ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 300

[EPA–HQ–SFUND–2010–1086; FRL–9925–69–OLEM]

RIN 2050–AG67

Addition of a Subsurface Intrusion Component to the Hazard Ranking System

AGENCY: Environmental Protection Agency (EPA).

ACTION: Proposed rule.

SUMMARY: The U.S. Environmental Protection Agency (EPA) is proposing to add a subsurface intrusion (SsI) component to the Hazard Ranking System (HRS) which is the principal mechanism that EPA uses to evaluate sites for placement on the National Priorities List (NPL). The subsurface intrusion component (this addition) would expand the number of available options for EPA and state and tribal organizations performing work on behalf of EPA to evaluate potential threats to public health from releases of hazardous substances, pollutants, or contaminants. This addition will allow an HRS evaluation to directly consider human exposure to hazardous substances, pollutants, or contaminants that enter regularly occupied structures through subsurface intrusion in assessing a site's relative risk, and thus, enable subsurface intrusion contamination to be evaluated for placement of sites on the NPL. The agency is not considering changes to the remainder of the HRS except for minor updates reflecting changes in terminology.

DATES: Comments must be received on or before April 29, 2016.

ADDRESSES: Submit your comments, identified by Docket ID No. EPA–HQ–SFUND–2010–1086, to the *Federal eRulemaking Portal: http://www.regulations.gov.* Follow the online instructions for submitting comments. Once submitted, comments cannot be edited or withdrawn. The EPA may publish any comment received to its public docket. Do not submit electronically any information you consider to be Confidential Business Information (CBI) or other information whose disclosure is restricted by statute. Multimedia submissions (audio, video, etc.) must be accompanied by a written comment. The written comment is considered the official comment and should include discussion of all points you wish to make. The EPA will generally not consider comments or comment contents located outside of the primary submission (*i.e.* on the Web, cloud, or other file sharing system). For additional submission methods, the full EPA public comment policy, information about CBI or multimedia submissions, and general guidance on making effective comments, please visit *http://www.epa.gov/dockets/commenting-epa-dockets.*

FOR FURTHER INFORMATION CONTACT: Terry Jeng, phone: (703) 603–8852, email: *jeng.terry@epa.gov,* Site Assessment and Remedy Decisions Branch, Assessment and Remediation Division, Office of Superfund Remediation and Technology Innovation (Mail Code 5204P), U.S. Environmental Protection Agency, 1200 Pennsylvania Avenue NW., Washington, DC 20460; or the Superfund Hotline, phone (800) 424–9346 or (703) 412–9810 in the Washington, DC metropolitan area.

SUPPLEMENTARY INFORMATION: The information presented in this preamble is organized as follows:

I. General Information

A. What is EPA seeking comment on?

EPA is proposing an addition of one new component to one part of the current Hazard Ranking System (HRS). No major structural changes to other parts of the HRS are proposed. EPA is seeking comments on the addition of the subsurface intrusion component to the HRS. Comments on unmodified parts of the HRS are not being requested and will not be considered if submitted.

B. How does this action apply to me?

This action proposes an addition to the HRS. The HRS is used for evaluating the relative potential risk posed by the uncontrolled release, or potential release, of hazardous substances to human health or the environment. This addition will enable EPA to identify risks posed by subsurface intrusion of hazardous substances into regularly occupied structures for all populations who live and work in areas where the subsurface environment may create exposures. The agency considers that including the evaluation of subsurface intrusion in the HRS serves the public interest by widening EPA's ability to evaluate these threats.

This proposed regulatory change expands the available options for EPA and organizations performing work on behalf of EPA (state and tribal partners) to evaluate potential threats to public health and the environment from subsurface intrusion contamination. State and tribal partners may receive financial assistance from EPA to evaluate sites through a Cooperative Agreement. EPA and states or tribes collaborate closely throughout the Cooperative Agreement process, particularly when identifying sites to be evaluated and establishing priorities for performing evaluations. As necessary, sites where subsurface intrusion threats exist may be evaluated using the HRS and, if warranted, proposed for placement on the NPL. EPA does not expect that this proposed change will result in additional site assessments being conducted per year or placement of more sites on the NPL per year. Rather, given potentially limited budgets and the possibility of increased costs for an SsI site assessment, EPA may conduct fewer assessments per year. The pipeline of sites will be reviewed to identify those sites that pose the highest risk and prioritized accordingly. This is not a change to how EPA currently evaluates and prioritizes sites for the NPL; EPA will simply have an additional mechanism to address sites that pose the greatest risk. Because assessing the worst sites first is a priority, EPA will continue to identify the sites posing the highest risk or potential risk and develop a strategy to assess those sites in a timely manner, while balancing their other site assessment needs.

The addition of a subsurface intrusion component to the HRS affirms that EPA is fulfilling its regulatory requirements by ensuring ''to the maximum extent feasible, that the hazard ranking system accurately assesses the relative degree of risk to human health and the environment posed by sites and facilities subject to review.'' 42 U.S.C. 9605(c)(1), as mandated by the Superfund Amendments and Reauthorization Act (SARA) amendments to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

This proposed addition is necessary because no present authority consistently and comprehensively addresses subsurface intrusion contamination across all non-federal potential sites, particularly when subsurface intrusion is the key exposure pathway. While most states have identified sites with subsurface intrusion contamination issues, not all states have subsurface intrusion programs, and states with subsurface intrusion remediation programs vary in their authority, resources, and remediation criteria. A redirection of resources available through Cooperative Agreement funding is expected to provide for greater national consistency in the identification and evaluation of subsurface intrusion sites.

Additionally, EPA finalized the OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air, in June 2015. This guide and this proposed addition to the HRS would further the agency's efforts to establish national consistency in evaluating vapor intrusion threats by enabling EPA to use remedial authority under CERCLA.

This proposed regulatory change does not affect the status of sites currently on or proposed to be added to the NPL.

II. Statutory Authority

The authority for these proposed technical modifications to the HRS (40 CFR 300, Appendix A) is in section 105(a)(8)(A) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) enacted in 1980. Under this law, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300) must include criteria for determining priorities among releases or threatened releases for the purpose of taking remedial or removal actions. In 1986, Congress passed the Superfund Amendments and Reauthorization Act (SARA) (Pub. L. 99 499), which added section 105(c)(1) to CERCLA, requiring EPA to amend the HRS to assure ''to the maximum extent feasible, that the hazard ranking system accurately assesses the relative degree of risk to human health and the environment posed by sites and facilities subject to review.'' Furthermore, CERCLA section 115 authorizes EPA to promulgate any regulations necessary to carry out the provisions of CERCLA.

III. Background

EPA is proposing this addition to protect human health from the threat posed by subsurface intrusion. By adding this component to the HRS, EPA will be able to consider subsurface intrusion threats when evaluating sites for placement on the NPL and implement the requirements of CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This proposed addition is a technical modification to the current HRS that will allow EPA and its partners to more comprehensively address the releases of hazardous substances into the environment.

A. Why is EPA proposing an addition to the Hazard Ranking System?

Contaminant subsurface intrusion [1] is defined as the migration of hazardous substances, pollutants, or contaminants [2] from the subsurface environment, or more specifically, the surficial ground water into overlying structures and/or the unsaturated zone. Subsurface intrusion can result in people being exposed to harmful levels of hazardous substances and cause negative health effects. While subsurface intrusion can take multiple forms, the most common form of subsurface intrusion is vapor intrusion. There are several reasons why EPA is proposing this addition to the HRS.

First, the current HRS (40 CFR 300, Appendix A), promulgated December 14, 1990 (hereafter referred to as the current HRS), discussed in more detail in section IV of this preamble, does not consider the threat posed by subsurface intrusion in its evaluation of relative risk posed by a site; therefore, it does not provide a complete assessment of the relative risk that a site may pose to the public. The existing pathways used to evaluate threats posed by hazardous substances do not include those entering a regularly occupied structure from the subsurface. For example, the ground water migration pathway evaluates the threat posed by

[1] *Subsurface intrusion, for the purposes of this preamble, refers to the intrusion of hazardous substances from the subsurface into a structure.*

[2] *For the purpose of this preamble, the term ''hazardous substances, pollutants or contaminants'' will be referred to simply as ''hazardous substances.'' See section 1.1, of the current HRS for the definition of a hazardous substance.*

contaminated ground water if there is an indication that ground water is being consumed. Similarly, the soil exposure pathway evaluates the threat posed by contaminated surfaces (*e.g.,* surface soils) if there is an indication of human exposure. The air migration pathway considers the threat posed by hazardous substances released to atmospheric air (ambient air), but does not address indoor air, and has no subsurface component. The surface water migration pathway does not cover subsurface intrusion as it only considers the threat posed by contaminated surface water bodies.

In fact, in a May 2010 report,[3] the Government Accountability Office (GAO) concluded that if vapor intrusion sites ''are not assessed and, if needed, listed on the NPL, some seriously contaminated hazardous waste sites with unacceptable human exposure may not otherwise be cleaned up.'' The GAO recommended that EPA consider vapor intrusion as part of the NPL process; EPA agreed with the GAO recommendation. With the addition of a subsurface intrusion component, a site with vapor intrusion may qualify for the NPL, whereas presently the site may not have qualified using the threats evaluated in the current HRS. Therefore, without this addition, EPA may not be identifying the sites that most warrant further investigation.

Second, EPA is offering this proposal because of the substantial public support for this action. EPA conducted outreach activities to determine the level of interest and support from the public. This included a Notice of Opportunity for Public Input (76 FR 5370, January 31, 2011) and four public listening sessions held across the country. More than 40 written comments, from a diverse group of private citizens, businesses, states, American Indian tribes, environmental action groups, and other governmental agencies, were received during the public comment period. Of the public who attended the listening sessions and provided comments, the majority were supportive of the addition of a subsurface intrusion component to the HRS. In addition, five states and two tribes submitted comments—all in support of the addition. The Association of State and Territorial Solid Waste Management Officials (ASTSWMO) compiled and presented input from 14 states—all but one favoring the addition of subsurface intrusion to the HRS. The comments opposing the HRS addition were, in general, from industry representatives.

Third, to support development of this proposal, EPA evaluated the need for this proposed addition to the current HRS by identifying the scope of the subsurface intrusion contamination problem. These efforts to identify and classify sites that may pose a subsurface intrusion threat have resulted in the identification of 1,073 sites that may or may not qualify for the NPL but are suspected of having vapor intrusion issues. Many of the sites in this inventory are currently listed in EPA's Superfund Enterprise Management System[4] (SEMS). Of the 1,073 identified sites:

- 328 sites are identified as having a suspected subsurface intrusion threat based on SEMS and Agency for Toxic Substances and Disease Registry (ATSDR) key word searches, as well as EPA or state self-identification, but for which no sampling data were obtained
- 532 sites are identified as having characteristics or evidence that indicate subsurface intrusion (*e.g.,* volatile hazardous substance in ground water) may have occurred or will occur.
- 202 sites are identified as having a subsurface intrusion threat documented by subslab, crawl space, or indoor air samples but insufficient HRS-required evaluation factors to qualify for the NPL.
- 11 sites are identified as having a subsurface intrusion threat with documented actual exposure of a sufficient number of targets and sufficient other HRS-required evaluation factors to suggest the site may qualify for the NPL.

EPA is also considering sites with another form of subsurface intrusion, namely, intrusion of contaminated ground water into regularly occupied structures—which is an emerging issue. For example, a site was discovered where shallow (surficial) ground water contaminated with chromium had intruded into residential basements and after the water receded, or evaporated, a precipitate of chromium remained as a residue. The presence of this residue posed a significant threat to public health; however, the site could not be evaluated under the current HRS due to the lack of a mechanism to evaluate human exposure resulting from intrusion of contaminated ground water (subsurface intrusion contamination). The only viable option to place the site on the NPL was to rely on ATSDR to make a determination that the exposure at the site posed a significant threat to public health. The decision to include sites on the NPL based on a determination by the ATSDR is made infrequently because the HRS is the primary mechanism for placing a site on the NPL.

EPA regional site assessment programs have identified 7 additional sites where intrusion of contaminated ground water is a potential issue and the related threat cannot be evaluated using the current HRS. Under the proposed SsI addition, ground water intrusion would be evaluated using current conditions, which may involve situations where metals have precipitated from water or where volatile substances have entered a structure via infiltrating ground water.

As EPA further explores this emerging issue, the agency considers it likely that other ground water intrusion sites requiring evaluation will be identified. The inventory of sites, identified by EPA, with a possible threat from contaminated vapor or ground water intruding into overlying regularly occupied structures is not representative of the magnitude of the potential scope of sites with subsurface intrusion contamination. EPA identified these sites based on currently available information to initially assess the subsurface intrusion problem. In the case of vapor intrusion, certain states undertook comprehensive efforts to identify and evaluate subsurface intrusion threats, which resulted in the identification of a proportionately higher number of sites with potential vapor intrusion problems in those states. In the case of ground water intrusion, the issue is still emerging. For these reasons, EPA recognizes that a degree of inherent uncertainty is associated with compiling an inventory of sites with potential subsurface intrusion problems and that additional analysis is necessary, especially in cases where little information exists. See Appendix A of the Technical Support Document for this proposed addition (Proposal TSD) for the inventory of vapor intrusion sites. As additional information is gathered and new sites are added to SEMS and undergo the site assessment process, the number of sites with subsurface intrusion threats is likely to change. Nevertheless, the aforementioned illustrates that there currently exists at least 1,073 sites that have significant actual or potential human exposure due to subsurface intrusion, but because of the shortcomings of the current HRS, cannot be evaluated to determine if they warrant addition to the NPL.

[3] *EPA's Estimated Costs to Remediate Existing Sites Exceed Current Funding Levels, and More Sites are Expected to Be Added to the National Priorities List, GAO Report to Congressional Requesters, GAO–10–380, May 2010.*

[4] *This information was previously stored in a predecessor database called the Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS).*

It is also important to emphasize that the inventory of sites compiled (where subsurface intrusion has been identified as a possible issue) does not represent a list of sites that will be placed on the NPL. EPA recognizes that, in many instances, additional information is needed to verify the presence, and to determine the nature/extent, of a subsurface intrusion problem. As such, the inventory should not be considered a list of NPL candidate sites. EPA notes that less than 5% of all sites evaluated through the site assessment process are actually added to the NPL. This percentage is not expected to change significantly with this addition to the HRS.

Finally, EPA has concluded that for non-federal facilities no other national program is able to consistently and comprehensively evaluate and, if warranted, address subsurface intrusion contamination. This topic is further discussed in section V.A.2 of this preamble.

B. What is the history of the hazard ranking system?

In 1980, Congress enacted CERCLA (42 U.S.C. 9601 *et seq.*), commonly called Superfund, in response to the dangers posed by uncontrolled releases of hazardous substances into the environment. To implement section 105 (a)(8)(A) of CERCLA and Executive Order 12316 (46 FR 42237, August 20, 1981), EPA revised the NCP on several occasions, with the most recent comprehensive revision occurring on March 8, 1990 (55 FR 8666). The NCP sets forth the guidelines and procedures needed for responding to releases, or potential releases, of hazardous substances. Section 105(a)(8)(A) of CERCLA required EPA to establish:

> [C]riteria for determining priorities among releases or threatened releases [of hazardous substances] throughout the United States for the purpose of taking remedial action and, to the extent practicable, taking into account the potential urgency of such action, for the purpose of taking removal action. Criteria and priorities . . . shall be based upon relative risk or danger to public health or welfare or the environment . . . taking into account to the extent possible the population at risk, the hazard potential of hazardous substances at such facilities, the potential for contamination of drinking water supplies, the potential for direct human contact [and] the potential for destruction of sensitive ecosystems. . . .

To meet this requirement and provide criteria to set priorities, EPA adopted the HRS as Appendix A to the NCP (47 FR 31180, July 16, 1982). The HRS was last revised on December 14, 1990 (55 FR 51532) to include the evaluation of additional threats to ensure a complete assessment of the relative risk that a site may pose to the public. The HRS is a scoring system used to assess the relative risk associated with actual or potential releases of hazardous substances from a site based on the information that can be collected in a limited, typically one to two day site inspection (SI). The HRS is designed to be applied consistently to each site, enabling sites to be ranked relative to each other with respect to actual or potential hazards. As EPA explained when it originally adopted the HRS, ''the HRS is a means for applying uniform technical judgment regarding the potential hazards presented by a facility relative to other facilities. It does not address the feasibility, desirability, or degree of cleanup required.''[5] (47 FR 31220, July 16, 1982).

Section 105(a)(8)(B) of CERCLA requires that the statutory criteria described in section 105(a)(8)(A) be used to prepare a list of national priorities among the known releases, or threatened releases throughout the United States. The list, which is Appendix B of the NCP, is the NPL.

The HRS is a crucial part of the agency's program to address the identification and cleanup of actual and potential releases of hazardous substances because the HRS score is the primary criterion for determining whether a site is to be included on the NPL. The NPL (Appendix B to 40 CFR 300) includes those sites that emerge as potentially posing the most serious threats to public health and the environment and may warrant remedial investigation and possible cleanup under CERCLA. Only sites on the NPL are eligible for Superfund-financed remedial actions. Removal and enforcement actions can be conducted at any site, whether or not it is on the NPL.

In 1986, Congress passed the Superfund Amendments and Reauthorization Act (SARA) (Pub. L. 99 499), which added section 105(c)(1) to CERCLA, requiring EPA to amend the HRS to assure ''to the maximum extent feasible, that the hazard ranking system accurately assesses the relative degree of risk to human health and the environment posed by sites and facilities subject to review.'' The HRS was previously amended in 1990. This proposed action will amend the HRS to add a subsurface intrusion component to the evaluation.

[5] *Although the HRS is designed to assess the relative risk of a site compared to other sites, it is not designed to be used as a site-specific quantitative risk assessment. Such an assessment is conducted later in the Superfund process, as necessary.*

C. What is the impact of this proposed rule?

1. Impact on Current Cleanup Programs, Resources and Cost

This proposed addition to the HRS will have the most significant impact on EPA's Superfund cleanup program. The current HRS considers releases to the ground water, surface water and air, as well as direct exposure to contamination such as soil in identifying releases which warrant further investigation. If promulgated, this proposed rule will not impact the way the current HRS addresses these releases. However, in the course of present HRS assessments, sometimes subsurface intrusion issues are coincident with a ground water or soil contamination problem. The HRS presently does not consider the threat posed at sites by subsurface intrusion problems and direct human exposure, when ground water is not being used as a drinking water source or surficial soils are not contaminated. If promulgated, this proposed rule will for the first time allow the EPA site assessment program to address sites with only subsurface intrusion issues and no coincidental exposure. When hazardous substances are released and enter the subsurface environment, they can move from the subsurface into buildings as a gas, vapor, or liquid. The addition of a subsurface intrusion component to the HRS would enable EPA to directly evaluate at sites the relative degree of risk posed by human exposure to hazardous substances that enter regularly occupied structures through the subsurface environment.

To the extent practicable, EPA attempts to score all pathways that pose significant threats. If the contribution of a pathway is minimal to the overall score, in general, that pathway will not be scored. This proposed regulatory change would expand available options for EPA and organizations performing work on behalf of EPA (state and tribal partners) to evaluate potential threats to public health and the environment from hazardous waste sites. This modification to the HRS, by itself, only augments the criteria for applying the HRS. EPA also does not expect this proposed rulemaking to affect the status of sites currently on or proposed to the NPL. Sites that are currently on or proposed to the NPL have already been evaluated under another pathway (*i.e.,* ground water migration, air migration, surface water migration, or soil exposure) and, consistent with section 105(c)(3) of CERCLA, as amended, would not be re-evaluated. Proposal of this addition also will not disrupt EPA's listing of sites.

Because federal agencies currently address subsurface intrusion issues as part of their environmental programs, it is unlikely that a significant number of sites will be added to the NPL. However, it could lead to an increase in site assessment activities and related costs. Executive Order 12580 delegates broad CERCLA authority to federal agencies for responding to actual and potential releases of hazardous substances where a release is either on, or the sole source of the release is from, any facility or vessel under the jurisdiction, custody, or control of the federal agency. Federal agencies are required to exercise this authority consistent with the requirements of CERCLA section 120, as amended, and implement regulations under the NCP, for both NPL and non-NPL sites. Therefore, federal agencies are in a position to proactively identify and respond to risks posed by subsurface intrusion of hazardous substances into regularly occupied structures for all populations who live and work in areas where the subsurface environment may create exposures. If it is determined that releases of hazardous substances pose immediate threats to public health and the environment, EPA fully expects that the appropriate federal agency will continue to undertake response actions to address such threats. In fact, some federal agencies, including EPA, have developed or are developing new or updated agency-specific policy and guidance documents to address subsurface intrusion threats.

This proposed addition will impact both resources and costs to federal cleanup programs. EPA does not expect that this proposed change will result in additional site assessments being conducted per year or placement of more sites on the NPL per year. Rather, given potentially limited budgets and the possibility of increased costs for a subsurface intrusion (SsI) site assessment, EPA may conduct fewer assessments per year. The pipeline of sites will be reviewed to identify those sites that pose the highest risk and prioritized accordingly. This is not a change to how EPA currently evaluates and prioritizes sites for the NPL; EPA will simply have an additional mechanism to address sites that pose the greatest risk. Because assessing the worst sites first is a priority, EPA will continue to identify the sites posing the highest risk or potential risk and develop a strategy to assess those sites in a timely manner, while balancing their other site assessment needs.

The proposed addition, which could lead to the inclusion of a site on the NPL, does not itself impose any costs on outside parties; it does not establish that EPA will necessarily undertake response actions, nor does it require any action by a private party or determine liability for site response costs. Costs are limited to screening relevant sites for subsurface intrusion contamination during site inspections and the resulting HRS evaluation and documentation record preparation. Costs that arise from site remedial responses are the result of site-specific decisions made post-listing, not directly from the act of listing itself.

Later decisions that consider information collected under the proposed addition could separately have specific economic costs and benefits (*e.g.,* remediation costs and reduced risk), but these impacts are contingent upon a series of separate and sequential actions after listing a site on the NPL. The addition of subsurface intrusion to the HRS is several regulatory steps removed from imposing costs on private entities.

The HRS addition may increase the costs to government agencies conducting assessments at subsurface intrusion sites because the scope of a typical site inspection may need to be expanded or may require more expensive sampling to collect information for an SsI evaluation. SsI sampling may require additional sampling and different sample types than those collected at other sites. This may result in an increase in some site assessment costs at some sites with possible subsurface intrusion issues. However, SsI site assessment costs at some other sites may be comparable to, or even less than, sites scored under the existing HRS. For example, a site assessment requiring sampling of deep ground water monitoring wells under the existing HRS may cost as much as, or more, than sampling conducted at sites with possible subsurface intrusion issues. The exact cost of any sampling at a site, including sites with possible SsI issues, varies greatly based on site-specific factors (*e.g.,* number and type of samples required, difficulty in establishing sources of contamination or attribution of releases, number of HRS pathways being evaluated, and availability of data from previous sampling events). Additionally, any newly increased costs to government agencies conducting assessments at SsI sites are expected to be minimal because federal agencies should already be identifying and addressing subsurface intrusion as part of their environmental programs. Any increase in the cost of site assessments conducted by EPA for SsI sites will require EPA to realign and prioritize its site assessment budget to address sites with subsurface intrusion. The addition of an SsI component to the HRS is not expected to result in additional site assessment funding to account for any increase in site assessment costs. Instead, the pipeline of sites will continue to be reviewed under the current site assessment process. If it is found that SsI-contaminated sites potentially pose a greater risk than other sites, then these sites will be prioritized over other sites. EPA will develop a strategy to assess these sites in a timely manner, while balancing other site assessment needs.

2. Children's Environmental Health and Environmental Justice

This rulemaking is not subject to Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks because this rulemaking is expected to only have moderate costs[6] and this executive order only applies to significant rulemakings. EPA has also found that this rulemaking will have no direct impact on communities considered under Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.

Although the rule will not have any direct impact on human health or risk within minority or low-income populations located near potential SsI sites, populations of concern under Executive Order 12898, EPA did consider whether the proposed action might have contingent impacts on these communities if future actions affect remediation of these sites. This analysis concluded that potentially affected sites are located in areas that have slightly higher concentrations of minority populations and populations below the poverty line than surrounding areas. Therefore, any future actions addressing risks in these communities would not contribute to disproportionate adverse impacts on human health.

IV. Hazard Ranking System

A. Purpose

The current HRS serves as a screening tool to evaluate the potential for uncontrolled hazardous substances to cause human health problems or environmental damage at one site relative to other sites evaluated. The pre-remedial portion of the Superfund

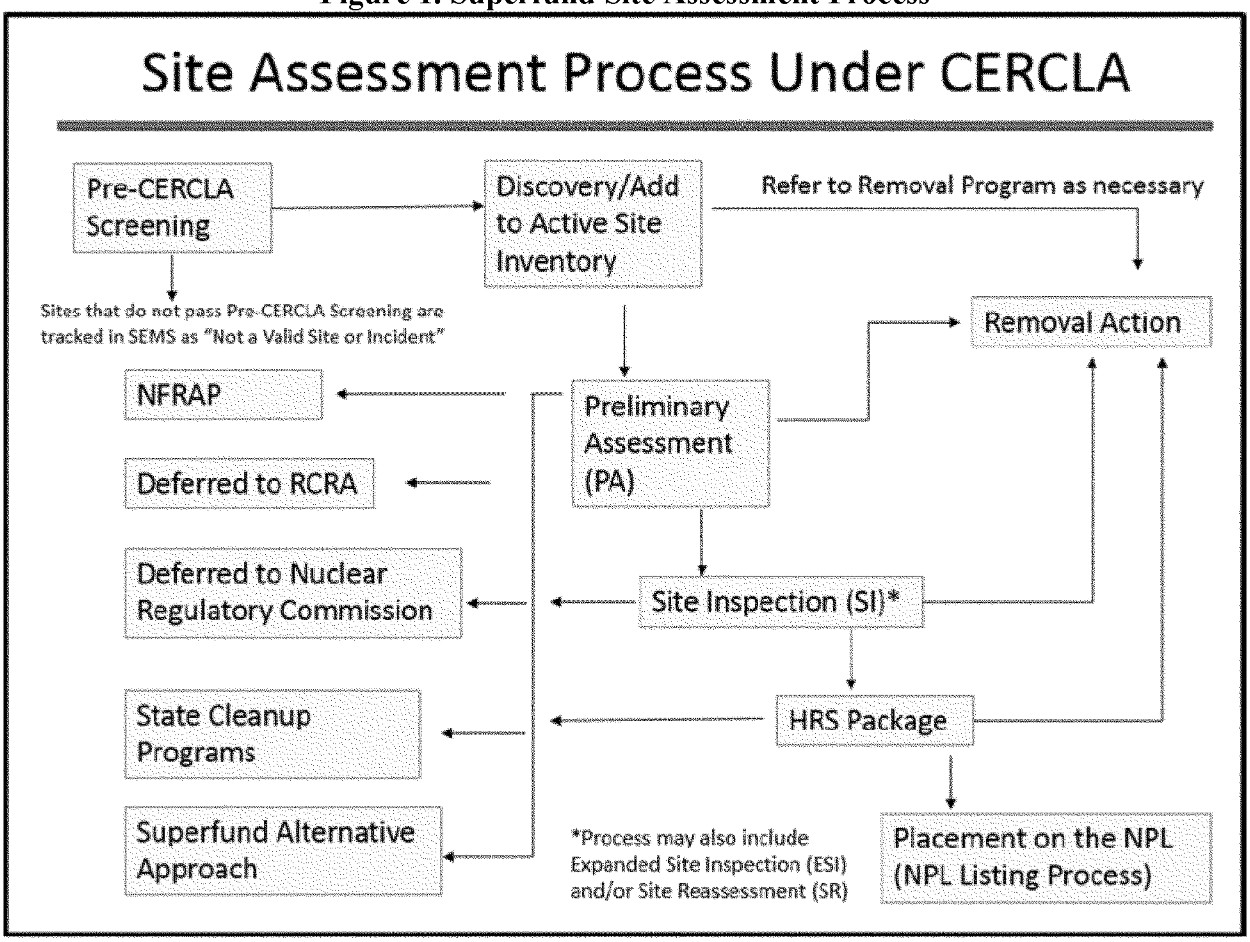
[6] *The regulatory impact analysis (RIA) found this rulemaking will only have moderate costs and will not be a significant rulemaking. The RIA for this rulemaking can be found in the official Docket for this action.*

program—the portion prior to placing sites on the NPL—is intended to identify those sites which warrant further investigation and possible cleanup under CERCLA. (See Figure 1 for a general depiction of the Superfund Site Assessment process.) During Pre-CERCLA screening, which is the first step of the pre-remedial process, EPA determines if there is indication of a possible significant release. If so, EPA determines if a substance in the release is regulated by CERCLA, whether it is already being addressed, and whether any statutorily mandated limitations on CERCLA response may exist. If EPA determines the release meets these requirements, then the suspected release is listed in EPA's Superfund Enterprise Management System (SEMS).

Determining whether hazardous substances, pollutants, or contaminants can be addressed by CERCLA requires the application of site-specific facts to CERCLA statutory requirements and EPA policy. One such statutory requirement is CERCLA's limit on response actions to some naturally occurring substances. CERCLA expressly limits any response actions taken in response to a release, or threat of release, of a naturally occurring substance in its unaltered form from a location where it is naturally found, from products which are part of a structure, or into drinking water supplies due to deterioration of the system. (See CERCLA section 104(a)(3) and 104(a)(4) for additional guidance on limitations on response and exception to limitations). Therefore, even though a naturally occurring substance in its unaltered form may potentially be regulated by CERCLA, the response actions taken in response to these releases, or threat of releases, may be expressly limited by CERCLA. For example, although radon and asbestos may qualify as a CERCLA hazardous substance, CERCLA section 104(a)(3) may limit responses to releases of radon or asbestos in some situations where the release is from building products or occurs from in situ natural sources, but section 104(a)(4) identifies specific circumstances that, if present, would allow CERCLA response in such situations. (See also EPA OSWER Directive 9360.3–12, Response Actions at Sites with Contamination Inside Buildings, August 12, 1993). If EPA finds an eligible release of a CERCLA eligible substance and response actions are permissible under CERCLA, then EPA proceeds to address the release under CERCLA. This may include a preliminary assessment.

