(ft)

Outdoor Air Parameters		Value	(Units)
U_{air}	Ambient air velocity in mixing zone	NA	(ft/s)
δ_{air}	Air mixing zone height	NA	(ft)
Q/C	Inverse mean concentration at the center of source	NA	
P_a	Areal particulate emission rate	NA	(g/cm^2/s)
V	Fraction of vegetative cover	NA	
U_m	Mean annual airvelocity at 7m	NA	
U_t	Equivalent 7m air velocity threshold value	NA	
F(x)	Windspood function dependant on Um/Ut	NA	
PEF	Partculate Emission Factor	NA	

Building Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	NA	(ft)
A_b	Foundation area	NA	NA	(ft^2)
X_{crk}	Foundation perimeter	NA	NA	(ft)
ER	Building air exchange rate	NA	NA	(1/s)
L_{crk}	Foundation thickness	NA	NA	(ft)
Z_{crk}	Depth to bottom of foundation slab	NA	NA	(ft)
η	Foundation crack fraction	NA	NA	(-)
dP	Indoor/outdoor differential pressure	NA	NA	(g/cm/s^2)
Q_s	Convective air flow through slab	NA	NA	(ft^3/s)
θ_{wcrack}	Volumetric water content of cracks	NA	NA	(-)
θ_{acrack}	Volumetric air content of cracks	NA	NA	(-)
BV	Building Volume	NA	NA	(ft^3)
w	Building Width Perpendicular to GW flow	NA	NA	(ft)
L	Building Length Parallel to GW flow	NA	NA	(ft)
v	Saturated Soil Zone Porosity	NA	NA	(-)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	6.56167979	(ft)
I_f	Net groundwater infiltration rate	35	(cm/yr)
U_{gw}	Groundwater Darcy velocity	30	(ft/yr)
V_{gw}	Groundwater seepage velocity	78.94736842	(ft/yr)
K_s	Saturated hydraulic conductivity	3000	(ft/yr)
i	Groundwater gradient	0.01	(-)
S_w	Width of groundwater source zone	49.21259843	(ft)
S_d	Depth of groundwater source zone	6.56167979	(ft)
θ_{en}	Effective porosity in water bearing unit	0.35	(-)
f_{oc-sat}	Fraction organic carbon in water-bearing unit	0.001	(-)
pH_{sat}	Groundwater pH	6.2	(-)
	Biodegradation considered?	No	

Transport Parameters		Off-site 1	Off-site 2	Off-site 1	Off-site 2	(Units)
Lateral Groundwater Transport		Groundwater Ingestion		Groundwater to Indoor Air		
α_x	Longitudinal dispersivity	2.0E+1	3.0E+1	NA	NA	(ft)
α_y	Transverse dispersivity	6.6E+0	9.9E+0	NA	NA	(ft)
α_z	Vertical dispersivity	1.0E+0	1.5E+0	NA	NA	(ft)
Lateral Outdoor Air Transport		Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
σ_y	Transverse dispersion coefficient	NA	NA	NA	NA	(ft)
σ_z	Vertical dispersion coefficient	NA	NA	NA	NA	(ft)
ADF	Air dispersion factor	NA	NA	NA	NA	(-)

Surface Water Parameters		Off-site 2	(Units)
Q_{sw}	Surface water flowrate	NA	(ft^3/s)
W_{pl}	Width of GW plume at SW discharge	NA	(ft)
δ_{pl}	Thickness of GW plume at SW discharge	NA	(ft)
DF_{sw}	Groundwater-to-surface water dilution factor	NA	(-)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT

Site Name: DERBCAP-2019-1,3,5-TMB
Site Location:

Completed By: Patrick Boettcher
Date Completed: 8-Jan-19

Job ID:

1 OF 1

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-5
Target Hazard Quotient 1.0E+0

Groundwater DAF Option: Domenico - No Decay (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways (Checked if Pathway is Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	■ Groundwater Ingestion			□ Groundwater Volatilization to Indoor Air			□ Groundwater Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/L)	On-site (0 ft)	Off-site 1 (201 ft)	Off-site 2 (301 ft)	On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)	On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)			Only if "yes"
			Residential	Residential	Residential	None	None	None	None	None	None	(mg/L)	"■" if yes	left
108-67-8	Trimethylbenzene, 1,3,5-		1.0E+0	1.1E+1	2.3E+1							1.0E+0	☐	NA

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent solubility value. NA = Not applicable. NC = Not calculated.

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: DERBCAP-2019-1,3,5-TMB
Site Location:

Completed By: Patrick Boettcher
Date Completed: 8-Jan-19

Exposure Parameters		Residential				Commercial/Industrial		User Defined
		Child*	Adolescent	Adult	Age Adjusted**	Adult	Construct.	
ATc	Averaging time for carcinogens (yr)	70	70	70	NA	70	70	-
ATn	Averaging time for non-carcinogens (yr)	6	12	30	NA	25	1	-
BW	Body weight (kg)	15	35	80	NA	70	70	-
ED	Exposure duration (yr)	6	0.0001	26	NA	25	1	-
τ	Averaging time for vapor flux (yr)	30	30	30	NA	30	30	-
EF	Exposure frequency (days/yr)	350	350	350	NA	250	180	-
EFD	Exposure frequency for dermal exposure	350	350	350	NA	250	180	-
IRw	Ingestion rate of water (L/day)	0.78	0.78	2.5	2.9	1	NA	-
IRs	Ingestion rate of soil (mg/day)	200	200	100	323	50	100	-
SA	Skin surface area (dermal) (cm^2)	2023	2023	5800	NA	5800	5800	-
M	Soil to skin adherence factor	0.5	0.5	0.5	NA	0.5	0.5	-
ETswim	Swimming exposure time (hr/event)	1	3	3	NA	NA	NA	NA
EVswim	Swimming event frequency (events/yr)	12	12	12	NA	NA	NA	NA
IRswim	Water ingestion while swimming (L/hr)	0.5	0.5	0.05	NA	NA	NA	NA
SAswim	Skin surface area for swimming (cm^2)	3500	8100	23000	NA	NA	NA	NA
IRfish	Ingestion rate of fish (kg/yr)	0.025	0.025	0.025	0.050	NA	NA	NA
FIfish	Contaminated fish fraction (unitless)	1	1	1	NA	NA	NA	NA
IRbg	Below-ground vegetable ingestion	0.002	0.002	0.006	2.477	NA	NA	NA
IRabg	Above-ground vegetable ingestion	0.001	0.001	0.002	0.969	NA	NA	NA
VGbg	Above-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA
VGabg	Below-ground Veg. Ingest. Correction Factor	0.01	0.01	0.01	NA	NA	NA	NA

* = Child Receptor used for Non-Carcinogens

** = NS= Age Adjustment not selected for this parameter. Age-adjusted rate is effective value corresponding to adult exposure factors.

Complete Exposure Pathways and Receptors	On-site	Off-site 1	Off-site 2
Groundwater:			
Groundwater Ingestion	Residential	Residential	Residential
Soil Leaching to Groundwater Ingestion	Residential	Residential	Residential
Apply MCL Values	No	No	No
Applicable Surface Water Exposure Routes:			
Swimming	NA	NA	None
Fish Consumption	NA	NA	None
Aquatic Life Protection	NA	NA	None
Soil:			
Direct Contact: direct combined pathways	None	NA	NA
Apply CLEA- UK SGV levels		No	
Outdoor Air:			
Particulates from Surface Soils	None	None	None
Volatilization from Soils	None	None	None
Volatilization from Groundwater	None	None	None
Indoor Air:			
Volatilization from Soils	None	NA	NA
Volatilization from Groundwater	None	None	None
Soil Leaching to Groundwater Volatilization	None	None	None

Receptor Distance from Source Media	On-site	Off-site 1	Off-site 2	(Units)
Groundwater receptor	0	401	500	(ft)
Outdoor air inhalation receptor	NA	NA	NA	(ft)
Indoor air inhalation receptor	NA	NA	NA	(ft)

Target Health Risk Values		Individual	Cumulative
TR	Target Risk (carcinogens)	1.0E-5	1.0E-5
THQ	Target Hazard Quotient (non-carcinogenic risk)	1.0E+0	1.0E+0

Modeling Options	
RBCA tier	Tier 2
Outdoor air volatilization model	NA
Indoor air volatilization model	NA
Soil leaching model	ASTM leaching model
Use soil attenuation model (SAM) for leachate?	No
Use dual equilibrium desorption model?	No
Apply Mass Balance Limit for Soil Volatilization?	No
Apply UK (CLEA) SGV as soil concentration limit	No
Vegetable calculation options	NA
Air dilution factor	NA
Groundwater dilution-attenuation factor	Domenico model

Delaware Soil Submergence Model Parameters		Value	(Units)
θ_N	Residual NAPL content in submerged soils	NA	(-)
f	Water table fluctuation cycles per year	NA	(1/yr)
t_{HU}	Duration of high water table condition	NA	(d)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT — Input Parameter Summary

Site Name: DERBCAP-2019-1,3,5-TMB
Site Location:

Completed By: Patrick Boettcher
Date Completed: 8-Jan-19

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	NA			(ft)
h_v	Vadose zone thickness	NA			(ft)
ρ_s	Soil bulk density	1.78			(g/cm^3)
f_{oc}	Fraction organic carbon	0.01			(-)
θ_T	Soil total porosity	0.38			(-)
		capillary	vadose	foundation	
θ_w	Volumetric water content	0.342	0.12	0.12	(-)
θ_a	Volumetric air content	0.038	0.26	0.26	(-)
K_{vs}	Vertical hydraulic conductivity	10353.54331			(ft/yr)
k_v	Vapor permeability	1.07639E-11			(ft^2)
L_{gw}	Depth to groundwater	9.842519685			(ft)
pH	Soil/groundwater pH	6.8			(-)
W	Length of source-zone area parallel to wind	NA			(ft)
W_{gw}	Length of source-zone area parallel to GW flow	49.21259843			(ft)
L_{ss}	Thickness of affected surface soils	NA			(ft)
A	Source zone area	NA			(ft^2)
L_s	Depth to top of affected soils	NA			(ft)
L_{base}	Depth to base of affected soils	NA			(ft)
L_{subs}	Thickness of affected soils	NA			(ft)

Outdoor Air Parameters		Value	(Units)
U_{air}	Ambient air velocity in mixing zone	NA	(ft/s)
δ_{air}	Air mixing zone height	NA	(ft)
Q/C	Inverse mean concentration at the center of source	NA	
P_a	Areal particulate emission rate	NA	(g/cm^2/s)
V	Fraction of vegetative cover	NA	
U_m	Mean annual airvelocity at 7m	NA	
U_t	Equivalent 7m air velocity threshold value	NA	
F(x)	Windspeed function dependant on Um/Ut	NA	
PEF	Partculate Emission Factor	NA	

Building Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	NA	(ft)
A_b	Foundation area	NA	NA	(ft^2)
X_{crk}	Foundation perimeter	NA	NA	(ft)
ER	Building air exchange rate	NA	NA	(1/s)
L_{crk}	Foundation thickness	NA	NA	(ft)
Z_{crk}	Depth to bottom of foundation slab	NA	NA	(ft)
η	Foundation crack fraction	NA	NA	(-)
dP	Indoor/outdoor differential pressure	NA	NA	(g/cm/s^2)
Q_s	Convective air flow through slab	NA	NA	(ft^3/s)
θ_{wcrack}	Volumetric water content of cracks	NA	NA	(-)
θ_{acrack}	Volumetric air content of cracks	NA	NA	(-)
BV	Building Volume	NA	NA	(ft^3)
w	Building Width Perpendicular to GW flow	NA	NA	(ft)
L	Building Length Parallel to GW flow	NA	NA	(ft)
v	Saturated Soil Zone Porosity	NA	NA	(-)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	6.56167979	(ft)
I_f	Net groundwater infiltration rate	35	(cm/yr)
U_{gw}	Groundwater Darcy velocity	30	(ft/yr)
V_{gw}	Groundwater seepage velocity	78.94736842	(ft/yr)
K_s	Saturated hydraulic conductivity	3000	(ft/yr)
i	Groundwater gradient	0.01	(-)
S_w	Width of groundwater source zone	49.21259843	(ft)
S_d	Depth of groundwater source zone	6.56167979	(ft)
[illegible]	[illegible]	[illegible]	[illegible]
f_{oc-sat}	Fraction organic carbon in water-bearing unit	0.001	(-)
pH_{sat}	Groundwater pH	6.2	(-)
	Biodegradation considered?	No	

Transport Parameters		Off-site 1	Off-site 2	Off-site 1	Off-site 2	(Units)
Lateral Groundwater Transport		Groundwater Ingestion		Groundwater to Indoor Air		
α_x	Longitudinal dispersivity	4.0E+1	5.0E+1	NA	NA	(ft)
α_y	Transverse dispersivity	1.3E+1	1.7E+1	NA	NA	(ft)
α_z	Vertical dispersivity	2.0E+0	2.5E+0	NA	NA	(ft)
Lateral Outdoor Air Transport		Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
σ_y	Transverse dispersion coefficient	NA	NA	NA	NA	(ft)
σ_z	Vertical dispersion coefficient	NA	NA	NA	NA	(ft)
ADF	Air dispersion factor	NA	NA	NA	NA	(-)

Surface Water Parameters		Off-site 2	(Units)
Q_{sw}	Surface water flowrate	NA	(ft^3/s)
W_{pi}	Width of GW plume at SW discharge	NA	(ft)
δ_{pi}	Thickness of GW plume at SW discharge	NA	(ft)
DF_{sw}	Groundwater-to-surface water dilution factor	NA	(-)

NOTE: NA = Not applicable
Orange = Site-specific value (different from current default value)

RBCA SITE ASSESSMENT

Site Name: DERBCAP-2019-1,3,5-TMB
Site Location:

Completed By: Patrick Boettcher
Date Completed: 8-Jan-19

Job ID:

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-5
Target Hazard Quotient 1.0E+0

Groundwater DAF Option: Domenico - No Decay (One-directional vert. dispersion)

SSTL Results For Complete Exposure Pathways (Checked if Pathway is Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	■ Groundwater Ingestion			□ Groundwater Volatilization to Indoor Air			□ Groundwater Volatilization to Outdoor Air			Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/L)	On-site (0 ft) Residential	Off-site 1 (401 ft) Residential	Off-site 2 (500 ft) Residential	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	On-site (0 ft) None	Off-site 1 (0 ft) None	Off-site 2 (0 ft) None	(mg/L)	"■" if yes	Only if "yes" left
108-67-8	Trimethylbenzene, 1,3,5-		1.0E+0	4.1E+1	>5.1E+1							1.0E+0	☐	NA

* = Chemical with user-specified data

">" indicates risk-based target concentration greater than constituent solubility value. NA = Not applicable. NC = Not calculated.

