ORBCA GUIDANCE

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BACKGROUND AND INTRODUCTION

1.1 INTRODUCTION

The Oklahoma Corporation Commission (OCC) is faced with the challenging task of ensuring environmentally sound cleanup or other appropriate response actions at over 1,430 sites. Recent experience indicates that the traditional approach of treating all sites "equal" and requiring every site to be remediated to non-detect or other empirically derived levels is technically and economically infeasible. Often, this traditional approach results in inconsistent decisions, delays in site closure and is not conducive to cost-effective decisions that are protective of the state's resources. Although the OCC will not allow cost considerations to compromise public health or the environment, it recognizes the need to promote cost-effective site activities (both characterization as well as remediation) that are protective of human health and the environment. Thus, there is a need to develop a regulatory program that will streamline the process of site cleanup and closures. Such a program would enable the tank owners/operators (regulatory contact – RC) as well as the OCC to focus their efforts and finite resources on sites that pose unacceptable current and/or potential future risks.

In response to this need, the OCC has put in place modifications to the Corrective Action Requirements under Oklahoma Administrative Code (OAC) 165:29, Remediation Rules and adopted a risk-based corrective action (RBCA) program for the management (assessment, remediation, and closure) of regulated leaking petroleum storage tank (LPST) sites. This program is based on *Risk Based Corrective Action Applied at Petroleum Release Sites, Standard E 1739-95,* issued by the American Society of Testing Materials (ASTM, 1995). This ASTM standard has been modified for consistency with the OCC's regulations and policies. The overall objectives of the program are to protect human health and the environment in the most practical and resource effective manner using a scientifically defensible and consistent decision-making process.

1.2 APPLICABILITY AND PURPOSE OF THIS DOCUMENT

This risk-based corrective action program establishes step-by-step procedures to determine:

- type, quality, and quantity of data to be collected at a site
- need for, type and extent of initial remedial actions
- criteria for site cleanup
- development of target cleanup levels
- need for site-specific corrective action(s)
- criteria for closure of regulated underground storage tank spill sites
- use of monitoring as a site management tool
- use of natural attenuation as an effective site management tool.

This process shall be applicable to all petroleum storage tank release sites in Oklahoma regulated by the OCC.

This guidance document has been developed for environmental professionals with a working knowledge and experience in the areas of site assessment, site investigation, risk assessment and remedial actions. It includes technical information that describes the RBCA program and its elements, including site assessment, risk assessment, corrective action and the closure process as developed by the OCC. Since the development of risk-based target levels is an integral part of the overall process of risk management and has not been described earlier in other state guidance documents, it is described at length in Sections 4 through 7 and Appendices B and C.

Note, this document is not intended as a guide to every aspect of the risk assessment practice. Prior experience or training will be necessary for an individual to correctly implement risk assessment as part of the overall process of site closure. For appropriate certification as a UST consultant, refer to Oklahoma Administrative Code (OAC) 165:29-3-90. **It is the intent of the OCC to keep this guidance document evergreen**. Thus, as the Commission, consultants and responsible parties with sites in Oklahoma gain experience with this process and provide comments to the State, the guidance document may be revised.

1.3 OVERVIEW OF OKLAHOMA'S RISK-BASED CORRECTIVE ACTION PROCESS

Unless otherwise directed, the OCC will require that owners and/or operators at all confirmed release sites perform a Tier 1A site assessment and compare representative site concentrations to the ORBCA Tier 1A generated modified Risk-Based Screening Levels (RBSLs) for the appropriate routes of exposure and exposure points. Default values are established in the ORBCA Guidance Document for Exposure Factors and Fate and Transport Parameters.

The Tier 1A assessment must be performed using the models cited in Appendix C of this Guidance Document. The Fate and Transport Parameters cited in Table 5-3 should be replaced by site-specific information obtained through site investigation/assessment. Justification must be provided when any default Fate and Transport Parameters are modified. **The default Exposure Factors cannot be modified nor can degradation rates be used under a Tier 1A assessment.**

Once the Tier 1A assessment has been performed, the owner and/or operator must submit a Tier 1A report, using the appropriate worksheets and attachments. This report must include the owner and/or operator recommendations for future actions. These recommendations may include:

1. Closure under a Tier 1A assessment.
2. Remediate and close under a Tier 1A assessment.
3. Perform a Tier 2 assessment.
4. Monitor for closure through natural attenuation.

The site should be prioritized for remediation prior to beginning remediation and must be pre-approved if reimbursement from the Indemnity Fund is expected. The owner and/or operator must obtain approval from the OCC prior to initiating item numbers 2, 3 or 4 cited above, subsequent to submission of the Tier 1A report.

A Tier 2 or Tier 3 assessment may use any OCC pre-approved models, degradation rates, new site-specific information obtained from additional investigation and/or modification of

Exposure Factors and Fate and Transport Parameters for calculating risk or target levels. Any modifications to the default factors or parameter values, models or use of degradation must be explained and justified. Once a Tier 2 or Tier 3 assessment has been performed, the owner and/or operator must submit the report, using the appropriate worksheets and attachments, to the OCC. This report must include the owner and/or operators recommendations for further actions.

Their recommendations may include:

1. Remediate and close under a Tier 2 assessment.
2. Perform a Tier 3 assessment.
3. Remediate and close under a Tier 3 assessment.
4. Monitor for closure through natural attenuation.

Note, a higher tier SSTLs supersede any lower tier calculations. Key components of risk management for regulated underground storage tank impacted sites are presented in Figure 1-1. These include:

STEP 1: **Preliminary release investigation and confirmation**

A preliminary release investigation and confirmation is conducted by the regulatory contact as per OAC 165:29-3-3. The investigations may be triggered by one or more of the following:

STEP 1A: Suspicion from non-environmental evidence:

1. Water in UST
2. Tank or line tightness test failure
3. Inventory shortage

The Compliance department of the OCC PSTD will usually require a tightness test of the fuel storage system. If the test fails, the RC may expose the system, repair what is leaking and retest. If the retest fails, a confirmed release is declared. If the retest proves tight, even if there has been a significant amount of inventory unaccounted, for a soil and/or groundwater test will probably be required.

Click Here for ORBCA Flow Chart

STEP 1B: Suspicion from environmental evidence:

1. Unexplained vapors on or off-site
2. Greater than 4000 units on an OVM, or 1500 units for diesel or an increase of 500 units over historic background levels, in a vapor monitoring well for four (4) months
3. Unexplained surface water sheen downgradient of the property
4. Sheen on water in monitoring or vapor monitoring well
5. Backfill significantly above the OCC Action Levels [Listed in OAC 165:29-3-3(b)]
6. Tank system observation well concentrations above action levels.

A suspicion of release (SOR) issued for the above reasons will usually require a soil and/or groundwater test. **As with every other assessment step, if the regulatory contact is seeking reimbursement from the Indemnity Fund it is imperative to gain pre-approval through the form of a purchase order request.** A soil and/or groundwater sample must be collected from the location(s) most likely to be impacted. Whenever subsurface soils will allow both of these samples to be collected by direct-push drilling, that method is allowed. This method has the advantage of being able to collect multiple samples around the tanks, piping runs, dispensers and possibly even a critical receptor point. It may also help pinpoint the exact location of the release. If hollow-stem auger drilling is used, the groundwater sample must be collected from a completed and properly developed well. Solid-stem auger drilling is not permitted whenever sampling is required.

STEP 1C: Confirmed environmental contamination:

1. Any free product found below surface (including >1/8" on water in monitoring well) outside any secondary containment structure
2. Native soil exceeds the OCC Action Levels [Listed in OAC 165:29-3-3(b)]
3. Native ground water exceeds the OCC Action Levels [Listed in OAC 165:29-3-3(b)]

4. Two (2) tank or line tightness (one before and another after remedial actions, if any) test failures

STEP 2: **Suspicion of Release or Notice of Confirmed Release**

The OCC sends either suspicion of release letter or notice of confirmed release to the tank owner/operator.

STEP 3: **20-Day Report**

Preparation and submission to the OCC of the 20-day report by the responsible party per OAC 165:29-3-3, OAC 165:29-3-72, OAC 165:29-3-73, OAC 165:29-3-74 and OAC 165:29-3-75 (referred to as The Initial Response and Abatement and Initial Site Characterization Report).

STEP 3A: An initial site check consisting of either system tightness testing or native environment sampling as directed by the OCC, plus a description of activities performed in response to confirming the release and measures taken to abate and mitigate the release per OAC 165:29-3-72 and OAC 165:29-3-73.

STEP 3B: A description of activities performed in response to confirming the release, and measures taken to abate and mitigate the release as per OAC 165:29-3-72 and OAC 165:29-3-73 and any site check data obtained during those activities. Details of the initial response and abatement actions are presented in Section 2.0. (This step is not required if Step 3A is performed.)

STEP 4: **Initial Site Characterization and Tier 1A Analysis**

The responsible party performs a Tier 1A analysis as appropriate (165:29-3-76). This involves:

STEP 4A: Development of site conceptual exposure model [SCEM] (see Section 5.2).

STEP 4B: Development of Tier 1A modified RBSLs and Comparison of site concentrations with Tier 1A modified RBSLs, if appropriate (see Section 5.3).

STEP 4C: Preparation and submission of Tier 1A report and recommendations in a format acceptable to the OCC (see PSTD web site "Technical Forms").

STEP 5: Review of the Site Assessment and Tier 1A Report by the OCC

If site concentrations are below Tier 1A levels, the OCC may approve the report and issue a case closure. Alternatively, if the site concentrations are above these levels, the OCC will consider the site conditions and the recommendations presented in the report and direct the tank owner to do one or more of the following:

- Conduct interim remediation
- Perform Tier 2 analysis
- Develop and implement a remedial action plan to meet Tier 1A levels. The OCC will issue case closure when the Tier 1A levels have been achieved.

STEP 6: Tier 2 Analysis

This step requires the responsible party to do the following:

STEP 6A: Update the SCEM developed in Step 5A (see Section 6.2.1) as appropriate.

STEP 6B: Identification and collection of additional data as appropriate including delineation of the soil and groundwater plumes to modified RBSLs. One objective of this investigation is to eliminate or confirm whether pathways to the various receptors identified in Tier 1A are complete.

STEP 6C: Development of Tier 2 target levels or estimation of risk (see Sections 6.2.2, 6.2.3, and 6.2.4).

STEP 6D: Comparison of Tier 2 target levels with representative site concentrations or comparison of estimated risk with acceptable risk level (see Sections 6.2.4 and 6.2.5).

STEP 6E: Preparation and submission of Tier 2 report and recommendations to the OCC (see Section 6.2.6).

STEP 7: Review of Tier 2 Report by the OCC

If the site concentrations are below Tier 2 levels, the OCC may approve the report and issue a case closure. Alternatively, if the site concentrations are above Tier 2 levels, the OCC will consider the site conditions and the recommendations presented in the report and direct the RC to do one or more of the following:

- Conduct interim remediation
- Perform Tier 3 analysis
- Develop and implement a remedial action plan to meet Tier 2 levels. Subsequent to the successful implementation of the remedial action plan, the OCC will issue case closure.

STEP 8: Tier 3 Analysis

This step requires the RC to do the following:

STEP 8A: Identification and collection of additional data.

STEP 8B: Development of Tier 3 target levels (see Section 7.1).

STEP 8C: Comparison of Tier 3 target levels with representative site concentrations (see Section 7.1).

STEP 8D: Preparation and submission of Tier 3 report and recommendations to the OCC (see Section 7.1).

STEP 9: Review of Tier 3 report by the OCC

If site concentrations are below Tier 3 values, the OCC may approve the report and issue a case closure. Alternatively, if the site concentrations are above Tier 3 levels, the OCC will consider the site conditions and the recommendations outlined in the report and prepare correspondence directing the tank owner to develop and implement a remedial action plan to meet Tier 3 levels.

The process outlined above for the management of regulated fuel storage tank sites is referred to as the RBCA process. This process includes the entire gamut of site-specific activities: site assessment, site investigation, initial response actions, selection/development of target levels, site remediation, site monitoring and site closure with or without engineering controls.

In the context of RBCA, the remedial action plan at some sites may consist of monitoring only to demonstrate a decreasing trend in concentrations. In such situations, the intent would be to allow the natural attenuation processes (advection, diffusion, dispersion, volatilization, biochemical decay, etc.) to lower the site concentrations to Tier 1A, Tier 2 or Tier 3 levels within a reasonable period of time. The OCC intends to develop guidance on natural attenuation in the future.

Note that as the site moves from lower to higher tiers of analysis, it results in the following:

- The collection of additional site-specific data, thus increasing the cost of data collection and analysis, and reducing the overall uncertainty about the site;
- The need for additional analysis to develop site-specific target levels (SSTLs), thus increasing the cost of risk assessment;
- In general, the calculated SSTLs will be higher than the lower tier values because lower tier levels are designed to be more conservative than higher tier levels. Thus, the cost of corrective action to achieve the higher tier target levels may be lower;
- The need for and the extent of regulatory oversight and review will increase, and

- The level of uncertainty and conservatism will decrease due to the availability of more data.

With all of these differences among the three tiers, there is one very significant similarity. Each tier will result in an equally acceptable level of protection for the site-specific human and environmental receptors, where the acceptable level of protection is defined by the OCC (See Section 4.6).

2.0
INITIAL RESPONSE ACTIONS

2.1 INTRODUCTION

This chapter discusses the initial response actions to be taken by an owner/operator after a release has been confirmed. The reporting requirements for the release were discussed in Section 1.3. The objective of the initial response actions is to abate, control or prevent an emergency situation and to expeditiously perform actions necessary to avoid immediate threat to human health, safety and the environment. If the tanks still contain fuel, another objective is to verify that the entire storage tank system is tight.

2.2 DETERMINING THE NEED FOR INITIAL RESPONSE ACTION

The Oklahoma Corporation Commission has developed a priority index number to guide the selection of appropriate response actions to a confirmed release. **The priority index number is assigned by the PSTD Project Environmental Analyst (PEA) and is based on assessment information submitted by the consultant, third party reports and independent observations made at the site.**

The prioritity index number is a quantitative, early indicator of the degree to which human health and safety may be impacted. A high number implies the impacts could be very serious and exposure may have already happened. Whereas, a low index number is indicative of possible exposure to current receptors in the future. A variety of information that can be rapidly collected at a site is used to assign an index number. This information must be submitted on PSTD Form 373 and 373.1 (FirstRpt.doc) and turned in within 20 days of the activation of the case.

Note, the OCC may internally use the priority index number to determine the amount of oversight or response necessary for the site.

2.3 SELECTING THE TYPE OF INITIAL RESPONSE

Following the identification of the prioritity index number, a range of actions, from evacuation of property occupants to development of a long-term monitoring plan, may be appropriate.

2.4 USE OF PRIORITY INDEX NUMBER BEYOND THE INITIAL RESPONSE ACTIONS

Within the Oklahoma RBCA framework, the priority index number is an evergreen number whose value changes as the site-specific conditions change or become known. For example, if the implementation of a vapor control system significantly reduces the vapor levels, the priority index number may change. Thus, at the completion of each significant action at a site (e.g. corrective action or additional data collection resulting in a change in the understanding of site conditions), the priority index number may be re-assigned by the OCC.

3.0
SITE ASSESSMENT/INVESTIGATION

3.1 INTRODUCTION

This section defines and outlines the site assessment protocol and requirements for implementing the risk-based corrective action/decision-making process at confirmed release sites in Oklahoma. This guidance is subject to, and intended to be consistent with, the rules established under Oklahoma Administrative Code (OAC) 165:29~~5~~. The assessment and investigation process outlined in this document are intended to allow sufficient flexibility to adequately address each release site by a certified remediation consultant who has been retained by the owner and/or operator. It is ultimately the responsibility of the owner and/or operator and the certified remediation consultant to achieve the required assessment, and remediation goals. This document emphasizes the collection of the necessary data to conduct tier-appropriate evaluation(s) and for the OCC to prioritize.

References and protocols which must be followed while performing all site assessments and investigations include API Publication 1628 *"A Guide to the Assessment and Remediation of Underground Petroleum Releases"*, the *"EPA: NWWA Technical Enforcement Guidance Document"* and ASTM E 1739-95 *"Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites"* and "Professional Standards for Oklahoma LPST Investigation and Remediation Activities". Where any of these documents conflict with this Oklahoma Risk Based Corrective Action (ORBCA) Guidance Document, the ORBCA Guidance Document shall take precedence. Additionally, all soil borings and monitoring well installations must be performed by persons licensed to perform this work by the Oklahoma Water Resources Board (OWRB). In addition, all soil and water laboratory analyses submitted to the OCC must be performed by an Oklahoma Department of Environmental Quality (ODEQ) certified laboratory. All maps, figures, diagrams, cross-sections, etc. submitted to the OCC as a part of any report must be legible and not be larger than 11 inches by 17 inches and must be folded to a standard report format (8.5 inches by 11 inches).

3.2 OVERVIEW OF RBCA SITE ASSESSMENT PROCESS

Site assessment involves an evaluation of the area, which is or may be impacted by a release. Rule requirements for a Tier 1A assessment are cited under OAC 165:29-3-74, while the requirements for Tier 2 and Tier 3 are cited under OAC 165:29-3-76. The goals of the assessment are to obtain sufficient data to perform the appropriate Tier risk evaluation. The basic tasks necessary to achieve these goals are:

- identify the nearest actual or potential receptor(s), all appropriate exposure pathway(s) and any immediate and long-term hazards to human health and the environment
- identify areas impacted by chemicals of concern (COC) and determine COC concentrations for all appropriate affected media
- delineate the Tier appropriate horizontal and vertical extent of affected media;
- provide appropriate well points where groundwater is impacted
- identify any site conditions which control or limit movement of COC through the affected media
- Survey elevations of possibly impacted surface water bodies and their bottoms and provide a cross-section with monitoring well data, which shows whether the water body is gaining or losing.

RBCA requires identifying and investigating critical exposure pathways, establishing a site priority and determining Tier appropriate target levels. Tier 1A levels, called modified risk-based screening levels (RBSLs), are based on conservative standard exposure assumptions. Tier 2 and Tier 3 allow varying degrees of site-specific information to replace the conservative Tier 1A assumptions and default values. Tier 2 and Tier 3 evaluations typically require progressively more comprehensive site assessment and investigation and will usually result in establishing more achievable site-specific levels called site-specific target levels (SSTLs). This Guidance is designed to specifically support a Tier 1A risk evaluation and act as a guide to the collection of additional site assessment data to perform a Tier 2 or Tier 3 risk evaluation.

The Tier 1A evaluation must be conducted concurrently with the site assessment. The field data obtained while performing the activities associated with the initial site characterization assessment should be compared with Tier 1A COC target concentrations presented in Section 5.5 to identify any additional data needs. When it is apparent that Tier 1A COC target concentrations have been met, then additional assessment information may not be needed. If during the initial site characterization it becomes apparent that the concentrations of COC at the site exceed Tier 1A modified RBSLs and that the release is extensive, then adequate additional data should be collected to support limited remedial action or Tier 2 site assessment. The owner and/or operator must submit recommendations to the OCC in the Tier 1A report .

3.2.1 Preliminary Planning

A successful subsurface site investigation is directly related to the quality of pre-investigation planning. A Tier 1A risk assessment and site prioritization requires a determination of receptors and viable exposure pathways, current and potential future land use, transport mechanism, contaminant source area(s), and the determination of the maximum degree of contamination in affected media. Preliminary planning at a minimum must include a review of existing facility information, performance of a receptor survey, development of a site conceptual exposure model, and designing a scope of work for the fieldwork. It is essential that all available background information is collected and a receptor survey is performed to develop the site conceptual model (i.e., understanding of the site) prior to performing the site investigation.

3.2.2 Review Existing Facility Information

Regional Geology: Review local and regional geologic and/or hydrogeologic maps, nearby site assessments and/or investigations and any other pertinent publications. These should be used to identify general soil and rock types, regional depth to bedrock, depth to groundwater, aquifer properties, groundwater gradient and flow direction. Identify any aquifers and/or surface water bodies, which serve as sources of water for the area. Identify and evaluate the use and/or potential use of the uppermost groundwater zone within 0.5 miles of the source of chemical release at the facility.

Land Use: Investigate and describe past, current and potential future land uses of the site. Identify potential source areas, migration pathways and receptors. Determine past and current uses of adjacent properties to identify other potential sources of COC. If an off-site receptor is identified, the potential risk must be assessed by anticipating future land use based upon its current use and any existing zoning or development trends of adjacent properties. Document any ordinances, which prevent or influence the future installation of water wells at the site or the surrounding area, such as wellhead protection areas. Identify the current predominant land use of the area as either commercial/industrial or residential. If the predominant land use of the area is residential, identify whether it is considered a minority/non-minority and/or low-income neighborhood. This information is required only for the OCC's reporting requirements to EPA and has no impact on the ORBCA process.

Source History: Knowledge of a tank system layout is critical to a complete investigation of the source area. Locate current and/or former tank systems and other potential sources both on- and off-site (i.e., spills or overfill incidents and/or releases). Inventory control records and tank tightness tests may provide valuable data in evaluating possible sources. Investigate previous assessment work such as tank removal data, previous site assessments, release investigations and/or remediation activities both on-site and on adjacent properties. A detailed site map of the facility, made to scale with a bar scale and north arrow, denoting the layout of any current or past UST or AST systems (including piping) and **locations and depths of all utilities** on, and adjacent to, the site must be included in the ISCR and Tier 1A Report.

3.2.3 Perform A Receptor Survey

The identification of actual and potential receptors and exposure pathways is of critical importance and establishes the basis for site prioritization and determination of target cleanup levels. The receptor survey includes both a field and water well records inventory survey. This information must be clearly presented on a vicinity map or a recent aerial photograph of appropriate scale.

Water Well Inventory: Perform a water well records inventory within 0.5 miles of the source of contamination. Possible information sources include the Oklahoma Department of Environmental Quality, Oklahoma Water Resources Board, Garber Wellington Association, local and county governments, USGS, OGS, and site visit(s). A ground or door-to-door foot search for water wells must be made within a 660 feet radius of the source of contamination.

This is especially critical if the housing appears older than the public water supply system (check with the public water supplier) or if septic systems are observed in the neighborhood.

Modeling the Location of Future Water-Supply Wells (WSW): In areas where the shallowest aquifer can supply water adequate for human or livestock consumption or irrigation, it is necessary to consider where the exposure point (WSW) could be constructed in relationship to the source. If property at and surrounding the source (both primary and secondary and any gasoline storage tank system, current or proposed) is zoned or utilized as commercial, any future well should be considered a **public WSW**. For a definition of a public water supply system, see ODEQ Rule OAC 252:625-1-4. WSWs based on this definition are not permitted within 300 feet of the source [ODEQ Rule OAC 252:625-7-4(a)(5)(C & F)]. If the commercial property is already hooked up to a public water supply and there is very little landscaping, it should not be assumed that a WSW would ever be constructed on that property. It is a good idea to consult with the OCC Project Environmental Analyst when one of these water well scenarios is encountered.

If property surrounding the source in a down- or cross-gradient direction is zoned residential or agricultural, any well would be considered a **domestic (private) WSW**. This type of WSW should be modeled at the closest property line. In the Tier 1A assessment, all future WSWs must be considered drinking water wells and use the default exposure parameters.

Field Survey: The field survey performed within a 660 feet radius of the source of contamination must include, but not be limited, to the following:

- <u>Receptor Identification:</u> Locate all registered and unregistered water wells, schools, hospitals, residences, basements, day care centers, nursing homes and businesses. Other sensitive receptors such as surface water bodies, parks, recreational areas, wildlife sanctuaries, wetlands and agricultural areas must also be identified during the field survey; and
- <u>Migration Pathway Identification:</u> Identify location and depth of all subsurface utilities and structures, especially sanitary sewers, that may serve as preferential migration pathways for released COC.

If a receptor is identified, the potential for exposure or impact must be evaluated. When the receptor is off-site, the need for property access must be determined and obtained prior to mobilization. Any receptor(s) that are known, suspected to be exposed or impacted by COC require immediate action. This may include initiating abatement measures, providing an alternative water supply, relocation of residents, etc.

3.2.4 Develop A Site Conceptual Exposure Model

The information obtained during the preliminary planning phase, in conjunction with the requirements for a Tier 1A assessment, is used to develop an initial site conceptual exposure model (also see Section 4.7). The model is a general understanding, or working hypothesis, and depicts the relationship between the chemical source areas (e.g., impacted soils and groundwater, non-aqueous phase liquids, etc.), transport mechanisms (e.g., leaching, groundwater transport, volatilization, etc.), receptors (e.g., residents, groundwater users, surface waters, etc.) and exposure routes (e.g., inhalation, ingestion, dermal contact, etc.). A conceptual exposure model of the site requires a basic understanding of the following characteristics:

- CoC concentrations and distributions
- factors affecting CoC transport (including direction and rate)
- potential for CoC to reach a receptor.

Risk assessment and corrective action decisions must take these characteristics into account. Throughout the investigative process, the conceptual model must be re-evaluated and modified, if necessary, to reflect the known site conditions. The conceptual model must be described in written form and also portrayed graphically, or in a tabular format, with appropriate diagrams, maps, and/or cross-sections. This conceptual model must be included with the Initial Site Characterization Report and Tier 1A Report.

Considerations for a Tier 1A Assessment: The potential threat to useable groundwater will be a driving factor in establishing risk-based target cleanup concentrations for CoC. Consequently, target cleanup concentrations for most sites are derived from the present and potential future use of threatened useable groundwater.

