State of Alaska

DEPARTMENT OF ENVIRONMENTAL CONSERVATION

DIVISION OF SPILL PREVENTION AND RESPONSE

CONTAMINATED SITES PROGRAM

Guidance on Developing Conceptual Site Models

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TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

1 BACKGROUND

A conceptual site model (CSM) is a way to describe and evaluate how people, animals, and plants might come in contact with contaminants at a location. It shows the current and possible future spread of contamination in the environment. Developing a CSM is a critical step in evaluating a contaminated site, and must be prepared[1] during the initial stage of the cleanup process, the site characterization phase. The CSM identifies all:

- Present and future ways people, plants, or animals may be exposed to contamination (exposure pathways),
- Routes the contaminants may take as they move through the environment - migration routes (through soil, groundwater, and/or surface water, or plants and animals (biota), and
- Possible types of people, plants, and animals that could be exposed to contamination (potential receptors) for further analysis at a site.

A CSM guides the site characterization process, since it helps identify:

- The goals for gathering data to provide clear information (data quality objectives),
- Needs for more sampling, and
- Risk management decisions which may need to be made, such as cleanup levels and institutional controls.

A CSM is designed to show real or possible exposure pathways, not quantify the exposure or health risks presented by that exposure, as is done in a risk assessment. A CSM should be prepared for every site cleanup. The much more detailed effort of conducting a risk assessment is usually performed when proposing an alternative cleanup level for soil or groundwater based upon site specific conditions.

The preparation of a CSM does not need to be a complicated process. The CSM is used to assist project managers in properly evaluating a site. It should be continually revised as new site investigations produce updated and more accurate information. In general, a CSM can be developed with only the most basic information about the site. The less information on hand, the more the preparer needs to err on the conservative side, assuming that a person, plant or animal could be exposed to the contamination. As more information is gathered, however, the CSM can be refined. At closure, text accompanying the CSM should describe how exposure is being managed or minimized across all complete or potentially complete pathways.

This document provides guidance on how to develop both human health and ecological Conceptual Site Models for contaminated sites addressed under 18 Alaska Administrative Code (AAC) 75. It can also be used for leaking underground storage tank sites addressed under 18 AAC 78.

[1] Cumulative Risk Guidance, ADEC September 15, 2016, adopted by reference in 18 AAC 75

1.1 Exposure Pathways

A listing of all the ways in which exposure could take place, or the "exposure pathways", is essential to an accurate description of whom and what may be exposed to contamination. Consultation with any possible users of the land may be necessary to get a clear picture. Whether rural or urban, any site can have uses that are not obvious to someone unfamiliar with the site and the community. Evaluation of exposure pathways should start with identification of the many different kinds of potential users, including people that live at, visit, or gather food from the site and plants and animals that may be present.

An appropriate form of public consultation or involvement may be required of the responsible party to identify exposure pathways. Alaska's statutes (see AS 46.03.020) give the department broad powers to involve the public at its discretion. However, mechanisms of public involvement are not mandated in contaminated sites cleanup regulations so that the department can tailor its approach to public and community involvement to the needs of each site. Project managers should recognize the importance of involving interested people and groups to obtain the most accurate information about current and future land use. When the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) applies, methods of public participation are established by federal guidance.

1.2 Complete pathways

In the CSM, the distinction should be made between pathways which are complete and those which are incomplete. A complete pathway is a way by which a receptor, human, plant or animal, is or could be exposed to contamination.

Complete pathways should include both currently complete pathways and any that may be complete in the future based on contaminant migration or changes in land use. Remember that identifying a pathway as complete does <u>not automatically</u> mean there is actual harm or risk to humans or the environment. It means that exposure across the pathway needs further evaluation to determine if it presents a risk. Future restrictions placed on access to the site or the water on site does not make a pathway incomplete, although at closure it is acceptable to explain how exposure across a pathway will be controlled. Also, neither the quantity nor the concentration of a given chemical at the site makes any difference in determining if a pathway is complete. If chemical concentrations are below screening levels ($1/10^{th}$ of the ADEC health-based cleanup levels specific to that pathway) then the exposure across that pathway may be described as insignificant and no further evaluation of the pathway is necessary.

Often there will be insufficient information to determine if a pathway is complete. Take for example a family living on a site with subsurface soil and groundwater contamination. If contamination is measured in a drinking water well, then ingestion of the groundwater would be a complete pathway. However, if it's not clear whether the contaminants could evaporate from soil into outdoor air (because, for example, the source is small, the contamination is deep, or frozen ground limits volatilization of certain compounds) then breathing in (inhalation) of volatiles in the outdoor air pathway still has the potential to be complete and should be treated as such until further data is collected or approved modeling has been performed.

Complete **and** potentially complete pathways should be considered complete for development of the preliminary CSM. The preliminary CSM forms the basis of:

1. Further investigation (i.e., further site characterization), or
2. A risk assessment, or
3. Development of risk management decisions (i.e., institutional controls, engineering controls, or application of cleanup levels).

Comparison of concentrations of chemicals in soil or water with DEC cleanup levels or any other screening level is not sufficient justification for eliminating a pathway. If all contaminant concentrations are below $1/10^{th}$ of the risk based screening levels that are appropriate to both media (soil, water, air, food) and exposure route (ingestion, inhalation, dermal absorption) then the pathway can be considered insignificant. There may be multiple routes of exposure to contaminants in a single media, so contamination in the media should not be considered insignificant until all pathways are evaluated.

A CSM must be submitted as part of the site characterization step in the cleanup process (see Section 1.4 for more detail on site characterization). Throughout the rest of the process, the CSM is updated and continues to be used as information is gained. A potentially complete pathway may be dropped from further evaluation if sufficient evidence is presented to demonstrate, to the satisfaction of the State of Alaska Department of Environmental Conservation (DEC), that it is not a complete pathway. Sufficient evidence may include, for example, identification of impermeable, confining layers in the ground; or determining bioaccumulative compounds are not present at the site (such as for the ingestion of wild and farmed foods pathway).

Steps in the Cleanup Process

1. **Investigation**
   a. **Site characterization workplan**: is developed by a qualified environmental professional.* It includes initial and more detailed subsequent investigation, and <u>must include a CSM</u>. DEC approval of the workplan is required.
   b. **Site characterization report:** summarizes the investigation and recommends remediation for the site as necessary. An updated CSM may be necessary if conditions affecting the CSM evaluation change. A risk assessment, if conducted, is part of this step. DEC approval of the report is required.
2. **Cleanup/risk management**
   a. Actions taken
   b. Report submitted to DEC
3. **DEC determines closure,** with or without conditions

* A "qualified environmental professional" is defined in 18 AAC 75.333.

1.3 Graphical and Pictorial CSMs

A CSM consists of a graphical flow chart of the exposure pathways at a site, with text describing each element. An example graphical CSM is provided in Figure 1. Information should also be included on the physical setting, the land's surface and subsurface, contaminant source, routes by which the contaminant may spread, potentially exposed populations, land use, and exposure pathways. It is necessary to document what evidence and reasoning was used to determine which exposure pathways were complete or incomplete. Developing and documenting a CSM does not need to be a long and complicated process, but should provide the user with enough information to understand how decisions on complete pathways at a site were made. A pictorial representation of a CSM may be used **in addition** to the graphical one. A pictorial CSM is useful in explaining possible exposure at the site to interested members of the public as well as those involved in the cleanup. An example pictorial CSM is shown in Figure 2.

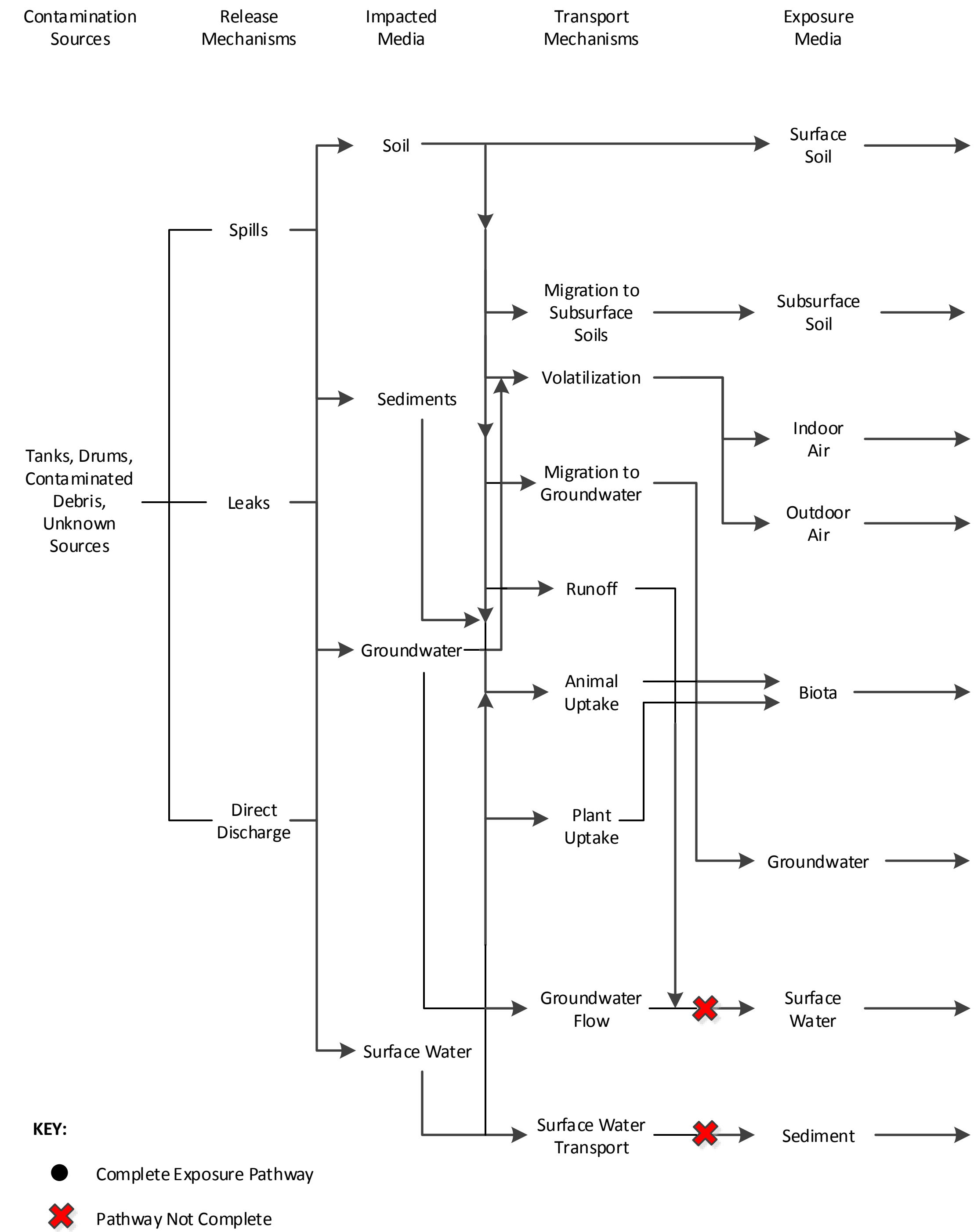
1.4 CSM Submittal to DEC

A ***preliminary CSM*** depicts the knowledge of complete or potentially complete exposure pathways at the site at the time it is developed. **Unless there is sufficient evidence to eliminate a pathway, consider it complete in this CSM.** Please note: designating a pathway as complete simply means that the pathway needs to be investigated. Preliminary CSMs should be updated as additional information becomes available through site investigation. Later versions of CSMs incorporate all additional information or results of site investigation that were not available at the time the preliminary CSM was developed.

