

NEZ PERCE TRIBE RISK-BASED CLEANUP GUIDANCE

SECTION 1 - RISK EVALUATION AND SITE-SPECIFIC CLEANUP LEVELS

Section 1-1 Overview. If the responsible party chooses not to use the default cleanup standards from Table 3-4 of the Nez Perce Tribe's Contaminated Site Cleanup Guidance, the only other acceptable process is for the responsible party to initiate a risk-based evaluation to estimate the site-specific cumulative risk based on WRD default exposure factors, fate and transport models, chemical-specific properties, quantitative toxicity values, and documented site-specific values for selected fate and transport parameters and ground water use evaluation. Estimated cumulative risk is then compared with acceptable risk. The risk evaluation process is made up of the following steps:

- (a) Develop and validate the site conceptual model.
- (b) Estimate representative concentrations.
- (c) Estimate cumulative site risk and, if necessary, risk-based cleanup standards for each chemical and each route of exposure.
- (d) Make recommendations for the next course of action.

Section 1-2 Develop and Validate the Site Conceptual Model. The objective of this step is to develop, validate, and refine the site conceptual model. Validation of the site conceptual model involves collecting site-specific data. The amount of data required is typically based on site-specific considerations; the categories of data needed are presented in Section 2-2. Responsible parties should refer to Section 2 for a discussion of the key elements of this step. The responsible party is encouraged to develop a work plan and to contact WRD to discuss data gaps and the specific data needs.

(a) Exposure Model. A key element of the site conceptual model is the exposure model. The responsible party should use information obtained during the site assessment to develop an exposure model for the site, identifying potentially complete exposure pathways. The exposure model shows the media which potentially contain COCs (surficial soils, subsurface soils, ground water, surface water, etc.), transport mechanisms for the COCs from each media (leaching, ground water transport, volatilization, etc.), receptors of concern (residents, nonresidential individuals, ecological), and routes of exposure (inhalation, ingestion, dermal contact, etc.) that are complete.

An exposure model is a critical element of the development of risk-based cleanup standards. At sites where multiple off-site properties are impacted, more than one exposure model should be developed. Throughout this process, the exposure model should be evaluated and revised to accurately reflect site conditions. Figure 1-2(a) is a graphical presentation that may be used as a

worksheet to develop an exposure model.

The responsible party should clearly document all the source-pathway-receptor-route combinations and present clear justification when pathways are determined to be complete or not complete.

(1) The exposure model requires a basic understanding of the following characteristics:

- (i)** Chemical concentrations and distribution of the COCs,
- (ii)** Factors affecting chemical transport, and
- (iii)** Potential for a chemical to reach a receptor.

(2) When conducting a site-specific evaluation under this process, a qualitative evaluation is an essential element to be performed by the responsible party to identify the mechanisms by which COCs will move from affected source media to the point of exposure (POE) 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 contaminated soil) under current and most likely future land use conditions, the site-specific COC concentrations may not pose risk. The exposure unit of all receptors needs to be considered. The exposure unit, or spatial area over which a given receptor is likely to be exposed, is necessary for the on-site scenario as well as any off-site impacted or potentially impacted properties. The same site may have different exposure units for current and future scenarios.

(3) For large sites with varying exposure conditions and receptors, it may be necessary to divide the site into several different exposure units and develop an exposure model for each exposure unit. For example, at a commercial site where the plume has migrated off site under residential conditions, it may be necessary to divide the site into two areas: on-site commercial and off-site residential.

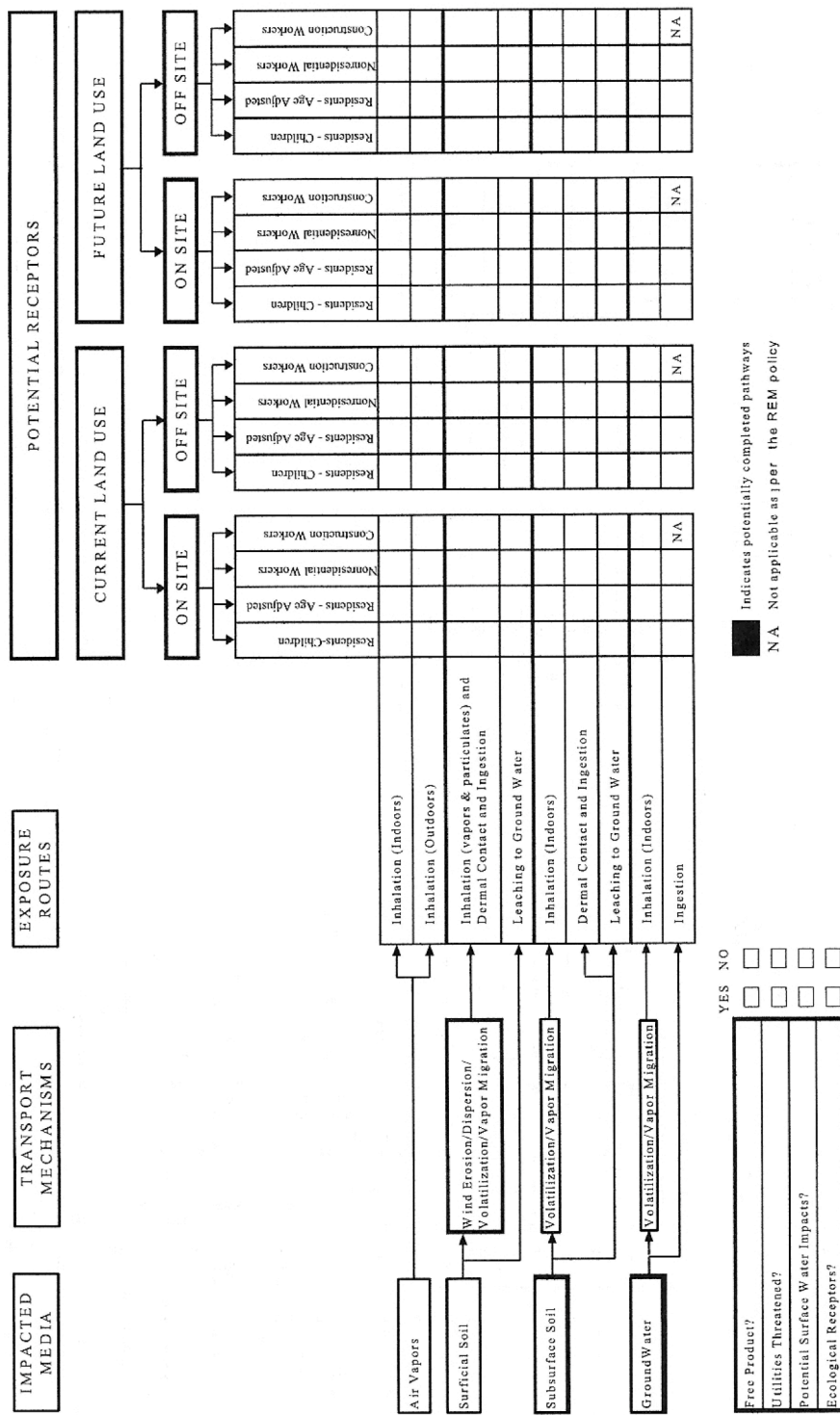


Figure 1-2(a) Site Conceptual Exposure Model

(b) Point of Exposure. The point of exposure (POE) is the location where a receptor comes in contact with COCs under current and likely future conditions. A separate POE is associated with each complete exposure pathway combination identified in the exposure model discussed above. For direct exposure pathways, the POE is located at the source of the COCs. For example, for the ingestion of surface soil, the POE is at the same location as the soil source. For indirect exposure pathways, the POE and the source of COCs are physically separate. For example, for the case of indoor inhalation of vapors from soil, the POE is inside the building (the breathing space) whereas the source is the soil below and adjacent to the building.

The POE location for the protection of the groundwater, for groundwater ingestion under a risk-based evaluation, is the downgradient property boundary, as it existed when the release occurred, or the nearest downgradient location where a well could be reasonably placed, whichever is closer to the source. However, if an on-site well, used for domestic purposes, is completed in the impacted groundwater system or in a separate system that may be impacted by the chemical release, the POE will be every point in the impacted plume where chemical concentrations exceed the default concentrations presented in Table 3-4 of the Nez Perce Tribe's Contaminated Site Cleanup Guidance.

For each complete exposure pathway, it is necessary to identify the source, exposure unit, and the POE to appropriately determine risk and develop site-specific standards.

(c) Point of Compliance. A point of compliance (POC) is a location where concentrations are measured to determine if compliance with remedial goals has been achieved. Concentration measurements at the POC may be in any media (e.g., soil, ground water, soil vapor, etc.). The location of a POC may be identical to the POE or may be located between the source and the POE. In the latter case, the risk-based cleanup standards at the POC are back-calculated to ensure that the concentrations at the POE do not exceed the cleanup standards. For example, for the protection of the groundwater pathway, the POC well may serve as a sentry well for protection of the POE. The calculated risk-based cleanup standards for the POC are then compared to measured concentrations. POC locations may be predetermined based on program-specific requirements. Most sites, particularly those involving groundwater impacts, will have multiple POC locations. The responsible party should work with WRD to develop potential POC locations.

Section 1-3 Estimation of Representative Concentrations

(a) Background. When performing a risk evaluation under the NPT-RBCA, it is assumed that a receptor would typically be exposed to COCs over a defined geographical area, for a specified exposure duration, and through one or more routes of exposure. The geographical area and the exposure duration for a receptor may vary for different routes of exposure. The geographical area over which a receptor is exposed to COCs is called the exposure domain. Because COC

concentrations typically vary over the exposure domain and exposure duration, it is necessary to estimate a representative COC concentration consistent with the receptor's exposure domain and exposure duration. For purposes of calculating the representative COC concentration for risk evaluation purposes, the area of impact(s) within the exposure domain should be used if the exposure domain is larger than the area of impact(s). This avoids the potential for inappropriate "dilution" of the representative concentration that can result from inclusion of non-detect values outside the area of impact and helps to address any concerns associated with use of "average" concentrations in lieu of the more traditional 95% Upper Confidence Limit (UCL) concentration approach articulated in EPA guidance. A representative COC concentration is the average concentration to which the receptor is exposed over the specified exposure duration, within a specified geographical area, and for a specific route of exposure. In most risk evaluations, the exposure point concentration is assumed constant over the exposure duration.

(1) Purpose of Representative Concentrations. Representative concentrations are necessary for both the "backward" and "forward" mode of risk evaluations. The backward mode of risk evaluation results in risk-based cleanup standards for each complete route of exposure identified in the exposure model and each COC. Representative concentrations are used in the cleanup action step in which the target risk levels are compared with the representative concentrations. The forward mode of risk evaluation results in the calculation of risk for each complete route of exposure identified in the exposure model, and representative concentrations are used to estimate risk.

The calculation of representative concentrations is complicated by several factors. These include:

- (i) Spatial variability in the concentrations,
- (ii) Temporal variability in the concentrations, and
- (iii) Lack of sufficient site-specific concentration data.

Further complication arises because environmental data is typically obtained through biased sampling in that the sampling is focused on identifying the source areas and extent of contamination and does not consist of samples collected systematically over the exposure domain (area of impact). Additional complications arise because the concept of representative concentration is often associated with a site as opposed to an exposure pathway and receptor. Because several complete pathways may exist at a site, several representative concentrations, one for each complete pathway, need to be estimated for each receptor. Section 1-3 discusses the methodology used to estimate the representative concentrations for each complete route of exposure.

(2) Steps for Each Receptor. The following steps are necessary for an appropriate calculation of the representative concentration for each receptor:

- (i) Identification of all of the media of concern. Typically these include surficial soil, subsurface soil, soil up to the depth of construction, and groundwater,

(ii) Identification of all the complete routes of exposure under current and future conditions,

(iii) Identification of the exposure domain (area of impact) for each media identified in Step (i), and each complete route of exposure identified in Step (ii),

(iv) Identification of the COC concentration data available within the exposure domain (area of impact) for each media, and

(v) Calculation of the representative concentration, which would be the average of the data from Step (iv) above. When using the average concentration as the representative concentration, the value should not be artificially lowered or “diluted.” To avoid this, the following should be kept in mind:

(A) Do not use data beyond the exposure domain (area of impact) unless there is not enough data within the domain and data is available just outside the domain. If data is available just outside the exposure domain, judgment should be used whether to interpolate and use this data or to collect additional data within the exposure domain.

(B) Within the area of impact, replace the non-detect values with half the detection limit. Concentrations with a J laboratory qualifier, which is a judgment made at the laboratory, should use the laboratory-estimated value.

(C) As a simple red flag check, determine if the maximum concentration of any COC exceeds ten times the representative concentration of that COC for any exposure pathway. Note the maximum concentration here refers to the maximum concentration within an area of impact, not the site-wide maximum concentration. Possible reasons for an exceedance could be: the maximum concentration is an outlier, the average concentration was inaccurately calculated, the area of impact is not adequately characterized, or a hot spot may not have been adequately characterized.

(D) If the representative concentration is based on extrapolation using a model, the model must be supported by site-specific data.

(E) When calculating the representative groundwater concentration, first estimate the average concentration in each well based on recent data, assuming data from multiple events is available, and then use the average of each well to estimate the representative concentration.

(F) If free product is present at a monitoring point, use the effective solubility or effective vapor pressure to estimate the concentration at that point.

(G) For wells with multiple years of groundwater data, use the most recent two years of data to estimate the representative concentration. In certain cases, data that is more than two years old may be used, but it must be justified and approved by WRD.

(H) If the area of impact is smaller than the exposure domain, the exposure factors may be modified to account for this circumstance.

(I) For the subsurface soil-to-indoor-inhalation pathway, do not use soil data collected below the water table. Similarly, for the groundwater-to-indoor-inhalation pathway, groundwater data from the first encountered saturated zone must be used.

(b) Calculation of Representative Concentrations for Surficial Soil (3 feet below ground surface).

(1) There are four routes of exposure associated with surficial soil that need to be examined as part of the risk-based evaluation process:

- (i) The ingestion of COCs in groundwater due to leaching of residual COCs present in the surficial soil,
- (ii) Accidental ingestion of soil,
- (iii) Outdoor inhalation of vapors and particulates from surficial soil emissions, and
- (iv) Dermal contact with surficial soil.

The latter three pathways are combined and referred to as the “direct contact with soil” pathway. Thus, at least two different surficial soil representative concentrations are required, one for leaching to groundwater, and one for direct contact with soil. In certain cases, depending on use and characteristics of the site, a single representative concentration may suffice for both pathways.

(2) Representative Surficial Soil Concentration for Leaching to Groundwater. The exposure domain for this pathway is the area of impact through which leachate generation may occur and COCs can migrate to the water table. The representative surficial soil concentration should be calculated using the surficial soil data collected within the area of impact. Thus, prior to calculating the representative concentration, it is necessary to clearly define the horizontal extent of the impacted area and to identify the surficial soil data available within this area.