A preliminary assessment uses readily available data to determine if there is evidence of an unacceptable potential threat. If based on the results of a preliminary assessment, EPA determines that a site warrants further screening under the CERCLA remedial program, the agency initiates a site inspection as specified in the NCP (40 CFR 300.420). The site inspection usually includes the collection of samples for chemical analysis. Such samples aid in ascertaining what substances are present at the site and whether they are being released. The purpose of the site inspection is to determine if there is an actual or potential threat to human health or the environment, to determine if there is an immediate threat to people or the environment in the area, and to collect sufficient data to enable the site to be scored using the HRS.

Figure 1. Superfund Site Assessment Process



EPA has designed the Superfund program to focus its resources on sites that warrant further investigation. Consequently, the initial studies, the preliminary assessment and site inspection, which are performed on a large number of sites, are relatively modest in scope and cost compared to the remedial investigations and feasibility studies subsequently performed on NPL sites. Because of the need to carry out the initial studies expeditiously, EPA elected to place certain constraints on the data requirement for an HRS evaluation. The required HRS data should be information that, for most sites, can be collected during a screening level site inspection or that are already available. Thus, the HRS does not rely on data that require extensive sampling or repeated sampling over a long period of time. The HRS has also been designed so that it can be applied consistently to a wide variety of sites. The HRS is not a tool for conducting quantitative risk assessment and was designed to be a measure of relative risk among sites rather than absolute risk at an individual site.

The narrow technical modifications being proposed reflect the agency's actions to encompass additional risks posed by releases of hazardous substances and to address the SARA statutory requirement that EPA amend the HRS to assure ''to the maximum extent feasible, that the HRS accurately assesses the relative degree of risk to human health and the environment posed by sites subject to review.'' Thus, the fundamental purpose and structure of the HRS approach will not be changed when the HRS is amended to include consideration of subsurface intrusion.

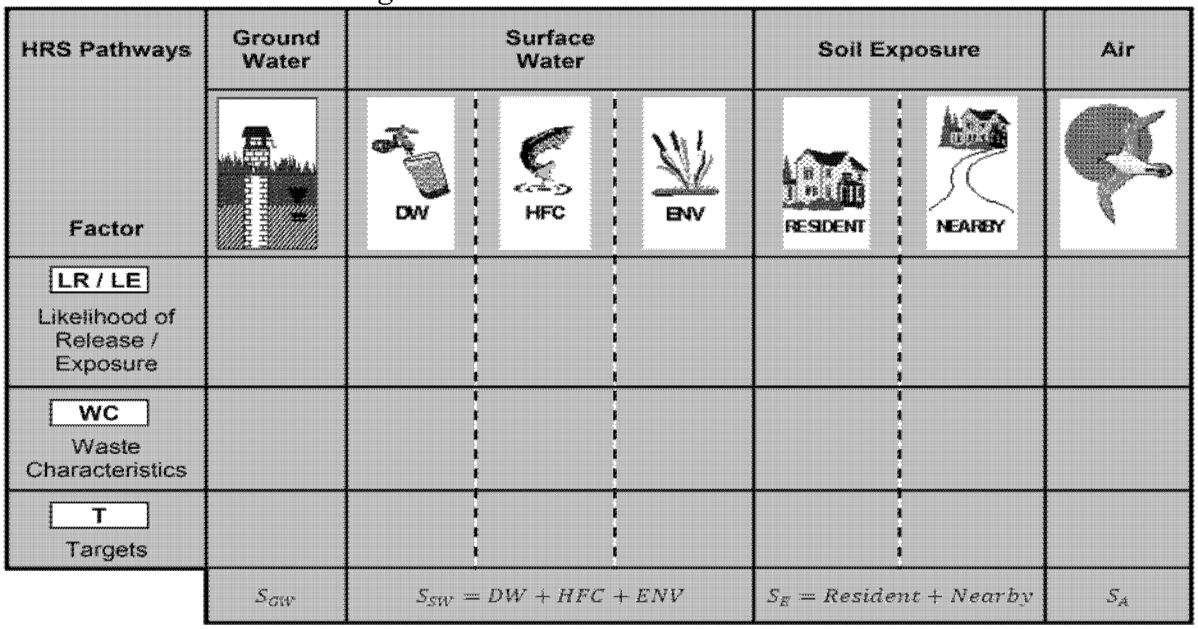
B. Structure

The current HRS (40 CFR 300, Appendix A) evaluates four pathways in projecting the relative threat a site poses:

- The ground water migration pathway evaluates the likelihood that hazardous substances will migrate to ground water and contaminate aquifers and drinking water wells that draw on those aquifers.
- The surface water migration pathway evaluates the likelihood that hazardous substances can enter surface water and affect people or the environment. Threats to human health and the environment included in this pathway include drinking water (DW), the human food chain (HFC) (*i.e.,* hazardous substances accumulate in the aquatic organisms that humans in turn consume), and sensitive environments (ENV). The surface water migration pathway is also divided into two ''components'' reflecting different mechanisms for contaminant transport within each component (*i.e.,* overland/flood migration to surface water component and ground water to surface water migration component).
- The air migration pathway evaluates the likelihood of release of hazardous substances into the atmosphere and the number of people and sensitive environments actually or potentially exposed to hazardous substances carried in the ambient (outdoor) air, including gases and particulates. The air migration pathway does not evaluate releases to indoor air originating from the subsurface.
- The soil exposure pathway evaluates the potential threats to humans and terrestrial environments posed by direct, physical contact with, and subsequent ingestion of, hazardous substances. This pathway includes threats to people living on property where hazardous substances are present in the surface/subsurface, including contaminated soils (resident population threat), and to people living nearby with access to the contaminated area (nearby population threat).

Figure 2 illustrates the general structure of the current HRS.

Figure 2. Structure of the Current HRS



Ground Water Migration Pathway Score (S_{GW})

Surface Water Migration Pathway Score (S_{SW})

Soil Exposure Pathway Score (S_{SE})

Air Migration Pathway Score (S_A)

The scoring system for each pathway is based on a number of individual factors associated with risk-related conditions at the site. These factors are grouped into three factor categories as discussed below. These categories include factors that are used to characterize the relative risk at the site.

1. Likelihood of release/exposure (*i.e.,* likelihood that hazardous substances have been released or potentially could be released from a source into the environment, or that people or sensitive environments could come into contact with hazardous substances).

2. Waste characteristics (*i.e.,* toxicity, mobility, and/or persistence of the substances in the environment and the quantity of the hazardous substances that have or could be released).

3. Targets (*i.e.,* people or sensitive environments actually or potentially exposed to the release).

An HRS score is determined for a site by summing the score for the four pathways. Specifically, the score for each pathway is obtained by evaluating a set of factors that characterize the potential of the release to cause harm via that pathway. The factors, which represent toxicity of the hazardous substance, or substances, at a site, waste quantity, and population are multiplied by a weighting factor, yielding the factor value; the factor values are used to assign factor category values. The factor category values are then multiplied together to develop a score for the pathway being evaluated. Finally, the pathway scores are combined according to the root-mean-square equation presented below to determine the HRS score for the site. See also Table 2–1 of the proposed addition (section 2.1.2) for additional discussion regarding the method for calculating an HRS site score.

$$S = \sqrt{\frac{S_{gw}^2 + S_{sw}^2 + S_{se}^2 + S_a^2}{4}}$$

S = site score
Sgw = ground water migration pathway score
Ssw = surface water migration pathway score
Sse = soil exposure pathway score
Sa = air migration pathway score

By using this formula to assign a site score, the HRS score will be low if all pathway scores are low. However, the final score can be relatively high if one pathway score is high. This approach was chosen to ensure that the site scores do not deemphasize single-pathway problems, underestimating their importance. EPA considers this an important requirement for the HRS scoring methodology because some extremely dangerous sites pose threats through only one pathway. For example, leaking drums of hazardous substances can contaminate drinking water wells, but if the drums are buried deeply enough and the hazardous substances are not very volatile, they may not release any hazardous substances to the air or to surface water.

It should be emphasized that the existing pathways can address subsurface contamination if it enters into ground water (in the ground water migration pathway), if it enters into surface water (in the surface water migration pathway), if it enters into ambient air (in the air migration pathway) from the soil surface or if it leads to surface soil contamination (in the soil exposure pathway). However, none of these scenarios address intrusion from the subsurface into regularly occupied structures.

Finally, it should also be emphasized that the HRS score does not represent a specific level of risk at a site. Rather, the score serves as a screening-level indicator of the relative risk among sites reflecting the hazardous substance releases or potential releases at sites based on the criteria identified in CERCLA.

V. Approach to HRS Addition

The following sections detail EPA's comprehensive approach to the consideration of exposures to hazardous substances due to subsurface intrusion and the relevant scientific and technical considerations in developing this proposed rule.

A. General Approach

1. What is the need for regulatory action on the HRS?

Without an evaluation of threats posed by subsurface intrusion contamination, the HRS is not a complete assessment and omits a known pathway of human exposure to contamination. EPA considers the addition of subsurface intrusion to the HRS to be consistent with CERCLA section 105 because it will improve the agency's ability to identify sites for further investigation and will enhance EPA's ability, in dialogue with other federal agencies and the states and tribes, to determine the most appropriate state or federal authority to address sites. As is currently the case, EPA often defers to other state and federal cleanup authorities based on the site assessments and HRS evaluations. While some states/tribes have programs to address subsurface intrusion contamination, they often have limited authority and resources, and variable remediation criteria. The availability of the federal remedial authority and the more comprehensive site assessment program should complement and strengthen these programs.

Other EPA programs such as the Resource Conservation and Recovery Act (RCRA) and the Brownfields program have limited authority and ability to address all subsurface intrusion threats. The RCRA Corrective Action/Enforcement is only applicable at sites subject to RCRA permitting or sites reachable by RCRA's enforcement activities. Furthermore, RCRA is a state delegated program and not all states recognize subsurface intrusion as a significant issue, and those that do may have variable remediation criteria. RCRA sites with subsurface intrusion issues may not be addressed in all states. Also, governmental entities with site-specific Brownfields assessment and/or revolving loan fund cleanup may only use grant funds on the selected eligible property. While subsurface intrusion sites may be eligible for Brownfields cleanup grants, site or property-specific limitations may not allow for permanent remediation where multiple properties may be involved or where Brownfields grant funds, as limited by statute, may not be adequate to fund long-term cleanups.[7]

EPA's removal program has the ability to quickly respond to immediate threats to public health and the environment from the release of hazardous substances, such as subsurface intrusion into a structure through a removal action. A removal action can be implemented regardless of NPL status to eliminate or reduce the threat of a release, or a potential release, of hazardous substances, pollutants or contaminants that pose an imminent and substantial danger to public health. However, removal actions are not intended to necessarily serve as a method for dealing with long term issues such as ground water contamination. Generally, EPA considers vapor intrusion mitigation systems as ''interim'' or ''early'' response actions to promptly reduce threats to human health. Installation of vapor intrusion mitigation systems addresses temporary human health problems, but fails to address the source of the problem.

The NCP expresses the preference for response actions that eliminate or substantially reduce the level of contamination in the source medium to acceptable levels, thereby achieving a permanent remedy. U.S. EPA, *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air,* OSWER Publication 9200.2–154, June 2015. OSWER's VI guidance states:

> The preferred long-term response to the intrusion of vapors into buildings is to eliminate or substantially reduce the level of contamination in the subsurface vapor source (*e.g.,* groundwater, subsurface soil, sewer lines) by vapor-forming chemicals to acceptable-risk levels, thereby achieving a permanent remedy. Remediation of the groundwater plume or a source of vapor-forming chemicals in the vadose zone will eventually eliminate potential exposure pathways and can include the following actions, among others: removal of contaminated soil via excavation; removal of contaminated groundwater with pump-and-treat approaches; decontaminating and/or rehabilitating sewer lines that harbor vapor-forming chemicals; and, treatment of contaminated soil and groundwater in situ, using technologies such as soil vapor extraction, multiphase extraction, and bioremediation, or natural attenuation.

In the case of vapor intrusion resulting from a subsurface contaminant plume, failing to address the source of contamination and the resulting plume may result in an increased exposure to individuals due to migration and expansion of the plume over time. In this instance, individuals in regularly occupied structures that were previously unaffected by the plume may become negatively impacted by subsurface intrusion. Additionally, a subsurface contaminant plume in a lesser-developed area has the potential to impact future development if left untreated.

There are several other concerns related to only addressing subsurface intrusion problems with a vapor mitigation system. The first concern is that vapor mitigation systems require ongoing monitoring and maintenance throughout the life of the system. Periodic inspections of the vapor mitigation system are necessary to make sure it is operating as designed. Over time the system can degrade, and maintenance will also be necessary, such as replacing the fan in an active sub-slab depressurization system. Non-mechanical failures of the system can occur as well, such as, electric power failure, turning off the fan or ignoring a damaged system.

A vapor intrusion mitigation system is a tool for protecting human health, but may not contribute to the Superfund program's goal of cleaning up uncontrolled hazardous waste sites. Furthermore, EPA still lacks a mechanism to assess human health hazards from vapor intrusion in the current HRS model, and therefore cannot currently evaluate the threat of vapor intrusion as part of its ranking of sites for placement on the NPL.

Under the Superfund remedial program for NPL sites, subsurface intrusion is only addressed at sites placed on the NPL based on threats from other pathways. That is, subsurface intrusion issues are addressed later in the remedial process after placement on the NPL. For example, this may be done as part of EPA's five-year review process. Sites with only subsurface intrusion issues are not being included on the NPL due to the lack of a subsurface intrusion component in the HRS. Therefore, many sites, especially those not evaluated under another HRS pathway or those not scoring high enough under another HRS pathway,

[7] *EPA's Estimated Costs to Remediate Existing Sites Exceed Current Funding Levels, and More Sites are Expected to Be Added to the National Priorities List, GAO Report to Congressional Requesters, GAO–10–380, May 2010.*

may not be addressed for threats due to subsurface intrusion because they may not qualify for placement on the NPL. As the Government Accountability Office (GAO) states in its May 2010 report:

EPA may not be listing some sites that pose health risks that are serious enough that the sites should be considered for inclusion on the NPL. While EPA is assessing vapor intrusion contamination at listed NPL sites, EPA does not assess the relative risks posed by vapor intrusion when deciding which sites to include on the NPL. By not including these risks, states may be left to remediate those sites without federal assistance, and given states' constrained budgets, some states may not have the ability to clean up these sites on their own . . . However, if these sites are not assessed and, if needed, listed on the NPL, some seriously contaminated hazardous waste sites with unacceptable human exposure may not otherwise be cleaned up.

EPA proposes the addition of the subsurface component to ensure the HRS does not omit this known pathway of human exposure to contamination and provides a mechanism for complete assessment of SsI threats to human health and the environment.

2. What alternative regulatory options to this action were considered by EPA?

EPA considered alternatives to this proposed regulatory action for addressing the need to evaluate subsurface intrusion threats as discussed below.

Specifically, EPA considered whether existing programs adequately address the risks associated with subsurface intrusion at contaminated sites, as discussed in the previous section. If one or more programs were in place to adequately address concerns from subsurface intrusion, this could obviate the need for EPA action. However, no other authority consistently and comprehensively addresses subsurface intrusion across all potential non-federal sites, particularly when subsurface intrusion is the key exposure route. In particular, state programs vary significantly in addressing subsurface intrusion. In fact, not all states have subsurface intrusion programs, and states with programs vary in their authority, resources, and remediation criteria. The 2004 Interstate Technology and Regulatory Council's (ITRC) Vapor Intrusion Team developed and conducted an on-line survey of state, federal, and tribal agencies regarding vapor intrusion regulations, policy, and guidance. Ninety-six percent (96%) of survey respondents consider vapor intrusion a concern; however, only 11% have a procedure for evaluating vapor intrusion codified into law, while a larger number of states have developed, or are developing, guidance for addressing vapor intrusion issues. A majority of the states that responded to the survey expressed that their processes for addressing vapor intrusion were only informally adopted by their agencies, and most defer to EPA. The 2009 Vapor Intrusion Pathway: A Guide for State and Territorial Federal Facilities Managers study also surveyed state and territorial subsurface intrusion programs. According to this study, there were no states with a statute directly addressing vapor intrusion or identifying requirements for assessing the risk. Nine states had regulations that address vapor intrusion specifically; three states had regulations under development. Thirty-four states either have guidance for addressing vapor intrusion or are in the process of developing guidance. In addition, the Association of State and Territorial Solid Waste Management Officials (ASTSWMO) has expressed support for the proposed rule and has requested that EPA take leadership on this issue. Since vapor intrusion is projected to be the most significant component of subsurface intrusion, these responses would apply to subsurface intrusion as well. As previously discussed in section V.A.1 of this preamble, other federal programs were reviewed; while some programs could address subsurface intrusion at some sites, they cannot comprehensively address all sites (federal and non-federal).

Two other mechanisms currently exist to place sites on the NPL. First, each state can designate a single site to the NPL as a state top priority site regardless of its HRS score; this can be done only once. (see NCP, 40 CFR 300.425(c)(2)). This state-designated sites option has been implemented for 44 states/territories, and the remaining state options would not be sufficient to address the subsurface intrusion issue nationally and comprehensively, given the projected number of sites with subsurface intrusion problems. Second, sites may be added in response to a health advisory from the ATSDR. (See NCP, 40 CFR 300.425(c)(3)). However, the ATSDR mechanism was designed to be used only when the Agency for Toxic Substances and Disease Registry (ATSDR) designated the threat found to warrant immediate dissociation from the release and other criteria are met. This is not a mechanism that can be used uniformly and consistently. It is highly resource intensive and may not comprehensively address all chronic threats.

Furthermore, CERCLA section 105 clearly mandates that EPA implement the HRS to take into account ''to the extent possible the population at risk, the hazard potential of hazardous substances . . . , the potential for contamination of drinking water supplies and the potential for direct human contact.'' When the HRS was last revised in 1990, the technology to detect and evaluate subsurface intrusion threats was not sufficiently developed. For example, there were no health-based benchmark concentration values for residences or standardized technologies for sampling indoor air, precision of analytical equipment prior to computerization was limited, and associations between contaminated ground water and soil vapors were not well understood. However, it is now possible for subsurface intrusion threats to be evaluated comprehensively. Therefore, it is now appropriate, given the potential that subsurface intrusion presents for direct human contact, to add to the HRS the consideration of threats due to subsurface intrusion.

3. What public outreach activities did EPA conduct?

Before making the decision to issue this proposed rulemaking, EPA conducted outreach activities to determine interest and support from the public. Thus, on January 31, 2011, EPA published a ''Notice of Opportunity for Public Input'' (76 FR 5370, January 31, 2011) soliciting stakeholder comment on whether to include a subsurface intrusion component in the HRS. Additionally, EPA sent letters to all federally recognized tribes, asking for their comments on the FR document. During the 75-day public comment period on this action, four listening sessions were held throughout the country (Arlington, VA; San Francisco, CA; Albuquerque, NM; and Edison, NJ). The comments made by a majority of speakers, including members of the public, at the listening sessions were supportive of the potential addition of a subsurface intrusion component into the HRS. Of the 43 written comments received during the public comment period, 35 were in support of adding a vapor intrusion component to the HRS, 6 comments (generally from industry representatives) were opposed to this addition, and 2 comments were neutral. The comments received during the public listening sessions and in response to the ''Notice of Opportunity for Public Input'' have been reviewed and considered in the development of this proposed rulemaking. EPA has also established a public Web site, *http://www.epa.gov/superfund/vapor-intrusion-and-superfund-program,* providing background information on why this addition to the HRS is being considered.

4. What peer review process did EPA use?

This proposed rule consists of narrow technical modifications and is an expansion of the current HRS, which was peer reviewed by the agency's Science Advisory Board (SAB). The 1988 SAB review was comprehensive and addressed the basic structure and concepts of the HRS. This proposed addition adheres to the basic structure and concepts of the current HRS, and thus, is consistent with the recommendations of the SAB. The 1988 SAB report focused on the following issues:

- The overall algorithm for the HRS;
- The inclusion of exposure in the HRS;
- How the HRS could be evaluated in the future;
- Work that could be done to provide better documentation for the next revision of the HRS;
- The types of toxicity the HRS should address and how it should do so;
- Distances from an uncontrolled hazardous waste site that are relevant when considering air pollutants from sites; and
- The feasibility of including waste concentration in the HRS and whether large volume waste sites had been treated differently than others in the HRS.

The 1988 SAB report is available in the public docket for this proposed rulemaking.

During development of this proposed HRS update, EPA determined that several subsurface intrusion-specific issues warranted external independent scientific peer review. As a result, EPA has identified elements that have undergone peer review including:

- Consideration of potential for subsurface exposure (intrusion) into regularly occupied structures;
- Determination of hazardous waste quantity for the subsurface intrusion component;
- Population scoring;
- Evaluating populations in multi-story and multi-subunit structures; and
- Evaluation of target values for workers.

The results of the 2011 peer review of the proposed addition are discussed in the Summary of Peer Review Comments and Suggested Responses on the Addition of a Subsurface Intrusion Component to the HRS, which is available in the public docket for this proposed rulemaking. This proposed addition reflects modifications made as a result of EPA's peer review process.

5. How did EPA select the approach for including the addition in the HRS?

The following six concepts were used as the basis for evaluating possible approaches to the HRS addition and the selection of a preferred approach:

1. Limit the proposed addition to the existing HRS structure to avoid confusion by minimizing the portions of the present HRS that would need to be revised.
2. Utilize the existing HRS basic structure and scoring algorithm, and maintain the relative weighting of the different pathways.
3. Base technical decisions on sound and proven science.
4. Ensure the HRS acts as an effective screening tool and minimizes unnecessary resource expenditures, while also minimizing the erroneous inclusion or exclusion of sites for possible NPL placement.
5. Assemble and utilize conceptual site models, case studies, and sensitivity analyses to test the model.
6. Ensure that an HRS scoring evaluation of the soil exposure and subsurface intrusion pathway can be completed using the information and level of effort that are typical of a site inspection or expanded site inspection (ESI).

In the process of developing the proposed rule, EPA identified multiple options that are consistent with the above concepts. Based on literature reviews and agency experience, EPA projected the range of conditions at which the proposed addition might be applied. Using the basic structure of the current HRS, EPA tested each option by simulating the scores for typical scenarios. Using the results of these studies, EPA selected the option that best met the above criteria. To verify that the selected option would provide comparable results at actual sites, EPA tested the scoring algorithm using existing subsurface intrusion data from actual sites. The results of these studies demonstrate that the proposed addition functioned as expected. See section 8.0 of the Technical Support Document for this proposed addition (Proposal TSD) for supplemental information regarding EPA's testing efforts.

B. Technical Considerations to Maintaining the Current HRS Structure and Algorithm

1. Maintaining the Current Ground Water, Surface Water, and Air Migration Pathways

The current approach for scoring the ground water, surface water, and air migration pathways is not being altered by the proposed addition of a subsurface intrusion component. Therefore, EPA is not soliciting comments on these pathways and will not respond to comments that are submitted on these pathways.

2. Addition of the New Component to the Soil Exposure Pathway

EPA is proposing to add the subsurface intrusion threat to the present soil exposure pathway, which already considers direct exposure to receptors. This pathway is proposed to be restructured and renamed the soil exposure and subsurface intrusion pathway. The restructured pathway will retain unchanged the existing two soil exposure threats (resident population and nearby population) in the pathway as one component. The threat posed by subsurface intrusion is proposed to be added as a new component.

The internal structure of the soil exposure component, including the two soil exposure threats within that component, remains unchanged. Therefore, EPA is not soliciting comments on the soil exposure component of the proposed soil exposure and subsurface intrusion pathway, nor will it respond to comments that are submitted on the soil exposure component.

The soil exposure pathway was selected for modification because its structure already focuses on populations actually coming into or potentially coming into direct contact with hazardous substances. The present soil exposure pathway addresses direct contact with contamination outside of structures. The new subsurface intrusion component also addresses direct contact with contamination that has already been demonstrated to have entered into regularly occupied structures or where the contamination is present beneath the regularly occupied structures and is likely to enter into regularly occupied structures. See section VI.A of this preamble for further discussion.

C. Supporting Materials

The proposed addition to the HRS is discussed in the following primary documents: (1) The proposed rule, (2) this preamble, (3) the Proposal TSD (including all supporting appendices), (4) the regulatory impact analysis (RIA). The proposed rule identifies the proposed changes to the NCP and focuses on the specific mechanics of scoring sites with the new component. This preamble provides an overview of the proposed HRS addition, along with an explanation of any modifications and the supporting justification. The Proposal TSD contains a more detailed explanation of the technical basis for the proposed additions to the HRS, along with descriptions of the options considered, analyses that were used to evaluate the performance of the new subsurface intrusion component, and technical literature that was used in the development of the addition. The Proposal TSD is available to help guide the evaluation of subsurface intrusion sites. The Proposal TSD follows the same general outline as the preamble, with one section describing the necessary narrow technical modifications that affect multiple pathways, and the remaining sections describing the addition of the subsurface intrusion component to the current soil exposure pathway. The Proposal TSD contains a description of the current HRS, the options considered, and the technical justifications for the option chosen. In addition, the Proposal TSD references other supporting documents that provide an even greater level of detail on the proposed additions.

These four documents are available to the public in the Docket for this rulemaking. To facilitate public review, EPA has prepared an index to the proposed rule, the preamble to the proposed rule, and the Proposal TSD with detailed cross referencing of issues. This index is available in the public Docket. See the **ADDRESSES** section of this preamble for further information.

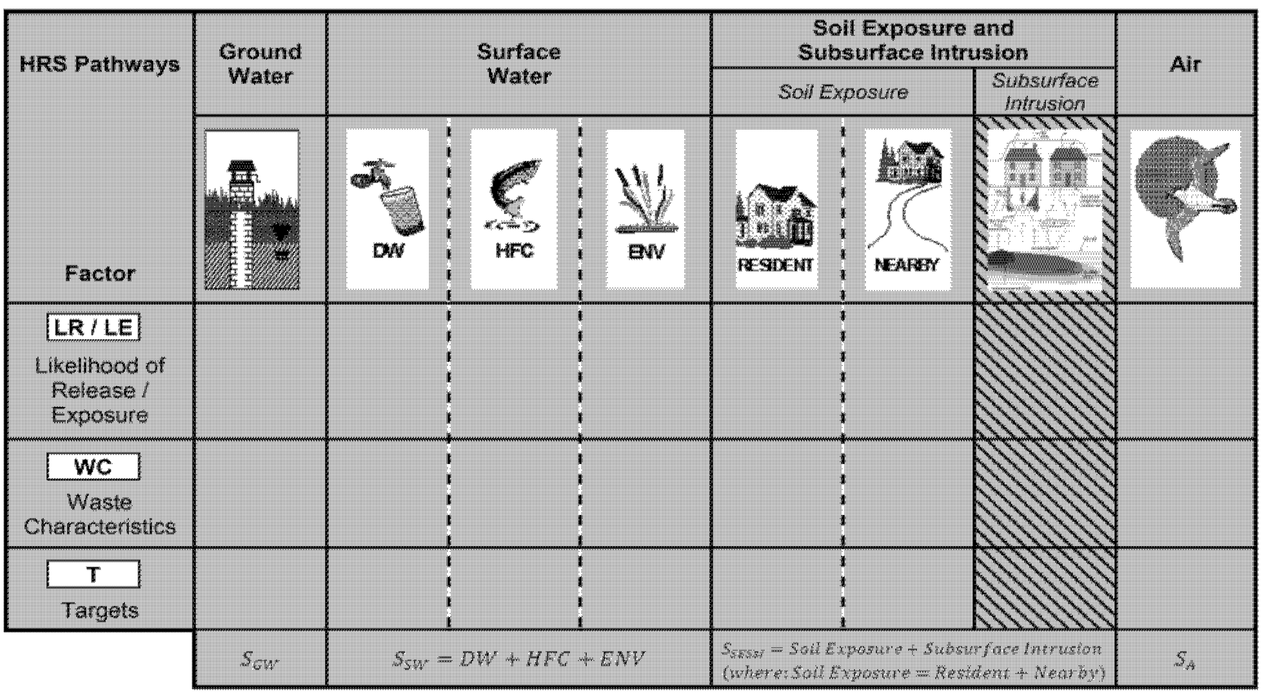
VI. Discussion of the Proposed SsI Addition to the HRS

This section first discusses why the evaluation of the relative risk posed by subsurface intrusion has been added as a component to the same HRS pathway as for soil exposure. It then discusses how the evaluation will be performed using a structure consistent with the other threats, components, and pathways in the HRS, but taking into account the unique parameters impacting the probability of exposure to subsurface intrusion.

A. Addition Within a Restructured Soil Exposure Pathway

EPA is proposing to add the evaluation of the relative risk posed by subsurface intrusion of hazardous substances into regularly occupied structures by restructuring the soil exposure pathway in the current HRS to include subsurface intrusion. As noted previously, no changes are being proposed for the other three pathways in the present HRS. The restructured soil exposure pathway is proposed to be renamed the soil exposure and subsurface intrusion pathway to reflect both components of the restructured pathway. See Figure 3 for a depiction of how the proposed addition fits into the HRS structure.

Figure 3. HRS Structure with Proposed Addition



Ground Water Migration Pathway Score (S_{GW})

Surface Water Migration Pathway Score (S_{SW})

Soil Exposure and Subsurface Intrusion Pathway Score (S_{SESSI})

Air Migration Pathway Score (S_A)

The threat posed by subsurface intrusion is proposed to be added to the soil exposure pathway because both consider the relative risk posed by direct contact with existing contamination areas. As identified in the preamble to the 1988 **Federal Register** document proposing the current HRS (53 FR 51997–52000, December 23, 1988), the soil exposure pathway, proposed in 1988 to be named the ''onsite exposure'' pathway, was added to the HRS to address the threat posed by direct contact with existing contamination and focused on ingestion of contaminated soil. This is in contrast with the other existing HRS pathways, which evaluate the relative risk posed by actual or potential migration of contamination from an original release location (called a ''source'' in HRS terminology) via ground water, surface water, or ambient air to other locations where exposure may occur. Given that the relative risk posed by subsurface intrusion is also due to direct contact with contamination already present in, or likely to be intruding into, regularly occupied structures and no further migration away from the existing contamination areas need occur, EPA considers it appropriate to incorporate the subsurface intrusion threat in the same direct exposure pathway that includes the soil exposure relative risk. See section 6.0 of the 1988 Revised HRS Technical Support Document (1988 Revised HRS TSD) for supplemental information (originally referred to as the onsite exposure pathway).