Preliminary and Revised CSMs must be submitted as required in 18 AAC 75.335. If a risk assessment is being conducted it is the first document that must be approved by DEC as part of the risk assessment process. This requirement does not supersede the CSM submittal requirements at the workplan stage in 18 AAC 75.335.

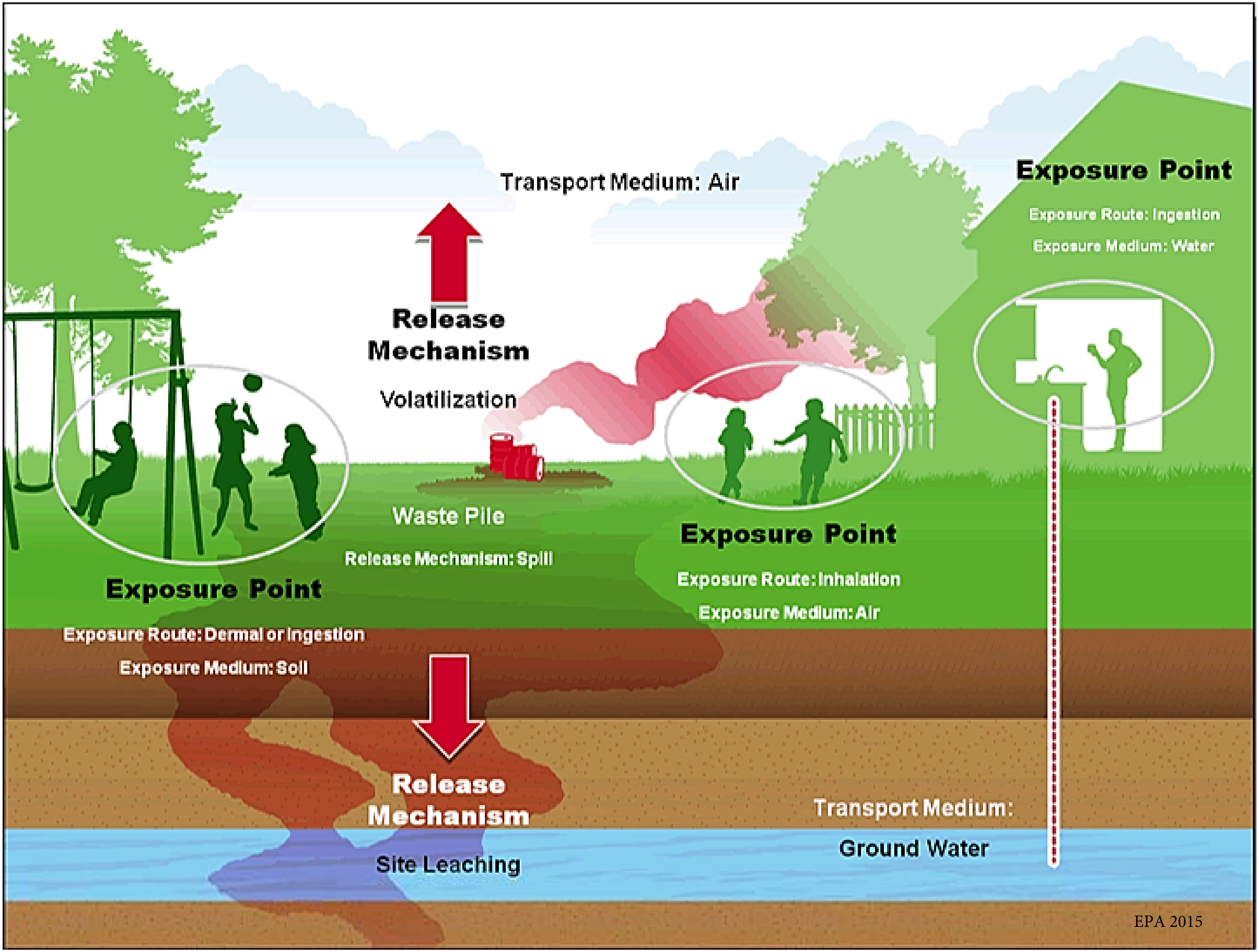
For consistency between contaminated site projects, DEC has developed a preliminary scoping form to assist consultants and contractors with a CSM (Appendix A). The preliminary scoping form can be used at any point in the investigation; however, the best use of the scoping form is to gain concurrence with the DEC project manager about the potential pathways that need to be investigated at the site.

FIGURE 1. EXAMPLE – HUMAN HEALTH CONCEPTUAL SITE MODEL (GRAPHICAL)



Exposure Route	Human Receptors: Residential	Site Worker	Site Visitors	Subsistence
Ingestion	●	●	●	●
Dermal	●	●	●	●
Inhalation	●	●	●	●
Ingestion	●	●	●	●
Dermal	●	●	●	●
Inhalation	●	●		
Inhalation	●	●		
Inhalation	●	●	●	●
Fish Ingestion				●
Meat Ingestion	●			●
Plant Ingestion	●		●	●
Ingestion	●	●		
Dermal	●			
Inhalation				
Ingestion				
Dermal				
Ingestion				
Dermal				

FIGURE 2. EXAMPLE – HUMAN HEALTH CONCEPTUAL SITE MODEL (PICTORIAL)



1.5 Site Characterization

The first step toward cleaning up contamination and reducing risk of exposure is to thoroughly investigate and then describe the site and the contamination. The investigation plus the description in a report together comprise site characterization.

In a relatively simple situation, the level of effort will be fairly simple. Here's an example: the contamination covers a small area, will be completely removed, treated elsewhere, and replaced with clean soil. In a case where multiple contaminants are involved, they have been there for some time, their complete removal is unlikely, and they have spread to groundwater, site characterization may involve searching past records, multiple rounds of sampling, and even a risk assessment to fully describe how people may be at risk. In the case where a site is divided into multiple operable units, a CSM should be submitted for each one.

First of all, it is necessary to understand both the site's past uses and its current condition to evaluate the risks it may pose.

Information to be described in a site characterization

- Surface area of the site;
- Description of engineered structures and facilities on site, including buildings, access roads, storage tanks, etc.;
- Past and present uses of the site and nearby properties;
- Known and potential sources of contamination;
- Types of hazardous substances reportedly released at the site;
- Environmental media potentially impacted by past and ongoing releases; and
- Site topography and surface water bodies on and near the site

The magnitude and extent of migration of any hazardous substances reportedly released at the site.

To the extent possible, this information should be compiled from existing site characterization reports, if any, and other historical documents and records. A site reconnaissance may be necessary if the available reports are old and/or provide incomplete information. A **site map** should be prepared showing the locations of engineered structures, past sampling locations, spill locations, water bodies on and near the site, site topography, and other significant features. For additional natural features which must be described and displayed on the site map or on supplemental maps for an ecological CSM, see Section 3.2.

A preliminary list of compounds of potential concern (COPCs) should be developed based on site-specific history and/or laboratory analysis of environmental media. Early in the site characterization process, the history of site-specific use is more typically the source of information on COPCs. However, any available analytical data also should be used. For metals, it is important to understand the contribution of naturally occurring background sources to concentrations present on site.

2 COMMON ELEMENTS, HUMAN AND ECOLOGICAL CSMS

Exposure Pathway Terms and Examples

Conceptual Site Models identify exposure pathways and outline the course a chemical takes from the source of contamination to a potentially exposed person, animal, or plant (receptor). Complete exposure pathways consist of four necessary elements; if one of these elements is missing, the pathway is not complete:

1. A source of contamination and the way it was released into the environment;
2. An environmental medium (i.e., soil, water, or air) and the way in which the chemical moves through the medium;
3. A location at which a receptor may come in contact with the impacted environmental medium; and
4. A way a chemical comes in contact with a receptor (i.e., ingestion, inhalation, and dermal exposure).

Characterization of the physical setting of a site is essential in developing the CSM. Information on the physical setting can be found in preliminary investigations, site characterization reports, historical documents, site visits, and interviews with community members. Special attention should be paid to precipitation, erosion, wind speed and direction, vegetation, soil type, groundwater hydrology, and location of surface water.
Terms of a CSM, including examples of each term, are shown in Table 1. This guidance will help identify each of the terms listed in the table and how the elements fit together to develop a CSM for a site.

Table 1. Exposure Pathway Terms and Examples

Term (Defined below)	Examples
Source	Tanks, drums, transformers, landfills
Release Mechanism	Spills, leaks, direct discharge, burning
Impacted Media	Soil, sediment, groundwater, surface water, air, biota (plants and animals)
Transport Mechanisms	Uptake by plants, uptake by animals/fish, volatilization to indoor air, deposition from fugitive dust, migration through groundwater flow
Exposure Media	Soil, sediment, groundwater, surface water, air, biota (plants and animals)
Exposure Routes	Ingestion, inhalation, dermal contact
Receptors	Human: Adult residents, child residents, short-term workers, long-term workers, site visitors, trespassers, subsistence users. Ecological: Invertebrates, plants, fish, mammals, birds, etc.

2.1 Source

All sources of contamination at the site need to be identified. Many times the source is from a tank, drum, transformer, garage, shop, storage area, or landfill. Other sources may include discarded batteries, deteriorating buildings, or pesticide application. Information on how the contaminant was released into the environment will be described next.

2.2 Release Mechanism

The release mechanism describes how contaminants were released from the source into the environment. For instance, the source of contamination at a site may be an underground storage tank, but the release mechanism was a leak from that tank. Common release mechanisms include spills, leaks, direct discharge, and burning, etc. In some instances the release mechanism is unknown and may need to be an educated guess based on the available information.

2.3 Impacted Media

The impacted media at a site is the environmental substance to which a contaminant is in contact with. The impacted media primarily includes soil, sediment, groundwater, surface water, air, or biota. For instance, oil from a leaking underground storage tank would be released to the soil. Soil would be the impacted media.

It is important to keep in mind soil, groundwater, surface water, and sediment have specific definitions which should be considered when determining what type of media has been impacted. Definitions for each type of media are included below:

- **Soil** is unconsolidated geologic material, including clay, loam, loess, silt, sand, gravel, tills, or a combination of these materials (18 AAC 75.990[117]).
- **Groundwater** is :
  - Subsurface water in the saturated zone, for purposes of evaluating whether the groundwater is a drinking water source under 18 AAC 75.346; or
  - Water beneath the surface of the soil, for purposes of evaluating whether the water will act as a transport medium for hazardous substance migration (18 AAC 75.990[46]).
- **Surface water** is water of the state naturally open to the atmosphere, including rivers, lakes, ponds, reservoirs, streams, wetlands, impoundments, and seas (18 AAC 75.990[128]). Groundwater that is closely connected hydrologically to nearby surface water (i.e. groundwater that daylights through seeps or springs) should also be evaluated as surface water.
- **Sediment** is material of organic or mineral origin that is transported by, suspended in, or deposited from water. Sediments occur in both the freshwater and marine environments and can include the area along the coastline that is exposed at low tide and covered at high tide. Sediment includes chemical and biochemical precipitates and organic material, such as humus (18 AAC 70.990[51]).