(3) Representative Concentrations for Direct Contact Pathway. The representative surficial soil concentration (0 to 3 feet) is based on the area of impact - the area of the site over which the receptor might be exposed to contaminated surficial soil. The exact exposure domain of the receptor is difficult to estimate because the assumption is that the receptor is exposed over a period of time equal to the exposure duration. In the absence of specific information about the receptor's activities, the area(s) of impact should be considered the receptor's exposure domain. For potential future exposures and in the absence of any engineering controls, it may be necessary to assume that exposures that might otherwise be prevented/minimized (e.g., due to paving) will need to be evaluated as if exposure to contaminated surficial soil will occur.

The following steps are necessary to calculate the representative concentration for the direct contact pathway: determine the extent of impact; estimate the receptor's exposure domain(s); and determine the number of soil samples available within the area of impact or the number of samples necessary to adequately represent the area of impact.

For a nonresident worker, the average concentration over the area of impact may be used. For a child receptor, the maximum concentration must be used and, therefore, a representative concentration need not be calculated if a child is an actual or potential receptor. For direct soil contact pathway for a construction worker, refer to subsection (d).

(c) Subsurface Soil (greater than 3 feet below ground surface). The risk evaluation process includes the following two routes of exposure associated with subsurface soil: (i) leaching of residual COC concentrations in the subsurface soil to groundwater, and (ii) indoor inhalation of vapor emissions. Thus, a representative concentration needs to be calculated for each complete pathway. Calculation of additional representative concentrations may be required if the assumptions for current and future site conditions are different.

(1) Representative Subsurface Soil Concentration for Protection of Groundwater.

The representative concentration for this pathway should be the average concentration in subsurface soil measured within the area of impact.

(2) Representative Subsurface Soil Concentration for Protection of Indoor Inhalation. Subsurface soil concentrations protective of indoor inhalation are estimated using an emission model such as the Johnson and Ettinger (2001) model. This model assumes that chemicals volatilize from the subsurface soil source, travel vertically upwards without any lateral or transverse spreading, and enter the building through cracks in the foundation and floor. To ensure consistency with the model, the representative concentration for this pathway should be based on soil concentrations measured directly below or immediately adjacent to the footprint of the enclosed space.

To evaluate the potential future indoor inhalation pathway, (i.e., an enclosed structure is constructed over contaminated soil), the size (footprint) and location of the planned structure needs to be estimated. In the absence of site-specific information regarding planned structures,

the future location and size of the structure must be approximated based on the evaluator's professional judgment. A conservative option is to locate the hypothetical structure over the area of impact (that is, the area of maximum COC concentrations). However, this is only one conservative option and its applicability will vary from site to site. For sites where the footprint of a current onsite structure is or might be different from that of a structure erected in the future, a representative subsurface soil concentration must be calculated for both the current and potential future structure.

To estimate the representative concentration, the evaluator should: identify the footprint of the structure within which the receptor is located; identify the footprint of the potential future enclosed structure, identify the soil concentration data available within each of these two footprints; and calculate the average of these concentrations.

If sufficient data are not available within the building footprint, data collected within 20 feet of the building footprint may be used to calculate average COC concentrations in soil. Data from locations beyond the 20-foot building footprint buffer may be considered/needed in cases where preferential pathways such as soil macropores, utility conduits, or soil fractures may cause vapor migration towards the building. Generally, vapor concentrations are expected to decrease with increasing distances from the source.

When calculating the representative concentration, a horizontal attenuation factor may be applied to concentrations that are more than 20 feet from the building footprint, if adequate technical support is provided for derivation of the attenuation factor. If several samples within and adjacent to the building footprint are available, more weight should be given to the samples collected within the footprint. Two scenarios are possible: (i) the building footprint is located entirely within the contaminated area, and (ii) the building footprint is partially located within the contaminated area. For both scenarios, the representative soil concentration would typically be based on data collected within and directly adjacent to the footprint of the building. In the second scenario, the representative concentration may differ from that calculated in scenario one because a portion of the structure lies over uncontaminated soil.

(d) Representative Concentration for Construction Worker. For the construction worker, the following elements are critical to the evaluation of the three routes of exposure for the construction worker: accidental ingestion, dermal contact and outdoor inhalation of vapors and particulates from soil; outdoor inhalation of vapors from groundwater; and dermal contact with groundwater.

(1) Representative Soil Concentration. For the construction worker, no distinction is made between surficial and subsurface soil because, during construction, the construction worker might be exposed to both. To estimate the representative concentration for the construction worker, it is necessary to identify the (i) depth of construction, (ii) areal extent of construction, and (iii) the horizontal and vertical extent of soil impacts within the area of construction including the number of samples available to calculate the representative concentration within the zone of

construction. The potential future depth of construction should be estimated based on the likely type of structure that might be built and by identifying the typical depth of utilities on and adjacent to the site. If the areal extent of the construction area is not known, a conservative option (not the only option), would be to assume that the construction zone will be entirely within/across the area of impact. The representative concentration would be the averaged concentration within this zone of construction.

(2) Representative Groundwater Concentration for the Construction Worker

Exposure Pathway. As with estimating representative soil concentrations, it is necessary to estimate the areal extent of the construction zone and identify the groundwater data available for this zone. The representative concentration would then be calculated as the average concentration within this zone. Temporal variations in groundwater concentrations should also be evaluated. If contaminated groundwater is known to be present just below the depth of planned construction (as opposed to within the depth of planned construction), best professional judgment should be used in deciding if outdoor inhalation of vapors from groundwater should be evaluated.

(e) Representative Concentrations for Groundwater Contamination. For groundwater risk evaluation, there are three routes of exposure to be assessed: ingestion of groundwater, dermal contact with groundwater, and indoor inhalation of vapor emissions from groundwater (only from shallow groundwater).

Where multiple aquifers are present, the shallowest aquifer would be considered for the volatilization pathway. The specific aquifers that are or might be used for domestic use or in another manner in which dermal contact could occur must be considered for the ingestion and dermal contact pathways. Representative concentrations need to be calculated for each aquifer and associated exposure pathway(s). Thus, depending on the number of complete pathways, up to three different groundwater representative concentrations, one for each complete pathway, will need to be calculated.

(1) Representative Demonstration Well Concentration for Protection of Groundwater Ingestion (Drinking Water Pathway). For the ingestion of groundwater pathway, maximum contaminant levels (MCLs) or, where MCLs are lacking, calculated risk-based concentrations, need to be met at the point of exposure (POE) well. Often the point of exposure well is hypothetical and, therefore, data for the POE might not be available. During the course of groundwater remediation, one or more point of demonstration wells will be identified, target risk levels calculated, and the point of demonstration well(s) monitored to ensure that unacceptable exposures do not occur at the POE.

The representative concentration at the point of demonstration and POE should be calculated based on measured COC concentrations in groundwater, as follows:

- (i) If COC concentrations in groundwater are stable, the representative

concentration is the arithmetic average of the most recent data collected over a period of no more than two years on at least a quarterly basis;

(ii) If COC concentrations are decreasing, the representative concentration is the arithmetic average of the most recent data collected over a period of no more than one and one-half years on at least a quarterly basis.

(iii) If COC concentrations are increasing, the arithmetic average of the most recent data collected over a period of no more than one year on at least a quarterly basis.

(2) Representative Groundwater Concentration for Protection of Indoor

Inhalation. Groundwater concentrations protective of indoor inhalation are typically estimated using a model such as the Johnson and Ettinger (2001) model. This model assumes no lateral or transverse spreading of the vapors as they migrate upward from the water table through the capillary fringe and the vadose zone and into the enclosed space. Thus, representative concentrations for this pathway should be based on groundwater concentrations measured within the footprint of the building or up to 20 feet from the building. As mentioned above for soil, data beyond 20 feet may be considered/necessary based on the presence of features in vadose zone soils (e.g., macropores, fractures, utility conduits, etc.) that could influence vapor migration. Refer to Section 1-3(c)(2) for a discussion of the evaluation of future structures and their relationship to the area of impact.

For the groundwater to indoor air pathway, multiple representative concentrations might be needed if the plume has migrated below several current or potential future buildings. For example, if a plume has migrated or is likely to migrate below two different buildings, one onsite and one offsite, a representative concentration would have to be calculated for each building. After identifying the location of the building footprints (whether real or hypothetical) and the available groundwater monitoring data within or adjacent (within 20 feet and in some cases up to or more than 100 feet) to each footprint, the average concentration within each footprint must be estimated, as discussed in Section 1-3(c)(2). However, groundwater data may not be available for each footprint; therefore, several options are available. These include:

(i) Installation of additional monitoring wells within or adjacent to the footprint lacking data,

(ii) Interpolation or extrapolation of existing data (in the case where the plume originates under a building, extrapolated data gathered from areas adjacent to the footprint may not be adequate) or,

(iii) As a conservative approach, use of data from wells located upgradient of the building that are between the building and the source of contamination.

(3) Representative Groundwater Concentration for Dermal Contact. The average concentration of COCs in the groundwater that a receptor might come in contact with is used as the representative concentration. Note that temporal variations in COC concentrations will be considered as discussed in Section 1-3(f)(8)(i). More than one representative concentration might

be needed where a receptor might contact groundwater from more than one aquifer or saturated zone.

(f) General Considerations for Calculating Representative Concentrations. As discussed in this document, calculation of representative concentrations requires considerable professional judgment. Prior to performing the computations identified in Sections (b) through (e) above, the following should be considered:

(1) Evaluate whether the spatial resolution of the data is sufficient. While an exact number of samples cannot be specified herein due to the variability in conditions from site to site, data should be available from known or likely impacted areas within the various receptors' exposure domains.

(2) If the data are old (greater than four years old) and the COC concentrations exceed default cleanup standards, new data may need to be collected (especially groundwater data). If a new release has been documented, new data must be collected in order to characterize adequately the nature and extent of the current impact. If old data are to be eliminated from the risk evaluation, the reason for elimination must be clearly documented in the risk evaluation report.

(3) Non-detect soil and groundwater samples located at the periphery of the area of impact should not be used.

(4) Non-detect results associated with certain COCs within the exposure domain (area of impact) should be replaced by half the detection limit. In this context, certain COCs refers to those constituents that are below analytical detection limits in a particular sample but are within a known area of impact based on other COCs associated with that sample that are present above analytical detection limits. For example, if vinyl chloride was not present in a sample above its analytical detection limit but TCE was present above its limit, then for that sample one-half the detection limit for vinyl chloride would be used in figuring the average concentration of vinyl chloride since, based on the TCE detection, the sample is considered to be within an area of impact. This differs from the approach of using one-half the detection limit for samples where all COCs were non-detect. In that case, none of the sample results should be used to figure the average since that sample is not considered to be within an area of impact.

(5) If multiple surficial soil samples and/or multiple subsurface soil samples are available from the same borehole within the area of impact/exposure domain, the average concentration of these samples may be used.

(6) The maximum concentration of any COC within the area of impact should not exceed ten times the representative average concentration. If this situation occurs, further evaluation of the analytical data to assess its usability may be necessary.

(7) In certain cases, an area-weighted average may be a better estimate of the

representative concentration. An area-weighted average differs from an arithmetic average in that it considers the area over which an individual measurement applies as opposed to assuming equal weighting of all individual results. For example, if sampling has been focused on establishing the maximum concentration present (hot spot) and the limits of impact (horizontal and vertical extent), there may be limited concentration data available for the area of impact in between these two extremes.

In these cases, the results may need to be “area weighted” so that the resulting average is not skewed in a particular direction for risk assessment purposes. For example, if a single hot spot sample concentration is averaged with multiple edge-of-impact concentrations, the resulting average could be biased on the low side if a simple arithmetic average is used. If a gridded sampling pattern has been used to sample soil, the arithmetic average is a good approximation of the area-weighted average.

However, if a biased sampling pattern has been used, then it may be necessary to use an area-weighted average to accurately determine the representative concentration. There are different ways to calculate weighted averages across an area of impact. For relatively simple situations with few samples, a calculation methodology such as the Thiessen Polygon Method could be used. However, in the majority of cases, it will likely be more efficient to use available computer software to contour areas of impact and automatically perform area weighted average concentration calculations. Prior to performing any area-weighted average calculations, the remediating party should discuss the specifics with WRD. WRD will make an effort to see that responsible parties are treated fairly by not being prejudiced by the use of a particular sampling pattern, however, WRD will seek the use of an averaging system that is adequately protective of human health and the environment. As such, sampling patterns that may result in a low biased result will be strictly prohibited.

(8) The following considerations are necessary to evaluate representative groundwater concentrations.

(i) To account for temporal variations in groundwater concentrations, the representative concentration in a well may be estimated as follows:

(A) If COC concentrations in groundwater are stable, the arithmetic average of the most recent data collected over a period of no more than two years on at least a quarterly basis.

(B) If COC concentrations are decreasing, the arithmetic average of the most recent data collected over a period of no more than one and one-half years on at least a quarterly basis.

(C) If COC concentrations are increasing, the arithmetic average of the most recent data collected over a period of no more than one year on at least a quarterly basis. Data from wells on the periphery of the area(s) of impact having COC concentrations consistently below detection limits

cannot be used in the calculation of representative groundwater concentrations.

(ii) For wells that contain or have contained free product within the most recent two years, the concentration representative of those chemicals comprising the free product in the well should be the effective solubility of the various chemicals comprising the free product.

**Table 1-3
Calculation of Representative Concentrations**

Route of Exposure	Calculation of Representative Concentration
Surficial Soil (0 to 3 feet below ground)	
Soil concentration protective of leaching to groundwater or surface water body	Average of surface soil concentrations collected within the area of impact.
Direct contact with soil including ingestion of soil, dermal contact with soil, and the outdoor inhalation of vapors and particulates emitted by surficial soils	Average of the surface soil concentrations within area of impact for nonresidential receptor. Maximum concentration for child receptor.
Subsurface Soil (greater than 3 feet below ground)	
Indoor inhalation of vapor emissions	Average of the subsurface soil concentrations collected below or within 20 ft** of the real or hypothetical footprint of the building (Excluding concentrations below water table and capillary fringe).
Soil concentration protective of leaching to groundwater	Average of the subsurface soil concentrations within the area of impact (Excluding concentrations below water table and capillary fringe).
Groundwater	
Indoor inhalation of vapor emissions	Average of the groundwater concentrations within 20 ft** of the footprint of the real or hypothetical building.
Dermal contact with groundwater	Average of the groundwater concentrations that a receptor may come in contact with.
Groundwater domestic use pathway · Concentration at POE	Average of the groundwater concentrations*

· Concentration at POD	Average of the groundwater concentrations*
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* Refer to section 1-3(e)(1)

** Refer to discussion in section 1-3(c)(2)

Section 1-4 Estimating Risk and Developing Risk-Based Cleanup Standards

(a) Background. An essential element of the risk-based decision-making process is the specification of target or acceptable risk levels for both carcinogenic and non-carcinogenic health effects. For carcinogenic effects, risk is quantified using the individual excess lifetime cancer risk that represents an increase in the probability of an individual developing cancer due to exposure to a specific COC through a specific exposure pathway. Since a receptor may be exposed to multiple chemicals through multiple routes of exposure, the acceptable risk level should account for the effect of simultaneous exposure to multiple chemicals and multiple routes of exposure. For non-carcinogenic effects, risk is quantified using a hazard quotient (HQ) that represents the ratio of the estimated dose of a chemical for a route of exposure to the reference or allowable dose. When a receptor is exposed to multiple chemicals and multiple routes of exposure, individual HQs may be added together to estimate the Hazard Index (HI).