Exposure Pathway Calculation Sheets (Continued)

- Soil Direct Contact RBSLs

Site-specific Risk
Resident Equation Inputs for Soil

Variable	Value
LT (lifetime) years	70
ET_{--} (exposure time) hours/day	24
ET_{---c} (child exposure time) hours/day	24
ET_{---a} (adult exposure time) hours/day	24
ET_{0-3} (mutagenic exposure time) hours/day	24
ET_{1-6} (mutagenic exposure time) hours/day	24
ET_{6-16} (mutagenic exposure time) hours/day	24
ET_{16-26} (mutagenic exposure time) hours/day	24
ED_{---} (exposure duration) years	26
ED_{---c} (exposure duration - child) years	6
ED_{---a} (exposure duration - adult) years	20
ED_{0-3} (mutagenic exposure duration) years	2
ED_{1-6} (mutagenic exposure duration) years	4
ED_{6-16} (mutagenic exposure duration) years	10
ED_{16-26} (mutagenic exposure duration) years	10
BW_{---c} (body weight - child) kg	15
BW_{---a} (body weight - adult) kg	80
BW_{0-3} (mutagenic body weight) kg	15
BW_{1-6} (mutagenic body weight) kg	15
BW_{6-16} (mutagenic body weight) kg	80
BW_{16-26} (mutagenic body weight) kg	80
SA_{---c} (skin surface area - child) cm ^{2}/day	2373
SA_{---a} (skin surface area - adult) cm ^{2}/day	6032
SA_{0-3} (mutagenic skin surface area) cm ^{2}/day	2373
SA_{1-6} (mutagenic skin surface area) cm ^{2}/day	2373
SA_{6-16} (mutagenic skin surface area) cm ^{2}/day	6032
SA_{16-26} (mutagenic skin surface area) cm ^{2}/day	6032
EF_{---} (exposure frequency) days/year	350
EF_{---c} (exposure frequency - child) days/year	350
EF_{---a} (exposure frequency - adult) days/year	350
EF_{0-2} (mutagenic exposure frequency) days/year	350

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Site-specific Risk
Resident Equation Inputs for Soil

Variable	Value
$EF_{1,6}$ (mutagenic exposure frequency) days/year	350
$EF_{6,16}$ (mutagenic exposure frequency) days/year	350
$EF_{16,30}$ (mutagenic exposure frequency) days/year	350
$IFS_{res,adj}$ (age-adjusted soil ingestion factor) mg/kg	36750
$IFSM_{res,adj}$ (mutagenic age-adjusted soil ingestion factor) mg/kg	166833.3
$IRS_{res,c}$ (soil intake rate - child) mg/day	200
$IRS_{res,a}$ (soil intake rate - adult) mg/day	100
$IRS_{0,1}$ (mutagenic soil intake rate) mg/day	200
$IRS_{1,6}$ (mutagenic soil intake rate) mg/day	200
$IRS_{6,16}$ (mutagenic soil intake rate) mg/day	100
$IRS_{16,30}$ (mutagenic soil intake rate) mg/day	100
$AF_{res,a}$ (skin adherence factor - adult) mg/cm ^{2}	0.07
$AF_{res,c}$ (skin adherence factor - child) mg/cm ^{2}	0.2
$AF_{0,1}$ (mutagenic skin adherence factor) mg/cm ^{2}	0.2
$AF_{1,6}$ (mutagenic skin adherence factor) mg/cm ^{2}	0.2
$AF_{6,16}$ (mutagenic skin adherence factor) mg/cm ^{2}	0.07
$AF_{16,30}$ (mutagenic skin adherence factor) mg/cm ^{2}	0.07
$DFS_{res,adj}$ (age-adjusted soil dermal factor) mg/kg	103390
$DFSM_{res,adj}$ (mutagenic age-adjusted soil dermal factor) mg/kg	428260
AT_{res} (averaging time - resident carcinogenic)	365
$City_{SCS}$ (Climate Zone) Selection	Default
A_s (PEF acres)	0.5
Q/C_{unit} (g/m^2-s per kg/m^3)	93.77
PEF (particulate emission factor) m ^{3}/kg	1359344438
A (PEF Dispersion Constant)	16.2302
B (PEF Dispersion Constant)	18.7762
C (PEF Dispersion Constant)	216.108
V (fraction of vegetative cover) unitless	0.5
U_m (mean annual wind speed) m/s	4.69
U_t (equivalent threshold value)	11.32
F(x) (function dependent on U_m/U_t) unitless	0.194

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Site-specific Risk
Resident Equation Inputs for Soil

Variable	Value
City (Climate Zone) Selection	Default
A_s (VF acres)	0.5
Q/C (g/m²-s per kg/m³)	68.18
foc (fraction organic carbon in soil) g/g	0.006
ρ_b (dry soil bulk density) g/cm³	1.5
ρ_s (soil particle density) g/cm³	2.65
n (total soil porosity) L	0.43396
θ (air-filled soil porosity) L	0.28396
θ (water-filled soil porosity) L	0.15
T (exposure interval) s	819936000
A (VF Dispersion Constant)	11.911
B (VF Dispersion Constant)	18.4385
C (VF Dispersion Constant)	209.7845
City (Climate Zone) Selection	Default
Q/C (g/m²-s per kg/m³)	68.18
A_s (VF mass-limit acres)	0.5
T (exposure interval) yr	26
ρ_b (dry soil bulk density - mass limit) g/cm³	1.5
A (VF Dispersion Constant - Mass Limit)	11.911
B (VF Dispersion Constant - Mass Limit)	18.4385
C (VF Dispersion Constant - Mass Limit)	209.7845
T_w (groundwater temperature) °Celsius	25

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Site-specific Risk
Resident RISK for Soil

Chemical	CAS Number	Mutagen?	VOC?	Chronic RfD (mg/kg-day)	RfD Ref	Chronic RfC (mg/m^3)	RfC Ref	Ingestion SF $(mg/kg\text{-}day)^{-1}$	SFO Ref	Inhalation Unit Risk $(ug/m^3)^{-1}$	IUR Ref	ABS_{gi}	ABS_{derm}	Volatilization Factor (m^3/kg)
Acenaphthene	83-32-9	No	Yes	6.00E-02	I	-		-		-		1	0.13	1.41E+05
Anthracene	120-12-7	No	Yes	3.00E-01	I	-		-		-		1	0.13	5.23E+05
Benz[a]anthracene	56-55-3	Yes	Yes	-		-		1.00E-01	E	5.00E-05	E	1	0.13	4.41E+06
Benzene	71-43-2	No	Yes	4.00E-03	I	3.00E-02	I	5.50E-02	I	7.80E-06	I	1	-	3.54E+03
Benzo[a]pyrene	50-32-8	Yes	No	3.00E-04	I	2.00E-06	I	1.00E+00	I	6.00E-04	I	1	0.13	-
Benzo[b]fluoranthene	205-99-2	Yes	No	-		-		1.00E-01	E	6.00E-05	E	1	0.13	-
Benzo[k]fluoranthene	207-08-9	Yes	No	-		-		1.00E-02	E	6.00E-06	E	1	0.13	-
Chrysene	218-01-9	Yes	No	-		-		1.00E-03	E	6.00E-07	E	1	0.13	-
Cumene	98-82-8	No	Yes	1.00E-01	I	4.00E-01	I	-		-		1	-	6.21E+03
Dibromoethane, 1,2-	106-93-4	No	Yes	9.00E-03	I	9.00E-03	I	2.00E+00	I	6.00E-04	I	1	-	8.64E+03
Dichloroethane, 1,2-	107-06-2	No	Yes	6.00E-03	P	7.00E-03	P	9.10E-02	I	2.60E-05	I	1	-	4.57E+03
Ethylbenzene	100-41-4	No	Yes	1.00E-01	I	1.00E+00	I	1.10E-02	C	2.50E-06	C	1	-	5.67E+03
Fluoranthene	206-44-0	No	No	4.00E-02	I	-		-		-		1	0.13	-
Fluorene	86-73-7	No	Yes	4.00E-02	I	-		-		-		1	0.13	2.81E+05
Indeno[1,2,3-cd]pyrene	193-39-5	Yes	No	-		-		1.00E-01	E	6.00E-05	E	1	0.13	-
Methyl tert-Butyl Ether (MTBE)	1634-04-4	No	Yes	-		3.00E+00	I	1.80E-03	C	2.60E-07	C	1	-	4.90E+03
Naphthalene	91-20-3	No	Yes	2.00E-02	I	3.00E-03	I	-		3.40E-05	C	1	0.13	4.63E+04
Phenanthrene	85-01-8	No	Yes	-		-		-		-		1	0.13	6.43E+05
Pyrene	129-00-0	No	Yes	3.00E-02	I	-		-		-		1	0.13	2.38E+06
Toluene	108-88-3	No	Yes	8.00E-02	I	5.00E+00	I	-		-		1	-	4.29E+03
Trimethylbenzene, 1,2,4-	95-63-6	No	Yes	1.00E-02	I	6.00E-02	I	-		-		1	-	7.91E+03
Trimethylbenzene, 1,3,5-	108-67-8	No	Yes	1.00E-02	I	6.00E-02	I	-		-		1	-	6.61E+03
Xylenes	1330-20-7	No	Yes	2.00E-01	I	1.00E-01	I	-		-		1	-	5.74E+03
*Total Risk/HI				-		-		-		-		-	-	-

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Site-specific Risk
Resident RISK for Soil

DA	Particulate Emission Factor (m^3/kg)	Soil Saturation Concentration (mg/kg)	RBA	HLC (atm-m^3/mole)	Henry's Law Constant (unitless)	H` and HLC Ref	Henry's Law Constant Used in Calcs (unitless)	Normal Boiling Point T_{boil} (K)	BP Ref	Critical Temperature T_{crit} (K)
6.72E-07	1.36E+09	-	1	0.000184	7.52E-03	PHYSPROP	0.0075225	552.15	PHYSPROP	803.15
4.85E-08	1.36E+09	-	1	0.0000556	2.27E-03	PHYSPROP	0.0022731	613.05	PHYSPROP	873
6.83E-10	1.36E+09	-	1	0.000012	4.91E-04	PHYSPROP	0.0004906	710.75	PHYSPROP	979
1.06E-03	1.36E+09	1.82E+03	1	0.00555	2.27E-01	PHYSPROP	0.2269011	353.15	PHYSPROP	562
-	1.36E+09	-	1	4.57E-7	1.87E-05	PHYSPROP	0.0000187	768.15	PHYSPROP	-
-	1.36E+09	-	1	6.57E-7	2.69E-05	PHYSPROP	0.0000269	715.9	EPI	-
-	1.36E+09	-	1	5.84E-7	2.39E-05	PHYSPROP	0.0000239	753.15	PHYSPROP	-
-	1.36E+09	-	1	5.23E-6	2.14E-04	PHYSPROP	0.0002138	721.15	PHYSPROP	979
3.45E-04	1.36E+09	2.68E+02	1	0.0115	4.70E-01	PHYSPROP	0.4701554	425.55	PHYSPROP	631
1.78E-04	1.36E+09	1.34E+03	1	0.00065	2.66E-02	PHYSPROP	0.026574	404.75	PHYSPROP	650.15
6.36E-04	1.36E+09	2.98E+03	1	0.00118	4.82E-02	PHYSPROP	0.048242	356.65	PHYSPROP	561.5
4.14E-04	1.36E+09	4.80E+02	1	0.00788	3.22E-01	PHYSPROP	0.3221586	409.25	PHYSPROP	617.1
-	1.36E+09	-	1	8.86E-6	3.62E-04	PHYSPROP	0.0003622	657.15	PHYSPROP	905
1.68E-07	1.36E+09	-	1	0.0000962	3.93E-03	PHYSPROP	0.003933	568.15	PHYSPROP	826
-	1.36E+09	-	1	3.48E-7	1.42E-05	PHYSPROP	0.0000142	809.15	PHYSPROP	-
5.54E-04	1.36E+09	8.87E+03	1	0.000587	2.40E-02	PHYSPROP	0.0239984	328.15	PHYSPROP	497
6.20E-06	1.36E+09	-	1	0.00044	1.80E-02	PHYSPROP	0.0179886	491.05	PHYSPROP	748.3
3.21E-08	1.36E+09	-	1	0.0000423	1.73E-03	PHYSPROP	0.0017294	613.15	PHYSPROP	869
2.35E-09	1.36E+09	-	1	0.0000119	4.87E-04	PHYSPROP	0.0004865	677.15	PHYSPROP	936
7.24E-04	1.36E+09	8.18E+02	1	0.00664	2.71E-01	PHYSPROP	0.2714636	383.75	PHYSPROP	591.9
2.12E-04	1.36E+09	2.19E+02	1	0.00616	2.52E-01	PHYSPROP	0.2518397	442.45	PHYSPROP	649.1
3.04E-04	1.36E+09	1.82E+02	1	0.00877	3.59E-01	PHYSPROP	0.3585446	437.85	PHYSPROP	637.31
4.04E-04	1.36E+09	2.60E+02	1	0.00663	2.71E-01	PHYSPROP	0.2710548	411.65	PHYSPROP	620.21
-	-	-	-	-	-		-	-		-

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Site-specific Risk
Resident RISK for Soil

T_{crit} Ref	D_{ta} (cm^2/s)	D_{tw} (cm^2/s)	DA	Soil Concentration (mg/kg)	Child Ingestion HQ	Child Inhalation HQ	Child Dermal HQ	Child Total HI	Adult Ingestion HQ	Adult Inhalation HQ	Adult Dermal HQ	Adult Total HI
YAWS	5.06E-02	8.33E-06	6.72E-07	360	7.67E-02	-	2.37E-02	1.00E-01	7.19E-03	-	3.95E-03	1.11E-02
YAWS	3.90E-02	7.85E-06	4.85E-08	1800	7.67E-02	-	2.37E-02	1.00E-01	7.19E-03	-	3.95E-03	1.11E-02
YAWS	2.61E-02	6.75E-06	6.83E-10	0.82	-	-	-	-	-	-	-	-
CRC89	8.95E-02	1.03E-05	1.06E-03	1.2	3.84E-03	1.08E-02	-	1.47E-02	3.60E-04	1.08E-02	-	1.12E-02
	4.76E-02	5.56E-06	-	0.24	1.02E-02	8.46E-05	3.16E-03	1.35E-02	9.59E-04	8.46E-05	5.26E-04	1.57E-03
	4.76E-02	5.56E-06	-	1.11	-	-	-	-	-	-	-	-
	4.76E-02	5.56E-06	-	1.6	-	-	-	-	-	-	-	-
YAWS	2.61E-02	6.75E-06	-	16	-	-	-	-	-	-	-	-
CRC89	6.03E-02	7.86E-06	3.45E-04	190	2.43E-02	7.34E-02	-	9.77E-02	2.28E-03	7.34E-02	-	7.57E-02
YAWS	4.30E-02	1.04E-05	1.78E-04	0.036	5.11E-05	4.44E-04	-	4.95E-04	4.79E-06	4.44E-04	-	4.49E-04
CRC89	8.57E-02	1.10E-05	6.36E-04	0.46	9.80E-04	1.38E-02	-	1.48E-02	9.19E-05	1.38E-02	-	1.39E-02
CRC89	6.85E-02	8.46E-06	4.14E-04	5.8	7.42E-04	9.81E-04	-	1.72E-03	6.95E-05	9.81E-04	-	1.05E-03
YAWS	2.76E-02	7.18E-06	-	240	7.67E-02	-	2.37E-02	1.00E-01	7.19E-03	-	3.95E-03	1.11E-02
YAWS	4.40E-02	7.89E-06	1.68E-07	240	7.67E-02	-	2.37E-02	1.00E-01	7.19E-03	-	3.95E-03	1.11E-02
	4.48E-02	5.23E-06	-	1.3	-	-	-	-	-	-	-	-
CRC89	7.53E-02	8.59E-06	5.54E-04	47	-	3.07E-03	-	3.07E-03	-	3.07E-03	-	3.07E-03
CRC89	6.05E-02	8.38E-06	6.20E-06	3.8	2.43E-03	2.62E-02	7.49E-04	2.94E-02	2.28E-04	2.62E-02	1.25E-04	2.66E-02
YAWS	3.45E-02	6.69E-06	3.21E-08	180	-	-	-	-	-	-	-	-
YAWS	2.78E-02	7.25E-06	2.35E-09	180	7.67E-02	-	2.37E-02	1.00E-01	7.19E-03	-	3.95E-03	1.11E-02
CRC89	7.78E-02	9.20E-06	7.24E-04	490	7.83E-02	2.19E-02	-	1.00E-01	7.34E-03	2.19E-02	-	2.93E-02
CRC89	6.07E-02	7.92E-06	2.12E-04	5.8	7.42E-03	1.17E-02	-	1.91E-02	6.95E-04	1.17E-02	-	1.24E-02
CRC89	6.02E-02	7.84E-06	3.04E-04	220	2.81E-01	5.32E-01	-	8.13E-01	2.64E-02	5.32E-01	-	5.58E-01
YAWS	6.85E-02	8.46E-06	4.04E-04	58	3.71E-03	9.70E-02	-	1.01E-01	3.48E-04	9.70E-02	-	9.73E-02
[illegible]	-	-	-	-	7.97E-01	7.91E-01	1.22E-01	1.71E+00	7.47E-02	7.91E-01	2.04E-02	8.86E-01