As a part of the conceptual model and essential to the development of a Tier 1A risk assessment, the following items must be considered and incorporated into the scope of work:

- determination of maximum concentrations of CoC for each affected media (e.g., soil, groundwater, and surface water etc.)
- horizontal delineation of CoC to the tier-appropriate target concentrations is not required for a Tier 1A risk evaluation
- evaluation of inhalation exposure to vapors in enclosed spaces
- calculation of target soil concentrations protective of useable groundwater (If the beneficial use cannot be determined or is not known, it must be considered as useable groundwater.)
- evaluation of previously collected data at existing confirmed release sites.

3.3 DATA COLLECTION ACTIVITIES

3.3.1 Introduction

The site investigation must be guided by the scope of work prepared during the preliminary planning phase; however, adjustments to the scope of work and modifications to the conceptual model should be made as data is collected, analyzed and evaluated during on-going site activities. While the certified remediation consultant is performing an investigation, it is imperative that he/she remain flexible during the assessment procedure and evaluate the site information in the field to determine the next appropriate activity.

3.3.2 Data Collection

While performing drilling operations, field-screening techniques should always be used to guide the subsurface assessment and assist in selecting soil samples to submit for laboratory analysis. Field screening equipment must be properly calibrated and be appropriate for the CoC at the site. Continuous profiling and soil vapor field screening samples (a minimum of every 2 feet of depth drilled) of the subsurface should be conducted while drilling and continued until subsurface conditions are well understood or the total depth of drilling is reached. The more complex the subsurface conditions, the greater the need for and number of field screening data points to provide accurate profiling.

Geologic Descriptions: A continuous soil profile should be developed with detailed lithologic descriptions using the Unified Soil Classification System (See Appendix D). Particular emphasis should be placed on characteristics that appear to control contaminant migration and distribution such as zones of higher or lesser permeability, changes in lithology, correlation between soil vapor concentrations and different lithologic zones, obvious areas of soil discoloration, fraction organic carbon content, fractures and other lithologic characteristics. Soil boring logs must be submitted for each hole drilled at the site. The logs must denote depth correlated to changes in lithology (with lithologic descriptions), soil vapor analyses, occurrence of groundwater, soil sampling depths, total depth and any other pertinent data. When a monitoring well is installed, as-built diagrams with depth to groundwater denoted (observed during drilling and after completion) must be submitted for each well.

Sample Selection for Chemicals of Concern in Soil: The vertical extent of subsurface CoC must be defined during the site assessment. At a minimum, discrete soil samples must be collected for laboratory analysis from the following intervals:

- zone of greatest impact based upon field screening results, and
- immediately above the saturated zone (this may also be the zone of greatest impact).

Additional samples may be necessary to fully characterize the soil CoC distribution and exposure potential for a Tier 2 or Tier 3 evaluation or for the development of a remedial action plan. Generally, wells drilled near the source will require two soil samples and wells drilled outside the soil plume area will only require a sample taken immediately above the saturated zone.

Sample Selection for Physical Soil Properties: The sampling plan for measuring soil parameters should be adequate to determine average soil properties across the source area. The samples must also be representative of the soils that CoCs migrate through to reach groundwater or receptors. When there are occupied buildings that are possible recipients of hydrocarbon vapors from impacted soil or groundwater, a sample should be collected from the vadose zone. This sample should be collected from the least permeable zone that might act as a vapor barrier and protect the possible receptor. If there are any groundwater receptor points nearby, such as a water-supply well or a gaining stream, a sample of aquifer material should be obtained from the most permeable zone. These parameters must be determined using samples not impacted by the release (particularly in the case of fraction organic carbon content). Consideration must be given to collecting additional samples if multiple lithologies are present which might affect transport of the CoC, or if CoCs are contained within multiple lithologies. Site-specific physical soil properties should be utilized in Tier 1A, Tier 2, and Tier 3 as input parameters for contaminant fate and transport models.

Sample Selection for Chemicals of Concern in Surface Water: Appropriate samples should be collected when CoC migration is known or suspected to affect a surface water body. Sample selection should consist of sediment (when there is staining) and/or water upstream, downstream and/or radially from the discharge point(s).

Sample Selection for Chemicals of Concern in Groundwater: If the vertical extent of subsurface impact extends to groundwater, temporary sampling points (direct push, if feasible) may be used for Tier 2 or Tier 3 assessment for rapidly screening concentrations in groundwater and to assist in the location of permanent monitoring wells. A sufficient number of monitoring wells should be installed (a minimum of four (4) for a Tier 1A evaluation) to document CoC migration and groundwater flow. Well placement and design should consider:

- concentration of CoC in the source area
- proximity to potential or impacted receptor(s)
- occurrence of non-aqueous phase liquids (NAPLs) at the site
- hydrogeologic conditions
- groundwater usage.

3.3.3 Location of Monitoring Wells

Unless directed to do otherwise by the OCC, under Tier 1A the owner and/or operator must drill and install a minimum of four (4) monitoring wells outside of the UST pit or product piping trench excavation zones. These wells shall be located as follows:

- one (1) well must be installed in an apparent up-gradient location to any known potential source of release at the site
- one (1) well must be installed in a location where concentrations are expected to be highest (source location)

- one (1) well must be installed in a location that will allow the determination of an accurate groundwater gradient
- one (1) well must be installed in the direction of the nearest probable point of exposure (PoE) either at the nearest property line or fifty (50) feet from the source of release, whichever is less, or at another location determined by the OCC. This well will be the point of compliance (PoC) well for the Tier 1A evaluation unless there is a PoE nearer to the source of contamination, in which case the PoE will also become the PoC. The concentration for each CoC in the PoC well should not exceed the Tier 1A standards as discussed in Section 5.4.

For subsequent investigation required beyond a Tier 1A evaluation, selection of sampling point locations for both soil and groundwater should consider the following:

- source of release(s) or suspected area of major source(s) of CoC
- location of potential receptors
- physical characteristics of the surface and subsurface as determined through previous investigation or in the preliminary planning
- off-site access
- contingencies for possible future additional sampling points.

If the regulatory contact is expecting reimbursement for the cost of installing any soil boring or monitoring well, the location and design of that boring/well must be pre-approved by the Oklahoma Indemnity Fund.

3.3.4 Evaluate Data and Refine the Conceptual Model

As data is collected, it must be interpreted during the field investigation. The assimilation and evaluation of soil and groundwater analytical results, subsurface geologic conditions, groundwater flow direction and/or other preferential migration pathways should ensure that adequate data has been collected to completely assess the source area. This evaluation should resolve any data deficiencies to prevent potential unnecessary field mobilizations. Compilation of these data into figures such as site maps and cross-sections is required and will facilitate the evaluation of the data and refinement of the conceptual model.

Data collected during a site assessment, site investigation and/or other previous assessments or investigations should be adequate to perform the appropriate tier evaluation and determine the priority index n-umber for the site. The requirements to complete a Tier appropriate evaluation are:

- determination of actual or potential receptors, exposure pathways and both immediate and long-term hazards
- identification of chemical source area(s) and maximum concentrations of all affected media
- delineation of the vertical extent of affected media exceeding tier appropriate health-based target levels
- identification of site conditions which affect or limit chemical movement
- adequate tier appropriate monitoring wells when groundwater is affected.

3.4 RECOMMENDED LABORATORY ANALYTICAL METHODS

3.4.1 Introduction

The scope of work is the plan, derived from the conceptual model, used to complete the site assessment and is developed on a site-by-site basis by the certified remediation consultant retained by the owner and/or operator. To meet the minimum requirements of the site assessment, this plan must place emphasis on characterizing the source area, determining the maximum concentrations of the CoC and delineating the horizontal and vertical extent of CoCs exceeding appropriate cleanup levels. The scope of work should include selecting sampling technology/tools and analytical methods, locating sampling points, obtaining off-site access if needed, evaluating the presence of NAPL and/or vapor-phase hydrocarbons, surface water or groundwater receptors and determining waste management options.

3.4.2 Sampling Technology/Tools

The OCC recognizes that both conventional and innovative sampling technologies can be used effectively during site assessments and investigations. Site conditions will dictate the appropriate sampling technology/tools, which should be used. The assessment process is independent of the selected sampling technology. Temporary groundwater sampling points may be used to locate permanent monitoring wells or to provide additional information.

However, permanent monitoring wells are ultimately required when groundwater is impacted. When determining the appropriate data collection method and sampling technologies/tools, the following should be considered:

- purpose and anticipated scope of the site assessment
- anticipated geologic and hydrologic conditions
- known site features and layout
- speed by which samples can be obtained
- urgency of the need for data
- advantage of using a combination of tools
- capabilities, limitations and cost of each tool
- anticipated chemicals of concern and their concentrations
- disturbance to current site conditions or operations.

3.4.3 Laboratory Analytical Methods

Qualitative field screening methods assist in the assessment process but cannot replace quantitative analytical methods. The purpose of the analysis will determine the selection of a qualitative or quantitative method. Often, more numerous data points of a lower quality level can provide a better understanding of site conditions than fewer data points at a higher data quality level. However, a combination of data quality levels along with an appropriate number of data points may provide a better understanding of the site. Field screening methods may be sufficient to locate source areas, determine the selection of samples for laboratory analysis and/or placement of additional sampling points and determine the vertical extent of contamination in the subsurface. The relationship between field screening and analytical data is not necessarily linear, and the ability to directly correlate may not be possible. Considerations in selecting the analytical method and data quality level are:

- purpose of the sample or data point (e.g., needs for prioritization, risk evaluation, regulatory requirements)
- chemicals of concern
- media of concern
- detection limits.

Field screening methods must be supported by EPA-approved, ASTM-approved, ODEQ-approved or the OCC-approved quantitative analytical methods. All quantitative sample analyses required by the OCC must be performed at approved Oklahoma Department of Environmental Quality (ODEQ) laboratories. Table 3-1 lists the OCC required analysis and approved method(s) for each released substance.

The physical properties of the soils affect fate and transport of the CoC. In order to evaluate the potential for cross-media partitioning for chemical transport through the subsurface and for a Tier 2 or Tier 3 risk assessment, soil samples should be collected for the following physical property analyses:

- dry bulk density
- porosity
- water content (vadose zone only)
- fraction organic carbon content
- hydraulic conductivity of the aquifer (field measurement is rarely necessary) only when an active remediation system, e.g. pump and treat or interceptor trench, is necessary. (Otherwise, literature values based on either grain size distribution or site lithology should suffice).

Soil samples collected for determination of physical properties must be collected from the zone of probable chemical migration in an area that has not been impacted by any released substance. During collection of the sample, every attempt must be taken to obtain an undisturbed soil sample through the use of appropriate sampling tools (e.g., shelby tube, split-spoon sampler, etc.).

3.4.3.1 Laboratory Methods for Physical Properties of Soil

Dry Bulk Density (gm/cc):

- **ASTM Method D2937-83:**

Accurate measurement of bulk density requires weighing a known volume of soil or determining both the weight and volume of an undisturbed sample. This method involves collecting a core of a known volume, using a thin-walled sampler to minimize disturbance of the soil sample and transporting the core to the laboratory for measurement.

Porosity (cc/cc-soil):

- **No Established Method**

Many laboratories use dry bulk density and specific gravity data to determine porosity using the following derivation:

$$n = 1 - \frac{\rho_b}{\rho_s} \qquad (3\text{-}1)$$

where,

n	=	porosity (cc/cc)
ρ_b	=	dry bulk density (gm/cc)
ρ_s	=	specific gravity or particle density (gm/cc)

A value for specific gravity of 2.65 g/cc can be assumed for most mineral soils. Note: if effective porosity is required for a particular fate and transport model, it is recommended that this value be estimated from a literature source.

Volumetric Water Content/Moisture Content (cc/cc):

- **ASTM Method D2216-90**

This is a gravimetric oven drying method. Note: the water content value used in most models is the volumetric water content. Hence, the following conversion will be necessary to convert from gravimetric to volumetric:

$$\theta_{wv} = \theta_{wg} * \frac{\rho_b}{\rho_l} \tag{3-2}$$

where,

θ_{wv}	=	volumetric water content (cc water / cc soil)
θ_{wg}	=	gravimetric water content (cc water / cc soil)
ρ_b	=	dry bulk density (gm of dry soil/cc of soil)
ρ_l	=	density of water (gm/cc)

Fraction Organic Carbon Content in Soil (g-C/g-soil):

- **Walkley-Black Method**

The Walkley-Black Method is a chemical oxidation method (rapid dichromate oxidation) for determining fraction organic carbon content in soil. The results are usually reported as percent organic carbon content. Note, if reported result is percent organic matter using the ASTM method D2974, the value should be divided by 1.724 to get percent organic carbon content.

Hydraulic Conductivity (cm/sec):

- **Aquifer Pumping Test**

This method involves pumping groundwater at a steady rate from a well and measuring water level changes (aquifer response) over time in the pumped well and nearby observation wells. The rate of drawdown and recovery of water levels, once pumping has ceased, can be used to determine hydraulic conductivity. This test provides an estimate of the average conditions near the test and observation wells. Since this is a time consuming and “expensive” test, it is recommended primarily in situations where a pump and treat or an interceptor trench type remediation system is necessary.

- **ASTM Method D5084-90**

This method is the "Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter" and should be used with undisturbed samples that are estimated to have a hydraulic conductivity of less than or equal to 1E-03 cm/sec.

- **ASTM Method D2434-68**

This method is the "Standard Test Method for Permeability of Granular Soils (Constant Head)" and should be used for soils with hydraulic conductivity greater than 1E-03 cm/sec. Note that it may be difficult to collect an undisturbed sample in granular soils.

- **Grain Size Distribution**

Under certain circumstances, the OCC may direct the owner and/or operator to use an alternative method for determining the hydraulic conductivity. One of these alternatives would be to perform a sieve test and estimate the hydraulic conductivity based on grain size distribution for the soil sample. Refer to *"Correlation of Permeability and Grain Size"* (Russell G. Shepherd, 1989).

- **Slug or Bail-down Tests**

Slug tests to determine hydraulic conductivity are not recommended where a monitoring well is installed such that the screened interval intersects the water table. The hydraulic characteristics of the sand pack in a well constructed in this manner can significantly influence the results of the tests because the initial results after a slug is added or removed from the well reflect the characteristics of the sand pack, not the formation. Where the screened interval of a monitoring well is submerged below the water table and intersects the lithology of concern, the well may be suitable for slug tests. However, under these circumstances, the results should still be carefully reviewed.

NOTE: If the groundwater of concern is in a different lithology than adsorbed contaminants in the unsaturated zone, it may be necessary to determine the hydraulic conductivity for both lithologies.

4.0
RISK-BASED EVALUATION: GENERAL CONSIDERATIONS

4.1 INTRODUCTION

A risk-based evaluation requires consideration of several factors. These include the chemicals of concern and their properties, land use, receptors, exposure pathways, target risk levels, target clean-up levels, etc. Several of these issues are common to all the Tiers and are discussed below. The Agency for Toxic Substances and Disease Registry (ATSDR) has identified five (5) essential elements to every exposure pathway in its Public Health Assessment Guidance Manual (PHAGM). They are (1) source of contamination (2) environmental media and transport mechanisms (3) point of exposure (4) route of exposure and (5) receptor population.

4.1.1 Source of Contamination

The **primary source** of contamination would be petroleum released from any regulated tank and any associated piping and dispensers. A **secondary source** of contamination would be any light non-aqueous phase liquid (LNAPL) or free product that exists at the top of any saturated zone and any soils highly impacted by a released petroleum. The source area should have the highest concentration of CoCs (with the possible exception of MtBE) and up-gradient data should rule out any other source.

4.1.2 Environmental Media and Transport

This is the media that may serve to transport contaminants from the source to possible points of receptor exposure. After petroleum is released into the environment, there can be movement (in a liquid or vapor phase), physical transformation (volatilization), chemical transformation, biologic transformation and accumulation. There are four basic categories of fate and transport mechanisms. They are (1) emission (release or discharge) (2) advection or convection (3) dispersion (spreading of the CoCs due to impingement by phase material) and (4) attenuation (retardation, degradation or adsorption). There are various chemical-specific and site-specific factors that can influence fate and transport. Chemical-specific factors include water solubility, vapor pressure, Henry's law constant, the organic carbon partition coefficient and various transformation and degradation processes. Site-specific factors include precipitation rates, temperature conditions, hydrogeologic characteristics, surface water channels, soil characteristics and man-made objects such as sewers and trenches.

4.1.3 Point of Exposure

This is the point at which people contact the contaminated medium. Groundwater exposure points can be water-supply wells or natural springs. Soil may serve as an exposure point for workers involved in excavation or drilling. Occupied structures may be an exposure point for indoor airborne contaminants from migrating soil gases.

Where the presence of physical controls and barriers (e.g., permanent fences, gates, etc.) or institutional controls (e.g., ordinances, building permits, etc.) prevent contact with the contaminated medium of concern, health assessors should assume that no exposure point exists for persons unable to gain access to the contaminated medium (ATSDR – PHAGM).

4.1.4 Route of Exposure

How contaminants enter the human body is considered the exposure route. They generally include ingestion, inhalation and dermal contact and absorption. The exposure route can be assumed to not exist if there are institutional controls or physical barriers and controls that prevent contact with the contaminated medium.

4.1.5 Receptor Populations

This is the population that is exposed or potentially exposed through the identified exposure routes to contaminants at an exposure point. Exposed populations should be identified as accurately as possible. The population of a contaminated municipal well is much greater than if the well is just a private domestic well. Whenever possible and practical, all exposed or potentially exposed populations should be interviewed to better ascertain the magnitude and frequency of contaminant exposure.

4.2 CHEMICALS OF CONCERN

As mentioned in Section 1.1, the OCC is responsible for ensuring the cleanup of all regulated underground storage tank releases including, but not limited to, the following types of product:

Gasoline	Fuel Oil	Aviation Fuel	Ethylene Glycol (Antifreeze)
Kerosene	Diesel	Used Oil	

Each of these products is a complex mixture of several hundred hydrocarbon compounds and additives (anti-knock agents, corrosion inhibitors, anti-oxidants, etc.). The actual composition of these products varies depending on the source, age, temperature and other factors and conditions. Thus, no unique composition exists for any of these products. Further, the behavior of these products in the environment and their toxic effects depend on the properties of the individual constituents, their concentrations and the characteristics of the environment where they are located.

The OCC focuses on a limited set of key components that pose the majority of the risk for each product. Thus, for each product, the OCC has identified the CoC that will be used for conducting the risk assessment. Table 4-1 lists the matrix of CoC for each product.

For some release sites, it may be necessary to sample for and consider other constituents in the product spilled. In such situations, the OCC personnel may require the consideration of additional CoC.

The implications for the COC within the RBCA framework are two-fold:

- Depending on the product spilled, it will be necessary to sample the soil and groundwater for the CoC identified in Table 4-1. The recommended analytical methods are specified in Table 3-1. At sites with historical spills, where data for these CoC have not been collected, the OCC may require additional data collection.

- The selected CoCs have to be carried through the risk calculations. For Tier 1A, the modified RBSLs and for Tier 2 and Tier 3 analysis, site-specific target levels (SSTLs) will have to be developed for each relevant CoC.

For each CoC, the risk assessment process requires, (i) fate and transport parameters (ii) exposure parameters and (iii) toxicity parameters. These values are included in Tables 4-2 and 4-3 respectively. Note, some of the fate and transport properties are based on laboratory experiments. Hence, values for several of these properties reported in different references may vary. The OCC requires that the values listed in Tables 4-2 and 4-3 be used for risk assessment unless there are compelling reasons to change the values, in which case, the RC/risk assessor must provide sufficient justification for using different values and get the OCC's prior approval.

4.3 LAND USE

This section describes the role that land use at the site plays in the RBCA process.

The Oklahoma RBCA process is used to establish whether acceptable levels of risk exist or have been achieved at a regulated storage tank site for any current or reasonably foreseeable uses of the site and surrounding area. The use of a site and surrounding area determines the activities that occur on the site and the potential for exposures consistent with these activities. To adequately evaluate exposures, the risk assessment must identify and describe the site activities and uses associated with the impacted site and the surrounding environment.

The terms "activity" and "use" are both used as site-specific attributes that affect exposure to human or environmental receptors. As used here, "use" usually refers to the property itself and is generally a broader term than "activity", which describes actions by a receptor that could potentially affect the nature and types of exposure. Site use includes descriptors such as residential, commercial and industrial. Activity includes scenarios such as construction.

Knowledge about the current and foreseeable uses of the site is necessary to identify exposure points and exposure pathways and to ensure that the risk assessment decisions are protective of future resources/use. The exposures to be evaluated in a human health or environmental risk assessment depend upon the activities that could occur under the current and reasonable foreseeable uses of the land and groundwater at the site.

A distinction exists between the current use of the site and the reasonable foreseeable use. "*Current*" is actual or under current circumstances; hence, there is little ambiguity about current use. "*Foreseeable*" (or potential future) use has not yet occurred, is hypothetical and may be changed or avoided, e.g., by institutional controls. Current uses and activities must be identified and evaluated to be protective of present receptors. Reasonable foreseeable uses and activities must be identified (based on local zoning ordinances, current land use, knowledge of changing land use patterns, etc.) to be protective against reasonable potential future exposures, which could occur.

If the area of buried utilities is impacted, the construction worker scenario must always be evaluated as a current rather than future condition. If construction of an occupiable building is scheduled for an area where the shallow soils or groundwater is impacted, that exposure pathway should be evaluated as current. When debating between current and future, you should compare when the exposure point will occur with how long the CoCs may exist in the environmental media.

4.4 RECEPTORS

The objective of risk assessment is to quantify the adverse health effects to the current as well as reasonable potential future receptors. For human health risk assessment, the receptors to be considered include persons who live within 660 feet of the site. A distance of 660 feet is selected because historic data indicates that plumes for leaking UST sites and the CoC being considered generally do not exceed 660 feet. For residential receptors, risk to both adults and children should be evaluated. In addition, adults who work in the area (i.e., industrial as well as commercial workers) should be evaluated. Finally, construction workers also should be considered. Thus, the receptors of concern for human health risk assessment include:

Residential – Adult	Commercial/Industrial Worker
Residential – Child	Construction Worker

Each of these receptors may be exposed to site-specific chemicals by several routes of exposures as discussed in Section 4.5.

At some sites, particularly those located within agricultural or conservation areas, livestock, wildlife and vegetation may be additional receptors of concern. Procedures to evaluate the risk to such receptors have not been completely developed. The OCC should be consulted when such receptors are present, as a Tier 3 analysis may be required.

4.5 EXPOSURE ROUTES

An adverse health effect cannot occur unless the receptors are exposed to the chemicals. The OCC has identified the following as the most commonly encountered routes of exposure:

<u>For surface soil:</u>

- Leaching to groundwater and potential ingestion of groundwater
- Ingestion of soil and dermal contact with soil
- Indoor inhalation from shallow impacted soil. (This pathway and route of exposure is expected to be complete in those rare cases where a building is constructed directly on top of impacted soil.)

(Note the OCC does not require the consideration of outdoor inhalation pathways except for the construction worker.)

<u>For subsurface soil:</u>

- Indoor inhalation of volatile emissions
- Leaching to groundwater
- Ingestion of soil, inhalation of vapors and particulates from soil emissions, and dermal contact with soil (for construction worker only to three feet below the deepest utility)

<u>For shallow groundwater:</u>

- Ingestion of water at the most reasonable point of exposure
- Indoor inhalation of volatile emissions

<u>For deep groundwater:</u>

- Ingestion of water at the most reasonable point of exposure.

Surface soils are defined as soils extending from the ground surface to 2 feet.

Subsurface soils are defined as soils greater than 2 feet below the ground surface.

Shallow groundwater is defined as water that is now, or has been within the last 12 months, at a depth equal to or less than 10 feet.

Deep groundwater is defined as water that has been encountered at a depth greater than 10 feet below the ground surface for at least the most recent 12 months.

Each of these routes of exposure must be considered. Note, depending on land and groundwater use, a few of these routes of exposure may be incomplete and hence need not be considered.

At sites where other routes are considered significant (e.g., ingestion of produce grown in impacted soils, or exposure routes related to use of impacted water for irrigation purposes), the responsible party must contact the OCC for additional guidance.

4.6 ACCEPTABLE RISK LEVEL

Risk-based decision making requires the specification of an acceptable risk level for both carcinogenic and non-carcinogenic adverse health effects. For carcinogenic effects, the OCC considers 1×10^{-6} as the maximum allowable risk under current land use and activities. For non-carcinogenic effects, the acceptable risk level is a hazard quotient of unity (1.0) for points of exposure under current land use and activities. For reasonable potential future complete exposure pathways, the OCC considers 1×10^{-4} as the acceptable risk level. As appropriate, the OCC may require assurance based on sufficient monitoring well data that concentrations of CoC indicate a general downward trend. When monitoring indoor air space of an occupied building for benzene, the OCC will usually not require any further action if concentrations fall in the 1×10^{-5} range or lower (< 4.5 ug/m^3). If the concentration falls in the 1×10^{-4} (13 to 45 ug/m^3) range, additional monitoring will probably be required. If the 1×10^{-4}

range is exceeded and no surface source can be found, vapor control and subsurface remediation should be initiated. These levels apply to all tiers (i.e., Tier 1A, Tier 2, and Tier 3).