Within the risk evaluation process, WRD calculated the default cleanup standards using an individual excess lifetime cancer risk of 1×10^{-6} for each chemical and each pathway; and a HQ of 1. In the development of default cleanup standards, WRD did not consider the cumulative effect of multiple COCs and multiple routes of exposure because the default standards are based on conservative assumptions.

(b) Risk Evaluation Target Risk Criteria. The risk evaluation process uses specified target risk levels rather than ranges to streamline the decision-making process, while remaining protective of human health and the environment. While the selection of specified target risk levels minimizes some of the flexibility of having a target risk range, its use is a key component of streamlining this process and provides a consistent risk target for developing cleanup levels. For risk evaluation purposes, the following target risk criteria must be satisfied for each current and potential future receptor at the site.

(1) Site-wide Individual Excess Lifetime Cancer Risk. The sum of individual excess lifetime cancer risk for each COC that has carcinogenic health effects and each complete ROE must be less than or equal to 1×10^{-5} . The target risk level of 1×10^{-5} was selected since it is within the risk range for carcinogens (1×10^{-4} to 1×10^{-6}) generally used to evaluate CERCLA actions. The 1×10^{-5} level is protective based on the overall conservative nature of exposure scenarios used in this process and the underlying health criteria.

(2) Site-wide HI. The sum of HQs for each COC that has non-carcinogenic health effects and each ROE must be less than or equal to 1.0.

(3) Groundwater Ingestion Specific Calculations. In addition to the target risk levels, WRD requires that maximum contaminant levels (MCLs), or comparable risk-based values for

ground water ingestion, be met at the point of exposure when there is any probability of ground water use. Similarly, for impacts to surface waterbodies, as discussed in Section 2-13, target risk levels must be met.

(c) Chemical-Specific Toxicological Factors. The toxicity of chemicals is quantified using slope factors (or potency values) for chemicals with carcinogenic adverse health effects. For chemicals that cause non-carcinogenic health effects, toxicity is typically quantified by reference dose and reference concentrations. The primary source of information for toxicity factors is the U.S. Environmental Protection Agency's (EPA) Integrated Risk Information System (IRIS) (EPA, 2002a). EPA's toxicity factors are used as default toxicity factors for the purposes of this Title. Alternate toxicity factors may be used if approved by WRD. In selecting alternate toxicity factors for the COCs, the following sources should be consulted in the order listed:

- (1) IRIS.
- (2) EPA Provisional Peer Reviewed Toxicity Values (PPRTVs).
- (3) Health Effects Assessment Summary Tables (HEAST).
- (4) State-approved or recommended values.
- (5) Values withdrawn from IRIS and HEAST and values under review.

(d) Receptor-Specific Exposure Factors. Exposure factors describe the physiological and behavioral characteristics of the receptor. These factors include the following:

- (1) Water ingestion rate,
- (2) Body weight,
- (3) Exposure duration for each ROE,
- (4) Exposure frequency,
- (5) Soil ingestion rate,
- (6) Hourly inhalation rates,
- (7) Exposure times for indoor/outdoor inhalation,
- (8) Dermal relative absorption factor,
- (9) Skin surface area for dermal contact with soil,
- (10) Soil-skin adherence factor, and
- (11) Oral relative absorption factor.

A list of default exposure factors used to compute the default cleanup standards and risk-based cleanup standards are presented in Table 1-4(1). Site-specific values of exposure factors, other than default values, may be used if approved by WRD as discussed in Section 1-4(j).

**Table 1-4(1). Initial Cleanup Standards and Risk-Based Cleanup Standards
Default Exposure Factors**

EXPOSURE PARAMETER	SYMBOL	UNITS	DEFAULT VALUE	REFERENCE
Averaging Time - Carcinogen	AT _c	years	70	HHEM
Averaging Time - Noncarcinogen (equals exposure duration)	AT _{nc}	years	Receptor dependent = ED	HHEM
Body Weight (BW)				
Child	BW _c	kg	15	EFH
Adolescent	BW _{as}	kg	55	EFH
Adult	BW _a	kg	70	SDEF
Exposure Duration (ED)				
Resident (child)	ED _c	years	6	PJ
Resident (adolescent)	ED _{as}	years	9	PJ
Resident (adult)	ED _a	years	15	PJ
Nonresidential Worker	ED	years	6.6	SDEF
Construction Worker	ED	years	1	PJ
Exposure Frequency (EF)				
Resident (child)	EF _c	days/yr	350	SDEF
Resident (adolescent)	EF _{as}	days/yr	350	SDEF
Resident (adult)	EF _a	days/yr	350	SDEF
Nonresidential Worker	EF	days/yr	250	SDEF
Construction Worker	EF	days/yr	30	SDEF
Resident (child)	EF _{d-c}	days/yr	270	PJ

Table 1-4(1). (continued)

EXPOSURE PARAMETER	SYMBOL	UNITS	DEFAULT VALUE	REFERENCE
Exposure Frequency for Direct Contact Pathways (EF)				
Resident (adolescent)	EF _{d-as}	days/yr	270	PJ
Resident (adult)	EF _{d-a}	days/yr	270	PJ
Nonresidential Worker	EF _d	days/yr	180	PJ
Construction Worker	EF _d	days/yr	30	PJ
Soil Ingestion Rate (IR)				
Resident (child)	IR _{s-c}	mg/day	200	EFH
Resident (adolescent)	IR _{s-as}	mg/day	100	PJ
Resident (adult)	IR _{s-a}	mg/day	100	EFH
Nonresidential Worker	IR _s	mg/day	100	EFH
Construction Worker	IR _s	mg/day	480	RBCA
Daily Water Ingestion Rate (IRW)				
Resident (child)	IR _{w-c}	L/day	1.5	EFH
Resident (adolescent)	IR _{w-as}	L/day	1.7	EFH
Resident (adult)	IR _{w-a}	L/day	2	SDEF
Nonresidential Worker	IR _w	L/day	1	SDEF
Hourly Indoor Inhalation Rate (IR)				
Resident (child)	IR _{ai-c}	m ³ /hr	0.7	EFH, PJ
Resident (adolescent)	IR _{ai-as}	m ³ /hr	0.7	EFH, PJ
Resident (adult)	IR _{ai-a}	m ³ /hr	0.7	EFH, PJ
Nonresidential Worker	IR _{ai}	m ³ /hr	1.0	EFH, PJ
Construction Worker	IR _{ai}	m ³ /hr	NA	

EXPOSURE PARAMETER	SYMBOL	UNITS	DEFAULT VALUE	REFERENCE
Exposure Time for Indoor Inhalation (ET)				
Resident (child)	ET _{i-c}	hr/day	21	EFH
Resident (adolescent)	ET _{i-as}	hr/day	15.8	EFH
Resident (adult)	ET _{i-a}	hr/day	15	EFH
Nonresidential Worker	ET _i	hr/day	7.5	EFH
Hourly Outdoor Inhalation Rate (IR)				
Resident (child)	IR _{ao-c}	m ³ /hr	1.1	EFH
Resident (adolescent)	IR _{ao-as}	m ³ /hr	1.3	EFH
Resident (adult)	IR _{ao-a}	m ³ /hr	1.3	EFH
Nonresidential Worker	IR _{ao}	m ³ /hr	1.6	EFH
Construction Worker	IR _{ao}	m ³ /hr	2.4	EFH
Exposure Time for Outdoor Inhalation (ET)				
Resident (child)	ET _{o-c}	hr/day	2	PJ
Resident (adolescent)	ET _{o-as}	hr/day	2	PJ
Resident (adult)	ET _{o-a}	hr/day	2	PJ
Nonresidential Worker	ET _o	hr/day	6	PJ
Construction Worker	ET _o	hr/day	10	PJ
Oral Relative Absorption Factor (RAF)	RAF _o	---	Assume 100%	PJ
Dermal Relative Absorption Factor (RAF_d)				
Volatiles*	RAF _d	---	0.0005	EPA Region III
Volatiles**	RAF _d	---	0.03	EPA Region III
Arsenic	RAF _d	---	0.032	EPA Region III
PAHs	RAF _d	---	0.10	EPA Region III
SVOCs and Pesticides	RAF _d	---	0.10	EPA Region III

Table 1-4(1). (continued)

EXPOSURE PARAMETER	SYMBOL	UNITS	DEFAULT VALUE	REFERENCE
Pentachlorophenol	RAF _d	---	0.25	SGDRA
PCB	RAF _d	---	0.14	SGDRA
Chlordane	RAF _d	---	0.04	SGDRA
Cadmium	RAF _d	---	0.001	SGDRA
Metals	RAF _d	---	0.01	EPA Region III
Soil-to-Skin Adherence Factor (M)				
Residential (child)	M _c	mg/cm ²	1.0	MDEP
Residential (adolescent)	M _{as}	mg/cm ²	0.3	MDEP
Residential (adult)	M _a	mg/cm ²	0.3	MDEP
Nonresidential Worker	M	mg/cm ²	0.1	MDEP
Construction Worker	M	mg/cm ²	0.5	MDEP
Skin Surface Area for Dermal Contact with Soil (SA)				
Child Receptors	SA _c	cm ² /d	2434	MDEP
Adolescent Receptors	SA _{as}	cm ² /d	2434	MDEP
Adult Receptors	SA _a	cm ² /d	5657	MDEP
Nonresidential Worker Receptors	SA	cm ² /d	3477	MDEP
Construction Worker Receptors	SA	cm ² /d	3477	MDEP

*Chemicals with vapor pressures less than benzene

**Chemicals with vapor pressure greater than benzene

Note: Exposure factors for the age-adjusted resident are calculated from the values listed for child, adolescent, and adult receptors using the equations in Appendix H.

Reference Abbreviations

EFH – EPA Exposure Factors Handbook

EPA Region III – Technical Guidance Manual, Assessing Dermal Exposure from Soil

HHEM – Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual

MDEP – Massachusetts Department of Environmental Protection, Weighted Skin-Soil Adherence Factors

PJ – Professional Judgement

RBCA – Idaho Risk-Based Corrective Action Guidance for Petroleum Releases

SDEF – EPA Standard Default Exposure Factors

SGDRA – EPA RAGS Volume I: HHEM, Part E, Supplemental Guidance for Dermal Risk Assessment

(e) Fate and Transport Parameters. Fate and transport parameters are necessary to estimate target levels for indirect ROEs. These factors characterize the physical site properties such as depth to ground water, soil porosity, and infiltration rate at a site. For calculating risk-based cleanup standards, WRD has selected conservative default fate and transport values, which are listed in Table 1-4(2). Site-specific fate and transport values may be used where justified and approved by WRD.

Table 1-4(2). Default Fate and Transport Parameters

PARAMETER	SYMBOL	UNITS	DEFAULT VALUE	REFERENCE
SOIL PARAMETERS				
Unsaturated Zone Soil				
Source-building separation	L_{Ts}	cm	30	PJ
Source bottom-building separation	L_{TSB}	cm	183	PJ
Vapor permeability	K_v	cm ²	5.0E-9	Calculated
Mean particle diameter	D	cm	0.030	EPA, 2003
Van Genuchten curve shape parameter	N	-	1.449	EPA, 2003
Thickness of capillary fringe zone	h_{cap}	cm	25	EPA, 2003
DAF in the unsaturated zone (user-defined)	DAF_{unsat}	--	1	PJ
Total soil porosity in the vadose zone	θ_T	cm ³ /cm ³ -soil	0.39	EPA, 2003
Volumetric water content in vadose zone	θ_{ws}	cm ³ /cm ³	0.17	PJ
Volumetric air content in vadose zone	θ_{as}	cm ³ /cm ³	0.22	Calculated
Dry soil bulk density	ρ_s	g/cm ³	1.64	PJ
Fractional organic carbon content in the vadose zone	f_{oc}	g-C/g-soil	0.001	PJ
Volumetric water content in the foundation/wall cracks	θ_{wcrack}	cm ³ /cm ³	0.17	PJ
Volumetric air content in the foundation/wall cracks	θ_{acrack}	cm ³ /cm ³	0.22	Calculated
Volumetric water content in capillary fringe zone	θ_{wcap}	cm ³ /cm ³	0.32	EPA, 2003
Volumetric air content in capillary fringe zone	θ_{acap}	cm ³ /cm ³	0.07	EPA, 2003
Saturated Zone Soil				
Dry soil bulk density	ρ_{ss}	g/cm ³	1.64	PJ
Fractional organic carbon content	f_{ocs}	g-C/g-soil	0.001	PJ
Total soil porosity	θ_{Ts}	cm ³ /cm ³ -soil	0.39	PJ

PARAMETER	SYMBOL	UNITS	DEFAULT VALUE	REFERENCE
Volumetric water content	θ_{wss}	cm ³ /cm ³	0.39	PJ
Volumetric air content	θ_{ass}	cm ³ /cm ³	0.0	PJ
AIR PROPERTY				
Viscosity of air	μ	g/cm-s	1.8E-4	
GROUND WATER PARAMETERS				
Water table-building separation	L_{Tgw}	cm	30	PJ
Ground water darcy velocity	U_{gw}	cm/year	3340	DEQ, 1996
Ground water mixing zone thickness	δ_{gw}	cm	153	DEQ, 1996
Length of ground water source parallel to ground water flow direction	L_{mz}	cm	1220	PJ
Width of ground water source perpendicular to ground water flow direction	W_{gw}	cm	1220	PJ
Infiltration rate	I	cm/year	25	PJ
ENCLOSED SPACE PARAMETERS				
Area of the Enclosed Space Below Grade				
Residential	A_B	cm ²	1561600	Calculated
Nonresidential	A_B	cm ²	4782069	Calculated
Enclosed Space Foundation/Wall Thickness				
Residential	L_{crack}	cm	15	EPA, 2003
Nonresidential	L_{crack}	cm	15	EPA, 2003
Total area of Cracks				
Residential	A_{crack}	cm ²	484	Calculated
Non-residential	A_{crack}	cm ²	861	Calculated
Number of Air Exchanges per Second				
Residential	ER	1/s	2.78E-4	MDEQ, 1998
Nonresidential	ER	1/s	5.56E-4	MDEQ, 1998