The existing soil exposure pathway will be retained as one component of the restructured pathway, with the two threats within the present soil exposure pathway, resident and nearby populations, being retained as threats within the soil exposure component. The scoring of the soil exposure component will remain unaltered, but the score will be assigned as the soil exposure component score, not the pathway score. (See section 5.1 of the Proposed HRS Addition.) The proposed subsurface intrusion component will be added as a new component of the restructured soil exposure and subsurface intrusion pathway. As discussed in greater detail below, it will have the same basic structure, scoring, and weighting as other parts of the HRS.

The score for the restructured pathway is based on a combination of the two component scores—soil exposure and subsurface intrusion. The soil exposure component score is added to the subsurface intrusion component score to determine the pathway score. The two component scores are proposed to be additive because the populations may be subjected to exposures via both routes: The soil exposure component reflects exposures to people when outside a structure and focuses on ingestion and the subsurface intrusion component reflects exposures inside a structure and focuses on inhalation. Hence, the addition of the two component scores reflects the potential cumulative risk of multiple exposure routes and is not double counting the relative risk.

A maximum pathway score is not contingent on scoring both the soil exposure and subsurface intrusion components. It is possible for a site to have only one component evaluated and still reach the maximum pathway score. Because the scoring of the soil exposure component is not being altered, this component would contribute the same score to the overall site score absent the addition of subsurface intrusion.

B. Subsurface Intrusion Component Addition

The structure of the current HRS is basically the same for all individual pathways, components, and/or threats. This structure was first used in the original HRS (47 FR 31220, 1982) and was only slightly altered when the HRS was revised in 1990 (55 FR 51532, December 14, 1990) to fit pathway-specific parameters and to address comments on the proposed rule. See also section 2.2 of the 1988 Revised HRS TSD for supplemental information. The design of the HRS reflects a conceptual understanding of how hazardous substance releases from CERCLA sites can result in risks to public health and welfare and the environment. The risk scenario at these sites is a function of:

- The probability of exposure to (or releases to a medium in a migration pathway of) hazardous substances,
- The expected magnitude and duration of the releases or exposures,
- The toxicity or other potential adverse effects to a receptor (target) from the releases,
- The probability that the release will reach a receptor and the expected change in the concentration of hazardous substances during the movement from the location of the contamination to the receptors,
- The expected dose to the receptor, and
- The expected number and character of the receptors.

The above considerations are addressed in three factor categories: likelihood of exposure (or release), waste characteristics, and targets.

The following subsections describe the structure of the proposed subsurface intrusion component and how this structure is consistent conceptually with the existing structure of the other HRS pathways and components: (1) New definitions, (2) delineation of areas of subsurface intrusion, (3) likelihood of exposure, (4) waste characteristics, (5) targets, and (6) calculating and incorporating the subsurface intrusion component score into the HRS site score. For background on why this structure was selected by EPA and peer reviewed by the SAB, see section 2.0 of the 1988 Revised HRS TSD.

1. New Definitions—See Section 1.1 of the Proposed HRS Addition [8]

EPA is proposing that 14 new definitions be added to the HRS, section 1.1, with additional modifications to existing definitions. EPA is adding these new definitions to aid the site evaluator in establishing the environmental boundaries that are being evaluated in this component (*e.g.,* contamination in or above the surficial aquifer), in identifying factors unique to the subsurface intrusion component (*e.g.,* channelized flow through which soil gas transports with no resistance), and to ensure consistent application of the HRS.

2. Delineation of Areas of Subsurface Intrusion—See Section 5.2.0 of the Proposed HRS Addition

EPA is proposing to include in the subsurface intrusion component evaluation two areas in which exposure due to subsurface intrusion contamination exists or is likely to exist: (1) Areas of observed exposure—areas in which contaminant intrusion into regularly occupied structures has been documented, and (2) areas of subsurface contamination—areas in which subsurface contamination underlying regularly occupied structures (such as in surficial ground water or soil vapor) has been documented, but at which either sampling of indoor air has not documented that subsurface contamination has entered a regularly occupied structure or no sampling of indoor air has been undertaken. See Figure 4 for an illustration of the two areas. Additionally, special considerations are given to buildings with multiple subunits and multiple levels (*e.g.,* apartment buildings) when establishing areas of subsurface intrusion. For a more detailed discussion on the selection of these areas, see section 6.0 of the Proposal TSD.

[8] *For references to a specific section of the proposed HRS addition, please refer to the regulatory text of the proposed rulemaking.*

a. Area of Observed Exposure (AOE)—See Section 5.2.0 of the Proposed HRS Addition

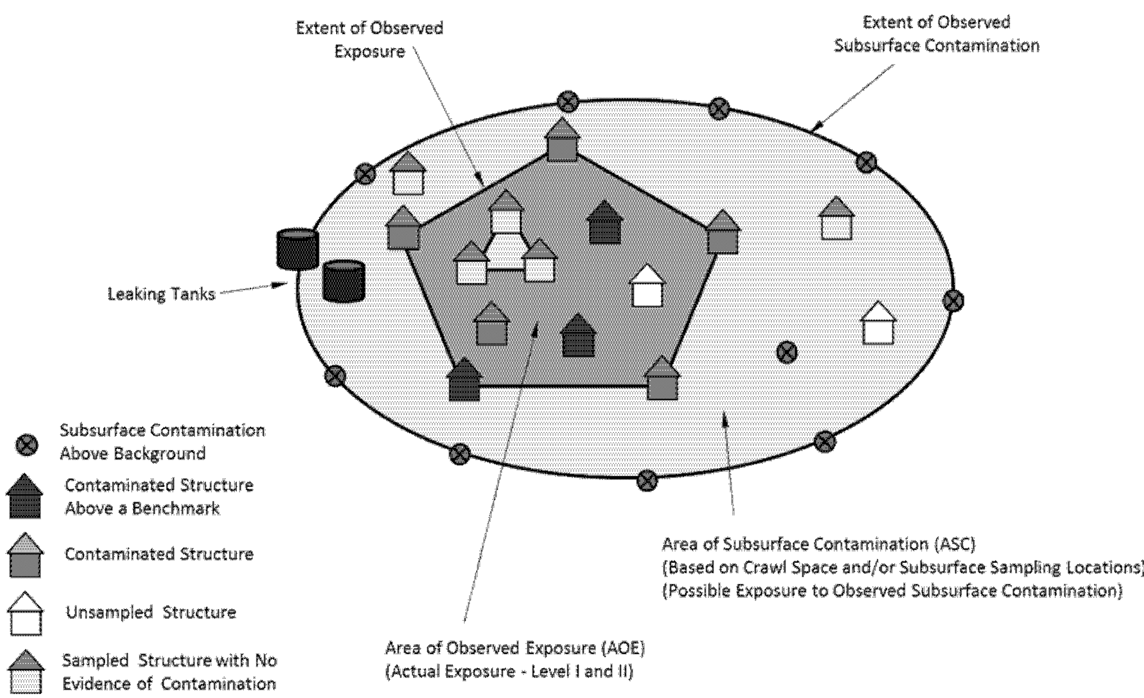
EPA is proposing to identify an area (or areas) of observed exposure at a site based on the location of regularly occupied structures with documented contamination resulting from subsurface intrusion attributable to the site being evaluated. The area encompassed by such structures constitutes the area of observed exposure (AOE). Other regularly occupied structures within this encompassed area (or areas) will also be inferred to be in the AOE unless available information indicates otherwise. Populations occupying structures within the AOE are considered exposed to subsurface contamination for HRS scoring purposes, and thus, are included in the HRS evaluation. See section 6.0 of the Proposal TSD for further discussion on the delineation of an AOE and the rationale for the inclusion of this area in an HRS evaluation.

b. Area of Subsurface Contamination (ASC)—See Section 5.2.0 of the Proposed HRS Addition

EPA is proposing to also identify an area (or areas) of subsurface contamination as an area outside that of the AOE, but for which subsurface contamination has been documented at levels meeting observed release criteria (contamination at levels significantly above background and the significant increase can be attributed at least in part to the site). The contamination would be present either in surficial ground water samples, in subslab or semi-enclosed or enclosed crawl space samples, in subsurface soil samples, or in soil gas samples in the unsaturated zone. An ASC may also include regularly occupied structures where indoor air sampling has not documented that an observed exposure has occurred. (See current HRS section 2.3 for observed release criteria.) In addition, EPA is proposing to limit the delineation of an ASC based on the location of subsurface volatile hazardous substances. However, non-volatile hazardous substances may be used to establish an ASC if they have also been documented in an observed exposure.

Populations in regularly occupied structures within an ASC are considered potentially contaminated, but are weighted less in the HRS evaluation than those populations in an AOE. The populations in an ASC are assigned a weighting value ranging from 0.1 to 0.9 depending on such factors as the distance of subsurface contamination to a regularly occupied structure's foundation and the sample media (see section 5.2.1.3.2.3 of the Proposed HRS Addition). The ASC is included in the HRS evaluation because there is currently contamination below regularly occupied structures in the ASC, and although a sampling event has not documented intrusion into these structures, based on previous studies, it is likely that intrusion has occurred or could occur when suitable climatic and lifestyle conditions were or are present. The populations in the ASC are weighted less to reflect the relatively lower demonstrated risk in the ASC in comparison to the AOE. See section 6.0 of the Proposal TSD for further discussion on the delineation of an ASC and the rationale for inclusion of this area in an HRS evaluation.

Figure 4. Areas of Observed Exposure or Subsurface Contamination



c. Other Area of Subsurface Intrusion Considered: Potential Migration Zone

In the three current HRS migration pathways (ground water, surface water, and air migration pathways), a projected present and future migration distance called the target distance limit is assigned based on studies performed when the HRS was revised in 1988. Targets (receptors) within that distance are considered either actually or potentially exposed and the values assigned to these receptors are weighted based on the level of contamination, the distance from a source, and the possible amount of hazardous substance dilution.

As a result, EPA considered including within the subsurface intrusion component an approach for incorporating populations subject to future migration (outside the ASC) similar to that used for the ground water migration pathway. The approach included a standard 4-mile distance (modified if site-specific geologic information indicates otherwise) radiating either in all directions or only in the probable downgradient direction from each source at a site to establish this future migration zone. This approach could account for the possibility of future horizontal migration of either volatile substances in contaminated ground water or as a soil gas beyond the demonstrated boundaries of the subsurface contamination and subsequently into regularly occupied structures (*i.e.,* a potential future migration zone). This might happen, for example, if hazardous substance plumes expand or migrate due to the additional release of hazardous substances, shift side-to-side due to ground water gradient changes resulting from seasonal variations or tidal influences, or change direction due to the sequencing of dry and wet years or pumping at municipal water supply or other well fields. Additionally, natural and anthropogenic influences, such as utility corridors, fracture patterns, karst features, or buried stream channels or other geologic heterogeneity may alter or enhance hazardous substance migration.

However, EPA's confidence in the present science to accurately project hazardous substance migration through both the ground water and the unsaturated zone is limited. Several fate and transport models, many based on the Johnson and Ettinger Model, currently exist and are used to project vapor migration and predict contaminant vapor intrusion into a structure. The ability of a site assessor to accurately evaluate the potential future migration of subsurface hazardous substances would rely heavily on the ability to gather site-specific data in all areas of future migration in the relatively short time period and with minimal resources available when data collection for an HRS evaluation is performed (*i.e.,* during the site inspection). EPA's review of existing models indicate that in most instances, to obtain acceptable projections, extensive site-specific data collection efforts and often multiple rounds of site investigations are required to develop an accurate model for projecting the future extent of vapor migration, especially in the unsaturated zone. As discussed in section 2.5 of the 1988 TSD, the ''. . . misapplication of a model or the use of incomplete data would, of course, result in less accuracy . . . [and] a very conservative model may also increase the frequency with which sites that do not pose significant risks are placed on the NPL.''

Therefore, after thorough review of this option, the agency has chosen not to include the consideration of future subsurface contaminant migration in the proposed subsurface intrusion component. The possibility of placing sites on the NPL based on speculative projections with no demonstrated risk of actual exposure is too significant. The exclusion of this option in the proposed HRS addition does not directly prevent a site from being considered for listing on the NPL based on demonstrated intrusion, nor does it restrict future investigations from expanding the site boundaries or re-evaluating a site if further studies indicate that the extent of contamination at a site may have increased due to future migration. Please refer to section 6.0 of the Proposal TSD for supplemental information regarding consideration of a potential migration zone.

3. Likelihood of Exposure—See Section 5.2.1.1 of the Proposed HRS Addition

A key factor considered in the HRS relative risk ranking is whether any exposure has occurred and if not, whether there is a probability that exposure could occur. This is termed the likelihood of exposure for the subsurface intrusion component. For purposes of an exposure assessment, not only must subsurface intrusion have occurred, but the structure must be regularly occupied. Consistent with other HRS pathways and components, likelihood of exposure is evaluated in two ways within the proposed subsurface intrusion component. The first step is to determine whether contamination has entered a regularly occupied structure; if this has occurred, ''observed exposure'' is established. If an observed exposure can be demonstrated in at least one structure, the likelihood of exposure category value is assigned the highest possible score. If observed exposure has not been documented, the second step is to evaluate the ''potential for exposure.'' The potential for exposure factor is assigned a score lower than that given when an observed exposure has been documented. How to evaluate the likelihood of exposure is discussed below. See section 4.0 of the Proposal TSD for supplemental information regarding likelihood of exposure.

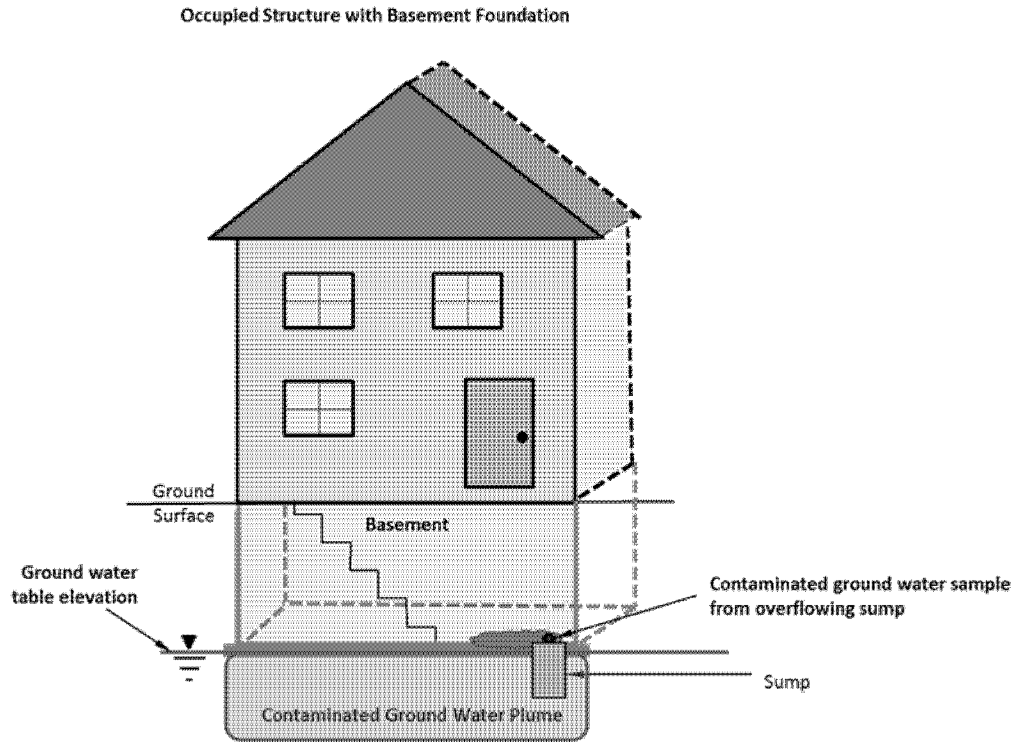
a. Observed Exposure—See Section 5.2.1.1.1 of the Proposed HRS Addition

For HRS purposes, an observed exposure is established if it can be documented that a hazardous substance from the site being evaluated has moved through the subsurface and has entered at least one regularly occupied structure. When it can be documented that subsurface intrusion has occurred, the likelihood of exposure is assigned its maximum value. The HRS identifies for all the pathways a consistent approach for establishing observed exposure (or observed release in migration pathways) and is discussed in section 2.3 of the current HRS. Also, the requirements for establishing observed exposure (or observed releases) are equivalent to those used to establish releases throughout the HRS. See section 2.6 of the 1988 Revised HRS TSD for supplemental information. Consistent with the current HRS structure, EPA is proposing to establish observed exposure in the subsurface intrusion component by any of the following methods:

i. Observed Exposure by Direct Observation—See Section 5.2.1.1.1 of the Proposed HRS Addition

The identification of an observed exposure by direct observation can be based on a solid, liquid, or gaseous hazardous substance attributable to the site being observed or known to have entered a regularly occupied structure from the subsurface. This finding will generally require the observation that a solid, liquid, or gas is entering the structure, and can be documented from a sample of the material that shows the hazardous substance is present due to the release from the site being evaluated. For example, this type of direct exposure could be documented if: (1) Contaminated vapors are found in a sample from a sump open to the regularly occupied structure, and (2) the same hazardous substances are found in subsurface samples collected beneath the regularly occupied structure or otherwise can be demonstrated as having emanated from known contamination underlying the structure. Another example would be if chromium precipitate is found in basements subject to ground water flooding and it is known that a chromium contaminant plume is present, and its presence is not from indoor sources. In neither example would a significant increase above a background contaminant level be required. For exposures to intruded ground water, EPA is proposing documented observed exposure by direct observation as the only method for establishing likelihood of exposure. Figure 5 below depicts an additional example of documenting observed exposure by direct observation through collection of a contaminated water sample taken from the sump of an occupied structure that is known to be subject to flooding. Other methods may also be used to establish direct observation depending on site-specific conditions. See section 4.0 of the Proposal TSD for further information.

Figure 5. Observed Exposure by Direct Observation Example: Intrusion of Contaminated Ground Water



ii. Observed Exposure by Chemical Analysis—See Section 5.2.1.1.1 of the Proposed HRS Addition

Observed exposure by ''chemical analysis'' is established by comparing hazardous substance concentrations in background and release samples that have been chemically analyzed. The concentration of one or more hazardous substance in one or more indoor air sample taken from a regularly occupied structure (termed the ''release sample'') is compared to the concentration at appropriate background locations and under appropriate background conditions. If the chemical analyses document a significant increase over background levels and if at least part of the significant increase can be shown to be attributable to a release from the site being evaluated, then observed exposure by chemical analysis has been documented. This option for establishing observed exposure differs from observed exposure by direct observation in that comparison of the hazardous substance concentration in a release sample to a background level is required. This method for establishing observed exposure by chemical analysis is outlined in detail below.

Background levels for this situation, in some cases, may be determined by chemical analysis of samples from similar environments collected from outside the area impacted by the release, or releases, from the site being evaluated. While the appropriate sample locations to be used to establish this background level will vary based on site-specific conditions, an appropriate background level needs to account for both outdoor air concentrations and indoor air concentrations in structures of similar construction type (*e.g.,* basement, slab-on-grade) within the vicinity. This is to ensure that the background level represents the concentration of a hazardous substance in the absence of the subsurface intrusion. In some cases it may be possible to use published studies on typical background concentrations in establishing an appropriate background level. See section 4.0 of the Proposal TSD for further discussion on background levels.

The first step in determining if observed exposure by chemical analysis has occurred is to document that the magnitude of the difference between the background level concentration and the release sample concentration is sufficient to rule out the possibility that neither the difference nor the similarity is due to variation in site conditions; and to ensure the sampling and analytical procedures are precise and can be replicated. The magnitude of this ''significant increase'' was established for all HRS pathways based on studies peer reviewed by the Science Advisory Board when the HRS was last revised in 1990. See section 2.6 of the 1988 Revised HRS TSD for supplemental information.

A significant increase is generally identified to have occurred if the release sample hazardous substance concentration is above quantification limits and at least three times the background level, provided the background sample concentrations for the hazardous substance are found at or above appropriate detection limits. If the hazardous substance background level is below the appropriate detection limit, any quantifiable level of the hazardous substance detected in the targeted structure is considered to have a concentration significantly above background.

The second step in determining if observed exposure by chemical analysis has occurred is to document that at least part of the significant increase can be attributed to a release from the site being evaluated. This step is required for establishing observed releases or observed exposures in all HRS pathways. See section 2.3 of the current HRS and section 2.6 of the 1988 Revised HRS TSD for supplemental information. This step is conducted to ensure that the increase is due to the release being evaluated and not from other potential contaminant sources located in the vicinity. (See section 4.0 of the Proposal TSD for further discussion.) For the proposed subsurface intrusion component, establishing significant increase over background is particularly critical because many of the projected intrusion contaminants are solvents and, in particular, chlorinated solvents. Chlorinated solvents are commonly found in multiple household and commercial cleaning products and in various consumer goods found in regularly occupied structures. These products present a substantial challenge for discerning the contribution from the environmental release that is being evaluated. Therefore, it is critical that a significant increase in these hazardous substances be documented as coming from the subsurface and not simply emanating from these products.

It is suggested that the evidence to support this determination include multiple lines of evidence, including determining outdoor air hazardous substance concentrations; finding the hazardous substance at the source facility, site, or release being investigated; and finding the hazardous substance in subsurface samples. (See section 4.0 of the Proposal TSD regarding lines of evidence.) In addition, actions should be taken to ensure that sources of the hazardous substances inside a structure (*e.g.,* household chemicals) have been removed from the structure prior to sampling. Establishing attribution to the site in some situations, however, may be straightforward to document, such as when the hazardous substance is manmade, unique, and not used in consumer products and thus, there would be no need to follow all the steps identified above to establish attribution. EPA expects that future advancement in methods for establishing the source of indoor contamination will be helpful for drawing conclusions about attribution.

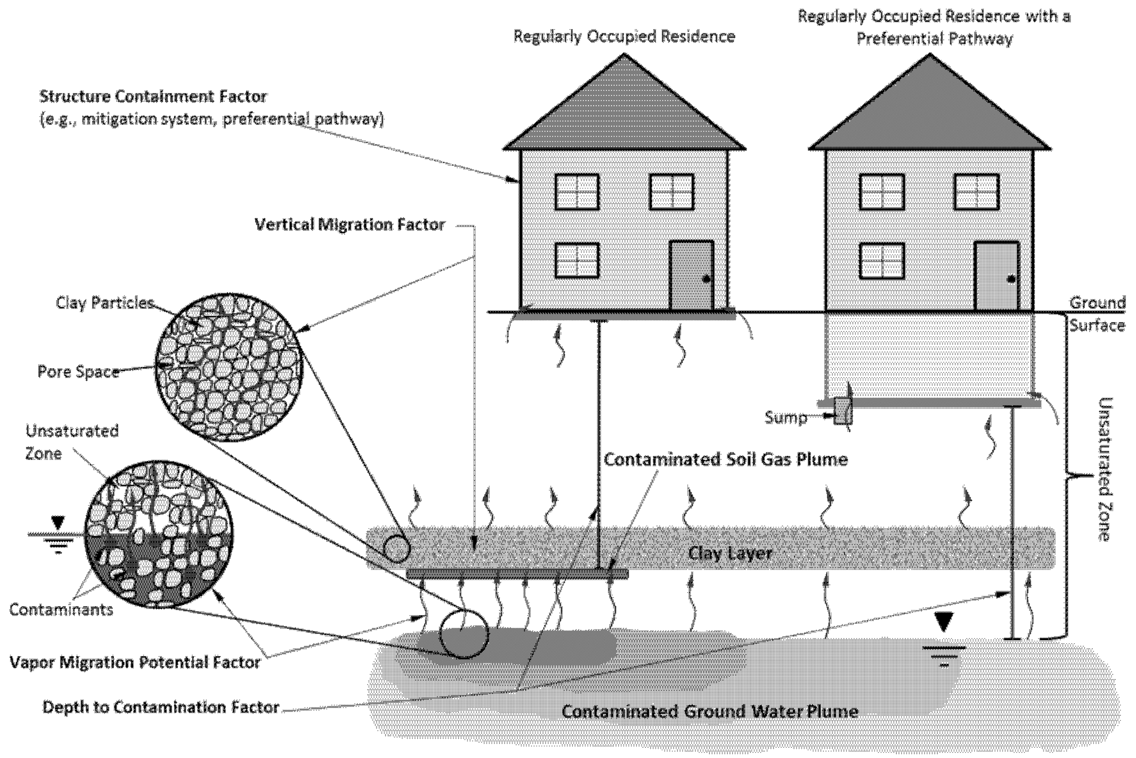
In summary, if it is demonstrated that there is a significant increase in hazardous substance levels in a regularly occupied structure and it is demonstrated that the significant increase in the contamination is in part due to the release from subsurface intrusion being evaluated, then an observed release by chemical analysis has been established.

b. Potential for Exposure—See Section 5.2.1.1.2 of the Proposed HRS Addition

When an observed exposure has not been established, EPA is proposing to evaluate the potential for exposure within structures located in an ASC using the subsurface intrusion component. Given that within an ASC, contamination has been demonstrated to be below or in the subsurface encompassing regularly occupied structures, it is probable that exposure to the intruding hazardous substance has occurred but that sampling has not been performed at the time the exposure took place. As explained in section 4.0 of the Proposal TSD, the factors affecting when intrusion will occur and the rate of subsurface intrusion are extremely time-, site-, and climate-specific. Sampling may not have been performed in these structures for a number of reasons, or, even if performed during the limited time period (due to resource limitations, site inspections are conducted over a limited period of time, usually 1 to 2 days) of a site inspection, the sampling may have been conducted during conditions in which the subsurface intrusion was not occurring, or occurring at levels not detectable or differentiable from that in background sources of the hazardous substance. Therefore, it is important that the potential for exposure be included as a consideration when evaluating subsurface intrusion threats, especially when volatile substances are documented in the subsurface below regularly occupied structures.

As also explained in section 4.0 of the Proposal TSD, EPA is proposing to evaluate the potential for exposure for the subsurface intrusion component using the same concept and framework used to estimate the potential to release in other pathways. (See section 2.3 of current HRS.) As depicted in Figure 6 below, this involves predicting the probability of exposure in an area of subsurface contamination based on structural containment features of the regularly occupied structure and the route characteristics in the subsurface, including hazardous substance physical and chemical properties and physical subsurface properties that influence the probability that intrusion is occurring.

Figure 6. Potential for Exposure



Potential for Exposure = Structure Containment x (Depth to Contamination + Vertical Migration + Vapor Migration Potential)

i. Structure Containment—See Section 5.2.1.1.2.1 of the Proposed HRS Addition

Containment within the current HRS is used to consider barriers that restrict the movement of hazardous substances. See the preamble to the 1988 Revised HRS (53 FR 51985, December 23, 1988) for supplemental information. For the proposed subsurface intrusion component, the containment features considered represent structural features that block the movement of hazardous substances so as to minimize or prevent indoor exposures resulting from subsurface intrusion into a regularly occupied structure. As is consistent with the current HRS, EPA is proposing containment factor values that range from zero to ten where a low containment factor value indicates a low chance for exposure. For example, in Table 5–12 of the proposed HRS addition, a structure with no visible open preferential pathways from the subsurface has a lower containment value than a structure with documented open preferential pathways because open preferential pathways (*e.g.,* sumps, foundation cracks) represent a situation in which a greater probability for subsurface intrusion to occur is present. Populations in structures that show no possible SsI intrusion route are not evaluated in this new component. Supplemental information regarding containment and the factor values specified in Table 5–12 is provided in section 4.0 of the Proposal TSD.

ii. Route Characteristics—See Section 5.2.1.1.2 of the Proposed HRS Addition

The HRS uses ''route characteristics'' to index the relative degree to which hazardous substances move into or have already moved into specific areas, such as from a source into ground water, or for the subsurface intrusion component into a regularly occupied structure (see the 1988 TSD and section 4.0 of the Proposal TSD for supplemental information). These characteristics represent the physical and chemical properties of the specific hazardous substances and the media in which they must have moved through or could move through. To determine which route characteristics are appropriate for evaluating potential exposure to subsurface hazardous substances, EPA examined the literature to identify the modeling methods that are currently used to estimate the levels of hazardous substance exposure. Numerous route characteristics and the relationship of these and site-specific input requirements were identified. EPA also gave careful consideration to ensure that route characteristic factors may be measured or calculated on a site-specific basis in a manner appropriate with current HRS evaluations. See section 4.0 of the Proposal TSD for supplemental information evaluated as part of this process.

EPA reviewed existing sensitivity analyses and performed further analyses to evaluate the intrinsic relationships among the examined route characteristics to identify those that have the greatest impact on potential for exposure. Based on the agency's analysis, three factors represented the greatest impact on potential for exposure and for which sufficient site-specific information could be collected during a site inspection: (1) Depth to contamination, (2) vertical migration, and (3) vapor migration potential. These three factors are described in the following sections.

a. Depth to Contamination—See Section 5.2.1.1.2.2 of the Proposed HRS Addition

The depth to contamination factor represents the vertical distance between contamination (either in soil, soil gas, or surficial ground water) and the lowest horizontal point of an overlying regularly occupied structure (*e.g.,* a basement floor). This distance represents how far a hazardous substance would have to travel through the subsurface to intrude into that structure. Based on available data, the probability of exposure decreases as the depth to contamination increases. In addition, as part of EPA's sensitivity analysis in developing route characteristics, at depths greater than 150 feet it became increasingly unlikely that exposure would occur. This is reflected in Table 5–13 (section 5.2.1.1.2.2 of the Proposed HRS Addition). EPA is proposing depth to contamination factor values ranging from zero to ten, where increasing depth results in a lower factor value.

EPA is also proposing to give special consideration in two situations in which it is likely that exposure has occurred. One situation is when subsurface profiles may be impacted by channelized flow features, such as fractured bedrock or karst. The other situation is at locations where the contamination is measured directly below the structure (*e.g.,* in subslab or enclosed/semi-enclosed crawl space samples). These features reflect a situation with a high probability of exposure to intruded hazardous substances because of limited resistance to migration of the substances into the structure. See section 4.0 of the Proposal TSD for supplemental information on how the depths to contamination were weighted when assigning the factor values to different distances.

b. Vertical Migration—See Section 5.2.1.1.2.3 of the Proposed HRS Addition

The vertical migration factor considers the geologic makeup of materials between a regularly occupied structure and the hazardous substance plume and the rate at which substances are likely to have moved through the materials. EPA is proposing to index vertical migration based on two factors: Effective porosity (or equivalently, the permeability) of geologic materials and the thickness of the lowest porosity layer.

Factor values for effective porosity (as it relates to permeability) of geologic materials range from one to four and are based solely on the typical range of porosity of subsurface materials (*e.g.,* gravel, sand, silt and clay). These factor values are used in conjunction with the thickness of the lowest porosity layer (greater than 1 foot thickness) to establish a vertical migration factor value, ranging from one to fifteen.