2.4 Transport Mechanisms

Transport mechanisms show how contaminants in the impacted environmental media may be moved to other media. For example, a transport mechanism explains how contamination from the soil migrates to the groundwater at a site. After a chemical is released in the environment it may be:

- Physically transported (e.g., volatilization, precipitation, movement downstream in water or on suspended sediment, or movement through the atmosphere);
- Chemically transformed (e.g., photolysis, hydrolysis, oxidation, reduction, etc.);
- Biologically transformed (e.g., biodegradation);
- Accumulated in one or more media.

Examples of common sources, transport mechanisms, and exposure media that are found at contaminated sites are shown in Table 2. Other transport mechanisms are possible and should be investigated on a case-by-case basis (see Section 3.2.3).

Table 2. Examples of Common Chemical Sources, Transport Mechanisms, and Exposure Media at Contaminated Sites.

Source or Impacted Media	Transport Mechanisms	Exposure Media
Contaminated Surface Soil	Volatilization	Air
	Fugitive Dust	Air
	Surface Runoff	Surface water
	Leaching	Groundwater
	Tracking	Soil
	Biota Uptake	Biota
Surfaces Wastes – spills and lagoons	Volatilization	Air
	Overland flow	Surface water or soil
	Leaching	Groundwater
Subsurface Soil or Buried Wastes	Leaching	Groundwater/ soil
	Volatilization	Air (indoor or outdoor)
Surface Water / Wetlands	Water flow	Surface water
	Sorption to particles and deposition	Sediment
	Biota uptake	Biota
Groundwater	Seepage	Soil , sediment, surface water
	Volatilization	Air (indoor)
Biota	Uptake	Other biota
Leaking Containers	Overland flow	Soil, water

Source: *Risk Assessment Guidance for Superfund, Volume 1, Part A*, Exhibit 6-3 (EPA 1989).

A complete pathway may not mean that there is a significant risk from exposure. Exposure may not be significant in some cases because of the extent to which a contaminant can be transported through a particular media. The CSM narrative should explain why the pathway is considered insignificant. For example, how well a contaminant dissolves in water, clings to soil, moves through water or air, or accumulates in biota may determine whether there is potential for exposure to a particular media. Therefore, consideration of a specific contaminant's chemical and physical properties may be helpful in developing the CSM. Once a pathway is considered complete, more work can be done to determine if exposure via the pathway is going to pose a significant risk. For more information on this, see Appendix E.

2.5 Exposure Media

Exposure media is the environmental substance an individual (receptor) is exposed to. Exposure media may include soil, sediment, groundwater, surface water, air, and biota (plants and animals). Exposure media includes all impacted media that receptors may contact.

2.6 Exposure Routes

An exposure route is the way a contaminant comes in contact with a receptor and the way a chemical enters the body (i.e. inhalation, ingestion, dermal contact). See Section 3 for Human CSMs and Section 4 for Ecological CSMs for information on specific routes.

3 HUMAN HEALTH CONCEPTUAL SITE MODELS

The main exposure routes for humans are eating/drinking (ingestion), breathing (inhalation), and skin (dermal) contact. In this section each exposure route is discussed, including the scenario or pathway in which it is commonly found. For instance, ingestion is a main exposure route and is commonly associated with the ingestion of soil, sediment, groundwater, surface water, and wild or farmed foods.

Not all of the following exposure routes are expected to be encountered at every site. Also, unique site-specific conditions may require additional exposure routes be investigated. Complete pathways should include both currently complete pathways and any that may be complete in the future based on contaminant migration or changes in land use. Remember that identifying a pathway as complete does not mean that negative health outcomes are anticipated, but that the route of exposure may need evaluation. Consultation with the public is recommended as an important method to help determine exposure routes.

Is the soil ingestion pathway complete?

- ❑ Are contaminants present or potentially present in surface soil between 0 and 15 feet below the ground surface (ft bgs)?*

If you answered "yes" to this question, the **soil ingestion pathway** is complete.

Is the dermal contact with soil pathway complete?

- ❑ Are contaminants present or potentially present in surface soil between 0 and 15 ft bgs?*
- ❑ Can the soil contaminants permeate the skin (see Appendix B)?

If you answered "yes" to the questions above, the **dermal contact pathway** is complete.

* Contamination at deeper depths may require evaluation on a site specific basis.

3.1 Direct Contact with Soil

Direct contact with soil comprises two exposure routes, ingestion of soil and dermal absorption of contaminants from soil. It is unusual for one of these pathways to be complete without the other being complete as well. For this reason they are often considered one pathway.

This pathway must be investigated if contamination is found or suspected in the surface soil (0 to 2 feet below the ground surface [ft bgs]) and/or the subsurface soil down to a depth of at least 15 ft bgs. Consider the pathway complete for subsurface soil between 2 and 15 ft bgs unless permafrost, bedrock, or site conditions prohibit excavation. Generally, 15 feet is the depth from which subsurface soil is brought to the surface by excavation. In most cases it is unlikely the direct contact exposure pathway will be complete for contaminated soil below 15 feet. However, contamination at deeper depths may require evaluation on a site- specific basis (e.g., where deeper excavation is possible such as in areas were utilities are located below 15 feet, or where the surface grade may be lowered such as on hill slopes or bluffs). Please note that instituting dig restrictions to prevent exposure to subsurface soil is not a basis for identifying this pathway as incomplete.

Once the above criteria have been used to determine if the direct contact pathway (ingestion and dermal) is complete, concentrations of contaminants can be compared to human health soil cleanup levels in Table B1 of 18 AAC 75. The pathway is still complete regardless of concentration, but may be considered insignificant if concentrations are below 1/10th the

Table B1 human health soil cleanup values. The human health soil cleanup level is considered protective of both ingestion of soil and dermal exposure to soil.

3.1.1 Incidental Soil Ingestion

The soil ingestion pathway includes both the incidental ingestion of soil through everyday hand-to-mouth activities and the ingestion of soil as airborne dust particles. See Section 3.3.3 for further information on the evaluation of fugitive dusts.

3.1.2 Dermal Absorption of Contaminants from Soil

Contaminants may be absorbed into the body through the skin, thus making the dermal absorption of contaminants in soil a complete pathway. The dermal pathway for soil is considered a complete exposure pathway for compounds with the ability to permeate the skin and reach the bloodstream. Common contaminants of concern for dermal exposure to soil are shown in Appendix B. Non-residential activities, such as construction or trenching activities, can result in dermal exposure to subsurface soil and should be investigated. Although during months of cold weather, soil contact with skin may be minimal because the soil is either covered with snow or the skin may be covered due to the cold temperatures; this is not the case year round and, therefore, is not sufficient reason to eliminate this exposure pathway.

3.2 Water Ingestion

3.2.1 Ingestion of Groundwater

The ingestion of contaminants in groundwater should be considered a complete pathway if contaminants are detected in groundwater or could migrate to groundwater and the groundwater is considered a drinking water source. Groundwater at a site is assumed to be a current or future drinking water source unless it can be demonstrated, to DEC's satisfaction, that it will not be used as such, consistent with pertaining items in 18 AAC 75.350.

Determining that the ingestion of groundwater pathway is complete does not mean that there is current exposure resulting in unacceptable risk. Information on chemical concentration can be compared to groundwater cleanup levels in Table C of 18 AAC 75. Concentrations below cleanup levels do not mean the pathway is incomplete, but it may be considered insignificant if concentrations are below 1/10th of Table C values.

If soil is contaminated and groundwater is present, soil contaminants may **migrate to groundwater**. Ingestion of groundwater is a complete pathway in this case as well, unless the requirements of 18 AAC 75.350 have been met to determine that groundwater is not a current or future drinking water source.

Is the ingestion of groundwater pathway complete?

- ❑ Have contaminants been detected or are they expected to be detected in groundwater, or are contaminants expected to migrate to groundwater in the future?
- ❑ Could the potentially affected groundwater be used as a current or future drinking water source? (Please note, this question can only be answered "no" if DEC has determined the groundwater is not a currently or reasonably expected future source of drinking water based on 18 AAC 75.350.)

If you answered "yes" to all the questions above the **ingestion of groundwater pathway** is complete.

Lack of current contamination in groundwater alone may not be sufficient evidence to determine if contaminants could migrate in the future. Characterization of site conditions (e.g., presence of impermeable layers, attenuation of contaminants with depth) or modeling, subject to DEC approval, may also be used to determine the likelihood that contamination in groundwater could occur in the future. If contaminants in soil are less than 1/10 Table B1 and B2 Cleanup Levels for the human health exposure pathways in addition to being less than the migration to groundwater cleanup level, then the migration to groundwater pathway may be deemed insignificant.

3.2.2 Ingestion of Surface Water

Surface water can become affected by site contaminants from direct discharge, overland flow, or migration from groundwater. It is important to know if a contaminated surface water body, such as a lake or stream, is used as a drinking water source. Use of the drinking water could be seasonal, such as during recreational or subsistence activities, but this is not preclude it from being considered a complete exposure pathway.

Exposure to surface water while swimming is addressed in the additional pathways section.

Even if ingestion of surface water is not a complete pathway, Alaska's water quality standards for surface water (18 AAC 70) must be met during cleanup.

Is the ingestion of surface water pathway complete?

For contaminants in surface water:

- ❑ Have contaminants been detected or are they expected to be detected in surface water, or are contaminants expected to migrate to surface water in the future?
- ❑ Could potentially affected surface water bodies be used, currently or in the future, as a drinking water source? Consider both public water systems and private use (i.e., during residential, recreational or subsistence activities).

If you answered "yes" to all the questions above the **ingestion of surface water pathway** is complete.

3.2.3 Ingestion of Wild and Farmed Foods

Many of Alaska's contaminated sites are located in areas where people rely on wild plants and animals as their primary source of food. This is an important part of the rural economy and one of the most highly valued parts of a rural lifestyle. The use of traditional foods provides a basis for nutritional, cultural, spiritual, medicinal, and economic well being among indigenous peoples and those who have adopted a similar lifestyle. In other areas of the state, gardens, small-scale agriculture, and aquaculture are important recreational and economic pursuits as well.

Exposure to site-related contaminants through the ingestion of wild or farmed foods should be investigated if the site is

Is the ingestion of wild and farmed foods pathway complete?

- ❑ Is the site in an area that is used or reasonably could be used for hunting, fishing, or harvesting of wild or farmed foods?
- ❑ Do the site contaminants have the potential to bioaccumulate (see Appendix C)?
- ❑ Are site contaminants located where they would have the potential to be taken up into biota? (i.e. soil within the root zone for plants or burrowing depth for animals, in groundwater that **could be** connected to surface water, etc.)