PARAMETER	SYMBOL	UNITS	DEFAULT VALUE	REFERENCE
Length of Enclosed Space				
Residential	L_B	cm	1220	DOE, 1995
Nonresidential	L_B	cm	2157	DOE, 2001
Width of Enclosed Space				
Residential	W_B	cm	1220	DOE, 1995
Nonresidential	W_B	cm	2157	DOE, 2001
Height of Enclosed Space				
Residential	H_B	cm	244	PJ
Nonresidential	H_B	cm	244	PJ
Floor-Wall Seam Perimeter				
Residential	X_{crack}	cm	4880	Calculated
Nonresidential	X_{crack}	cm	8628	Calculated
Crack depth below grade	Z_{crack}	cm	15	Calculated
Equivalent crack radius	r_{crack}	cm	0.1	EPA, 2003
Pressure differential between enclosed space and soil surface beneath	ΔP	g/cm-s ²	40	EPA, 2003
COWHERD PARTICULATE EMISSION MODEL				
Inverse of the mean concentration at the center of a square source	Q/C	(g/m ² -s)/ (kg/m ³)	69.41	EPA, 1996
Fractional vegetative cover	V	m ² /m ²	0.5	EPA, 1996
Mean annual wind speed	U_m	m/s	3.98	EPA, 1996
Equivalent threshold value of wind speed at 7 m	U_t	m/s	11.32	EPA, 1996
Wind speed distribution function from Cowherd et. al, 1985	$F(x)$	--	4.95E-2	EPA, 1996
AVERAGING TIME FOR VAPOR FLUX				
Resident child	τ	sec	1.89E8	PJ

PARAMETER	SYMBOL	UNITS	DEFAULT VALUE	REFERENCE
Resident adolescent	τ	sec	2.84E9	PJ
Resident adult	τ	sec	4.73E9	PJ
Nonresidential adult worker	τ	sec	2.08E9	PJ
Construction worker	τ	sec	3.15E7	PJ
GROUND WATER PROTECTION				
Distance to the point of exposure	X_{poe}	cm	0	PJ
Distance to the point of compliance	X_{poc}	cm	0	PJ
Half life (if with decay option is used)	$T_{1/2}$	days		

PJ – Professional Judgment

DAF – Dilution Attenuation Factor

References

Cowherd, C., Muleski, G., Englehart, P., and Gillete, D. 1985. Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination. Prepared for EPA Office of Health and Environmental Assessment. EPA/600/8-85/002.

DEQ, 1996. Risk Based Corrective Action Guidance Document for Petroleum Releases. Idaho Department of Environmental Quality. August 1996.

DOE, 1995. Housing Characteristics 1993. United States Department of Energy. Energy Information Administration. DOE/EIA-0314 (93). June 1995.

DOE, 2001. Commercial Building Energy Characteristics Survey. United States Department of Energy. Energy Information Administration. Summary Table B2. (http://www.eia.doe.gov/emeu/cbecs/detailed_tables_1999.htm).

EPA, 1996. Soil Screening Guidance: Technical Background Document. United States Environmental Protection Agency. OSWER. 9355.4-17A. EPA/540/R-95/128. May 1996.

EPA, 2003. User's Guide for Evaluating Subsurface Vapor Intrusion Into Buildings (Revised). United States Environmental Protection Agency. Prepared for EPA by Environmental Quality Management, Inc. OSWER. June 19, 2003.

MDEQ, 1998. Part 201 Generic Groundwater and Soil Volatilization to Indoor Air Inhalation Criteria: Technical Support Document. Michigan Department of Environmental Quality. Environmental Response Division. August 1998.

(f) Physical and Chemical Properties of the Chemicals of Concern. The development of risk-based cleanup standards requires the selection of values for the physical and chemical properties of COCs. The Nez Perce Tribe finds that the physical and chemical properties identified by Idaho's Department of Environmental Quality are appropriate, and in an effort to enhance simplicity across jurisdictions, the NPT uses the same physical and chemical properties as Idaho's Department of Environmental Quality. Values of these parameters are listed in Appendix G to Idaho's Risk Evaluation Manual (IREM). WRD requires the use of values tabulated in IREM Appendix G for all risk evaluations. The responsible party must provide sufficient justification to WRD to use different values. The use of different values will be allowed only upon approval of WRD. WRD retains the right to use alternate default physical and chemical property values in the future through amendment of this section.

(g) Mathematical Models. Two types of models or equations, uptake equations and fate and transport models, should be used to calculate risk-based cleanup standard. The Nez Perce Tribe finds that the mathematical models identified by Idaho's Department of Environmental Quality are appropriate, and in order to promote quick and efficient cleanups within the Reservation, the NPT requires the use of the same models and equations as Idaho's DEQ. A schematic and the equations for each of these models are presented in Appendix H of the Idaho Risk Evaluation Manual. For the default cleanup standards and the default models for the risk-based evaluation, WRD has selected the following fate and transport models:

(1) Indoor Inhalation of Volatile Emissions from Soil and Water: This pathway requires an emission model and an indoor air-mixing model. These models are combined together and included in the Johnson and Ettinger Model (EPA, 2003).

(2) Surficial Soil Outdoor Inhalation: This pathway requires an emission model for vapors, an emission model for particulates, and an outdoor air mixing model. The vapor emission model used is based on the volatilization model developed by Jury et al. (1983) for an infinite source, the particulate emission model is the Cowherd model (Cowherd, et al., 1985), and the outdoor air mixing model is based on a simplified form of the Gaussian Dispersion model. These models are presented in *Soil Screening Guidance: Technical Background Document* (EPA, 1996a).

(3) Leaching to Ground Water: This pathway uses a three-phase equilibrium partitioning algorithm to convert soil concentrations to leachate concentrations, and a dilution attenuation model to mix leachate with regional ground water. Models used are described in *Soil Screening Guidance: Technical Background Document* (EPA, 1996).

(4) Horizontal Migration in Ground Water: The Domenico steady-state analytical, infinite source model is used to quantify downgradient migration of chemicals (Domenico, 1982, 1990). This model incorporates the processes of advection, sorption, three-dimensional dispersion, and degradation. The use of different values will be allowed only upon approval of WRD.

(h) Calculating Risk-Based Cleanup Standards. Risk-based cleanup standards must be estimated using an allocated risk process: apportioning allowable (target) cumulative risk and HI to each chemical-pathway combination. As no unique way to apportion the cumulative risk exists several alternatives are available.

(1) Available Methods to Apportion Cumulative Risk. Common methods to apportion cumulative risk are:

- (i) Apportion cumulative risk equally among all complete chemical-pathway combinations,
- (ii) Apportion cumulative risk proportional to chemical toxicity, or
- (iii) Apportion cumulative risk so target risk levels are proportional to representative concentrations.

(2) Default Risk Apportionment Methodology. To develop risk-based cleanup standard, the default option selected by WRD apportions cumulative risk and HI equally among all contributing chemical-pathway combinations.

Site-specific considerations may result in a responsible party choosing to utilize a different method for calculating risk-based cleanup standards. For example, at a site having volatile and semi-volatile COCs contributing to the cumulative risk, the responsible party may choose a technology that specifically reduces the volatile chemical's concentrations but marginally reduces the concentration of the semi-volatile chemical. A different responsible party may choose to significantly reduce the concentration of the semi-volatile chemical and marginally reduce the concentration of the volatile chemical. The two strategies will result in different cleanup levels for each chemical; however, both will be acceptable provided cumulative risk meets acceptable risk criteria.

The default method for developing risk-based cleanup standards is described in the following steps:

Step 1: Based on complete or potentially complete routes of exposure identified earlier and estimated representative concentrations, calculate the corresponding risk ($Risk_{i,j}^{rep}$) and hazard quotient ($HQ_{i,j}^{rep}$) for each chemical (i) for each complete pathway (j).

Using the inputs to calculate risk and HQ discussed in subsection (a) through (g) above, the responsible party can generate a matrix of risk and HQ values as shown in Table 1-4(3) below.

Table 1-4(3) Example Matrix for Calculation of Remedial Action Risk-Based Cleanup Standards

COC	Pathway						Cumulative		Number	
	Pathway 1		Pathway 2		Pathway 3		Risk	HI	Carc.	Non-carc.
	Risk	HQ	Risk	HQ	Risk	HQ				
C1	X	N/A	X	N/A	-	N/A	SUM	SUM	2	0
C2	N/A	X	N/A	X	N/A	X	SUM	SUM	0	3
C3	N/A	X	-	X	N/A	X	SUM	SUM	0	3
C4	X	N/A	X	N/A	X	N/A	SUM	SUM	3	0
C5	X	X	N/A	X	N/A	X	SUM	SUM	1	3
Site Cumulative							Risk_{site}= SUM(SUM)	HI_{site}= SUM(SUM)	6	9

X: Pathway complete.

N/A: Not applicable because there is no relevant toxicity data or physical-chemical property.

- : Not calculated because there was no entry under representative concentrations. This could mean that the chemical is not a COC for the pathway being evaluated based on release history or based on site characterization data.

Step 2: Calculate cumulative risk and HI at the site (site risk and site HI).

$$Risk_{site} = \sum_{i=1}^{n_c} \sum_{j=1}^{m_i} Risk_{i,j} \quad \sum_{i=1}^{n_c} \sum_{j=1}^{m_i} Risk_{i,j}$$

$$HI_{site} = \sum_{i=1}^{n_c} \sum_{j=1}^{m_i} HI_{i,j}$$

Where:

Risk_{i,j} = Risk from exposure to chemical i through pathway j

HQ_{i,j} = Hazard quotient for exposure to chemical i through pathway j

m_i = Number of complete pathways for chemical i (the suffix to m indicates that the number of complete pathways can be different for different chemicals)

n_c = Number of carcinogenic chemicals at the site

n_{nc} = Number of non-carcinogenic chemicals at the site

If the cumulative risk and HI for all the receptors at the site are below the acceptable levels, the site does not require the development of risk-based cleanup standards. Site closure may be appropriate if other required regulatory issues have been resolved.

Step 3: Determine the number of chemical-pathway combinations (for carcinogens and non-carcinogens separately) at the site.

Number of chemical-pathway combinations for carcinogens,
$$N_c = \sum_{i=1}^{n_c} \sum_{j=1}^{m_i} P_{i,j}$$

Number of chemical-pathway combinations for carcinogens,
$$N_{nc} = \sum_{i=1}^{n_{nc}} \sum_{j=1}^{m_i} P_{i,j}$$

Where:

$p_{i,j}$ = Complete pathway for chemical i and pathway j
 m_i = Number of complete pathways for chemical i (the suffix to m indicates that the number of complete pathways can be different for different chemicals)
 n_c = Number of carcinogenic chemicals at the site
 n_{nc} = Number of non-carcinogenic chemicals at the site

Note that some chemicals show both carcinogenic and non-carcinogenic toxicity and should be counted in both categories. For example, chemical C5 in the example above has three complete pathways for the non-carcinogenic effects and one pathway for the carcinogenic effects.

Step 4: Based on equal apportioning of target cumulative risk and HI, compute allocated risk and HQ contribution by chemical i through pathway j using:

$$Risk_{i,j}^{allocated} = \frac{1 \times 10^{-5}}{N_c}$$

$$Risk_{i,j}^{allocated} = \frac{1}{N_{nc}}$$

Step 5: Estimate the risk reduction factor (RRF) in risk or the necessary HQ (HQRF) so the contribution by chemical i acting through pathway j is equal to the allocated risk or allocated HQ.

Risk reduction factor for chemical i acting through pathway j:

$$RRF_{ij} = \frac{Risk_{i,j}^{rep}}{Risk_{i,j}^{allocated}}$$

Hazard quotient reduction factor for chemical i acting through pathway j:

$$HQRF_{ij} = \frac{HQ_{i,j}^{rep}}{HQ_{i,j}^{allocated}}$$

Step 6: Calculate the target risk level for chemical i acting through pathway j.

For carcinogens:

$$C_{i,j}^{allowable} = \frac{C_{i,j}^{rep}}{RRF_{i,j}}$$

For non-carcinogens:

$$C_{i,j}^{allowable} = \frac{C_{i,j}^{rep}}{HQRF_{i,j}}$$

If a chemical has $C_{i,j}^{allowable}$ based on carcinogenic and non-carcinogenic toxicity, the applicable risk-based cleanup standard for that chemical should be the lower of the two allowable concentrations.

(i) Developing Risk-Based Cleanup Standards: Example

The following is an example of target risk level calculations described in Section 1-4(h). Table 1-4(4) presents fictitious representative concentrations for each of five chemical and three pathways, two of which are soil and one ground water.

Table 1-4(4) Fictitious Representative Concentrations Used in Target Level Calculation Example

COC	Pathway		
	P1(mg/kg)	P2 (mg/kg)	P3 (mg/l)
C1	1	2	--
C2	2	4	2
C3	3	6	3
C4	4	8	4
C5	5	10	5

Step 1: Use these representative concentrations to calculate risk and HQ for each chemical and pathway the chemical acts through. The resulting matrix of risk and HQ values is shown in Table 2-1-4(5).

Table 1-4(5) Example of Risk/COC/Pathway Matrix for Target Level Calculation

COC	Pathway						Cumulative		Number	
	Pathway 1		Pathway 2		Pathway 3		Risk	HI	Carc.	Non-Carc.
	Risk	HQ	Risk	HQ	Risk	HQ				
C1	1E-5	N/A	2E-5	N/A	N/A	N/A	3E-5	N/A	2	0
C2	N/A	1	N/A	3	N/A	1	N/A	5	0	3
C3	N/A	1	-	1	N/A	3	N/A	5	0	3
C4	1E-5	N/A	1E-5	N/A	1E-5	N/A	3E-5	N/A	3	0
C5	2E-5	1	N/A	1	N/A	1	1E-5	3	1	3
Site Cumulative							Risk_{site}= 7E-5	HI_{site}= 13	6	9

N/A: Not applicable because there is no relevant toxicity data or physical-chemical property or because there was no entry under representative concentrations. This could mean that the chemical is not a COC for the pathway being evaluated based on release history or based on site characterization data.

-: Not calculated because there was no entry under representative concentrations. This could mean that the chemical is not a COC for the pathway being evaluated based on release history or based on site characterization data.

Step 2: Calculate the cumulative site risk and HI for all chemicals and pathways for a given

receptor (in this case the risk and HI are 7×10^{-5} and 13, respectively).