As part of the vertical migration factor, EPA identified soil moisture content to potentially be a significant route characteristic variable. Thus, to incorporate soil moisture in EPA's assessment of potential for exposure, the agency used published ''average soil moisture content'' values for specific soil types. These averages were used to develop effective porosity/permeability factor values. See section 4.0 of the Proposal TSD for supplemental information.

c. Vapor Migration Potential—See Section 5.2.1.1.2.4 of the Proposed HRS Addition

The vapor migration potential factor is based on hazardous substance-specific chemical properties, including both the vapor pressure and Henry's constant values for hazardous substances associated with the site. This factor evaluates the volatile nature of these hazardous substances and is projected to be the most influential route characteristic factor on calculating potential for exposure based on a sensitivity analysis using subsurface migration modeling. When calculating the vapor migration potential, a factor value is determined only for the most volatile hazardous substance based on vapor pressure and Henry's constant values. Those values are used to establish the vapor migration potential factor value. See section 4.0 of the Proposal TSD for supplemental information on this topic.

iii. Calculation of the Potential for Exposure Factor Value—See Section 5.2.1.1.2.5 of the Proposed HRS Addition

Consistent with potential to release determinations in the HRS, the potential for exposure for this component is calculated by summing all route characteristic factor values and multiplying the sum by the containment factor value to determine a potential for exposure factor value.

c. Calculation of the Likelihood of Exposure Factor Category Value—See Section 5.2.1.1.3 of the Proposed HRS Addition

As in all HRS pathways and components, the likelihood of exposure factor category value is assigned based on the higher of the observed exposure (or release) value or the potential for exposure (or release) value. The maximum value assigned for the likelihood of exposure factor category is 550 and is assigned if observed exposure is documented. If observed exposure is not documented, the value assigned when evaluating potential for exposure ranges between 0 and 500. This approach is consistent with the current HRS structure. See sections 2.2 of the 1988 Revised HRS TSD for supplemental information regarding this approach.

4. Waste Characteristics—See Section 5.2.1.2 of the Proposed HRS Addition

The waste characteristics factor category is based on factors that are related to the relative risk considerations included in the basic HRS structure: (1) The toxicity or other potential adverse effects to a receptor from the releases, (2) the potential to degrade in the subsurface prior to intruding into a regularly occupied structure, and (3) the expected magnitude and duration of the exposure. The factors considered in determining the waste characteristics factor category value are the toxicity of the hazardous substances, the ability of the hazardous substance to degrade, and an estimate of the quantity of the hazardous substances to which occupants could be exposed. Consistent with the soil exposure component, the assigned factor values are multiplied together to determine this category value for the subsurface intrusion component. (See sections 2.2 and 2.4 of the 1988 Revised HRS TSD for further discussion on the structure of this factor category and how it fits within the overall HRS structure.) How and why these factors are proposed to be included in this factor category is discussed below.

a. Toxicity/Degradation—See Section 5.2.1.2.1 of the Proposed HRS Addition

The combined toxicity/degradation factor includes consideration of both the toxicity and the possibility for degradation of hazardous substances being evaluated for HRS purposes.

The toxicity factor in the overall HRS structure reflects the toxicity of a hazardous substance associated with a release or exposure, and is assigned the same factor value for all the pathways and components in the current HRS. As in all HRS pathways and components, it is proposed to be assigned the same corresponding factor value as for other parts of the HRS. The rationale for the assignment of the factor value is discussed in the section 2.3 of the 1988 Revised HRS TSD. This toxicity factor is based on the toxicity of the substances present at a site. In the HRS addition, a different factor value is proposed to be assigned to each hazardous substance that an occupant has been or is potentially exposed to. The factor value is driven by the magnitude of each hazardous substance's acute and chronic toxicity to humans. The toxicity factor value is directly related to the concentration at which the hazardous substance is known to have a health effect: The more toxic the chemical, the higher the toxicity value. Any hazardous substance identified in an observed exposure within the AOE or meeting the observed release criteria in either the AOE or ASC will be assigned a toxicity factor value. The method for assigning this value is contained in section 2.4.1.1 of the current HRS (40 CFR 300, Appendix A) and is discussed in section 2.3 of the 1988 Revised HRS TSD.

The degradation factor represents the possibility for a substance to degrade in the subsurface prior to intruding into a regularly occupied structure. The potential of a substance to degrade has been identified as a significant factor in numerous studies evaluating the potential for intrusion by a vapor. The possibility that a substance may degrade is both a substance- and location-specific evaluation that is influenced by factors such as molecular structure, makeup of the immediate subsurface geology, and the presence or absence of oxygen within intervening unsaturated soils.

Because many of the site-specific characteristics impacting the rate of degradation are considered beyond the scope of a typical site investigation, EPA is proposing to evaluate degradation based on the substance being evaluated, the depth to contamination, and if appropriate environmental conditions are present to ensure that sufficient degradation will occur to diminish the threat. Based on EPA's review of the current literature and research on this topic, the assigned degradation factor is limited to three possible factor values, two for substances that are readily degradable and the appropriate environmental factors are present, and one for when either of these parameters are not present.

EPA seeks public input on the following question regarding the degradation factor: *Is there a way to determine the presence and extent of biologically active soil at a site during a limited site investigation? If so, what soil characteristics should EPA consider to determine whether biologically active soil is documented to be present?*

EPA proposes the degradation factor also be based on the half-life of a substance, with the half-life being determined by biodegradation and hydrolysis rates. If this information is not available then a hazardous substance's estimated half-life will be based on the substance's chemical structure, unless available information indicates otherwise. Substances with relatively low structural complexity, such as petroleum and petroleum-like substances (having straight carbon chain or simple ring structures), have the greatest potential to degrade in the subsurface while halogenated and poly-aromatic ringed substances (*e.g.,* tetrachloroethylene, PCBs) are less likely to significantly degrade as result of subsurface microbial activity.

If it has been documented that a hazardous substance has been found to have entered a regularly occupied structure, regardless of the substance or the site conditions, the degradation value is assigned to reflect the likelihood that the substance is not significantly degrading in the subsurface. Also, if the substance is a daughter, or degradation product, of a parent substance that is also present, then the degradation factor will reflect this relationship. Parent and daughter substances are assigned values to reflect that the daughter substance will be continuously created by degradation of the parent substance. See also section 5.0 of the Proposal TSD for additional discussion regarding the inclusion of a degradation factor.

The toxicity and degradation factors are multiplied together to assign a combined factor value. If multiple substances are present, the highest combined factor value is selected for use in determining the waste characteristics factor category value, as discussed below.

b. Hazardous Waste Quantity—See Section 5.2.1.2.2 of the Proposed HRS Addition

In the basic HRS structure used in all pathways and components, the hazardous waste quantity factor reflects the risk consideration related to the magnitude and duration of either the release for a migration pathway or the exposure for an exposure pathway. In other words, for an exposure pathway, the risk posed by a release of hazardous substances is directly related to the amount of hazardous substances to which receptors (targets) are exposed and the length of the exposure.

As explained in the preamble to the 1990 HRS and in the 1988 Revised HRS TSD, an estimate of the waste quantity associated with a site was the best surrogate for the amount of hazardous substances that receptors were exposed to and that the duration of the exposure was probably correlated to the magnitude of the exposure. In the current three migration pathways (ground water, surface water, air), the hazardous waste quantity factor reflects the total amount of hazardous substances in sources at the site to take into account not only where contamination has already migrated to, but also future migration of contamination to other locations. For the soil exposure pathway, however, the estimate does not include the total amount in or released from the site sources, but only the amount of hazardous substance in the top two feet of contaminated soils sources and in the surface portions of other source types in an area of observed contamination. (See section 5.0.1 of the current HRS.)

EPA is proposing that since the subsurface intrusion component also focuses on exposure and not the amount of hazardous substances that might migrate to targets in the future, the waste quantity factor value for this component should also reflect only the amount of hazardous substances that people currently are exposed to, that is, the amount in regularly occupied structures. EPA is proposing a four-tiered hierarchical approach consistent with the current HRS (see section III.C of the preamble of the current HRS (55 FR 51542, December 14, 1990)) as well as minimum waste quantity factors (see section 2.4.2 of the current HRS). The minimum waste quantity factors are included because of insufficient information at many sites to adequately estimate waste quantity with confidence, as discussed in section I of the preamble to the current HRS (55 FR 51533, December 14, 1990). The current HRS establishes a minimum waste quantity factor value of 10 for each pathway or component at sites with no actually contaminated targets and a waste quantity factor value of 100 for the migration pathways if observed exposure has been documented. (See section 2.4.2 of the current HRS.)

It is proposed for the estimation of waste quantity for the subsurface intrusion component, that regularly occupied structures within the AOE and ASC be considered. For sites at which the component waste quantity (the sum waste quantities for all occupied structures in the AOE and ASC) is below 10, it is proposed that a minimum factor of 10 should apply the same as in other pathways and components. This minimum factor reflects that in a limited site inspection, it is likely that information on the actual waste quantity at a site may not be available and a lower value would likely underestimate the actual conditions. Furthermore, if any target is subject to Level I or II contaminant concentrations a minimum hazardous waste quantity factor value of 100 could be assigned.

EPA seeks public input on the following question regarding the calculation of hazardous waste quantity: *How could EPA further take into account the differences in dilution and* *air exchange rates in large industrial buildings as compared to smaller residential and commercial structures when calculating the hazardous waste quantity for the HRS SsI Addition?*

The component waste quantity is the sum of all the waste quantities for all the regularly occupied structures found in both the AOE and ASC. The component waste quantity factor value assigned is then based on the magnitude of this sum, subject to minimum values. See section 5.0 of the Proposal TSD for supplemental information regarding this topic.

c. Calculation of the Waste Characteristics Factor Category Value—See Section 5.2.1.2.3 of the Proposed HRS Addition

As in all HRS pathways and components, the waste characteristics category value is the product of the toxicity/degradation factor value (or the functional equivalent) and the hazardous waste quantity factor value, scaled so as to be weighted consistently in all pathways. Similar to the likelihood of exposure factor category, the waste characteristics factor category is subject to a maximum value to maintain the balance between factor categories. This approach is consistent with the current HRS structure. See sections 2.2 and 2.4 of the 1988 Revised HRS TSD for supplemental information regarding this approach.

5. Targets—See section 5.2.1.3 of the Proposed HRS Addition

The targets factor is based upon estimates of the expected dose to each receptor and the number and type of receptors present. In a human health risk assessment, it is critical to understand the nature and extent of exposure to individuals, populations, and resources. The relative risk assessment embodied within the current HRS uses the targets factor as an index of the nature and extent of exposure to individuals, populations, resources, if appropriate for the migration or exposure route being evaluated, sensitive environments. This will remain the same in the proposed HRS addition, except sensitive environments will not be considered an eligible target.

a. Identification of Eligible Targets—See Section 5.2.1.3 of the Proposed HRS Addition.

The target factors evaluated by all pathways under the current HRS include the following:

- The most exposed individual (*i.e.,* nearest well for ground water migration, nearest intake for drinking water threat, food chain individual for human food chain threat, resident individual for resident population threat, and nearest individual for nearby population threat and air migration),
- Populations (including residents, workers, students, and those in daycare),
- Resources (including economic and cultural uses of contaminated resources),
- Sensitive environments (except for the ground water migration pathway). (Examples of sensitive environments include government designated protected areas (*e.g.,* national wildlife refuge), wetlands and critical habitat known to be used by a State or Federally-designated threatened or endangered species.)

See sections 2.5 and 5.1.3 of the current HRS for supplemental information on how eligible targets are identified.

Given that the subsurface intrusion component is proposed to be included as an exposure component within the modified soil exposure and subsurface intrusion pathway, the agency is proposing to use the same target categories used in the current soil exposure pathway, including exposed individual, resident populations, workers, and resources. However, unlike the current soil exposure pathway, workers are proposed to be evaluated as exposed individuals and as part of the population within an area of subsurface contamination instead of being evaluated under a separate worker factor value. See section 5.2.0 and its subsections of the proposed HRS addition. Additionally, sensitive environments are not being considered as eligible targets because exposures related to subsurface intrusion are limited to indoor areas and it is unlikely that sensitive environments would be exposed. See section 5.2.1.3 of the proposed HRS addition.

EPA seeks public input on the following question regarding subsurface source strength: *The HRS SsI Addition considers source strength in delineating ASCs and AOEs, in scoring likelihood of exposure, in assigning waste quantity specifically when estimating hazardous constituent quantity and in weighting targets in an ASC. The HRS algorithm for all pathways incorporates the consideration of source strength in determining an HRS site score. Could EPA further take into account source strength in performing an HRS evaluation?*

b. Exposed Individual and Levels of Exposure—See Section 5.2.1.3.1 of the Proposed HRS Addition

This section introduces the methods used to identify and establish the levels of contamination and benchmarks proposed to be used within the subsurface intrusion component. Additionally, the exposed individual factor is discussed, as well as how to apply a factor value based on the benchmarks and the resulting levels of exposure.

i. Identifying Levels of Exposure and Benchmarks for Subsurface Intrusion—See Section 5.2.1.3.1 of the Proposed HRS Addition

For all current HRS pathways, the magnitude of the values assigned to the individual and population factors depend on the concentration of the contamination to which the receptors (targets) are exposed. If receptors are exposed to hazardous substance levels that meet observed release criteria, they are identified as actually contaminated; however, if the receptors are not exposed to hazardous substances that meet the observed release criteria but are within the target area being evaluated, they may be considered potentially contaminated. Potential targets are evaluated because a typical site inspection may not identify the extent of contamination. A site inspection typically includes 1 to 3 days of sampling and investigation activities. These limited investigations may not adequately characterize the annual or longer term indoor exposure levels (see page 4 of the 1988 SAB report and section 6.0 of the Proposal TSD), especially in the case of subsurface intrusion where seasonal and temporal fluctuations can significantly impact the rate of subsurface intrusion.

Actually contaminated targets are further divided into two categories based on whether the hazardous substance concentrations are above standard health-based benchmarks (or for environmental receptors, ambient water quality criteria). If so, they are identified as Level I; if they are not, they are identified as Level II. See section 2.5.2 of the current HRS for a discussion of applicable benchmarks.

EPA is proposing to use a similar target weighting structure in the subsurface intrusion component. (See sections 5.2.1.3.1 and 5.2.1.3.2 of the proposed HRS addition.) Those targets in the AOE are considered actually contaminated, whereas, those in the ASC are considered potentially contaminated. The targets in an AOE are further divided into Level I and II, based on whether the hazardous substance concentrations are at or above identified health-based benchmarks. EPA is proposing to use the following benchmarks for the subsurface intrusion component:

- Screening concentrations for cancer
- Screening concentrations for noncancer toxicological responses

Targets associated with an observed exposure by direct observation are only considered subject to Level II contamination in all parts of the HRS and EPA is proposing that this remains consistent in the subsurface intrusion component. Furthermore, because intrusion by contaminated ground water is documented by direct observation only, targets residing within a structure subject to intrusion by contaminated ground water are also proposed to be evaluated as Level II (see section 2.5 of the proposed HRS addition).

The targets within an ASC are also further divided based on the type of sample (*e.g.,* gas, soil, water) and the distance of the sample from the targets (*e.g.,* the depth of the sample below the structure). Weighting factors ranging from 0.1 to 0.9 are then assigned accordingly as discussed below in section 5.c.ii. See also section III.H. of the preamble to the current HRS (55 FR 51547, December 14, 1990) for supplemental information.

ii. Exposed Individual—See Section 5.2.1.3.1 of the Proposed HRS Addition

The standard HRS approach for scoring targets includes a measure reflecting the maximum level of exposure to individuals. The evaluation of exposed individuals is proposed to include individuals living, attending school or day care, or working in a regularly occupied structure. The reasonably maximally exposed individuals are those individuals in the eligible target population that are expected to be exposed to the highest concentration of the hazardous substance in question for a significant time. See section V.C.9 of the preamble to the proposed 1988 HRS (53 FR 51978, December 28, 1988) for supplemental information.

EPA is proposing to retain the basic scoring approach used throughout the current HRS for evaluating the exposed individual factor. As is consistent with all pathways, a value of 50 points is assigned if there is any individual exposed to Level I concentrations or 45 points if there is any individual exposed to Level II concentrations. If there are no individuals exposed to Level I or Level II concentrations, but at least one individual is living, attending school or day care, or working in a regularly occupied structure within an ASC, EPA proposes to assign a value of 20. See section 2.5 of the current HRS for supplemental information as to how EPA addresses exposed individuals within the HRS structure.

c. Population—See Section 5.2.1.3.2 of the Proposed HRS Addition

The population factor is evaluated using media-specific, health-based benchmarks as discussed above. EPA proposes the population factor include all populations qualifying as exposed individuals, including residents, students, workers and those attending day care. However, workers are weighted slightly differently than other exposed individuals to reflect that a worker's exposure is limited to the time present in a workplace. Additionally, as workers may be employed on a full-time or part-time basis, the number of workers present in a structure or subunit is proposed to be adjusted by an appropriate factor reflecting this difference in exposure durations. EPA is proposing to retain the current scoring methodology for weighting populations used throughout the HRS, with actual exposure more heavily weighted than those potentially exposed. The proposed subsurface intrusion component will evaluate populations based on the number of individuals located within an identified AOE (*i.e.,* those populations exposed to Level I and Level II concentrations) and the number of individuals located within an ASC (*i.e.,* potential contamination as determined based on subsurface sampling), which is further subdivided as described in subsection ii below.

i. Weighting of Targets in the Area of Observed Exposure (AOE)—See Sections 5.2.1.3.2.1 and 5.2.1.3.2.2 of the Proposed HRS Addition

EPA is proposing to establish an AOE based on documented contamination meeting observed exposure criteria (either by direct observation or chemical analysis). Consistent with the weighting of populations throughout the HRS (see section 2.5 of the current HRS), the proposed subsurface intrusion component will weight targets subject to Level I contaminant concentrations by a factor of 10 and weight targets subject to Level II contaminant concentrations by a factor of 1. As noted previously, eligible populations also include individuals working in regularly occupied structures. However, the number of workers present in a regularly occupied structure will be adjusted to reflect that their exposure is limited to the time they are in a workplace. Therefore, the number of full- and part-time workers in a structure or subunit will be identified and divided by an appropriate factor prior to being summed with the number of other individuals present. If information is unavailable to classify a worker as full- or part-time, that worker will be evaluated as full-time.

For example, if a single residence occupied by a family of four was observed to be exposed to hazardous substance concentrations above a media-specific, health-based benchmark, the number of residents would be multiplied by 10 for a factor value of 40. However, if that same family was exposed to a hazardous substance and the hazardous substance concentration was below the applicable benchmark but met the criteria for observed exposure, the number of residents would be multiplied by 1 for a factor value of 4. To ensure the entire population within an AOE is included in the HRS evaluation, both Level I and Level II factor values are counted and summed together.

Within the AOE, EPA is proposing to consider as actually contaminated those populations in regularly occupied structures for which observed exposures have not been established but the structures are surrounded by regularly occupied structures in which observed exposures have been identified, unless evidence indicates otherwise. This action is proposed because it is considered likely that if these structures were sampled during the correct conditions, observed exposures would be identified at levels similar to those in surrounding structures. Targets inferred to be exposed to this contamination will be weighted as Level II as there are no actual sample results to compare against benchmarks. However, EPA has included an exception to allow for situations where site-specific conditions clearly document that there may be no observed exposures in these structures. The rule language states that targets can be inferred to have observed exposures in these situations ''unless available information indicates otherwise''. This concept of inferred exposure is also included in the existing soil exposure pathway and in the air migration pathway.

In the case of multi-story/multi-subunit structures, all regularly occupied subunits on a level with an observed exposure and all levels below are considered to be within an AOE, unless available information indicates otherwise. For multi-story/multi-subunit structures located within an AOE, but where an observed exposure has not been documented, only those regularly occupied spaces on the lowest level are considered to be within an AOE, unless available information indicates otherwise. (See sections 5.0.1 and 6.3 of the current HRS.)

ii. Weighting of Targets in the Area of Subsurface Contamination (ASC)—See Section 5.2.1.3.2.3 of the Proposed HRS Addition

EPA is proposing to establish an ASC as defined by documented ground water, subslab, soil, semi-enclosed or enclosed crawl space, or soil gas contamination meeting observed release criteria. These areas are included in the subsurface intrusion component due to the potential that limited sampling conducted during a site inspection may not identify that subsurface intrusion is occurring because of the high temporal and spatial variability associated with detecting subsurface intrusion. Temporal and spatial differences can significantly impact the rate at which volatile hazardous substances enter a structure. However, when an ASC has been defined, that area represents a location where subsurface hazardous substances have the potential to intrude into a structure. EPA is limited in its extent of preliminary screening activities, and a single indoor air sampling event is unlikely to identify the full threat posed by subsurface intrusion.

As is consistent with the 1990 HRS, EPA is proposing to weight these potentially exposed targets at a value less than those targets that have been identified to be actually exposed. Due to the variability in subsurface intrusion rates, the potential weighting factor values for targets within an ASC range from 0.1 to 0.9 and depend on where the subsurface contamination has been found. Using EPA's vapor intrusion attenuation factors published in 2012 and basic subsurface contaminant transport concepts, EPA developed a relatively proportional weighting for potential targets based on the sampling media being considered. This range of weighting factors represents the proportional probability of a target to be exposed as a result of contaminant intrusion from the subsurface in a variety of likely sampling scenarios. The potential target weighting factors presented in the proposed addition do not directly correspond to attenuation factors in themselves. Instead, the relative weighting between these values is based on the published attenuation factors. These weighting factors are presented in this manner to project that contaminants found in a crawl space sample, for example, are more likely to attenuate less before entering into an overlying structure, and thus more likely to pose a threat, as opposed to those found in a shallow ground water sample.

EPA is proposing that the weighting of potential targets also reflect the distance to or the depth at which contamination is found. For any contamination found at a horizontal or vertical distance of five feet or less from a regularly occupied structure's foundation, EPA is proposing to assign a minimum weighting factor of 0.4 regardless of the sample medium. Similarly, EPA is proposing to assign a weighing factor of 0.1 to any contamination found or inferred at depths greater than 30 feet regardless of sampling medium. These minimum weighting values are in response to an analysis of the data used in deriving published attenuation values. The attenuation values were published based on real-world sampling data collected from numerous sites across the United States. The majority of sampling data collected as part of this effort came from sites where contamination was generally found at depths less than 30 feet. Therefore, EPA considers the attenuation factors and relative weightings between them to only be appropriate for shallower depths. The minimum value for the upper five feet allows consideration of sites where contamination is found at extremely shallow depths and therefore has a minimal vertical distance to travel before intruding into a regularly occupied structure.

In the case of multi-story/multi-subunit structures, all regularly occupied subunits on a level above one where an observed exposure has been documented or inferred, or where a gaseous indoor air sample meeting observed release criteria is present, are considered to be located within an ASC, unless available information indicates otherwise. For multi-story/multi-subunit structures located only within an ASC, only those regularly occupied subunits within the lowest level are considered in an HRS evaluation.

EPA proposes eligible populations include individuals living in, or attending school or day care in the structure, and workers in regularly occupied structures. The number of workers is adjusted to reflect that their exposure is limited to the time they are in a workplace. Therefore, the number of full- and part-time workers in a structure or subunit will be divided by an appropriate factor prior to being summed with the number of other individuals present. If information is unavailable to classify a worker as full- or part-time, that worker will be evaluated as full-time.

The proposed weighting factors for exposed individuals in any structure within an ASC are based on the probability of contamination entering into occupied structures from the subsurface. The weighting factors reflect depth to contamination, sample type, and media. The magnitude of the factor is also based on attenuation factors from current scientific literature including EPA's 2012 vapor intrusion attenuation factors publication. Additional information regarding this analysis is presented in section 6.0 of the Proposal TSD.

d. Resources—See Section 5.2.1.3.3 of the Proposed HRS Addition

The resources target factor is evaluated in all pathways under the current HRS. A factor value of five is assigned if at least one resource is present and a factor value of zero if no resource is present. Eligible resources are pathway-, component-, or threat-specific. These resources represent uses of a contaminated medium or area where exposures occur and are not covered by the other identified targets. For example, resources within the air migration pathway include commercial agriculture or silviculture and major/designated recreation areas. The resident population threat also includes commercial livestock production or grazing. See section III.I of the preamble to the current HRS (55 FR 51549, December 14, 1990) for supplemental information.

Because subsurface intrusion is limited to indoor spaces, EPA is proposing to include regularly occupied structures that are located within a defined AOE or ASC (as previously discussed in section VI.B.2 of this preamble) and in which populations, not including those already counted as exposed individuals, may be exposed to contamination due to subsurface intrusion. For example, libraries, recreational facilities, and religious or tribal structures used by individuals, may qualify as eligible resources.

e. Calculation of the Targets Factor Category Value—See Section 5.2.1.3.4 of the Proposed HRS Addition

As is done throughout the HRS, EPA is proposing to sum all of the target factor values together to establish a target factor category value in calculating the proposed subsurface intrusion component score. Unlike the likelihood of exposure and waste characteristics factor category values in all HRS pathways, which are subject to maximum values, the target factor category is not limited in the current HRS. This is to ensure that all individuals, populations, resources, and sensitive environments are included; thereby, representing the full relative risk associated with the identified threat. It is also consistent with the direction of CERCLA section 105 to amend the HRS ''to the maximum extent feasible'' to address ''the relative degree of risk to human health and the environment'' by putting the emphasis on the number of receptors exposed to contamination.

6. Calculation and Incorporation of the SsI Component Score Into the HRS Site Score

The following subsections summarize the calculation of the subsurface intrusion component score, how the component score is then used in the calculation of the soil exposure and subsurface intrusion pathway score, and how, in turn, the pathway score is subsequently incorporated into the HRS site score.

a. Calculation of the SsI Component Score—See Section 5.2.2 of the Proposed HRS Addition

EPA is proposing to calculate the subsurface intrusion component score using the same algorithm as in other components and pathways of the HRS. (See section 2.2 of the 1988 Revised HRS TSD.) This involves multiplying the likelihood of exposure factor category value times the waste characteristics factor category value times the targets factor category value and dividing that value by a weighting factor so that it has equal magnitude to other component scores (subject to a maximum value). The values are multiplied to reflect that it is the product of these values that represents a relative risk level.

In a relative risk (or in a site-specific risk) assessment, the use of the product of the factor category values is considered appropriate because the magnitude of each of the factor category values reflects the probability of exposure occurring: Likelihood of releases reflects the probability of exposure actually occurring, waste characteristics reflects the probable quantity and duration of the exposure, and targets reflect the probable number of receptors at risk. Thus, since each factor category value reflects a probability in a series of events, the overall probability associated with the series is the product of the individual probabilities. For example, if any factor category value is zero, such as when there are no targets exposed or potentially exposed to subsurface intrusion, the component score is zero, consistent with there being no risk due to subsurface intrusion.

b. Incorporation of the SsI Component Score Into the Soil Exposure and Subsurface Intrusion Pathway Score—See Section 5.3 of the Proposed HRS Addition

The score for this restructured pathway is proposed to be a combination of two component scores. The subsurface intrusion component score is added to the soil exposure component score (subject to a maximum value) to determine the pathway score. The two component scores are proposed to be additive because the populations may be subjected to exposures separately via both routes: The soil exposure component reflects exposures to people when outside a structure and focuses on ingestion, while the subsurface intrusion component reflects exposures to people when inside a structure and focuses on inhalation. Hence, the addition of the two component scores reflects the cumulative potential risk and is not double counting the relative risk.

In addition, a pathway score can be assigned without scoring both the soil exposure and subsurface intrusion components using this approach. It is possible for a site to have only one component evaluated and still reach the same pathway score as under the current HRS. It should be observed that because the scoring of the soil exposure component is not being altered, the soil exposure component would contribute the same score to the overall site score as it would if the subsurface intrusion component is not added.

c. Incorporation of the Soil Exposure and Subsurface Intrusion Pathway Score Into a Site Score—See Section 2.1.1 of the Proposed HRS Addition

EPA is not proposing any changes to the methodology used to assign an overall site score due to the addition of the subsurface intrusion component to the soil exposure pathway and renaming that pathway the soil exposure and subsurface intrusion pathway. The overall site score remains a function of four pathway scores and the same weighting is given to each pathway score as in the current HRS. See section 2.2 of the 1988 Revised HRS TSD for supplemental information on why the existing methodology was chosen.

7. Example Site Scoring Scenarios

To evaluate the proposed subsurface intrusion component and factor category weighting, EPA developed three conceptual site scenarios: One that would not qualify for the NPL (score below 28.50); one that would qualify marginally for the NPL (score of about 28.50); and one that should clearly qualify for the NPL (site score considerably above 28.50).

The first scenario consists of a ground water plume contaminated with a hazardous substance with moderate toxicity that underlies approximately 3 acres of a residential neighborhood comprised of single-family detached homes. Indoor air samples have been collected from inside two homes and have reported hazardous substance concentrations above background, but below the applicable benchmarks. Additionally, several other occupied structures were sampled for indoor air and subslab contaminant concentrations; however, no other detections of hazardous substances were observed. This site would not qualify for the NPL based on available information (*i.e.,* score below 28.50).

The second scenario also consists of a ground water plume contaminated with a hazardous substance with moderate toxicity as in the first scenario, but it has a considerably larger plume and more targets. The ground water plume underlies approximately 20 acres of a residential neighborhood and commercial area comprised of single-family detached homes, a daycare facility, and a single-story office building. Indoor air samples collected inside 19 homes, the daycare facility, and office building have hazardous substance concentrations above the applicable benchmark. Indoor air samples in 5 homes, the daycare facility with approximately 25 children enrolled and 6 full-time and 2 part-time workers, and the office building with 18 full-time workers have hazardous substance concentrations above background, but below the applicable benchmark. The homes and daycare facility were checked for indoor sources of hazardous substances prior to sampling and such sources were removed if found. This site would likely qualify for the NPL based on available information (*i.e.,* score of about 28.50).

The third scenario consists of a ground water plume contaminated with a highly toxic hazardous substance and a larger number of targets than the second scenario. The plume underlies approximately 25 acres of a residential neighborhood and hazardous substance concentrations above a benchmark were detected in indoor air samples from 25 homes and one daycare with approximately 25 children enrolled and 5 full-time workers. Hazardous substance concentrations above background but below benchmarks were detected within 15 homes. The homes and daycare facility were checked for indoor sources of hazardous substances prior to sampling and such sources were removed if found. Based on available information, this site would qualify for the NPL and would likely achieve the maximum HRS score for a single component and pathway (*i.e.,* 50.00).