Since the number of chemicals of concern at most regulated storage tank impacted sites are few and the OCC has generally adopted reasonably conservative values, the OCC will not consider the additive effects of different chemicals or routes of exposure. Thus, the risk and hazard quotient from different chemicals will not be added. Likewise, risk and hazard quotient from different routes of exposure will not be added together except for the routes of exposure associated with the surface soil (see Section 5-4).

4.7 SITE CONCEPTUAL EXPOSURE MODELS

To conduct a Tier 1A, Tier 2, or Tier 3 analysis, the user must conduct a qualitative evaluation to identify the mechanisms by which CoCs will move from an affected source medium to the exposure point where contact with the receptor occurs. If this migration or contact is not possible (e.g., due to engineering controls such as a paved site that will prevent human contact with a contaminated source) under current and reasonable future conditions, the site-specific chemicals cannot pose a risk. This qualitative evaluation is facilitated by developing site conceptual exposure model(s) [SCEM], as discussed further in Section 4.7.1.

4.7.1 Development of Site Conceptual Exposure Models

Site Conceptual Exposure Models (SCEM) identify the source of release, the source of chemicals, the media of concern and potential receptors. The SCEM's identify the combination of factors that could result in complete exposure pathways and potential human routes of exposure that result in the uptake of chemicals. SCEM helps to identify a matrix that includes potential receptors, pathways by which chemicals migrate from the source to each receptor, and the routes of exposure associated with each pathway for each receptor.

The development of a SCEM is required for Tier 1A, Tier 2, and Tier 3 analyses. At most sites, at least two SCEM's may be developed: one representative of current site conditions and the second representative of potential future site conditions. In some cases, SCEM may be developed for short-term activities (current or potential future) during which different receptors may be exposed for a short duration. An example of a current short-term activity would be the ‘construction scenario’ during which the construction worker would be the primary receptor.

By way of illustration, Figures 4-1, 4-2, and 4-3 show SCEMs for an inactive but fenced gas station located in a mixed residential and commercial land use area. Site investigation revealed that the shallow groundwater cannot be developed for use because of very low yield. Also, shallow groundwater contamination has not yet traveled off-site. The deep aquifer, although currently not used as a source of potable water, may be used in the future. Figure 4-1 indicates that under current conditions there are no complete source-pathway-receptor-route combinations. Note that the OCC does not require the consideration of outdoor inhalation pathways.

Similarly Figures 4-2 and 4-3 illustrate SCEMs for reasonable construction and reasonable potential future site conditions. Since the site is located in a mixed land use area, the most conservative future use of the site is residential. The complete routes of exposure include:

Potential Construction Activity

- Outdoor inhalation of volatiles from soil
- Outdoor inhalation of particulates from soil
- Ingestion and dermal contact with soil
- Inhalation of volatiles from shallow groundwater
- Dermal contact with groundwater

Potential Future Conditions

- Indoor inhalation of vapors from soil and groundwater
- Indoor inhalation of particulates from soil
- Ingestion and dermal contact with soil
- Indoor inhalation of volatiles from shallow groundwater
- Ingestion with both shallow and deep groundwater
- Dermal contact with shallow groundwater

If the owner and/or operator proposes the use of institutional controls (e.g., the property will be used for commercial purposes only), the OCC will evaluate the risk assessment based on future commercial use.

A SCEM may be presented in either graphical or tabular format. In either case, the objective is to identify the complete pathways and routes of exposure. An example of the tabular format, corresponding to Figure 4-1, is included in Table 4-4. The Tier 1A Report format (ORBCA.doc) requires you to list all pathways that are considered complete and list the reason why they are considered complete. You are also required to list any possible completed pathways, and describe why you do not consider them complete. There is no need to list pathways that have no possibility of being complete.

After the combination of the various routes of exposure for all the receptors have been developed, it may be possible to screen out a few source-pathway-receptor-route combinations using qualitative considerations. For example, if there are on-site and off-site commercial workers, both exposed to site concentrations by the inhalation route, it is reasonable not to quantify the risk to the off-site worker, because the risk to the on-site worker will almost always be greater than the estimated risk to the off-site worker. Thus, if the site is remediated to levels that are safe for the on-site worker, then these levels should be protective for the off-site worker. Note, quantitative analysis of the development of Tier 1A modified RBSLs, Tier 2 and Tier 3 site-specific target levels will be necessary for those combinations that are not screened out.

It is important that the regulatory contact documents all the possibly complete source-pathway-receptor-route combinations, clearly stating those that are being eliminated and present the rationale for those that are considered complete as well as those that are eliminated. Also, the final list of selected combinations should be clearly summarized**.** This will facilitate the review by the OCC personnel and any other interested party.

While developing the SCEM, it is important to specify the point of exposure for each receptor and for each route of exposure. Clearly, the closer the point of exposure to the site, the lower the risk-based target concentrations. For the groundwater pathway, the nearest current and reasonable potential future location of a drinking water well (i.e., the exposure point) is determined based on site-specific conditions. As an example, if the site is surrounded by residential areas where there is potential to drill a well and use the groundwater, the potential drinking water well should be located at the property boundary (point of exposure). However, if a busy thoroughfare is located directly downgradient of the site, the point of exposure for groundwater may be a well located on the other side of the thoroughfare. The point of exposure is used to back calculate the acceptable soil levels at the source (see Appendix C) and acceptable concentrations in the compliance well (see Section 6).

Thus the location of the groundwater point of exposure is based on site-specific considerations such as:

- whether the area is supplied by public water supply
- any municipal, county or state restrictions on drilling wells
- any activity use limitations proposed by the property owner and acceptable to the OCC
- location of well screens in existing water wells to address the shallow water bearing vs. the deeper aquifer
- way the water well was completed. For example, if a shallow impacted zone is isolated from deeper usable water zone by well construction techniques.

4.8 RISK-BASED TARGET LEVELS

Risk-based target levels are back calculated based on (i) acceptable or target risk levels (ii) fate and transport parameters (iii) exposure parameters and (iv) toxicological and chemical properties of the chemicals of concern. These levels are termed as modified RBSLs for Tier 1A, and Site-Specific Target Levels (SSTLs) for Tier 2 and Tier 3. Appendix B describes the procedure used to calculate these levels.

4.9 MANAGEMENT AND CONTROL OF NUISANCE CONDITIONS

The Tier 1A, and Tier 2 RBSLs and SSTLs are based on the CoC (that are the most toxic constituents of petroleum products) and protection of human health due to chronic exposure. The remaining constituents may result in objectionable nuisance conditions. Therefore, it is important for RCs and/or their consultants to confirm that no nuisance conditions, such as odor, groundwater taste, staining of soil, free product or other visual impacts, exist on site. The OCC may not grant site closure if such nuisance conditions exist even if the site concentrations are below the RBSLs or SSTLs.

Currently, no generally acceptable quantitative measures indicative of nuisance conditions are available. Hence, the determination of discernible nuisance conditions will be based on the judgment of the OCC regulatory personnel.

4.9.1 MtBE

Low concentrations of MtBE in water may give the water a bad taste and odor, but this is very receptor-specific. As of this date, EPA has not published any toxicological data suggesting that dissolved MtBE is a health concern. The OCC has a level of concern for MtBE of 20 ug/L. If an unpalatable level of MtBE is found in a drinking water well, the Regulatory Contact must take steps to either cleanup the impacted groundwater or remove that exposure point (water well). Treatment or an alternate water supply will be required until that goal is met.

If there is a groundwater-ingestion receptor within one (1) mile of the source, the exposure point or waterwell, it must be sampled for MtBE. Groundwater must be collected from the well that is the farthest from the source and closest to the groundwater exposure point (WSW) by EPA Method 8021. As this analytical method commonly produces “false positives” for MtBE, if the resulting level of MtBE exceeds 20 ug/L, a second analysis must be run by EPA Method 8260.

4.10 DOCUMENTATION OF RBCA EVALUATION

4.10.1 Tier 1A Evaluation

The OCC has developed a standardized reporting format Tier 1A RBCA evaluation. All individuals/entities submitting Tier 1-A evaluations to OCC must submit them using the ORBCA.doc file and the attachments in the correct order as established by the OCC. An electronic copy of this file is available from the OCC. Include contoured maps of all CoCs that exceed action levels.

4.10.2 Tier 2 and Tier 3 Evaluations

The documentation of Tier 2 and Tier 3 RBCA evaluations should be clear and precise. It should describe each of the steps required to conduct the evaluation as discussed in Section 6.0 of this guidance document. Emphasis should be placed on (i) identifying the decisions made, and (ii) the justification for the decisions. Submit all pages and attachments from the Tier 1A assessment that have been changed.

4.11 COMPUTATIONAL ASPECT OF RBCA EVALUATION

Several computational software tools are available to compute Tier 1A RBSLs, Tier 2 and Tier 3 RBSLs. These include the RBCA tool kit (GSI, 1995), ORBCA's Spreadsheet System and other spreadsheets developed by other individuals to perform RBCA. The OCC does not intend to specify any particular software. The responsible party or their consultant is free to choose any computational tool. The OCC has supported the development of a computational spreadsheet that can be used to perform Tier 1A and in some cases Tier 2 evaluations. The OCC intends to use this software to check the accuracy of calculations submitted to the OCC.

5.0
TIER 1A EVALUATION

5.1 OVERVIEW

Tier 1 evaluation is the simplest level of risk evaluation in the ASTM RBCA process. The OCC requires the assessor to go one step further and incorporate site-specific fate and transport data that can be measured during the initial investigation. For that reason, the initial assessment is referred to as Tier 1A. **As with every other assessment step, if the regulatory contact is seeking reimbursement from the Indemnity Fund it is imperative to gain pre-approval through the form of a purchase order request.**

Tier 1A analysis requires the following steps:

Step 1	Development of a site conceptual exposure model (SCEM)
Step 2	Comparison of the modified risk-based screening levels with site-specific concentrations
Step 3	Recommendation for the next course of action to the OCC

Each of these steps is discussed below.

5.2 STEP 1 - DEVELOPMENT OF A SITE CONCEPTUAL EXPOSURE MODEL

The development of a SCEM has been discussed in Section 4.7. The SCEM must be developed for current and potential future site conditions and will result in the identification of the matrix of complete pathways and routes of exposure. Each of these complete pathways and routes of exposure have to be quantitatively addressed as discussed below. The results of this step (complete pathways and routes of exposure) should be clearly documented in the RBCA report.

A key decision in this step is the identification of the current and reasonable potential future location of the nearest point of exposure for groundwater. A point of exposure (for Tier 1A) for groundwater is the location/point where the receptor comes in contact with the chemical (i.e., a drinking water well or a spring). Exposure to groundwater is also possible in situations where groundwater may impact a surface water body or irrigation well. Such conditions will be evaluated under Tier 2 and Tier 3. The following are a few considerations that may be used to select the nearest point of exposure:

- Location of current drinking water well(s)
- Land use that may restrict future drilling of a drinking water well e.g., a major highway, building, etc.
- Historic use of groundwater in the site vicinity
- Source of water supply for the area
- Any federal, state, county, city or municipality imposed restrictions to drill wells

5.3 STEP 2 - COMPARISON OF SITE CONCENTRATIONS WITH TIER 1A MODIFIED RBSLs

The Tier 1A assessment must be performed using the models cited in Appendix C of the Guidance Document. However, Fate and Transport Parameters, and other parameters, should **only** be replaced by site-specific information obtained through site investigation/assessment. Justification will be required when any of the default Fate and Transport Parameters, or other parameters, are modified. The Tier 1 default Exposure Factors cannot be modified nor can degradation rates be used under a Tier 1A assessment.

Specific combinations of routes of exposure and the receptors are presented in Table 5-1. Modified RBSLs should be developed using conservative exposure values shown in Table 5-2 and chemical specific properties shown in Tables 4-2 and 4-3 and site-specific fate and transport parameter data. For fate and transport data unable to be obtained from the site, use the default Tier 1 values shown in Table 5-3.

Modified RBSLs are back calculated using an individual excess lifetime cancer risk of 1×10^{-6} (or 1×10^{-4}) for each chemical or each route of exposure, except for surface soils. Similarly, for non-carcinogenic effects, Tier 1A levels are back calculated using a hazard quotient of one (1) for each chemical and each route of exposure (except for exposures related to surface soils). Note, for surface soils, each chemical is treated separately, but the risk and hazard quotient for the relevant routes of exposure were cumulatively set equal to 1×10^{-6} (or 1×10^{-4}) and 1 respectively. Specifically for the construction worker, inhalation of vapors, dermal contact and ingestion of soil are considered simultaneously. Similarly for other receptors, ingestion and dermal contact with surficial soil are considered simultaneously. Details of the back calculation procedure used to develop RBSLs are shown in Appendices B and C.

For leaching to groundwater, the target soil concentrations depend on the distance of the exposure point from the source of contamination and the infiltration rate for different zones presented in Table 5-4. The ORBCA software must let you back calculate the allowable soil concentrations protective of the groundwater ingestion at the exposure point. For example, using the default parameter values, if the receptor is a resident child in a west zone county, if the nearest drinking water well is 500 feet away, the allowable soil concentration of benzene is 8.36 mg/kg. Note, the target soil concentrations are developed assuming no attenuation in the unsaturated zone and no biochemical transformation in the saturated zone (only dilution).

For groundwater, dilution attenuation factors (DAFs) should be used to estimate target groundwater concentrations at compliance points located at different distances from the source. These Tier 1 DAF factors are presented in Figure 5-1 and Table 5-5. For example, with the potential drinking water (exposure) well at 500 feet, the allowable toluene concentration in a compliance well located 300 feet from the source, i.e., 200 feet upgradient from the exposure well, is estimated as follows:

$$C_{allow} = C_{target} \times \frac{DAF_{500}}{DAF_{300}} \qquad (5\text{-}1)$$

where

C_{allow} = Allowable concentration in the compliance well [mg/l]

C_{target} = Target concentration in the exposure well (water standard) [mg/l]

DAF_{500} = Dilution attenuation factor to the exposure well located at 500 feet from the source [--]

DAF_{300} = Dilution attenuation factor to the compliance well located at 300 feet from the source [--]

therefore,

$$C_{allow} = 3.13 \times \frac{126.4}{46.1} = 8.6 \ \frac{mg}{l} \qquad (5\text{-}2)$$

The target compliance well concentrations are used to establish compliance point monitoring requirements (see Section 8).

For each completer source-pathway-receptor-route combination identified in the SCEM in Section 5.2, target levels should be calculated.

It is important to note that the Tier 1 default values presented in this section are based on currently available data as indicated above. Should these data change, the OCC will revise the Tier 1 defaults.

Once the Tier 1A assessment has been completed, the owner and/or operator must submit a report on the Tier 1-A evaluation. This report must include recommendations for future actions as discussed below.

5.4 STEP 3 - COMPARISON OF THE TARGET LEVELS SELECTED IN STEP 3 WITH MAXIMUM SITE-SPECIFIC CONCENTRATIONS

After the Tier 1A target levels have been identified for each CoC, these have to be compared with the representative on-site or source medium concentrations. Note, surface soil RBSLs should be compared with representative surface soil values and not subsurface soil values. For purposes of this comparison, the representative on-site concentration is the maximum concentration observed in the relevant media (i.e., surface soil, sub-surface soil and/or the groundwater).

If data from several soil-sampling events from the same area, collected at different times, is available, it is best to compare the Tier 1 levels with the most recent maximum value. For comparing the groundwater concentrations measured at the compliance point with the back-calculated compliance point concentrations, the maximum value from the two most recent years or eight quarters of data should be used. This would account for variation in concentrations due to seasonal fluctuations.

5.5 STEP 4 - SELECTION OF THE NEXT COURSE OF ACTION

If the representative site concentrations are lower than the Tier 1A levels and no nuisance conditions (see Section 4.9) exist at the site, the OCC may grant case closure without any further activity at the site. In some cases, depending on the assumptions used in developing the SCEM, the OCC may request activity use limitations, and/or compliance point monitoring.

If the site concentrations exceed the Tier 1A modified RBSLs, then three risk management alternatives are available as presented in Figure 1-1. These alternatives are discussed below:

- **Alternative 1: Localized exceedences**. Site concentrations exceed the Tier 1A levels in a small portion of the site. The RC, with the OCC's approval, may choose to conduct remediation/removal of the localized exceedences to meet Tier 1A levels. Following the successful completion of the localized response actions, the OCC may grant case closure. An example of this scenario is a small volume of soil near a recent release that exceeds the Tier 1A levels. Removal or treatment of this soil may be sufficient to get case closure based on Tier 1A analysis.

- **Alternative 2: Selection of Tier 2 analysis**. The RC may recommend a Tier 2 analysis as discussed in Section 6.

- **Alternative 3: Remediation to Tier 1A levels by monitoring for closure through natural attenuation.** The RC may also elect to develop a formal remedial action plan, have it approved by the OCC and implement the plan. This plan should include specific criteria (e.g., monitoring or sampling requirements) to determine the successful completion of the project. The OCC may grant closure when these criteria have been met. Details of the remedial action plan are discussed in Section 9.

The RC should carefully review site conditions and propose one of the three alternatives listed above. The selection of Alternative 1, 2 or 3 will most likely be based on technical feasibility and cost-benefit considerations. For example, where the cost of cleanup is low (relative to the cost of additional data collection and analysis and potentially lower cleanup costs to meet Tier 2 levels), it may be most expeditious to adopt the Tier 1A screening levels as the cleanup levels.

6.0
TIER 2 EVALUATION

6.1 INTRODUCTION

This section presents details of a Tier 2 evaluation that may be conducted when Tier 1A modified risk-based screening levels are exceeded, and it is decided not to take corrective action to meet those levels. **As with every other assessment step, if the RC is seeking reimbursement from the Indemnity Fund it is imperative to gain pre-approval through the form of a purchase order request.**

Steps used in Tier 2 evaluation are presented below.

6.2 STEPS IN TIER 2 EVALUATION

6.2.1 Step 1: Development of Site Conceptual Exposure Model

The first step in Tier 2 evaluation is to develop the SCEM and identify the complete exposure routes and pathways for CoC migration. The SCEM for Tier 2 will be very similar, if not exactly the same, as Tier 1A. However, only those pathways and routes of exposure that exceed the Tier 1A levels will be evaluated under Tier 2. The pathways and routes being evaluated should be clearly documented in the RBCA report. One exception is if water-supply wells are discovered at greater than 660 feet from the source that had not been identified earlier in the Tier 1A assessment. The water well inventory search should be extended in the cross- and down-gradient direction as far as the dissolved benzene (MtBE, if present) plume dictates.

6.2.2 Step 2: Identification and Collection of Additional Data As Appropriate

The objective of this task is to collect any additional data necessary to complete the Tier 2 evaluation. The specific data to be collected will depend on site-specific conditions, complete pathways, and routes of exposure and the amount of existing data available. For general information on this step, refer to Section 3.0.

Tier 1A very conservatively assumes that the pathways are complete for most receptors within 660 feet of the storage tank system. Part of a Tier 2 assessment is to delineate the contaminant plumes in the various media (soil, groundwater or vapor phase) and determine which pathways may be complete. Some may be eliminated, but other more-distant receptors may have to be added if any of the plumes are unexpectedly long.

To the extent possible, site-specific fate and transport parameters should be used. If any data are not available for certain parameters, Tier 1 default values should be used. In the RBCA report, the owner/operator must provide justification for the site-specific values used for the Tier 2 analysis.

Typically, exposure data will not be collected on a site-specific basis. The OCC will allow the use of most likely exposure or reasonable average exposure values as indicated in Table 6-1.

Finally, the OCC requires the use of chemical-specific fate and transport and toxicity values as listed in Tables 4-2 and 4-3. Sufficient justification should be provided in the report if values other than those listed in these tables are used.

One of the factors that may also affect the Tier 2 data needs is the specific fate and transport model that will be used to evaluate the indirect routes of exposure identified in Step 1. In general, the models used to develop Tier 1A levels may be used. Additional models that may be considered include a model for the unsaturated zone such as SESOIL, JURY, VLEACH and a model for the saturated zone such as the AT123D model. All models selected should be peer-reviewed, publicly available and with a track record of having been used on similar projects. Further, the OCC has the right to review software/models before making decisions. The specific model(s) used should be clearly documented in the RBCA report.

It is also during this stage that full delineation of the soil and groundwater plumes should be made. The delineation should provide all of the data needed to put together a remediation plan that will clean up the site to below SSTLs. Most important is the full three-dimensional delineation of the suspected continuing source zone, even that which is below the current water table. Cleaning up this zone is critical in bringing the entire groundwater plume to below SSTLs. Where conditions allow, direct-push is an excellent tool for acquiring this data. Data can be_collected in a much more closely spaced grid pattern than would be feasible with a hollow-stem auger rig.

6.2.3 Step 3: Development of Tier 2 Target Levels or Estimation of Risk

The OCC allows Tier 2 analysis to be conducted in the forward or the backward mode. In the forward mode, the end result will be the estimate of individual excess lifetime cancer risk and hazard quotient. For these calculations, a key input parameter is the representative site concentration. Depending on the site-specific conditions and availability of data, the OCC may accept the use of area-weighted average concentration as the representative concentration. You should only average concentrations from a certain media or area that could impact a particular receptor. One example would be an occupant of a building. You should only average samples taken from borings or wells located within 10 or 15 feet of that building or average samples taken adjacent to a utility corridor for the construction worker. The only time you might ever average an entire plume is for a receptor located down gradient of a moving plume such as a drinking water well. In the backward mode, the end result will be the site-specific target levels (SSTLs). The computations necessary for this step may be performed using any software or spreadsheet system that uses the models and data selected in Step 2.

6.2.4 Step 4: Decision Making Using Tier 2 Results

The estimated risk calculated in Step 4 should be compared with the target risk of 1 x 10^{-6} for current exposures and 1x-10^{-4} for reasonable potential future exposure and hazard index of unity (1.0). If the resulting risk and/or the hazard index does not exceed these values, the OCC may accept no further action and close the site. If the risk is only exceeded for a future receptor such as a possible water well or the only current receptor at risk is the construction worker and no construction is planned, monitoring natural attenuation is an acceptable strategy. If the risk exceeds the acceptable level, either Tier 2 cleanup levels should be developed as discussed below or a Tier 3 investigation and analysis should be conducted.

In most cases, the estimated risk is proportional to the input concentrations. Thus, simple proportionality may be used to estimate the Tier 2 target concentrations when using the forward mode as follows:

$$C_{Tier2} = \frac{TR}{CR} \times C \qquad (6\text{-}1)$$

where:

C_{Tier2}	=	Tier 2 target concentration (mg/l or mg/kg)
TR	=	Target or acceptable risk level (--)
CR	=	Site-specific risk estimated using the forward mode (--)
C	=	Concentration used to calculate risk in the forward mode (mg/l or mg/kg)

Note, Equation 6-1 has to be applied to each chemical and each pathway. Similarly, for non-carcinogenic effects

$$C_{Tier2} = \frac{THQ}{CHQ} \times C \qquad (6\text{-}2)$$

where:

C_{Tier2}	=	Tier 2 target concentration (mg/l or mg/kg)
THQ	=	Target hazard quotient (--)
CHQ	=	Site-specific hazard quotient using the forward mode (--)
C	=	Concentration used to calculate the hazard quotient (mg/l or mg/kg)

If the backward mode of calculations is used, the calculated Tier 2 levels should be compared with the representative concentrations on site. Depending on the site-specific conditions and availability of data, the OCC may accept the use of area-weighted average concentration as the representative concentration (Refer to Appendix E). If the Tier 2 target concentrations exceed the site concentrations, the OCC may close the site with no further action. Alternatively, if the site concentrations exceed the Tier 2 site-specific target levels, the owner/operator may recommend to the OCC either (i) to conduct a Tier 3 analysis, (ii) allow remediation through natural attenuation, or (iii) perform corrective action to meet Tier 2 levels. For the latter option, it will be necessary to develop and submit a remedial action plan to the OCC for approval.

6.2.5 Step 5: Preparation and Submission of Tier 2 Evaluation Report

As part of this step, a Tier 2 evaluation report should be prepared. If a Tier 1A evaluation has already been conducted, the Tier 2 report should not repeat the information already submitted to the OCC unless it is necessary. If you use the Tier 1A reporting format, be sure to submit any pages with changes. Submit maps showing the plumes delineated, the groundwater surface contoured, any changes in the receptor scenario (including those that need to be notified), cross-sections and any other relevant maps. The Tier 2 report should be clearly and concisely written and focused on (i) justifying the use of non-default values, (ii) the calculated risk and target levels, and (iii) must include recommendations based on the Tier 2 evaluation.

7.0
TIER 3 EVALUATION

7.1 OVERVIEW

Tier 3 is the most sophisticated and detailed site-specific analysis that can be conducted under the Oklahoma Risk-Based Corrective Action Program for Underground Storage Tanks. Tier 3 provides the most flexibility for developing site-specific target levels for estimating the site-specific risks. Also, a Tier 3 analysis may delay the overall process of site closure as this will require the most regulatory review and oversight. **As with every other assessment step, if the regulatory contact is seeking reimbursement from the Indemnity Fund it is imperative to gain pre-approval through the form of a purchase order request.**

Prior to conducting a Tier 3 analysis, the owner and/or operator must submit a detailed workplan and discuss the specifics of the plan with the OCC. Tier 3 analysis is expected to vary significantly from site to site; hence, specific guidance is not provided in this document.

The completion of a Tier 3 analysis can result in one of three decisions: (i) site closure with no further action if the calculated risk is below the OCC acceptable level or if the Tier 3 target levels are below the representative site concentrations, (ii) remediation to Tier 3 levels with or without the consideration of activity use limitations, and (iii) monitoring to confirm that natural attenuation will reduce the concentrations to Tier 3 levels.