If you answered "yes" to the questions above, the **ingestion of wild and farmed foods pathway** is complete.

used for hunting, fishing, or harvesting of wild or farmed foods. It should also be investigated if hunting or fishing is conducted near the site and animals are exposed to the site. This pathway is of particular concern when contaminants have the potential to bioaccumulate (see definition in text box, as well as Appendix C) in the food chain. Other scenarios exist which are less common, but still can present a health hazard, such as fish coated in free product from a spill to surface water; berries coated in contaminated dust; or plants taking up contaminants from soil or water.

Bioaccumulate and Biomagnify

Bioaccumulation is a general term for the build-up of substances over time within an organism. An organism may be exposed to these substances in soil, air, or water. Examples of some substances that may bioaccumulate include some pesticides, some metals, and some other organic chemicals. Bioaccumulation occurs when an organism absorbs a toxic substance at a rate greater than that at which the substance is lost.

The term biomagnification refers to the progressive build-up of persistent substances up the food chain. It relates to the concentration ratio in a tissue of a predator organism as compared to that in its prey. Compounds that biomagnify also bioaccumulate.

Current and future land use should be considered. This pathway is of particular concern to residents, subsistence users, and recreational users at a site. The parts and quantities of animals and plants consumed by subsistence harvesters vary greatly across Alaska. Consultation with subsistence users to determine relevant pathways is strongly recommended.

Contaminants from soil, sediment, surface water, or other plant and animal life can accumulate in plants and animals that are eaten by people. Although there are many ways to determine a chemical's ability to bioaccumulate or biomagnify in the food chain, DEC considers the compounds listed in Appendix C to be bioaccumulative. An explanation of how this list was developed is also included in Appendix C.

DEC does not have cleanup levels specifically designed to be protective of the ingestion of wild and farmed foods pathway. If this pathway is complete, further evaluation -- either qualitative or quantitative -- may be necessary to aid risk management decisions.

3.3 Inhalation

3.3.1 Inhalation of Outdoor Air

The inhalation of contaminants in outdoor air is a complete pathway for volatile chemicals that are present in surface and subsurface soil to a depth of 15 feet below ground surface (ft bgs). Again, investigating this pathway to that depth accounts for the possibility that subsurface soil can be excavated and brought to the surface where exposure can occur. In addition, compounds are able to volatilize from the subsurface soil and into outdoor air.

Is the inhalation of outdoor air pathway complete?

- ❑ Are contaminants present or potentially present in surface soil between 0 and 15 feet below the ground surface (ft bgs)?*
- ❑ Are the contaminants in soil volatile (see Appendix D)?

If you answered "yes" to the questions above, the **inhalation of outdoor air pathway** is complete.

* Contamination at deeper depths may require evaluation on a site specific basis.

This pathway should only be eliminated if there are no volatile compounds in soil. Those chemicals listed in the cleanup tables in 18 AAC 75 that meet the definition of volatile are listed in Appendix D. This pathway should also be investigated for gasoline range organics (GRO) and diesel range organics (DRO).

A complete pathway does not mean that the exposure results in unacceptable risk at the site. Information about chemical concentrations is necessary to make that determination. Low concentrations of contaminants do not imply that the pathway is incomplete, but if they are below 1/10th of the human health cleanup level, the pathway may be considered insignificant. The CSM should display all complete pathways, even if they are considered insignificant.

3.3.2 Inhalation of Indoor Air

Vapor intrusion is the migration of volatile compounds from the subsurface soil or groundwater into overlying buildings. People may inhale the contaminant vapors that migrate into buildings.

Is the inhalation of indoor air pathway complete?

- ❑ Are occupied buildings on the site or reasonably expected to be placed on the site in an area that could be affected by contaminant vapors? (Within 30 feet of petroleum contamination; within 100 feet of non-petroleum contamination; **or** subject to "preferential pathways.")
- ❑ Are volatile compounds present in soil or groundwater (see Appendix D)?

If you answered "yes" to the questions above, the **inhalation of indoor air pathway** is complete.

The vapor intrusion pathway should be considered complete if petroleum contamination is found within 30 feet, or other non-petroleum contamination is found within100 feet (horizontally or vertically) of a building or potential location for a building. This pathway may be important for buildings both with and without a basement. However, this pathway is typically not complete for buildings on pilings where airflow is not restricted (e.g., by air-tight skirting).

Significant "preferential pathways" could allow vapors to migrate into a building at distances greater than 100 feet. In general, petroleum vapors are not expected to migrate as far because these contaminants are less persistent and degrade more readily than halogenated compounds. Preferential pathways may include subsurface fractures, utility conduits, and drains that intersect subsurface vapors. In Alaska, the presence of permafrost or seasonal frost may result in additional concerns about vapor intrusion into structures. A frozen surface in conjunction with the thaw bulb that is typically present beneath buildings may create a preferential pathway to the building.

Volatile contaminants that are of concern for this pathway are listed in Appendix D. DEC will generally not require an evaluation for vapor intrusion if the only chemicals of concern at a site are the GRO, DRO, and residual range organic (RRO) petroleum fractions. Other volatile compounds to evaluate when petroleum contamination is present are shown in bold in Appendix D.

DEC does not have regulatory cleanup levels for the vapor intrusion pathway; however, the DEC Vapor Intrusion Guidance for Contaminated Sites (2016) provides target levels for groundwater, soil gas, and indoor air. Soil data are not good predictors of soil gas concentrations, and are therefore not used by DEC to predict risk posed by the indoor air pathway. Once chemical concentrations are measured in groundwater, soil gas, and indoor air, risk from the vapor intrusion pathway can be estimated using the target levels. Decisions about site characterization, assessment, management and cleanup should take this additional pathway under consideration. Absence of existing buildings on site does not necessarily preclude the elimination of the vapor intrusion pathway from possible consideration.

3.3.3 Additional Pathways

Although the above pathways are the most common ones found at contaminated sites, there may be additional pathways of concern. These may include dermal exposure to groundwater or surface water, inhalation of volatiles from groundwater, inhalation of fugitive dust, incidental ingestion of sediment, or others. Standard DEC cleanup levels for soil and groundwater are protective of the pathways in this section (Section 3.3.3), but in some instances, as described below, these additional pathways should be further investigated. It may also be important to consider the contribution to cumulative risks posed by exposure through additional pathways. DEC's risk assessor should be contacted for guidance when additional pathways are a concern.

Dermal exposure to contaminants in groundwater and surface water may be a complete pathway if:

- Climate permits recreational use of waters for swimming.
- Climate permits exposure to groundwater during activities, such as construction.
- Groundwater or surface water is used for household purposes such as bathing or cleaning.

Generally, DEC groundwater cleanup levels in 18 AAC 75, Table C, are deemed protective of this pathway because dermal absorption is incorporated into the groundwater exposure equation for residential uses.

Inhalation of volatile compounds in tap water may be a complete pathway if:

- The contaminated water is used for indoor purposes such as showering, laundering, or dish washing.
- The contaminants of concern are volatile (common volatile contaminants are listed in Appendix D).

DEC groundwater cleanup levels in 18 AAC 75, Table C are protective of this pathway because the inhalation of vapors during normal household activities is incorporated into the groundwater exposure equation.

Inhalation of fugitive dust may be a complete pathway if:

- Nonvolatile compounds are found in the top 2 centimeters of soil. The top 2 centimeters of soil are likely to be dispersed in the wind as dust particles.
- Dust particles are less than 10 micrometers (Particulate Matter - PM_{10}). Particles of this size are called respirable particles and can reach the pulmonary parts of the lungs when inhaled.

DEC human health soil cleanup levels in Table B1 of 18 AAC 75 are protective of this pathway because the inhalation of particulates is incorporated into the soil exposure equation.

Direct contact with sediment involves people coming into contact with sediment, such as during some recreational, subsistence, or industrial activities. People then incidentally **ingest** sediment from normal hand-to-mouth activities. In addition, **dermal absorption of contaminants** may be of concern if the contaminants are able to permeate the skin (see Appendix B). This type of exposure should be investigated if:

- Climate permits recreational activities around sediment.
- The community has identified subsistence or recreational activities that would result in exposure to the sediment, such as clam digging.

Generally, DEC direct contact soil cleanup levels in 18 AAC 75, Table B1, are assumed to be protective of direct contact with sediment.

Exposure to contaminants that have been taken up from sediment into plants and animals that are eaten by humans is addressed under *Ingestion of Wild and Farmed Foods*, Section 3.2.3.

3.4 Human Receptors

Types of people called "receptors", who may be exposed to contamination at a site, are selected based on the locations and activities of people currently using the site and people reasonably anticipated to use it in the future. When determining human receptors for a site, it is important to keep in mind both current and future land use. This information should be included in the human health CSM. Potential receptors may include the following:

- Resident (adult and child);
- Commercial or industrial worker;
- Construction/trench worker;
- Site visitor;
- Trespasser;
- Recreational user;
- Farmer;
- Subsistence harvester, or
- Subsistence consumer

Residential receptors are addressed through DEC's default cleanup levels (Section 3.5) or by developing soil cleanup levels under method four (18 AAC 75.340). Method three soil cleanup levels can also be developed for commercial or industrial workers. For all other receptors, DEC requires evaluation through a risk assessment.

Special subpopulations that could potentially be exposed to contaminants should also be identified. Special subpopulations may be at increased risk from chemical exposure due to increased sensitivity or behavior patterns, for example, infants and children, elderly people, pregnant or nursing women, or people with chronic illnesses. Subpopulations of potential concern can be identified by determining the location and proximity of the site to schools, day care centers, hospitals, nursing homes, and retirement communities. Consultation with the public is recommended, including neighbors and others who would know about subpopulations of people who may be exposed.

3.4.1 Determining Current and Future Land Use

The current and anticipated future use of the site should be used to determine the human receptors at a site and to develop the CSM. The reasonably expected future use of the site may differ from the current use. For instance, even if groundwater in the area is not currently used for drinking water, it may be in the future. Therefore, ingestion of the groundwater should be considered as a complete pathway at the site. The CSM should note which pathways are current and which are future, even though both are considered complete.

Assuming that people will live at the site (residential land use) means that they are assumed to have the most exposure. Therefore, assuming the land use is residential is protective of most other land uses. However, an assumption of future residential land use may not be necessary if residential use in the future is highly unlikely, such as in areas zoned for commercial or industrial land use.

Before it can be assumed in the CSM that future land use will be commercial or industrial, a formal determination of land use is necessary. DEC ultimately makes that determination, which needs to be consistent with the definition in 18 AAC 75.990(19) and the process outlined in 18 AAC 75.340(e)(3). DEC will base a land-use determination upon the following:

- Consultation with the public, including the local zoning authority, if any;
- A determination that the site does not serve a residential land use;
- A determination that the site will not serve a future residential land use based on consideration of the factors in the EPA's *Land Use in the CERCLA Remedy Selection Process*, OSWER Dir. No. 9355.7-04, dated May 25, 1995 (EPA 1995); land in an undeveloped area for which it would be difficult to determine a future use pattern is capable of being a residential area, unless demonstrated otherwise; and
- Consent of each landowner of property with contamination left in place above cleanup levels

3.4.2 Determining Insignificant Exposure

When a pathway is complete, but exposure is unlikely to result in unacceptable levels of risk due to conditions present at the site, the CSM can refer to the pathway as insignificant. If DEC concurs with this decision, no further evaluation of the pathway will be required.