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Site-specific Risk
Resident RISK for Soil

Adjusted Ingestion HQ	Adjusted Inhalation HQ	Adjusted Dermal HQ	Adjusted Total HI	Ingestion Risk	Inhalation Risk	Dermal Risk	Total Risk
2.32E-02	-	8.50E-03	3.17E-02	-	-	-	-
2.32E-02	-	8.50E-03	3.17E-02	-	-	-	-
-	-	-	-	5.35E-07	1.10E-08	1.79E-07	7.25E-07
1.16E-03	1.08E-02	-	1.20E-02	9.49E-08	9.43E-07	-	1.04E-06
3.10E-03	8.46E-05	1.13E-03	4.32E-03	1.57E-06	1.04E-10	5.23E-07	2.09E-06
-	-	-	-	7.25E-07	4.83E-11	2.42E-07	9.67E-07
-	-	-	-	1.04E-07	6.97E-12	3.49E-08	1.39E-07
-	-	-	-	1.04E-07	6.97E-12	3.49E-08	1.39E-07
7.36E-03	7.34E-02	-	8.07E-02	-	-	-	-
1.55E-05	4.44E-04	-	4.59E-04	1.04E-07	8.90E-07	-	9.94E-07
2.97E-04	1.38E-02	-	1.41E-02	6.02E-08	9.31E-07	-	9.92E-07
2.25E-04	9.81E-04	-	1.21E-03	9.18E-08	9.11E-07	-	1.00E-06
2.32E-02	-	8.50E-03	3.17E-02	-	-	-	-
2.32E-02	-	8.50E-03	3.17E-02	-	-	-	-
-	-	-	-	8.49E-07	5.66E-11	2.83E-07	1.13E-06
-	3.07E-03	-	3.07E-03	1.22E-07	8.88E-07	-	1.01E-06
7.36E-04	2.62E-02	2.69E-04	2.72E-02	-	9.93E-07	-	9.93E-07
-	-	-	-	-	-	-	-
2.32E-02	-	8.50E-03	3.17E-02	-	-	-	-
2.37E-02	2.19E-02	-	4.56E-02	-	-	-	-
2.25E-03	1.17E-02	-	1.40E-02	-	-	-	-
8.52E-02	5.32E-01	-	6.17E-01	-	-	-	-
1.12E-03	9.70E-02	-	9.81E-02	-	-	-	-
2.41E-01	7.91E-01	4.39E-02	1.08E+00	4.36E-06	5.57E-06	1.30E-06	1.12E-05

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Soil

Resident
Exposure to Soil

Instructions

Exposure Assessment Details

Age Segment (yr)	AF (mg/cm^2)	BW (kg)	ED (yr)	EF (day/yr)	ET (hr/event)	IRS (mg/day)	SA (cm^2/day)
0-2	0.2	15	2	350	24	200	2373
2-6	0.2	15	4	350	24	200	2373
6-16	0.07	80	10	350	24	100	6032
16-30	0.07	80	10	350	24	100	6032
Child (0-6)	0.2	15	6	350	24	200	2373
Adult (6-70)	0.07	80	20	350	24	100	6032

NOTES:

1. Input fields with a " " background are a required entry.
2. Input fields with a "blue" background are calculated dynamically.
3. The supporting equations below are used to compute the child and adult exposure parameters.

Soil Supporting Equations - Adult

$$ED_{res\text{-}a}(20\ \text{years}) = ED_{6\text{-}16}(10\ \text{years}) + ED_{16\text{-}26}(10\ \text{years})$$

$$BW_{res\text{-}a}(80\ \text{kg}) = \frac{BW_{6\text{-}16}(80\ \text{kg}) \times ED_{6\text{-}16}(10\ \text{years}) + BW_{16\text{-}26}(80\ \text{kg}) \times ED_{16\text{-}26}(10\ \text{years})}{ED_{6\text{-}16}(10\ \text{years}) + ED_{16\text{-}26}(10\ \text{years})}$$

$$EF_{res\text{-}a}\left(\frac{350\ \text{days}}{\text{year}}\right) = \frac{EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{6\text{-}16}(10\ \text{years}) + EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{16\text{-}26}(10\ \text{years})}{ED_{6\text{-}16}(10\ \text{years}) + ED_{16\text{-}26}(10\ \text{years})}$$

$$AF_{res\text{-}a}\left(\frac{0.07\ \text{mg}}{\text{cm}^2}\right) = \frac{AF_{6\text{-}16}\left(\frac{0.07\ \text{mg}}{\text{cm}^2}\right) \times ED_{6\text{-}16}(10\ \text{years}) + AF_{16\text{-}26}\left(\frac{0.07\ \text{mg}}{\text{cm}^2}\right) \times ED_{16\text{-}26}(10\ \text{years})}{ED_{6\text{-}16}(10\ \text{years}) + ED_{16\text{-}26}(10\ \text{years})}$$

$$SA_{res\text{-}a}\left(\frac{6{,}032\ \text{cm}^2}{\text{day}}\right) = \frac{SA_{6\text{-}16}\left(\frac{6{,}032\ \text{cm}^2}{\text{day}}\right) \times ED_{6\text{-}16}(10\ \text{years}) + SA_{16\text{-}26}\left(\frac{6{,}032\ \text{cm}^2}{\text{day}}\right) \times ED_{16\text{-}26}(10\ \text{years})}{ED_{6\text{-}16}(10\ \text{years}) + ED_{16\text{-}26}(10\ \text{years})}$$

$$IRS_{res\text{-}a}\left(\frac{100\ \text{mg}}{\text{day}}\right) = \frac{IRS_{6\text{-}16}\left(\frac{100\ \text{mg}}{\text{day}}\right) \times ED_{6\text{-}16}(10\ \text{years}) + IRS_{16\text{-}26}\left(\frac{100\ \text{mg}}{\text{day}}\right) \times ED_{16\text{-}26}(10\ \text{years})}{ED_{6\text{-}16}(10\ \text{years}) + ED_{16\text{-}26}(10\ \text{years})}$$

Soil Supporting Equations - Age-adjusted

$$ED_{res}(26\ \text{years}) = ED_{0\text{-}2}(2\ \text{years}) + ED_{2\text{-}6}(4\ \text{years}) + ED_{6\text{-}16}(10\ \text{years}) + ED_{16\text{-}26}(10\ \text{years})$$

$$EF_{res}\left(\frac{350\ \text{days}}{\text{year}}\right) = \frac{EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{0\text{-}2}(2\ \text{years}) + EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{2\text{-}6}(4\ \text{years}) + EF_{6\text{-}16}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{6\text{-}16}(10\ \text{years}) + EF_{16\text{-}26}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{16\text{-}26}(10\ \text{years})}{ED_{0\text{-}2}(2\ \text{years}) + ED_{2\text{-}6}(4\ \text{years}) + ED_{6\text{-}16}(10\ \text{years}) + ED_{16\text{-}26}(10\ \text{years})}$$

$$ET_{res}\left(\frac{24\ \text{hour}}{\text{day}}\right)$$

Soil Supporting Equations - Child

$$ED_{res\text{-}c}(6\ \text{years}) = ED_{0\text{-}2}(2\ \text{years}) + ED_{2\text{-}6}(4\ \text{years})$$

$$BW_{res\text{-}c}(15\ \text{kg}) = \frac{BW_{0\text{-}2}(15\ \text{kg}) \times ED_{0\text{-}2}(2\ \text{years}) + BW_{2\text{-}6}(15\ \text{kg}) \times ED_{2\text{-}6}(4\ \text{years})}{ED_{0\text{-}2}(2\ \text{years}) + ED_{2\text{-}6}(4\ \text{years})}$$

$$EF_{res\text{-}c}\left(\frac{350\ \text{days}}{\text{year}}\right) = \frac{EF_{0\text{-}2}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{0\text{-}2}(2\ \text{years}) + EF_{2\text{-}6}\left(\frac{350\ \text{days}}{\text{year}}\right) \times ED_{2\text{-}6}(4\ \text{years})}{ED_{0\text{-}2}(2\ \text{years}) + ED_{2\text{-}6}(4\ \text{years})}$$

$$AF_{res\text{-}c}\left(\frac{0.2\ \text{mg}}{\text{cm}^2}\right) = \frac{AF_{0\text{-}2}\left(\frac{0.2\ \text{mg}}{\text{cm}^2}\right) \times ED_{0\text{-}2}(2\ \text{years}) + AF_{2\text{-}6}\left(\frac{0.2\ \text{mg}}{\text{cm}^2}\right) \times ED_{2\text{-}6}(4\ \text{years})}{ED_{0\text{-}2}(2\ \text{years}) + ED_{2\text{-}6}(4\ \text{years})}$$

$$SA_{res\text{-}c}\left(\frac{2{,}373\ \text{cm}^2}{\text{day}}\right) = \frac{SA_{0\text{-}2}\left(\frac{2{,}373\ \text{cm}^2}{\text{day}}\right) \times ED_{0\text{-}2}(2\ \text{years}) + SA_{2\text{-}6}\left(\frac{2{,}373\ \text{cm}^2}{\text{day}}\right) \times ED_{2\text{-}6}(4\ \text{years})}{ED_{0\text{-}2}(2\ \text{years}) + ED_{2\text{-}6}(4\ \text{years})}$$

$$IRS_{res\text{-}c}\left(\frac{200\ \text{mg}}{\text{day}}\right) = \frac{IRS_{0\text{-}2}\left(\frac{200\ \text{mg}}{\text{day}}\right) \times ED_{0\text{-}2}(2\ \text{years}) + IRS_{2\text{-}6}\left(\frac{200\ \text{mg}}{\text{day}}\right) \times ED_{2\text{-}6}(4\ \text{years})}{ED_{0\text{-}2}(2\ \text{years}) + ED_{2\text{-}6}(4\ \text{years})}$$

Carcinogenic Dermal

$$CDI_{res\text{-}soil\text{-}ca\text{-}der}\left(mg/kg\text{-}day\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times DFS_{res\text{-}adj}\left(\frac{103{,}390\ mg}{kg}\right)\times ABS_{d}\times\left(\frac{10^{-6}\ kg}{1\ mg}\right)}{AT_{res}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)}$$

where:

$$DFS_{res\text{-}adj}\left(\frac{103{,}390\ mg}{kg}\right)=\left(\frac{ED_{res\text{-}c}\left(6\ years\right)\times EF_{res\text{-}c}\left(\frac{350\ days}{year}\right)\times SA_{res\text{-}c}\left(\frac{2{,}373\ cm^{2}}{day}\right)\times AF_{res\text{-}c}\left(\frac{0.2\ mg}{cm^{2}}\right)}{BW_{res\text{-}c}\left(15\ kg\right)}+\frac{\left(ED_{res}\left(26\ years\right)-ED_{res\text{-}c}\left(6\ years\right)\right)\times EF_{res\text{-}a}\left(\frac{350\ days}{year}\right)\times SA_{res\text{-}a}\left(\frac{6{,}032\ cm^{2}}{day}\right)\times AF_{res\text{-}a}\left(\frac{0.07\ mg}{cm^{2}}\right)}{BW_{res\text{-}a}\left(80\ kg\right)}\right)$$

Carcinogenic Ingestion

$$CDI_{res\text{-}soil\text{-}ca\text{-}ing}\left(mg/kg\text{-}day\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times IFS_{res\text{-}adj}\left(\frac{36{,}750\ mg}{kg}\right)\times RBA\times\left(\frac{10^{-6}\ kg}{1\ mg}\right)}{AT_{res}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)}$$

where:

$$IFS_{res\text{-}adj}\left(\frac{36{,}750\ mg}{kg}\right)=\left(\frac{ED_{res\text{-}c}\left(6\ years\right)\times EF_{res\text{-}c}\left(\frac{350\ days}{year}\right)\times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right)}{BW_{res\text{-}c}\left(15\ kg\right)}+\frac{\left(ED_{res}\left(26\ years\right)-ED_{res\text{-}c}\left(6\ years\right)\right)\times EF_{res\text{-}a}\left(\frac{350\ days}{year}\right)\times IRS_{res\text{-}a}\left(\frac{100\ mg}{day}\right)}{BW_{res\text{-}a}\left(80\ kg\right)}\right)$$

Carcinogenic Inhalation

$$CDI_{res\text{-}soil\text{-}ca\text{-}inh}\left(\mu g/m^{3}\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times EF_{res}\left(\frac{350\ days}{year}\right)\times ED_{res}\left(26\ years\right)\times ET_{res}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times\left(\frac{1}{VF_{a}\left(\frac{m^{3}}{kg}\right)}+\frac{1}{PEF_{w}\left(\frac{m^{3}}{kg}\right)}\right)}{AT_{res}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)\times\left(\frac{1\ mg}{1000\ \mu g}\right)}$$

Non-Carcinogenic (Child) Dermal

$$CDI_{res\text{-}soil\text{-}nc\text{-}der}\left(mg/kg\text{-}day\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times EF_{res\text{-}c}\left(\frac{350\ days}{year}\right)\times ED_{res\text{-}c}\left(6\ years\right)\times SA_{res\text{-}c}\left(\frac{2{,}373\ cm^2}{day}\right)\times AF_{res\text{-}c}\left(\frac{0.2\ mg}{cm^2}\right)\times ABS_d\times\left(\frac{10^{-6}\ kg}{1\ mg}\right)}{AT_{res\text{-}c}\left(\frac{365\ days}{year}\times ED_{res\text{-}c}\left(6\ years\right)\right)\times BW_{res\text{-}c}\left(15\ kg\right)}$$

Non-Carcinogenic (Child) Ingestion

$$CDI_{res\text{-}soil\text{-}nc\text{-}ing}\left(mg/kg\text{-}day\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times EF_{res\text{-}c}\left(\frac{350\ days}{year}\right)\times ED_{res\text{-}c}\left(6\ years\right)\times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right)\times RBA\times\left(\frac{10^{-6}\ kg}{1\ mg}\right)}{AT_{res\text{-}c}\left(\frac{365\ days}{year}\times ED_{res\text{-}c}\left(6\ years\right)\right)\times BW_{res\text{-}c}\left(15\ kg\right)}$$