Step 3: Determine the number of chemical-pathway combinations (for carcinogens and non-carcinogens separately) at the site. In this example the number of chemical-pathway combinations for carcinogens is six and the number of chemical-pathway combinations for non-carcinogens is nine.

Step 4: Based on equal apportioning of the target cumulative risk and HI, calculate the allocated risk and HQ contribution by chemical *i* through pathway *j*.

Step 5: Estimate the RRF in risk or HQ required so that the contribution by a given chemical acting through a particular pathway is equal to the allocated risk or HQ.

$$Risk_{i,j}^{allocated} = \frac{1 \times 10^{-5}}{6} = 1.67 \times 10^{-6}$$

$$HQ_{i,j}^{allocated} = \frac{1}{9} = 0.111$$

Risk reduction factor for chemical *i* acting through pathway *j*:

$$RRF_{ij} = \frac{Risk_{i,j}^{rep}}{Risk_{i,j}^{allocated}}$$

Hazard quotient reduction factor for chemical *i* acting through pathway *j*:

$$HQRF_{ij} = \frac{HQ_{i,j}^{rep}}{HQ_{i,j}^{allocated}}$$

The calculations of the RFs for the example are presented in Table 1-4(6). At actual sites the reduction factors are rarely as uniform as in the example.

Table 1-4(6) Reduction Factor Example for Target Level Calculations

COC	Pathway					
	Pathway 1		Pathway 2		Pathway 3	
	RRF	HQRF	RRF	HQRF	RRF	HQRF
C1	$\frac{1E-5}{1.67E-6} = 5.9$	N/A	$\frac{2E-5}{1.67E-6} = 11.9$	N/A	-	N/A
C2	N/A	$\frac{1}{0.111} = 9.0$	N/A	$\frac{3}{0.111} = 27.0$	N/A	$\frac{1}{0.111} = 9.0$
C3	N/A	$\frac{1}{0.111} = 9.0$	-	$\frac{1}{0.111} = 9.0$	N/A	$\frac{3}{0.111} = 27.0$
C4	$\frac{1E-5}{1.67E-6} = 5.9$	N/A	$\frac{1E-5}{1.67E-6} = 5.9$	N/A	$\frac{1E-5}{1.67E-6} = 5.9$	N/A
C5	$\frac{2E-5}{1.67E-6} = 11.9$	$\frac{1}{0.111} = 9.0$	N/A	$\frac{1}{0.111} = 9.0$	N/A	$\frac{1}{0.111} = 9.0$

N/A: Not applicable because there is no relevant toxicity data or physical-chemical property or because there was no entry under representative concentrations. This could mean that the chemical is not a COC for the pathway being evaluated based on release history or based on site characterization data.

-: Not calculated because there was no entry under representative concentrations. This could mean that the chemical is not a COC for the pathway being evaluated based on release history or based on site characterization data.

Step 6: Calculate the target level for a chemical acting through a given pathway.

For carcinogens:

$$C_{i,j}^{allowable} = \frac{C_{i,j}^{rep}}{RRF_{i,j}}$$

For non-carcinogens:

$$C_{i,j}^{allowable} = \frac{C_{i,j}^{rep}}{HQRF_{i,j}}$$

The resulting risk-based cleanup standard calculations, carcinogenic and/or non-carcinogenic, for the example are presented in Table 1-4(7). The risk-based cleanup standard concentrations are

presented in bold.

Table 1-4(7) Example Risk-Based Cleanup Standard Concentrations for Target Level Calculations

COC	Pathway					
	Pathway 1 (mg/kg)		Pathway 2 (mg/kg)		Pathway 3 (mg/l)	
	RBCSc	RBCSnc	RBCSc	RBCSnc	RBCSc	RBCSnc
C1	$\frac{1}{5.99} = \mathbf{0.17}$	N/A	$\frac{2}{11.98} = \mathbf{0.17}$	N/A	-	N/A
C2	N/A	$\frac{2}{9} = \mathbf{0.222}$	N/A	$\frac{4}{27} = \mathbf{0.148}$	N/A	$\frac{2}{9} = \mathbf{0.222}$
C3	N/A	$\frac{3}{9} = \mathbf{0.333}$	-	$\frac{6}{9} = \mathbf{0.667}$	N/A	$\frac{3}{27} = \mathbf{0.111}$
C4	$\frac{4}{5.99} = \mathbf{0.67}$	N/A	$\frac{8}{5.99} = \mathbf{1.34}$	N/A	$\frac{4}{5.99} = \mathbf{0.67}$	N/A
C5	$\frac{5}{11.98} = \mathbf{0.42}$	$\frac{5}{9} = \mathbf{0.555}$	N/A	$\frac{10}{9} = \mathbf{1.11}$	N/A	$\frac{5}{9} = \mathbf{0.555}$

N/A: Not applicable because there is no relevant toxicity data or physical-chemical property or because there was no entry under representative concentrations. This could mean that the chemical is not a COC for the pathway being evaluated based on release history or based on site characterization data.

-: Not calculated because there was no entry under representative concentrations. This could mean that the chemical is not a COC for the pathway being evaluated based on release history or based on site characterization data.

In this example, for chemical C5 and pathway P1, both carcinogenic and non-carcinogenic risk-based cleanup standards are calculated. The lower of the two, 0.42 mg/kg, the carcinogenic risk-based cleanup standard, would be used.

(j) Alternative Values. The risk evaluation process relies heavily on default parameters and assumptions. The responsible party may determine, through site-specific evaluation, that these default parameters are not justified at an individual site due to site-specific conditions. WRD will consider the use of alternative values for the risk evaluation process if the responsible party can provide adequate justification for the change. However, WRD is charged with making conservative decisions with respect to remediation standards to protect human health and the environment, and therefore the justification required for use of alternate values must be clear and compelling.

(k) Next Steps Following Completion of the Risk Evaluation. After calculating site risks as mentioned above, the responsible party should document and submit results to WRD with recommendations for further actions required at the site (i.e. no further action needed, or proceed with development of a Cleanup Action Plan).

(1) Conditions Required for No Further Action Decision. If the following conditions are met, WRD should issue a “no further action” (NFA) letter:

- (i)** The site satisfies all (individual COC, ROE, and cumulative) risk conditions discussed in Section 1-4, or meets default cleanup standards,
- (ii)** No nuisance conditions exist,
- (iii)** Free product (both DNAPL and light non-aqueous phase liquid [LNAPL]) has been removed to the maximum extent practicable,
- (iv)** WRD agrees with the overall risk evaluation,
- (v)** Fate and transport parameters used to estimate risk-based cleanup levels values are either representative of those used as defaults in the risk evaluation or are more conservative, and
- (vi)** No wells have increasing concentrations or concentrations consistently above the risk-based cleanup standards. Thus, an important requirement for NFA is a ground water plume that is stable or decreasing in size and concentration.

(2) Remediate to Applicable Cleanup Standards. If the above conditions are not met, then the responsible party should develop a Cleanup Action Plan to remediate the site to either default or risk-based cleanup standards. Development of a Cleanup Action Plan is discussed in Section 3-6 of this Guidance.

SECTION 2 - DEVELOPMENT AND VALIDATION OF THE SITE CONCEPTUAL MODEL

Section 2-1 Introduction. This section discusses a systematic planning process for the data collection activities required to complete the site characterization necessary to conduct a Risk-Based Evaluation under Section 1. Environmental data used in the Nez Perce Tribe Risk-Based Corrective Action (NPT-RBCA) process must be scientifically valid, defensible, and of known and documented quality. This can be achieved by the use of adequate quality assurance and quality control procedures throughout the entire process (from initial study planning through data usage). This section briefly discusses techniques used to collect the data, but references are cited to provide more detailed information about methodologies for the collection of data.

In the NPT-RBCA process, data is used to:

- (a)** Develop and validate a site conceptual model,
- (b)** Delineate the extent of impacts in each media necessary to quantify the risk to receptors,

- (c) Identify the maximum media-specific site concentrations,
- (d) Identify the exposure domains for each complete receptor, route of exposure, and exposure pathway,
- (e) Estimate the representative concentration for each exposure domain,
- (f) Develop a feasible Cleanup Action Plan, if necessary, and
- (g) Confirm the effectiveness of cleanup action alternatives.

It is extremely important that careful attention be paid to the data collection work plan preparation and implementation to ensure that the nature and extent of contamination is accurately characterized.

Section 2-2 Components of a Site Conceptual Model. On a given project, different individuals may collect data over a long period of time. Therefore, it is important to compile the relevant data in a format that is easy to understand and use. A site conceptual model provides a convenient format to present an overall understanding of the site. A site conceptual model may be developed at the start of a project and refined and updated throughout the life of the site activities. A complete and detailed conceptual model is essential to making sound professional judgments about sampling design and for optimizing that design. It can help identify the pros and cons of various remediation activities or institutional controls. Finally, it is an important communication tool for the Tribe, responsible parties and stakeholders.

(a) Elements Required. Key elements of the site conceptual model include:

- (1) The chemical release scenario, source(s), and chemicals of concern (COCs),
- (2) Spatial and temporal distribution of COCs in the various affected media,
- (3) Current and future land and groundwater use,
- (4) Description of any known existing or proposed land or water use restrictions,
- (5) Description of site stratigraphy, determination of the predominant vadose zone soil type, hydrogeology, meteorology, and surface water bodies that may potentially be affected by site COCs,
- (6) Remedial activities conducted to date, and
- (7) An exposure model that identifies the receptors and exposure pathways under current and future land use conditions.

(b) Categories of Data. To adequately characterize a site to determine risks, the following categories of data should be collected:

- (1) Site information, as defined in Section 2-3,
- (2) Description and magnitude of the spill or release, as defined in Section 2-4,
- (3) Adjacent land use, institutional controls, and receptor information, as defined in Section 2-5,
- (4) Analysis of current and future groundwater use, as defined in Section 2-6,
- (5) Vadose zone soil characteristics, as defined in Section 2-7,
- (6) Characteristics of saturated zones, as defined in Section 2-8,

- (7) Surface water body characteristics, as defined in Section 2-9,
- (8) Meteorology (such as rainfall, infiltration rate, evapotranspiration, wind speed and direction),
- (9) Distribution of chemicals of concern in soil, as discussed in Section 2-10,
- (10) Distribution of chemicals of concern in groundwater, as discussed in Section 2-11,
- (11) Distribution of chemicals of concern in soil vapor, as discussed in Section 2-12, and
- (12) Distribution of chemicals of concern in sediments and surface water bodies, as discussed in Section 2-13.
- (13) Background soil and water concentrations, as discussed in Section 2-14.

(c) Data Quality. As part of the NPT-RBCA evaluation, the responsible party needs to carefully review all the available data and identify any data gaps. A systematic planning process is used to develop a work plan to be approved by WRD. To fill in data gaps, the work plan must include: (i) a sampling and analysis plan and (ii) a Quality Assurance Project Plan (QAPP) that meets *EPA Requirements for Quality Assurance Project Plans (EPA QA/R5)* along with *EPA Guidance for Quality Assurance Project Plans (EPA QA/G5)* (QAPPs can be site specific or activity specific).

The objectives of the QAPP and the Sampling and Analysis Plan components of the work plan are to ensure that:

- (1) The intended use of the data is clearly defined and understood to ensure that the collected data will be of adequate quality and quantity,
- (2) All environmental data used to make risk assessment and risk management decisions is scientifically valid, defensible and of known quality, and
- (3) The specific location where samples will be collected, the handling requirements for the samples, and methods of analysis are clearly specified to avoid any confusion or ambiguity once the field work begins.

The responsible party should only use or develop target risk levels, calculate representative concentrations, prepare a risk assessment, and prepare a Cleanup Action Plan after all the necessary data has been collected.

Section 2-3 Site Information.

- (a)** The following information is necessary to complete an NPT-RBCA site conceptual model:
- (1) A site location map,
 - (2) A site map,
 - (3) Ground surface conditions,
 - (4) Location of utilities on and adjacent to the site,

- (5) Surface water bodies,
- (6) Onsite and adjacent offsite groundwater use, and
- (7) Local hydrogeology and aquifer characteristics.

A brief discussion of each of the above items is presented below. Relevant site information can be obtained by various means, including: site visits, deed search, historical records, aerial photographs, review of engineering drawings showing the layout of the site, review of regional information, and review of files at WRD related to the site or adjacent sites.

(b) Site Location Map. A site location map must be prepared using United States Geological Survey (USGS) 7½ minute topographic maps as a base. The site location should be centered on the topographic map (cropping the maps as necessary), with the location clearly marked. Contour lines on the topographic map must be legible.

(c) Site Map. A detailed map(s) of the site should show:

- (1) Property boundaries,
- (2) Layout of past and current site features such as containment or storage systems; process areas; transportation and delivery distribution systems; waste handling and storage areas, including associated components and piping runs; sumps; paved and unpaved areas; and buildings,
- (3) Locations of area(s) of release,
- (4) Locations of onsite monitoring wells (including those that have been abandoned, identified in some way but for which exact information is missing, or destroyed),
- (5) Locations of water wells (public and private),
- (6) Location of surface water features,
- (7) Ecological or terrestrial sensitive features, and
- (8) Locations of soil borings, soil vapor extraction wells, and soil excavation areas.

Multiple maps showing these features may be necessary. Site maps must be drawn to scale and include a bar scale and a north arrow. In addition to the site map(s), a land use map is also necessary (refer to Section 2-5).

(d) Ground Surface Conditions. Identify the portion of the site that is paved, unpaved or landscaped. Note the type, extent, date of installation, and general condition of the pavement. Describe the unpaved areas (for example, vegetated, gravel, or bare soil). Determine the direction in which the surface is sloping and note relevant topographic features (for example, swales, drainage, or detention ponds).

(e) Location of Utilities On and Adjacent to the Site. Contaminated groundwater and vapors can flow preferentially into and through underground utility lines and conduits and thereby increase the probability of utility workers being exposed. Therefore, a thorough assessment of potential and actual migration and impacts of COCs to underground utilities should be

performed. Utilities include cable, electrical and telephone lines, sanitary and storm sewers, and water and natural gas lines. A combination of site observations, knowledge of buried utilities, and discussions with utility representatives and the site owner should be used to determine the location of site utilities.

(1) At a minimum, the following needs to be performed:

- (i)** If explosive conditions are encountered, immediately inform the local fire department and the NPT Emergency Response Team.
- (ii)** Locate all underground utility lines and conduits within the area of known or suspected soil and groundwater impact, both on and offsite, where the release may have migrated or may migrate in the future.