As noted in Section 1.2, if chemical concentrations are below screening levels (1/10th of DEC health-based cleanup levels specific to that pathway) then the exposure across that pathway may be described as insignificant and no further evaluation of the pathway is necessary. Other considerations that may lead to identification of an insignificant pathway include:

- The site is located in a remote area and is expected to remain remote (e.g., not accessible by road) and short term exposure to contaminant levels present at the site are not expected to cause effects;
- People are not expected to be on the site for more than 10 days a year and short term exposure to contaminant levels present at the site are not expected to cause effects; or
- Contaminants are limited in extent, volume, and toxicity and are not expected to cause a significant exposure threat

3.5 Default Cleanup Levels CSM

It is important to understand the exposure pathways on which the cleanup levels are based. Cleanup levels for soil and groundwater can be found in 18 AAC 75 tables. These values are based on a default Conceptual Site Model and are primarily risk-based.[2] If the exposure pathways, exposure routes, or assumptions used in the cleanup level equations do not match the site of interest or are not protective of the site's conditions, further evaluation may be necessary. The default CSM used for the development of cleanup levels is shown in Figure 3.

The values in 18 AAC 75 assume contaminants were released from a source to soil and/or groundwater. The source and release mechanism are not defined in this default CSM. The tabled cleanup levels are protective of long-term (chronic) exposure in a residential setting, consistent with unrestricted land use. These receptors include both adult and child residents. In general, other receptors are less exposed to contaminants than residents and, therefore, these cleanup levels also would be protective for other types of receptors. However, the 18 AAC 75 cleanup levels do not take into account subsistence use (Section 3.2.3), vapor intrusion into a building (Section 3.3.2), other less common human exposures (Section 3.3.3), Alaska's water quality standards for surface water (18 AAC 70) (3.2.2) or ecological effects (Section 4). If there is a potential for exposure through any of these pathways, then further evaluation is required.

For soil, the cleanup levels are developed for incidental ingestion, dermal contact and inhalation of volatiles and particulates emitted from soil for a combined human health cleanup level, and potential migration of contaminants to groundwater. Specific exposure scenarios, chemical properties, and soil and aquifer parameters used to develop the cleanup levels are outlined in the *Procedures for Calculating Cleanup Levels* (2016).

The cleanup levels for the <u>human health pathway</u> are designed to be protective for exposures through three pathways: the incidental ingestion of soil, dermal exposure to soil, and the inhalation of volatile and particulates. The assumptions used in the equations are for a residential exposure scenario. The cleanup levels are calculated separately for each pathway and a sum of ratio is used as the final cleanup level. The cleanup levels for the individual pathways reflect the following:

a. The cleanup levels for incidental ingestion of soil is based off upper bound rates from the general population and accounts for soil ingestion.

b. The cleanup levels for dermal contact is based off contact with chemicals in contaminated soil and is calculated using parameters associated with the exposure event (i.e. skin surface area, dermal absorbed dose, body weight etc.).

c. The cleanup levels for the inhalation pathway were developed to be protective of the inhalation of chemicals volatilizing from soil to outdoor air and contaminants adsorbed onto respirable particulates (PM10). Some of these cleanup levels are capped at the soil saturation concentration where it is lower than the risk-based value.

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[2] These cleanup levels are calculated using standard risk equations and back-calculating a cleanup level that is associated with DEC's risk standards (cancer risk of 1 in 100,000 and a HQ = 1.0).

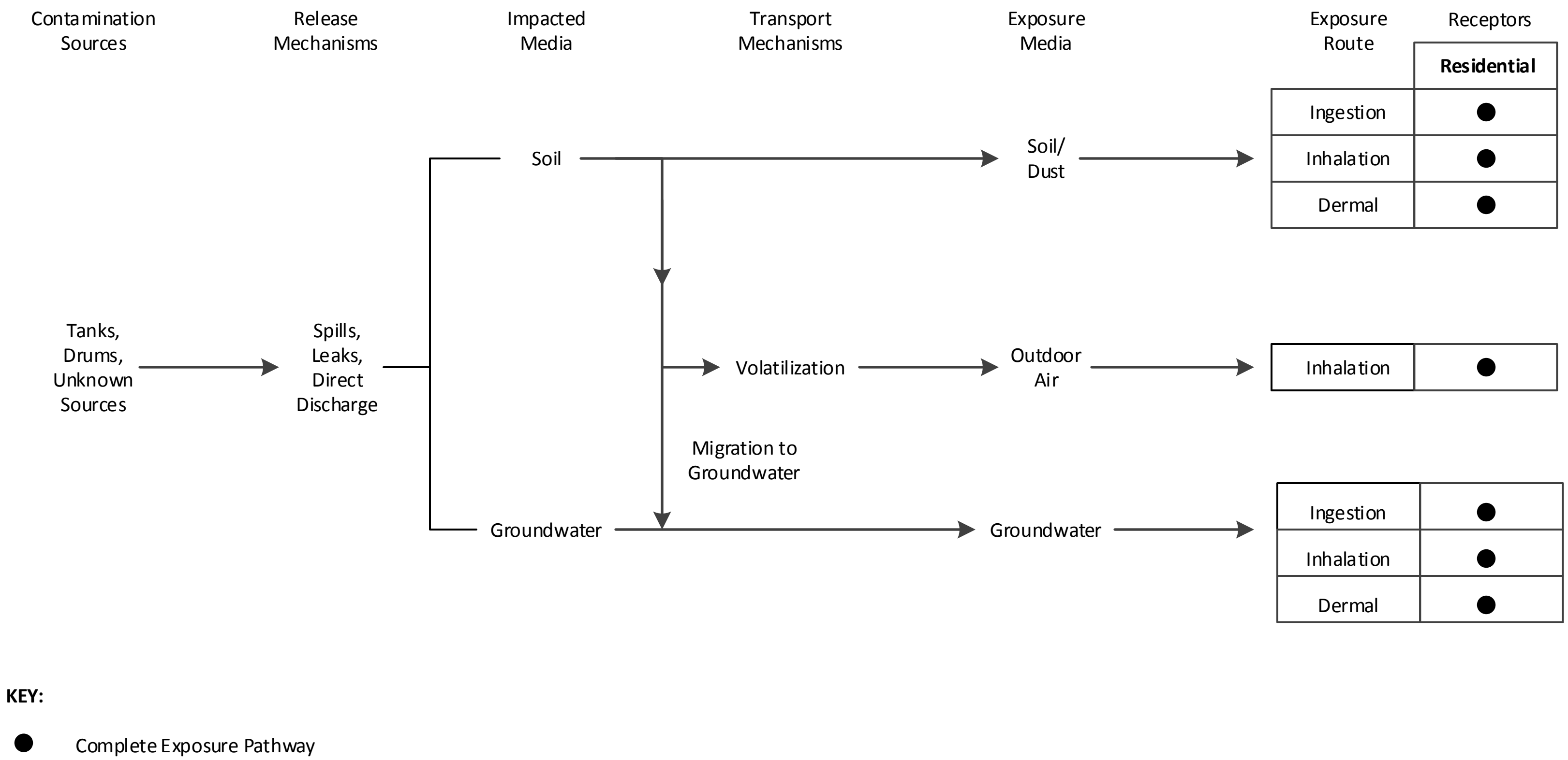
2. The cleanup levels for the migration to groundwater pathway are developed to be protective of residential domestic use of the groundwater from a well located at the downgradient edge of the contaminated soil source. The equations used to develop the tabled values for this pathway incorporate a three-phase partitioning equation that estimates the contaminant concentration in soil leachate and a water-balance equation that calculates a dilution factor that accounts for the dilution of soil leachate in an aquifer. This exposure pathway is not evaluated in the arctic zone because of the presence of permafrost and the lack of use of groundwater as a source of drinking water. The migration to groundwater cleanup level equations make the following assumptions:

- The source is infinite;
- There is uniform distribution of contaminants in the soil;
- The soil contamination extends from the surface to the water table, but is not in contact with groundwater or below the groundwater;
- No chemical or biological degradation takes place in the unsaturated zone or aquifer;
- Equilibrium is instantaneous;
- The aquifer is homogenous;
- Non-aqueous phase liquids are not present at the site; and
- The drinking water well is located (or could be located) at the edge of the contamination source (i.e., there is no dilution from recharge downgradient of the site; EPA 1996b).

The target groundwater concentration used in the migration to groundwater pathway equations is set at the groundwater cleanup levels. The groundwater cleanup levels are protective of the domestic use of the groundwater by ingestion, dermal contact and inhalation of volatiles by residents.

Please note, cleanup levels for two compounds listed in the cleanup tables, polychlorinated biphenyls (PCBs), and lead, are not derived from the CSM described above, but were developed based on other considerations. They are still assumed to be protective of human health.

FIGURE 3. DEFAULT – HUMAN HEALTH CONCEPTUAL SITE MODEL FOR TABLED CLEANUP LEVELS



4 ECOLOGICAL CONCEPTUAL SITE MODELS

4.1 Introduction

An ecological conceptual site model identifies sources of contamination, routes of contaminant transport, contaminated media, routes of exposure, and potentially exposed plant and animal receptors. A CSM is presented in the form of a flow chart and descriptive narrative.

This section discusses the types of information that should be collected and reviewed to develop an ecological CSM for a contaminated site. Development of the CSM from this information relies on training and professional judgment to qualitatively evaluate both the potential exposure of ecological receptors to site-related contaminants and the site-specific conditions. Not every site will require an ecological CSM. DEC's Ecological Scoping Guidance (March 2014) should be used to determine if an ecological CSM is necessary at a site and in turn aid in the development of the ecological CSM.

The sections below describe the information typically found in an ecological CSM. Early in the process, it is not necessary to fully develop all of the information listed below regarding the characteristics of the site and surrounding habitats; it is acceptable to develop a simple CSM based on readily available information.

For example, an initial ecological CSM for a site may consist of:

- A site map;
- Photographs of nearby habitats; and
- One or two pages of text describing sources of contamination, transport pathways, affected media, and potential receptors and exposure routes.

If warranted based on site concerns, the initial CSM can be supplemented and refined.

4.2 Ecological Characterization

In order to develop an ecological CSM, it is necessary to identify the terrestrial and aquatic habitat and the plants and animals (biota) that use them. The following elements should be considered during ecological characterization of the site:

- Vegetative communities and water bodies found on the site.
- Off-site vegetative communities and water bodies that have the potential to be impacted by site-related contaminants.
- Locations of all wildlife areas, preserves, reserves, sanctuaries, parks, natural areas, conservation areas, and other protected natural areas near the site.
- Species (non-human) and types of communities present or potentially present at the site. Species and communities should be considered to be potentially present if they are known to have been present historically at the site, or if they are present or have historically been present in similar habitats in the ecoregion (see DEC's Users Guide for Selection and Application of Default Assessment Endpoints and Indicator Species in Alaskan Ecoregions).
- Special species and their habitats at and near the site. Special species include: (1)

state and federally listed rare, threatened, and endangered species; (2) species that are proposed or recommended for state or federal listing; and (3) other Alaska "species of special concern."