Non-Carcinogenic (Child) Inhalation

$$CDI_{res\text{-}soil\text{-}nc\text{-}inh}\left(mg/m^3\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times EF_{res\text{-}c}\left(\frac{350\ days}{year}\right)\times ED_{res\text{-}c}\left(6\ years\right)\times ET_{res}\left(\frac{24\ hours}{day}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times\left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)}+\frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)}{AT_{res\text{-}c}\left(\frac{365\ days}{year}\times ED_{res\text{-}c}\left(6\ years\right)\right)}$$

103390 $DFS_{res\text{-}adj}$ (age-adjusted soil dermal factor) mg/kg	24 ET_{res} (exposure time) hours/day
26 ED_{res} (exposure duration) years	36750 $IFS_{res\text{-}adj}$ (age-adjusted soil ingestion factor) mg/kg
350 EF_{res} (exposure frequency) days/year	70 LT (lifetime) years

NOTES:

1. CSF_o=ingestion slope factor $(mg/kg\text{-}day)^{-1}$. chemical-specific
2. IUR=inhalation unit risk $(\mu g/m^3)^{-1}$. chemical-specific
3. RfD_o=ingestion reference dose (mg/kg-day). chemical-specific
4. RfC=inhalation reference concentration (mg/m^3). chemical-specific
5. Q/C_{wind}=calculations based on site size and climactic zone. Further details on the derivation of Q/C_{wind} can be found in Appendix D

Mutagenic Dermal

$$CDI_{res\text{-}soil\text{-}mu\text{-}der}\left(\frac{mg}{kg\text{-}day}\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times DFSM_{res\text{-}adj}\left(\frac{428{,}260\ mg}{kg}\right)\times ABS_d\times\left(\frac{10^{-6}\ kg}{1\ mg}\right)}{AT_{res}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)}$$

where:

$$DFSM_{res\text{-}adj}\left(\frac{428{,}260\ mg}{kg}\right)=\left(\begin{array}{l}\frac{ED_{0\text{-}2}\ (2\ years)\times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times AF_{0\text{-}2}\left(\frac{0.2\ mg}{cm^2}\right)\times SA_{0\text{-}2}\left(\frac{2{,}373\ cm^2}{day}\right)\times 10}{BW_{0\text{-}2}\ (15\ kg)}+\\ \frac{ED_{2\text{-}6}\ (4\ years)\times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times AF_{2\text{-}6}\left(\frac{0.2\ mg}{cm^2}\right)\times SA_{2\text{-}6}\left(\frac{2{,}373\ cm^2}{day}\right)\times 3}{BW_{2\text{-}6}\ (15\ kg)}+\\ \frac{ED_{6\text{-}16}\ (10\ years)\times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times AF_{6\text{-}16}\left(\frac{0.07\ mg}{cm^2}\right)\times SA_{6\text{-}16}\left(\frac{6{,}032\ cm^2}{day}\right)\times 3}{BW_{6\text{-}16}\ (80\ kg)}+\\ \frac{ED_{16\text{-}26}\ (10\ years)\times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times AF_{16\text{-}26}\left(\frac{0.07\ mg}{cm^2}\right)\times SA_{16\text{-}26}\left(\frac{6{,}032\ cm^2}{day}\right)\times 1}{BW_{16\text{-}26}\ (80\ kg)}\end{array}\right)$$

Mutagenic Ingestion

$$CDI_{res\text{-}soil\text{-}mu\text{-}ing}\left(\frac{mg}{kg\text{-}day}\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times IFSM_{res\text{-}adj}\left(\frac{166{,}833\ mg}{kg}\right)\times RBA\times\left(\frac{10^{-6}\ kg}{1\ mg}\right)}{AT_{res}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)}$$

where:

$$IFSM_{res\text{-}adj}\left(\frac{166{,}833\ mg}{kg}\right)=\left(\begin{array}{l}\frac{ED_{0\text{-}2}\ (2\ years)\times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times IRS_{0\text{-}2}\left(\frac{200\ mg}{day}\right)\times 10}{BW_{0\text{-}2}\ (15\ kg)}+\\ \frac{ED_{2\text{-}6}\ (4\ years)\times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times IRS_{2\text{-}6}\left(\frac{200\ mg}{day}\right)\times 3}{BW_{0\text{-}2}\ (15\ kg)}+\\ \frac{ED_{6\text{-}16}\ (10\ years)\times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times IRS_{6\text{-}16}\left(\frac{100\ mg}{day}\right)\times 3}{BW_{6\text{-}16}\ (80\ kg)}+\\ \frac{ED_{16\text{-}26}\ (10\ years)\times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times IRS_{16\text{-}26}\left(\frac{100\ mg}{day}\right)\times 1}{BW_{16\text{-}26}\ (80\ kg)}\end{array}\right)$$

Mutagenic Inhalation

$$C_{soil}\left(\frac{mg}{kg}\right)\times\left(\frac{1\ day}{24\ hours}\right)\times\left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)}+\frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)\times$$

$$CDI_{res\text{-}soil\text{-}mu\text{-}inh}\left(\mu g/m^3\right)=\frac{\left(\begin{array}{l}\left(ED_{0\text{-}2}\ (2\ years)\times EF_{0\text{-}2}\left(\frac{350\ days}{year}\right)\times ET_{0\text{-}2}\left(\frac{24\ hours}{day}\right)\times 10\right)+\\ \left(ED_{2\text{-}6}\ (4\ years)\times EF_{2\text{-}6}\left(\frac{350\ days}{year}\right)\times ET_{2\text{-}6}\left(\frac{24\ hours}{day}\right)\times 3\right)+\\ \left(ED_{6\text{-}16}\ (10\ years)\times EF_{6\text{-}16}\left(\frac{350\ days}{year}\right)\times ET_{6\text{-}16}\left(\frac{24\ hours}{day}\right)\times 3\right)+\\ \left(ED_{16\text{-}26}\ (10\ years)\times EF_{16\text{-}26}\left(\frac{350\ days}{year}\right)\times ET_{16\text{-}26}\left(\frac{24\ hours}{day}\right)\times 1\right)\end{array}\right)}{AT_{res}\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)\times\left(\frac{1\ mg}{1000\ \mu g}\right)}$$

428260 $DFSM_{res\text{-}adj}$ (mutagenic age-adjusted soil dermal factor) mg/kg	166833.3 $IFSM_{res\text{-}adj}$ (mutagenic age-adjusted soil ingestion factor) mg/kg

NOTES:

1. Input fields with a " " background are a required entry.
2. Input fields with a "light" background are calculated dynamically.

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Particulate Emission Factor Wind Driven

PEF Equation

$$PEF\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{Q}{C_{wind}}\left(\frac{\left(\frac{g}{m^2\cdot s}\right)}{\left(\frac{kg}{m^3}\right)}\right) \times \frac{3{,}600\left(\frac{s}{hour}\right)}{0.036\times(1-V)\times\left(\frac{U_m\left(\frac{m}{s}\right)}{U_t\left(\frac{m}{s}\right)}\right)^3 \times F(x)}$$

where:

$$\frac{Q}{C_{wind}} = A\times\exp\left[\frac{\left(\ln A_s\,(acre)-B\right)^2}{C}\right]$$

and:

$$\text{if } x<2,\ F(x) = 1.91267 - 0.0278085\,x + 0.48113\,x^2 - 1.09871\,x^3 + 0.336341\,x^4$$

$$\text{if } x\geq 2,\ F(x) = 0.18\left(8x^3+12x\right)e^{\left(-x^2\right)}$$

where:

$$x = 0.886\times\left(\frac{U_t}{U_m}\right)$$

Default — City (Climatic Zone) - Selection based on most likely climatic conditions for the site	11.32 U_t (equivalent threshold value)
0.5 A_s (acres)	0.5 V (fraction of vegetative cover) unitless
4.69 U_m (mean annual wind speed) m/s	[No Title]
16.2302 A (PEF Dispersion Constant)	0.194 F(x) (function dependent on U_m/U_t) unitless
18.7762 B (PEF Dispersion Constant)	1359344438 PEF (particulate emission factor) m^3/kg
216.108 C (PEF Dispersion Constant)	93.77 Q/C_{wind} (inverse of the ratio of the geometric mean air concentration to the emission flux at the center of a square source) g/m^2-s per kg/m^3

NOTES:

1. The Q/C_{wind} equation and the dispersion constants A, B and C were taken from Exhibit D-2 of the Supplemental Soil Screening Guidance.
2. A, B, C = PEF region-specific dispersion constants (unitless)

Volatilizatten Factor and Soll Saturation

Csat Equation

$$C_{sat}\left(\frac{mg}{kg}\right)=\frac{S\left(\frac{mg}{L}\right)}{\rho_b\left(\frac{kg}{L}\right)}\cdot\left(K_d\left(\frac{L}{kg}\right)\cdot\rho_b\left(\frac{kg}{L}\right)+\theta_w\left(\frac{L_{water}}{L_{soil}}\right)+H'\cdot\theta_a\left(\frac{L_{air}}{L_{soil}}\right)\right)$$

Kd( )=oc (2)" r (0.006) (oc) , organic compound i

Kd values for hor911nic 1:cmp9'indUate listed in theu 1u guide

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right)=n\left(\frac{L_{pore}}{L_{soil}}\right)-\theta_w\left(\frac{L_{water}}{L_{soil}}\right)$$

and

$$n=1-\left(\frac{\rho_b\left(\frac{kg}{L}\right)}{\rho_s\left(\frac{kg}{L}\right)}\right)$$

Diffusivity In air (Dia) Equation

$$D_{ia}\left(\frac{cm^2}{s}\right)=\frac{0.00229\cdot\left(T^{\circ}C+273.16\right)^{1.5}\cdot\sqrt{\left(0.034+\left(\frac{1}{MW\left(\frac{g}{mol}\right)}\right)\right)\cdot MW_{cor}}}{\left(\left(\frac{MW\left(\frac{g}{mol}\right)}{2.5\cdot\rho\left(\frac{g}{cm^3}\right)}\right)^{0.333}+1.8\right)^2}$$

where

Hypcally - 25° c

MWcor (1-0.0000'5 · MWai) If MWai ≥ IOS$ then 0.4 Ulen MWcor ,, $allo8.4

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o.[']-- +r(J (I)]

For dioxins, furans, and dioxin-like PCBs always use,

$$D_{ia}\left(\frac{cm^2}{s}\right)=\left(\frac{154\left(\frac{g}{mol}\right)}{MW\left(\frac{g}{mol}\right)}\right)^{0.5}\cdot 0.068\left(\frac{cm^2}{s}\right)$$

C_{sat} Equation

$$C_{sat}\left(\frac{mg}{kg}\right)=\frac{S\left(\frac{mg}{L}\right)}{\rho_b\left(\frac{kg}{L}\right)}\times\left(K_d\left(\frac{L}{kg}\right)\times\rho_b\left(\frac{kg}{L}\right)+\theta_w\left(\frac{L_{water}}{L_{soil}}\right)+H'\times\theta_a\left(\frac{L_{air}}{L_{soil}}\right)\right)$$

where:

$$K_d\left(\frac{L}{kg}\right)=K_{oc}\left(\frac{L}{kg}\right)\times f_{oc}\left(\frac{0.006\ g\text{-}carbon}{g\text{-}soil}\right),\ \text{for organic compounds;}$$

K_d values for inorganic compounds are listed in the user guide.

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right)=n\left(\frac{L_{pore}}{L_{soil}}\right)-\theta_w\left(\frac{L_{water}}{L_{soil}}\right)$$

and:

$$n=1-\left(\frac{\rho_b\left(\frac{kg}{L}\right)}{\rho_s\left(\frac{kg}{L}\right)}\right)$$

Diffusivity in air (D_{ia}) Equation

$$D_{ia}\left(\frac{cm^2}{s}\right)=\frac{0.00229\times\left(T^0C+273.16\right)^{1.5}\times\sqrt{0.034+\left(\frac{1}{MW\left(\frac{g}{mol}\right)}\right)}\times MW_{cor}}{\left(\left(\frac{MW\left(\frac{g}{mol}\right)}{2.5\times\rho\left(\frac{g}{cm^3}\right)}\right)^{0.333}+1.8\right)^2}$$

where:

T typically = 25°C

$MW_{cor}=\left(1-0.000015\times MW^2\right)$ If MW_{cor} is less than 0.4, then MW_{cor} is set to 0.4.

If density is not available use,

$$D_{ia}\left(\frac{cm^2}{s}\right)=1.9\times\left(MW\left(\frac{g}{mol}\right)^{-\left(\frac{2}{3}\right)}\right)$$

For dioxins, furans, and dioxin-like PCBs always use,

$$D_{ia}\left(\frac{cm^2}{s}\right)=\left(\frac{154\left(\frac{g}{mol}\right)}{MW\left(\frac{g}{mol}\right)}\right)^{0.5}\times 0.068\left(\frac{cm^2}{s}\right)$$

VF Unlimited Reservoir Equation - Method 1

unlimited source model for chronic exposure

$$VF_{ulim}\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{\frac{Q}{C_{vol}}\left(\frac{\left(\frac{g}{m^2\text{-}s}\right)}{\left(\frac{kg}{m^3}\right)}\right) \times \left(3.14 \times D_A\left(\frac{cm^2}{s}\right) \times T(s)\right)^{1/2} \times 10^{-4}\left(\frac{m^2}{cm^2}\right)}{2 \times \rho_b\left(\frac{g}{cm^3}\right) \times D_A\left(\frac{cm^2}{s}\right)}$$

where:

$$\frac{Q}{C_{vol}}\left(\frac{\left(\frac{g}{m^2\text{-}s}\right)}{\left(\frac{kg}{m^3}\right)}\right) = A \times \exp\left[\frac{\left(\ln A_s(acre) - B\right)^2}{C}\right]$$

where:

$$D_A\left(\frac{cm^2}{s}\right) = \frac{\left(\theta_a\left(\frac{L_{air}}{L_{soil}}\right)^{10/3} \times D_{ta}\left(\frac{cm^2}{s}\right) \times H' + \theta_w\left(\frac{0.15\,L_{water}}{L_{soil}}\right)^{10/3} \times D_{tw}\left(\frac{cm^2}{s}\right)\right) \Big/ n^2\left(\frac{L_{pore}}{L_{soil}}\right)}{\rho_b\left(\frac{1.5g}{cm^3}\right) \times K_d\left(\frac{cm^3}{g}\right) + \theta_w\left(\frac{0.15\,L_{water}}{L_{soil}}\right) + \theta_a\left(\frac{L_{air}}{L_{soil}}\right) \times H'}$$

where:

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right) = n\left(\frac{L_{pore}}{L_{soil}}\right) - \theta_w\left(\frac{0.15\,L_{water}}{L_{soil}}\right) \text{ and } n\left(\frac{L_{pore}}{L_{soil}}\right) = 1 - \left(\rho_b\left(\frac{1.5g}{cm^3}\right) \Big/ \rho_s\left(\frac{2.65\,g}{cm^3}\right)\right)$$

where:

$$K_d\left(\frac{L}{kg}\right) = K_{oc}\left(\frac{L}{kg}\right) \times f_{oc}\left(\frac{0.006\ g\text{-carbon}}{g\text{-soil}}\right), \text{ for organic compounds.}$$

K_d values for inorganic compounds are listed in the user guide.