Further evaluation of the varying factor values and resulting HRS site scores, along with further discussion of these three scenarios is presented in section 8.1.c of the Proposal TSD.

VII. Summary of Proposed Updates to the HRS (Sections 2, 5, 6, and 7)

A. Addition of an SsI Component to the HRS (Sections 2, 5, and 7)

1. Chapter 5

The proposed addition of a subsurface intrusion component is proposed to be added to the existing Soil Exposure pathway as section 5.2 in Chapter 5 to the current HRS. The new pathway name is proposed as the Soil Exposure and Subsurface Intrusion Pathway. The existing method for evaluating the soil exposure threat will remain unchanged.

2. Chapter 2

Evaluations Common to All Pathways is proposed to be updated to reflect the addition of the subsurface intrusion component to the existing soil exposure pathway. The evaluations for the current four pathways remain unchanged and a comparable evaluation will be added for the subsurface intrusion component.

3. Chapter 7

Sites Containing Radioactive Substances currently reflects how radioactive substances are evaluated in the context of the four current HRS pathways. Updates will be made to reflect how radioactive substances are evaluated using the proposed subsurface intrusion component.

B. Terminology Updates Affecting Specific Sections of the HRS (Sections 2, 5 and 6)

During the development of this proposed addition to the HRS, the agency determined that the following terms should be updated to reflect current terminology and procedures used by EPA in performing risk assessments.

1. Ambient Water Quality Criteria

Ambient Water Quality Criteria (AWQC) are now identified also as National Recommended Water Quality Criteria (NRWQC). In addition, the acute AWQC are now identified as the Criterion Maximum Concentration (CMC) and the chronic criteria are referred to as the Criterion Continuous Concentration (CCC). (See section 1.1 of the proposed HRS addition.) These criteria are used to determine the level of threat to environmental targets.

2. Reference Concentrations

For inhalation exposures, EPA is adopting the use of Reference Concentrations (RfCs) instead of Reference Doses (RfDs) when determining non-cancer related risk levels. RfCs are used in determining the level of threat to human targets due to possible inhalation and when determining the toxicity of the substances.

3. Cancer Unit Risk

For inhalation exposures, EPA is adopting the use of Inhalation Unit Risk (IUR) instead of cancer slope factors in determining cancer-related risk levels. IURs are used in determining the level of threat to human targets due to possible inhalation and when determining the toxicity of the substances.

4. Weight-of-Evidence Groupings

The 2005 EPA weight-of-evidence groupings supporting the designation of a substance as a human carcinogen have been incorporated into the HRS algorithm for determining the toxicity factor value. (The former EPA weight-of-evidence categories included as part of the 1990 HRS have been retained as EPA has not yet completed assigning all substances to the revised categories and are doing so at the time the EPA substance literature reviews are updated.)

VIII. Statutory and Executive Order Reviews

Additional information about these statutes and Executive Orders can be found at *http://www2.epa.gov/laws-regulations/laws-and-executive-orders.*

A. Executive Order 12866: Regulatory Planning and Review and Executive Order 13563: Improving Regulation and Regulatory Review

This action is a significant regulatory action that was submitted to the Office of Management and Budget (OMB) for review. This action may raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the EO. Any changes made in response to OMB recommendations have been documented in the docket.

EPA prepared an analysis of the potential costs and benefits associated with this action. This analysis, Addition of a Subsurface Intrusion (SsI) Component to the Hazard Ranking System (HRS): Regulatory Impact Analysis is available in the docket for this action.

B. Paperwork Reduction Act (PRA)

This action does not impose any new information collection burden under the PRA. OMB has previously approved the information collection activities contained in the existing regulations and has assigned OMB control number 2050–0095.

This proposed regulatory change will only affect how EPA and organizations performing work on behalf of EPA (state or tribal partners) conduct site assessments and HRS scoring at sites where certain environmental conditions exist. This proposed regulatory change will result in data collection at these types of sites to allow evaluation under the HRS. EPA expects that the total number of site assessments performed and the number of sites added to the NPL per year will not increase, but rather expects that there will be a realignment and reprioritization of its internal resources and state cooperative agreement funding.

C. Regulatory Flexibility Act (RFA)

I certify that this action will not have a significant economic impact on a substantial number of small entities under the RFA. This action will not impose any requirements on small entities. This proposed regulatory change enables the HRS evaluation to directly consider human exposure to hazardous substances that enter building structures through subsurface intrusion. This addition to the HRS would not impose direct impacts on any other entities. For additional discussion on this subject see section 4.9 of the Regulatory Impact Analysis (see the docket for this action).

D. Unfunded Mandates Reform Act (UMRA)

This action does not contain any unfunded mandate as described in UMRA, 2 U.S.C. 1531–1538, and does not significantly or uniquely affect small governments. The action imposes no enforceable duty on any state, local, or tribal governments or the private sector.

E. Executive Order 13132: Federalism

This action does not have federalism implications. It will not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government.

F. Executive Order 13175: Consultation and Coordination With Indian Tribal Governments

This action does not have tribal implications, as specified in Executive Order 13175. EPA's evaluation of a site using the HRS does not impose any costs on a tribe (except those already in a cooperative agreement relationship with EPA). Thus, Executive Order 13175 does not apply to this action.

Although Executive Order 13175 does not apply to this action, EPA consulted with tribal officials through meetings and correspondence, including a letter sent to all federally recognized tribes asking for comment on the ''Notice of Opportunity for Public Input'' that was published in the **Federal Register** on January 31, 2011 (76 FR 5370), and public listening sessions regarding the decision to proceed with the development of this action. All tribal comments indicated support for this action.

EPA specifically solicits additional comment on this proposed action from tribal officials.

G. Executive Order 13045: Protection of Children From Environmental Health Risks and Safety Risks

EPA interprets Executive Order 13045 as applying only to those regulatory actions that concern environmental health or safety risks that EPA has reason to believe may disproportionately affect children, per the definition of ''covered regulatory action'' in section 2–202 of the Executive Order. This action is not subject to Executive Order 13045 because it does not concern an environmental health risk or safety risk.

H. Executive Order 13211: Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution or Use

This action is not a ''significant energy action'' because it is not likely to have a significant adverse effect on the supply, distribution, or use of energy. The site assessment activities affected by this rule are limited in scope and number and rely on existing energy distribution systems. Further, we have concluded that this proposed rule would not significantly expand the energy demand for site assessments, and would not require an entity to conduct any action that would require significant energy use, that would significantly affect energy supply, distribution, or usage. Thus, Executive Order 13211 does not apply to this action.

I. National Technology Transfer and Advancement Act

This rulemaking does not involve technical standards.

J. Executive Order 12898: Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations

EPA believes the human health or environmental risk addressed by this action will not have potential disproportionately high and adverse human health or environmental effects on minority, low-income or indigenous populations. The results of this evaluation are contained in section III.C.4 of this preamble and section 4.3 (and all subsections) and Appendix C of the Regulatory Impact Analysis for this proposed rulemaking. A copy of the Addition of a Subsurface Intrusion (SsI) Component to the Hazard Ranking System (HRS): Regulatory Impact Analysis is available in the docket for this action.

K. Executive Order 12580: Superfund Implementation

Executive Order 12580, section 1(d), states that revisions to the NCP shall be made in consultation with members of the National Response Team (NRT) prior to publication for notice and comment. Revisions shall also be made in consultation with the Director of the Federal Emergency Management Agency (FEMA) and the Nuclear Regulatory Commission (NRC) to avoid inconsistent or duplicative requirements in the emergency planning responsibilities of those agencies. Executive Order 12580 delegates responsibility for revision of the NCP to EPA.

The agency has complied with Executive Order 12580 to the extent that it is related to the addition of a new component to the HRS, through consultation with members of the NRT.

List of Subjects in 40 CFR Part 300

Environmental protection, Air pollution control, Chemicals, Hazardous substances, Hazardous waste, Intergovernmental relations, Natural resources, Oil pollution, Penalties, Reporting and recordkeeping requirements, Superfund, Water pollution control, Water supply.

Dated: February 3, 2016.

Gina McCarthy,

Administrator.

For the reasons set out in the preamble, Title 40, Chapter 1 of the Code of Federal Regulations is proposed to be amended as follows:

PART 300—NATIONAL OIL AND HAZARDOUS SUBSTANCES POLLUTION CONTINGENCY PLAN

■ 1. The authority citation for part 300 continues to read as follows:

Authority: 33 U.S.C. 1251 *et seq.*

■ 2. Amend Appendix A to Part 300:

■ a. In section 1.1 by:

■ i. Amending by removing the definition heading ''Ambient Water Quality Criteria (AWQC) and adding ''Ambient Water Quality Criteria (AWQC)/National Recommended Water Quality Criteria'', in its place; and removing the text ''maximum acute or chronic toxicity'' and adding ''maximum acute (Criteria Maximum Concentration or CMC) or chronic (Criterion Continuous Concentration or CCC) toxicity.'' in its place;

■ ii. Adding in alphabetical order the definitions ''Channelized flow'' and ''Crawl space'';

■ iii. Revising the definitions ''Distance weight'' and ''Half-life'';

■ iv. Amending the definition ''HRS pathway'' by removing the word ''soil,'' and adding ''soil exposure and subsurface intrusion,'' in its place;

■ v. Adding in alphabetical order the definitions ''Indoor air'', ''Inhalation Unit Risk (IUR)'', ''Occupied structures'', ''Preferential subsurface intrusion pathways''; and ''Reference concentration (RfC)'';

■ vi. Revising the definition ''Reference dose (RfD)''; ''Screening concentration'', and ''Slope factor (also referred to as cancer potency factor)'';

■ vii. Adding in alphabetical order the definitions ''Soil gas'', ''Soil porosity''; ''Subslab'', ''Subsurface Intrusion'', ''Surficial ground water'', ''Unit Risk'', and ''Unsaturated Zone''; and

■ viii. Revising the introductory text of the definition ''Weight-of-evidence''.

■ b. Revising section 2.0 to include sections 2.0 through 2.5.2;

■ c. Revising section 5.0 to include sections 5.0 through 5.3;

■ d. In section 6.0 by revising Table 6–14, entitled ''Health-Based Benchmarks for Hazardous Substances in Air''; and

■ e. In section 7.0 by:

■ i. Revising the table entitled ''Table 7–1. HRS Factors Evaluated Differently For Radionuclides'';

■ ii. Under Table 7–1, the second undesignated paragraph, revising the third sentence ;

■ iii. Revising sections 7.1, 7.1.1, and 7.1.2; 7.2.3; 7.2.4; 7.2.5.1, 7.2.5.1.1 through 7.2.5.1.3; 7.2.5.2; 7.2.5.3; 7.3, 7.3.1, and 7.3.2; and

■ iv. Adding section 7.3.3.

The revisions and additions read as follows:

Appendix A of Part 300—Hazard Ranking System

* * * * *

1.1 Definitions

* * * * *

Channelized flow: Natural geological or manmade features such as karst, fractures, lava tubes, and utility conduits (*e.g.,* sewer lines), which allow ground water and/or soil gas to move through the subsurface environment more easily.

* * * * *

Crawl space: The enclosed or semi-enclosed area between a regularly occupied structure's foundation (*e.g.,* pier and beam construction) and the ground surface. Crawl space samples are collected to determine the concentration of hazardous substances in the air beneath a regularly occupied structure.

* * * * *

Distance weight: Parameter in the HRS air migration pathway, ground water migration pathway, and the soil exposure component of the soil exposure and subsurface intrusion pathway that reduces the point value assigned to targets as their distance increases from the site. *[unitless].*

* * * * *

Half-life: Length of time required for an initial concentration of a substance to be halved as a result of loss through decay. The HRS considers five decay processes for determining surface water persistence: Biodegradation, hydrolysis, photolysis, radioactive decay, and volatilization. The HRS considers two decay processes for determining subsurface intrusion degradation: Biodegradation and hydrolysis.

* * * * *

Indoor air: The air present within a structure.

Inhalation Unit Risk (IUR): The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent (*i.e.,* hazardous substance) at a concentration of 1μg/m3 in air.

* * * * *

Occupied structures: Structures with enclosed air space, either where people are present on a regular basis or that were previously occupied but vacated due to a site-related hazardous substance(s).

* * * * *

Preferential subsurface intrusion pathways: Subsurface features such as animal burrows, cracks in walls, spaces around utility lines or drains through which a hazardous substance moves more easily into a regularly occupied structure.

* * * * *

Reference concentration (RfC): An estimate of a continuous inhalation exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime.

Reference dose (RfD): An estimate of a daily oral exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime.

* * * * *

Screening concentration: Media-specific benchmark concentration for a hazardous substance that is used in the HRS for comparison with the concentration of that hazardous substance in a sample from that media. The screening concentration for a specific hazardous substance corresponds to its reference concentration for inhalation exposures or reference dose for oral exposures, as appropriate, and, if the substance is a human carcinogen with either a weight-of-evidence classification of A, B, or C, or a weight-of-evidence classification of carcinogenic to humans, likely to be carcinogenic to humans or suggestive evidence of carcinogenic potential, to that concentration that corresponds to its 10^{-6} individual lifetime excess cancer risk for inhalation exposures or for oral exposures, as appropriate.

* * * * *

Slope factor (also referred to as cancer potency factor): Estimate of the probability of response (for example, cancer) per unit intake of a substance over a lifetime. The slope factor is typically used to estimate upper-bound probability of an individual developing cancer as a result of exposure to a particular level of a human carcinogen with either a weight-of-evidence classification of A, B, or C, or a weight-of-evidence classification of carcinogenic to humans, likely to be carcinogenic to humans or having suggestive evidence of carcinogenic potential. [$(mg/kg\text{-}day)^{-1}$ for non-radioactive substances and $(pCi)^{-1}$ for radioactive substances].

Soil gas: The gaseous elements and compounds in the small spaces between particles of soil.

Soil porosity: The degree to which the total volume of soil is permeated with pores or cavities through which fluids (including air or gas) can move. It is typically calculated as the ratio of the pore spaces within the soil to the overall volume of the soil.

* * * * *

Subslab: The area immediately beneath a regularly occupied structure with a basement foundation or a slab-on-grade foundation. Subslab samples are collected to determine the concentration of hazardous substances in the soil gas beneath a home or building.

Subsurface Intrusion: The migration of hazardous substances from the unsaturated zone and/or the surficial ground water into overlying structures.

Surficial ground water: The uppermost saturated zone, typically unconfined.

* * * * *

Unit Risk: The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent (*i.e.,* hazardous substance) at a concentration of 1 μg/L in water, or 1 μg/m^3 in air.

Unsaturated Zone: The portion of subsurface between the land surface and the zone of saturation. It extends from the ground surface to the surficial water table (excluding localized or perched water).

* * * * *

Weight-of-evidence: EPA classification system for characterizing the evidence supporting the designation of a substance as a human carcinogen. The EPA weight-of-evidence groupings, depending on the date EPA updated the profile, include either:

* * * * *

2.0 Evaluations Common to Multiple Pathways

2.1 *Overview.* The HRS site score (S) is the result of an evaluation of four pathways:

- Ground Water Migration (S_{gw}).
- Surface Water Migration (S_{sw}).
- Soil Exposure and Subsurface Intrusion (S_{sessi}).
- Air Migration (S_a).

The ground water and air migration pathways use single threat evaluations, while the surface water migration and soil exposure and subsurface intrusion pathways use multiple threat evaluations. Three threats are evaluated for the surface water migration pathway: Drinking water, human food chain, and environmental. These threats are evaluated for two separate migration components—overland/flood migration and ground water to surface water migration. Two components are evaluated for the soil exposure and subsurface intrusion pathway: Soil exposure and subsurface intrusion. The soil exposure component evaluates two threats: Resident population and nearby population, and the subsurface intrusion component is a single threat evaluation.

The HRS is structured to provide a parallel evaluation for each of these pathways, components and threats. This section focuses on these parallel evaluations, starting with the calculation of the HRS site score and the individual pathway scores.

2.1.1 *Calculation of HRS site score.* Scores are first calculated for the individual pathways as specified in sections 2 through 7 and then are combined for the site using the following root-mean-square equation to determine the overall HRS site score, which ranges from 0 to 100:

$$S = \sqrt{\frac{S_{gw}^2 + S_{sw}^2 + S_{sessi}^2 + S_a^2}{4}}$$

2.1.2 *Calculation of pathway score.* Table 2–1, which is based on the air migration pathway, illustrates the basic parameters used to calculate a pathway score. As Table 2–1 shows, each pathway (component or threat) score is the product of three ''factor categories'': Likelihood of release, waste characteristics, and targets. (The soil exposure and subsurface intrusion pathway uses likelihood of exposure rather than likelihood of release.) Each of the three factor categories contains a set of factors that are assigned numerical values and combined as specified in sections 2 through 7. The factor values are rounded to the nearest integer, except where otherwise noted.

2.1.3 *Common evaluations.* Evaluations common to all four HRS pathways include:

- Characterizing sources.
  — Identifying sources (and, for the soil exposure and subsurface intrusion pathway, areas of observed contamination, areas of observed exposure and/or areas of subsurface contamination (see sections 5.1.0 and 5.2.0)).
  — Identifying hazardous substances associated with each source (or area of observed contamination, or observed exposure, or subsurface contamination).
  — Identifying hazardous substances available to a pathway.

TABLE 2–1—SAMPLE PATHWAY SCORESHEET

Factor category	Maximum value	Value assigned
Likelihood of Release		
1. Observed Release	550	
2. Potential to Release	500	
3. Likelihood of Release (higher of lines 1 and 2)	550	
Waste Characteristics		
4. Toxicity/Mobility	([a])	
5. Hazardous Waste Quantity	([a])	
6. Waste Characteristics	100	
Targets		
7. Nearest Individual:		
7a. Level I	50	
7b. Level II	45	
7c. Potential Contamination	20	
7d. Nearest Individual (higher of lines 7a, 7b, or 7c)	50	
8. Population	([b])	
8a. Level I	([b])	
8b. Level II	([b])	
8c. Potential Contamination	([b])	
8d. Total Population (lines 8a+8b+8c).		
9. Resources	5	
10. Sensitive Environments	([b])	
10a. Actual Contamination	([b])	
10b. Potential Environments	([b])	
10c. Sensitive Environments (lines 10a+10b)	([b])	
11. Targets (lines 7d+8d+9+10c)	([b])	
12. Pathway Score is the product of Likelihood of Release, Waste Characteristics, and Targets, divided by 82,500. Pathway scores are limited to a maximum of 100 points.		

[a] Maximum value applies to waste characteristics category. The product of lines 4 and 5 is used in Table 2–7 to derive the value for the waste characteristics factor category.
[b] There is no limit to the human population or sensitive environments factor values. However, the pathway score based solely on sensitive environments is limited to a maximum of 60 points.

- Scoring likelihood of release (or likelihood of exposure) factor category.
  —Scoring observed release (or observed exposure or observed contamination).
  —Scoring potential to release when there is no observed release.
- Scoring waste characteristics factor category.
  —Evaluating toxicity.
  - Combining toxicity with mobility, persistence, degradation and/or bioaccumulation (or ecosystem bioaccumulation) potential, as appropriate to the pathway (component or threat).
  - Evaluating hazardous waste quantity.
  —Combining hazardous waste quantity with the other waste characteristics factors.
  - Determining waste characteristics factor category value.
- Scoring targets factor category.

—Determining level of contamination for targets.

These evaluations are essentially identical for the three migration pathways (ground water, surface water, and air). However, the evaluations differ in certain respects for the soil exposure and subsurface intrusion pathway.

Section 7 specifies modifications that apply to each pathway when evaluating sites containing radioactive substances.

Section 2 focuses on evaluations common at the pathway, component and threat levels. Note that for the ground water and surface water migration pathways, separate scores are calculated for each aquifer (see section 3.0) and each watershed (see sections 4.1.1.3 and 4.2.1.5) when determining the pathway scores for a site. Although the evaluations in section 2 do not vary when different aquifers or watersheds are scored at a site, the specific factor values (for example, observed release, hazardous waste quantity, toxicity/mobility) that result from these evaluations can vary by aquifer and by watershed at the site. This can occur through differences both in the specific sources and targets eligible to be evaluated for each aquifer and watershed and in whether observed releases can be established for each aquifer and watershed. Such differences in scoring at the aquifer and watershed level are addressed in sections 3 and 4, not section 2.

2.2 *Characterize sources.* Source characterization includes identification of the following:

- Sources (and areas of observed contamination, areas of observed exposure or areas of subsurface contamination) at the site.
- Hazardous substances associated with these sources (or areas of observed contamination, areas of observed exposure or areas of subsurface contamination).
- Pathways potentially threatened by these hazardous substances.

Table 2–2 presents a sample worksheet for source characterization.

2.2.1 *Identify sources.* For the three migration pathways, identify the sources at the site that contain hazardous substances. Identify the migration pathway(s) to which each source applies. For the soil exposure and subsurface intrusion pathway, identify areas of observed contamination, areas of observed exposure, and/or areas of subsurface contamination at the site (see sections 5.1.0 and 5.2.0).

Table 2–2—Sample Source Characterization Worksheet

Source:____

A. Source dimensions and hazardous waste quantity.

Hazardous constituent quantity:____

Hazardous wastestream quantity:____

Volume:____

Area:____

Area of observed contamination:____

Area of observed exposure:____

Area of subsurface contamination:____

B. Hazardous substances associated with the source.

Hazardous substance	Available to pathway								
	Air		Ground water (GW)	Surface water (SW)		Soil exposure/subsurface intrusion (SESSI)			
						Soil exposure		Subsurface intrusion	
	Gas	Particulate		Overland/ flood	GW to SW	Resident	Nearby	Area of observed exposure	Area of subsurface contamination
....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....

2.2.2 *Identify hazardous substances associated with a source.* For each of the three migration pathways, consider those hazardous substances documented in a source (for example, by sampling, labels, manifests, oral or written statements) to be associated with that source when evaluating each pathway. In some instances, a hazardous substance can be documented as being present at a site (for example, by labels, manifests, oral or written statements), but the specific source(s) containing that hazardous substance cannot be documented. For the three migration pathways, in those instances when the specific source(s) cannot be documented for a hazardous substance, consider the hazardous substance to be present in each source at the site, except sources for which definitive information indicates that the hazardous substance was not or could not be present.

For an area of observed contamination in the soil exposure component of the soil exposure and subsurface intrusion pathway, consider only those hazardous substances that meet the criteria for observed contamination for that area (see section 5.1.0) to be associated with that area when evaluating the pathway.

For an area of observed exposure or area of subsurface contamination (see section 5.2.0) in the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, consider only those hazardous substances that:

• Meet the criteria for observed exposure, or

• Meet the criteria for observed release in an area of subsurface contamination and has a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to 10^{-5} atm-m^3/mol, or

• Meet the criteria for an observed release in a structure within, or in a sample from below, an area of observed exposure and has a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to 10^{-5} atm-m^3/mol.

2.2.3 *Identify hazardous substances available to a pathway.* In evaluating each migration pathway, consider the following hazardous substances available to migrate from the sources at the site to the pathway:

• Ground water migration.

— Hazardous substances that meet the criteria for an observed release (see section 2.3) to ground water.

— All hazardous substances associated with a source with a ground water containment factor value greater than 0 (see section 3.1.2.1).

• Surface water migration—overland/flood component.

— Hazardous substances that meet the criteria for an observed release to surface water in the watershed being evaluated.

— All hazardous substances associated with a source with a surface water containment factor value greater than 0 for the watershed (see sections 4.1.2.1.2.1.1 and 4.1.2.1.2.2.1).

• Surface water migration—ground water to surface water component.

— Hazardous substances that meet the criteria for an observed release to ground water.

— All hazardous substances associated with a source with a ground water containment factor value greater than 0 (see sections 4.2.2.1.2 and 3.1.2.1).

• Air migration.

— Hazardous substances that meet the criteria for an observed release to the atmosphere.

— All gaseous hazardous substances associated with a source with a gas containment factor value greater than 0 (see section 6.1.2.1.1).

— All particulate hazardous substances associated with a source with a particulate containment factor value greater than 0 (see section 6.1.2.2.1).

• For each migration pathway, in those instances when the specific source(s) containing the hazardous substance cannot be documented, consider that hazardous substance to be available to migrate to the pathway when it can be associated (see section 2.2.2) with at least one source having a containment factor value greater than 0 for that pathway.

In evaluating the soil exposure and subsurface intrusion pathway, consider the following hazardous substances available to the pathway:

• Soil exposure component—resident population threat.

— All hazardous substances that meet the criteria for observed contamination at the site (see section 5.1.0).

• Soil exposure component—nearby population threat.

— All hazardous substances that meet the criteria for observed contamination at areas with an attractiveness/accessibility factor value greater than 0 (see section 5.1.2.1.1).

• Subsurface intrusion component.

— All hazardous substances that meet the criteria for observed exposure at the site (see section 5.2.0).

—All hazardous substances with a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to 10^{-5} atm-m^3/mol that meet the criteria for an observed release in an area of subsurface contamination (see section 5.2.0).

—All hazardous substances that meet the criteria for an observed release in a structure within, or in a sample from below, an area of observed exposure (see section 5.2.0).

2.3 *Likelihood of release.* Likelihood of release is a measure of the likelihood that a waste has been or will be released to the environment. The likelihood of release factor category is assigned the maximum value of 550 for a migration pathway whenever the criteria for an observed release are met for that pathway. If the criteria for an observed release are met, do not evaluate potential to release for that pathway. When the criteria for an observed release are not met, evaluate potential to release for that pathway, with a maximum value of 500. The evaluation of potential to release varies by migration pathway (see sections 3, 4 and 6).

Establish an observed release either by direct observation of the release of a hazardous substance into the media being evaluated (for example, surface water) or by chemical analysis of samples appropriate to the pathway being evaluated (see sections 3, 4 and 6). The minimum standard to establish an observed release by chemical analysis is analytical evidence of a hazardous substance in the media significantly above the background level. Further, some portion of the release must be attributable to the site. Use the criteria in Table 2–3 as the standard for determining analytical significance. (The criteria in Table 2–3 are also used in establishing observed contamination for the soil exposure component and for establishing areas of observed exposure and areas of subsurface contamination in the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, see section 5.1.0 and section 5.2.0). Separate criteria apply to radionuclides (see section 7.1.1).

TABLE 2–3—OBSERVED RELEASE CRITERIA FOR CHEMICAL ANALYSIS

Sample Measurement < Sample Quantitation Limit.[a]
No observed release is established.

TABLE 2–3—OBSERVED RELEASE CRITERIA FOR CHEMICAL ANALYSIS—Continued

Sample Measurement ≥ Sample Quantitation Limit.[a]

An observed release is established as follows:

- If the background concentration is not detected (or is less than the detection limit), an observed release is established when the sample measurement equals or exceeds the sample quantitation limit.[a]
- If the background concentration equals or exceeds the detection limit, an observed release is established when the sample measurement is 3 times or more above the background concentration.

[a] If the sample quantitation limit (SQL) cannot be established, determine if there is an observed release as follows:

If the sample analysis was performed under the EPA Contract Laboratory Program, use the EPA contract-required quantitation limit (CRQL) in place of the SQL.

If the sample analysis is not performed under the EPA Contract Laboratory Program, use the detection limit (DL) in place of the SQL.

2.4 *Waste characteristics.* The waste characteristics factor category includes the following factors: Hazardous waste quantity, toxicity, and as appropriate to the pathway or threat being evaluated, mobility, persistence, degradation, and/or bioaccumulation (or ecosystem bioaccumulation) potential.

2.4.1 *Selection of substance potentially posing greatest hazard.* For all pathways (components and threats), select the hazardous substance potentially posing the greatest hazard for the pathway (component or threat) and use that substance in evaluating the waste characteristics category of the pathway (component or threat). For the three migration pathways (and threats), base the selection of this hazardous substance on the toxicity factor value for the substance, combined with its mobility, persistence, and/or bioaccumulation (or ecosystem bioaccumulation) potential factor values, as applicable to the migration pathway (or threat). For the soil exposure component of the soil exposure and subsurface intrusion pathway, base the selection on the toxicity factor alone. For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, base the selection on the toxicity factor value for the substance, combined with its degradation factor value. Evaluation of the toxicity factor is specified in section 2.4.1.1. Use and evaluation of the mobility, persistence, degradation, and/or bioaccumulation (or ecosystem bioaccumulation) potential factors vary by pathway (component or threat) and are specified under the appropriate pathway (component or threat) section. Section 2.4.1.2 identifies the specific factors that are combined with toxicity in evaluating each pathway (component or threat).

2.4.1.1 *Toxicity factor.* Evaluate toxicity for those hazardous substances at the site that are available to the pathway being scored. For all pathways and threats, except the surface water environmental threat, evaluate human toxicity as specified below. For the surface water environmental threat, evaluate ecosystem toxicity as specified in section 4.1.4.2.1.1.

Establish human toxicity factor values based on quantitative dose-response parameters for the following three types of toxicity:

- Cancer—Use slope factors (also referred to as cancer potency factors) combined with weight-of-evidence ratings for carcinogenicity for all exposure routes except inhalation. Use inhalation unit risk (IUR) for inhalation exposure. If an inhalation unit risk or a slope factor is not available for a substance, use its ED_{10} value to estimate a slope factor as follows:

$$\text{Slope factor} = \frac{1}{6\,(\mathrm{ED}_{10})}$$

- Noncancer toxicological responses of chronic exposure—use reference dose (RfD) or reference concentration (RfC) values as applicable.
- Noncancer toxicological responses of acute exposure—use acute toxicity parameters, such as the LD_{50}.

Assign human toxicity factor values to a hazardous substance using Table 2–4, as follows:

- If RfD/RfC and slope factor/inhalation unit risk values are available for the hazardous substance, assign the substance a value from Table 2–4 for each. Select the higher of the two values assigned and use it as the overall toxicity factor value for the hazardous substance.
- If either an RfD/RfC or slope factor/inhalation unit risk value is available, but not both, assign the hazardous substance an overall toxicity factor value from Table 2–4 based solely on the available value (RfD/RfC or slope factor/inhalation unit risk).
- If neither an RfD/RfC nor slope factor/inhalation unit risk value is available, assign the hazardous substance an overall toxicity factor value from Table 2–4 based solely on acute toxicity. That is, consider acute toxicity in Table 2–4 only when both RfD/RfC and slope factor/IUR values are not available.
- If neither an RfD/RfC, nor slope factor/inhalation unit risk, nor acute toxicity value is available, assign the hazardous substance an overall toxicity factor value of 0 and use other hazardous substances for which information is available in evaluating the pathway.