8.0
REMEDIAL ACTION PLAN AND COMPLIANCE MONITORING

8.1 INSTALLED REMEDIATION SYSTEMS

Unless directed to do otherwise by the Commission, the owner and/or operator will be required to perform all parts of this section which includes remediation of a site as directed by the Commission. The objectives of remediation are both short-term and long-term. The short-term objective is to eliminate or reduce risk of exposure at current receptors that are threatened with exposure above target levels. The long-term goal is to prevent exposure to future receptors. To achieve these objectives, concentrations must be reduced by active remediation or natural attenuation to levels below the site-specific target levels (SSTLs) at all points between the source(s) and the point(s) of exposure as well as all means necessary to eliminate or prevent exposure until those levels are reached. After those levels are achieved, monitoring must continue until data indicates the contaminant plume is steady or declining.

Before implementation of any remediation corrective action plan, an analysis interpretation of the continuing source for CoC in soils will be conductred.

After the remediation plan has been approved by the Commission, the owner and/or operator must perform a baseline round of sampling and analyses from all approved monitoring wells during the two (2) weeks period prior to implementation of the remedial action plan (RAP) which was approved by the Commission. The owner and/or operator is also responsible for preparing a report that documents the remediation timetable and critical performance benchmarks, a system design, operation and maintenance plan, start-up plan, monitoring plan, waste disposal plan including vapors and influent/effluent and the security/system protection plan. The owner and/or operator must notify the Commission in writing of the date of implementation within seven (7) working days of the actual date of implementation. Subsequent to the implementation date, the owner and/or operator will perform monthly sampling and analyses for the next six (6) months. For the first five (5) months only, those monitoring wells, which were impacted by contamination in the baseline-sampling event, will be required to be sampled and analyzed. During the sixth month sampling event, all monitoring wells that have been, or may possibly be, impacted due to site characteristics will be required to be sampled and analyzed.

All sampling events must occur during the respective week of each month in which implementation occurred (that is, if the implementation date was during the third week of January, subsequent sampling events must occur during the third week of February, the third week of March, and so forth). A six-month monitoring report will be required to be submitted to the Commission within thirty days after the six-month sampling event. This report must contain as-built diagrams and maps of the remediation system, monthly water table elevation maps, contoured groundwater plume maps for chemicals, which exceed site cleanup levels and graphs of all impacted monitoring wells showing chemical concentrations versus time, with time beginning with the baseline-sampling event. The report must also include a discussion of the efficiency and effectiveness of the RAP including a comparison to the initial remediation timetable and critical performance benchmarks, and a discussion of the waste disposal plan for vapors and influent/effluent.

Subsequent to the six-month sampling event, the owner and/or operator will begin quarterly monitoring sampling events. During quarterly sampling events, key monitoring wells that have been, or may possibly be, impacted due to site characteristics will be required to be sampled and analyzed. All quarterly sampling events must occur during the respective week of the month in which implementation occurred. A quarterly monitoring report containing water table elevation maps, contoured groundwater plume maps for CoC, which exceed site cleanup levels, and graphs of key monitoring wells showing CoC concentrations versus time, with time beginning with the baseline sampling event, will be required to be submitted to the Commission within thirty days after a quarterly sampling event. The report must also include a discussion of the efficiency and effectiveness of the RAP including a comparison to the initial remediation timetable and critical performance benchmarks, and a discussion of the waste disposal plan for vapors and influent/effluent.

While the six-month monitoring report and subsequent quarterly monitoring reports, if required, are being completed, it will be the responsibility of the owner and/or operator to determine whether the RAP implemented at the site is functioning effectively and efficiently and performing as designed. If not, it is the responsibility of the owner and/or operator to inform the Commission in a timely manner of the deficiency of the RAP and submit changes or alternatives to the current RAP for approval by the Commission. The following discussion highlights criteria for the evaluation of some of the more common methods of remediation including natural attenuation, soil vapor extraction (SVE), sparge wells, pumping methods, bioventing and excavation.

8.2 REMEDIATION THROUGH NATURAL ATTENUATION

Unless directed to do otherwise by the Commission, the owner and/or operator must perform all parts of this section. Remediation through monitoring natural attenuation (MNA) is generally acceptable at sites where there is no current receptor exposed to any contaminated media (soil, groundwater, surface water or vapors). Even if a utility corridor is impacted, if there is no construction scheduled, MNA is an acceptable remediation strategy. After approval by the Commission to implement remediation through natural attenuation at a release site, the owner and/or operator must perform a baseline round of sampling and analyses from all approved monitoring wells during the two (2) week period prior to implementation of the remedial action plan (RAP). The owner and/or operator must notify the Commission in writing of the date of implementation within seven (7) working days of the actual date of implementation. Subsequent to the implementation date, the owner and/or operator will perform quarterly sampling and analyses for the next twelve (12) months. For the first three (3) sampling events, only those key monitoring wells, which were impacted by contamination in the baseline sampling event, will be required to be sampled and analyzed. During the twelfth month sampling event, all key monitoring wells that have been, or may possibly be impacted due to site characteristics, will be required to be sampled and analyzed. If the OCC has determined the site has a low priority based on the risk assessment, the RC and their consultant may receive a schedule to implement sampling of key wells for MNA.

All sampling events must occur during the respective week of each month in which implementation occurred (that is, if the implementation date was during the third week of January then subsequent sampling events must occur during the third week of April, the third week of July, and so forth). A six month and twelve month monitoring report will be required to be submitted to the Commission within thirty days after the respective sixth and twelfth month sampling events. These reports must contain quarterly water table elevation maps, contoured groundwater plume maps for CoC which exceed site cleanup levels and graphs of key impacted monitoring wells showing CoC concentrations versus time, with time beginning with the baseline sampling event. The report must also include a discussion of how efficiently and effectively natural attenuation is remediating the chemicals of concern.

Subsequent to the twelve-month sampling event, the owner and/or operator will continue quarterly monitoring sampling events. During quarterly sampling events, key monitoring wells that have been, or may possibly be impacted due to site characteristics, will be required to be sampled and analyzed. All quarterly sampling events must occur during the respective week of the month in which implementation occurred. An eighteen (18) month and twenty-four (24) month monitoring report containing water table elevation maps, contoured groundwater plume maps for CoC which exceed site cleanup levels and graphs of all key monitoring wells showing CoC concentrations versus time, with time beginning with the baseline sampling event, will be required to be submitted to the Commission within thirty days after the respective sixth and eighth quarterly sampling events.

It is the responsibility of the owner and/or operator to determine whether the remediation through natural attenuation RAP implemented at the site has been effective. If not, it is the responsibility of the owner and/or operator to inform the Commission in a timely manner of the deficiency of the RAP and submit changes or alterations to the current RAP for approval by the Commission.

8.3 REMEDIATION USING SOIL VAPOR EXTRACTION (SVE) WELLS

Unless directed to do otherwise by the Commission, the owner and/or operator must perform all parts of this section. Soil vapor extraction (SVE), also known as soil venting or vacuum extraction, is an in situ method for removing contaminants from unsaturated soils. The system creates a negative pressure gradient resulting in the movement to the extraction wells. The contaminants are then brought to the surface and are collected, treated and safely discharged. SVE is most effective in coarse-grained soils (sands and gravel) and with lighter hydrocarbons such as gasoline. SVE can be used in conjunction with air sparge wells, pumping systems or bioremediation. It is also effective in removing contamination from near or under fixed structures, which can be an effective protection for structures over an existing plume.

8.4 REMEDIATION USING SPARGE WELLS IN CONJUNCTION WITH SVE

Unless directed to do otherwise by the Commission, the owner and/or operator must perform all parts of this section. Air sparging in conjunction with SVE can be an effective technique for removing dissolved volatile contaminants from groundwater. The system injects air into the saturated zone. The air forms bubbles that rise into the unsaturated zone, carrying trapped and dissolved contaminants. The extraction wells then capture the sparged air. This air can be treated if necessary. This system works the best in homogeneous, permeable aquifers. This can be a rapid technique and does work to remove VOC's from below the groundwater table. **If there are any enclosed structures (whether occupied or not) near or within the air-sparging area, adequate SVE is required.**

8.5 REMEDIATION USING PUMP AND TREAT METHODS

Unless directed to do otherwise by the Commission, the owner and/or operator must perform all parts of this section. There are some effective pump and treat methods, and there are some that are very inefficient. Generally, pump and treat methods have been found to be ineffective as stand-alone treatment systems. They can be useful for plume containment purposes and in conjunction with surfactants. A pump and treat system can take an excessive amount of time to remediate the site and can smear contaminants across the water table during water table fluctuations, which complicates a clean up. It is the Operator and/or owner's responsibility, in conjunction with the consultant, to be careful when implementing a pump and treat method, such as an eductor system. A pump and treat method brings the contaminated groundwater above the ground to be treated at the surface. Treatment usually takes one of three methods: activated carbon, air stripping or bioremediation. A pump and treat method is most effective in a permeable aquifer. It can be used with an in situ SVE system to enhance the removal of volatile contaminants from the zone of water table fluctuation.

8.6 REMEDIATION USING EXCAVATION

Unless directed to do otherwise by the Commission, the owner and/or operator must perform all parts of this section. Excavation and off-site treatment is a method for removing contaminants from a smaller volume of soil. Once the soil is removed, it can be disposed of or remediated by natural attenuation or other methods. The soil type or contaminant does not affect this method. It is important to test the soil before determining the cost of soil disposal. High hydrocarbon concentrations, high lead and other metals can make it both dangerous to remove the soil and difficult to find a disposal site. These criteria should be addressed during the investigation and before the remediation plan is completed. It will probably be necessary to conduct a direct-push investigation of the soil plume area before submitting the RAP.

9.0
NON-ASSESSMENT PROCEDURES

9.1 REQUIREMENTS OF NON-ASSESSMENT PROCEDURES

This section is for compliance with the OCC Rules OAC 165:29-3-78 (Free product removal); OAC 165:2~~5~~9-3-~~77~~80 (Remedial action plan); OAC 165:29-3 Property owners affected by release; notice) and OAC 165:29-382 (Closure of a case). **As with the other assessment steps, if the regulatory contact is seeking reimbursement from the Indemnity Fund, it is imperative to gain pre-approval through the form of a purchase order request.** For the purposes of this section, a Remediation plan is the same as Remedial Action Plan (RAP). Except for emergency responses, the RAP should be submitted prior to performing any soil or groundwater cleanup at a confirmed UST release site. The RAP may be submitted in conjunction with a Tier 1A report or at any time thereafter prior to closure. The RAP may consist of an active remediation system, a "dig and haul", remediation through natural attenuation or any of a number of combinations of the above or other appropriate technologies not cited herein.

9.2 Free Product Removal (OAC 165:29-3-78)

This rule requires that if free product is discovered while assessing or remediating a release, the RC must contact the OCC within 48 hours (24 hours if found in a utility or its trench). At a minimum, this notification should include the type, location, depth and thickness of the free product. It should also mention if any subsurface structures, utilities or subsurface bodies are likely to be impacted and if so what steps are planned to minimize that impact. This notification may be made by voice phone, facsimile or e-mail. If done by e-mail, and before the end of the required reporting period you have not received confirmation that it has been received, you should resort to another method. **This applies to all communication by e-mail.** If any utility is impacted, it is important to also notify all affected utilities directly within 24 hours of the discovery. The RC must also submit an initial Free Product Removal report with in 45 days to the OCC on the form required by the Commission.

Except in cases where initial abatement measures are necessary, commission approval must be secured prior to free product removal. Free product removal must begin immediately after discovery if any receptor or utility is endangered or if there is data that indicates the free product is substantially moving. Under water-table conditions, free product does not substantially move away from the source unless there is a much more permeable pathway such as uncompacted soil in a utility trench. **If free product is found in contact with a waterline composed of PVC**, you should recommend to the water utility that they test the integrity of their line to be certain it has not been compromised. This interim free product removal will probably consist of hand bailing or periodic pumping. You must contact your PSTD-assigned PEA to determine at what frequency the removal must occur. If the product is not significantly removed during the first several removal episodes, you must start taking the steps to install a permanent removal system (see Section 9.4). The first step would be to submit a Remedial Selection Proposal (RSP). Upon approval of your selected remediation technology proposal by the OCC, submit a RAP to perform product removal. A Pay-For-Performance Contract with required cleanup milestones and reimbursement schedule may be implemented.

There are several considerations you should take into account. A properly screened monitor well usually creates a sink for free product, and thickness measures taken in the well are usually much thicker than what is found in the surrounding soil. There is usually a tendency for product to thicken when the water table drops. Measurements of product in bailers is substantially less than what would be measured in the well by an interface probe. Additional guidance can be found in *How to Effectively Recover Free Product At Leaking Underground Storage Tank Sites: A Guide for State Regulators.* (EPA 510-R-96-001). September 1996. This document can be downloaded at: http://www.epa.gov/swerust1/pubs/fprg.htm or ordered from the EPA. API Publication Number 4711, *Methods for Determining Inputs to Environmental Petroleum Hydrocarbon Mobility and Recovery Models* is another useful document that can be downloaded at http://api-ep.api.org/filelibrary/4711.pdf.

9.3 Property Owners Affected By Release; Notice (OAC 165:29-3-81)

For each confirmed release that requires remediation or can be closed by ORBCA, the owner and/or operator must provide notice by registered mail to all property owners for any property where there has been an impacted by CoC above action levels. You must also contact utilities whose lines or corridor have a reasonable chance of being impacted by the release. The optimum time to do this notification is subsequent to the delineation of CoC plumes exceeding established RBSLs or SSTLs. This notice must describe any planned remedial action or risk-based closure for the confirmed release and must include at a minimum:

1. The origin and extent of the release.
2. Significant release information, (this must include the specific type of product released, e.g. gasoline, diesel, etc.)
3. The availability of information at the OCC, including the name and phone number of the appropriate OCC PEA with oversight on the confirmed release case and the name, address and telephone number of the owner or operator or his or her designee who may be contacted for more information about the release.

The original registered mail receipts must be included in the Public Notification Report format and submitted to the OCC. If any remediation is planned (including MNA), the notification should mention that the case will close soon after clean-up levels are met. If all of the proceeding information is conveyed, one notification per case should be adequate. However, if several years pass between RAP approval and clean-up goals being achieved, it may be proper to conduct a second notification especially if you are aware that some property has a different owner. You do not need to notify the facility owner even if there has been a change in ownership.

If a remediation system is installed on a site, it is imperative to install a sign with emergency contact information for the operator of the system and the OCC PSTD. Be sure to include a contact number that can reach a person in charge anytime, day or night. Whenever a remediation system is not planned, a sign is not required unless there has been difficulty in sending registered mail to all property owners.

Prior to RAP approval or risk-based closure, the OCC may hold a public meeting to consider comments on the proposed action if there is sufficient public interest, or for any other reason the OCC deems appropriate. In addition, the owner and/or operator must provide notice that complies with items 1 through 3 cited above if implementation of an approved RAP does not achieve the established clean-up levels and termination of the RAP is approved by the OCC.

The RC should allow a minimum of four (4) weeks between the mailing of any notifications and the commencement of any closure activities such as the plugging of any monitor wells.

9.4 Remedial Action Plan (RAP - OAC 165:29-3-80)

The RAP should consist of a written proposal consisting of a recommendation of the type of remedial action proposed for the cleanup. The RAP must be capable of achieving either the appropriate risk-based screening levels, modified risk based screening levels, or site-specific target levels, which were determined through the ORBCA process. Completing a RAP is a three-step process. The third step is not required if the RC is not planning on seeking reimbursement from the Indemnity Fund.

9.4.1 Remedial Selection Proposal (RSP)

A remedial selection proposal should be included in the Tier 2 Report after the RC has successfully delineated the soil and groundwater plumes to OCC-approved RBSLs.

Additional guidance can be found at: *How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviewers.* (EPA 510-B-94-003 and EPA 510-B-95-007). These documents can be downloaded at: http://www.epa.gov/swerust1/pubs/tums.htm or ordered from EPA.

9.4.2 Remediation Plan Proposal (RPP)

The data requested in this step will be used to evaluate the proposed soil and/or ground water remediation technique(s). The Remediation Corrective Action Plan Disposal Report will include a section to list (1) site location data, (2) Owner/Operator data and (3) Consultant data. It also includes sections to discuss (A) Site History, (B) the Site Risk Assessment Data, (C) Site Hydrology, (D) the Proposed Remediation Process and (E) the System Implementation Method. This proposal is to be submitted after the Remediation Selection Proposal has been approved and after site clean-up levels have been approved.

Follow the standardized PSTD Remediation Plan Proposal Report format when submitting this report.

Please provide all of the requested information. These data are needed to fully evaluate each Remedial Action Plan OAC 165:29-3-80 Proposal. After these data are received, each Remediation Plan Proposal will be reviewed and evaluated on its technical merit.

Upon approval of the Remedial Action Plan OAC 165:29-3-80 Proposal, a Pay-for-Performance (P-f-P) Remediation Proposal may be submitted as directed by the PSTD. This is an iterative process that can be shortened by the presentation of complete and accurate information.

This proposal is to be submitted after the Remediation Plan Proposal has been approved and after site clean-up levels have been approved. The data requested in the following sections will be used to evaluate the price of the approved soil, groundwater and/or free product remediation technique(s).

This report will include a section to list (1) site location data, (2) owner/operator data and (3) consultant data. It also includes sections to discuss (A) the approved remediation technology, (B) the operation and maintenance schedule, (C) the monitoring schedule, (D) the remediation implementation method, (E) the approved clean up levels and (F) the price summary and contract terms. Follow the standardized PSTD Pay for Performance Proposal and Work Plan Report format when submitting this report.

Please provide all of the requested information. These data are needed to fully evaluate each Performance-Based Work Plan Proposal. After these data are received, each Performance-Based Work Plan will be reviewed and evaluated on its technical merit and the proposed price. Once the final proposal is approved and the price is negotiated, the Consultant, the Applicant and the State will enter into a Written Mutual Agreement for Performance-Based Corrective Action Contract.

9.4.3 Non-Attainment of Clean-up Criteria

It is the responsibility of the owner and/or operator to determine whether the RAP implemented at the site is functioning effectively and efficiently and performing as designed. If it is not, then it is the responsibility of the owner and/or operator to inform the OCC in a timely manner of the deficiency of the RAP and also submit changes or alterations to the current RAP for approval by the OCC. This may initiate another notification requirement as described in Section 9.3. If a site has not achieved the required clean-up levels and goals within three years from the date of the initial RAP implementation date, the owner and/or operator must recommend to the OCC to perform a new assessment of the risk posed to human health, safety, and/or the environment at the site.

The RC or their agent cannot turnoff, disconnect, deactivate or decommission any OCC-approved remediation system or significant part of a system without receiving prior approval from the OCC to do so. If any part of any remediation system fails and could cause any person to be exposed to unhealthy or dangerous conditions the OCC should be notified immediately or at a minimum within 24 hours. During non-office hours, the emergency pager number is (405) 575-5255. If a portion of any system should fail and that failure may cause a plume to expand, then the OCC should be notified if the system cannot be placed back into full operation within one week. Examples might include SVE systems that prevent the migration of vapors into a building or hydraulic control systems that prevent a dissolved plume from expanding.

9.4.4 WASTE DISPOSAL

During assessment and remediation activities, petroleum-impacted soils and water will be generated. If there is enough room on the same property where the release occurred, it is permissible to land-farm impacted soils. Such activity would require the permission of the OCC. Permission will generally not be given if there are any occupied buildings within about 200 feet of the land farm area.

If the soil has to be moved over a public road to another site (even if owned by the RC), a permit must be obtained from the ODEQ for any land farming. The Indemnity Fund will only reimburse costs for land farming up to a rate equivalent to hauling the soil to a nearby ODEQ-approved landfill.

Any impacted soil or groundwater that must be disposed of off site must be analyzed before shipment. The ODEQ-approved disposal facilities will specify which analyses to run and at what rate (so many composite samples per 100 cubic yards). Transporters usually remove impacted fluids from a site by stinging the drums and removing the fluid as bulk. Any

Purchase Order (PO) request must specify whether the soil or water is being removed as bulk or in drums. A manifest must be generated for the removal of any impacted soils or water or free product from a site. The manifest must specify whether the waste was removed as bulk or in drums.

If any fluid container has a 1/10 of an inch or more of free product, the fluid should be recycled as off-spec product. An analysis should not be required, and the product is usually removed as bulk.

9.5 CLOSURE OF A CASE (OAC 165:29-3-82)

Closure occurs when the OCC has determined that the appropriate clean-up levels have been achieved for all chemicals of concern (CoC) and/or the release no longer poses a significant risk to any receptor, current or future. If a RAP was required, the owner and/or operator must submit evidence that the CoCs have been monitored to ensure that they are remaining below the required clean-up levels for a period of time as determined by the OCC.

The OCC will notify the owner and/or operator once the OCC has approved the confirmed release case for closure. The date of the OCC approval letter for closure will initiate the timetable for the decommissioning process.

All confirmed release cases that have or are closed with CoCs exceeding the Tier 1A modified RBSLs will be maintained on a data base. Any dissolved plumes that exceed drinking water standards within Class I, II or III groundwater aquifers will be reported to the Oklahoma Water Resources Board to ensure that human health and safety will be protected in the future.

Subsequent to completion of the decommissioning process at the release site, the owner and/or operator will be required to submit a final report to the OCC on a form specified by PSTD (FCR.doc). This report must include a description and appropriate pictures of the restoration of the site. All monitoring and remediation wells must be decommissioned according to OWRB rules. Generally this means overdrilling the entire well (casing, screen, grout and sand pack) and filling the hole with grout. A copy of the plugging reports submitted to OWRB must be submitted to the OCC. If a well can serve some other purpose, the owner of the property may keep the well but must sign a statement in the final closure report to that effect. Responsibility for a well may be transferred to a neighboring release case that is not ready for closure. This must be acknowledged by the RC (or eligible party as defined by the Indemnity Fund) of the neighboring case by signing such a statement in the final closure report.

Once the OCC has reviewed the final closure report and approves it as acceptable, the OCC will notify the owner and/or operator in writing of closure of the confirmed release case.

10.0
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APPENDICES

APPENDIX A
DEFINITIONS OF SELECTED TERMS

In addition to the terms defined in 17 O.S. §303, the following words or terms, when used in this Chapter, shall have the following meaning unless the context clearly indicates otherwise:

"ANSI" means American National Standards Institute.

"API" means American Petroleum Institute.

"ASTM" means American Society for Testing and Materials.

"Abandoned system" means an underground storage tank system which:

(A) Has been taken permanently out of service as a storage vessel for any reason and is not intended to be returned to service; or

(B) Has been out of service for 1 year or more prior to April 21, 1989; or

(C) Has been rendered permanently unfit for use as determined by the Commission.

"Aboveground release" means any release to the surface of the land or to surface water. It includes, but is not limited to, releases from the aboveground portion of an underground storage tank system and aboveground releases associated with overfills and transfer operations as the regulated substance moves to or from an underground storage tank system.

"Aquifer" means a formation that contains sufficient saturated, permeable material to yield significant quantities of water to wells and springs. This implies an ability to store and transmit water for beneficial uses.

"Agricultural tank" or **"farm tank"** means a tank located on a tract of land devoted to the production of crops, or raising animals, including fish, and associated residences and improvements. To be excluded from this Chapter, an agricultural tank must be located on the farm property and its use must be devoted to agricultural activities. "Farm" includes fish hatcheries, rangeland, and nurseries with growing operations.

"Ancillary equipment" means any device including, but not limited to, such devices as piping, fittings, flanges, valves, and pumps that are used to distribute, meter, or control the flow of regulated substances to or from an underground storage tank.

"Belowground release" means any release to the subsurface of the land or to groundwater. It includes, but is not limited to, releases from belowground portions of an underground storage tank system and belowground releases associated with overfills and transfer operations as the regulated substance moves to or from an underground storage tank system. "Belowground release" does not include those releases to a secondary containment system.

"Beneath the surface of the ground" means beneath the ground's surface or otherwise covered with materials so that physical inspection is precluded or impaired.

"Beneficial uses" means a classification of the waters of the State, according to their best uses in the interest of the public.

"CASRN" means Chemical Abstracts Service Registry Number.

"CERCLA", also known as **"Superfund"**, means the Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 U.S.C.A. §9601 et seq., and any amendments thereto.

“**CoC”** means Chemicals of Concern.

"Carcinogenic risk" means the estimated increased probability of an individual developing cancer over a lifetime due to exposure to a chemical. This estimated risk is over and above the background risk of cancer which depends on many factors (genetics, lifestyle, age, etc.)

"Cathodic protection" means a technique designed to prevent the corrosion of a metal surface by making that surface the cathode of an electrochemical cell. For example, protection can be accomplished by means of an impressed current system or a galvanic anode system.

"Change in service" means the process of continuing to use an underground storage tank system that had previously contained a regulated substance, but now contains a non-regulated substance. Compliance with 165:25-3-64(f) and 165:25-3-65 shall be required before a change in service is acknowledged.

"Commission" means the Oklahoma Corporation Commission and includes its designated agents or representatives.

"Compatible" means the ability of two or more substances to maintain their respective physical properties upon contact with one another for the design life of the tank system under conditions likely to be encountered in the underground storage tank system.

"Contaminants" or **"contamination"** means concentrations of chemicals at levels that may cause adverse human health or environmental effects and/or nuisance conditions.