To the extent possible, this information should be acquired from existing site reports and by communication with state and federal agencies, including the United States Fish and Wildlife Service (USFWS), the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries), and the Alaska Department of Fish and Game (ADF&G). A site visit by an ecological risk assessor and/or trained ecologist may be warranted to verify and supplement the information gained from these sources.

A **habitat map** should be drawn for the site and surrounding area. It may be based on such sources as aerial photographs, United States Geological Survey (USGS) topographic maps, or soil maps. Vegetative communities, wetlands, aquatic habitats, and other habitat types should be shown. The site perimeter should be drawn on the habitat map. Alternatively, habitat types can be illustrated on the site map described in Section 1.5 if the overall amount of information displayed is not excessive.

4.3 Identification of Potential Exposure Pathways

Section 2 of this guidance discusses the movement of contamination from source and impacted media to exposure media. This section applies equally to ecological CSMs.

Once the vegetative communities, water bodies, and species likely to be impacted are identified, the next step is to identify complete exposure pathways. Any contact between biota and COPCs in any medium by any route should be considered a complete pathway. In general, a complete exposure pathway exists when:

- A release to the environment has occurred as documented by site history or preliminary characterization data;
- Transport of the contaminant to a point of contact is possible;
- A point of contact exists for the contaminant and potential ecological receptor; and
- An exposure route, such as ingestion or inhalation, exists at the point of contact.

Current and future exposure pathways should be considered complete unless there is evidence that the COPC will not enter the medium or the receptor will not contact the medium, either directly or indirectly.

Complete exposure pathways for ecological receptor groups should be summarized in a CSM figure similar to Figure 4. The figure should include sources, transport mechanisms from sources to exposure media, routes of exposure, and receptors (see Table 1, Exposure Pathway Terms). A narrative should accompany the CSM figure and should describe the contents of the diagram in sufficient detail to ensure that the user can understand it.

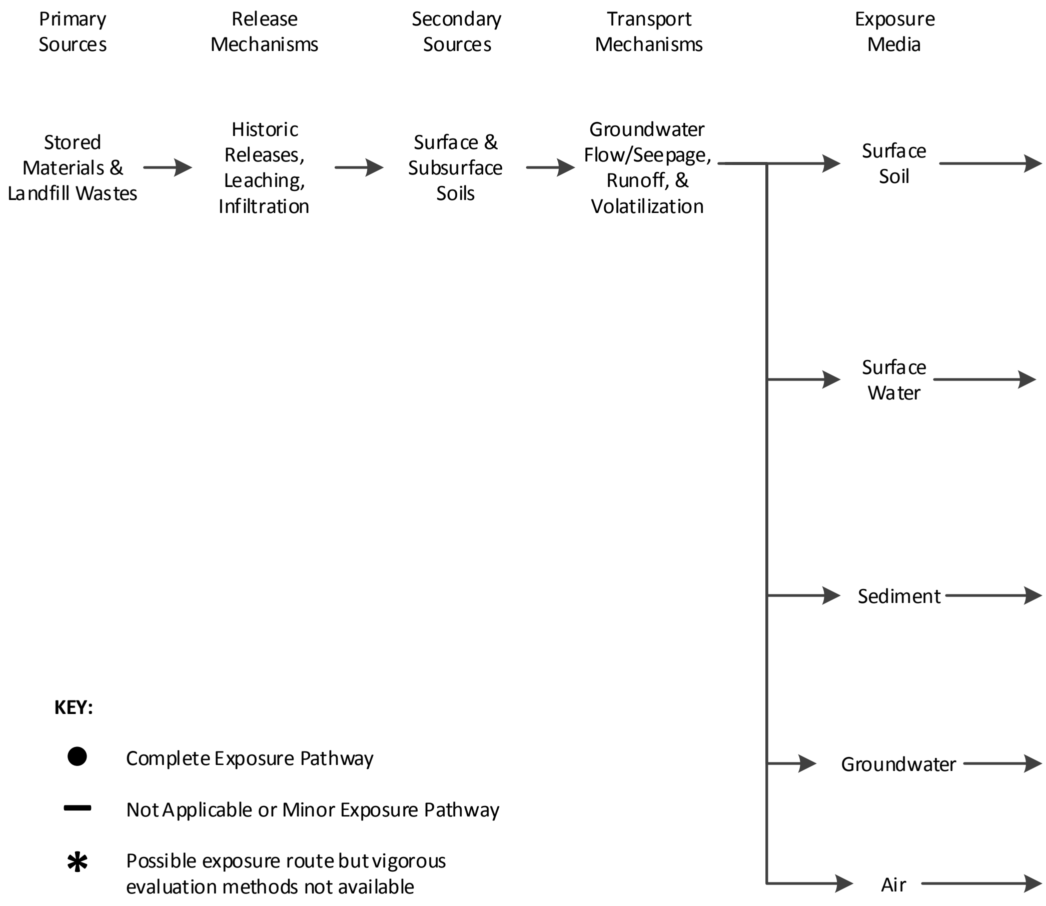
The following points should be considered when developing the ecological CSM:

- Wildlife exposure routes usually include ingestion of food, drinking water, and incidental ingestion of soil or sediment.[3]

- Plants, soil invertebrates, and soil microbes are assumed to be directly exposed to soil.
- Benthic invertebrates are assumed to be directly exposed to whole sediment, which consists of sediment particles and pore water. However, for simplicity, the graphic version of the CSM need not depict this distinction.
- Dermal exposure of terrestrial wildlife usually is considered to be minor due to protection provided by fur and feathers.
- In most cases, respiratory exposure of wildlife usually is considered to be insignificant. However, in some instances this pathway may be significant (e.g., exposure of burrowing rodents to volatile organic chemicals in soil).
- Rigorous quantitative methods for estimated risk are not available for all receptor groups, such as amphibians and reptiles. Nonetheless, if such receptors are present at a site and potentially exposed to site-related chemicals, they should be included in the CSM.
- Bioaccumulation potential varies greatly among chemical groups. As a starting point, the chemicals listed in Appendix C should be considered as bioaccumulative when developing the ecological CSM for a site.
- Dietary exposure is not routinely evaluated for fish, aquatic invertebrates, reptiles, and amphibians due to a lack of standardized evaluation methods for these receptor groups. Nonetheless, for highly hydrophobic organic compounds (e.g., PCBs) and some metals (e.g., methyl mercury), food chain exposure is likely to be of great importance for these receptor groups and should be indicated as such in the ecological CSM.
- Complete pathways should be included in the ecological CSM, even if there is no standard method of assessing exposure across those pathways.

[3] Soil or sediment exposure can be assumed negligible for species that have little exposure to soil or sediment.

FIGURE 4. EXAMPLE – ECOLOGICAL RISK ASSESSMENT CONCEPTUAL MODEL



Ecological Receptors

Exposure Media	Exposure Route	Vegetation	Invertebrates	Reptiles & Amphibians	Fish	Birds & Mammals
Surface Soil	Direct Contact & Uptake	●	●	—	—	—
	Incidental Ingestion	—	●	●	—	●
	Food Chain	—	●	●	—	●
Surface Water	Absorption/ Direct Contact	●	●	●	●	—
	Ingestion	—	●	—	—	—
	Food Chain	—	●	●	●	●
Sediment	Absorption/ Direct Contact	●	●	●	—	—
	Ingestion	—	●	●	●	—
	Food Chain	—	●	●	●	—
Groundwater	Evaluate as surface water at discharge points					
Air	Inhalation	—	—	*	—	*

KEY:

● Complete Exposure Pathway

— Not Applicable or Minor Exposure Pathway

* Possible exposure route but vigorous evaluation methods not available

5 REFERENCES

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__________, December 1989, *Risk Assessment Guidance for Superfund Volume 1 Human Health Evaluation Manual (Part A),* Office of Emergency and Remedial Response, Washington, D.C., EPA/540/1-89/002.

APPENDIX A

HUMAN HEALTH SCOPING FORM

Print Form

Appendix A - Human Health Conceptual Site Model
Scoping Form and Standardized Graphic

Site Name:

File Number:

Completed by:

Introduction
The form should be used to reach agreement with the Alaska Department of Environmental Conservation (DEC) about which exposure pathways should be further investigated during site characterization. From this information, summary text about the CSM and a graphic depicting exposure pathways should be submitted with the site characterization work plan and updated as needed in later reports.

General Instructions: Follow the italicized instructions in each section below.

1. General Information:

Sources *(check potential sources at the site)*

- ☐ USTs
- ☐ ASTs
- ☐ Dispensers/fuel loading racks
- ☐ Drums
- ☐ Vehicles
- ☐ Landfills
- ☐ Transformers
- ☐ Other:

Release Mechanisms *(check potential release mechanisms at the site)*

- ☐ Spills
- ☐ Leaks
- ☐ Direct discharge
- ☐ Burning
- ☐ Other:

Impacted Media *(check potentially-impacted media at the site)*

- ☐ Surface soil (0-2 feet bgs*)
- ☐ Subsurface soil (>2 feet bgs)
- ☐ Air
- ☐ Sediment
- ☐ Groundwater
- ☐ Surface water
- ☐ Biota
- ☐ Other:

Receptors *(check receptors that could be affected by contamination at the site)*

- ☐ Residents (adult or child)
- ☐ Commercial or industrial worker
- ☐ Construction worker
- ☐ Subsistence harvester (i.e. gathers wild foods)
- ☐ Subsistence consumer (i.e. eats wild foods)
- ☐ Site visitor
- ☐ Trespasser
- ☐ Recreational user
- ☐ Farmer
- ☐ Other:

* bgs - below ground surface

2. Exposure Pathways: *(The answers to the following questions will identify complete exposure pathways at the site. Check each box where the answer to the question is "yes".)*

a) Direct Contact -

1. Incidental Soil Ingestion

Are contaminants present or potentially present in surface soil between 0 and 15 feet below the ground surface? (Contamination at deeper depths may require evaluation on a site-specific basis.) ☐

If the box is checked, label this pathway complete:

Comments:

2. Dermal Absorption of Contaminants from Soil

Are contaminants present or potentially present in surface soil between 0 and 15 feet below the ground surface? (Contamination at deeper depths may require evaluation on a site specific basis.) ☐

Can the soil contaminants permeate the skin (see Appendix B in the guidance document)? ☐

If both boxes are checked, label this pathway complete:

Comments:

b) Ingestion -

1. Ingestion of Groundwater

Have contaminants been detected or are they expected to be detected in the groundwater, or are contaminants expected to migrate to groundwater in the future? ☐

Could the potentially affected groundwater be used as a current or future drinking water source? Please note, only leave the box unchecked if DEC has determined the ground-water is not a currently or reasonably expected future source of drinking water according to 18 AAC 75.350. ☐

If both boxes are checked, label this pathway complete:

Comments:

2. Ingestion of Surface Water

Have contaminants been detected or are they expected to be detected in surface water, or are contaminants expected to migrate to surface water in the future? ☐