TABLE 2–4—TOXICITY FACTOR EVALUATION

	Assigned value
Chronic toxicity (Human)	
Reference dose (RfD) (mg/kg-day):	
RfD < 0.0005	10,000
0.0005 ≤ RfD < 0.005	1,000
0.005 ≤ RfD < 0.05	100
0.05 ≤ RfD < 0.5	10
0.5 ≤ RfD	1
RfD not available	0
Reference concentration (RfC) (mg/m³):	
RfC < 0.0001	10,000
0.0001 ≤ RfC < 0.006	1,000
0.006 ≤ RfC < 0.2	100
0.2 ≤ RfC < 2.0	10
2.0 ≤ RfC	1
RfC not available	0

Carcinogenicity (Human)			
A or Carcinogenic to humans	B or Likely to be carcinogenic to humans	C or Suggestive evidence of carcinogenic potential	Assigned value
Weight-of-evidence [a]/Slope factor (mg/kg-day) $^{-1}$			
0.5 ≤ SF [b]	5 ≤ SF	50 ≤ SF	10,000

Carcinogenicity (Human)			
A or Carcinogenic to humans	B or Likely to be carcinogenic to humans	C or Suggestive evidence of carcinogenic potential	Assigned value
$0.05 \leq SF < 0.5$	$0.5 \leq SF < 5$	$5 \leq SF < 50$	1,000
$SF < 0.05$	$0.05 \leq SF < 0.5$	$0.5 \leq SF < 5$	100
—	$SF < 0.05$	$SF < 0.5$	10
Slope factor not available	Slope factor not available	Slope factor not available	0
Weight-of-evidence [a]/Inhalation unit risk (μg/m³)			
$0.00004 \leq IUR$ [c]	$0.0004 \leq IUR$	$0.004 \leq IUR$	10,000
$0.00001 \leq IUR < 0.00004$	$0.0001 \leq IUR < 0.0004$	$0.001 \leq IUR < 0.004$	1,000
$IUR < 0.00001$	$0.00001 \leq IUR < 0.0001$	$0.0001 \leq IUR < 0.001$	100
—	< 0.00001	$IUR < 0.0001$	10
Inhalation unit risk not available	Inhalation unit risk not available	Inhalation unit risk not available	0

[a] A, B, and C, as well as Carcinogenic to humans, Likely to be carcinogenic to humans, and Suggestive evidence of carcinogenic potential refer to weight-of-evidence categories. Assign substances with a weight-of-evidence category of D (inadequate evidence of carcinogenicity) or E (evidence of lack of carcinogenicity), as well as inadequate information to assess carcinogenic potential and not likely to be carcinogenic to humans a value of 0 for carcinogenicity.
[b] SF = Slope factor.
[c] IUR = Inhalation Unit Risk.

Acute Toxicity (Human)				
Oral LD_{50} (mg/kg)	Dermal LD_{50} (mg/kg)	Dust or mist LC_{50} (mg/l)	Gas or vapor LC_{50} (ppm)	Assigned value
$LD_{50} < 5$	$LD_{50} < 2$	$LC_{50} < 0.2$	$LC_{50} < 20$	1,000
$5 \leq LD_{50} < 50$	$2 \leq LD_{50} < 20$	$0.2 \leq LC_{50} < 2$	$20 \leq LC_{50} <200$	100
$50 \leq LD_{50} < 500$	$20 \leq LD_{50} < 200$	$2 \leq LC_{50} <20$	$200 \leq LC_{50} <2,000$	10
$500 \leq LD_{50}$	$200 \leq LD_{50}$	$20 \leq LC_{50}$	$2,000 \leq LC_{50}$	1
LD_{50} not available	LD_{50} not available	LD_{50} not available	LD_{50} not available	0

If a toxicity factor value of 0 is assigned to all hazardous substances available to a particular pathway (that is, insufficient toxicity data are available for evaluating all the substances), use a default value of 100 as the overall human toxicity factor value for all hazardous substances available to the pathway. For hazardous substances having usable toxicity data for multiple exposure routes (for example, inhalation and ingestion), consider all exposure routes and use the highest assigned value, regardless of exposure route, as the toxicity factor value.

For HRS purposes, assign both asbestos and lead (and its compounds) a human toxicity factor value of 10,000.

Separate criteria apply for assigning factor values for human toxicity and ecosystem toxicity for radionuclides (see sections 7.2.1 and 7.2.2).

2.4.1.2 *Hazardous substance selection.* For each hazardous substance evaluated for a migration pathway (or threat), combine the human toxicity factor value (or ecosystem toxicity factor value) for the hazardous substance with a mobility, persistence, and/or bioaccumulation (or ecosystem bioaccumulation) potential factor value as follows:

- Ground water migration.

—Determine a combined human toxicity/mobility factor value for the hazardous substance (see section 3.2.1).

- Surface water migration—overland/flood migration component.

—Determine a combined human toxicity/persistence factor value for the hazardous substance for the drinking water threat (see section 4.1.2.2.1).

—Determine a combined human toxicity/persistence/bioaccumulation factor value for the hazardous substance for the human food chain threat (see section 4.1.3.2.1).

—Determine a combined ecosystem toxicity/persistence/bioaccumulation factor value for the hazardous substance for the environmental threat (see section 4.1.4.2.1).

- Surface water migration—ground water to surface water migration component.

—Determine a combined human toxicity/mobility/persistence factor value for the hazardous substance for the drinking water threat (see section 4.2.2.2.1).

—Determine a combined human toxicity/mobility/persistence/bioaccumulation factor value for the hazardous substance for the human food chain threat (see section 4.2.3.2.1).

—Determine a combined ecosystem toxicity/mobility/persistence/bioaccumulation factor value for the hazardous substance for the environmental threat (see section 4.2.4.2.1).

- Air migration.
- Determine a combined human toxicity/mobility factor value for the hazardous substance (see section 6.2.1).

Determine each combined factor value for a hazardous substance by multiplying the individual factor values appropriate to the pathway (or threat). For each migration pathway (or threat) being evaluated, select the hazardous substance with the highest combined factor value and use that substance in evaluating the waste characteristics factor category of the pathway (or threat).

For the soil exposure and subsurface intrusion pathway, determine toxicity and toxicity/degradation factor values as follows:

- Soil exposure and subsurface intrusion—soil exposure component.
  - Select the hazardous substance with the highest human toxicity factor value from among the substances that meet the criteria for observed contamination for the threat evaluated and use that substance in evaluating the waste characteristics factor category (see section

5.1.1.2.1).

- Soil exposure and subsurface intrusion—subsurface intrusion component.
  - Determine a combined human toxicity/degradation factor value for each hazardous substance being evaluated that:
    - Meets the criteria for observed exposure, or
    - Meets the criteria for observed release in an area of subsurface contamination and has a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to 10^{-5} atm-m^3/mol, or
    - Meets the criteria for an observed release in a structure within, or in a sample from below, an area of observed exposure and has a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to 10^{-5} atm-m^3/mol.
  - Select the hazardous substance with the highest combined factor value and use that substance in evaluating the waste characteristics factor category (see sections 5.2.1.2.1 and 5.2.1.2).

2.4.2 *Hazardous waste quantity.* Evaluate the hazardous waste quantity factor by first assigning each source (or area of observed contamination, area of observed exposure or area of subsurface contamination) a source hazardous waste quantity value as specified below. Sum these values to obtain the hazardous waste quantity factor value for the pathway being evaluated.

In evaluating the hazardous waste quantity factor for the three migration pathways, allocate hazardous substances and hazardous wastestreams to specific sources in the manner specified in section 2.2.2, except: Consider hazardous substances and hazardous wastestreams that cannot be allocated to any specific source to constitute a separate ''unallocated source'' for purposes of evaluating only this factor for the three migration pathways. Do not, however, include a hazardous substance or hazardous wastestream in the unallocated source for a migration pathway if there is definitive information indicating that the substance or wastestream could only have been placed in sources with a containment factor value of 0 for that migration pathway.

In evaluating the hazardous waste quantity factor for the soil exposure component of the soil exposure and subsurface intrusion pathway, allocate to each area of observed contamination only those hazardous substances that meet the criteria for observed contamination, for that area of observed contamination and only those hazardous wastestreams that contain hazardous substances that meet the criteria for observed contamination for that area of observed contamination. Do not consider other hazardous substances or hazardous wastestreams at the site in evaluating this factor for the soil exposure component of the soil exposure and subsurface intrusion pathway.

In evaluating the hazardous waste quantity factor for the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, allocate to each area of observed exposure or area of subsurface contamination only those hazardous substances and hazardous wastestreams that contain hazardous substances that:

- Meet the criteria for observed exposure, or
- Meet the criteria for observed release in an area of subsurface contamination and has a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to 10^{-5} atm-m^3/mol, or
- Meet the criteria for an observed release in a structure within, or in a sample from below, an area of observed exposure and has a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to 10^{-5} atm-m^3/mol.

Do not consider other hazardous substances or hazardous wastestreams at the site in evaluating this factor for the subsurface intrusion component of the soil exposure and subsurface intrusion pathway. When determining the hazardous waste quantity for multi-subunit structures, use the procedures identified in section 5.2.1.2.2.

2.4.2.1 *Source hazardous waste quantity.* For each of the three migration pathways, assign a source hazardous waste quantity value to each source (including the unallocated source) having a containment factor value greater than 0 for the pathway being evaluated. Consider the unallocated source to have a containment factor value greater than 0 for each migration pathway.

For the soil exposure component of the soil exposure and subsurface intrusion pathway, assign a source hazardous waste quantity value to each area of observed contamination, as applicable to the threat being evaluated.

For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, assign a source hazardous waste quantity value to each regularly occupied structure within an area of observed exposure or an area of subsurface contamination that has a structure containment factor value greater than 0.

For determining all hazardous waste quantity calculations except for an unallocated source or an area of subsurface contamination, evaluate using the following four measures in the following hierarchy:

- Hazardous constituent quantity.
- Hazardous wastestream quantity.
- Volume.
- Area.

For the unallocated source, use only the first two measures. For an area of subsurface contamination, evaluate non-radioactive hazardous substances using only the last two measures and evaluate radioactive hazardous substances using hazardous wastestream quantity only. See also section 7.0 regarding the evaluation of radioactive substances.

Separate criteria apply for assigning a source hazardous waste quantity value for radionuclides (see section 7.2.5).

2.4.2.1.1 *Hazardous constituent quantity.* Evaluate hazardous constituent quantity for the source (or area of observed contamination) based solely on the mass of CERCLA hazardous substances (as defined in CERCLA section 101(14), as amended) allocated to the source (or area of observed contamination), except:

- For a hazardous waste listed pursuant to section 3001 of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (RCRA), 42 U.S.C. 6901 *et seq.,* determine its mass for the evaluation of this measure as follows:

—If the hazardous waste is listed solely for Hazard Code T (toxic waste), include only the mass of constituents in the hazardous waste that are CERCLA hazardous substances and not the mass of the entire hazardous waste.

— If the hazardous waste is listed for any other Hazard Code (including T plus any other Hazard Code), include the mass of the entire hazardous waste.

- For a RCRA hazardous waste that exhibits the characteristics identified under section 3001 of RCRA, as amended, determine its mass for the evaluation of this measure as follows:

—If the hazardous waste exhibits only the characteristic of toxicity (or only the characteristic of EP toxicity), include only the mass of constituents in the hazardous waste that are CERCLA hazardous substances and not the mass of the entire hazardous waste.

—If the hazardous waste exhibits any other characteristic identified under section 3001 (including any other characteristic plus the characteristic of toxicity [or the characteristic of EP toxicity]), include the mass of the entire hazardous waste.

Based on this mass, designated as C, assign a value for hazardous constituent quantity as follows:

- For the migration pathways, assign the source a value for hazardous constituent quantity using the Tier A equation of Table 2–5.
- For the soil exposure and subsurface intrusion pathway—soil exposure component, assign the area of observed contamination a value using the Tier A equation of Table 5–2 (section 5.1.1.2.2).
- For the soil exposure and subsurface intrusion pathway—subsurface intrusion component, assign the area of observed exposure a value using the Tier A equation of Table 5–18 (section 5.2.1.2.2).

If the hazardous constituent quantity for the source (or area of observed contamination or area of observed exposure) is adequately determined (that is, the total mass of all CERCLA hazardous substances in the source and releases from the source [or in the area of observed contamination or area of observed exposure] is known or is estimated with reasonable confidence), do not evaluate the other three measures discussed below. Instead assign these other three measures a value of 0 for the source (or area of observed contamination or area of observed exposure) and proceed to section 2.4.2.1.5.

If the hazardous constituent quantity is not adequately determined, assign the source (or area of observed contamination or area of observed exposure) a value for hazardous constituent quantity based on the available data and proceed to section 2.4.2.1.2.

TABLE 2–5—HAZARDOUS WASTE QUANTITY EVALUATION EQUATIONS

Tier	Measure	Units	Equation for assigning value [a]
A	Hazardous constituent quantity (C)	lb	C
B [b]	Hazardous wastestream quantity (W)	lb	W/5,000
C [b]	Volume (V).		
	Landfill	yd^3	V/2,500
	Surface impoundment	yd^3	V/2.5
	Surface impoundment (buried/backfilled)	yd^3	V/2.5
	Drums [c]	gallon	V/2.5
	Tanks and containers other than drums	yd^3	V/2.5
	Contaminated soil	yd^3	V/2,500
	Pile	yd^3	V/2.5
	Other	yd^3	V/2.5
D [b]	Area (A).		
	Landfill	ft^2	A/3,400
	Surface impoundment	ft^2	A/13
	Surface impoundment (buried/backfilled)	ft^2	A/13
	Land treatment	ft^2	A/270
	Pile [d]	ft^2	A/13
	Contaminated soil	ft^2	A/34,000

[a] Do not round to nearest integer.
[b] Convert volume to mass when necessary: 1 ton = 2,000 pounds = 1 cubic yard = 4 drums = 200 gallons.
[c] If actual volume of drums is unavailable, assume 1 drum = 50 gallons.
[d] Use land surface area under pile, not surface area of pile.

2.4.2.1.2 *Hazardous wastestream quantity.* Evaluate hazardous wastestream quantity for the source (or area of observed contamination or area of observed exposure) based on the mass of hazardous wastestreams plus the mass of any additional CERCLA pollutants and contaminants (as defined in CERCLA section 101[33], as amended) that are allocated to the source (or area of observed contamination or area of observed exposure). For a wastestream that consists solely of a hazardous waste listed pursuant to section 3001 of RCRA, as amended or that consists solely of a RCRA hazardous waste that exhibits the characteristics identified under section 3001 of RCRA, as amended, include the mass of that entire hazardous waste in the evaluation of this measure.

Based on this mass, designated as W, assign a value for hazardous wastestream quantity as follows:

- For the migration pathways, assign the source a value for hazardous wastestream quantity using the Tier B equation of Table 2–5.
- For the soil exposure and subsurface intrusion pathway—soil exposure component, assign the area of observed contamination a value using the Tier B equation of Table 5–2 (section 5.1.1.2.2).
- For the soil exposure and subsurface intrusion pathway—subsurface intrusion component, assign the area of observed exposure a value using the Tier B equation of Table 5–18 (section 5.2.1.2.2).

Do not evaluate the volume and area measures described below if the source is the unallocated source or if the following condition applies:

- The hazardous wastestream quantity for the source (or area of observed contamination) is adequately determined—that is, total mass of all hazardous wastestreams and CERCLA pollutants and contaminants for the source and releases from the source (or for the area of observed contamination) is known or is estimated with reasonable confidence.

If the source is the unallocated source or if this condition applies, assign the volume and area measures a value of 0 for the source (or area of observed contamination) and proceed to section 2.4.2.1.5. Otherwise, assign the source (or area of observed contamination) a value for Hazardous wastestream quantity based on the available data and proceed to section 2.4.2.1.3.

2.4.2.1.3 *Volume.* Evaluate the volume measure using the volume of the source (or the volume of the area of observed contamination, area of observed exposure, or area of subsurface contamination). For the soil exposure and subsurface intrusion pathway, restrict the use of the volume measure to those areas of observed contamination, areas of observed exposure, or areas of subsurface contamination as specified in sections 5.1.1.2.2 and 5.2.1.2.2.

Based on the volume, designated as V, assign a value to the volume measure as follows:

• For the migration pathways, assign the source a value for volume using the appropriate Tier C equation of Table 2–5.

• For the soil exposure and subsurface intrusion pathway—soil exposure component, assign the area of observed contamination a value for volume using the appropriate Tier C equation of Table 5–2 (section 5.1.1.2.2).

• For the soil exposure and subsurface intrusion pathway—subsurface intrusion component, assign the value based on the volume of the regularly occupied structures within the area of observed exposure or area of subsurface contamination using the Tier C equation of Table 5–18 (section 5.2.1.2.2).

If the volume of the source (or volume of the area of observed contamination, area of observed exposure, or area of subsurface contamination, if applicable) can be determined, do not evaluate the area measure. Instead, assign the area measure a value of 0 and proceed to section 2.4.2.1.5. If the volume cannot be determined (or is not applicable for the soil exposure and subsurface intrusion pathway), assign the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination) a value of 0 for the volume measure and proceed to section 2.4.2.1.4.

2.4.2.1.4 *Area.* Evaluate the area measure using the area of the source (or the area of the area of observed contamination, area of observed exposure, or area of subsurface contamination). Based on this area, designated as A, assign a value to the area measure as follows:

• For the migration pathways, assign the source a value for area using the appropriate Tier D equation of Table 2 –5.

• For the soil exposure and subsurface intrusion pathway—soil exposure component, assign the area of observed contamination a value for area using the appropriate Tier D equation of Table 5–2 (section 5.1.1.2.2).

• For the soil exposure and subsurface intrusion pathway—subsurface intrusion component, assign a value based on the area of regularly occupied structures within the area of observed exposure or area of subsurface contamination using the Tier D equation of Table 5–18 (section 5.2.1.2.2).

2.4.2.1.5 *Calculation of source hazardous waste quantity value.* Select the highest of the values assigned to the source (or areas of observed contamination, areas of observed exposure, or areas of subsurface contamination) for the hazardous constituent quantity, hazardous wastestream quantity, volume, and area measures. Assign this value as the source hazardous waste quantity value. Do not round to the nearest integer.

2.4.2.2 *Calculation of hazardous waste quantity factor value.* Sum the source hazardous waste quantity values assigned to all sources (including the unallocated source) or areas of observed contamination, areas of observed exposure, or areas of subsurface contamination for the pathway being evaluated and round this sum to the nearest integer, except: If the sum is greater than 0, but less than 1, round it to 1. Based on this value, select a hazardous waste quantity factor value for the pathway from Table 2–6.

TABLE 2–6—HAZARDOUS WASTE QUANTITY FACTOR VALUES

Hazardous waste quantity value	Assigned value
0	0
1 [a] to 100	[b] 1
Greater than 100 to 10,000	100
Greater than 10,000 to 1,000,000	10,000
Greater than 1,000,000	1,000,000

[a] If the hazardous waste quantity value is greater than 0, but less than 1, round it to 1 as specified in text.

[b] For the pathway, if hazardous constituent quantity is not adequately determined, assign a value as specified in the text; do not assign the value of 1.

For a migration pathway, if the hazardous constituent quantity is adequately determined (see section 2.4.2.1.1) for all sources (or all portions of sources and releases remaining after a removal action), assign the value from Table 2–6 as the hazardous waste quantity factor value for the pathway. If the hazardous constituent quantity is not adequately determined for one or more sources (or one or more portions of sources or releases remaining after a removal action) assign a factor value as follows:

• If any target for that migration pathway is subject to Level I or Level II concentrations (see section 2.5), assign either the value from Table 2–6 or a value of 100, whichever is greater, as the hazardous waste quantity factor value for that pathway.

• If none of the targets for that pathway is subject to Level I or Level II concentrations, assign a factor value as follows:

—If there has been no removal action, assign either the value from Table 2–6 or a value of 10, whichever is greater, as the hazardous waste quantity factor value for that pathway.

—If there has been a removal action:

▪ Determine values from Table 2–6 with and without consideration of the removal action.

▪ If the value that would be assigned from Table 2–6 without consideration of the removal action would be 100 or greater, assign either the value from Table 2–6 with consideration of the removal action or a value of 100, whichever is greater, as the hazardous waste quantity factor value for the pathway.

▪ If the value that would be assigned from Table 2–6 without consideration of the removal action would be less than 100, assign a value of 10 as the hazardous waste quantity factor value for the pathway.

For the soil exposure component of the soil exposure and subsurface intrusion pathway, if the hazardous constituent quantity is adequately determined for all areas of observed contamination, assign the value from Table 2–6 as the hazardous waste quantity factor value. If the hazardous constituent quantity is not adequately determined for one or more areas of observed contamination, assign either the value from Table 2–6 or a value of 10, whichever is greater, as the hazardous waste quantity factor value.

For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, if the hazardous constituent quantity is adequately determined for all areas of observed exposure, assign the value from Table 2–6 as the hazardous waste quantity factor value. If the hazardous constituent quantity is not adequately determined for one or more areas of observed exposure, assign either the value from Table 2–6 or assign a factor value as follows:

• If any target for the subsurface intrusion component is subject to Level I or Level II concentrations (see section 2.5), assign either the value from Table 2–6 or a value of 100, whichever is greater, as the hazardous waste quantity factor value for this component.

- If none of the targets for the subsurface intrusion component is subject to Level I or Level II concentrations and if there has been a removal action, assign a factor value as follows:

—Determine the values from Table 2–6 with and without consideration of the removal action.

—If the value that would be assigned from Table 2–6 without consideration of the removal action would be 100 or greater, assign either the value from Table 2–6 with consideration of the removal action or a value of 100, whichever is greater, as the hazardous waste quantity factor value for the component.

—If the value that would be assigned from Table 2–6 without consideration of the removal action would be less than 100, assign a value of 10 as the hazardous waste quantity factor value for the component.

- Otherwise, if none of the targets for the subsurface intrusion component is subject to Level I or Level II concentrations and there has not been a removal action, assign a value from Table 2–6 or a value of 10, whichever is greater.

2.4.3 *Waste characteristics factor category value.* Determine the waste characteristics factor category value as specified in section 2.4.3.1 for all pathways and threats, except the surface water-human food chain threat and the surface water-environmental threat. Determine the waste characteristics factor category value for these latter two threats as specified in section 2.4.3.2.

2.4.3.1 *Factor category value.* For the pathway (component or threat) being evaluated, multiply the toxicity or combined factor value, as appropriate, from section 2.4.1.2 and the hazardous waste quantity factor value from section 2.4.2.2, subject to a maximum product of $1x10^8$. Based on this waste characteristics product, assign a waste characteristics factor category value to the pathway (component or threat) from Table 2–7.

TABLE 2–7—WASTE CHARACTERISTICS FACTOR CATEGORY VALUES

Waste characteristics product	Assigned value
0	0
Greater than 0 to less than 10	1
10 to less than $1x10^2$	2
$1x10^2$ to less than $1x10^3$	3
$1x10^3$ to less than $1x10^4$	6
$1x10^4$ to less than $1x10^5$	10
$1x10^5$ to less than $1x10^6$	18
$1x10^6$ to less than $1x10^7$	32
$1x10^7$ to less than $1x10^8$	56
$1x10^8$ to less than $1x10^9$	100
$1x10^9$ to less than $1x10^{10}$	180
$1x10^{10}$ to less than $1x10^{11}$	320
$1x10^{11}$ to less than $1x10^{12}$	560
$1x10^{12}$	1,000

2.4.3.2 *Factor category value, considering bioaccumulation potential.* For the surface water-human food chain threat and the surface water-environmental threat, multiply the toxicity or combined factor value, as appropriate, from section 2.4.1.2 and the hazardous waste quantity factor value from section 2.4.2.2, subject to:

- A maximum product of $1x10^{12}$, *and*
- A maximum product exclusive of the bioaccumulation (or ecosystem bioaccumulation) potential factor of $1x10^8$.

Based on the total waste characteristics product, assign a waste characteristics factor category value to these threats from Table 2–7.

2.5 *Targets.* The types of targets evaluated include the following:

- Individual (factor name varies by pathway, component, and threat).
- Human population.
- Resources (these vary by pathway, component, and threat).
- Sensitive environments (included for the surface water migration pathway, air migration pathway, and soil exposure component of the soil exposure and subsurface intrusion pathway).

The factor values that may be assigned to each type of target have the same range for each pathway for which that type of target is evaluated. The factor value for most types of targets depends on whether the target is subject to actual or potential contamination for the pathway and whether the actual contamination is Level I or Level II:

- Actual contamination: Target is associated either with a sampling location that meets the criteria for an observed release (or observed contamination or observed exposure) for the pathway or with an observed release based on direct observation for the pathway (additional criteria apply for establishing actual contamination for the human food chain threat in the surface water migration pathway, see sections 4.1.3.3 and 4.2.3.3). Sections 3 through 6 specify how to determine the targets associated with a sampling location or with an observed release based on direct observation. Determine whether the actual contamination is Level I or Level II as follows:

—Level I:

- Media-specific concentrations for the target meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway and are at or above media-specific benchmark values. These benchmark values (see section 2.5.2) include both screening concentrations and concentrations specified in regulatory limits (such as Maximum Contaminant Level (MCL) values), or
- For the human food chain threat in the surface water migration pathway, concentrations in tissue samples from aquatic human food chain organisms are at or above benchmark values. Such tissue samples may be used in addition to media-specific concentrations only as specified in sections 4.1.3.3 and 4.2.3.3.

—Level II:

- Media-specific concentrations for the target meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway, but are less than media-specific benchmarks. If none of the hazardous substances eligible to be evaluated for the sampling location has an applicable benchmark, assign Level II to the actual contamination at the sampling location, or
- For observed releases or observed exposures based on direct observation, assign Level II to targets as specified in sections 3, 4, 5, and 6, or
- For the human food chain threat in the surface water migration pathway, concentrations in tissue samples from aquatic human food chain organisms, when applicable, are below benchmark values.

—If a target is subject to both Level I and Level II concentrations for a pathway (or threat), evaluate the target using Level I concentrations for that pathway (or threat).

- Potential contamination: Target is subject to a potential release (that is, target is not associated with actual contamination for that pathway or threat).

Assign a factor value for individual risk as follows (select the highest value that applies to the pathway or threat):

- 50 points if any individual is exposed to Level I concentrations.
- 45 points if any individual is exposed to Level II concentrations.

• Maximum of 20 points if any individual is subject to potential contamination. The value assigned is 20 unless reduced by a distance or dilution weight appropriate to the pathway.

Assign factor values for population and sensitive environments as follows:

• Sum Level I targets and multiply by 10. (Level I is not used for sensitive environments in the soil exposure component of the soil exposure and subsurface intrusion and air migration pathways.)

• Sum Level II targets.

• Multiply potential targets in all but the soil exposure and subsurface intrusion pathway by distance or dilution weights appropriate to the pathway, sum, and divide by 10. Distance or dilution weighting accounts for diminishing exposure with increasing distance or dilution within the different pathways. For targets within an area of subsurface contamination in the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, multiply by a weighting factor as directed in section 5.2.1.3.2.3.

• Sum the values for the three levels.

In addition, resource value points are assigned within all pathways for welfare-related impacts (for example, impacts to agricultural land), but do not depend on whether there is actual or potential contamination.

2.5.1 *Determination of level of actual contamination at a sampling location.* Determine whether Level I concentrations or Level II concentrations apply at a sampling location (and thus to the associated targets) as follows:

• Select the benchmarks applicable to the pathway (component or threat) being evaluated.

• Compare the concentrations of hazardous substances in the sample (or comparable samples) to their benchmark concentrations for the pathway (component or threat), as specified in section 2.5.2.

• Determine which level applies based on this comparison.

• If none of the hazardous substances eligible to be evaluated for the sampling location has an applicable benchmark, assign Level II to the actual contamination at that sampling location for the pathway (component or threat).

In making the comparison, consider only those samples, and only those hazardous substances in the sample, that meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway, except: Tissue samples from aquatic human food chain organisms may also be used as specified in sections 4.1.3.3 and 4.2.3.3 of the surface water-human food chain threat. If any hazardous substance is present in more than one comparable sample for the sampling location, use the highest concentration of that hazardous substance from any of the comparable samples in making the comparisons.

Treat sets of samples that are not comparable separately and make a separate comparison for each such set.

2.5.2 *Comparison to benchmarks.* Use the following media-specific benchmarks for making the comparisons for the indicated pathway (or threat):

• Maximum Contaminant Level Goals (MCLGs)—ground water migration pathway and drinking water threat in surface water migration pathway. Use only MCLG values greater than 0.

• Maximum Contaminant Levels (MCLs)—ground water migration pathway and drinking water threat in surface water migration pathway.

• Food and Drug Administration Action Level (FDAAL) for fish or shellfish—human food chain threat in surface water migration pathway.

• EPA Ambient Water Quality Criteria (AWQC/National Recommended Water Quality Criteria) for protection of aquatic life—environmental threat in surface water migration pathway.

• EPA Ambient Aquatic Life Advisory Concentrations (AALAC)—environmental threat in surface water migration pathway.

• National Ambient Air Quality Standards (NAAQS)—air migration pathway.

• National Emission Standards for Hazardous Air Pollutants (NESHAPs)—air migration pathway. Use only those NESHAPs promulgated in ambient concentration units.

• Screening concentration for cancer corresponding to that concentration that corresponds to the 10^{-6} individual cancer risk for inhalation exposures (air migration pathway or subsurface intrusion component of the soil exposure and subsurface intrusion pathway) or for oral exposures (ground water migration pathway; drinking water and human food chain threats in surface water migration pathway; and soil exposure and subsurface intrusion pathway).

• Screening concentration for noncancer toxicological responses corresponding to the RfC for inhalation exposures (air migration pathway and subsurface intrusion component of the soil exposure and subsurface intrusion pathway) or RfD for oral exposures (ground water migration pathway; drinking water and human food chain threats in surface water migration pathway; and soil exposure and subsurface intrusion pathway).

Select the benchmark(s) applicable to the pathway (component or threat) being evaluated as specified in sections 3 through 6. Compare the concentration of each hazardous substance from the sampling location to its benchmark concentration(s) for that pathway (component or threat). Use only those samples and only those hazardous substances in the sample that meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway, except: Tissue samples from aquatic human food chain organisms may be used as specified in sections 4.1.3.3 and 4.2.3.3. If the concentration of any applicable hazardous substance from any sample equals or exceeds its benchmark concentration, consider the sampling location to be subject to Level I concentrations for that pathway (or threat). If more than one benchmark applies to the hazardous substance, assign Level I if the concentration of the hazardous substance equals or exceeds the lowest applicable benchmark concentration.