"Corrosion expert" means a person who, by reason of thorough knowledge of the physical sciences and the principles of engineering and mathematics, acquired by a professional education and related practical experience, is qualified to engage in the practice of corrosion control on buried or submerged metal tanks and metal piping systems. Such a person must be accredited as having been qualified by NACE or be a registered professional engineer who has education and experience in corrosion control of buried or submerged metal tanks and metal piping systems.

"Corrosion technician" or **"cathodic protection tester"** means a person who can demonstrate an understanding of the principles and measurements of all common types of cathodic protection systems as applied to buried or submerged metal piping and tank systems. At a minimum, such persons must have education and experience in soil resistivity, stray current, structure-to-soil potential, and component electrical isolation measurements of buried metal piping and tank systems.

"DAF" means dilution attenuation factor.

"DEQ" means the Oklahoma Department of Environmental Quality.

"DWS" means Drinking Water Standards.

"de minimis" means, for the purposes of this Chapter, very small, as in very small amounts or concentrations of regulated substances being stored in underground storage tank systems.

"Dielectric material" means a material that does not conduct direct electric current. Dielectric coatings are used to electrically isolate underground storage tank systems from the surrounding area. Dielectric bushings are used to electrically isolate portions of the underground storage tank system (e.g., tank from piping).

"Dilution Attenuation Factor" means a unitless number greater than or equal to unity and represents the ratio of dissolved phase concentration at a downgradient location to the concentration at an upgradient location. It represents the reduction in concentration due to the combined influence of several factors (diffusion, dispersion, adsorption, decay, volatilization). It is applicable for all media, but is most commonly used for the unsaturated and saturated zones. DAF is generally estimated using a fate and transport model or based on site-specific data.

"EPA" means the United States Environmental Protection Agency.

"Electrical equipment" means underground equipment which contains dielectric fluid which is necessary for the operation of equipment such as transformers and buried electric cable.

"Environment" means any water, water vapor, any land including land surface or subsurface, fish, wildlife, biota and all other natural resources.

"Environmental experience" means work related experience in any type of activities associated with impacted or potentially impacted soil, water and/or atmosphere.

"Excavation zone" means the volume containing the underground storage tank system and backfill materials, bounded by the ground surface, walls, and floor of the pit and trenches into which the underground storage tank system is placed at the time of installation.

"Existing tank" means an underground storage tank system used to contain an accumulation of regulated substances for which installation of that system commenced prior to April 21, 1989.

Installation will be considered to have commenced if the owner has obtained all federal, state, and local approvals or permits necessary to begin physical construction of the site or installation of the tank system, and if either:

(A) A continuous on-site physical construction or installation program has commenced; or

(B) The owner has entered into contractual obligations for physical construction at the site of installation of the tank system; and

(i) Construction or installation will be commenced within 60 days of the effective date of this Chapter; or

(ii) The contractual obligations cannot be canceled or modified without substantial financial loss to the owner.

If installation has not commenced within such time, the tank system shall be deemed to be a new tank and shall fall under all regulations that apply to new tanks.

"Facility" means any location or part thereof containing one or more underground storage tanks or systems.

"Field-constructed tank" means a tank that is largely constructed in the field. Such tanks are usually constructed of concrete or steel, shaped like flat vertical cylinders, and have a capacity of greater than 50,000 gallons. Field-constructed tank does not mean a tank that is principally factory-built, but is constructed in the field, such as a tank which has 2 factory-built halves that are welded together in the field.

"Flow-through process tank" means a tank that forms an integral part of a production process through which there is a steady, variable, recurring or intermittent flow of material during the operation of the process. Flow-through process tanks do not include tanks used for the storage of materials prior to their introduction to the process or for the storage of finished products or by-products from the production process.

"Fraction organic carbon content" means fraction of organic carbon in soil that influences the adsorption of organic chemicals. It can be estimated in soils using high temperature combustion and oxidation techniques such as ASTM method D2974.

"Free product" means a regulated substance that is present as a non-aqueous phase liquid (e.g., liquid not dissolved in water).

"Fresh groundwater" means groundwater with total dissolved solids (TDS) less than five thousand (5,000) parts per million.

"Gathering lines" means any pipeline, equipment, facility, or building used in the transportation of oil or gas during oil or gas production or gathering operations.

"Groundwater" means that part of water that is below the water table.

"Half-life" means the time required for the decay or transformation of one-half of the amount of chemical.

"Hazard index" means the sum of the hazard quotients.

"Hazard quotient" means the estimated dose, or intake, for a specific chemical and a specific pathway, divided by the reference dose (RfD).

"Hazardous substance underground storage tank system" means an underground storage tank system that contains either:

(A) An accumulation of hazardous substance as defined in §101(14) of CERCLA, other than any substance regulated as a hazardous waste under Subtitle C of the Solid Waste Disposal Act (RCRA) or any substance regulated as a hazardous waste under the Oklahoma Hazardous Waste Disposal Act; or

(B) A mixture of such substances and petroleum, and which is not a petroleum underground storage tank system.

"Heating oil" means petroleum that is No. 1; No. 2; No. 4-light; No. 4-heavy; No. 5-light; No. 5-heavy; No. 6; technical grades of fuel oil; other residual fuel oils (including Navy Special Fuel Oil and Bunker C); and other fuels when used as substitutes for one of these fuel oils. Heating oil is typically used in the operation of heating equipment boilers, or furnaces.

"Hydraulic lift tank" means a tank holding hydraulic fluid for a closed-loop mechanical system that uses compressed air and hydraulic fluid to operate lifts, elevators, and other similar devices.

"Impervious barrier" means a barrier of sufficient thickness, density, and composition that is impenetrable to the regulated substance, has a permeability of at least $1 \text{ X } 10^{-6}$ cm/sec., and will prevent the discharge to the environment of any regulated substance for a period of at least as long as the maximum anticipated time during which the regulated substance will be in contact with the impervious material.

"In service" means an underground storage tank or facility which is not abandoned, contains regulated substances, and/or has regulated substances regularly added to or withdrawn from it.

"Interstitial monitoring" means a leak detection method which entails the surveillance of the space between the underground storage tank system's walls and the secondary containment system for a change in the steady state conditions. In a double-walled tank, this change may be indicated by a loss of vacuum, a drop in pressure, a drop or rise in the fluid level in the visible reservoir, or the detection of regulated substances and/or water in the interstitial space. In a secondary containment system consisting of a liner (natural or synthetic) or a vault, the surveillance consists of frequent-to-continuous sampling of a monitoring well between the underground storage tank and the liner to detect the presence of regulated substances in the wells.

"Inventory controls" means techniques used to identify a loss of regulated substances that are based on volumetric measurements in the tank and reconciliation of those measurements with product delivery and withdrawal records.

"Liquid trap" means sumps, well cellars, and other traps used in association with oil or gas production, gathering, and extraction operations (including gas production plants), for the purpose of collecting oil, water, and other liquids. Such liquid traps may temporarily collect liquids for subsequent disposition or reinjection into a production or pipeline stream, or may collect and separate liquids from a gas stream.

"Low-Yield Aquifer" means an aquifer that produces less than, or equal to, 0.5 gallons per minute.

"MCL" means Maximum Contamination Level.

"Maintenance" means the normal operational upkeep to prevent an underground storage tank system from releasing product.

"Motor fuel" means any petroleum or a petroleum-based substance that is motor gasoline, aviation gasoline, No. 1 or No. 2 diesel fuel, or any grade of gasohol, and is typically used in the operation of a motor engine.

"Monitor well" means a piezometer or other cased and screened excavation, boring or drilled hole, installed in any way that can be used for the continuous or periodic evaluation of groundwater quality or the detection of soil vapors.

"NACE" means National Association of Corrosion Engineers.

"NFPA" means National Fire Protection Association, Inc.

"NPDES" means National Pollutant Discharge Elimination System.

"New tank" means an underground storage tank system that will be used to contain an accumulation of regulated substance and for which the installation of the tank or facility began on or after the effective date of this Chapter. The description of installation in "Existing tank" shall apply to determine if the tank or system is new or existing.

"Non-commercial purposes" with respect to motor fuel means not for resale.

"Nuisance conditions" means unpleasant odors, unpleasant visual impacts or other observable aesthetic impacts as determined by the Commission.

"ORBCA" means Oklahoma risk-based corrective action.

"OSDA" means the Oklahoma State Department of Agriculture.

"OWRB" means the Oklahoma Water Resources Board.

"Observation tube" means a leak detection device placed within the tank field which reaches two (2) feet below the tank bottom and can be inspected periodically to determine whether contamination by a regulated substance has occurred.

"Operational life" means the period beginning from the time installation of the tank or system is commenced until it is properly closed or removed as provided for in this Chapter.

"Operator" means any person in control of or having responsibility for the daily operation of the underground storage tank system, whether by lease, contract, or other form of agreement.

"Out of service" means an underground storage tank or system which:

(A) Is not in use (i.e., does not have regulated substances added to or withdrawn from the tank system); and

(B) Is intended to be placed back in service.

"Overfill" means a release that occurs when an underground storage tank is filled beyond its capacity, resulting in a discharge of regulated substance to the environment.

"Owner":

(A) means:

(i) In the case of an underground storage tank system in use on November 8, 1984, or brought into use after that date, any person who holds title to, controls or possesses an interest in an underground storage tank system used for the storage, use, or dispensing of regulated substances; or

(ii) In the case of an underground storage tank system in use before November 8, 1984, but no longer in service on that date, any person who holds title to, controls or possesses an interest in an underground storage tank system immediately before the discontinuation of its use.

(B) Does not include a person who holds an interest in an underground tank system solely for financial security, unless through foreclosure or other related actions the holder of the security interest has taken possession of the underground tank system.

"PEI" means Petroleum Equipment Institute.

"POC" means point of compliance.

"POE" means point of exposure.

"PSI" means pounds per square inch.

"Person" means any and all persons, including any individual, trust, firm, joint stock company or corporation, limited liability company, federal agency, including a government corporation, partnership, association, the state or any state agency, municipality, county or other political subdivision of the state, or any interstate body. It also includes a consortium, a joint venture, a commercial entity, and the United States Government or any other legal entity.

"Person in charge" means the owner or person designated by the owner, the operator, or permittee as the one with direct supervisory responsibility for an activity or operation at the underground storage tank system or facility, such as the transfer of regulated substances to or from any points at a facility.

"Petroleum" means ethylene glycol-based antifreeze, crude oil, crude oil fractions, and refined petroleum fractions, including motor oils fuel, jet fuels, distillate fuel oils, residual fuel oils, lubricants, petroleum solvents, and used oil which are liquid at standard conditions of temperature and pressure (60 degrees Fahrenheit and 14.7 pounds per square inch absolute). "Petroleum" also means a mixture of petroleum and hazardous substances provided the amount of the hazardous substances is of a de minimus quantity.

"Petroleum underground storage tank system" means an underground storage tank or system that contains:

(A) An accumulation of petroleum; or

(B) Mixtures of petroleum with de minimum quantities of other regulated substances.

"Pipe" or **"Piping"** means a hollow cylinder or tubular conduit that is constructed of non-earthen materials.

"Pipeline facilities" means new and existing pipe rights-of-way and any equipment, facilities, or buildings regulated under:

(A) The Natural Gas Pipeline Safety Act of 1968 (49 U.S.C. App. 1671, et seq.).

(B) The Hazardous Liquid Pipeline Safety Act of 1979 (49 U.S.C. 2001, et seq.).

(C) The State Hazardous Liquid Transportation System Safety Act, Section 47.1 et seq. of Title 52 of the Oklahoma Statutes.

(D) Intrastate pipeline facilities regulated under state laws.

"Point of exposure" means a location at which an individual or population may be exposed to site specific chemicals of concern through ingestion, inhalation and/or by dermal contact.

"Point of compliance" means a select location where the concentration of a chemical released must be at, or below, back-calculated levels. The back-calculated levels are such that estimated concentrations at the point of exposure are below health based levels.

"Pollution" means contamination or other alteration of the physical, chemical or biological properties of any natural waters of the state, contamination or alteration of the physical, chemical or biological properties of the land surface or subsurface, when such contamination or alteration will or is likely to create a nuisance or render the waters or land harmful or detrimental or injurious to the public health, safety or welfare, or the environment.

"Positive sampling, testing, or monitoring results" means the results of sampling, testing, or monitoring using any of the release detection methods described in this Chapter that indicate that a release from an underground storage tank system may have occurred.

"Potency factor" means plausible upper-bound estimate of the probability of a response (cancer) per unit intake of chemical over a lifetime. Also referred to as Slope Factor.

"RBCA" means risk-based corrective action.

"RBSL" means risk-based screening level.

"RC" means Regulatory Contact.

"RCRA" means the Resource Conservation and Recovery Act of 1976, 42 U.S.C.A. §6912, §6991(a) through (f), and §6991(h), and any amendments thereto.

"RfD" means reference dose.

"Reasonable Maximum Exposure (RME)" means highest rate of exposure that has a small probability (5%) of being exceeded.

"Reference dose" means the estimate of the daily intake of a chemical over a lifetime that is not likely to result in any significant adverse health effects (including in sensitive subpopulations).

"Regulated substances" or **"product"** means:

(A) Any substance defined in §101(14) of CERCLA but not including any substance regulated as a hazardous waste under Subtitle C of the Solid Waste Disposal Act (RCRA) or any substance regulated as a hazardous waste under the Oklahoma Hazardous Waste Disposal Act; and

(B) Petroleum, including crude oil or any fraction thereof which is liquid at standard conditions of temperature and pressure (60 degrees Fahrenheit and 14.7 pounds per square inch absolute) and as defined under "Petroleum" in this Section.

"Release" means any spilling, overfilling, leaking, emitting, discharging, escaping, leaching, or disposing of regulated substances from an underground storage tank system into the environment of the State. It includes but is not limited to suspected releases identified as a result of positive sampling, testing, or monitoring results, or identified in any other manner.

"Release detection" means determining whether a release of regulated substances has occurred from an underground storage tank or system into the environment or into the interstitial area between the underground storage tank system and the secondary barrier around it.

"Repair" means to restore a tank or underground storage tank system component that has caused a release of product from the underground storage tank system.

"Reportable quantity" or **"RQ"** means (when used in reference to hazardous substances) the amount of such hazardous substance, the release of which is required to be reported to appropriate federal, state, and/or local officials.

"Residential tank" means an underground storage tank or system located on the property where contents are used primarily for household purposes.

"Retrofit" means to modify an underground storage tank or system to meet the standards promulgated by this Chapter.

"Risk-based corrective action" means all of the activities necessary to manage a site such that any residual concentrations of chemicals released from a regulated facility are protective of public health and the environment. It includes, but is not limited to, collection of site-specific data, analysis of the data to quantify the risk, comparison of the risk with acceptable levels, and implementation of engineering and non-engineering measures to reduce the risk to acceptable levels.

"SARA" means Superfund Amendments and Reauthorization Act of 1986.

“SCEM” means Site Conceptual Exposure Model.

"SCL" means Soil Cleanup Level.

"STI" means the Steel Tank Institute.

"Saturated zone" means a subsurface zone below which all pore space is filled with water.

"Sacrificial anode" means a device to reduce or prevent corrosion of a metal in an electrolyte by galvanic coupling to a more anodic metal.

"Secondary containment" means a system installed around an underground storage tank or system that is designed to prevent a release from migrating beyond the secondary containment system outer wall (in the case of a double-walled tank system) or excavation area (in the case of a liner or vault system) before the release can be detected. Such a system may include, but is not limited to, impervious barriers (both natural and synthetic), double walls, or vaults.

"Septic tank" means a water-tight covered receptacle designed to receive or process, through liquid separation or biological digestion, the sewage discharge from a building sewer.

"Slope factor" means plausible upper-bound estimate of the probability of a response (cancer) per unit intake of chemical over a lifetime. Also referred to a Potency Factor.

"Source of contamination" means the location where the highest concentration of chemical contaminants in soil and groundwater exist.

"Source of release" means the location where chemical constituent(s) from a regulated tank system entered the environment.

"Spill" means a release that occurs during transfer operations of regulated substances to or from an underground storage tank system, resulting in a discharge of such substances to the environment.

"Stormwater collection system" or "wastewater collection system" means piping, pumps, conduits, and any other equipment necessary to collect and transport the flow of surface water run-off resulting from precipitation or domestic, commercial, or industrial wastewater to and from retention areas or any areas where treatment is designated to occur. The collection of stormwater and wastewater does not include treatment except where incidental to conveyance.

"Surface impoundment" means a natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials) that is not an injection well.

"TDS" means total dissolved solids.

"TPH" means Total Petroleum Hydrocarbons.

"Tank" means a stationary vessel designed to contain an accumulation of regulated substances which is constructed of primarily non-earthen materials (e.g., concrete, steel, plastic) that provide structural support.

"Tank tightness testing" or **"precision testing"** means a procedure for testing an underground storage tank system's ability to prevent an inadvertent release of any stored regulated substances into the environment. After December 22, 1990, the tightness test must be capable of detecting a 0.1 gallon per hour leak rate with a probability of detection of 0.95 and a probability of false alarm of 0.05.

"Target Risk Level" means the level set by the Oklahoma Corporation Commission that must be achieved at each site prior to a risk-based closure of the site. Currently this level has been set at 1E-06 (one-in-a-million level) and a hazard quotient of less than 1.0 (one).

"Temporary closure" means the status of an underground storage tank system which has been taken out of service for more than 3 months, but less than 12 months.

"Temporary removal from service" means the status of an underground storage tank system which has been taken out of service for less than 3 months.

"Transporter" means any person who transports, delivers, or distributes any quantity of regulated substance from one point to another for the purpose of wholesale or retain gain.

"UL" means Underwriter's Laboratory.

"U.S.G.S." means the United States Geological Survey.

"Usable groundwater" means fresh groundwater which may be produced from an aquifer for beneficial uses.

"UST experience" means work related experience showing a working knowledge of state and federal UST regulations, and the design, investigation, analysis, assessment, monitoring, and/or remediation of impacted soil and water.

"Underground area" means an underground room such as a basement, cellar, shaft, or vault providing enough space for physical inspection of the exterior of a tank situated on or above the surface of the floor.

"Underground storage tank" or **"UST"** means any one or combination of tanks, including underground piping connected thereto, that is used to contain an accumulation of regulated substances, and the volume of which, including the volume of underground piping connected thereto, is 10 percent or more beneath the surface of the ground. Such term shall not include any of the underground storage tanks or systems specifically exempted or excluded under 165:25-1-23(A) and 165:25-1-24.

"Underground storage tank system" means an underground storage tank, connected underground piping, underground ancillary equipment and containment system, if any.

"Unsaturated zone" or **"vadose zone"** means the subsurface zone containing water under pressure less than that of the atmosphere, including water held by capillary forces within the soil, and containing air or gases generally under atmospheric pressure. This zone is limited above by the ground surface and below by the upper surface of the water table itself.

"Upgrade" means the addition or retrofit of some systems, such as cathodic protection, lining, and spill and overfill controls, to improve the ability of the underground storage tank system to prevent the release of product in accordance with Subchapter 5.

"Vault" means an underground passage, room or storage compartment, when used for an underground storage tank system must be large enough for a person to visually inspect all areas around the underground storage tank.

"Wastewater treatment tank" means a tank that is designed to receive and treat an influent wastewater through physical, chemical, or biological methods.

"Waters of the State" means all streams, lakes, ponds, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems and all other bodies or accumulations of water, surface and underground, natural or artificial, public or private, which are contained within, flow through, or border upon the State of Oklahoma or any portion thereof.

[Source: Amended at 9 Ok Reg 849, eff 1-6-92 (emergency); Amended at 9 Ok Reg 2731, eff 7-13-92; Amended at 10 Ok Reg 2617, eff 6-25-93; Amended at 11 Ok Reg 3705, eff 7-11-94]

APPENDIX B
BACK-CALCULATION OF RISK BASED TARGET LEVELS

B.1 INTRODUCTION

The back-calculation of risk based target concentrations essentially answers the question *How clean is clean?* This procedure can be used to answer the following types of questions :

1. What residual concentrations can be left in the soil such that concentrations in a potential drinking water well do not exceed the MCL values for the chemical of concern?

2. What residual concentrations can be left in the soil such that the risk due to inhalation of volatile emissions from the soil to an on- or off-site receptor does not exceed an acceptable level?

3. What residual concentrations can be left in the soil such that the risk due to accidental ingestion, direct contact, and inhalation of volatiles does not exceed an acceptable level?

In each of these cases, the estimated or back calculated soil concentrations are termed as the risk-based target levels. Calculation of these concentrations depend on a variety of factors including the acceptable level of risk, receptor characteristics (commercial vs. residential; child vs. adult), transport mechanisms, properties of the chemical, distance between the receptor and the source, etc.

While performing these calculations it is important to distinguish between direct and indirect exposure pathways. Direct exposure pathways are those in which the receptor comes in direct contact with the affected medium. Examples of direct exposure pathways include accidental ingestion of soil, and dermal contact with soil. Indirect pathways are those where the exposure occurs away from the source. For example, volatilization of chemicals from subsurface soil may result in exposure by inhalation to off-site receptors, or leaching of chemicals to the groundwater may result in exposure by ingestion of water from an off-site well. Note, for indirect exposure pathways the back-calculation procedure requires the use of chemical fate and transport models.

The following section presents a step-by-step method to back-calculate the target levels.

B.2 STEPS IN BACK-CALCULATING TARGET LEVELS

B.2.1 Step 1: Identify Acceptable Risk and Hazard Quotient

The acceptable individual excess lifetime cancer risk for carcinogenic effects and the acceptable hazard quotient for non-carcinogenic effects is a policy choice. For the assessment and closure of petroleum-impacted sites, the OCC currently uses values of 1.0E-6 (one in one million) and unity for current exposures and values of 1.0E-04 and 1.0 for potential future exposures respectively. The estimated cleanup levels are linear with respect to this value. Thus if the acceptable risk level were changed from 1.0E-06 to 1.0E-5 (one in one hundred thousand) with all other factors remaining the same, the target level would increase by a factor of 10. Similarly if the target hazard quotient is reduced to 0.5, the target levels would reduce by a factor of 2.0.

B.2.2 Step 2: Estimate the toxicity of the Chemicals of concern

The toxicity of chemicals with carcinogenic effects is quantified using the slope factor or the potency value. For non-carcinogenic effects, the toxicity is quantified using the reference dose. For each of the chemicals of concern included in the spilled product, these toxicity values are tabulated in Table 4-3. These values should be used unless there is a strong reason to use alternative values. Any alternative values must be approved by the OCC personnel.

B.2.3 Step 3: Estimate the Allowable Dose

For carcinogenic health effects, the allowable dose for the chemical of concern is estimated by dividing the acceptable risk (refer to Step 1) with the Potency value (refer to Step 2). For non-carcinogenic adverse health effects, the acceptable dose is equal to the hazard quotient (refer to Step 1) multiplied by the reference dose (refer to Step 2).

B.2.4 Step 4: Estimate the Allowable Exposure Point Concentration

The allowable exposure point concentration is estimated using the uptake equations for the relevant route of exposure and appropriate exposure factors (see Appendix C for examples). For Tier 1 analysis, default exposure factors presented in Table 5-2 were used. For Tier 1-A, these exposure factors cannot be changed. For Tier 2 and Tier 3 analysis alternative site-specific factors if available and justifiable may be used. It is the responsibility of the person/organization conducting the analysis to provide justification for the use of these alternative values and get the concurrence of the OCC case officer.

For direct routes of exposure, the estimated concentration will be the risk-based target level. However for indirect routes of exposures, the estimated target concentrations are applicable at the point of exposure. Additional analysis as presented in the following step is necessary to relate the exposure point concentrations to the source concentrations.

B.2.5 Step 5: Estimate the Allowable Source Concentration

This step varies depending on the specific indirect route of exposure and the transport mechanism from the source to the receptor point. However, the objective in each case is to quantitatively relate the allowable exposure point concentration estimated in Step 4 to the source concentration. Two examples are presented below:

<u>Example 1: Estimation of subsurface soil concentrations protective of inhalation exposures</u>. (Refer to Figure B-1) For this exposure pathway, the concentration estimated in Step 4 would be the concentration in the air that the receptor is breathing. A two-step procedure may be used to estimate allowable soil concentrations. Initially, if the receptor is located on-site, a closed box-model may be used to estimate the allowable emission rate. Secondly, using an emission model the estimated allowable emission rate is related to the allowable soil concentration. Implementation of these two models requires several fate and transport parameters. It is important that the responsible party clearly identify the data used and provide adequate justification for the specific values used for Tier 1-A, Tier 2 and Tier 3 analyses.

<u>Example 2: Estimation of soil concentrations protective of ingestion of ground water</u>. (Refer to Figure B-2). For this exposure pathway, the concentration estimated in Step 4 would be the concentration in the exposure well. The allowable leachate concentration at the source is calculated as the allowable concentration at the exposure point multiplied by the overall dilution attenuation factor (DAF).

The dilution attenuation factor is the ratio of the concentration at the source to the concentration at the receptor (termed as the concentration reduction factor, or dilution attenuation factor, or the natural attenuation factor), and is estimated using a fate and transport model. The DAF (greater than or equal to one) depends on several factors such as the distance to the well, groundwater velocity, chemical properties, size of the source, etc. that are site-specific and are accounted for by the groundwater model(s). Several coupled models may be required to estimate the dilution attenuation factor, e.g., an unsaturated zone transport model, a saturated zone-mixing model, and a saturated zone transport model. The allowable leachate concentration is finally converted to an allowable soil concentration either by using the results of a site-specific leachate test or most commonly by assuming equilibrium partitioning between the soil concentration and the leachate concentration.