0.006 foc (fraction organic carbon in soil) g/g	0.5 A_s (acres)
Default climatic conditions for the site	25 T_w (groundwater temperature) degrees Celsius
1.5 ρ_b (dry soil bulk density) g/cm^3	0.15 θ_w (water-filled soil porosity) L_{water}/L_{soil}
2.65 ρ_s (soil particle density) g/cm^3	819936000 T (exposure interval) s
11.911 A (VF Dispersion Constant)	0.43396 n (total soil porosity) L_{pore}/L_{soil}
18.4385 B (VF Dispersion Constant)	68.18 Q/C_{vol} (inverse of the ratio of the geometric mean air concentration to the emission flux at the center of a square source) g/m^2-s per kg/m^3
209.7845 C (VF Dispersion Constant)	0.28396 θ_a (air-filled soil porosity) L_{air}/L_{soil}

NOTES:

1. The Q/C_{vol} equation and the dispersion constants A, B and C were taken from Exhibit D-3 of the Supplemental Soil Screening Guidance.
2. θ_a(air-filled soil porosity) $L_{air}/L_{soil} = n\text{-}\theta_w$
3. H' (dimensionless Henry's law constant) - chemical-specific
4. n (total soil porosity) $L_{pore}/L_{soil} = 1\text{-}(\rho_b/\rho_s)$
5. K_d (soil-water partition coefficient) L/kg = $K_{oc} \times f_{oc}$ (organics) - chemical-specific
6. K_{oc} (soil organic carbon/water partition coefficient) L/kg - chemical specific

Volitization Factor - Mass Limit

VF Mass Limit Equation - Method 2

mass limit model for chronic exposure

$$VF_{mlim}\left(\frac{m^3_{air}}{kg_{soil}}\right) = \frac{Q}{C_{vol}}\left(\frac{\left(\frac{g}{m^2 \cdot s}\right)}{\left(\frac{kg}{m^3}\right)}\right) * \frac{\left[T\,(year) * \left(3.15 \times 10^7\left(\frac{s}{year}\right)\right)\right]}{\rho_b\left(\frac{mg}{m^3}\right) * d_s\,(m) * 10^6\left(\frac{g}{mg}\right)}$$

where

$$\frac{Q}{C_{vol}}\left(\frac{\left(\frac{g}{m^2 \cdot s}\right)}{\left(\frac{kg}{m^3}\right)}\right) = A * \exp\left[\frac{\left(\ln A_s\,(acre) - B\right)^2}{C}\right]$$

[ ] d_s (average source depth) m	0.5 A_s (acres)
Default City (Climatic Zone) - Selection based on most likely climatic conditions for the site	26 T (exposure interval) yr
1.5 ρ_b (dry soil bulk density) g/cm^3	
11.911 A (VF Dispersion Constant - Mass Limit)	68.18 Q/C_{vol} (inverse of the ratio of the geometric mean air concentration to the emission flux at the center of a square source) g/m^2-s per kg/m^3
18.4385 B (VF Dispersion Constant - Mass Limit)	
209.7845 C (VF Dispersion Constant - Mass Limit)	VF_{mlim} (volitization factor) m^3/kg

NOTES:

1. Enter values for the missing variables in this section if you would like to use the VF Method 2 equation.
2. The Q/C_{vol} equation and the dispersion constants A, B and C were taken from Exhibit D-3 of the Supplemental Soil Screening Guidance.
3. The VF equation is from Equation 4-13 in the Supplemental Soil Screening Guidance.
4. t_s (hr) = T(s) per Equation E-16 in the Supplemental Soil Screening Guidance.
5. Mg = megagram

Appendix 5.
RBSL and SSTL Equations

Table A.2: RBSL and SSTL Equations Used in the RBCA Tool Kit

GROUNDWATER EXPOSURE PATHWAY	
Groundwater Ingestion	
Carcinogens: $RBSL_{GW} = \frac{TR \cdot BW \cdot AT_C \cdot 365 days/yr}{SF_o \cdot EF \cdot ED \cdot IR_w}$ Non-Carc.: $RBSL_{GW} = \frac{THQ \cdot RfD_o \cdot BW \cdot AT_n \cdot 365 days/yr}{EF \cdot ED \cdot IR_w}$	$SSTL_{GW} = RBSL_{GW} \cdot DAF$
Soil Leaching to Groundwater → Groundwater Ingestion	
Carcinogens: $RBSL_S = \frac{TR \cdot BW \cdot AT_C \cdot 365 days/yr}{SF_o \cdot EF \cdot ED \cdot IR_w \cdot LF}$ Non-Carc.: $RBSL_S = \frac{THQ \cdot RfD_o \cdot BW \cdot AT_n \cdot 365 days/yr}{EF \cdot ED \cdot IR_w \cdot LF}$	$SSTL_S = RBSL_S \cdot DAF$
SOIL EXPOSURE PATHWAY	
Surface Soil Combined Exposure	
$RBSL_{SS} = \left[\frac{1}{{}^{ss}RBSL_{Ingest}} + \frac{1}{{}^{ss}RBSL_{Dermal}} + \frac{1}{{}^{ss}RBSL_{Inhal}} + \frac{1^*}{{}^{ss}RBSL_{Veg}} \right]^{-1}$ *Vegetable ingestion applies to residential receptors only. This term equals zero for any non-residential receptor.	$SSTL_{SS} = RBSL_{SS}$ (No lateral transport; receptor at source)
Surface Soil Ingestion	
Carcinogens: ${}^{ss}RBSL_{Ingest} = \frac{TR \cdot BW \cdot AT_C \cdot 365 days/yr}{SF_o \cdot EF \cdot ED \cdot IR_s \cdot RBAF \cdot 10^{-6} kg/mg}$ Non-Carcinogens: ${}^{ss}RBSL_{Ingest} = \frac{THQ \cdot RfD_o \cdot BW \cdot AT_n \cdot 365 days/yr}{EF \cdot ED \cdot IR_s \cdot RBAF \cdot 10^{-6} kg/mg}$	
Dermal Contact with Surface Soils	
Carcinogens: ${}^{ss}RBSL_{Dermal} = \frac{TR \cdot BW \cdot AT_C \cdot 365 days/yr}{SF_o \cdot EF \cdot ED \cdot SA \cdot M \cdot RAF_d \cdot 10^{-6} kg/mg}$ Non-Carcinogens: ${}^{ss}RBSL_{Dermal} = \frac{THQ \cdot RfD_o \cdot BW \cdot AT_n \cdot 365 days/yr}{EF \cdot ED \cdot SA \cdot M \cdot RAF_d \cdot 10^{-6} kg/mg}$ $RAF_d = ABS_d / ABS_{GI}$	

(continued)

Table A.2: RBSL and SSTL Equations Used in the RBCA Tool Kit ***(continued)***

SOIL EXPOSURE PATHWAY

Outdoor Inhalation of Vapors and Particulates from Surface Soils

Carcinogens:
$$^{ss}RBSL_{Inhal} = \frac{TR \cdot AT_C \cdot 365\ days/yr}{EF \cdot ED \cdot URF \cdot 1000 \mu g/mg \cdot (VF_{ss} + PEF)}$$

Non-Carcinogens:
$$^{ss}RBSL_{Inhal} = \frac{THQ \cdot RfC \cdot AT_n}{EF \cdot ED \cdot (VF_{ss} + PEF)}$$

Consumption of Vegetables Grown in Surface Soils (Residential Land Use Only)

Organic COCs*:
$$^{ss}RBSL_{Veg} = K_{sw} \cdot \left[\frac{RCF \cdot VG_{bg}}{RBEL_{BgVeg}} + \frac{LCF \cdot VG_{abg}}{RBEL_{AbgVeg}} \right]^{-1}$$

$$RCF = 10^{[(0.77 \log K_{ow}) - 1.52]} + 0.82$$

$$LCF = \left(0.784 \cdot 10^{\left[-0.434(\log K_{ow} - 1.78)^2 / 2.44 \right]} \right) \times \left(0.82 + 10^{\left[0.95 \log K_{ow} - 2.05 \right]} \right)$$

** For organic COCs vegetable ingestion applies only to those COCs for which Kow > log $K_{ow,min}$ and H < H_{max}, where these limits are defined by the user.*

Inorganic COCs:
$$^{ss}RBSL_{Veg} = \left[\frac{Br_{Abg}}{RBEL_{AbgVeg}} + \frac{Br_{Bg}}{RBEL_{BgVeg}} \right]^{-1}$$

Carcinogens:
$$RBEL_{AbgVeg} = \frac{TR \cdot BW \cdot AT_C \cdot 365\ days/yr}{SF_o \cdot EF \cdot ED \cdot IR_{abg}}$$

$$RBEL_{BgVeg} = \frac{TR \cdot BW \cdot AT_C \cdot 365\ days/yr}{SF_o \cdot EF \cdot ED \cdot IR_{bg}}$$

Non-Carcinogens:
$$RBEL_{AbgVeg} = \frac{THQ \cdot RfD_o \cdot BW \cdot AT_n \cdot 365\ days/yr}{EF \cdot ED \cdot IR_{abg}}$$

$$RBEL_{BgVeg} = \frac{THQ \cdot RfD_o \cdot BW \cdot AT_n \cdot 365\ days/yr}{EF \cdot ED \cdot IR_{bg}}$$

(continued)

Table A.2: RBSL and SSTL Equations Used in the RBCA Tool Kit *(continued)*

OUTDOOR AIR EXPOSURE PATHWAY	
Subsurface Soil Volatilization → Ambient Air	
Carcinogens : $RBSL_S = \frac{TR \cdot AT_C \cdot 365\ days/yr}{EF \cdot ED \cdot URF \cdot 1000\mu g/mg \cdot VF_{samb}}$ Non-Carcinogens: $RBSL_S = \frac{THQ \cdot RfC \cdot AT_n \cdot 365\ days/yr}{EF \cdot ED \cdot VF_{samb}}$	$SSTL_S = RBSL_S \cdot ADF$
Groundwater Volatilization → Ambient Air	
Carcinogens : $RBSL_{GW} = \frac{TR \cdot AT_C \cdot 365\ days/yr}{EF \cdot ED \cdot URF \cdot 1000\mu g/mg \cdot VF_{wamb}}$ Non-Carcinogens: $RBSL_{GW} = \frac{THQ \cdot RfC \cdot AT_n \cdot 365\ days/yr}{EF \cdot ED \cdot VF_{wamb}}$	$SSTL_{GW} = RBSL_{GW} \cdot ADF$
INDOOR AIR EXPOSURE PATHWAY	
Subsurface Soil Volatilization → Enclosed Space	
Carcinogens : $RBSL_S = \frac{TR \cdot AT_C \cdot 365\ days/yr}{EF \cdot ED \cdot URF \cdot 1000\mu g/mg \cdot VF_{sesp}}$ Non-Carcinogens: $RBSL_S = \frac{THQ \cdot RfC \cdot AT_n \cdot 365\ days/yr}{EF \cdot ED \cdot VF_{sesp}}$	$SSTL_{GW} = RBSL_{GW}$ *(No lateral transport; receptor at source.)*
Groundwater Volatilization → Enclosed Space	
Carcinogens: $RBSL_{GW} = \frac{TR \cdot AT_C \cdot 365\ days/yr}{EF \cdot ED \cdot URF \cdot 1000\mu g/mg \cdot VF_{wesp}}$ Non-Carcinogens: $RBSL_{GW} = \frac{THQ \cdot RfC \cdot AT_n \cdot 365\ days/yr}{EF \cdot ED \cdot VF_{wesp}}$	$SSTL_{GW} = RBSL_{GW}$ *(No lateral transport; receptor at source.)*
SURFACE WATER EXPOSURE PATHWAY	
Groundwater Discharge to Surface Water → Swimming and Fish Consumption	
RBSL not applicable. *(Receptor located away from source.)*	Carc.: $SSTL_{GW} = \frac{TR \cdot BW \cdot AT_C \cdot 365\ days/yr \cdot DAF \cdot DF_{gw-sw}}{ED \cdot \left[(SF_o \cdot EV \cdot ET \cdot IR_{sw}) + (SF_d \cdot EV \cdot SA_{sw} \cdot Z) + (SF_o \cdot IR_{fish} \cdot FI_{fish} \cdot BCF)\right]}$ Non-Carc.: $SSTL_{GW} = \frac{THQ \cdot BW \cdot AT_n \cdot 365\ days/yr \cdot DAF \cdot DF_{gw-sw}}{ED \cdot \left[\left(\frac{EV \cdot ET \cdot IR_{sw}}{RfD_o}\right) + \left(\frac{EV \cdot SA_{sw} \cdot Z}{RfD_d}\right) + \left(\frac{IR_{fish} \cdot FI_{fish} \cdot BCF}{RfD_o}\right)\right]}$
Soil Leaching to Groundwater → Groundwater Discharge to Surface Water→ Swimming and Fish Consumption	
RBSL not applicable. *(Receptor located away from source.)*	Carc: $SSTL_S = \frac{TR \cdot BW \cdot AT_C \cdot 365\ days/yr \cdot DAF \cdot DF_{gw-sw}}{ED \cdot \left[(SF_o \cdot EV \cdot ET \cdot IR_{sw}) + (SF_d \cdot EV \cdot SA_{sw} \cdot Z) + (SF_o \cdot IR_{fish} \cdot FI_{fish} \cdot BCF)\right]} \cdot LF$ Non-Carc.: $SSTL_S = \frac{THQ \cdot BW \cdot AT_n \cdot 365\ days/yr \cdot DAF \cdot DF_{gw-sw}}{ED \cdot \left[\left(\frac{EV \cdot ET \cdot IR_{sw}}{RfD_o}\right) + \left(\frac{EV \cdot SA_{sw} \cdot Z}{RfD_d}\right) + \left(\frac{IR_{fish} \cdot FI_{fish} \cdot BCF}{RfD_o}\right)\right]} \cdot LF$

(continued)

Table A.2: RBSL and SSTL Equations Used in the RBCA Tool Kit *(continued)*

SURFACE WATER EXPOSURE PATHWAY

Groundwater Discharge to Surface Water → Aquatic Life Protection

RBSL not applicable. *(Receptor located away from source.)*	Carcinogens: $SSTL_{GW} = AQL \cdot DAF \cdot DF_{gw-sw}$
	Non-Carcinogens: $SSTL_{GW} = AQL \cdot DAF \cdot DF_{gw-sw}$

Soil Leaching to Groundwater → Groundwater Discharge to Surface Water → Aquatic Life Protection

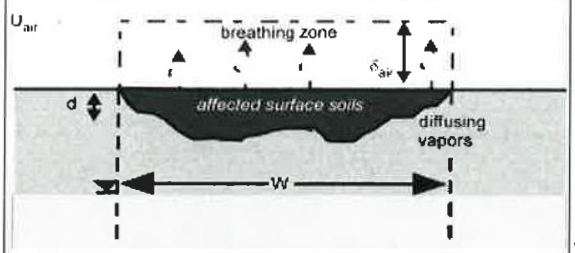
RBSL not applicable. *(Receptor located away from source.)*	Carcinogens: $SSTL_S = \frac{AQL \cdot DAF \cdot DF_{gw-sw}}{LF}$
	Non-Carcinogens: $SSTL_S = \frac{AQL \cdot DAF \cdot DF_{gw-sw}}{LF}$