(2) Then, if available and if utilities are located in the area of contamination, the following information may be useful in the analysis:

- (i)** Direction of water flow in utility lines (potable water, storm water, and sewage).
- (ii)** Location of the utility lines and conduits on a base map that shows the extent and thickness of non-aqueous phase liquid (NAPL), free product, if any, and soil and groundwater contamination.
- (iii)** Depth of the utility lines and conduits relative to the depth of groundwater. Seasonal fluctuations of groundwater levels (relative to the depth of utilities) must be carefully evaluated. A cross-sectional diagram that illustrates the depth to groundwater and the locations and depths of the utility lines and conduits is recommended.
- (iv)** Types of materials used for utility lines and conduits for example, polyvinyl chloride (PVC), terra cotta, concrete or steel and the type of backfill around the utilities.
- (v)** Any historical work completed on any of the utilities and if any contamination related issues were identified at the time the work was performed.

(f) Onsite Groundwater Use. Current and former site owners and operators should be interviewed to determine whether any water well(s) is or was located on site. The level of effort necessary will be especially critical for WRD to make a determination whether the domestic use of groundwater pathway is complete or incomplete.

To the extent that such information is available, well construction details are essential to the conceptual site modeling process. Relevant construction details include the total depth of the well, casing depth, screened or open interval, static and/or pumping level, and the use of water from the well. If available, average well pumping rates and drawdown information also should be provided.

(g) Local Hydrogeology and Aquifer Characteristics. Local hydrogeology, soil types and aquifer characteristics should be evaluated to determine the type and depth of aquifers in the area and whether they are confined, semiconfined or unconfined. This information may be found in published literature especially United States Geological Survey (USGS), as well as in WRD files. General aquifer characteristics such as yield and total dissolved solids will help determine whether the domestic consumption exposure pathway is a concern. The responsible party should use regional information to better understand site-specific soil and groundwater conditions.

Section 2-4 Description and Magnitude of Spill or Release

(a) Purpose. Knowledge about the nature, location and magnitude of a release(s) is necessary to identify the: soil and groundwater source(s) at the site, chemicals of concern, methods that will be used to analyze the samples, and horizontal and vertical extent of soil and groundwater contamination.

(1) Required Information. The responsible party should collect as much of the following information as is available for each release that has occurred at the site:

- (i)** History of site activities related to the release,
- (ii)** Location(s) and date(s) of spill(s) or release(s),
- (iii)** Quantity of the release(s) (best estimate if not readily ascertainable),
- (iv)** Product(s) or chemical(s) released, and
- (v)** Interim response or corrective action measure(s) taken with respect to each release.

(2) Sources of Release Information. Release related information can be obtained from a variety of sources, including:

- (i)** Review of product or waste inventory records,
- (ii)** Interviews with past and current onsite employees,
- (iii)** Review of USEPA files,
- (iv)** Review of historic spill incident reports filed with WRD, or other government agencies,
- (v)** Review of permits, and
- (vi)** Review of administrative or consent orders related to the site.

(b) History of Activities at the Site. At many contaminated sites, one or more site investigations, monitoring events, system (such as tanks, pipelines, or lagoons) removal activities, or remediation activities may have taken place over an extended period of time. Therefore, a key step in the NPT-RBCA process is to develop a comprehensive chronology of historical events related to any chemical impacts. A chronology will help create a complete picture of the site activities and identify COC and data collection needs. The chronology should

include information such as the dates, descriptions and results of: installation, removal or upgrade of containment, process, delivery or waste systems, remedial activities such as excavation and disposal of contaminated soil, drilling, sampling and gauging of monitoring wells, and collection of environmental media samples.

Interim response actions may have removed all or part of the COCs released at a site. Soil and groundwater data collected prior to the completion of these activities may not be representative of current conditions and should not be used in the calculation of current exposure and risk. At such sites, the responsible party must collect additional soil and groundwater concentration data representative of current conditions. However, data collected prior to the completion of interim action(s) may be used to guide decisions on additional data collection. The intent of developing a site history is to clearly understand site activities in order to develop a site conceptual model that can be used to accurately assess any associated current and future risks.

(c) Location and Date of Spill or Release. The identification of the location of a release helps define the source area(s). Likely release locations at contaminated sites include: corroded or damaged containment or process system components, piping, especially at pipe bends and joints and floor drains, dispenser and delivery systems, deposition near smoke stacks or air discharge points, accidental releases at areas for receiving, delivering, or handling chemicals and wastes, waste water lagoons and runoff basins, and waste/chemical/hazardous product storage and disposal areas.

A release may occur within the surficial soil. Surficial soil is the zone that a receptor could directly come into contact with and be exposed to COCs in the soil by ingestion, dermal contact, or inhalation of vapor and particulates. In the NPT-RBCA process, for both residential and nonresidential receptors, surficial soil is defined as from 0 to 3 feet below ground surface (bgs). Subsurface soil is defined as from 3 feet bgs to the water table. If the groundwater is less than 3 feet bgs, then the surficial soil extends to the depth of the water table and there is no subsurface soil for purposes of risk evaluation.

During collection of surface soil samples where metals are a potential concern, it is important to collect data from the shallowest depth that can be practicably obtained, rather than choosing a random sampling interval in the 0 to 3 foot zone, or compositing samples across the entire zone. Simply using data from a 0 to 3 foot interval can dilute the concentration if contamination is not homogenous across the soil profile. These types of concerns should be addressed in the data collection work plan.

Based on the site chronology and operational history described in Section 2-4(b), the responsible party may be able to determine the location and date of the release(s). However, often the exact location and date of the release(s) cannot be known. In such cases, field screening, such as the use of a photoionization detector (PID), x-ray fluorescence (XRF) spectrophotometer, field bioassays, and/or collection of samples for laboratory analysis must be used to identify the likely location and extent (vertical and horizontal) of COCs in the soil and groundwater. Decisions

regarding the use and application of field screening technologies and collection of samples need to be based on site-specific conditions and chemicals. For example, PIDs may not be accurate for soils above a certain moisture content, and the PID does not detect all types of chemicals. Visual observations may be used to identify soil sample locations. This information is part of a sampling and analysis plan.

(d) Quantity of Spill or Release. The NPT-RBCA process does not necessarily require knowledge of the exact quantity of the released chemicals or wastes. Often this information is not known. However, having a general idea of the amount released can assist in assessing the potential extent and severity of a chemical impact. Approximate amounts may also be used to provide the basis for any chemical mass balance calculations.

(e) Product(s) or Chemical(s) Released. The NPT-RBCA process primarily focuses on developing risk-based cleanup levels for individual chemicals. However, cleanup levels may at times be developed for products or wastes that are mixtures of chemicals such as oil, gasoline, deicing agent, Stoddard solvent, polychlorinated biphenyls (PCBs), and polychlorinated dioxin. It is essential that the responsible party identify the COCs comprising such products or wastes.

Section 2-5 Adjacent Land use, Institutional Controls and Receptor Information

(a) Purpose. Land use information is used to identify the (i) location and type of potential receptors, (ii) exposure pathways by which the potential receptors may be exposed to the COCs, and (iii) presence of any site institutional controls that may affect the completion of exposure pathways. This information is critical in developing a site exposure model. Specifically, the following information should be collected:

- (1) Current land use and zoning,
- (2) Potential future land use and zoning,
- (3) Local ordinances, easements and restrictions that affect land or groundwater use,
- (4) Quality and availability of potable water supplies,
- (5) Offsite groundwater use, and
- (6) Ecological receptor survey.

At a minimum, a land use and receptor survey covering the entire contaminated and potentially contaminated area is necessary to adequately understand potential risks.

(b) Current Land Use. Knowledge of the uses of the site and nearby properties is necessary to define potential onsite and offsite receptors that may be exposed to the COCs. A visual, onsite

land use reconnaissance survey within the area of impact must be conducted to avoid ambiguity about site uses. The survey should clearly identify the following: schools, hospitals, residences (apartments, condominiums, townhouses, and single family homes), buildings with basements, day care centers, churches, nursing homes, and types of businesses. The survey should also identify surface water bodies, parks, recreational areas, wildlife sanctuaries, wetlands and agricultural areas. The results of the survey should be accurately documented on a land use map. The land use map need not be drawn to an exact scale, in most cases, an approximate scale will suffice. However, a north arrow on any map is required.

(c) Future Land Use. Future land use and receptors need to be established for an acceptable risk-evaluation. These are more difficult to determine than current land use and receptors. Unless future land use is known and can be documented (for example, by development plans or building permits), predictions of reasonably anticipated future use must be based on local zoning laws and surrounding land use patterns. As appropriate, zoning maps, aerial photographs, local planning offices, the U.S. Bureau of the Census, community master plans, changing land use patterns, and interviews with current property owners can provide information with which future land use can be predicted. Proximity to wetlands, critical habitat and other environmentally sensitive areas should also be considered in predicting future land uses.

(d) Offsite Groundwater Use. A water well survey must be conducted to locate all public water supply wells within a one-mile radius of the site and all private water wells within a quarter-mile radius of the site (the radial distances referenced above are minimum requirements; relevant federal requirements or differences in COC mobility and/or hydrogeology at the specific site may necessitate well surveys of greater areal extent). A few of these wells may be known prior to the water well survey; others may be identified during the survey.

The level of effort expended in a well survey depends on site-specific considerations. It can extend to searches of local, state and federal records and databases and windshield or door-to-door surveys. For example, in newly developed areas with a municipal water supply, a door-to-door survey might not be necessary. However, in rural areas where groundwater is the primary source of water or in older developed areas, a door-to-door survey may be needed. The level of effort for this task is especially critical if the responsible party and WRD are to evaluate the domestic consumption pathway during the risk evaluation process.

For onsite wells, to the extent that such information is available, the responsible party must provide well construction details for all wells identified. Relevant construction details include the total depth of the well, casing depth, screened or open interval, static and/or pumping level, and the use of water from the well. If available, average well pumping rates and drawdown information also should be provided.

(e) Ecological Receptor Survey. Ecological receptors include both specific species and general populations of flora and fauna and their habitats, including wetlands, surface water bodies, sensitive habitats, and threatened and endangered species. As appropriate, a walking survey

within a 0.5 miles radius of the site may be necessary to identify ecological receptors. Refer to Section 3-3(e) of the Nez Perce Tribe's Contaminated Site Cleanup Guidance for further information regarding ecological risk assessment.

Section 2-6 Analysis of Current and Future Groundwater Use

(a) Purpose. Impacts to groundwater and potential exposures via the domestic use of groundwater are of significant concern on the Nez Perce Reservation because a large part of the reservation obtains drinking water from groundwater sources. The NPT-RBCA process can be used in cases where groundwater has been contaminated or is likely to be contaminated by a site-specific release. The process has the following objectives:

- (1) To protect all current and reasonably anticipated future uses of groundwater,
- (2) To provide a rational basis for incorporating site specific characteristics into the determination of groundwater target levels, and
- (3) To facilitate the development of properties based on reasonable expectations for groundwater cleanup.

A key determination in developing risk-based groundwater cleanup levels is if the groundwater domestic use pathway is complete under current or future conditions. The analysis of current and future groundwater domestic use must include all groundwater zones beneath or in the vicinity of the site that could potentially be (i) impacted by site specific COCs, or (ii) targeted in the future for the installation of water use wells. For the purposes of this analysis, groundwater-bearing zones must be evaluated in a three dimensional context.

As a part of this step, other groundwater uses (for example, cooling water, irrigation, livestock watering, and industrial process water) also need to be identified and documented.

(b) Current Groundwater Use. The current groundwater domestic consumption pathway is considered complete if water use wells are located on or near the site and the wells may be impacted by site-specific chemical releases. Whether a well may be impacted depends on the hydrogeological conditions, well construction and use of the well, including the following factors:

- (1) Characteristics of soil and rock formations,
- (2) Groundwater flow direction,
- (3) Hydraulic conductivity,
- (4) Distance to the well,

(5) The zone where the well is screened,

(6) Casing of the well,

(7) Zone(s) of influence and capture generated by well pumpage, and

(8) Biodegradability and other physical and chemical properties of the COCs. If it is determined that any groundwater zone will not be impacted, then justification for this determination should be provided in the risk evaluation report and in the Cleanup Action Plan.

(c) Future Groundwater Use. For each zone, determining if the future groundwater use pathway is complete or likely to be complete is based on consideration of the following factors. All of these factors should be evaluated on a “weight of evidence” basis; the weight that a single factor will be given in determining the probability of future groundwater use will vary based on site specific considerations, including the durability of any institutional controls.

(1) Suitability for Use Determination. For groundwater to be considered a viable domestic water supply source, it must meet appropriate total dissolved solids (TDS) and yield criteria.

(i) Total Dissolved Solids Criteria. Groundwater containing less than 10,000 mg/L total dissolved solids is considered a potential source of domestic consumption.

(ii) Yield Criteria. Groundwater zones capable of producing a minimum of 1/4 gallon per minute or 360 gallons per day on a sustained basis have sufficient yield to serve as a potential source of domestic consumption. The yield of a bedrock aquifer should be based on the measured or calculated production of a 6-inch drilled well that penetrates the lesser of either the full-saturated thickness of the aquifer or the uppermost 200 feet of the saturated zone. The yield of a low-yield, unconsolidated (glacial drift or alluvial) aquifer should be based on the measured or calculated production of a 3-foot diameter, augered or bored well that penetrates the lesser of either the entire saturated thickness of the aquifer or the uppermost 50 feet of the saturated zone.

(2) Determination of Sole Source/Availability of Alternative Water Supplies. If the groundwater zone being considered is the only viable source of water at or in the vicinity of the site, then the responsible party must assume that future domestic use is reasonable. This conclusion is irrespective of TDS or yield considerations, and this zone must be evaluated if it is likely to be impacted by COCs from the site. Determining the availability of alternative water supplies should include consideration of other groundwater zones, municipal water supply systems, and surface water sources.

(3) Reasonably Anticipated Future Use Determination. The probability that a

groundwater zone could be used as a future source of water for domestic consumption must be evaluated based on consideration of the following factors:

- (i) Current groundwater use patterns in the vicinity of the site under evaluation,
- (ii) Suitability of use (TDS and yield criteria),
- (iii) Well location and construction requirements/restrictions,
- (iv) Availability of alternative water supplies,
- (v) Institutional controls,
- (vi) Aquifer capacity limitations (ability to support a given density of production wells).

(4) Probability of Impact Determination. If a groundwater zone has a reasonably anticipated future use as a domestic water supply, the probability that the zone could be impacted by site COCs is an essential task. The evaluation should consider the nature and extent of contamination at the site, site hydrogeology including the potential presence of karst features, contaminant fate and transport factors and mechanisms, and other pertinent variables. To evaluate potential site impacts to groundwater zones that could serve as future water supply sources, the potential impact must be evaluated at the nearest down gradient location that could reasonably be considered for installation of a groundwater supply well. In the absence of durable institutional controls, the nearest location might be on the site itself.