B.3 IMPLEMENTATION OF THE ABOVE STEPS FOR THE OCC'S RBCA PROGRAM

The specific equations used to implement the above steps for Tier 1 look-up values are presented in Appendix C. Several softwares, including one sponsored by the OCC, are available to calculate Tier 1-A and Tier 2 target levels.

APPENDIX C
ESTIMATION OF RISK-BASED SCREENING LEVELS

The following equations were used to estimate risk-based levels for carcinogenic and non-carcinogenic effects respectively, for different routes of exposure. For Tier 1 levels, these equations were solved using generic, default, conservative values presented in Section 5.0. The same equations shall be solved using site-specific fate and transport data to develop Tier 1-A modified RBSLs. The use of site-specific data must be justified based on site-specific measurements or other considerations.

C.1 INHALATION OF VAPOR EMISSIONS

The screening level concentration in air for this route for carcinogenic effects is estimated using:

$$RBSL_a = \frac{TR * BW * AT_C * 365}{IR_a * ED * EF * ET * SF} \qquad (C\text{-}1)$$

where:

$RBSL_a$	=	Risk-based screening level in air [mg/m^3]
TR	=	Target risk or the increased chance of developing cancer over a lifetime due to exposure to a chemical [---]
BW	=	Body weight [kg]
AT_c	=	Averaging time for carcinogens [years] (Note 365 converts years to days)
IR_a	=	Inhalation rate of air [m^3/hr]
ED	=	Exposure duration [years]
EF	=	Exposure frequency [days/year]
ET	=	Exposure time [hr/day]
SF	=	The chemical-specific slope or potency factor [(mg/kg-day)$^{-1}$]

The screening level concentration in air for inhalation for noncarcinogenic effects is estimated using the following equation:

$$RBSL_a = \frac{THI * BW * AT_{NC} * 365 * RfD}{IR_a * ED * EF * ET} \qquad (C\text{-}2)$$

where:

RfD	=	The chemical-specific reference dose [(mg/kg-day)]
THI	=	Target hazard index for individual constituents [--]
AT_{NC}	=	Averaging time for non-carcinogens [years]

and the other remaining parameters are the same as in Equation C-1.

C.2 INGESTION AND DERMAL CONTACT WITH SOIL

The screening level soil concentration protective of a receptor simultaneously exposed to chemicals from these two routes of exposure for <u>carcinogenic effects</u> is estimated using:

$$RBSL_S = \frac{TR * BW * AT_C * 365}{EF * ED\,[(SF_O * 10^{-6} (IR_S * RAF_O + SA * M * RAF_d))]} \qquad (C\text{-}3)$$

where:

SF_o	=	Oral cancer slope factor [(mg/kg-day)$^{-1}$]
IR_s	=	Soil ingestion rate [mg/day]
RAF_o	=	Oral relative absorption factor [---]
SA	=	Skin surface area [cm^2/day]
RAF_d	=	Dermal relative absorption factor [---]
M	=	Soil to skin adherence factor, soil specific factor [mg/cm^2]

and all the remaining parameters are the same as previously defined.

The screening level concentration in soil protective of a receptor simultaneously exposed to chemicals from these two routes of exposure for <u>noncarcinogenic</u> effects is estimated using:

$$RBSL_S = \frac{THI * BW * AT_{NC} * 365}{EF * ED\left[\dfrac{10^{-6} * \left(IR_{soil} * RAF_O + SA * M * RAF_d\right)}{RfD_O}\right]} \qquad (C\text{-}4)$$

where:

RfD_o = The chemical-specific oral reference dose [(mg/kg-day)]

THI = Target hazard index for individual constituents [--]

and the remaining parameters are the same as previously defined.

C.3 SOIL CONCENTRATIONS PROTECTIVE OF GROUNDWATER

Consider the leaching of chemicals from the soil to a downgradient exposure well as shown in Figure C-1. The acceptable concentrations in the exposure well were estimated using equation C-6 or C-7. The acceptable soil concentration protective of the exposure well is:

$$RBSL_S = \frac{RBSL_w * DAF_M * DAF_{GW}}{EC_f} \qquad (C\text{-}5)$$

where:

$RBSL_s$ = Risk-based screening level in soil [mg/kg-soil]

$RBSL_w$ = Risk-based screening level of water at the point of exposure calculated using equation C-6 or C-7 [mg/l]

EC_f = the equilibrium conversion factor to convert the leachate concentration to soil concentration [mg/l/mg/kg]

DAF_M = The dilution attenuation factor in the mixing zone directly beneath the site.

DAF_{GW} = The dilution attenuation factor for the migration of dissolved phase from beneath the site to the exposure point.

In Equation C-5, $RBSL_w$ for carcinogenic effects is calculated as:

$$RBSL_w = \frac{TR * BW * AT_C * 365}{IR_w * ED * EF * SF_{ing}} \qquad (C\text{-}6)$$

where:

IR_w = Ingestion rate of water [liter/day]
SF_{ing} = The slope factor for ingestion[(mg/kg-d)$^{-1}$]

all the remaining parameters are as defined earlier.

In Equation C-5, $RBSL_w$ for <u>non-carcinogenic effects</u> is calculated as:

$$RBSL_w = \frac{THI * BW * AT_{NC} * 365 * RfD}{IR_w * ED * EF} \qquad (C\text{-}7)$$

where:

IR_w = Ingestion rate of water [liter/day]

all the remaining parameters are as defined earlier.

In Equation C-5, EC_f is calculated as:

$$EC_f = \frac{\rho_b + \rho_w * \theta_{ws}}{(\theta_{ws} + K_d * \rho_b + H * \theta_{as})} \qquad (C\text{-}8)$$

where:

ρ_b = Soil bulk density [g-soil/cm^3-soil]
ρ_w = Density of water [gm/ cm^3]
θ_{ws} = Volumetric water content of soil in the impacted zone [cm^3-H_2O/cm^3-soil]
K_d = Chemical specific solid-water partition coefficient [g-H_2O/g-soil]
H = Dimensionless form of the Henry's Law Constant [(cm^3-H_2O)/(cm^3-air)]
θ_{as} = Volumetric air content in the impacted zone soil [cm^3-air/cm^3-soil]

In equation C-5, the dilution attenuation factor in the mixing zone is calculated as:

$$DAF_M = 1 + \frac{U_{gw} * \delta_{gw}}{I * W} \qquad (C\text{-}9)$$

where,

U_{gw}	=	Groundwater Darcy velocity [cm/s]
δ_{gw}	=	Groundwater mixing zone thickness [cm]
I	=	Infiltration rate of water through soil [cm/yr]
W	=	Width of source area parallel to the groundwater flow direction [cm]

In equation C-5, DAF_{GW} is estimated using Domenico's steady-state model (see Figure C-2) along the centerline of the plume without decay:

$$\frac{C_x}{C_{source}} = \left(erf\left[\frac{S_w}{4\sqrt{a_y x}} \right] \right) \left(erf\left[\frac{S_d}{4\sqrt{a_z x}} \right] \right) \qquad (C\text{-}10)$$

where:

C_x	=	Concentration at distance "x" feet along the centerline of the plume [mg/L]
C_{source}	=	Concentration at the downgradient edge of the impacted zone [mg/L]
S_w	=	Source thickness perpendicular to the flow in the horizontal direction [feet]
S_d	=	Source depth in the vertical direction [feet]
erf	=	The error function
α_x	=	Longitudinal dispersivity [feet] (= $x/10$)
α_y	=	Transverse dispersivity [feet] (= $\alpha_x/3$)
α_z	=	Vertical dispersivity [feet] (= $\alpha_x/20$)

Note DAF_{GW} is computed as:

$$DAF_{GW} = \frac{C_{source}}{C_x} \qquad \textit{(C-11)}$$

C.4 INHALATION OF VAPORS AND PARTICULATES, DERMAL CONTACT AND INGESTION OF CHEMICALS IN SURFICIAL SOIL

The screening level soil concentration protective of a receptor simultaneously exposed to chemicals from these three routes of exposure for carcinogenic effects is estimated using:

$$RBSL_S = \frac{TR * BW * AT_C * 365}{EF * ED\,[(SF_O * 10^{-6} (IR_S * RAF_O + SA * M * RAF_d)) + (SF_i * IR_a (VF_{SS} + VF_p))]} \qquad \textit{(C-12)}$$

where:

SF_o = Oral cancer slope factor [(mg/kg-day)$^{-1}$]
IR_s = Soil ingestion rate [mg/day]
RAF_o = Oral relative absorption factor [---]
SA = Skin surface area [cm^2/day]
RAF_d = Dermal relative absorption factor [---]
M = Soil to skin adherence factor [mg/cm^2]

and all the remaining parameters are the same as previously defined.

In Equation C-12, the VF_{ss} factor accounts for the volatilization of vapors from soil to air and is the lower of the two values calculated using Equation C-13 or Equation C-14 (shown below).

$$VF_{ss} = \frac{2 * W * \rho_b}{U_a * \delta_a} \sqrt{\frac{D_s^{eff} * H}{\pi [\theta_{ws} + K_d * \rho_b + H * \theta_{as}]\,\tau}} * 10^3 \qquad \textit{(C-13)}$$

where:

W = Width of source area parallel to wind, or groundwater flow direction [cm]
ρ_b = Soil bulk density [g-soil/cm^3-soil]
U_a = Wind speed above ground surface in the ambient mixing zone [cm/s]
δ_a = Ambient air mixing zone height [cm]

D_s^{eff}	=	Effective diffusion coefficient in soil based on vapor-phase concentration [cm^2/s]
H	=	Chemical-specific Henry's Law constant [(cm^3-H_2O)/(cm^3-air)]
$\square_{ws}$	=	Volumetric water content in vadose zone soils [cm^3-H_2O/cm^3- soil]
K_d	=	Solid-water sorption coefficient [g-H_2O/g-soil]
$\square_{as}$	=	Volumetric air content in the vadose zone soils [cm^3-air/cm^3-soil]
$\square$	=	Averaging time for vapor flux [s]

In Equation C-13, the effective diffusion coefficient D_s^{eff} is calculated as:

$$D_s^{eff} = D^a * \frac{\theta_{as}^{3.33}}{\theta_T^{2.0}} + D^w * \frac{1}{H} * \frac{\theta_{ws}^{3.33}}{\theta_T^{2.0}} \qquad (C\text{-}14)$$

where:

D^a	=	Chemical-specific diffusion coefficient in air [cm^2/s]
$\square_T$	=	Total soil porosity in the impacted zone [cm^3/cm^3-soil]
D^w	=	Chemical-specific diffusion coefficient in water [cm^2/s]

and the remaining parameters are the same as in Equation C-13.

An alternative expression for VF_{ss} is:

$$VF_{ss} = \frac{W * \rho_b * d}{U_a * \delta_a * \tau} * 10^3 \qquad (C\text{-}15)$$

where:

W	=	Width of source area parallel to wind, or groundwater flow direction [cm]
$\square_s$	=	Soil bulk density [g-soil/cm^3-soil]
d	=	Depth to surficial soil zone [cm]
U_a	=	Wind speed above ground surface in ambient mixing zone [cm/s]
$\square_a$	=	Ambient air mixing zone height [cm]
$\square$	=	Averaging time for vapor flux [s]

In Equation C-12 the VF_p factor accounts for the volatilization of particulates from soil to air. VF_p is calculated as:

$$VF_p = \frac{P_e * W}{U_a * \delta_a} * 10^3 \qquad (C\text{-}16)$$

where:

VF_p	=	Volatilization factor from soil to ambient air (particulates) [(mg/m^3-air)/(mg/kg-soil)]
P_e	=	Particulate emission rate [g/cm^2-s]
W	=	Width of source area parallel to wind, or groundwater flow direction [cm]
U_a	=	Wind speed above ground surface in ambient mixing zone [cm/s]
$\square_a$	=	Ambient air mixing zone height [cm]

The screening level concentration in soil protective of a receptor simultaneously exposed to chemicals from these routes of exposure for noncarcinogenic effects is estimated using:

$$RBSL_S = \frac{THI * BW * AT_{NC} * 365}{EF * ED * \left[\frac{10^{-6} * \left(IR_{soil} * RAF_o + SA * M * RAF_d \right)}{RfD_o} + \frac{\left(IR_a * \left(VF_{ss} + VF_p \right) \right)}{RfD_i} \right]} \qquad (C\text{-}17)$$

where:

RfD_i	=	The chemical-specific reference dose for inhalation [(mg/kg-day)]
THI	=	Target hazard index for individual constituents [--]

and the remaining parameters are the same as previously defined.

Note that the factors VF_{ss} and VF_p are estimated using Equations C-13 through C-16.

C.5 SUBSURFACE AND SHALLOW SOIL CONCENTRATIONS PROTECTIVE OF ENCLOSED SPACE AIR (INDOOR) VAPOR INHALATION

Step 1: Estimation of allowable indoor air concentration

For inhalation, the allowable indoor air concentration for carcinogenic effects is estimated using equation C-1. Similarly, for noncarcinogenic effects the indoor air concentration is estimated using equation C-2.

Step 2: Estimation of allowable chemical mass circulating indoors

Allowable mass of benzene circulating in the building per second in the enclosed air space is estimated using:

$$\text{Air circulating per second} = \frac{W * L * h * N}{86400} \tag{C-18}$$

$$\text{Allowable chemical mass circulating} = \frac{W * L * h * N}{86400} * RBSL_a \tag{C-19}$$

where,

W	=	Width of the indoor space [m]
L	=	Length of the indoor space [m]
h	=	Height of the indoor space [m]
N	=	Volume of air changes per day [1/day]
		(Note 86400 converts day to seconds)

Step 3: Estimation of chemical emission rate

Using Fick's Law of diffusion (Freeze and Cherry, 1989) the emission rate can be estimated as:

$$E = \frac{D_{eff}}{d} * f * 100W * 100L * \left[\frac{C_v}{1000} - \frac{RBSL_a}{10^6}\right] \tag{C-20}$$

D_{eff}	=	Effective diffusion coefficient in soil [cm^2/s]
d	=	Depth to chemical in soil [cm]
$100W$	=	Width of the indoor space [cm]
$100L$	=	Length of the indoor space [cm]
		[Note the factor of 100 converts m to cm]
f	=	Fraction of the floor area through which diffusion occurs [--]
$C_v/1000$	=	Vapor concentration in soil [mg/cm^3]
$RBSL_a/10^6$	=	Vapor concentration in indoor air [mg/cm^3]

[Note the factor of 10^6 converts m^3 to cm^3 since RBSLa is in mg/m^3]

Step 4: Equating the emission rates in Step 2 and Step 3

The allowable vapor concentration in soil is calculated as:

$$C_v = \frac{RBSL_a}{1000} * \left[\frac{h * N * d}{f * 864 * D_{eff}} + 1 \right] \quad \text{(C-21)}$$

Step 5: Converting soil vapor concentration to (i) water and (ii) soil concentrations

The allowable soil vapor concentration can be converted to (i) water, and (ii) soil using the equilibrium partitioning theory as follows:

(i) $$RBSL_{winh} = \frac{C_v}{H} \quad \text{(C-22)}$$

(ii) $$RBSL_{sinh} = \frac{C_v}{H} * \left[\frac{\rho_b * K_d + \theta_{ws} + (\theta - \theta_{ws}) H}{\rho_b + \rho_l * \theta_{ws}} \right] \quad \text{(C-23)}$$

where:

$RBSL_{winh}$	=	Allowable concentration in groundwater protective of indoor inhalation [mg/l]
$RBSL_{sinh}$	=	Allowable concentration in soil protective of indoor inhalation [mg/kg]
H	=	Henry's Law constant [(cm^3-H_2O)/(cm^3-air)]
ρ_b	=	Soil bulk density [g-soil/cm^3-soil]
θ_{ws}	=	Volumetric water content in vadose zone soils [cm^3-H_2O/cm^3-soil]

K_d	=	Soil-water sorption coefficient [g-H_2O/g-soil]
□as	=	Volumetric air content in vadose zone soils [cm^3-air/cm^3- soil]
D_{eff}	=	Effective diffusion coefficient in soil [cm^2/s] which is expressed as:

$$D_{eff} = D^a * \frac{\theta_{as}^{3.33}}{\theta_T^{2.0}} \qquad (C\text{-}24)$$

the parameters in Equation C-24 are defined on *pp C-7*.

C.7 DERMAL CONTACT WITH SHALLOW GROUNDWATER

The screening level water concentration protective of a receptor exposed to chemicals from this route of exposure for carcinogenic effects is estimated using:

$$RBSL_w = \frac{TR * BW * AT_C * 365}{ED * EF * ET\left[PC * SF_O * 10^{-3} * SSA\right]} \qquad (C\text{-}25)$$

where:

SF_o	=	Oral cancer slope factor [$(mg/kg\text{-}day)^{-1}$]
PC	=	Chemical-specific dermal permeability coefficient [cm/hr]
SSA	=	Skin surface area [cm^2]
ET	=	Exposure time [hr/day]

and all the remaining parameters are the same as previously defined.

The screening level concentration in water protective of a receptor exposed to chemicals from these route of exposure for noncarcinogenic effects is estimated using:

$$RBSL_W = \frac{THI * BW * AT_{NC} * 365}{EF * ED * ET * \left[\frac{10^{-3} * (PC * SSA)}{RfD_O}\right]} \qquad (C\text{-}26)$$

where:

RfD_o = The chemical-specific oral reference dose [(mg/kg-day)]

THI = Target hazard index for individual constituents [--]

and the remaining parameters are the same as previously defined.

Appendix D
Unified Soil Classificatiom

ASTM Terminology

The basic reference for the Unified Soil Classification System is ASTM D 2487. Terms include:

Coarse-Grained Soils More than 50 percent retained on a 0.075 mm (No. 200) sieve

Fine-Grained Soils 50 percent or more passes a 0.075 mm (No. 200) sieve

Gravel Material passing a 75-mm (3-inch) sieve and retained on a 4.75-mm (No. 4) sieve.

Coarse Gravel Material passing a 75-mm (3-inch) sieve and retained on a 19.0-mm (3/4-inch) sieve.

Fine Gravel Material passing a 19.0-mm (3/4-inch) sieve and retained on a 4.75-mm (No. 4) sieve.

Sand Material passing a 4.75-mm sieve (No. 4) and retained on a 0.075-mm (No. 200) sieve.

Coarse Sand Material passing a 4.75-mm sieve (No. 4) and retained on a 2.00-mm (No. 10) sieve.

Medium Sand Material passing a 2.00-mm sieve (No. 10) and retained on a 0.475-mm (No. 40) sieve.

Fine Sand Material passing a 0.475-mm (No. 40) sieve and retained on a 0.075-mm (No. 200) sieve.

Clay Material passing a 0.075-mm (No. 200) that exhibits plasticity, and strength when dry (PI ³ 4).

Silt Material passing a 0.075-mm (No. 200) that is non-plastic, and has little strength when dry (PI < 4).

Peat Soil of vegetable matter.

Note that these definitions are Unified Soil Classification system definitions and are slightly different than those of AASHTO. The table below shows the Unified Soil Classification system (ASTM).

Unified Soil Classification (USC) System (from ASTM D 2487)

Major Divisions			Group Symbol	Typical Names
Course-Grained Soils More than 50% retained on the 0.075 mm (No. 200) sieve	**Gravels** 50% or more of course fraction retained on the 4.75 mm (No. 4) sieve	Clean Gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		Gravels with Fines	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	Sands 50% or more of course fraction passes the 4.75 (No. 4) sieve	Clean Sands	SW	Well-graded sands and gravelly sands, little or no fines
			SP	Poorly graded sands and gravelly sands, little or no fines
		Sands with Fines	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
Fine-Grained Soils More than 50% passes the 0.075 mm (No. 200) sieve	**Silts and Clays** Liquid Limit 50% or less		ML	Inorganic silts, very fine sands, rock four, silty or clayey fine sands
			CL	Inorganic clays of low to medium plasticity, gravelly/sandy/silty/lean clays
			OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays Liquid Limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
			CH	Inorganic clays or high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
Highly Organic Soils			PT	Peat, muck, and other highly organic soils

Prefix: G = Gravel, S = Sand, M = Silt, C = Clay, O = Organic
Suffix: W = Well Graded, P = Poorly Graded, M = Silty, L = Clay, LL < 50%, H = Clay, LL > 50%

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TABLE 3-1
APPROVED ANALYTICAL METHODS FOR CHEMICALS OF CONCERN

Released Substance	Media			Approved Method(s)
	Groundwater	Soil	Air	
Gasoline	BTEX	BTEX	BTEX	EPA 8021
	Naphthalene	Naphthalene		EPA 8270 (GC/MS)
	TPH (GRO)	TPH (GRO)		EPA 8015 (Modified)
Diesel, Jet Fuel	BTEX	BTEX	BTEX	EPA 8021
Kerosene, Fuel Oil	Naphthalene	Naphthalene		EPA 8270 (GC/MS)
	TPH (DRO)	TPH (GRO)		EPA 8015 (Modified)
Used (Waste) Oil	BTEX	BTEX	BTEX	EPA 8021
	Naphthalene	Naphthalene		EPA 8270 (GC/MS)
	TPH (GRO & DRO)	TPH (GRO & DRO)		EPA 8015 (Modified)
	TCLP*	TCLP*		

* Toxicity Characteristic Leachate Procedure (TCLP) analysis for Metals, semi-volatiles and volatiles.
Note: The OCC is evaluating the risk associated with MTBE and additional guidance will be forthcoming.

TABLE 4-1
CHEMICALS OF CONCERN FOR DIFFERENT PRODUCT SPILLS

CHEMICAL	PRODUCT					
	Gasoline	**Diesel**	**Jet Fuel**	**Kerosene**	**Fuel Oil 2**	**Used Oil***
Benzene	x	x	x	x	x	x
Ethylbenzene	x	x	x	x	x	x
Toluene	x	x	x	x	x	x
Xylenes (mixed)	x	x	x	x	x	x
MTBE ‡	x	--	--	--	--	--
Total Petroleum Hydrocarbons (TPH)	x	x	x	x	x	x
Naphthalene	x	x	x	x	x	x
Volatiles	--	--	--	--	--	x
Semi-volatiles	--	--	--	--	--	x
Toxicity Characteristic Leaching Procedure (TCLP)†	**	--	--	--	--	x

Note :

x : chemical of concern

-- : Not a chemical of concern

* : For used oil releases as determined through a TPH analysis (soil $\geq$ 50 mg/kg, water $\geq$ 2 mg/l), in addition to BTEX and naphthalene, TCLP analysis for metals, semi-volatiles, and volatiles must be performed to determine the chemicals of concern.

** : Analyze for lead if believed to be a historic release.

† : Performed when there are soil samples indicating a release from a used oil UST and the analyses exceed 50 mg/kg TPH (combined GRO and DRO). The TCLP should be performed on the soil sample with the highest OVM reading that was most likely to be impacted by the used oil UST.

‡ : No RBSLs have been developed as of now.

TABLE 4-2
PHYSICAL AND CHEMICAL PROPERTIES OF CHEMICALS OF CONCERN

CHEMICAL	Mol. Wt. [g/mole]	Koc [ml/g]	Henry's Constant [Dimensionless]	Diffusion coefficient in air [cm^2/s]	Diffusion coefficient in water [cm^2/s]	Pure Product Solubility [mg/L]	LEL [ppm]	Dermal Permeability Constant [cm/hr]
Benzene	78	38.02	0.22	0.093	0.000011	1750	13000	0.021
Toluene	92	134.9	0.26	0.085	0.0000094	535	12700	0.045
Ethylbenzene	106	1288.25	0.32	0.076	0.0000085	152	10000	0.074
Xylenes (mixed)	106	239.88	0.29	0.072	0.0000085	198	11000	0.08
Naphthalene	128	1288.25	0.049	0.072	0.0000094	31	9000	0.069

Sources:

1. ASTM. 1995. Standard Guide for Risk-Based Corrective Action at Petroleum Release Sites. E-1739-95.
2. Lyman, W.J., et al. *Handbook of Chemical Property Estimation Methods* , McGraw-Hill, NY, 1982.

TABLE 4-3
TOXICITY PARAMETERS OF CHEMICALS OF CONCERN

CHEMICAL	Slope Factor [kg-d/mg]				Reference Dose [mg/kg-d]			
	Oral	REF	Inhalation	REF	Oral	REF	Inhalation	REF
Benzene	0.029	1	0.029	1	na	--	na	--
Toluene	na	--	na	--	0.2	1	0.11	1
Ethylbenzene	na	--	na	--	0.1	1	0.29	1
Xylenes (mixed)	na	--	na	--	2	1	0.086	2
Naphthalene	na	--	na	--	0.04	3	0.003	4

Notes:

na = Not Applicable

Note : Oral slope factors and reference doses were used for dermal exposure

[a] Based on systemic toxicity and route extrapolation.

1 US EPA. July 1995. Integrated Risk Information System (IRIS).

2 US EPA. 1991. Health Effects Assessment Summary Tables (HEAST). Washington, DC: Office of Solid Waste and Emergency Response. NTIS PB91-921100.

3 US EPA. 1992. Health Effects Assessment Summary Tables (HEAST). Washington, DC: Office of Solid Waste and Emergency Response. OHEA ECAO-CIN-821.