If no hazardous substance individually equals or exceeds its benchmark concentration, but more than one hazardous substance either meets the criteria for an observed release (or observed contamination or observed exposure) for the sample (or comparable samples) or is eligible to be evaluated for a tissue sample (see sections 4.1.3.3 and 4.2.3.3), calculate the indices I and J specified below based on these hazardous substances.

For those hazardous substances that are carcinogens (that is, those having either a carcinogen weight-of-evidence classification of A, B, or C or a weight-of-evidence classification of carcinogenic to humans, likely to be carcinogenic to humans, or suggestive evidence of carcinogenic potential), calculate an index I for the sample location as follows:

$$I = \sum_{i=1}^{n} \frac{C_i}{SC_i}$$

Where:

C_i = Concentration of hazardous substance i in sample (or highest concentration of hazardous substance i from among comparable samples).

SC_i = Screening concentration for cancer corresponding to that concentration that corresponds to its 10^{-6} individual cancer risk for applicable exposure (inhalation or oral) for hazardous substance i.

n = Number of applicable hazardous substances in sample (or comparable samples) that are carcinogens and for which an SC_i is available.

For those hazardous substances for which an RfD or RfC is available, calculate an index J for the sample location as follows:

$$I = \sum_{j=1}^{m} \frac{C_j}{CR_j}$$

Where:

C_j = Concentration of hazardous substance j in sample (or highest concentration of hazardous substance j from among comparable samples).

CR_j = Screening concentration for noncancer toxicological responses corresponding to RfD or RfC for applicable exposure (inhalation or oral) for hazardous substance j.

m = Number of applicable hazardous substances in sample (or comparable samples) for which a CR_j is available.

If either I or J equals or exceeds 1, consider the sampling location to be subject to Level I concentrations for that pathway (component or threat). If both I and J are less than 1, consider the sampling location to be subject to Level II concentrations for that pathway (component or threat). If, for the sampling location, there are sets of samples that are not comparable, calculate I and J separately for each such set, and use the highest calculated values of I and J to assign Level I and Level II.

See sections 7.3.1 and 7.3.2 for criteria for determining the level of contamination for radioactive substances.

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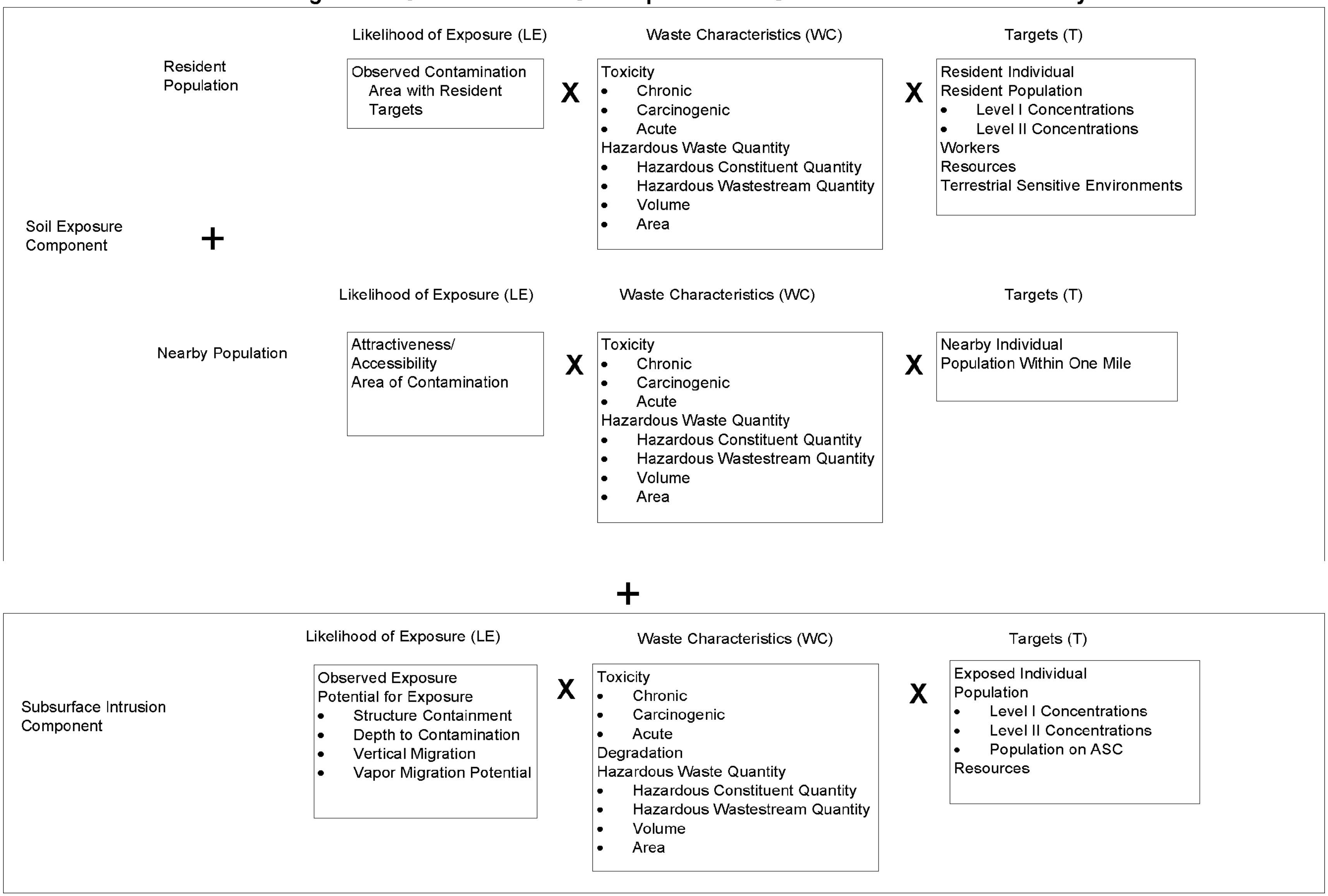
5.0 Soil Exposure and Subsurface Intrusion Pathway

5.0. *Exposure components.* Evaluate the soil exposure and subsurface intrusion pathway based on two exposure components:

- Soil exposure component (see section 5.1).
- Subsurface intrusion component (see section 5.2).

Score one or both components considering their relative importance. If only one component is scored, assign its score as the soil exposure and subsurface intrusion pathway score. If both components are scored, sum the two scores and assign it as the soil exposure and subsurface intrusion pathway score, subject to a maximum of 100.

Figure 5-1 Overview of the Soil Exposure and Subsurface Intrusion Pathway



5.1 *Soil exposure component.* Evaluate the soil exposure component based on two threats: Resident population threat and nearby population threat. Evaluate both threats based on three factor categories:

Likelihood of exposure, waste characteristics, and targets. Figure 5–1 indicates the factors included within each factor category for each type of threat.

Determine the soil exposure component score (S_{se}) in terms of the factor category values as follows:

$$S_{se} = \frac{\sum_{i=1}^{2}(LE_i)(WC_i)(T_i)}{SF}$$

Where:

LE_i = Likelihood of exposure factor category value for threat i (that is, resident population threat or nearby population threat).
WC_i = Waste characteristics factor category value for threat i.
T_i = Targets factor category value for threat i.
SF = Scaling factor.

Table 5–1 outlines the specific calculation procedure.

TABLE 5–1—SOIL EXPOSURE COMPONENT SCORESHEET

Factor categories and factors	Maximum value	Value assigned
Resident Population Threat		
Likelihood of Exposure		
1. Likelihood of Exposure	550	
Waste Characteristics		
2. Toxicity	([a])	
3. Hazardous Waste Quantity	([a])	
4. Waste Characteristics	100	
Targets		
5. Resident Individual	50	
6. Resident Population:		
6a. Level I Concentrations	([b])	
6b. Level II Concentrations	([b])	
6c. Resident Population (lines 6a + 6b)	([b])	
7. Workers	15	
8. Resources	5	
9. Terrestrial Sensitive Environments	(c)	
10. Targets (lines 5 + 6c + 7 + 8 + 9)	([b])	
Resident Population Threat Score		
11. Resident Population Threat (lines 1x4x10)	([b])	
Nearby Population Threat		
Likelihood of Exposure		
12. Attractiveness/Accessibility	100	
13. Area of Contamination	100	
14. Likelihood of Exposure	500	
Waste Characteristics		
15. Toxicity	([a])	
16. Hazardous Waste Quantity	([a])	
17. Waste Characteristics	100	
Targets		
18. Nearby Individual	1	
19. Population Within 1 Mile	([b])	
20. Targets (lines 18 + 19)	([b])	
Nearby Population Threat Score		
21. Nearby Population Threat (lines 14x17x20)	([b])	
Soil Exposure Component Score		
22. Soil Exposure Component Score [d] (S_{se}), (lines [11+21]/82,500, subject to a maximum of 100)	100	

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However, pathway score based solely on terrestrial sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

5.1.0 *General considerations.* Evaluate the soil exposure component based on areas of observed contamination:

• Consider observed contamination to be present at sampling locations where analytic evidence indicates that:

—A hazardous substance attributable to the site is present at a concentration significantly above background levels for the site (see Table 2–3 in section 2.3 for the criteria for determining analytical significance), *and*

—This hazardous substance, if not present at the surface, is covered by 2 feet or less of cover material (for example, soil).

• Establish areas of observed contamination based on sampling locations at which there is observed contamination as follows:

—For all sources except contaminated soil, if observed contamination from the site is present at any sampling location within the source, consider that entire source to be an area of observed contamination.

— For contaminated soil, consider both the sampling location(s) with observed contamination from the site and the area lying between such locations to be an area of observed contamination, unless available information indicates otherwise.

• If an area of observed contamination (or portion of such an area) is covered by a permanent, or otherwise maintained, essentially impenetrable material (for example, asphalt) that is not more than 2 feet thick, exclude that area (or portion of the area) in evaluating the soil exposure component.

• For an area of observed contamination, consider only those hazardous substances that meet the criteria for observed contamination for that area to be associated with that area in evaluating the soil exposure component (see section 2.2.2).

If there is observed contamination, assign scores for the resident population threat and the nearby population threat, as specified in sections 5.1.1 and 5.1.2. If there is no observed contamination, assign the soil exposure component of the soil exposure and subsurface intrusion pathway a score of 0.

5.1.1 *Resident population threat.* Evaluate the resident population threat only if there is an area of observed contamination in one or more of the following locations:

• Within the property boundary of a residence, school, or day care center *and* within 200 feet of the respective residence, school, or day care center, or

• Within a workplace property boundary *and* within 200 feet of a workplace area, or

• Within the boundaries of a resource specified in section 5.1.1.3.4, or

• Within the boundaries of a terrestrial sensitive environment specified in section 5.1.1.3.5.

If not, assign the resident population threat a value of 0, enter this value in Table 5–1, and proceed to the nearby population threat (section 5.1.2).

5.1.1.1 *Likelihood of exposure.* Assign a value of 550 to the likelihood of exposure factor category for the resident population threat if there is an area of observed contamination in one or more locations listed in section 5.1.1. Enter this value in Table 5–1.

5.1.1.2 *Waste characteristics.* Evaluate waste characteristics based on two factors: Toxicity and hazardous waste quantity. Evaluate only those hazardous substances that meet the criteria for observed contamination at the site (see section 5.1.0).

5.1.1.2.1 *Toxicity.* Assign a toxicity factor value to each hazardous substance as specified in section 2.4.1.1. Use the hazardous substance with the highest toxicity factor value to assign the value to the toxicity factor for the resident population threat. Enter this value in Table 5–1.

5.1.1.2.2 *Hazardous waste quantity.* Assign a hazardous waste quantity factor value as specified in section 2.4.2. In estimating the hazardous waste quantity, use Table 5–2 and:

• Consider only the first 2 feet of depth of an area of observed contamination, except as specified for the volume measure.

• Use the volume measure (see section 2.4.2.1.3) only for those types of areas of observed contamination listed in Tier C of Table 5–2. In evaluating the volume measure for these listed areas of observed contamination, use the full volume, not just the volume within the top 2 feet.

• Use the area measure (see section 2.4.2.1.4), not the volume measure, for all other types of areas of observed contamination, even if their volume is known.

Enter the value assigned in Table 5–1.

TABLE 5–2—HAZARDOUS WASTE QUANTITY EVALUATION EQUATIONS FOR SOIL EXPOSURE COMPONENT

Tier	Measure	Units	Equation for assigning value [a]
A	Hazardous Constituent Quantity (C)	lb	C
B [b]	Hazardous Wastestream Quantity (W)	lb	W/5,000
C [b]	Volume (V).		
	Surface Impoundment [c]	yd^3	V/2.5
	Drums [d]	gallon	V/500
	Tanks and Containers Other Than Drums	yd^3	V/2.5
D [b]	Area (A).		
	Landfill	ft^2	A/34,000
	Surface Impoundment	ft^2	A/13
	Surface Impoundment (Buried/backfilled)	ft^2	A/13
	Land treatment	ft^2	A/270
	Pile [e]	ft^2	A/34
	Contaminated Soil	ft^2	A/34,000

[a] Do not round nearest integer.
[b] Convert volume to mass when necessary: 1 ton = 2,000 pounds = 1 cubic yard = 4 drums = 200 gallons.
[c] Use volume measure only for surface impoundments containing hazardous substances present as liquids. Use area measures in Tier D for dry surface impoundments and for buried/backfilled surface impoundments.
[d] If actual volume of drums is unavailable, assume 1 drum = 50 gallons.
[e] Use land surface area under pile, not surface area of pile.

5.1.1.2.3 *Calculation of waste characteristics factor category value.* Multiply the toxicity and hazardous waste quantity factor values, subject to a maximum product of 1×10^8. Based on this product, assign a value from Table 2–7 (section 2.4.3.1) to the waste characteristics factor category. Enter this value in Table 5–1.

5.1.1.3 *Targets.* Evaluate the targets factor category for the resident population threat based on five factors: Resident individual, resident population, workers, resources, and terrestrial sensitive environments.

In evaluating the targets factor category for the resident population threat, count only the following as targets:

• Resident individual—a person living or attending school or day care on a property with an area of observed contamination *and* whose residence, school, or day care center, respectively, is on or within 200 feet of the area of observed contamination.

• Worker—a person working on a property with an area of observed contamination *and* whose workplace area is on or within 200 feet of the area of observed contamination.

• Resources located on an area of observed contamination, as specified in section 5.1.1.

• Terrestrial sensitive environments located on an area of observed contamination, as specified in section 5.1.1.

5.1.1.3.1 *Resident individual.* Evaluate this factor based on whether there is a resident individual, as specified in section 5.1.1.3, who is subject to Level I or Level II concentrations.

First, determine those areas of observed contamination subject to Level I concentrations and those subject to Level II concentrations as specified in sections 2.5.1 and 2.5.2. Use the health-based benchmarks from Table 5–3 in determining the level of contamination. Then assign a value to the resident individual factor as follows:

- Assign a value of 50 if there is at least one resident individual for one or more areas subject to Level I concentrations.
- Assign a value of 45 if there is no such resident individuals, but there is at least one resident individual for one or more areas subject to Level II concentrations.
- Assign a value of 0 if there is no resident individual.

Enter the value assigned in Table 5–1.

5.1.1.3.2 *Resident population.* Evaluate resident population based on two factors: Level I concentrations and Level II concentrations. Determine which factor applies as specified in sections 2.5.1 and 2.5.2, using the health-based benchmarks from Table 5–3. Evaluate populations subject to Level I concentrations as specified in section 5.1.1.3.2.1 and populations subject to Level II concentrations as specified in section 5.1.1.3.2.2.

TABLE 5–3—HEALTH-BASED BENCHMARKS FOR HAZARDOUS SUBSTANCES IN SOILS

Screening concentration for cancer corresponding to that concentration that corresponds to the 10^{-6} individual cancer risk for oral exposures.
Screening concentration for noncancer toxicological responses corresponding to the Reference Dose (RfD) for oral exposures.

Count only those persons meeting the criteria for resident individual as specified in section 5.1.1.3. In estimating the number of people living on property with an area of observed contamination, when the estimate is based on the number of residences, multiply each residence by the average number of persons per residence for the county in which the residence is located.

5.1.1.3.2.1 *Level I concentrations.* Sum the number of resident individuals subject to Level I concentrations and multiply this sum by 10. Assign the resulting product as the value for this factor. Enter this value in Table 5–1.

5.1.1.3.2.2 *Level II concentrations.* Sum the number of resident individuals subject to Level II concentrations. Do not include those people already counted under the Level I concentrations factor. Assign this sum as the value for this factor. Enter this value in Table 5–1.

5.1.1.3.2.3 *Calculation of resident population factor value.* Sum the factor values for Level I concentrations and Level II concentrations. Assign this sum as the resident population factor value. Enter this value in Table 5–1.

5.1.1.3.3 *Workers.* Evaluate this factor based on the number of workers that meet the section 5.1.1.3 criteria. Assign a value for these workers using Table 5–4. Enter this value in Table 5–1.

TABLE 5–4—FACTOR VALUES FOR WORKERS

Number of workers	Assigned value
0	0
1 to 100	5
101 to 1,000	10
Greater than 1,000	15

5.1.1.3.4 *Resources.* Evaluate the resources factor as follows:

- Assign a value of 5 to the resources factor if one or more of the following is present on an area of observed contamination at the site:

—Commercial agriculture.
—Commercial silviculture.
—Commercial livestock production or commercial livestock grazing.

- Assign a value of 0 if none of the above are present.

Enter the value assigned in Table 5–1.

5.1.1.3.5 *Terrestrial sensitive environments.* Assign value(s) from Table 5–5 to each terrestrial sensitive environment that meets the eligibility criteria of section 5.1.1.3.

Calculate a value (ES) for terrestrial sensitive environments as follows:

$$ES = \sum_{i=1}^{n} S_i$$

where:
S_i=Value(s) assigned from Table 5–5 to terrestrial sensitive environment i.
n=Number of terrestrial sensitive environments meeting section 5.1.1.3 criteria.

Because the pathway score based solely on terrestrial sensitive environments is limited to a maximum of 60, determine the value for the terrestrial sensitive environments factor as follows:

TABLE 5–5—TERRESTRIAL SENSITIVE ENVIRONMENTS RATING VALUES

Terrestrial sensitive environments	Assigned value
Terrestrial critical habitat [a] for Federal designated endangered or threatened species	100
National Park	
Designated Federal Wilderness Area	
National Monument	
Terrestrial habitat known to be used by Federal designated or proposed threatened or endangered species	75
National Preserve (terrestrial)	
National or State Terrestrial Wildlife Refuge	
Federal land designated for protection of natural ecosystems	
Administratively proposed Federal Wilderness Area	
Terrestrial areas utilized for breeding by large or dense aggregations of animals [b]	
Terrestrial habitat known to be used by State designated endangered or threatened species	50
Terrestrial habitat known to be used by species under review as to its Federal designated endangered or threatened status	
State lands designated for wildlife or game management	25
State designated Natural Areas	
Particular areas, relatively small in size, important to maintenance of unique biotic communities	

[a] Critical habitat as defined in 50 CFR 424.02.

[b] Limit to vertebrate species.

- Multiply the values assigned to the resident population threat for likelihood of exposure (LE), waste characteristics (WC), and ES. Divide the product by 82,500.

—If the result is 60 or less, assign the value ES as the terrestrial sensitive environments factor value.

—If the result exceeds 60, calculate a value EC as follows:

$$EC = \frac{(60)(82{,}500)}{(LE)(WC)}$$

Assign the value EC as the terrestrial sensitive environments factor value. Do not round this value to the nearest integer.

Enter the value assigned for the terrestrial sensitive environments factor in Table 5–1.

5.1.1.3.6 *Calculation of resident population targets factor category value.* Sum the values for the resident individual, resident population, workers, resources, and terrestrial sensitive environments factors. Do not round to the nearest integer. Assign this sum as the targets factor category value for the resident population threat. Enter this value in Table 5–1.

5.1.1.4 *Calculation of resident population threat score.* Multiply the values for likelihood of exposure, waste characteristics, and targets for the resident population threat, and round the product to the nearest integer. Assign this product as the resident population threat score. Enter this score in Table 5–1.

5.1.2 *Nearby population threat.* Include in the nearby population only those individuals who live or attend school within a 1-mile travel distance of an area of observed contamination at the site and who do not meet the criteria for resident individual as specified in section 5.1.1.3.

Do not consider areas of observed contamination that have an attractiveness/accessibility factor value of 0 (see section 5.1.2.1.1) in evaluating the nearby population threat.

5.1.2.1 *Likelihood of exposure.* Evaluate two factors for the likelihood of exposure factor category for the nearby population threat: Attractiveness/accessibility and area of contamination.

5.1.2.1.1 *Attractiveness/accessibility.* Assign a value for attractiveness/accessibility from Table 5–6 to each area of observed contamination, excluding any land used for residences. Select the highest value assigned to the areas evaluated and use it as the value for the attractiveness/accessibility factor. Enter this value in Table 5–1.

5.1.2.1.2 *Area of contamination.* Evaluate area of contamination based on the total area of the areas of observed contamination at the site. Count only the area(s) that meet the criteria in section 5.1.0 and that receive an attractiveness/accessibility value greater than 0. Assign a value to this factor from Table 5–7. Enter this value in Table 5–1.

TABLE 5–6—ATTRACTIVENESS/ACCESSIBILITY VALUES

Area of observed contamination	Assigned value
Designated recreational area	100
Regularly used for public recreation (for example, fishing, hiking, softball)	75
Accessible and unique recreational area (for example, vacant lots in urban area)	75
Moderately accessible (may have some access improvements, for example, gravel road), with some public recreation use	50
Slightly accessible (for example, extremely rural area with no road improvement), with some public recreation use	25
Accessible, with no public recreation use	10
Surrounded by maintained fence or combination of maintained fence and natural barriers	5
Physically inaccessible to public, with no evidence of public recreation use	0

TABLE 5–7—AREA OF CONTAMINATION FACTOR VALUES

Total area of the areas of observed contamination (square feet)	Assigned value
Less than or equal to 5,000	5
Greater than 5,000 to 125,000	20
Greater than 125,000 to 250,000	40
Greater than 250,000 to 375,000	60
Greater than 375,000 to 500,000	80
Greater than 500,000	100

5.1.2.1.3 *Likelihood of exposure factor category value.* Assign a value from Table 5–8 to the likelihood of exposure factor category, based on the values assigned to the attractiveness/accessibility and area of contamination factors. Enter this value in Table 5–1.

TABLE 5–8—NEARBY POPULATION LIKELIHOOD OF EXPOSURE FACTOR VALUES

Area of contamination factor value	Attractiveness/accessibility factor value						
	100	75	50	25	10	5	0
100	500	500	375	250	125	50	0
80	500	375	250	125	50	25	0
60	375	250	125	50	25	5	0
40	250	125	50	25	5	5	0

TABLE 5–8—NEARBY POPULATION LIKELIHOOD OF EXPOSURE FACTOR VALUES—Continued

Area of contamination factor value	Attractiveness/accessibility factor value						
	100	75	50	25	10	5	0
20	125	50	25	5	5	5	0
5	50	25	5	5	5	5	0

5.1.2.2 *Waste characteristics.* Evaluate waste characteristics based on two factors: Toxicity and hazardous waste quantity. Evaluate only those hazardous substances that meet the criteria for observed contamination (see section 5.1.0) at areas that can be assigned an attractiveness/accessibility factor value greater than 0.

5.1.2.2.1 *Toxicity.* Assign a toxicity factor value as specified in section 2.4.1.1 to each hazardous substance meeting the criteria in section 5.1.2.2. Use the hazardous substance with the highest toxicity factor value to assign the value to the toxicity factor for the nearby population threat. Enter this value in Table 5–1.

5.1.2.2.2 *Hazardous waste quantity.* Assign a value to the hazardous waste quantity factor as specified in section 5.1.1.2.2, except: Consider only those areas of observed contamination that can be assigned an attractiveness/accessibility factor value greater than 0. Enter the value assigned in Table 5–1.

5.1.2.2.3 *Calculation of waste characteristics factor category value.* Multiply the toxicity and hazardous waste quantity factor values, subject to a maximum product of 1×10^8. Based on this product, assign a value from Table 2–7 (section 2.4.3.1) to the waste characteristics factor category. Enter this value in Table 5–1.

5.1.2.3 *Targets.* Evaluate the targets factory category for the nearby population threat based on two factors: Nearby individual and population within a 1-mile travel distance from the site.

5.1.2.3.1 *Nearby individual.* If one or more persons meet the section 5.1.1.3 criteria for a resident individual, assign this factor a value of 0. Enter this value in Table 5–1.

If no person meets the criteria for a resident individual, determine the shortest travel distance from the site to any residence or school. In determining the travel distance, measure the shortest overland distance an individual would travel from a residence or school to the nearest area of observed contamination for the site with an attractiveness/accessibility factor value greater than 0. If there are no natural barriers to travel, measure the travel distance as the shortest straight-line distance from the residence or school to the area of observed contamination. If natural barriers exist (for example, a river), measure the travel distance as the shortest straight-line distance from the residence or school to the nearest crossing point and from there as the shortest straight-line distance to the area of observed contamination. Based on the shortest travel distance, assign a value from Table 5–9 to the nearest individual factor. Enter this value in Table 5–1.

TABLE 5–9—NEARBY INDIVIDUAL FACTOR VALUES

Travel distance for nearby individual (miles)	Assigned value
Greater than 0 to ¼	[a]1
Greater than ¼ to 1	0

[a] Assign a value of 0 if one or more persons meet the section 5.1.1.3 criteria for resident individual.

5.1.2.3.2 *Population within 1 mile.* Determine the population within each travel distance category of Table 5–10. Count residents and students who attend school within this travel distance. Do not include those people already counted in the resident population threat. Determine travel distances as specified in section 5.1.2.3.1.

In estimating residential population, when the estimate is based on the number of residences, multiply each residence by the average number of persons per residence for the county in which the residence is located.

Based on the number of people included within a travel distance category, assign a distance-weighted population value for that travel distance from Table 5–10.

Calculate the value for the population within 1 mile factor (PN) as follows:

$$PN = \frac{1}{10}\sum_{i=1}^{3} W_i$$

Where:

W_i = Distance-weighted population value from Table 5–10 for travel distance category i.

If PN is less than 1, do not round it to the nearest integer; if PN is 1 or more, round to the nearest integer. Enter this value in Table 5–1.

5.1.2.3.3 *Calculation of nearby population targets factor category value.* Sum the values for the nearby individual factor and the population within 1 mile factor. Do not round this sum to the nearest integer. Assign this sum as the targets factor category value for the nearby population threat. Enter this value in Table 5–1.

TABLE 5–10—DISTANCE WEIGHTED POPULATION VALUES FOR NEARBY POPULATION THREAT [a]

Travel distance category (miles)	Number of people within the travel distance category											
	0	1 to 10	11 to 30	31 to 100	101 to 300	301 to 1,000	1,001 to 3,000	3,001 to 10,000	10,001 to 30,000	30,001 to 100,000	100,001 to 300,000	300,001 to 1,000,000
Greater than 0 to ¼	0	0.1	0.4	1.0	4	13	41	130	408	1,303	4,081	13,034
Greater than ¼ to ½	0	0.05	0.2	0.7	2	7	20	65	204	652	2,041	6,517
Greater than ½ to 1	0	0.02	0.1	0.3	1	3	10	33	102	326	1,020	3,258

[a] Round the number of people present within a travel distance category to nearest integer. Do not round the assigned distance-weighted population value to nearest integer.

5.1.2.4 *Calculation of nearby population threat score.* Multiply the values for likelihood of exposure, waste characteristics, and targets for the nearby population threat, and round the product to the nearest integer. Assign this product as the nearby population threat score. Enter this score in Table 5–1.

5.1.3 *Calculation of soil exposure component score.* Sum the resident population threat score and the nearby population threat score, and divide the sum by 82,500. Assign the resulting value, subject to a maximum of 100, as the soil exposure component score (S_{se}). Enter this score in Table 5–1.

5.2 *Subsurface intrusion component.* Evaluate the subsurface intrusion component based on three factor categories: Likelihood of exposure, waste characteristics, and targets. Figure 5–1 indicates the factors included within each factor category for the subsurface intrusion component.

Determine the component score (S_{ssi}) in terms of the factor category values as follows:

$$S_{ssi} = \frac{(LE)(WC)(T)}{SF}$$

Where:

LE = Likelihood of exposure factor category value.
WC = Waste characteristics factor category value.
T = Targets factor category value.
SF = Scaling factor.

Table 5–11 outlines the specific calculation procedure.

TABLE 5–11—SUBSURFACE INTRUSION COMPONENT SCORESHEET

Factor categories and factors	Maximum value	Value assigned
Subsurface Intrusion Component		
Likelihood of Exposure:		
1. Observed Exposure	550	
2. Potential for Exposure:		
2a. Structure Containment	10	
2b. Depth to contamination	10	
2c. Vertical Migration	15	
2d. Vapor Migration Potential	25	
3. Potential for Exposure (lines 2a * (2b + 2c + 2d), subject to a maximum of 500)	500	
4. Likelihood of Exposure (higher of lines 1 or 3)	550	
Waste Characteristics:		
5. Toxicity/Degradation	[a]	
6. Hazardous Waste Quantity	[a]	
7. Waste Characteristics (subject to a maximum of 100)	100	
Targets:		
8. Exposed Individual	50	
9. Population:.		
9a. Level I Concentrations	[b]	
9b. Level II Concentrations	[b]	
9c. Population within an Area of Subsurface Contamination	[b]	
9d. Total Population (lines 9a + 9b + 9c)	[b]	
10. Resources	5	
11. Targets (lines 8 + 9d + 10)	[b]	
Subsurface Intrusion Component Score:		
12. Subsurface Intrusion Component (lines 4 × 7 × 11)/82,500[c] (subject to a maximum of 100)	100	
Soil Exposure and Subsurface Intrusion Pathway Score:		
13. Soil Exposure Component + Subsurface Intrusion Component (subject to a maximum of 100)	100	

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to the nearest integer.