Could potentially affected surface water bodies be used, currently or in the future, as a drinking water source? Consider both public water systems and private use (i.e., during residential, recreational or subsistence activities). ☐

If both boxes are checked, label this pathway complete:

Comments:

3. Ingestion of Wild and Farmed Foods

Is the site in an area that is used or reasonably could be used for hunting, fishing, or harvesting of wild or farmed foods? ☐

Do the site contaminants have the potential to bioaccumulate (see Appendix C in the guidance document)? ☐

Are site contaminants located where they would have the potential to be taken up into biota? (i.e. soil within the root zone for plants or burrowing depth for animals, in groundwater that could be connected to surface water, etc.) ☐

If all of the boxes are checked, label this pathway complete:

Comments:

c) Inhalation-

1. Inhalation of Outdoor Air

Are contaminants present or potentially present in surface soil between 0 and 15 feet below the ground surface? (Contamination at deeper depths may require evaluation on a site specific basis.) ☐

Are the contaminants in soil volatile (see Appendix D in the guidance document)? ☐

If both boxes are checked, label this pathway complete:

Comments:

2. Inhalation of Indoor Air

Are occupied buildings on the site or reasonably expected to be occupied or placed on the site in an area that could be affected by contaminant vapors? (within 30 horizontal or vertical feet of petroleum contaminated soil or groundwater; within 100 feet of non-petroleum contaminted soil or groundwater; or subject to "preferential pathways," which promote easy airflow like utility conduits or rock fractures) ☐

Are volatile compounds present in soil or groundwater (see Appendix D in the guidance document)? ☐

If both boxes are checked, label this pathway complete:

Comments:

3. **Additional Exposure Pathways:** *(Although there are no definitive questions provided in this section, these exposure pathways should also be considered at each site. Use the guidelines provided below to determine if further evaluation of each pathway is warranted.)*

Dermal Exposure to Contaminants in Groundwater and Surface Water

Dermal exposure to contaminants in groundwater and surface water may be a complete pathway if:

- Climate permits recreational use of waters for swimming.
- Climate permits exposure to groundwater during activities, such as construction.
- Groundwater or surface water is used for household purposes, such as bathing or cleaning.

Generally, DEC groundwater cleanup levels in 18 AAC 75, Table C, are deemed protective of this pathway because dermal absorption is incorporated into the groundwater exposure equation for residential uses.

Check the box if further evaluation of this pathway is needed: ☐

Comments:

Inhalation of Volatile Compounds in Tap Water

Inhalation of volatile compounds in tap water may be a complete pathway if:

- The contaminated water is used for indoor household purposes such as showering, laundering, and dish washing.
- The contaminants of concern are volatile (common volatile contaminants are listed in Appendix D in the guidance document.)

DEC groundwater cleanup levels in 18 AAC 75, Table C are protective of this pathway because the inhalation of vapors during normal household activities is incorporated into the groundwater exposure equation.

Check the box if further evaluation of this pathway is needed: ☐

Comments:

Inhalation of Fugitive Dust

Inhalation of fugitive dust may be a complete pathway if:

- o Nonvolatile compounds are found in the top 2 centimeters of soil. The top 2 centimeters of soil are likely to be dispersed in the wind as dust particles.
- o Dust particles are less than 10 micrometers (Particulate Matter - PM_{10}). Particles of this size are called respirable particles and can reach the pulmonary parts of the lungs when inhaled.

DEC human health soil cleanup levels in Table B1 of 18 AAC 75 are protective of this pathway because the inhalation of particulates is incorporated into the soil exposure equation.

Check the box if further evaluation of this pathway is needed: ☐

Comments:

Direct Contact with Sediment

This pathway involves people's hands being exposed to sediment, such as during some recreational, subsistence, or industrial activity. People then incidentally ingest sediment from normal hand-to-mouth activities. In addition, dermal absorption of contaminants may be of concern if the the contaminants are able to permeate the skin (see Appendix B in the guidance document). This type of exposure should be investigated if:

- o Climate permits recreational activities around sediment.
- o The community has identified subsistence or recreational activities that would result in exposure to the sediment, such as clam digging.

Generally, DEC direct contact soil cleanup levels in 18 AAC 75, Table B1, are assumed to be protective of direct contact with sediment.

Check the box if further evaluation of this pathway is needed: ☐

Comments:

4. Other Comments *(Provide other comments as necessary to support the information provided in this form.)*

Print Form

HUMAN HEALTH CONCEPTUAL SITE MODEL GRAPHIC FORM

Site: ____

____

Completed By: ______________________________

Date Completed: ______________________________

***Instructions**: Follow the numbered directions below. Do not consider contaminant concentrations or engineering/land use controls when describing pathways.*

(1)
Check the media that could be directly affected by the release.

(2)
For each medium identified in (1), follow the top arrow and check possible transport mechanisms. Check additional media under (1) if the media acts as a secondary source.

(3)
Check all exposure media identified in (2).

(4)
*Check all pathways that could be complete. The pathways identified in this column **must** agree with Sections 2 and 3 of the Human Health CSM Scoping Form.*

(5)
Identify the receptors potentially affected by each exposure pathway: Enter "C" for current receptors, "F" for future receptors, "C/F" for both current and future receptors, or "I" for insignificant exposure.

Media / Transport Mechanisms

Media	Transport Mechanisms	
☐ Surface Soil (0-2 ft bgs)	Direct release to surface soil	check soil
	☐ *Migration to subsurface*	*check soil*
	☐ *Migration to groundwater*	*check groundwater*
	☐ *Volatilization*	*check air*
	☐ *Runoff or erosion*	*check surface water*
	☐ *Uptake by plants or animals*	*check biota*
	☐ *Other (list):* ______________	
☐ Subsurface Soil (2-15 ft bgs)	Direct release to subsurface soil	check soil
	☐ *Migration to groundwater*	*check groundwater*
	☐ *Volatilization*	*check air*
	☐ *Uptake by plants or animals*	*check biota*
	☐ *Other (list):* ______________	
☐ Ground-water	Direct release to groundwater	check groundwater
	☐ *Volatilization*	*check air*
	☐ *Flow to surface water body*	*check surface water*
	☐ *Flow to sediment*	*check sediment*
	☐ *Uptake by plants or animals*	*check biota*
	☐ *Other (list):* ______________	
☐ Surface Water	Direct release to surface water	check surface water
	☐ *Volatilization*	*check air*
	☐ *Sedimentation*	*check sediment*
	☐ *Uptake by plants or animals*	*check biota*
	☐ *Other (list):* ______________	
☐ Sediment	Direct release to sediment	check sediment
	☐ *Resuspension, runoff, or erosion*	*check surface water*
	☐ *Uptake by plants or animals*	*check biota*
	☐ *Other (list):* ______________	

Exposure Media / Exposure Pathway/Route / Current & Future Receptors

Exposure Media	Exposure Pathway/Route	Residents (adults or children)	Commercial or industrial workers	Site visitors, trespassers, or recreational users	Construction workers	Farmers or subsistence harvesters	Subsistence consumers	Other
☐ soil	☐ Incidental Soil Ingestion							
	☐ Dermal Absorption of Contaminants from Soil							
	☐ Inhalation of Fugitive Dust							
☐ groundwater	☐ Ingestion of Groundwater							
	☐ Dermal Absorption of Contaminants in Groundwater							
	☐ Inhalation of Volatile Compounds in Tap Water							
☐ air	☐ Inhalation of Outdoor Air							
	☐ Inhalation of Indoor Air							
	☐ Inhalation of Fugitive Dust							
☐ surface water	☐ Ingestion of Surface Water							
	☐ Dermal Absorption of Contaminants in Surface Water							
	☐ Inhalation of Volatile Compounds in Tap Water							
☐ sediment	☐ Direct Contact with Sediment							
☐ biota	☐ Ingestion of Wild or Farmed Foods							

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APPENDIX B

SOIL CONTAMINANTS EVALUATED FOR DERMAL EXPOSURE

Soil contaminants are evaluated for dermal exposure when a specific absorption factor is available (EPA, 2004c). Where specific absorption factors were not available for an organic compound and it is not considered a volatile, an absorption fraction of 0.10 is applied. It is generally accepted that volatile compounds evaporate from skin before significant absorption occurs and are addressed through the inhalation exposure pathway.

Acenaphthene	Dichlorophenol, 2,4-	Naphthalene
Acenaphthylene	Dichlorophenoxy Acetic Acid, 2,4-	Nitroglycerin
Anthracene	Dieldrin	Nitroguanidine
Arsenic, Inorganic	Diethyl Phthalate	Nitroso-di-N-propylamine, N-
Benz[a]anthracene	Dimethylphenol, 2,4-	Nitrosodiphenylamine, N-
Benzo[a]pyrene	Dimethylphthalate	Nitrotoluene, m-
Benzo[b]fluoranthene	Dinitrobenzene, 1,2-	Nitrotoluene, p-
Benzo[g,h,i]perylene	Dinitrobenzene, 1,3-	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
Benzo[k]fluoranthene	Dinitrobenzene, 1,4-	Octyl Phthalate, di-N-
Benzoic Acid	Dinitrophenol, 2,4-	Pentachlorophenol
Benzyl Alcohol	Dinitrotoluene, 2,4-	Pentaerythritol tetranitrate (PETN)
Bis(2-ethylhexyl)phthalate	Dinitrotoluene, 2,6-	Perfluorooctane Sulfonate (PFOS)
Butyl Benzyl Phthalate	Dinitrotoluene, 2-Amino-4,6-	Perfluorooctanoic acid (PFOA)
Cadmium (Diet)	Dinitrotoluene, 4-Amino-2,6-	Phenanthrene
Chlordane	Diphenylamine	Phenol
Chlordecone (Kepone)	Endrin	Polychlorinated Biphenyls (high risk)
Chloroaniline, p-	Ethylene Glycol	Pyrene
Chloronaphthalene, Beta-	Fluoranthene	TCDD, 2,3,7,8-
Chrysene	Fluorene	Tetryl (Trinitrophenylmethylnitramine)
Cresol, m-	Hexachlorocyclohexane, Alpha-	Toxaphene
Cresol, o-	Hexachlorocyclohexane, Beta-	Trichlorophenol, 2,4,5-
Cresol, p-	Hexachlorocyclohexane, Gamma- (Lindane)	Trichlorophenol, 2,4,6-
DDD	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	Trichlorophenoxyacetic Acid, 2,4,5-
DDT	Indeno[1,2,3-cd]pyrene	Trichlorophenoxypropionic acid, -2,4,5
Dibenz[a,h]anthracene	Isophorone	Trinitrobenzene, 1,3,5-
Dibenzofuran	Methoxychlor	Trinitrotoluene, 2,4,6-
Dibutyl Phthalate	Methylnaphthalene, 1-	
Dichlorobenzidine, 3,3'-	Methylnaphthalene, 2-	

APPENDIX C

BIOACCUMULATIVE COMPOUNDS OF POTENTIAL CONCERN

Bioaccumulation factors (BAFs) and bioconcentration factors (BCFs) provide a direct indication of a chemical's ability to bioaccumulate, although they can vary widely depending on their basis (estimated or measured), the species used, and the measurement method. A BAF is the ratio of contaminants in tissues to the concentration in the surrounding environment (e.g., via food, sediment and water). A BCF is the ratio of the concentration of a chemical in an organism to its concentration in the surrounding water only.