PARAMETER DEFINITIONS

ABS_d	Dermal absorption factor (unitless)	RAF_d	Relative absorption factor for soil dermal contact (unitless)
ABS_{GI}	Gastrointestinal absorption factor (unitless)	RDAF	Relative bioavailability factor (unitless)
ADF	Lateral air dispersion factor (unitless)	RBEL	Risk-based exposure limit for exposure medium.
AF	Soil-to-skin adherence factor (mg/cm^2-d)	$RBSL_{gw}$	Risk-based screening level for groundwater (mg/L)
AQL	Aquatic protection criteria (mg/L)	$RBSL_s$	Risk-based screening level for soil (mg/kg)
AT_C	Averaging time - carcinogens (yr)	$RBSL_{ss}$	Risk-based screening level for surface soil (mg/kg)
AT_n	Averaging time -non-carcinogens (yr)	RCF	Ratio of concentration in roots to concentration in soil pore water (mg/kg-veg) / (mg/L-water)
BCF	Bioconcentration factor (mg/kg-fish)/(mg/L-water	RfC	Reference concentration (mg/m^3)
Br_{Abg}	Soil-to-above-ground biotransfer factor (kg-soil/kg-dry plant tissue)	RfD_d	Chronic dermal reference dose (mg/kg/d)
Br_{Bg}	Soil-to-below-ground biotransfer factor (kg-soil/kg-dry plant tissue)	RfD_o	Chronic oral reference dose (mg/kg/d)
BW	Body weight (kg)	SA	Skin surface area for soil dermal contact (cm^2)
DAF	Lateral groundwater dilution-attenuation factor (unitless)	SA_{sw}	Skin surface area for swimming dermal contact (cm^2)
DF_{gw-sw}	Groundwater to surface water dilution factor (unitless)	SF_d	Dermal slope factor (mg/kg/day)$^{-1}$
ED	Exposure duration (yr)	SF_o	Oral slope factor (mg/kg/day)$^{-1}$
EF	Exposure frequency (d/yr)	$SSTL_{gw}$	Site-specific target level for groundwater (mg/L)
ET	Exposure time (hr/event)	$SSTL_s$	Site-specific target level for soil (mg/kg)
EV	Event frequency (events/yr)	$SSTL_{ss}$	Site-specific target level for surface soil (mg/kg)
FI_{fish}	Fraction of ingested fish from affected surface water (unitless)	THQ	Target Hazard Quotient
IR_{abg}	Above-ground vegetable ingestion rate	TR	Target Risk
IR_{bg}	Below-ground vegetable ingestion rate	URF	Unit Risk factor (mg/m^3)$^{-1}$
IR_{fish}	Rate of fish consumption (kg/yr)	VF_{samb}	Subsurface soil to ambient air volatilization factor (mg/m^3-air) / (mg/kg-soil)
IR	Soil Ingestion rate (kg/day)	VF	Subsurface soil to enclosed space volatilization factor (mg/m^3-air) / (mg/kg-soil)
IR_{sw}	Water Ingestion rate while swimming (L/hr)	VF_{ss}	Surface soil to ambient air volatilization factor (mg/m^3-air) / (mg/kg-soil)
IR_w	Water Ingestion rate while swimming (L/hr) Water Ingestion rate while swimming (L/hr)	VF_{wamb}	GW to ambient air volatilization factor (mg/m^3-air) / (mg/L-water)
K_{sw}	Soil leachate partition factor (mg/L-water) / (mg/kg-soil)	VF_{wesp}	GW to enclosed space volatilization factor (mg/m^3-air) / (mg/L-water)
LCF	Leaf Concentration Factor (mg/kg-veg)/(mg/L-water)	VG_{abg}	Above-ground vegetable correction factor (unitless)
LF	Soil-to-GW leaching factor (mg/L-water)/(mg/kg-soil)	VG_{bg}	Below-ground vegetable correction factor (unitless)
M	Soil to skin adherence factor (mg/cm^2/day)Soil-to-GW leaching factor (mg/L-water)/(mg/kg-soil)	Z	Water to skin dermal absorption factor (cm/event)
PEF	Particulate emission factor (mg/m^3-air) / (mg/kg-soil)		

Appendix 6.
Cross-Media Lateral Transfer and Lateral Transport Equations

Surface Soil Volatilization Factor (VF_{ss})



USEPA Q/C Model:

CM-1a:

$$VF_{ss}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right]=\frac{2\rho_s}{(Q/C)}\sqrt{\frac{D_s^{eff}H}{\pi\tau\left(\theta_{ws}+k_s\rho_s+H\theta_{as}\right)}}\times10^4$$

or CM-1b:

$$VF_{ss}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right]=\frac{\rho_s d}{(Q/C)\tau}\times10^4$$

whichever is less

ASTM Model:

CM-1c:

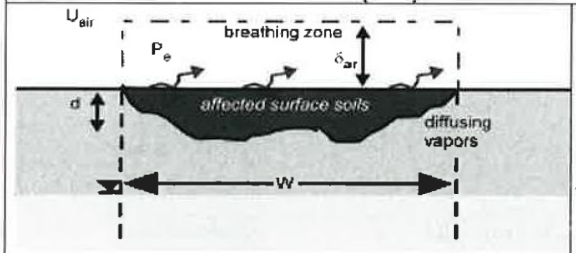
$$VF_{ss}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right]=\frac{2W\rho_s}{U_{air}\delta_{air}}\sqrt{\frac{D_s^{eff}H}{\pi\tau\left(\theta_{ws}+k_s\rho_s+H\theta_{as}\right)}}\times10^3$$

or CM-1d:

$$VF_{ss}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right]=\frac{W\rho_s d}{U_{air}\delta_{air}\tau}\times10^3$$

whichever is less

Soil Particulate Emission Factor (PEF)



USEPA Q/C Model:

CM-2a:

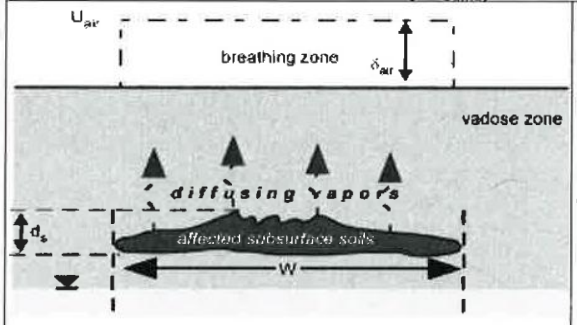
$$PEF\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right]=\frac{(1-V)\left(\frac{U_m}{U_t}\right)^3F(x)}{Q/C}\times10^{-5}$$

ASTM Model:

CM-2b

$$PEF\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right]=\frac{P_e W}{U_{air}\delta_{air}}\times10^3$$

Subsurface Soil Volatilization Factor (VF_{samb})



CM-3a:

$$VF_{samb}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right]=\frac{H\rho_s}{\left[\theta_{ws}+k_s\rho_s+H\theta_{as}\left[1+\frac{U_{air}\delta_{air}L_s}{D_s^{eff}W}\right]\right.}\times10^3$$

or CM-3b:

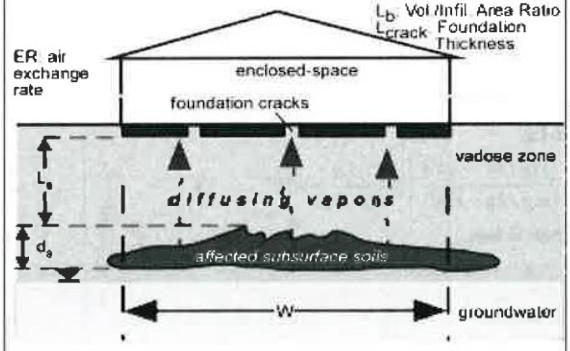
$$VF_{samb}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right]=\frac{W\rho_s d_s}{U_{air}\delta_{air}\tau}\times10^3$$

whichever is less

Figure B.2: Cross-Media Transfer Factors in the RBCA Tool Kit ***(continued)***

continued

Subsurface Soil to Enclosed Space Volatilization Factor (VF_{sesp})



CM-4a:

For $Q_s = 0$:

$$VF_{sesp}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right] = \frac{\frac{H\rho_s}{[\theta_{ws}+k_s\rho_s+H\theta_{as}]}\left[\frac{D_s^{eff}/L_s}{ER\,L_B}\right]}{1+\left[\frac{D_s^{eff}/L_s}{ER\,L_B}\right]+\left[\frac{D_s^{eff}/L_s}{(D_{crack}^{eff}/L_{crack})\cdot\eta}\right]}\times 10^3$$

For $Q_s > 0$:

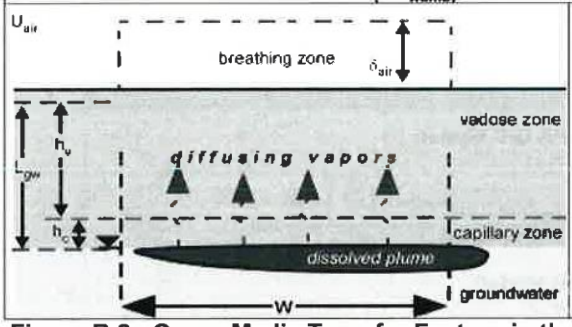
$$VF_{sesp}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right] = \frac{\frac{H\rho_s}{[\theta_{ws}+k_s\rho_s+H\theta_{as}]}\left[\frac{D_s^{eff}/L_s}{ER\,L_B}\right]e^{\xi}}{e^{\xi}+\left[\frac{D_s^{eff}/L_s}{ER\,L_B}\right]+\left[\frac{D_s^{eff}/L_s}{(Q_s/A_b)}\right]\left[e^{\xi}-1\right]}\times 10^3$$

or CM-4b:

$$VF_{sesp}\left[\frac{(mg/m^3-air)}{(mg/kg-soil)}\right] = \frac{\rho_s d_s}{L_B ER\tau}\times 10^3$$

whichever is less

Groundwater Volatilization Factor (VF_{wamb})



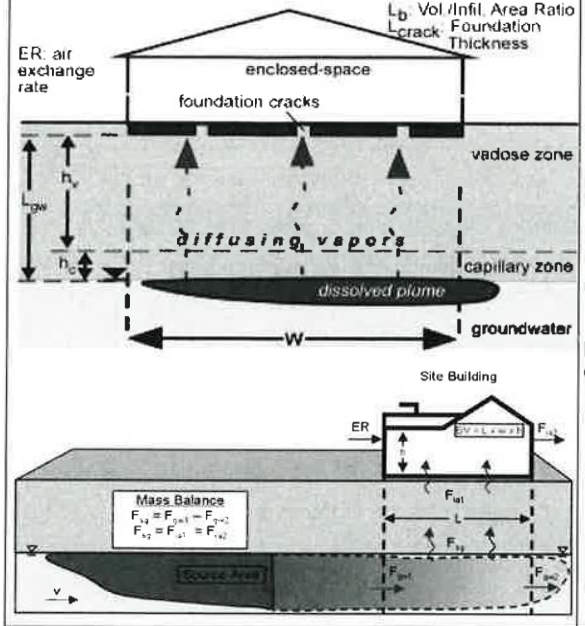
CM-5:

$$VF_{wamb}\left[\frac{(mg/m^3-air)}{(mg/L-H_2O)}\right] = \frac{H}{1+\left[\frac{U_{air}\,\delta_{air}\,L_{GW}}{D_{ws}^{eff}\,W}\right]}\times 10^3$$

Figure B.2: Cross-Media Transfer Factors in the RBCA Tool Kit ***(continued)***

continued

Groundwater to Enclosed Space Volatilization Factor (VF_{wesp})



Johnson-Ettinger Model:

CM-6a:

For $Q_s = 0$:

$$VF_{wesp}\left[\frac{(mg/m^3-air)}{(mg/L-H_2O)}\right]=\frac{H\left[\frac{D_{ws}^{eff}/L_{GW}}{ER\,L_B}\right]}{1+\left[\frac{D_{ws}^{eff}/L_{GW}}{ER\,L_B}\right]+\left[\frac{D_{ws}^{eff}/L_{GW}}{(D_{crack}^{eff}/L_{crack})\cdot\eta}\right]}\times 10^3$$

For $Q_s > 0$:

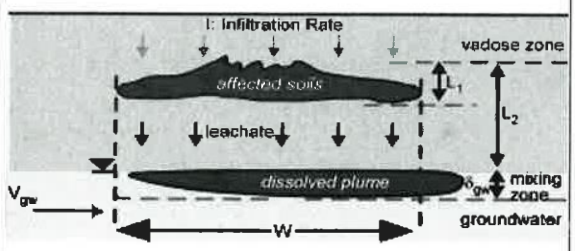
$$VF_{wesp}\left[\frac{(mg/m^3-air)}{(mg/L-H_2O)}\right]=\frac{H\left[\frac{D_{ws}^{eff}/L_{GW}}{ER\,L_B}\right]e^{\xi}}{e^{\xi}+\left[\frac{D_{ws}^{eff}/L_{GW}}{ER\,L_B}\right]+\left[\frac{D_{ws}^{eff}/L_{GW}}{Q_s/A_b}\right]\left[e^{\xi}-1\right]}\times 10^3$$

Mass Flux Model:

CM-6b:

$$VF_{wesp}\left[\frac{(mg/m^3-air)}{(mg/L-H_2O)}\right]=\frac{2wn\sqrt{\frac{D_s Lv}{\pi}}}{BV\cdot ER}$$

Soil to Groundwater Leaching Factor (LF)



CM-7:

$$LF\left[\frac{(mg/L-H_2O)}{(mg/kg-soil)}\right]=\frac{K_{SW}\cdot SAM}{LDF}$$

Soil-Water Partition Factor:

CM-8:

$$K_{sw}\left[\frac{(mg/L-H_2O)}{(mg/kg-soil)}\right]=\frac{\rho_s}{\theta_{ws}+k_s\rho_s+H\theta_{as}}$$

Soil Attenuation Model Factor (Optional):

CM-9:

$$SAM\,[dimensionless]=\frac{L_1}{L_2}$$

Leachate Dilution Factor

CM-10:

$$LDF\,[dimensionless]=1+\frac{V_{gw}\delta_{gw}}{I\cdot W}$$

Mixing Zone Thickness Estimation (Optional)

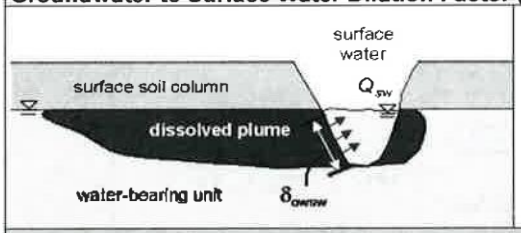
CM-11:

$$\delta_{gw}=\min\left\{b,0.10583\cdot W+b\left[1+\exp\left(\frac{-I\cdot W}{V_{gw}\cdot b}\right)\right]\right\}$$

Figure B.2: Cross-Media Transfer Factors in the RBCA Tool Kit ***(continued)***

continued

Groundwater to Surface Water Dilution Factor (DF_{gwsw})



CM-12:

$$DF_{gwsw} = \left[1 + \frac{Q_{sw}}{V_{gw}\delta_{sw}W_{gwsw}}\right]^{-1}$$

Soil-Water Sorption/Desorption

Linear Sorption/Desorption:

Organics: $k_s = k_{oc} f_{oc}$

Inorganics: $k_s = k_d$

Dual-Equilibrium Desorption (option for organics only):
CM-13:

$$k_s^{DED} = k_{oc} f_{oc} + \frac{k_{oc}^{2nd} f_{oc} C_{s,\max}^{2nd}}{C_{s,\max}^{2nd} + k_{oc}^{2nd} f_{oc} C_L}$$

$$C_{s,\max}^{2nd} = f_{oc} \cdot \left(k_{ow} C_{sol}\right)^{0.534}$$

$$k_{oc}^{2nd} = 10^{5.92}$$

Effective Diffusion Coefficients

Effective diffusivity in vadose zone soils:

$$D_s^{eff}\left[\frac{cm^2}{s}\right] = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + \left[\frac{D^{wat}}{H}\right]\left[\frac{\theta_{ws}^{3.33}}{\theta_T^2}\right]$$