4 ATSDR. 1994. Toxicological Profile of Naphthalene. Draft Update. Public Health Service. US Department of Health and Human Services.

TABLE 4-4

TABULAR FORMAT FOR SITE CONCEPTUAL EXPOSURE SCENARIO, CURRENT CONDITIONS

(FOR ILLUSTRATION PURPOSES ONLY)

Potentially Exposed Population	**Exposure Route, Medium, and Exposure Point**	**Pathway Selected for Evaluation ?**	**Reason for Selection or Non-Selection**
Off-site Resident (adult and child)	Inhalation of volatiles	No	Volatile emission from impacted soils is possible
	Inhalation of particulates	No	Site is paved and surficial soil is not impacted
	Ingestion of soil	No	Residents are off-site, and the site is paved
	Dermal contact with surficial soil	No	Residents are off-site, and the site is paved
	Ingestion of shallow groundwater	No	No wells screened in the shallow groundwater zone
	Inhalation of volatiles from shallow groundwater	No	Impacted shallow groundwater has not migrated below residential buildings
	Dermal contact with shallow groundwater	No	No wells screened in the shallow groundwater zone
	Ingestion of deep groundwater	No	No existing wells in deep groundwater
	Inhalation of volatiles from deep groundwater	No	Not relevant for depths > 15' - 20'
	Dermal contact with deep groundwater	No	Deep groundwater not being used
Off-site Commercial Worker	Inhalation of volatiles	Yes	Volatile emission from impacted soils is possible
	Inhalation of particulates	No	Site is paved and surficial soil is not impacted
	Ingestion of soil	No	Commercial worker is off-site
	Dermal contact with surficial soil	No	Commercial worker is off-site
	Ingestion of shallow groundwater	No	No wells screened in the shallow groundwater zone
	Inhalation of volatiles from shallow groundwater	No	Impacted shallow groundwater has not migrated below commercial buildings
	Dermal contact with shallow groundwater	No	No wells screened in the shallow groundwater zone
	Ingestion of deep groundwater	No	No existing wells in deep groundwater
	Inhalation of volatiles from deep groundwater	No	Not relevant for depths > 15' - 20'
	Dermal contact with deep groundwater	No	Deep groundwater not being used

TABLE 5-1
TIER 1/1-A ROUTES OF EXPOSURE FOR DIFFERENT MEDIA AND RECEPTORS

RECEPTOR	SURFACE SOIL (< 2 feet deep)	SUBSURFACE SOIL (> 2 feet deep)	SHALLOW GROUNDWATER (< 10 feet bgs)	DEEP GROUNDWATER (> 10 feet bgs)
Resident - Adult and Child	Ingestion and dermal contact with soil	Indoor inhalation of vapor emissions	Ingestion of water	Ingestion of water
	Indoor inhalation of vapor emissions *		Indoor inhalation of vapor emissions	
	Potential leachate to groundwater	Potential leachate to groundwater		
Commercial Worker	Ingestion and dermal contact with soil	Indoor inhalation of vapor emissions	Ingestion of water	Ingestion of water
	Indoor inhalation of vapor emissions		Indoor inhalation of vapor emissions	
	Potential leachate to groundwater	Potential leachate to groundwater		
Construction Worker	Ingestion and dermal contact with soil, and inhalation of vapor and particulates	Ingestion and dermal contact with soil, and inhalation of vapor and particulates	Dermal contact with groundwater	--

* This pathway or route of exposure is expected to be complete in those rare cases when a building is constructed directly on top of impacted soil without any soil removal

TABLE 5-2
TIER 1 DEFAULT EXPOSURE FACTORS
(RME VALUES)

	UNITS	Default Values
Body Weight		
On/Off-site Resident (adult)	kg	70
On/Off-site Resident (child)	kg	15
On/Off-site Commercial Worker	kg	70
Construction Worker	kg	70
Exposure Duration		
On/Off-site Resident (adult)	yr	30
On/Off-site Resident (child)	yr	6
On/Off-site Commercial Worker	yr	25
Construction Worker	yr	0.083
Exposure Time for indoor inhalation, dermal contact, and soil ingestion		
On/Off-site Resident (adult)	hrs/day	16
On/Off-site Resident (child)	hrs/day	16
On/Off-site Commercial Worker	hrs/day	8
Construction Worker	hrs/day	8
Exposure Frequency		
On/Off-site Resident (adult and child)	days/yr	350
On-site Commercial Worker	days/yr	250
Construction Worker	days/yr	250
Soil ingestion rate		
On/Off-site Resident (adult)	mg/day	100
On/Off-site Resident (child)	mg/day	200
On/Off-site Commercial Worker	mg/day	50
Construction Worker	mg/day	50
Daily Indoor Inhalation Rate		
On/Off-site Resident (child)	m^3/hr	0.937
On/Off-site Resident (adult)	m^3/hr	0.937
On/Off-site Commercial Worker	m^3/hr	2
Daily Outdoor Inhalation Rate		
Construction Worker	m^3/hr	2
Exposure Time for outdoor inhalation, dermal contact, and soil ingestion		
On/Off-site Resident (adult)	hrs/day	16
On/Off-site Resident (child)	hrs/day	16
On/Off-site Commercial Worker	hrs/day	8
Construction Worker	hrs/day	8
Daily water ingestion rate		
On/Off-site Resident (adult)	L/day	2
On/Off-site Resident (child)	L/day	1
On/Off-site Commercial Worker	L/day	1
Construction Worker	L/day	1
Skin surface area for dermal contact with soil		
On/Off-site Resident (adult)	cm^2	3160
On/Off-site Resident (child)	cm^2	3160
On/Off-site Commercial Worker	cm^2	3160
Construction Worker	cm^2	3160
Soil skin adherence factor	mg/cm^2	0.5
Oral relative absorption factor	---	1
Dermal relative absorption factor (volatiles)	---	0.5
Dermal relative absorption factor (PAHs)	---	0.05
Target Risk and Hazard Quotient		
Target Hazard Quotient		
Curent Conditions	---	1
Future Conditions	---	1
Target Excess Individual Lifetime Cancer Risk		
Curent Conditions	---	1.E-06
Future Conditions	---	1.E-04

TABLE 5-3
TIER 1 DEFAULT FATE AND TRANSPORT PARAMETERS

	UNITS	Default Values
Source parameters		
Depth to groundwater	cm	304.8
Depth to surficial soil sources	cm	30.48
Depth to subsurface soil sources	cm	304.8
Thickness of vadose zone	cm	295
Building parameters		
Height of the indoor space (Building)		
On/Off-site Resident (adult and child)	cm	300
On-site Commercial Worker	cm	300
Construction Worker	cm	300
Width of the indoor space (Building)	cm	1500
Length of the indoor space (Building)	cm	1500
Fraction of area exposed by cracks	--	0.01
Enclosed space air exchange rate		
On/Off-site Resident (adult)	1/day	12
On/Off-site Resident (child)	1/day	12
On/Off-site Commercial Worker	1/day	18
Averaging time for vapor flux		
On/Off-site Resident (adult)	sec	9.46E+08
On/Off-site Resident (child)	sec	1.89E+08
On/Off-site Commercial Worker	sec	7.88E+08
Construction Worker	sec	3.15E+07
Groundwater parameters		
Groundwater Darcy velocity	cm/year	2500
Groundwater mixing zone thickness (Source thickness)	cm	200
Source width parallel to flow direction	cm	1500
Soil parameters		
Total soil porosity	cc/cc	0.35
Volumetric water content in vadose zone soils	cc/cc	0.20
Volumetric air content in vadose zone soils	cc/cc	0.15
Soil bulk density	g/cc	1.7
Fractional organic carbon content in soil	g-C/g-soil	0.01
Other parameters		
Particulate emission rate	g/cm^2-s	6.90E-09
Wind speed above ground surface in ambient mixing zone	cm/s	225
Width of source parallel to wind direction	cm/yr	1500
Ambient air mixing zone height	cm	200
Infiltration Rate *		
West Zone County	cm/yr	7
Central Zone County	cm/yr	10
East Zone County	cm/yr	13

* See Table 5-4

TABLE 5-4
TIER 1 DEFAULT INFULTRATION RATES FOR OKLAHOMA

LISTED BY ZONES AN COUNTIES

WEST ZONE COUNTIES (Infiltration Rate = 7cm/year)	CENTRAL ZONE COUNTIES (Infiltration Rate = 10 cm/year)	EAST ZONE COUNTIES (Infiltration Rate = 13 cm/year)
Cimmaron	Grant	Nowata
Texas	Kay	Craig
Beaver	Osage	Ottawa
Harper	Garfield	Mayes
Woods	Noble	Delaware
Alfalfa	Pawnee	Wagoner
Woodward	Payne	Cherokee
Major	Kingfisher	Adair
Ellis	Logan	Muskogee
Roger Mills	Lincoln	Sequoyah
Dewey	Creek	McIntosh
Custer	Tulsa	Haskell
Blaine	Washington	Hughes
Beckham	Rogers	Pittsburgh
Washita	Okmulgee	Latimer
Greer	Okfuskee	LeFlore
Kiowa	Canadian	Coal
Harmon	Oklahoma	Atoka
Jackson	Pottawatomie	Pushmataha
	Cleveland	McCurtain
	Seminole	Choctaw
	Caddo	Bryan
	Grady	
	McClain	
	Garvin	
	Pontotoc	
	Comanche	
	Stephens	
	Murray	
	Johnston	
	Carter	
	Cotton	
	Jefferson	
	Love	
	Marshall	
	Tillman	

Table 5-5
Dilution Attenuation Factor (DAF) in the Saturated Zone Versus the Distance from the Source

Distance (feet)	**DAF** No Decay
0	1
50	2.2
100	5.9
200	21
300	46.1
400	81.2
500	126.4
600	181.7
700	247
800	322.4
900	407.8
1000	503.2

TABLE 6-1
TIER 2 DEFAULT EXPOSURE FACTORS
(RAE VALUES)

EXPOSURE PARAMETER	Units	Default Value	Reference
Averaging Time - Carcinogen	yr	70	USEPA, 1989(a)
Averaging Time - Noncarcinogen (equals exposure duration) :			
On-site Commercial Worker	yr	9	USEPA, 1989(a)
On/Off-site Resident (adult)	yr	9	USEPA, 1989(a)
On/Off-site Resident (child)	yr	6	USEPA, 1989(a)
Construction Worker	yr	1	Prof. Judgement
Body Weight :			
Adult receptors	kg	70	USEPA, 1989(a)
Child receptors	kg	15	USEPA, 1989(a)
Exposure Duration :			
On-site Commercial Worker	yr	9	USEPA, 1989(a)
On/Off-site Resident (adult)	yr	9	USEPA, 1989(a)
On/Off-site Resident (child)	yr	6	USEPA, 1989(a)
Construction Worker	yr	1	Prof. Judgement
Exposure Frequency :			
On/Off-site Residents	days/yr	350	USEPA, 1989(a)
On-site Commercial Worker	days/yr	250	USEPA, 1989(a)
Construction Worker	days/yr	250	Prof. Judgement
Soil ingestion rate* :			
On/Off-site Resident (adult)	mg/day	100	USEPA, 1989(a)
On/Off-site Resident (child)	mg/day	200	USEPA, 1989(a)
On-site Commercial Worker	mg/day	50	USEPA, 1991
Construction Worker	mg/day	50	Prof. Judgement
Daily Indoor Inhalation Rate :			
On/Off-site Resident (child)	m^3/day	15	USEPA, 1989(a)
On/Off-site Resident (adult)	m^3/day	15	USEPA, 1989(a)
Commercial and Construction Workers	m^3/day	20	USEPA, 1989(a)
Daily water ingestion rate			
On/Off-site Resident (adult)	L/day	2	USEPA, 1991
On/Off-site Resident (child)	L/day	1	USEPA, 1991
Commercial and Construction Workers	L/day	1	USEPA, 1991
Skin surface area for dermal contact with soil:			
Adult receptors	cm^2	3160	USEPA, 1989(a)
Child receptors	cm^2	3160	USEPA, 1989(a)
Target Hazard Quotient for individual constituents	---	1	USEPA, 1989(a)
Target Excess Indvidual Lifetime Cancer Risk	---	1×10^{-6}	USEPA, 1989(a)
Soil skin adherence factor	mg/cm^2	0.5	USEPA, 1989(a)
Oral relative absorption factor	---	1	USEPA, 1989(a)
Dermal relative absorption factor (volatiles)	---	0.5	USEPA, 1989(b)
Dermal relative absorption factor (PAHs)	---	0.05	USEPA, 1989(b)

Sources

USEPA. 1989. Risk Assessment Guidance for Superfund: Volume 1- Human Health Evaluation Manual (Part A)
USEPA, 1989(a)(b). Supplemental Risk Assessment Guidance for the Superfund Program. EPA/901/5-89/001.
USEPA. 1991. Risk Assessment Guidance for Superfund: Volume 1- Human Health Evaluation Manual
(Part B, Development of Risk-Based Preliminary Remediation Goals)

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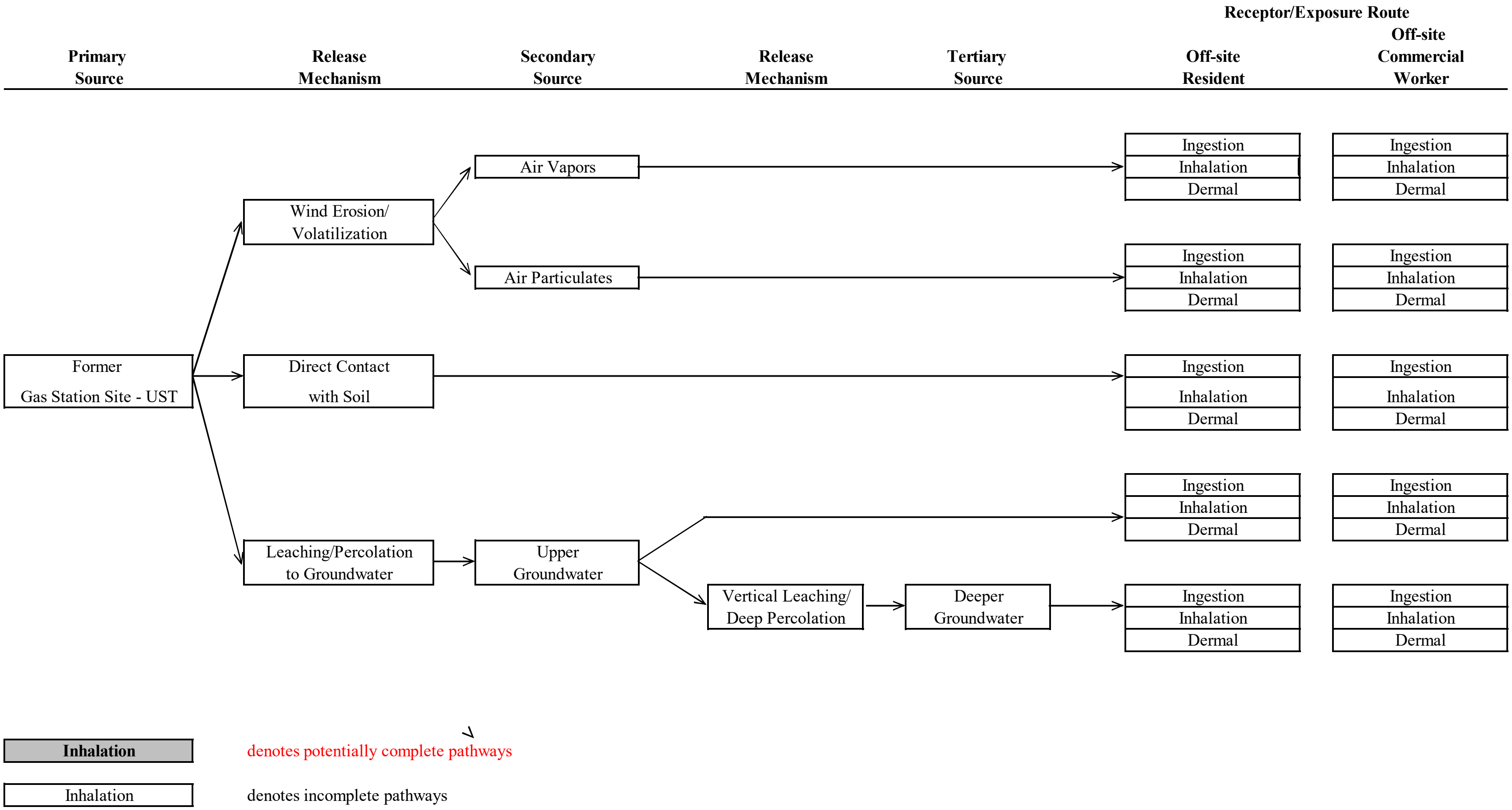


Figure 4-1. Site Conceptual Exposure Scenario for Current Conditions (for illustration purposes only)

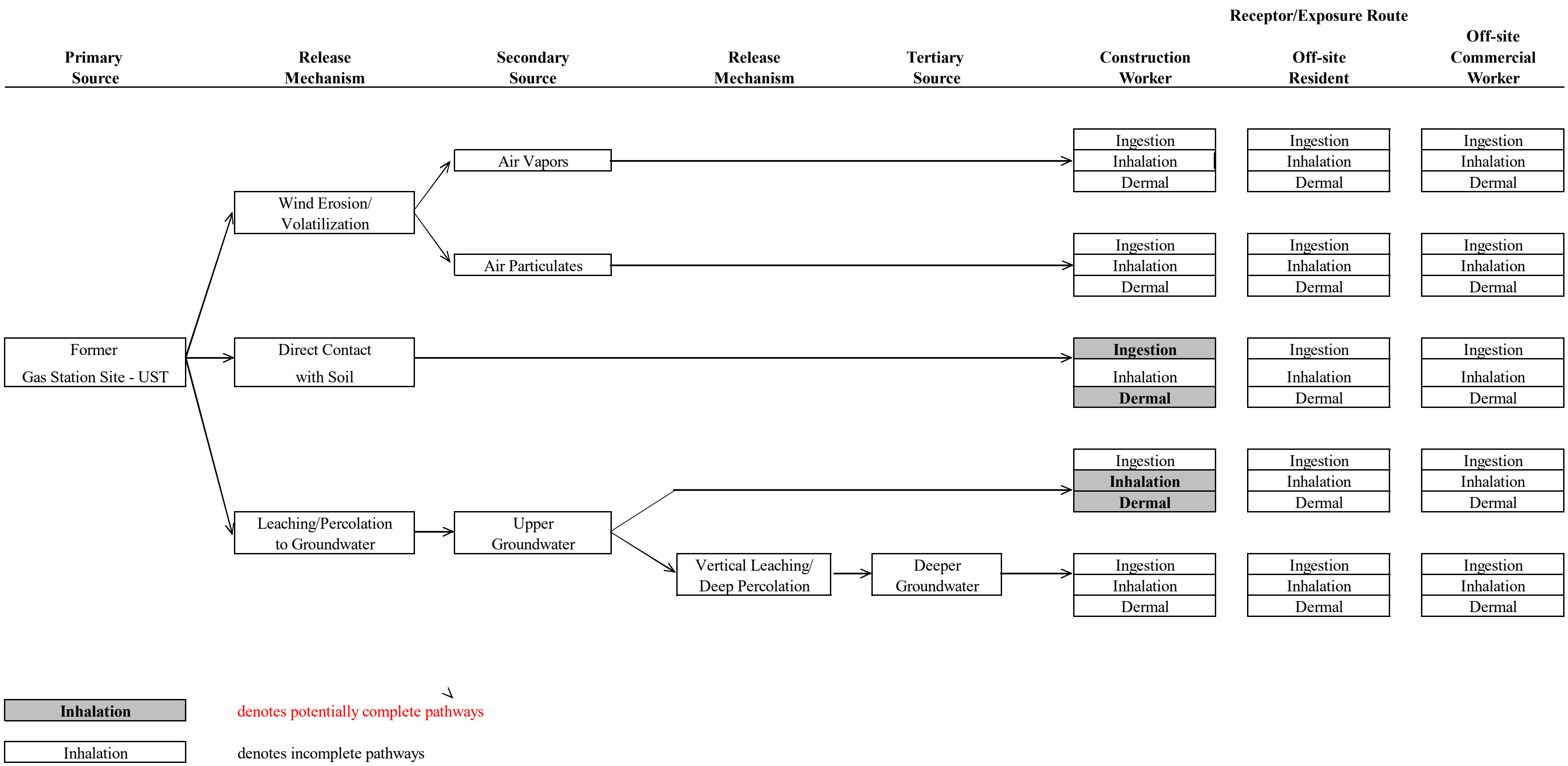
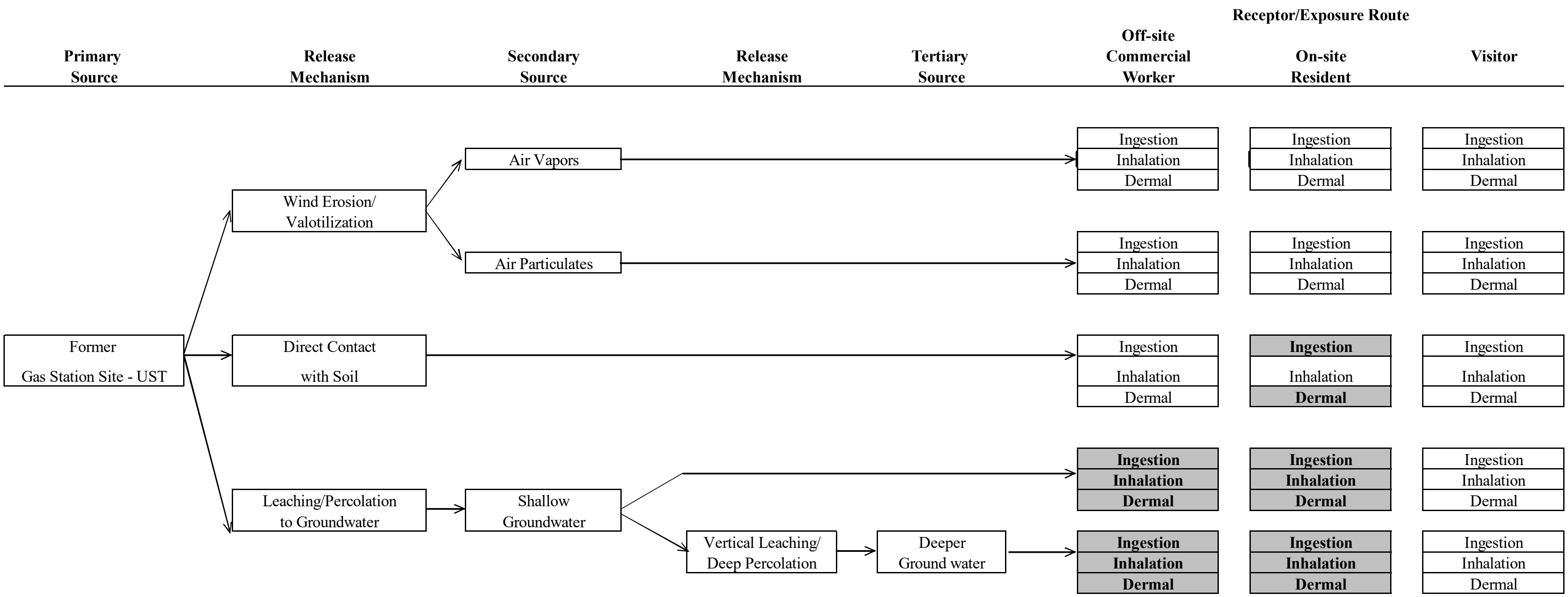


Figure 4-2. Site Conceptual Exposure Scenario for Construction Activity (for illustration purposes only)



Inhalation	denotes potentially complete pathways
Inhalation	denotes incomplete pathways

Figure 4-3. Site Conceptual Exposure Scenario for Future Residential Conditions (for illustration purposes only)