Section 2-7 Vadose Zone Soil Characteristics

(a) Purpose. Vadose zone soil is a medium through which COCs can migrate to groundwater and through which vapors can migrate upward to indoor and outdoor air. The following vadose zone parameters and their variability across the contaminated area significantly affect the movement of chemicals through vadose zone soil:

- (1) Dry bulk density,
- (2) Total porosity,
- (3) Volumetric water content,
- (4) Fractional organic carbon content,
- (5) Thickness of vadose zone and depth to groundwater, and
- (6) Thickness of capillary fringe.

The first four parameters dry bulk density, porosity, water content, and fractional organic carbon content are often collectively referred to as the soil geophysical or geotechnical parameters. Consideration should be given to preferential pathways. For example, desiccation cracks may

provide a preferential pathway at sites where the primary soil type is clay.

For the development of default cleanup standards, WRD assumed conservative values of these parameters. For the NPT-RBCA risk evaluation process, site-specific parameters may be used from representative data collected from the site.

Generally, collection of geophysical soil samples will require more than one boring or probe, depending on site conditions and recovery volumes. Ultimately, the number of borings or probes necessary to obtain representative values of these parameters will be a site specific decision of the driller and environmental consultant based on professional experience and judgment. The objective is to collect enough samples so that the results are representative of site-specific conditions. Fewer samples will be required at sites with relatively homogeneous vadose zone characteristics, while more samples will be required if heterogeneous conditions exist.

In situations where undisturbed samples cannot practically be collected for the purposes of measuring dry bulk density, literature values may be used for this parameter. However disturbed samples must be collected and analyzed for fractional organic carbon, gravimetric water content, and particle density.

(b) Thickness of Vadose Zone and Depth to Groundwater. The vadose zone is the uppermost layer of the earth and is conceptualized as a three-phase system consisting of solids, liquid and vapors. The thickness of the vadose zone can be determined based on information presented on boring logs and/or from measurements taken from monitoring wells or piezometers. It represents the distance from the ground surface to the depth at which the water table is encountered. For NPT-RBCA evaluation, the capillary fringe thickness is not considered part of the vadose zone and is subtracted. Depth to groundwater is used to estimate vapor emissions from groundwater and to determine the vadose zone attenuation factor.

At sites where significant secondary porosity features are identified, the calculation of the dilution attenuation factor DAF should not be based on the assumption of granular media. Alternative methods to estimate the DAF and any alternative data needs must be proposed to WRD. For sites where DAF cannot be accurately evaluated, the responsible party may propose alternative methods to evaluate the indoor inhalation pathway for WRD approval.

For sites where the water table fluctuates considerably, the available data should be evaluated to determine whether the fluctuations are seasonal or represent a consistent upward or downward regional trend. For sites with significant seasonal fluctuations, the average depth to groundwater and the average thickness of the vadose zone should be used in development of the overall site conceptual model and any related modeling efforts. Averages can be determined by groundwater level measurements obtained on at least a quarterly basis over one year. These averages should not, however, be used in the development of site-specific potentiometric maps, plans for well installation, or any other activities that require specific knowledge of fluctuations in groundwater flow direction(s). At sites with consistent, long-term (greater than one year) upward or

downward water level trends that do not appear to represent seasonal fluctuations, the most recent data should be used to estimate the depth to groundwater and the thickness of the vadose zone.

At sites where the cleanup decision critically depends on the vadose zone thickness and/or depth to groundwater, and the depth to groundwater is known to fluctuate significantly, WRD may request a sensitivity analysis. The analysis should be performed using different depths to groundwater and vadose zone thicknesses to assess the degree to which these parameters may affect the cleanup decision.

(c) Dry Bulk Density. Dry bulk density is the dry weight of a soil sample divided by its field volume. An accurate measurement of dry bulk density requires determination of the dry weight and volume of an undisturbed sample. An undisturbed soil core sample may be collected using a Shelby TM tube, a thin walled sampler, or an equivalent method. The sample must not be disturbed prior to laboratory analysis.

Dry bulk density is estimated using the American Society for Testing and Materials (ASTM) Method D2937, “*Standard Test Method for Density of Soil in Place by the Drive Cylinder Method.*” At sites where multiple, widely differing soil types occur in the vadose zone, one sample should be collected from each distinct, predominant soil type. At such sites, the percentage of each soil type relative to the overall volume of the vadose zone should be considered in collecting samples and calculating bulk density. Where soil at a site is homogeneous or nearly so, a single sample for bulk density analysis may suffice.

(d) Total Porosity. Total porosity is the ratio of the volume of voids to the volume of the soil sample. Many laboratories use dry bulk density and specific gravity of soil particles to calculate total porosity using the following:

$$n = 1 - \rho_b / \rho_s$$

where,

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

Thus, specific gravity and soil dry bulk density are needed to determine total porosity.

The “*Standard Test Method for Specific Gravity of Soil Solids by Water Pycnometer,*” ASTM Method D854, may be used to determine specific gravity. If specific gravity or particle density is not available, 2.65 g/cc can be assumed for most mineral soils. However, the use of this value must be justified.

If a site-specific total porosity value cannot be determined, literature values consistent with the

site lithology may be used, provided the source(s) of the value(s) is cited and justified. Effective porosity is the amount of void space available for fluid flow. Various studies have identified that even in very fine clays, such as lacustrine deposits, the effective porosity is practically the same as total porosity (Fetter, 2001). Where the total and effective porosities differ significantly, WRD may require a sensitivity analysis.

(e) Volumetric Water Content/Moisture Content. Volumetric water content is the ratio of the volume of water to the volume of field or undisturbed soil. The ASTM Method D2216, *“Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soils and Rock by Mass,”* may be used to calculate this ratio. However, this is a gravimetric method that uses the mass of the sample, not the volume, to determine the ratio of water to soil. Therefore, to obtain the volumetric water content, the following conversion should be used:

$$\theta_{wv} = \theta_{wg} \times \rho_b / \rho_l$$

where,

θ_{wv}	=	volumetric water content (cc water/cc soil)
θ_{wg}	=	gravimetric water content, typically reported by the laboratory (g of water/g of soil)
ρ_b	=	dry bulk density (g of dry soil/cc of soil)
ρ_l	=	density of water (g/cc).

Multiple samples from across the site at varying depths should be analyzed for water content to estimate a representative water content value for the vadose zone. Each soil sample analyzed for one or more of the applicable COCs must also be analyzed for water content (at sites where multiple samples from multiple depths are analyzed for COCs on a dry weight basis, additional samples solely for analysis of water content may not be necessary). In addition, water content values representative of each of the lithologic units that comprise the vadose zone must be determined. Because all soil COC concentration data need to be reported on a dry weight basis, the water content for each soil sample must be compiled, reported and used as needed in calculating target levels.

(f) Fractional Organic Carbon Content in Soil. Fractional organic carbon content is the weight of organic carbon in the soil divided by the weight of the soil and is expressed either as a ratio or as a percent. Organic carbon content must be determined using soil samples not impacted by petroleum or other anthropogenic chemicals. Therefore, a soil boring away from the contaminated area but within a soil type that is the same as, or very similar to, that found at the site must be drilled to determine fractional organic carbon content. At a screening level, one method of determining if certain anthropogenic chemicals have impacted the sample is to take a PID reading.

Samples representative of the vadose zone must be collected for fractional organic carbon content analysis. At sites where the vadose zone consists of several different soil types, each

predominant soil type must be sampled. Multiple aliquots of soil samples from the same lithologic unit may be collected vertically from a boring and horizontally from different borings and composited in the field to create a single sample. While creating a composite sample, care should be taken not to combine samples collected from different lithologic units. Surficial soils typically have the highest organic carbon content, and care should be taken not to bias the samples by collecting too much surficial soil.

For sites where subsurface soil types vary significantly, soil samples from the vadose and saturated zones should be collected at two or more boring or probe points that represent the differing soil types. As appropriate, the resulting fractional organic carbon content can then be averaged to establish a fractional organic carbon content for each media. If the individual data are representative of significantly different volumes of soil, a weighted average is preferable to the arithmetic average.

Fractional organic carbon content may be estimated using the Walkley Black Method (Page et al., 1982). However, some labs may not be familiar with this method. An alternative, though less preferred, method is ASTM Method D2974 “*Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils*”. This method measures the organic matter content of a sample. When using Method D2974, the result must be divided by 1.724 to get fractional organic carbon content. If the laboratory results are reported as a percent, fractional organic carbon content is obtained by dividing the results by 100.

(g) Thickness of Capillary Fringe. The capillary fringe is the zone immediately above the saturated zone where capillary attraction causes upward movement of water molecules from the saturated zone into the soil above. This zone is distinct in that it has characteristics of both the vadose and saturated zones. In a risk evaluation, the thickness or height of the capillary fringe can be measured or an appropriately justified value used. Because accurate field measurement of the thickness of the capillary fringe can be difficult, literature values based on the soil type immediately above the water table may be used to assign a site specific value for the capillary fringe thickness.

The thickness of the capillary fringe can significantly impact the concentrations in groundwater that are protective of indoor inhalation. Because this zone is not usually measured, WRD may suggest that the responsible party estimate the most likely ranges of capillary zone thickness and depth to contamination and perform a sensitivity analysis. Most models used to perform this calculation assume the capillary fringe to be uncontaminated, which may not be accurate.

Section 2-8 Characteristics of Saturated Zones

(a) Purpose. COCs may reach the water table by traveling vertically through the vadose zone. Vertical migration can be expected in the following conditions: when the matrix porosity of the subsurface medium of interest is conducive to vertical migration; when a natural or induced downward vertical gradient exists between shallow and deeper saturated zones; when vertically

oriented secondary porosity features are present; or when non-aqueous phase liquids (NAPLs) are present. Typically the vertical migration of light NAPLs (LNAPLs) will stop at the water table, whereas the dense NAPLs (DNAPLs) will continue to move vertically downwards through the saturated zone.

Saturated zone characteristics that determine the rate, magnitude and direction of migration of COCs in groundwater include:

- (1) Horizontal and vertical hydraulic conductivity,
- (2) Hydraulic gradients (magnitude in both horizontal and vertical direction),
- (3) Residual mass in capillary fringe,
- (4) Saturated zone soil geophysical characteristics (fractional organic carbon content, total and effective porosity, and bulk density),
- (5) Occurrence and rate of biodegradation and retardation due to other factors, such as sorption due to soil mineral oxide content, and
- (6) pH and redox potential especially at sites where the COCs include metals.

Of the characteristics mentioned above, the properties typically having the greatest influence on COC migration are hydraulic conductivity and hydraulic gradient. Early in the NPT-RBCA process, various groundwater zones and the hydraulic interconnection among them should have been identified. Qualitative and quantitative understanding of the above factors may be necessary for each of the zones. When necessary, values of hydraulic conductivity, hydraulic gradient, effective porosity, and fractional organic carbon content must be used to estimate the theoretical advective migration velocity for the COCs in groundwater. The theoretical migration rate and extent of the groundwater plume should be compared with actual data to further validate the site conceptual model.

(b) Hydraulic Conductivity. Reliable estimates of site-specific hydraulic conductivity can be obtained by field methods such as pump tests or slug tests. In the absence of these tests, literature values corresponding to the type of soil in the saturated zone may be used. When a literature value is used, adequate reference and justification for the value based on consideration of all predominant soil types comprising the saturated zone must be provided. Hydraulic conductivity may also be estimated based on the grain size distribution of the porous formation.

The hydraulic conductivity can vary significantly in the horizontal and vertical directions. When referring to hydraulic conductivity always indicate whether reference is to horizontal or vertical direction. Horizontal hydraulic conductivity and gradient should be used to calculate the horizontal velocity of water and vertical hydraulic conductivity and gradient should be used to

estimate the vertical velocity of water.

(c) Hydraulic Gradient. The magnitude and direction of the hydraulic gradient is estimated by comparing water levels measured in monitoring wells across a site. A contour map must be prepared, either manually or using a computer program, using field measured water level data corrected to elevations relative to, preferably, mean sea level, or other established datum.

These contour maps can be used to estimate both the direction and magnitude of the horizontal hydraulic gradient. When drawing the contour maps, care should be taken to ensure that measurements from monitoring wells screened in the same interval or hydrologic unit are used. For sites where wells are screened in multiple zones, a contour map for each zone should be developed (data from wells screened in different zones should not be combined to draw one contour map). For sites that have seasonal variation in hydraulic gradient or predominant flow direction, estimates of the average hydraulic gradient for each season and each flow direction can be used in modeling efforts. However, these estimates should not be used in the preparation of potentiometric maps or other activities where specific knowledge of the range of fluctuation in the groundwater flow direction is necessary (for example, locating and installing downgradient monitoring wells).

At sites with multiple groundwater zones, vertical gradients also need to be determined via a comparison of water levels in wells screened at different intervals. WRD will consider exceptions to this requirement on a site-specific basis.

(d) Saturated Zone Soil Characteristics. The saturated zone soil characteristics include fractional organic carbon content, porosity, and dry bulk density. These parameters are required to estimate the extent of the contamination, including the retardation factor that “slows” the movement of chemicals within the saturated zone. These parameters are also necessary when estimating future concentrations or performing contaminant mass balance calculations using models that include a finite source or biodecay. Section 2-8 discusses methods to measure these parameters.

(e) Occurrence and Rate of Natural Attenuation/Biodegradation. The occurrence of natural attenuation may be evaluated at a site. Monitoring appropriate indicators (such as chemical concentrations, geochemical indicators, electron acceptors, microorganisms, or carbon dioxide) may be required when natural attenuation is proposed as a principal element of the Cleanup Action Plan. Indicators of natural attenuation can be broadly classified into three groups: primary, secondary and tertiary lines of evidence. Data collected under each line of evidence is used to qualitatively evaluate the occurrence of natural attenuation/biodegradation.

(1) Primary Line of Evidence. The primary line of evidence is developed by demonstrating, via the evaluation of COC concentrations in groundwater, that reductions in chemical concentration or mass are occurring at a site. The primary line of evidence is best determined by:

- (i) Plotting concentrations of COCs as a function of distance along the plume center line,
- (ii) Plotting concentrations of COCs in each well as a function of time,
- (iii) Comparing COC concentration contour maps at various times,
- (iv) Performing contaminant mass balance calculations, and
- (v) As appropriate, generating three-dimensional depictions of plumes and their migration over time.

In performing the above analysis, other factors that could influence the data, such as seasonal water level or flow direction fluctuations, should be taken into account.

(2) Secondary and Tertiary Lines of Evidence. A secondary line of evidence is necessary when the primary line of evidence is insufficient, or when such information is necessary to design a remedial system (for example, the addition of oxygen). The secondary line of evidence involves measuring geochemical indicators such as dissolved oxygen, dissolved nitrates, manganese, ferrous iron, sulfate and methane. These indicators must be measured in at least three wells located along the plume center flow line. The wells need to be located to represent conditions at:

- (i) A background or upgradient location,
- (ii) An area within the plume near the source, and
- (iii) An area within the plume downgradient of the source.