Effective diffusivity above the water table:

$$D_{ws}^{eff}\left[\frac{cm^2}{s}\right] = \left(h_c + h_v\right)\left[\frac{h_c}{D_{cap}^{eff}} + \frac{h_v}{D_s^{eff}}\right]^{-1}$$

Effective diffusivity through foundation cracks:

$$D_{crack}^{eff}\left[\frac{cm^2}{s}\right] = D^{air}\frac{\theta_{acrack}^{3.33}}{\theta_T^2} + \left[\frac{D^{wat}}{H}\right]\left[\frac{\theta_{wcrack}^{3.33}}{\theta_T^2}\right]$$

Effective diffusivity in the capillary zone:

$$D_{cap}^{eff}\left[\frac{cm^2}{s}\right] = D^{air}\frac{\theta_{acap}^{3.33}}{\theta_T^2} + \left[\frac{D^{wat}}{H}\right]\left[\frac{\theta_{wcap}^{3.33}}{\theta_T^2}\right]$$

Convective Air Flow Through Foundation Cracks

$$\xi = \frac{Q_s / A_b}{\left(D_{crack}^{eff} / L_{crack}\right)\cdot\eta}$$

$$Q_s = \frac{2\pi\,\Delta p\, k_v\, X_{crack}}{\mu_{air}\ln\left[\frac{2\,Z_{crack}\,X_{crack}}{A_b\,\eta}\right]}$$

Figure B.2: Cross-Media Transfer Factors in the RBCA Tool Kit ***(continued)***

continued

Definitions for Cross-Media Transfer Equations

A_b	Area of building foundation (m^2)	Q_{sw}	Surface water flow rate at groundwater-to-surface water discharge (cm^3/s)
b	Aquifer saturated thickness (m)	U_{air}	Wind speed above ground surface in ambient mixing zone (m/s)
BV	Building volume (m^3)	V_{gw}	Groundwater Darcy velocity (cm/day)
C_L	Concentration of contaminant in leachate (mg/L)	v	Groundwater seepage velocity (cm/day)
C_{sol}	Aqueous Solubility (mg/L)	W	Width of source area parallel to groundwater flow direction (m)
D_a	Apparent diffusion coefficient (m^2/day)	w	Building width perpendicular to GW flow (m)
D^{air}	Diffusion coefficient in air (cm^2/s)	W_{gwsw}	Width of groundwater-to-surface water discharge (m)
D^{wat}	Diffusion coefficient in water (cm^2/s)	X_{crack}	Enclosed space foundation perimeter (cm) • Residential land use • Commercial land use
d_s	Thickness of affected subsurface soils (m)	Z_{crack}	Depth to base of enclosed space foundation (m)
ER	Enclosed-space air exchange rate (l/s) • Residential land use • Commercial land use	δ_{sw}	thickness of affected groundwater to surface water discharge (m)
f_{oc}	Fraction of organic carbon in soil (g-C/g-soil)	Δp	Differential indoor/outdoor air pressure ($g/cm\text{-}s^2$) • Residential land use • Commercial land use
H	Henry's law constant (cm^3-H_2O)/(cm^3-air)	δ_{air}	Ambient air mixing zone height (m)
h_c	Thickness of capillary fringe (cm)	δ_{gw}	Groundwater mixing zone thickness (cm)
h_v	Thickness of vadose zone (m)	η	Areal fraction of cracks in foundations/walls (cm^2-cracks/cm^2-total area)
I	Infiltration rate of water through soil (cm/year)	θ_{acap}	Volumetric air content in capillary fringe soils (cm^3-air/cm^3-soil)
k_d	Soil / water distribution coefficient (= K_{oc} * f_{oc}, cm^3/g)	θ_{acrack}	Volumetric air content in foundation/wall cracks (cm^3-air/cm^3 total volume)
K_{ow}	Octanol/Water Partitioning Coefficient	θ_{as}	Volumetric air content in vadose zone soils (cm^3-air/cm^3-soil)
k_{oc}	Carbon-water sorption coefficient (g-H_2O/g-C)	θ_T	Total soil porosity (cm^3-pore-space/ cm^3-soil)
k_s	Soil-water sorption coefficient = foc * koc (g-H_2O/g-soil)	θ_{wcap}	Volumetric water content in capillary fringe soils (cm^3-H_2O/cm^3-soil)
K_{sw}	Soil- Water Partition Factor (mg/L- water)/ (mg/kg-soil)	θ_{wcrack}	Volumetric water content in foundation/wall cracks (cm^3-H_2O)/cm^3 total volume)
K_v	Soil vapor permeability (m^2)	θ_{ws}	Volumetric water content in vadose zone soils (cm^3-H_2O/cm^3-soil)
L_B	Enclosed space volume/infiltration area ratio (m) • Residential land use • Commercial land use	ρ_s	Soil bulk density (kg-soil/L-soil)
L_{crack}	Enclosed space foundation or wall thickness (m)	τ	Averaging time for vapor flux (yr)
L_{GW}	Depth to groundwater = h_{cap} + h_v (m)		
L_s	Depth to subsurface soil sources (m)		
L	Building length parallel to GW flow [m]		
L_1	Thickness of affected soils (m)		
L_2	Distance from top of affected soils to top of water-bearing unit = LGW - L_S (m)		
n	Porosity of saturated aquifer [unitless]		
P_e	Particulate emission rate (g/cm^2-s)		

CS = Chemical-specific value. SS = Soil Type/Site Specific

Figure B.2: Cross-Media Transfer Factors in the RBCA Tool Kit

VF_{SS}: Surface Soil Volatilization Factor (Equation CM-1)

The surface volatilization factor is the steady-state ratio of the predicted concentration of an organic constituent in the ambient air breathing zone to the source concentration in the surface soil. The surface volatilization factor incorporates two cross-media transfer elements: i) organic vapor flux from the surface soil mass to ground surface, and ii) mixing of soil vapors in the ambient air breathing zone directly over the affected surface soil. For each site, the applicable VF_{ss} value corresponds to the lesser result of two calculation methods (flux-based vs. mass balance limited; corresponding to Eqns. CM-1a/c and CM-1b/d on Figure B.2). Equations CM-1a and CM-1c typically control for low-volatility compounds, as they assume there is an infinite source of chemical in the surface soils and uses a volatilization rate based primarily on chemical properties. Equations CM-1b/d, which typically control for volatile organic compounds (VOCs), are based on a mass balance approach. In these equations, a finite amount of chemical is assumed to be present in the surface soil (based on the representative COC concentration), volatilizing at a constant rate over the duration of the exposure period (e.g., 25-30 years). Both expressions account for the dilution of chemicals in ambient air above the source zone due to mixing with ambient air moving across the site. A simple box model is used for this dilution

Appendix 7.
Chemical-Specific Data for DERBCAP Chemicals of Concern

CHEMICAL DATA FOR SELECTED COCs

Physical Property Data

Orange = One or more parameter differs from User Chemical Database

Constituent	CAS Number	Type	Molecular Weight (g/mole)		Aqueous Solubility (@ 20 - 25 C) (mg/L)		Soil Saturation Limit Calculated (mg/kg)	Vapor Pressure (@ 20 - 25 C) (mm Hg)		Henry's Constant (@ 20 - 25 C) (unitless)		log (Koc) or log (Kd) (@ 20 - 25 C) log(L/kg)		
Benzene	71-43-2	O	78.11364	TX09	1770	TX09	1.35E+03	9.50E+01	TX09	2.27E-01	TX09	1.82E+00	Koc	TX09
Toluene	108-88-3	O	92.14052	TX09	530	TX09	7.99E+02	2.82E+01	TX09	2.76E-01	TX09	2.15E+00	Koc	TX09
Ethyl benzene	100-41-4	O	106.1674	TX09	169	TX09	3.64E+02	9.60E+00	TX09	3.28E-01	TX09	2.31E+00	Koc	TX09
Xylenes (mixed isomers)	1330-20-7	O	106.1674	TX09	198	TX09	4.97E+02	8.06E+00	TX09	2.93E-01	TX09	2.38E+00	Koc	TX09
Cumene	98-82-8	O	120.19428	TX09	50	TX09	1.74E+03	4.60E+00	TX09	6.07E-01	TX09	3.54E+00	Koc	TX09
Methyl t-Butyl ether (MTBE)	1634-04-4	O	88.14968	TX09	48000	TX09	1.02E+04	2.49E+02	TX09	2.44E-02	TX09	1.15E+00	Koc	TX09
Benz-a-anthracene	56-55-3	O	228.29328	TX09	0.01	TX09	3.55E+01	1.54E-07	TX09	1.39E-04	TX09	5.55E+00	Koc	TX09
Benzo-a-pyrene	50-32-8	O	252.31528	TX09	0.00162	TX09	1.55E+01	4.89E-09	TX09	4.70E-05	TX09	5.98E+00	Koc	TX09
Benzo-b-fluoranthene	205-99-2	O	252.31528	TX09	0.0015	TX09	1.80E+01	8.06E-08	TX09	4.99E-04	TX09	6.08E+00	Koc	TX09
Benzo-k-fluoranthene	207-08-9	O	252.31528	TX09	0.00055	TX09	6.77E+00	9.59E-11	TX09	4.45E-07	TX09	6.09E+00	Koc	TX09
Chrysene	218-01-9	O	228.29328	TX09	0.002	TX09	6.18E+00	7.80E-09	TX09	5.03E-05	TX09	5.49E+00	Koc	TX09
Indeno-1,2,3-cd-pyrene	193-39-5	O	276.33728	TX09	0.003750667	TX09	1.30E+02	1.40E-10	TX09	2.85E-06	TX09	6.54E+00	Koc	TX09
Acenaphthene	83-32-9	O	154.2114	TX09	4.24	TX09	1.69E+02	3.75E-03	TX09	6.44E-03	TX09	3.60E+00	Koc	TX09
Anthracene	120-12-7	O	178.2334	TX09	0.0434	TX09	1.02E+01	2.55E-05	TX09	4.61E-03	TX09	4.37E+00	Koc	TX09
Fluoranthene	206-44-0	O	202.2554	TX09	0.26	TX09	1.27E+02	8.13E-06	TX09	3.88E-04	TX09	4.69E+00	Koc	TX09
Fluorene	86-73-7	O	166.2224	TX09	1.98	TX09	1.50E+02	3.24E-03	TX09	2.64E-03	TX09	3.88E+00	Koc	TX09
Phenanthrene	85-01-8	O	178.2334	TX09	0.994	TX09	1.40E+02	6.80E-04	TX09	5.40E-03	TX09	4.15E+00	Koc	TX09
Pyrene	129-00-0	O	202.2554	TX09	0.135	TX09	5.13E+01	4.25E-06	TX09	4.57E-04	TX09	4.58E+00	Koc	TX09
Ethylene dibromide	106-93-4	O	187.86176	TX09	4320	TX09	2.63E+03	1.10E+01	TX09	2.93E-02	TX09	1.73E+00	Koc	TX09
Dichloroethane, 1,2-	107-06-2	O	98.95976	TX09	8700	TX09	2.17E+03	8.13E+01	TX09	5.32E-02	TX09	1.24E+00	Koc	TX09
Trimethylbenzene, 1,2,4-	95-63-6	O	120.19	TX09	56.8	TX09	5.35E+02	1.59E+00	TX09	1.84E-01	TX09	2.97E+00	Koc	TX09

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CHEMICAL DATA FOR SELECTED COCs

Physical Property Data

Orange = One or more parameter differs from User Chemical Database	pH specific Kd for non-organics							log(Kow)		Diffusion Coefficients			
	Surface Soil Column			Water Bearing Unit				(@ 20 - 25 C)		Air		Water	
Constituent	Slope	y-Intercept	logKd_pH (L/kg)	Slope	y-Intercept	logKd_pH (L/kg)		log(L/kg)		(cm^2/s)		(cm^2/s)	
Benzene	-	-	-	-	-	-	-	1.99E+00	TX09	8.8(E-02	TX09	9.80E-06	TX09
Toluene	-	-	-	-	-	-	-	2.54E+00	TX09	8.7(E-02	TX09	8.60E-06	TX09
Ethyl benzene	-	-	-	-	-	-	-	3.03E+00	TX09	7.5(E-02	TX09	7.80E-06	TX09
Xylenes (mixed isomers)	-	-	-	-	-	-	-	3.09E+00	TX09	7.4(E-02	TX09	8.50E-06	TX09
Cumene	-	-	-	-	-	-	-	3.45E+00	TX09	6.5(E-02	TX09	7.10E-06	TX09
Methyl t-Butyl ether (MTBE)	-	-	-	-	-	-	-	1.43E+00	TX09	7.9: E-02	TX09	9.41E-05	TX09
Benz-a-anthracene	-	-	-	-	-	-	-	5.52E+00	TX09	5.1(E-02	TX09	9.00E-06	TX09
Benzo-a-pyrene	-	-	-	-	-	-	-	6.11E+00	TX09	4.3(E-02	TX09	9.00E-06	TX09
Benzo-b-fluoranthene	-	-	-	-	-	-	-	6.11E+00	TX09	2.2(E-02	TX09	5.56E-06	TX09
Benzo-k-fluoranthene	-	-	-	-	-	-	-	6.11E+00	TX09	2.2(E-02	TX09	5.56E-06	TX09
Chrysene	-	-	-	-	-	-	-	5.52E+00	TX09	2.4(E-02	TX09	6.21E-06	TX09
Indeno-1,2,3-cd-pyrene	-	-	-	-	-	-	-	6.70E+00	TX09	1.9(E-02	TX09	5.66E-06	TX09
Acenaphthene	-	-	-	-	-	-	-	4.15E+00	TX09	4.2' E-02	TX09	7.69E-06	TX09
Anthracene	-	-	-	-	-	-	-	4.35E+00	TX09	3.2(E-02	TX09	7.74E-06	TX09
Fluoranthene	-	-	-	-	-	-	-	4.93E+00	TX09	3.0: E-02	TX09	6.35E-06	TX09
Fluorene	-	-	-	-	-	-	-	4.02E+00	TX09	3.6: E-02	TX09	7.88E-06	TX09
Phenanthrene	-	-	-	-	-	-	-	4.35E+00	TX09	3.3: E-02	TX09	7.47E-06	TX09
Pyrene	-	-	-	-	-	-	-	4.93E+00	TX09	2.7: E-02	TX09	7.24E-06	TX09
Ethylene dibromide	-	-	-	-	-	-	-	2.01E+00	TX09	2.1' E-02	TX09	1.90E-05	TX09
Dichloroethane, 1,2-	-	-	-	-	-	-	-	1.83E+00	TX09	1.0(E-01	TX09	9.90E-06	TX09
Trimethylbenzene, 1,2,4-	-	-	-	-	-	-	-	3.65E+00	TX09	6.2: E-02	TX09	7.28E-06	TX09

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CHEMICAL DATA FOR SELECTED COCs