In addition, it is common practice to use the log Kow to characterize the hydrophobicity, and thereby bioaccumulation potential, of organic compounds (EPA, 2000). The minimum criteria defining bioaccumulation potential for nonionic organic compounds is a log Kow greater than 3.5. The value of 3.5 was used as a minimum threshold based on observed relationships between the Kow of an unmetabolized chemical and its potential for biomagnification. Specifically, uptake efficiency tends to increase with increasing log Kow for values between 3 and 6 (Thomann, 1989). For inorganic compounds, the BCF approach has not been shown to be effective in estimating the compound's ability to bioaccumulate. Information available, either through scientific literature or site-specific data, regarding the bioaccumulative potential of an inorganic site contaminant should be used to determine if the pathway is complete.

The ADEC list was developed by including organic compounds that either have a BAF or BCF equal to or greater than 1,000 from the 2015 EPA national bioaccumulation factor supplemental information table (Excel) (January 2016) for human health water quality criteria. Compounds without a BCF or BAF were retained when the log Kow generated from the ADEC cleanup level calculator was greater than 3.5. These compounds were entered into EPA's Persistent, Bioaccumulative, and Toxic (PBT) Profiler (EPA 2016) to estimate the BCF. Compounds were included in the list when the BCF was greater than 1,000 and excluded when the BCF was less than 1000. The PBT Profiler is located at http://www.pbtprofiler.net/. Compounds with a log K_{ow} greater than 3.5 that are not found in the PBT Profiler are included in the list of bioaccumulative compounds below. Inorganic compounds are also identified as bioaccumulative if they are listed as such by EPA (2000).

Compounds from Table B-1 of 18 AAC 75.341 determined bioaccumulative based on the process above or otherwise footnoted.

Aldrin	DDT	Methoxychlor
Arsenic, Inorganic	Dibenz[a,h]anthracene	Methyl Mercury
Benz[a]anthracene	Dibutyl Phthalate	Nickel
Benzo[a]pyrene	Dieldrin	Perfluorooctane Sulfonate (PFOS)[1]
Benzo[b]fluoranthene	Dimethylphthalate	Perfluorooctanoic acid (PFOA)[2]
Benzo[g,h,i]perylene	Endrin	Phenanthrene
Benzo[k]fluoranthene	Fluoranthene	Polychlorinated Biphenyls
Butyl Benzyl Phthalate	Heptachlor	Selenium
Cadmium	Heptachlor Epoxide	Silver
Chlordane	Hexachlorobenzene	TCDD, 2,3,7,8-
Chlordecone (Kepone)	Hexachlorobutadiene	Toxaphene
Chromium(VI)	Hexachlorocyclohexane, Alpha-	Trichlorobenzene, 1,2,4-
Chrysene	Hexachlorocyclohexane, Gamma- (Lindane)	Tri-n-butyltin
Copper	Hexachloroethane	Zinc
DDD	Indeno[1,2,3-cd]pyrene	
DDE	Lead	

[1]The weight of evidence for trophic magnification was deemed sufficient to consider PFOS to be bioaccumulative by the Stockholm Convention Persistent Organic Pollutants Review Committee (OECD 2002).

[2]The weight of evidence for trophic magnification was deemed sufficient to consider PFOA to be bioaccumulative by the Stockholm Convention Persistent Organic Pollutants Review Committee (UNEP 2015).

APPENDIX D

VOLATILE COMPOUNDS OF POTENTIAL CONCERN

A chemical is identified here as sufficiently volatile and toxic for further evaluation if the Henry's Law constant is greater than 1 x 10^{-5} atm-m^3/mol or vapor pressure is greater than 1 millimeter of mercury (mm HG), and the vapor concentration of the pure component exceeds the indoor air target risk level when the subsurface vapor source is in soil or saturated vapor concentration exceeds the target indoor air risk level, when the subsurface vapor source is in groundwater (EPA, 2015).

Acenaphthene*	**Fluorene***
Acenaphthylene*	Formaldehyde
Acetone	Heptachlor
Aldrin	Heptachlor Epoxide
Anthracene*	Hexachlorobenzene
Benz[a]anthracene	Hexachlorobutadiene
Benzaldehyde*	Hexachlorocyclopentadiene
Benzene	Hexachloroethane
Bis(2-chloroethyl)ether	**Hexane, N-**
Bromobenzene	Hexanone, 2-
Bromodichloromethane	Hydrazine
Bromoform	Isopropanol
Bromomethane	Mercury (elemental)
Butadiene, 1,3-	Methanol
Butanol, N-*	Methyl Ethyl Ketone (2-Butanone)
Butylbenzene, n-*	Methyl Isobutyl Ketone (4-methyl-2-pentanone)
Butylbenzene, sec-*	Methyl tert-Butyl Ether (MTBE)
Butylbenzene, tert-*	Methylene Chloride
Carbon Disulfide	**Methylnaphthalene, 1-***
Carbon Tetrachloride	**Methylnaphthalene, 2-***
Chlordane	**Naphthalene**
Chlorobenzene	Nitrobenzene
Chloroform	Nitrosodimethylamine, N-
Chloromethane	Nitrotoluene, o-*
Chloronaphthalene, Beta-*	**Phenanthrene***
Chlorophenol, 2-*	Phosphorus, White*
Cumene	Polychlorinated Biphenyls
Cyanide (CN-)	**Propyl benzene**
Cyclohexane	**Pyrene***
DDE, p,p'-	Styrene
Dibenzofuran*	TCDD, 2,3,7,8-
Dibromochloromethane*	Tetrachloroethane, 1,1,1,2-
Dibromoethane, 1,2-	Tetrachloroethane, 1,1,2,2-
Dibromomethane (Methylene Bromide)	Tetrachloroethylene

Dichlorobenzene, 1,2-	**Toluene**
Dichlorobenzene, 1,3-	Trichloro-1,2,2-trifluoroethane, 1,1,2-
Dichlorobenzene, 1,4-	Trichlorobenzene, 1,2,3-*
Dichlorodifluoromethane	Trichlorobenzene, 1,2,4-
Dichloroethane, 1,1-	Trichloroethane, 1,1,1-
Dichloroethane, 1,2-	Trichloroethane, 1,1,2-
Dichloroethylene, 1,1-	Trichloroethylene
Dichloroethylene, 1,2-cis-*	Trichlorofluoromethane*
Dichloroethylene, 1,2-trans-*	Trichloropropane, 1,2,3-
Dichloropropane, 1,2-	**Trimethylbenzene, 1,2,4-**
Dichloropropene, 1,3-	**Trimethylbenzene, 1,3,5-***
Dioxane, 1,4-	Tri-n-butyltin*
Endosulfan*	Vinyl Acetate
Ethyl Chloride	Vinyl Chloride
Ethylbenzene	**Xylenes**

Notes:

1. Bolded chemicals should be investigated when petroleum is present. If fuel was spilled that contained additives (e.g., 1, 2-dichloroethane, ethylene dibromide, methyl *tert*-butyl ether), these chemicals should also be investigated.
2. The chemicals listed here are found in Table B1 of 18 AAC 75.341 and Table C of 18 AAC 75.345 and are volatile compounds as defined in DEC's Procedures for Calculating Cleanup Levels. If a chemical is not on this list, contact DEC to determine if a target level should be calculated.
3. At this time, DEC does not require evaluation of total petroleum ranges (GRO, DRO, or RRO) for the indoor air inhalation (vapor intrusion) pathway.
4. "*" indicates DEC has not calculated an inhalation screening level for this chemical due to a lack of toxicity information for the inhalation exposure pathways. The DEC project manager may require further evaluation of this chemical. Contact the DEC risk assessor for additional assistance.

APPENDIX E

CONTAMINANT PROPERTIES USED TO EVALUATE TRANSPORT MECHANISMS

These parameters describe chemical properties of the site contaminants. Important chemical parameters used to evaluate transport mechanisms are shown below. The values specific to each chemical determine how easily a chemical is transported by various mechanisms. The default values used by the DEC can be found in the DEC's Procedures for Calculating Cleanup Levels (September 2016).

Important Physical and Chemical Parameters Used to Evaluate Transport Mechanisms.

Purpose	Parameter	Symbol	Meaning
Does the contaminant cling to organic matter or does it move with water?	**Organic carbon partition coefficient**	**K_{oc}**	Provides a measure of the extent of chemical partitioning between organic carbon and water at equilibrium. The higher the K_{oc}, the more likely a chemical is to bind to soil or sediment than to remain in water.
	Soil/water partition coefficient	**K_d**	Provides a soil or sediment-specific measure of the extent of chemical partitioning between soil or sediment and water, unadjusted for dependence upon organic carbon. The higher the K_d, the more likely a chemical is to bind to soil or sediment than to remain in water.
	Octanol coefficient	**K_{ow}**	Provides a measure of the extent of chemical partitioning between water and octanol at equilibrium. The greater the K_{ow}, the more likely a chemical is to partition to octanol than to remain in water. Octanol is used as a surrogate for lipids (fat), and K_{ow} can be used to predict bioconcentration in aquatic organisms.
Does it dissolve in water?	**Solubility**		Is the upper limit on a chemical's dissolved concentration in water at a specified temperature? Aqueous concentrations in excess of solubility may indicate sorption onto sediments, the presence of solubilizing chemicals such as solvents, or the presence of a non-aqueous phase liquid.
Does it vaporize?	**Henry's Law Constant**	**H_1**	Provides a measure of the extent of chemical partitioning between air and water at equilibrium. The higher the Henry's Law

Purpose	Parameter	Symbol	Meaning
Does it vaporize?			constant, the more likely a chemical is to volatize than to remain in water.
	Vapor Pressure		Is the pressure exerted by a chemical vapor in equilibrium with its solid or liquid form at any given temperature? It is used to calculate the rate of volatilization of a pure substance from a surface or in estimating a Henry's Law constant for chemicals with low water solubility. The higher the vapor pressure, the more likely a chemical is to exist in a gaseous state.
Does it spread?	**Movement of molecules**	**Diffusivity**	Describes the movement of a molecule in a liquid or gas medium as a result of differences in concentration. It is used to calculate the dispersive component of chemical transport. The higher the diffusivity, the more likely a chemical is to move in response to concentration gradients.
Does it accumulate in living tissue?		**Bioconcentration Factor (BCF)**	Provides a measure of the extent of chemical partitioning at equilibrium between a biological medium such as fish tissue or plant tissue and an external medium such as water. The higher the BCF, the greater the accumulation in living tissue is likely to be.
How easily does it break down over time?	**Persistence**	**Media-Specific Half-Life**	Provides a relative measure of persistence of a chemical in a given medium, although actual values can vary greatly depending on site-specific conditions. The greater the half-life, the more persistent a chemical is likely to be.

Source: *Risk Assessment Guidance for Superfund, Volume 1, Part A*, Exhibit 6-4 (EPA 1989).