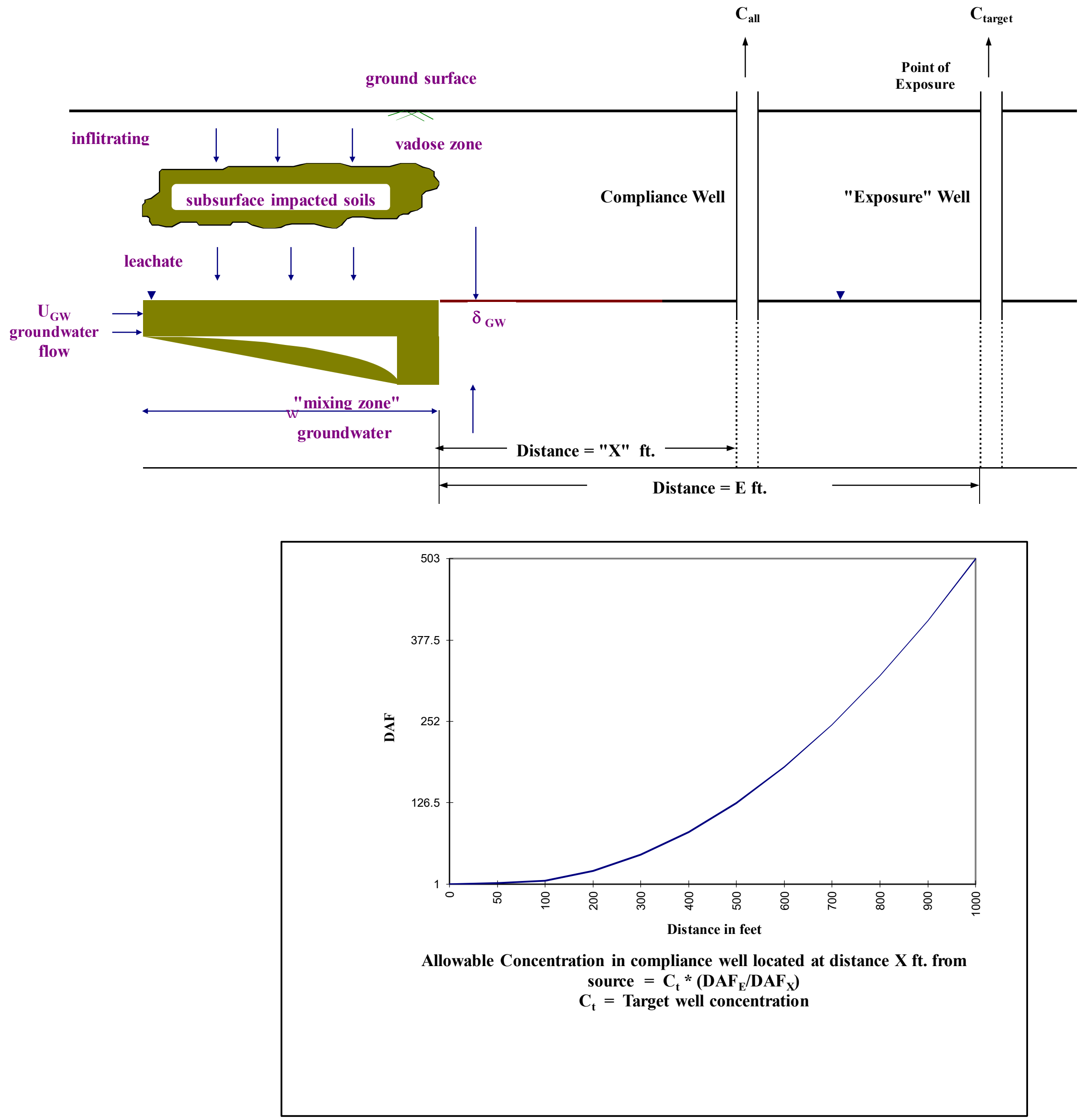


Figure 5-1. Dilution Attenuation Factor (DAF) in the Saturated Zone Used to Estimate Acceptable Compliance Point Concentration

FIGURES IN APPENDICES

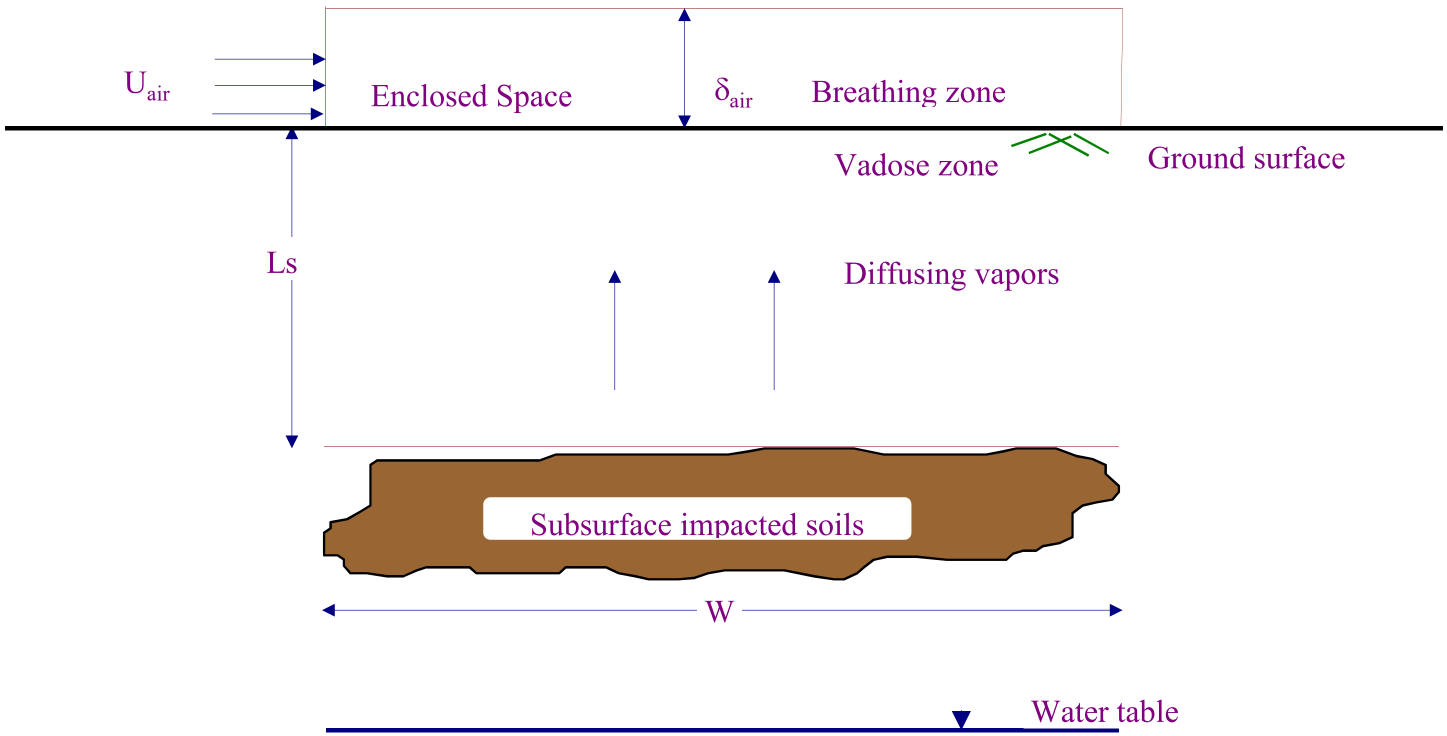


Figure B-1. Volatilization from Subsurface Soils to Enclosed Space

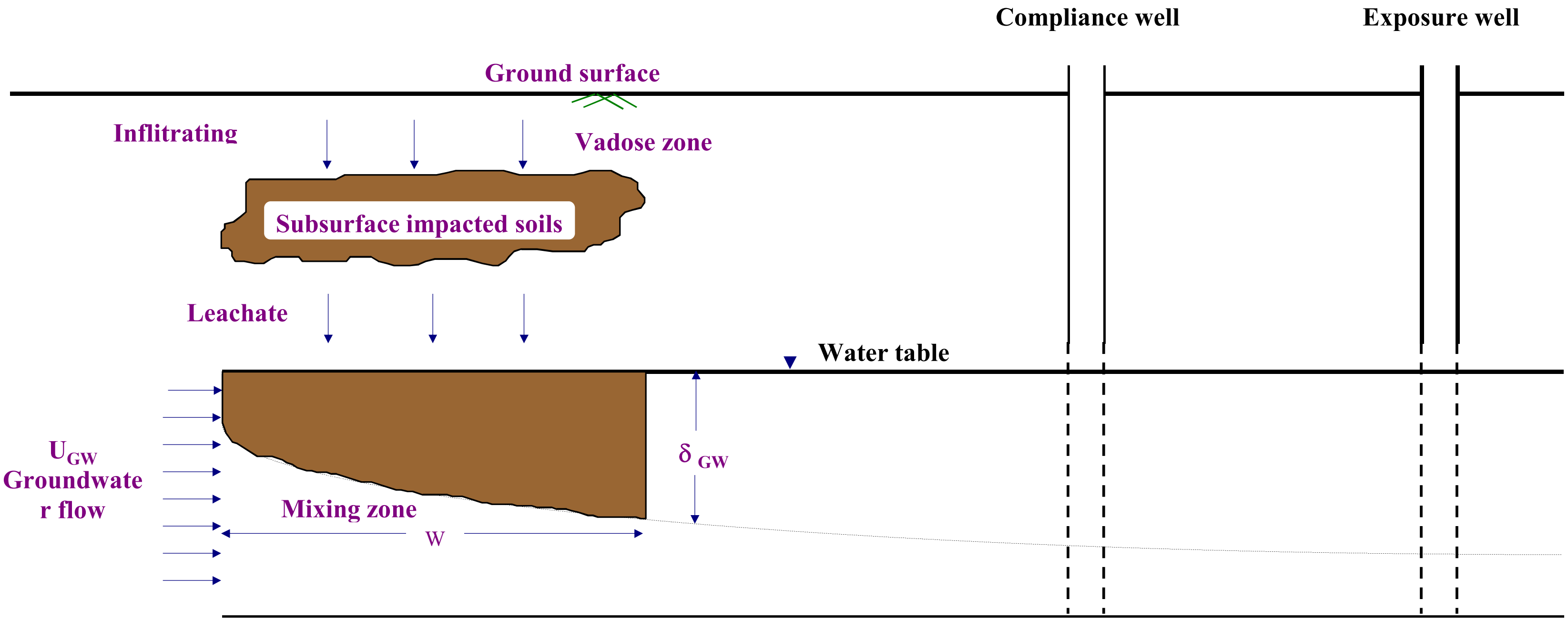


Figure B-2. Leaching from Subsurface Soils to Groundwater

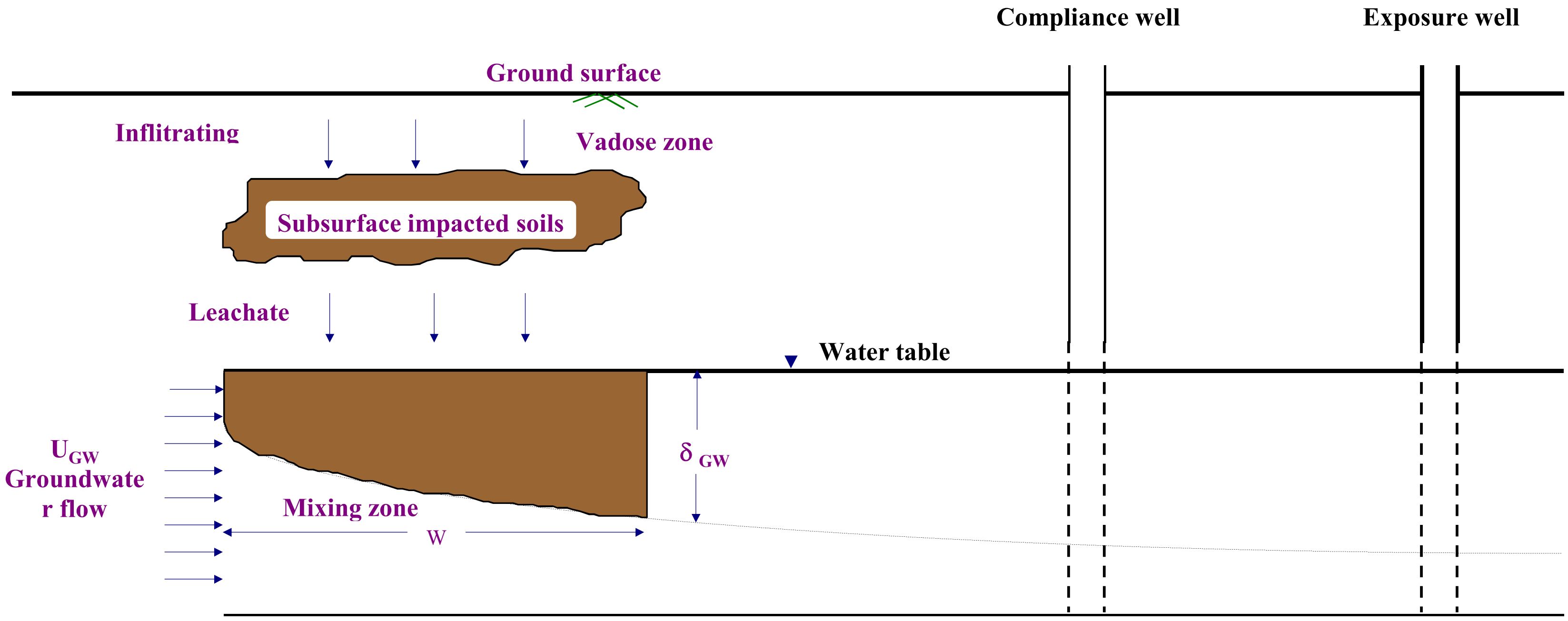
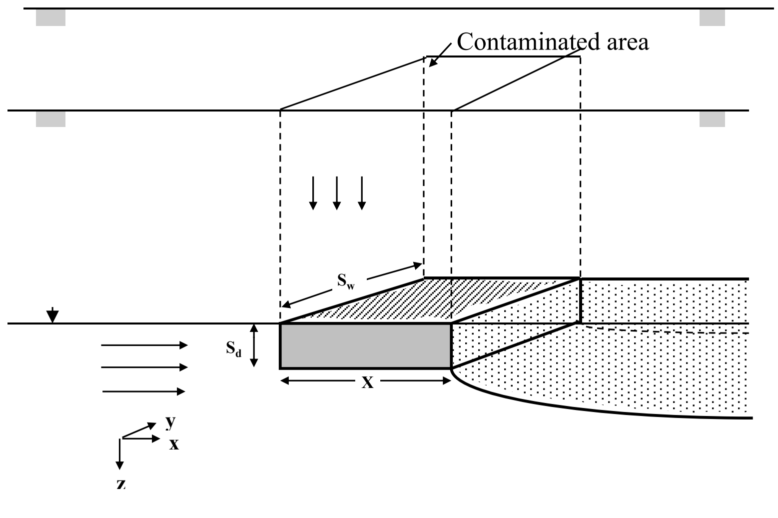


Figure C-1. Leaching from Subsurface Soils to Groundwater



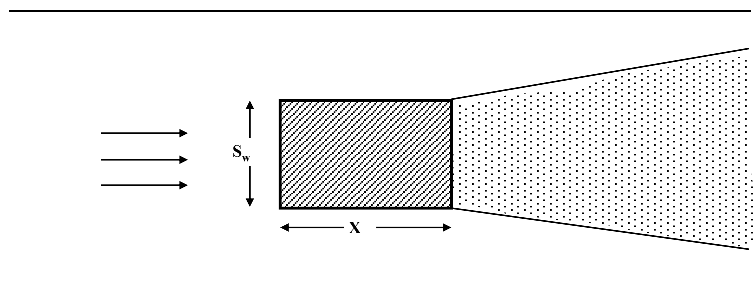


Figure C-2. Schematic Description of Domenico's Model

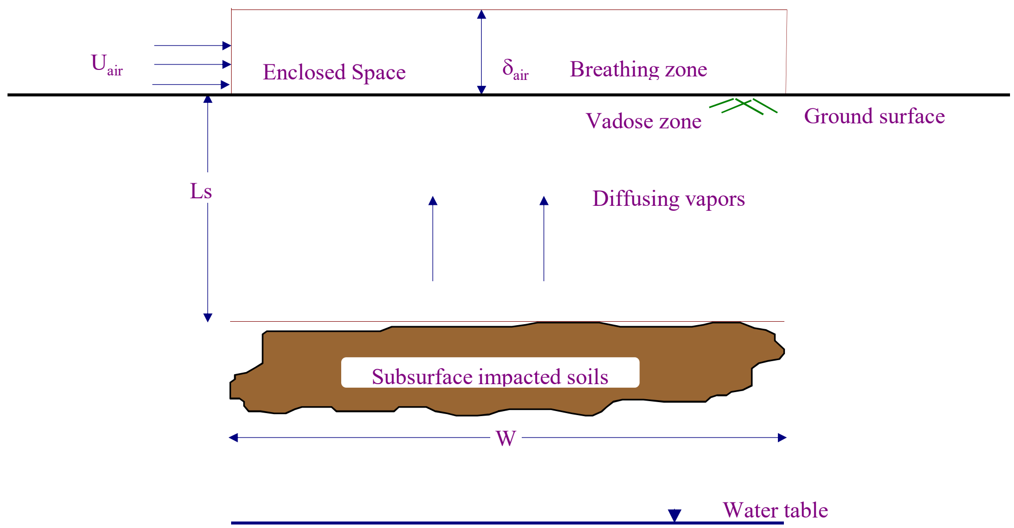


Figure C-3. Volatilization from Subsurface Soils to Enclosed Space

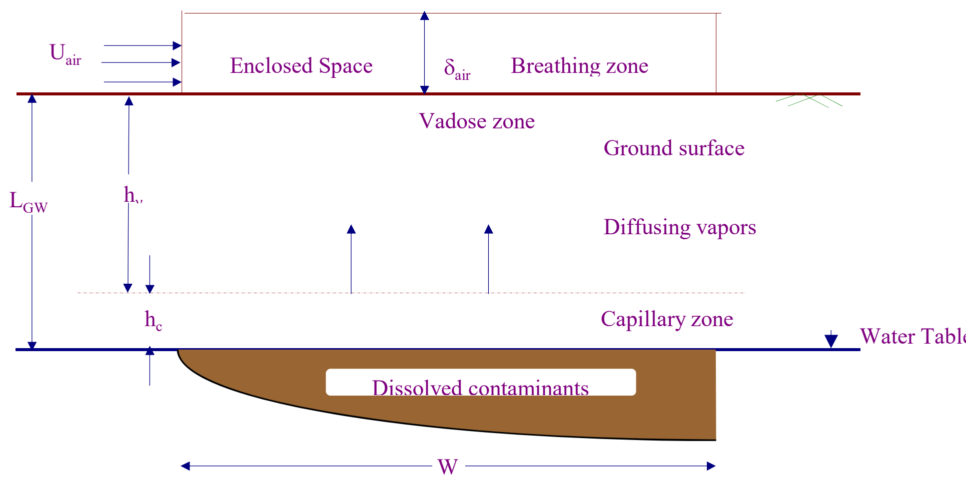
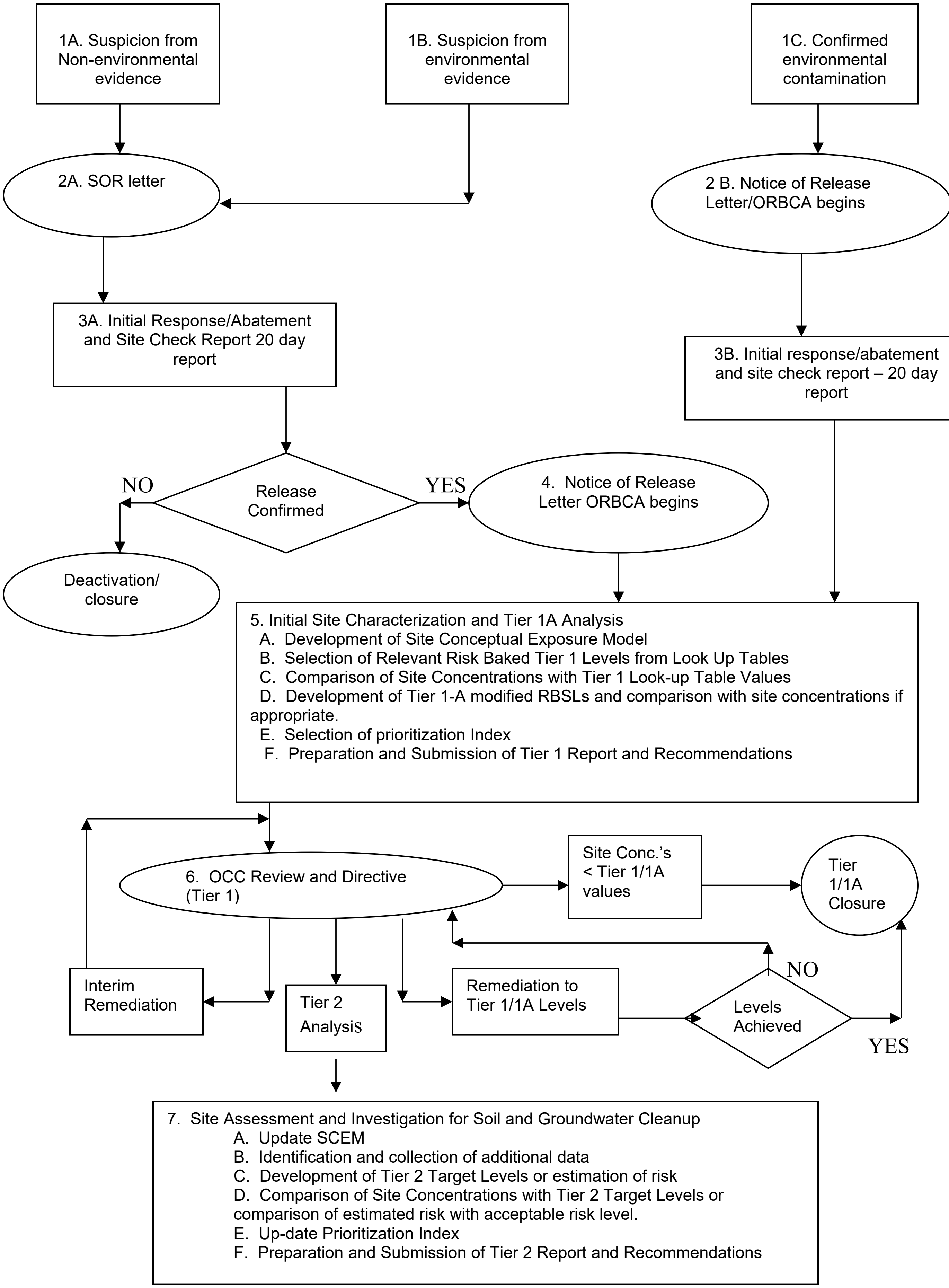
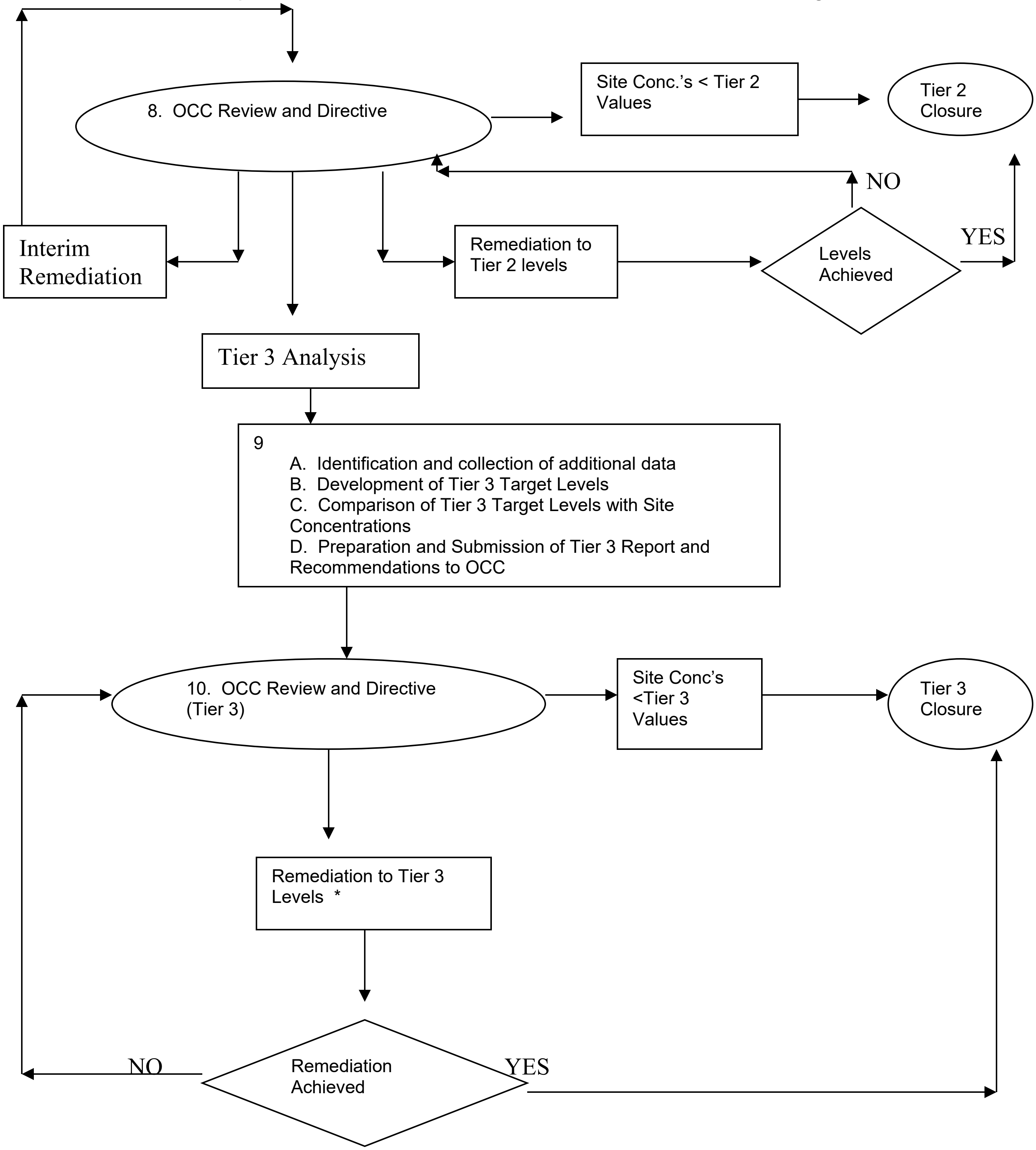


Figure C-4. Volatilization from Groundwater to Enclosed Space

Components of the OCC Risk Based Corrective Action Program



Components of the OCC Risk Based Corrective Action Program



* These steps will require the development and implementation of a Remedial Action Plan approved by the OCC.