Miscellaneous Parameters

Orange = One or more parameter differs from User Chemical Database

Constituent	Analytical Detection Limits: Groundwater (mg/L)		Analytical Detection Limits: Soil (mg/kg)		Half Life (First-Order Decay): Saturated (days)	Half Life (First-Order Decay): Unsaturated (days)		Soil-to-Plant Biotransfer Factors: Above-grd (unitless)	Soil-to-Plant Biotransfer Factors: Below-grd (unitless)		Relative Bioavailability Factor		Leaf Concen. Factor Calculated (mg/kg)/(mg/L)	Root Concen. Factor Calculated (mg/kg)/(mg/L)	Bioconcentration Factor	
Benzene	2.00E-03	S	5.00E-03	S	7.20E+02	7.20E+02	H	-	-	-	1.00E+00	TX09	1.17E+00	1.85E+00	12.6	LY
Toluene	2.00E-03	S	5.00E-03	S	2.80E+01	2.80E+01	H	-	-	-	1.00E+00	TX09	1.94E+00	3.55E+00	70	LY
Ethyl benzene	2.00E-03	S	5.00E-03	S	2.28E+02	2.28E+02	H	-	-	-	1.00E+00	TX09	3.13E+00	7.34E+00	120	LY
Xylenes (mixed isomers)	5.00E-03	S	5.00E-03	S	3.60E+02	3.60E+02	H	-	-	-	1.00E+00	TX09	3.29E+00	8.02E+00	130	LY
Cumene	-	-	-	-	1.60E+01	1.60E+01	H	-	-	-	1.00E+00	TX09	4.43E+00	1.45E+01	250	LY
Methyl t-Butyl ether (MTBE)	-	-	-	-	3.60E+02	1.80E+02	H	-	-	-	1.00E+00	TX09	7.63E-01	1.20E+00	7.2	LY
Benz-a-anthracene	1.00E-02	S2	6.60E-01	S2	1.36E+03	1.36E+03	H	-	-	-	1.00E+00	TX09	3.98E+00	5.39E+02	9200	LY
Benzo-a-pyrene	1.00E-02	S2	6.60E-01	S2	1.06E+03	1.06E+03	H	-	-	-	1.00E+00	TX09	2.06E+00	1.53E+03	26000	LY
Benzo-b-fluoranthene	1.00E-02	S2	6.60E-01	S2	1.22E+03	1.22E+03	H	-	-	-	1.00E+00	TX09	2.06E+00	1.53E+03	26000	LY
Benzo-k-fluoranthene	1.00E-02	S2	6.60E-01	S2	4.28E+03	4.28E+03	H	-	-	-	1.00E+00	TX09	2.06E+00	1.53E+03	26000	LY
Chrysene	1.00E-02	S	6.60E-01	S	2.00E+03	2.00E+03	H	-	-	-	1.00E+00	TX09	3.98E+00	5.39E+02	9200	LY
Indeno-1,2,3-cd-pyrene	1.00E-02	S2	6.60E-01	S2	1.46E+03	1.46E+03	H	-	-	-	1.00E+00	TX09	8.06E-01	4.33E+03	72000	LY
Acenaphthene	1.00E-02	S2	6.60E-01	S2	2.04E+02	2.04E+02	H	-	-	-	1.00E+00	TX09	6.20E+00	4.83E+01	387	LY
Anthracene	1.00E-02	S2	6.60E-01	S2	9.20E+02	9.20E+02	H	-	-	-	1.00E+00	TX09	6.38E+00	6.78E+01	1200	LY
Fluoranthene	1.00E-02	S2	6.60E-01	S2	8.80E+02	8.80E+02	H	-	-	-	1.00E+00	TX09	5.80E+00	1.91E+02	3300	LY
Fluorene	1.00E-02	S2	6.60E-01	S2	1.20E+02	1.20E+02	H	-	-	-	1.00E+00	TX09	5.97E+00	3.81E+01	1300	LY
Phenanthrene	1.00E-02	S2	6.60E-01	S2	4.00E+02	4.00E+02	H	-	-	-	1.00E+00	TX09	6.38E+00	6.78E+01	2630	LY
Pyrene	1.00E-02	S2	6.60E-01	S2	3.80E+03	3.80E+03	H	-	-	-	1.00E+00	TX09	5.80E+00	1.91E+02	3300	LY
Ethylene dibromide	-	-	-	-	1.20E+02	1.20E+02	H	-	-	-	1.00E+00	TX09	1.18E+00	1.89E+00	20	LY
Dichloroethane, 1,2-	5.00E-04	S	5.00E-03	S	3.60E+02	3.60E+02	H	-	-	-	1.00E+00	TX09	1.03E+00	1.60E+00	2	LY
Trimethylbenzene, 1,2,4-	-	-	-	-	5.60E+01	5.60E+01	H	-	-	-	1.00E+00	TX09	5.05E+00	2.03E+01	350	LY

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CHEMICAL DATA FOR SELECTED COCs

Dermal Exposure

Orange = One or more parameter differs from User Chemical Database	Water Dermal Permeability Data					
Constituent	Dermal Permeability Coeff. (cm/hr)	Lag time for Dermal Exposure (hr)	Critical Exposure Time (hr)	Relative Contr of Derm Perm Coeff	Water/Skin Derm Ads. Fact Calculated	
Benzene	0.021	0.26	0.63	0.013	0.073391787	D
Toluene	0.045	0.32	0.77	0.054	0.159834535	D
Ethyl benzene	0.074	0.39	1.3	0.14	0.266633684	D
Xylenes (mixed isomers)	0.08	0.39	1.4	0.16	0.286510345	D
Cumene	-	-	-	-	-	-
Methyl t-Butyl ether (MTBE)	-	-	-	-	-	-
Benz-a-anthracene	0.81	2.2	10	46	5.751586705	D
Benzo-a-pyrene	1.2	2.9	14	130	9.782988812	D
Benzo-b-fluoranthene	1.2	3	14	130	9.950231505	D
Benzo-k-fluoranthene	1.2	3	14	130	9.950231505	D
Chrysene	0.81	2.2	10	46	5.751586705	D
Indeno-1,2,3-cd-pyrene	1.9	4.2	20	380	18.64101509	D
Acenaphthene	-	-	-	-	-	-
Anthracene	-	-	-	-	-	-
Fluoranthene	0.36	1.5	7.3	8.9	2.110762851	D
Fluorene	-	-	-	-	-	-
Phenanthrene	0.23	1.1	5.6	2.9	1.154823174	D
Pyrene	-	-	-	-	-	-
Ethylene dibromide	0.0033	1.2	2.9	0.0091	0.017873567	D
Dichloroethane, 1,2-	0.0053	0.35	0.84	0.003	0.019584636	D
Trimethylbenzene, 1,2,4-	-	-	-	-	-	-

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CHEMICAL DATA FOR SELECTED COCs

Orange = One or more parameter differs from User Chemical Database Constituent	Dermal Relative Abs. Factor Calculated	Absorbtion Fraction		
		Dermal (unitless)	Gastrointestinal (unitless)	
Benzene	0	0	0.97	TX09
Toluene	0	0	0.8	TX09
Ethyl benzene	0	0	0.97	TX09
Xylenes (mixed isomers)	0	0	0.92	TX09
Cumene	0	0	0.8	TX09
Methyl t-Butyl ether (MTBE)	0	0	0.8	TX09
Benz-a-anthracene	0.146067416	0.13	0.89	TX09
Benzo-a-pyrene	0.146067416	0.13	0.89	TX09
Benzo-b-fluoranthene	0.146067416	0.13	0.89	TX09
Benzo-k-fluoranthene	0.146067416	0.13	0.89	TX09
Chrysene	0.146067416	0.13	0.89	TX09
Indeno-1,2,3-cd-pyrene	0.146067416	0.13	0.89	TX09
Acenaphthene	0.146067416	0.13	0.89	TX09
Anthracene	0.146067416	0.13	0.89	TX09
Fluoranthene	0.146067416	0.13	0.89	TX09
Fluorene	0.146067416	0.13	0.89	TX09
Phenanthrene	0.146067416	0.13	0.89	TX09
Pyrene	0.146067416	0.13	0.89	TX09
Ethylene dibromide	0	0	0.8	TX09
Dichloroethane, 1,2-	0	0	1	TX09
Trimethylbenzene, 1,2,4-	0	0	0.8	TX09

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CHEMICAL DATA FOR SELECTED COCs

Regulatory Standards

Orange = One or more parameter differs from User Chemical Database Constituent	Maximum Contaminant Level (mg/L)		Time-Weighted Average Workplace Criteria (mg/m^3)		UK Soil Guideline Values				
					Residential/Plant mg/kg	Residential/No Plant mg/kg	Allotments mg/kg	Commercial/Ind. mg/kg	
Benzene	0.005	MC	3.19	OS	-	-	-	-	-
Toluene	1	MC	754	OS	4	2	3	2	UK2
Ethyl benzene	0.7	MC	435	OS	3	3	3	1	UK1
Xylenes (mixed isomers)	10	MC	435	OS	-	-	-	-	-
Cumene	-	-	245	OS	-	-	-	-	-
Methyl t-Butyl ether (MTBE)	0.01	DE	144	AC	-	-	-	-	-
Benz-a-anthracene	-	-	0	AC	-	-	-	-	-
Benzo-a-pyrene	0.0002	MC	0.2	OS	-	-	-	-	-
Benzo-b-fluoranthene	-	-	0	AC	-	-	-	-	-
Benzo-k-fluoranthene	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-
Indeno-1,2,3-cd-pyrene	-	-	-	-	-	-	-	-	-
Acenaphthene	-	-	-	-	-	-	-	-	-
Anthracene	-	-	-	-	-	-	-	-	-
Fluoranthene	-	-	-	-	-	-	-	-	-
Fluorene	-	-	-	-	-	-	-	-	-
Phenanthrene	-	-	-	-	-	-	-	-	-
Pyrene	-	-	-	-	-	-	-	-	-
Ethylene dibromide	0.00005	MC	154	OS	-	-	-	-	-
Dichloroethane, 1,2-	0.005	MC	202.5	OS	-	-	-	-	-
Trimethylbenzene, 1,2,4-	-	-	-	-	-	-	-	-	-

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CHEMICAL DATA FOR SELECTED COCs

Regulatory Standards

Orange = One or more parameter differs from User Chemical Database

Constituent	Surface Water Quality Criteria									
	Aquatic Life Protection				Human Health Protection					
	Freshwater (mg/L)		Marine (mg/L)		Drink & Freshwater Fish (mg/L)		Freshwater Fish (mg/L)		Saltwater Fish (mg/L)	
Benzene	-	-	-	-	0.005	T3	0.106	T3	0.0708	T3
Toluene	-	-	-	-	6.8	E	200	E	200	E
Ethyl benzene	-	-	-	-	3.1	E	29	E	29	E
Xylenes (mixed isomers)	-	-	-	-	-	-	-	-	-	-
Cumene	-	-	-	-	-	-	-	-	-	-
Methyl t-Butyl ether (MTBE)	-	-	-	-	-	-	-	-	-	-
Benz-a-anthracene	-	-	-	-	0.000099	T3	0.00081	T3	0.00054	T3
Benzo-a-pyrene	-	-	-	-	0.000099	T3	0.00081	T3	0.00054	T3
Benzo-b-fluoranthene	-	-	-	-	0.0000028	E	0.000031	E	0.000031	E
Benzo-k-fluoranthene	-	-	-	-	0.0000028	E	0.000031	E	0.000031	E
Chrysene	-	-	-	-	0.000417	T3	0.0081	T3	0.0054	T3
Indeno-1,2,3-cd-pyrene	-	-	-	-	0.000044	E	0.000031	E	0.000031	E
Acenaphthene	-	-	-	-	-	-	-	-	-	-
Anthracene	-	-	-	-	9.6	E	110	E	110	E
Fluoranthene	-	-	-	-	0.3	E	0.37	E	0.37	E
Fluorene	-	-	-	-	1.3	E	14	E	14	E
Phenanthrene	0.03	T1	0.0046	T1	-	-	-	-	-	-
Pyrene	-	-	-	-	0.96	E	11	E	11	E
Ethylene dibromide	-	-	-	-	0.000014	T3	0.000335	T3	0.000223	T3
Dichloroethane, 1,2-	-	-	-	-	0.005	T3	0.0739	T3	0.0493	T3
Trimethylbenzene, 1,2,4-	-	-	-	-	-	-	-	-	-	-

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CHEMICAL DATA FOR SELECTED COCs

Toxicity Parameters

Orange = One or more parameter differs from User Chemical Database

Constituent	Oral RfD or TDSI (mg/kg/day)		Dermal RfD or TDSI (mg/kg/day)		Inhalation Equivalent RfC or TCA (mg/m^3)		Oral Equivalent Slope Factor 1/(mg/kg/day)		Dermal Equivalent Slope Factor 1/(mg/kg/day)		Inhalation Equivalent Unit Risk Factor $1/(\mu g/m^3)$	
Benzene	0.004	EPA-I	0.004	D2	0.28	TX09	0.055	EPA-I	0.055	D2	0.0000022	TX09
Toluene	0.08	EPA-I	0.08	D2	4.1	TX09	-	-	-	-	-	-
Ethyl benzene	0.1	EPA-I	0.1	D2	1	EPA-I	***0.011***	***RAIS***	-	-	-	-
Xylenes (mixed isomers)	0.2	EPA-I	0.2	D2	0.61	TX09	-	-	-	-	-	-
Cumene	0.1	EPA-I	0.1	D2	0.4	EPA-I	-	-	-	-	-	-
Methyl t-Butyl ether (MTBE)	0.01	OEHHA	0.01	D2	3	EPA-I	0.0018	OEHHA	0.001	D2	0.00000026	OEHHA
Benz-a-anthracene	-	-	-	-	-	-	***0.1***	***2017***	0.73	D2	0.000088	EPA-93
Benzo-a-pyrene	-	-	-	-	-	-	***1***	***2017***	7.3	D2	0.00088	EPA-N
Benzo-b-fluoranthene	-	-	-	-	-	-	***0.1***	***2017***	0.73	D2	0.000088	EPA-93
Benzo-k-fluoranthene	-	-	-	-	-	-	***0.01***	***2017***	0.073	D2	0.0000088	EPA-93
Chrysene	-	-	-	-	-	-	***0.001***	***2017***	0.007	D2	0.00000088	EPA-93
Indeno-1,2,3-cd-pyrene	-	-	-	-	-	-	***0.1***	***2017***	0.73	D2	0.000088	EPA-93
Acenaphthene	0.06	EPA-I	0.06	D2	-	-	-	-	-	-	-	-
Anthracene	0.3	EPA-I	0.3	D2	-	-	-	-	-	-	-	-
Fluoranthene	0.04	EPA-I	0.04	D2	-	-	-	-	-	-	-	-
Fluorene	0.04	EPA-I	0.04	D2	-	-	-	-	-	-	-	-
Phenanthrene	0.03	TX09	0.03	D2	-	-	-	-	-	-	-	-
Pyrene	0.03	EPA-I	0.03	D2	-	-	-	-	-	-	-	-
Ethylene dibromide	0.009	TX09	0.009	D2	0.009	EPA-I	2	EPA-I	2	D2	0.0006	EPA-I
Dichloroethane, 1,2-	0.02	TX09	0.02	D2	2.423504327	TX09	0.091	EPA-I	0.091	D2	0.000026	EPA-I
Trimethylbenzene, 1,2,4-	0.01	TX09	0.01	D2	0.007	TX09	-	-	-	-	-	-

Site Name: 2018 DERBCAP
Site Location: Delaware
Job ID:
Date Completed: 13-Dec-18
Completed By: PRB