Within the secondary line of evidence, measuring the degradation or breakdown products of COCs is another approach that can be used to demonstrate the occurrence of biodegradation. For example, natural degradation breaks down tetrachloroethylene (PCE) to trichloroethylene (TCE), cis-1,2-dichloroethene (DCE), and vinyl chloride. However, degradation products may be more toxic than the parent compound. Thus, the risk from degradation products also must be evaluated as part of any monitored natural attenuation proposal. Developing a tertiary line of evidence involves performing microbiological studies to identify and quantify microorganisms within and near the plume. A tertiary line of evidence is used in very rare cases.

The development of secondary and tertiary lines of evidence is not always necessary. However, at most sites, groundwater sampling data should be plotted to evaluate temporal trends. These trends can be used to determine whether the plume is expanding, stable or decreasing. It is essential that the groundwater plume be stable or decreasing prior to WRD issuing a **No Further Action Letter**.

Section 2-9 Surface Waterbody Characteristics

The following data sets are necessary for an adequate risk-based evaluation where a surface water body that may be impacted by site related COCs:

- (a) Distance to the surface water body,
- (b) Likely location where COCs from the site would discharge into a surface water body,
- (c) Flow direction and depth of any groundwater contamination plume(s) in relation to the water body,
- (d) Lake or pond acreage or stream 7Q10 flow rate,
- (e) Determination of the beneficial uses of the lake or stream, and
- (f) Water quality criteria based upon the beneficial uses of the lake or stream.

Section 2-10 Distribution of Chemicals of Concern in Soil

(a) Purpose. The objective of soil characterization is to delineate the vertical and horizontal extent of site-related COCs to identify the exposure domains for each combination of receptor pathway complete exposure pathway, and estimate maximum and representative concentrations for each area of impact/exposure domain.

(b) Methodology. Data collected in areas that are clean (either because the samples were collected beyond the extent of impact or the remedial activities eliminated the COCs) are not appropriate for use in the calculation of representative concentrations. Use of such data may incorrectly underestimate the representative concentrations. Because of the significance of accurately estimating the representative concentrations for each exposure domain, this concept is discussed in greater detail in Section 1-3.

As noted in Section 2-4(c), the NPT-RBCA process distinguishes between surficial soil and subsurface soil. A key difference between surface and subsurface soil is that, for surficial soil, the direct contact pathway (ingestion, dermal contact and outdoor inhalation of vapors and particulates) is considered complete for both the residential and nonresidential receptors. For the subsurface soil, this pathway is considered incomplete except for the construction worker who may be involved in excavation activities below the surficial zone and hence may come in direct contact with subsurface soil. Thus, for the construction worker, no distinction is made between the surface and subsurface soil.

Site-specific exposure conditions may allow the depth of surface soil default value to be modified if approved by WRD.

Because of the differences in exposure pathways for surface and subsurface soils, an adequate number of soil samples from each zone must be collected to meet the soil characterization objectives. Surficial soil (as well as subsurface soil) may include fill material the distinction

between surface and subsurface soil is one of depth rather than composition.

As previously indicated in Section 2-4(c), it is extremely important that careful attention be paid to the data collection work plan to ensure that the nature and extent of contamination is accurately characterized.

Surficial and subsurface soil impacts should be identified to the extent necessary to allow for evaluation of risks to human health, public welfare and the environment. The threshold for impacts is not a hard and fast number, but would depend on a number of site-specific factors. Typically the most conservative threshold criteria would be the lower of the levels protective of residential land use, background levels, or levels that could result in unacceptable contaminant transfers from soil to other media such as groundwater or air.

The number and locations of soil borings necessary to adequately characterize impacts at a site will vary from site to site depending on various factors; size of site, distribution of COCs, site hydrology and stratigraphy, exposure model, etc.

(c) Logging of Soil and Groundwater Monitoring Well Boreholes. A qualified professional – either by or under the supervision of a Professional Geologist (P.G.) or Professional Engineer (P.E.) – should log each soil boring to indicate depths correlating with changes in lithology (with lithologic descriptions), occurrence of groundwater, total depth, visual and olfactory observations, and other pertinent data such as a soil vapor screening reading. When a monitoring well is installed, as built diagrams with depth to groundwater indicated should be submitted for each well. A continuous soil profile from soil borings should be developed with detailed lithologic descriptions. Particular emphasis should be placed on characteristics that may control chemical migration and distribution such as zones of higher or lower permeability, changes in lithology, correlation between soil vapor concentrations and different lithologic zones, obvious areas of soil discoloration, organic content, fractures, and other lithologic characteristics.

Section 2-11 Distribution of Chemicals of Concerns in Groundwater

(a) Purpose. Adequate ground water samples should be collected to delineate the extent of dissolved contaminant plumes in all directions and to provide representative concentrations based on a site conceptual exposure model. Soil source delineation can serve as a guide in choosing monitoring well locations. An adequate number of groundwater samples should be collected to:

(1) Delineate the horizontal and vertical extent of dissolved groundwater COC plumes and non-aqueous phase liquids (NAPLs), and to identify the exposure domain for each receptor, pathway and exposure pathway combination,

(2) Allow calculation of representative COC concentrations for each exposure domain,
and

(3) Determine the status of the plume (increasing, stable or shrinking).

(b) Determination of Plume Stability. To assess plume stability, it is essential that groundwater monitoring be conducted for a period of time sufficient to show a reliably consistent trend in contaminant concentrations. Sampling and analysis of groundwater should be performed at a frequency and for parameters that are appropriate for site-specific conditions and are sufficient to enable assessment of contaminant trends, natural attenuation rates and seasonal or temporal variations in groundwater quality. Once cleanup levels are achieved, groundwater monitoring needs to continue for a period of time sufficient to ensure that residual subsurface contamination does not result in recontamination of groundwater above applicable maximum contaminant levels, or levels protective of other pathways, such as migration to surface water or indoor inhalation.

Groundwater monitoring for the purpose of evaluating plume stability may be conducted under a work plan approved by WRD if there is concern about the acceptability of the plan. Depending on site-specific data, statistical, graphical or other techniques may be used to demonstrate plume stability.

(c) Groundwater Sampling. If groundwater has been contaminated by COCs, direct push sampling methods or temporary sampling points may be used to screen for groundwater contamination and to assist in determining the optimal location of monitoring wells. Monitoring wells should utilize the following guidelines:

(1) An adequate number of monitoring wells should be installed to sufficiently delineate the horizontal and vertical extent of the dissolved and non-aqueous phase groundwater plume and the direction of groundwater flow.

(2) A sufficient number of monitoring wells should be installed to fully define the groundwater plume to levels protective of applicable exposure pathways.

(3) Well placement and design should consider the concentration of chemicals in the source area, the possible occurrence of both dense and light NAPLs at the site, presence of multiple water bearing zones, and groundwater flow direction.

(4) Well casing and screen materials should be compatible with the COCs to be monitored.

(5) Wells should be properly developed and the water level must be measured after installation.

(6) A land surveyor is the best qualified to conduct a site survey to establish well elevations and, by that, groundwater elevations. Accuracy should generally be to within plus or minus 0.01 foot relative to an established national geodetic vertical datum (NGVD) or some other

appropriate datum. Based on the groundwater elevations, groundwater flow direction and gradient should be determined and plotted on a site map.

(7) Appropriate geographic coordinates should be identified and documented.

Section 2-12 Distribution of Chemicals of Concern in the Vapor Migration to Indoor Air Pathway

For sites where soil or groundwater concentrations result in the exceedance of default cleanup standards for the vapor migration to indoor air pathway, additional tools and methodologies may be considered on a site-specific basis and implemented as appropriate. These methodologies include modeling, soil vapor monitoring, and/or foundation (crawl space and subslab)/indoor air sampling. For further details, refer to the most current version of USEPA's Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils. Soil vapor sampling and foundation/indoor air sampling methodologies would be included in a data collection work plan.

Section 2-13 Distribution of Chemicals of Concern in Sediments and Surface Waterbodies

When site investigation data or modeling shows or suggests that COCs may have migrated to a surface water body, surface water samples should be collected. If surface drainage pathways are suspected of having been impacted by any site contaminants, sediment (and surface water, if present) from those pathways should also be sampled.

Sediment analyses should include an analysis of sediment pore water to adequately characterize impacts in the hyporheic zone. Sampling must consider the representativeness of the samples with regard to the flow conditions. Water samples should be collected both upstream and downstream of each area where a discharge of contaminated groundwater is suspected.

If site investigation data shows or suggests that contaminated groundwater is discharging to surface water, sediment samples must be collected. The responsible party should compare the sediment sample data with sediment standards that are protective of human health and ecological receptors found in the default cleanup standards, or as part of a site-specific standard arrived at through the risk evaluation process described in Section 1.

Section 2-14 Background Soil and Water Concentrations

(a) Purpose. The objective of the Nez Perce Tribe's risk evaluation process is to identify and remediate chemical concentrations that exceed risk-based target levels and are related to site-specific activities. A key part of the site characterization is determining site-specific background concentrations of COCs.

Concentrations of chemicals in soil and ground water not directly related to site activities are considered background concentrations. For certain chemicals and in certain areas, the background concentrations may exceed the Tribe's default cleanup standards. If, upon presentation of the evidence, WRD determines that background chemical concentrations are definitively not related to site activities, then the responsible party will not need to remediate sites below the background concentrations. Thus, it is often necessary to distinguish between chemical concentrations attributable to current and past site activities and those attributable to other non-site related factors termed as background concentrations.

Technical issues associated with determining background concentrations include:

- (1) Identifying chemicals of concern,
- (2) Identifying media,
- (3) Selecting appropriate, representative background sampling locations,
- (4) Determining and following appropriate sampling procedures, and
- (5) Evaluating background concentrations using statistical analyses.

(b) Identification of Chemicals of Concern. COCs are determined based on knowledge of site history, site activities, and interviews with personnel who have direct knowledge of the site. Of these COCs, those that may have elevated background concentrations should be identified. Elevated background concentrations may be due to natural occurrence, such as the presence of certain metals in soil, or due to local anthropogenic activities, such as the historic use of pesticides in an agricultural area. Examples of potential elevated background concentrations include elevated concentrations of metals in mining areas, pesticides in agricultural areas, or chemicals in air due to emissions from automobiles, etc.

Thus, knowledge of site-specific activities, regional geology, and regional activities can help identify COCs for which background concentrations need establishing.

(c) Identification of Media. Depending on the media of concern at a site, background concentrations may have to be established for soil, surface water, sediments, ground water, and indoor and outdoor air. At large sites these media may have to be further subdivided; for example, different background concentrations may have to be established for shallow versus deep ground water. Similarly, soils may have to be divided into different zones or formations. Further background concentrations need to be established only for those zones and formations in which site concentrations exceed the default cleanup standards where the exceedance may be related to natural background or regional anthropogenic activities.

(d) Selection of Background Sampling Locations. Concentrations of naturally occurring

chemicals vary spatially and, in certain cases, temporally (e.g., diurnal variations in air concentrations, seasonal variations in sediment concentrations). Thus it may not be possible to establish a single background concentration at a site and it may be necessary to identify multiple sampling locations in each media and, in some cases, background measurements may have to be made over time. Due to spatial and temporal variability, it is often necessary to define a range of background concentrations for each chemical and in each relevant media, or use statistical analysis to establish a specific background concentration.

The location of background sampling points will depend on site-specific considerations. However, generally, background locations should be upgradient, upwind, upslope, or upstream of the site. Concentrations of COCs may be affected by factors such as pH, Eh, salinity, organic carbon content, soil texture, and cation exchange capacity. Thus, to the extent possible, background measurement points should be located where these factors are similar to site-specific factors, except at sites when hazardous waste site activities affect these parameters. At such sites, these factors should be measured concurrently with COCs.

(e) Determination of Appropriate Sampling Procedures. Sample collection, preservation, handling, and analytical analysis procedures for the background samples should be identical for the samples collected on site. All sampling analysis methods should follow standard EPA methods.

(f) Evaluation of Background Concentrations. Statistical analyses are often used to evaluate background concentrations. The objective of statistical analyses is to compare site media-specific concentrations with background concentrations to determine whether elevated site concentrations (those exceeding risk-based target levels) are due to site-specific activities or background concentrations. Several statistical procedures (t-tests, analysis of variance) are available depending on the number of data, underlying distribution, and variability in the measured concentrations, etc. The responsible party is encouraged to consult a statistician to design and review a sampling plan and have the plan approved by WRD prior implementing it. Additional acceptable information may be obtained from applicable EPA guidance.

Section 2-15 Data Quality

(a) Purpose. The risk evaluation process relies on site-specific data to make decisions related to the magnitude of site risk, nature and extent of remedial activity, and site-closure. Thus it is very important that data be reliable, representative, complete, and of known quality. In order to assure the data will be of appropriate quality, QA/QC activities should be applied throughout the site characterization and environmental data collection process.

(1) Elements of QA/QC include:

- (i) Using approved methodologies to collect data**
- (ii) Decontaminating field equipment as appropriate**

- (iii) Using EPA approved methods for laboratory analysis
- (iv) Including QA/QC samples, such as travel blanks, trip blanks, etc.

While the level of QA/QC applied to data collection efforts will vary (depending on factors such as site complexity, size of the release, and the immediacy of the response) all the elements of QA/QC described above that were used during a given data collection effort should be provided to WRD when reporting the results of environmental sampling. This will allow an adequate review of the quality of the data used in the analysis.

(2) Quality Assurance Project Plan. When a work plan is submitted to WRD for approval it should include a Quality Assurance Project Plan (QAPP). The QAPP integrates the appropriate technical and quality aspects of a project, including planning, implementation, and assessment. The purpose of the QAPP is to document planning for environmental data collection and to provide a project-specific “blueprint” for obtaining the type and quality of data needed for a specific decision or use. The QAPP documents the QA/QC procedures applied to various aspects of the project to assure that the data obtained are of the type and quality required. Documentation of all QA/QC efforts implemented during data collection, analysis, and reporting phases is important to data users, who can then consider the impact of these control efforts on data quality. Acceptable QAPP methodologies can be found from a brief literature review.

The QAPP is implemented during the data collection process. Problems can be identified and corrected at this stage. The impact of field and laboratory techniques and sampling and analysis conditions on data quality are determined using field and laboratory QC samples and periodic audits. Oversight and corrective action can prevent improper procedures or techniques from continuing.

Data verification, validation, and assessment should be performed to validate data quality and assess data quality and usability. Data verification and validation is particularly dependent on compliance with field and laboratory procedures for sample collection, identification, handling, preservation, chain of custody, shipping, analysis, and reporting.