5.2.0—*General considerations.* The subsurface intrusion component evaluates the threats from hazardous substances that have or could intrude into regularly occupied structures via surficial ground water or the unsaturated zone. Evaluate the subsurface intrusion component based on the actual or potential intrusion of hazardous substances into a regularly occupied structures that has structure containment value greater than zero; or actual or potential intrusion of hazardous substances exists in the unsaturated zone or the surficial ground water below the regularly occupied structures. These structures may or may not have subunits. Subunits are partitioned areas within a structure with separate heating, ventilating, and air conditioning (HVAC) systems or distinctly different air exchange rates. Subunits include regularly occupied partitioned tenant spaces such as office suites, apartments, condos, common or shared areas, and portions of residential, commercial or industrial structures with separate heating, ventilating, and air conditioning (HVAC) systems.

In evaluating the subsurface intrusion component, consider the following:

• Area(s) of observed exposure: An area of observed exposure is delineated by regularly occupied structures with documented contamination meeting observed exposure criteria; an area of observed exposure includes regularly occupied structures with samples meeting observed exposure criteria or inferred to be within an area of observed exposure based on samples meeting observed exposure criteria (see section 5.2.1.1.1 *Observed Exposure*). Establish areas of observed exposure as follows:

—For regularly occupied structures that have no subunits, consider both the regularly occupied structures containing sampling location(s) meeting observed exposure criteria for the site and the regularly occupied structure(s) in the area lying between such locations to be an area of observed exposure (*i.e.,* inferred to be in an area of observed exposure), unless available information indicates otherwise.

—In multi-story, multi-subunit, regularly occupied structures, consider all subunits on a level with sampling locations meeting observed exposure criteria from the site and all levels below, if any, to be within an area of observed exposure, unless available information indicates otherwise.

—In multi-tenant structures, that do not have a documented observed exposure, but are located in an area lying between locations where observed exposures have been documented, consider only those regularly occupied subunits, if any, on the lowest level of the structure, to be within an area of observed exposure (*i.e.,* inferred to be in an area of observed exposure, unless available information indicates otherwise.

• Area(s) of subsurface contamination: An area of subsurface contamination is delineated by sampling locations meeting observed release criteria for subsurface intrusion, excluding areas of observed exposure (see Table 2–3 in section 2.3). The area within an area of subsurface contamination includes potentially exposed populations. If the significant increase in hazardous substance levels cannot be attributed at least in part to the site and cannot be attributed to other sites, attribution can be established based on the presence of hazardous substances in the area of subsurface contamination. Establish areas of subsurface contamination as follows:

— Exclude those areas that contain structures meeting the criteria defined as an area of observed exposure.

— Consider both the sampling location(s) with subsurface contamination meeting observed release criteria from the site and the area lying between such locations to be an area of subsurface contamination (*i.e.,* inferred to be in an area of subsurface contamination), unless available information indicates otherwise.

— Evaluate an area of subsurface contamination based on hazardous substances that:

▪ Meet the criteria for observed exposure, or

▪ Meet the criteria for observed release in an area of subsurface contamination and have a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to 10^{-5} atm-m^3/mol, or

▪ Meet the criteria for an observed release in a structure within, or in a sample from below, an area of observed exposure and has a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to 10^{-5} atm-m^3/mol.

See Section 7.0 for establishing an area of subsurface contamination based on the presence of radioactive hazardous substances.

— Evaluate all structures with no subunits to be in an area of subsurface contamination if they are lying between locations of subsurface intrusion samples meeting observed release criteria.

— Evaluate multi-subunit structures as follows:

▪ If an observed exposure has been documented based on a gaseous indoor air sample, consider all regularly occupied subunit(s), if any, on the level immediately above the level where an observed exposure has been documented (or has been inferred to be within an area of observed exposure), to be within an area of subsurface contamination, unless available information indicates otherwise.

▪ If observed release criteria have been met based on a gaseous indoor air sample collected from a level not regularly occupied, consider all regularly occupied subunit(s), if any, on the level immediately above the level where the observed release criteria has been documented, to be within an area of subsurface contamination, unless available information indicates otherwise.

▪ If an observed exposure has been documented based on an intruded liquid or particulate sample, do not consider any regularly occupied subunit(s) above the level where an observed exposure has been documented to be within an area of subsurface contamination, unless available information indicates otherwise.

▪ If any regularly occupied multi-subunit structure is inferred to be in an area of subsurface contamination, consider only those regularly occupied subunit(s), if any, on the lowest level, to be within an area of subsurface contamination, unless available information indicates otherwise.

If there is no area of observed exposure and no area of subsurface contamination, assign a score of 0 for the subsurface intrusion component.

5.2.1 *Subsurface intrusion component.* Evaluate this component only if there is an area of observed exposure or area of subsurface contamination:

• Within or underlying a residence, school, day care center, workplace, or

• Within or underlying a resource specified in section 5.2.1.3.3.

5.2.1.1 *Likelihood of exposure.* Assign a value of 550 to the likelihood of exposure factor category for the subsurface intrusion component if there is an area of observed exposure in one or more locations listed in section 5.2.1. Enter this value in Table 5–11.

5.2.1.1.1 *Observed exposure.* Establish observed exposure in a regularly occupied structure by demonstrating that a hazardous substance has been released into a regularly occupied structure via the subsurface. Base this demonstration on either of the following criterion:

• Direct observation:

— A solid, liquid or gaseous material that contains one or more hazardous substances attributable to the site has been observed entering a regularly occupied structure through migration via the subsurface or is known to have entered a regularly occupied structure via the subsurface, or

— When evidence supports the inference of subsurface intrusion of a material that contains one or more hazardous substances associated with the site into a regularly occupied structure, demonstrated adverse effects associated with that release may be used to establish observed exposure.

• Chemical analysis:

— Analysis of indoor samples indicates that the concentration of hazardous substance(s) has increased significantly above the background concentration for the site for that type of sample (see section 2.3).

— Some portion of the significant increase must be attributable to the site to establish the observed exposure. Documentation of this attribution should account for possible concentrations of the hazardous substance(s) in outdoor air or from materials found in the regularly occupied structure, and should provide a rationale for the increase being from subsurface intrusion.

If observed exposure can be established in a regularly occupied structure, assign an observed exposure factor value of 550, enter this value in Table 5–11, and proceed to section 5.2.1.1.3. If no observed exposure can be established, assign an observed exposure factor value of 0, enter this value in Table 5–11, and proceed to section 5.2.1.1.2.

5.2.1.1.2 *Potential for exposure.* Evaluate potential for exposure only if an observed exposure cannot be established, but an area of subsurface contamination has been delineated. Evaluate potential for exposure based only on the presence of hazardous substances with a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to 10^{5} atm-m^3/mol. Evaluate potential for exposure for each area of subsurface contamination based on four factors: structure containment (see section 5.2.1.1.2.1), depth to contamination (see section 5.2.1.1.2.2), vertical migration (see section 5.2.1.1.2.3) and vapor migration potential (see section 5.2.1.1.2.4). For each area of subsurface contamination, assign the highest value for each factor. If information is insufficient to calculate any single factor value used to calculate the potential for exposure factor values at an identified area of subsurface contamination, information collected for another area of subsurface contamination at the site may be used when evaluating potential for exposure. Calculate the potential for exposure value for the site as specified in section 5.2.1.1.2.5.

5.2.1.1.2.1 *Structure containment.* Calculate containment for eligible hazardous substances within this component as directed in Table 5–12 and enter this value into Table 5–11. Assign each regularly occupied structure within an area of subsurface contamination the highest appropriate structure containment value from Table 5–12 and use the regularly occupied structure at the site with the highest structure containment value in performing the potential for exposure calculation. Assign a structure containment factor value of 10 to any regularly occupied structure located within an area of observed exposure that is established based on documented surficial ground water intrusion, unless available information indicates otherwise.

TABLE 5–12—STRUCTURE CONTAINMENT

No.	Evidence of structure containment	Assigned value
1	Regularly occupied structure with evidence of subsurface intrusion, including documented observed exposure or sampling of bio or inert gases, such as methane and radon.	10
2	Regularly occupied structure with open preferential pathways from the subsurface (*e.g.,* sumps, foundation cracks, unsealed utility lines).	10
3	Regularly occupied structure with an engineered vapor migration barrier system that does not address all preferential pathways.	7
4	Regularly occupied structure with an engineered passive vapor mitigation system *without* documented institutional controls (*e.g.,* deed restrictions) or evidence of regular maintenance and inspection.	6
5	Regularly occupied structure with no visible open preferential pathways from the subsurface (*e.g.,* sumps, foundation cracks, unsealed utility lines).	4
6	Regularly occupied structure with an engineered passive vapor mitigation system (*e.g.,* passive venting) *with* documented institutional controls (*e.g.,* deed restrictions) or evidence of regular maintenance and inspection.	3
7	Regularly occupied structure with an engineered, active vapor mitigation system (*e.g.,* active venting) *without* documented institutional controls (*e.g.,* deed restrictions) and funding in place for on-going operation, inspection and maintenance.	2
8	Regularly occupied structure with unknown containment features	2
9	Regularly occupied structure with a permanent engineered, active vapor mitigation system (*e.g.,* active venting) *with* documented institutional controls (*e.g.,* deed restrictions) and funding in place for on-going operation, inspection and maintenance. This does not include mitigation systems installed as part of a removal or other temporary response by federal, state or tribal authorities.	0
10	Regularly occupied structure with a foundation raised greater than 6 feet (*e.g.,* structure on stilts) or structure that has been built, and maintained, in a manner to prevent subsurface intrusion.	0

5.2.1.1.2.2 *Depth to contamination.* Assign each area of subsurface contamination a depth to contamination based on the least depth to either contaminated crawl space or subsurface media underlying a regularly occupied structure. Measure this depth to contamination based on the distance between the lowest point of a regularly occupied structure to the highest known point of hazardous substances eligible to be evaluated. Use any regularly occupied structure within an area of subsurface contamination with a structure containment factor greater than zero. Subtract from the depth to contamination the thickness of any subsurface layer composed of features that would allow channelized flow (*e.g.,* karst, lava tubes, open fractures).

Based on this calculated depth, assign a factor value from Table 5–13. If the necessary information is available at multiple locations, calculate the depth to contamination at each location. Use the location having the least depth to contamination to assign the factor value. Enter this value in Table 5–11.

TABLE 5–13—DEPTH TO CONTAMINATION

Depth range [1] [2]	Depth to contamination assigned value
0 to 10 ft.(Including subslab and semi-enclosed or enclosed crawl space contamination)	10
>10 to 20 ft	8
>20 to 50 ft	6
>50 to 100 ft	4
>100 to 150 ft	2
>150 ft	0

[1] If any part of the subsurface profile has channelized flow features, assign that portion of the subsurface profile a depth of 0.

[2] Measure elevation below any regularly occupied structure within an area of subsurface contamination at a site. Select the regularly occupied structure with the least depth to contamination below a structure.

5.2.1.1.2.3 *Vertical migration.* Evaluate the vertical migration factor for each area of subsurface contamination based on the geologic materials in the interval between the lowest point of a regularly occupied structure and the highest known point of hazardous substances in the subsurface. Use any regularly occupied structure either within an area of subsurface contamination or overlying subsurface soil gas or ground water contamination. Assign a value to the vertical migration factor as follows:

- If the depth to contamination (see section 5.2.1.1.2.2) is 10 feet or less, assign a value of 15.

• Do not consider layers or portions of layers within the first 10 feet of the depth to contamination.

• If, for the interval identified above, all layers that underlie a portion of a regularly occupied structure at the site are karst or otherwise allow channelized flow, assign a value of 15.

• Otherwise:

—Select the lowest effective porosity/permeability layer(s) from within the above interval. Consider only layers at least 1 foot thick. (If site-specific data is not available, use the layer with the highest value assigned in Table 5–14.)

—Assign a value for individual layers from Table 5–14.

—If more than one layer has the same assigned porosity/permeability value, include all such layers and sum their thicknesses. Assign a thickness of 0 feet to a layer with channelized flow features found within any area of subsurface contamination at the site.

—Assign a value from Table 5–15 to the vertical migration factor, based on the thickness and assigned porosity/permeability value of the lowest effective porosity/permeability layer(s).

Determine vertical migration only at locations within an area of subsurface contamination at the site. If the necessary subsurface geologic information is available at multiple locations, evaluate the vertical migration factor at each location. Use the location having the highest vertical migration factor value to assign the factor value. Enter this value in Table 5–11.

TABLE 5–14—EFFECTIVE POROSITY/PERMEABILITY OF GEOLOGIC MATERIALS

Type of material	Assigned porosity/permeability value
Gravel; highly permeable fractured igneous and metamorphic rocks; permeable basalt; karst limestones and dolomites	1
Sand; sandy clays; sandy loams; loamy sands; sandy silts; sediments that are predominantly sand; highly permeable till (coarse-grained, unconsolidated or compact and highly fractured); peat; moderately permeable limestones and dolomites (no karst); moderately permeable sandstone; moderately permeable fractured igneous and metamorphic rocks	2
Silt; loams; silty loams; loesses; silty clays; sediments that are predominantly silts; moderately permeable till (fine-grained, unconsolidated till, or compact till with some fractures); low permeability limestones and dolomites (no karst); low permeability sandstone; low permeability fractured igneous and metamorphic rocks	3
Clay; low permeability till (compact unfractured till); shale; unfractured metamorphic and igneous rocks	4

TABLE 5–15 VERTICAL MIGRATION FACTOR VALUES [a]

Assigned porosity/permeability value	Thickness of lowest porosity layer(s) [b] (feet)					
	0 to 5	Greater than 5 to 10	Greater than 10 to 20	Greater than 20 to 50	Greater than 50 to 100	Greater than 100 to 150
1	15	15	14	11	8	6
2	15	14	12	9	6	4
3	15	13	10	7	5	2
4	15	12	9	6	3	1

[a] If depth to contamination is 10 feet or less or if, for the interval being evaluated, all layers that underlie a portion of the structure at the site are karst or have other channelized flow features, assign a value of 15.

[b] Consider only layers at least 1 foot thick.

5.2.1.1.2.4 *Vapor migration potential.* Evaluate this factor for each area of subsurface contamination as follows:

• If the depth to contamination (see section 5.2.1.1.2.2) is 10 feet or less, assign a value of 25.

• Assign a value for vapor migration potential to each of the gaseous hazardous substances associated with the area of subsurface contamination (see section 2.2.2) as follows:

—Assign values from Table 5–16 for both vapor pressure and Henry's constant to each hazardous substance. If Henry's constant cannot be determined for a hazardous substance, assign that hazardous substance a value of 2 for the Henry's constant component.

—Sum the two values assigned to each hazardous substance.

—Based on this sum, assign each hazardous substance a value from Table 5–17 for vapor migration potential.

• Assign a value for vapor migration potential to each area of subsurface contamination as follows:

—Select the hazardous substance associated with the area of subsurface contamination with the highest vapor migration potential value and assign this value as the vapor migration potential factor for the area of subsurface contamination.

Enter this value in Table 5–11.

TABLE 5–16—VALUES FOR VAPOR PRESSURE AND HENRY'S CONSTANT

Vapor pressure (Torr)	Assigned value
Greater than 10	3

TABLE 5–16—VALUES FOR VAPOR PRESSURE AND HENRY'S CONSTANT—Continued

Vapor pressure (Torr)	Assigned value
1 to 10	2
Less than 1	0
Henry's constant (atm-m^3/mol)	**Assigned value**
Greater than 10^{-3}	3
Greater than 10^{-4} to 10^{-3}	2
10^{-5} to 10^{-4}	1
Less than 10^{-5}	0

TABLE 5–17—VAPOR MIGRATION POTENTIAL FACTOR VALUES FOR A HAZARDOUS SUBSTANCE

Sum of values for vapor pressure and Henry's constant	Assigned value
0	0
1 or 2	5
3 or 4	15
5 or 6	25

5.2.1.1.2.5 *Calculation of potential for exposure factor value.* For each identified area of subsurface contamination, sum the factor values for depth to contamination, vertical migration and vapor migration potential, and multiply this sum by the factor value for structure containment. Select the highest product for any area of subsurface contamination and assign this value as the potential for exposure factor value for the component. Enter this value in Table 5–11.

5.2.1.1.3 *Calculation of likelihood of exposure factor category value.* If observed exposure is established for the site, assign the observed exposure factor value of 550 as the likelihood of exposure factor category value for the site. Otherwise, assign the potential for exposure factor value for the component as the likelihood of exposure value. Enter the value assigned in Table 5–11.

5.2.1.2 *Waste characteristics.* Evaluate waste characteristics based on two factors: Toxicity/degradation and hazardous waste quantity.

5.2.1.2.1 *Toxicity/degradation.* For each hazardous substance, assign a toxicity factor value, a degradation factor value and a combined toxicity/degradation factor value as specified in sections 2.2.3, 2.4.1.2 and 5.2.1.2.1.1 through 5.2.1.2.1.3.

5.2.1.2.1.1 *Toxicity.* Assign a toxicity factor value to each hazardous substance as specified in sections 2.2.2 and 2.4.1.1.

5.2.1.2.1.2 *Degradation.* Assign a degradation factor value to each hazardous substance as follows:

- For any hazardous substance that meets the criteria for an observed exposure, assign that substance a degradation factor value of 1.
- For all hazardous substances at the site that meet subsurface intrusion observed release criteria but not observed exposure criteria, assign a degradation factor value of 1 if the depth to contamination below an area of subsurface contamination or area of observed exposure is less than 10 feet or if available evidence suggests that there is less than 10 feet of biologically active soil in the subsurface anywhere underneath a regularly occupied structure within an area of subsurface contamination or area of observed exposure.

For all other situations first calculate the half-life for each hazardous substance that meets subsurface intrusion observed release criteria as follows:

The half-life or a substance in the subsurface is defined for HRS purposes as the time required to reduce the initial concentration in the subsurface by one-half as a result of the combined decay processes of two components: biodegradation and hydrolysis.

Estimate the half-life ($t_{1/2}$) of a hazardous substance as follows:

$$t_{1/2} = \frac{1}{1/h + 1/b}$$

Where:

h=Hydrolysis half-life.
b=Biodegradation half-life.

If one of these component half-lives cannot be estimated for the hazardous substance from available data, delete that component half-life from the above equation.

If no half-life information is available for a hazardous substance and the substance is not already assigned a value of 1, unless information indicates otherwise, all straight-chain and simple-ring structure substances will be considered to have a half-life less than 30 days if not the hazardous substance will be assigned a half-life of greater than 100 days.

Based on the hazardous substance's assigned half-life the degradation factor is assigned as follows:

- For all hazardous substances at the site that meet subsurface intrusion observed release criteria but not observed exposure criteria, assign a degradation factor value of 0.1, if:

—The depth to contamination at the site is greater than or equal to 10 feet, but not if available evidence suggests that at least 10 feet of biologically active soil is not present in the subsurface anywhere underneath a structure within an area of subsurface contamination or area of observed exposure, and

—The hazardous substance has a half-life of 30 days or less.

- For all hazardous substances at the site that meet subsurface intrusion observed release criteria but not observed exposure criteria, assign a degradation factor value of 0.5, if:

—The depth to contamination at the site is greater than 30 feet, but not if available evidence suggests that at least 30 feet of biologically active soil is not present in the subsurface anywhere underneath a structure within an area of subsurface contamination or area of observed exposure, and

—The hazardous substance has a half-life equal to or less than 100 days.

- For all other situations assign a degradation factor of 1 for all hazardous substances at the site that meet subsurface intrusion observed release criteria.

In addition, for hazardous substances that meet observed release criteria, have a parent-daughter degradation relationship, and the daughter substance is found only in samples with a depth greater than 10 feet, assign the daughter substance degradation factor value as follows:

1. Identify the shallowest subsurface sample that contains the daughter substance.
2. Determine if the selected sample or another sample from the same relative position in the media of concern, or in a shallower sample, contains the parent substance.
3. If the parent substance is not present in the identified samples, assign the degradation factor value for the daughter substance based on the half-life for the daughter substance.
4. If the parent substance is present in a sample from the same relative position in the subsurface or in a shallower sample, compare the half-life-based degradation factor value for the daughter substance to the degradation factor value assigned to the parent substance. Assign the greater of the two values as the degradation factor value for the daughter substance.

5.2.1.2.1.3 *Calculation of toxicity/degradation factor value.* Assign each substance a toxicity/biodegradation value by multiplying the toxicity factor value by the degradation factor value. Use the hazardous substance with the highest combined toxicity/degradation value to assign the factor value to the toxicity/degradation factor for the subsurface intrusion threat. Enter this value in Table 5–11.

5.2.1.2.2 *Hazardous waste quantity.* Assign a hazardous waste quantity factor value as specified in section 2.4.2. Consider only those regularly occupied structures with a non-zero structure containment value. In estimating the hazardous waste quantity, use Tables 2–5 and 5–18 and:

- For Tier A, hazardous constituent quantity, use the mass of constituents found in the regularly occupied structure(s) where the observed exposure has been identified.

—For multi-subunit structures, when calculating Tier A, use the mass of constituents found in the regularly occupied subunit space(s) where the observed exposure has been identified.

• For Tier B, hazardous wastestream quantity, use the flow-through volume of the regularly occupied structures where the observed exposure has been identified.

—For multi-subunit structures, when calculating Tier B, use the flow-through volume of the regularly occupied subunit spaces where the observed exposure has been identified.

• For Tier C, volume, use the volume divisor listed in Tier C of Table 5–18. Volume is calculated for those regularly occupied structures located within areas of observed exposure with observed or inferred intrusion and within areas of subsurface contamination.

—In evaluating the volume measure for these listed areas of observed exposure and areas of subsurface contamination based on a gaseous/vapor intrusion or the potential for gaseous/vapor intrusion, consider the following:

• Calculate the volume of each regularly occupied structure based on actual data. If unknown, use a ceiling height of 8 feet.

• For multi-subunit structures, when calculating Tier C, calculate volume for those subunit spaces with observed or inferred exposure and all other regularly occupied subunit spaces on that level, unless available information indicates otherwise. If the structure has multiple stories, also include the volume of all regularly occupied subunit spaces below the floor with an observed exposure and one story above, unless evidence indicates otherwise.

• For multi-subunit structures within an area of subsurface contamination and no observed or inferred exposure, consider only the volume of the regularly occupied subunit spaces on the lowest story, unless available information indicates otherwise.

—In evaluating the volume measure for these listed areas of observed exposure and areas of subsurface contamination where intrusion of contaminated ground water has occurred, do not calculate the volume of each regularly occupied structure. Instead, consider only the volume of contaminated ground water known to have intruded into a regularly occupied structure.

• For Tier D, area, if volume is unknown, use the area divisor listed in Tier D of Table 5–18 for those regularly occupied structures within areas of observed exposure with observed or inferred intrusion and within areas of subsurface contamination. In evaluating the area measure for these listed areas of observed exposure and areas of subsurface contamination, calculate the area of each regularly occupied structure (including multi-subunit structures) based on actual footprint area data. If the actual footprint area of the structure(s) is unknown, use an area of 1,740 square feet for each structure (or subunit space).

TABLE 5–18—HAZARDOUS WASTE QUANTITY EVALUATION EQUATIONS FOR SUBSURFACE INTRUSION COMPONENT

Tier	Measure	Units	Equation for assigning value [a]
A	Hazardous Constituent Quantity (C)	lb	C.
B [b]	Hazardous Wastestream Quantity (W)	lb	W/5,000.
C [b c]	Volume (V).		
	Regularly occupied structure(s) in areas of observed exposure or subsurface contamination	yd^3	V/2.5.
D [b d]	Area (A).		
	Regularly occupied structure(s) in areas of observed exposure or subsurface contamination	ft^2	A/13.

[a] Do not round to the nearest integer.
[b] Convert volume to mass when necessary: 1 ton = 2,000 pounds = 1 cubic yard = 4 drums = 200 gallons.
[c] Calculate volume of each regularly occupied structure or subunit space in areas of observed exposure and areas of subsurface contamination—Assume 8-foot ceiling height unless actual value is known.
[d] Calculate area of the footprint of each regularly occupied structure in areas of observed exposure and areas of subsurface contamination. If the footprint area of a regularly occupied structure is unknown, use 1,740 square feet as the footprint area of the structure or subunit space.

For the subsurface intrusion component, if the hazardous constituent quantity is adequately determined for all areas of observed exposure, assign the value from Table 2–6 as the hazardous waste quantity factor value. If the hazardous constituent quantity is not adequately determined for one or more areas of observed exposure or if one or more areas of subsurface contamination are present, assign either the value from Table 2–6 or assign a factor value as follows:

• If any target for the subsurface intrusion component is subject to Level I or Level II concentrations (see section 2.5), assign either the value from Table 2–6 or a value of 100, whichever is greater, as the hazardous waste quantity factor value for this component.

• If none of the targets for the subsurface intrusion component is subject to Level I or Level II concentrations and if there has been a removal action that does not permanently interrupt target exposure from subsurface intrusion, assign a factor value as follows:

—Determine the values from Table 2–6 with and without consideration of the removal action.

—If the value that would be assigned from Table 2–6 without consideration of the removal action would be 100 or greater, assign either the value from Table 2–6 with consideration of the removal action or a value of 100, whichever is greater, as the hazardous waste quantity factor value for the component.

—If the value that would be assigned from Table 2–6 without consideration of the removal action would be less than 100, assign a value of 10 as the hazardous waste quantity factor value for the component.

• Otherwise, if none of the targets for the subsurface intrusion component is subject to Level I or Level II concentrations and there has not been a removal action, assign a minimum value of 10.

Enter the value assigned in Table 5–11.

5.2.1.2.3 *Calculation of waste characteristics factor category value.* Multiply the toxicity/degradation and hazardous waste quantity factor values, subject to a maximum product of 1×10^8. Based on this product, assign a value from Table 2–7 (section 2.4.3.1) to the waste characteristics factor category. Enter this value in Table 5–11.

5.2.1.3 *Targets.* Evaluate the targets factor category for the subsurface intrusion threat based on three factors: Exposed individual, population, and resources in regularly occupied structures. Evaluate only those targets within areas of observed exposure and areas of subsurface contamination (see section 5.2.0).

In evaluating the targets factor category for the subsurface intrusion threat, count only the following as targets:

- Exposed individual—a person living, attending school or day care, or working in a regularly occupied structure with observed exposure or in a structure within an area of observed exposure or within an area of subsurface contamination.
- Population—exposed individuals in a regularly occupied structure within an area of observed exposure or within an area of subsurface contamination.
- Resources—located within an area of observed exposure or within an area of subsurface contamination as specified in section 5.2.1.3.3.

If a former structure that has been vacated due to subsurface intrusion attributable to the site, count the initial targets as if they were still residing in the structure. In addition, if a removal action has occurred that has not completely mitigated the release, count the initial targets as if the removal action has not permanently interrupted target exposure from subsurface intrusion.

For populations residing in or working in a multi-subunit structure with multiple stories in an area of observed exposure or area of subsurface contamination, count these targets as follows:

- If there is no observed exposure within the structure, include in the evaluation only those targets, if any, in the lowest occupied level, unless available information indicates otherwise.
- If there is an observed exposure in any level, include in the evaluation those targets in that level, the level above and all levels below, unless available information indicates otherwise. (The weighting of these targets is specified in Section 5.2.1.3.2.)

5.2.1.3.1 *Exposed individual.* Evaluate this factor based on whether there is an exposed individual, as specified in sections 2.5.1, 2.5.2 and 5.2.1.3, who is subject to Level I or Level II concentrations.

First, determine those regularly occupied structures or partitioned subunit(s) within structures in an area of observed exposure subject to Level I concentrations and those subject to Level II concentrations as specified as follows (see section 5.2.0):

- Level I Concentrations: For contamination resulting from subsurface intrusion, compare the hazardous substance concentrations in any sample meeting the observed exposure by chemical analysis criteria to the appropriate benchmark. Use the health-based benchmarks from Table 5–19 to determine the level of contamination.
  - —If the sample is from a structure with no subunits and the concentration equals or exceeds the appropriate benchmark, assign Level I concentrations to the entire structure.
  - —If the sample is from a subunit within a structure and the concentration from that subunit equals or exceeds the appropriate benchmark, assign Level I concentrations to that subunit.
- Level II Concentrations: Structures, or subunits within structures, with one or more samples that meet observed exposure by chemical analysis criteria but do not equal or exceed the appropriate benchmark; structures, or subunits, that have an observed exposure by direct observation; and structures inferred to be in an area of observed exposure based on samples meeting observed exposure, are assigned Level II concentrations.
  - ○ For all regularly occupied structures, or subunits in such structures, in an area of observed exposure that are not assigned Level I concentrations, assign Level II concentrations.

Then assign a value to the exposed individual factor as follows:

- Assign a value of 50 if there is at least one exposed individual in one or more regularly occupied structures subject to Level I concentrations.
- Assign a value of 45 if there are no Level I exposed individuals, but there is at least one exposed individual in one or more regularly occupied structures subject to Level II concentrations.
- Assign a value of 20 if there is no Level I or Level II exposed individual but there is at least one individual in a regularly occupied structure within an area of subsurface contamination.

Enter the value assigned in Table 5–11.

5.2.1.3.2 *Population.* Evaluate population based on three factors: Level I concentrations, Level II concentrations, and population within an area of subsurface contamination. Determine which factors apply as specified in section 5.2.1.3.1, using the health-based benchmarks from Table 5–19. Evaluate populations subject to Level I and Level II concentrations as specified in section 2.5.

TABLE 5–19—HEALTH-BASED BENCHMARKS FOR HAZARDOUS SUBSTANCES IN THE SUBSURFACE INTRUSION COMPONENT

Screening concentration for cancer corresponding to that concentration that corresponds to the 10^{-6} individual cancer risk using the inhalation unit risk. For oral exposures use the oral cancer slope factor.
Screening concentration for noncancer toxicological responses corresponding to the reference dose (RfD) for oral exposure and the reference concentration (RfC) for inhalation exposures.

Count only those persons meeting the criteria for population as specified in section 5.2.1.3. In estimating the number of individuals in structures in an area of observed exposure or area of subsurface contamination if the actual number of residents is not known, multiply each residence by the average number of persons per residence for the county in which the residence is located.

5.2.1.3.2.1 *Level I concentrations.* Assign the population subject to Level I concentrations as follows:

1. Identify all exposed individuals regularly present in a structure, or if the structure has subunits, identify those regularly present in each subunit, located in an area of observed exposure subject to Level I concentrations as described in sections 5.2.0 and 5.2.1.3.1. Identify only once per structure those exposed individuals that are using more than one eligible subunit of the same structure (*e.g.,* using a common or shared area and other parts of the same structure).

2. For each structure or subunit count the number of individuals residing in or

attending school or day care in the structure or subunit.

3. Count the number of full-time and part-time workers in the structure or subunit(s) subject to Level I concentrations. If information is unavailable to classify a worker as full- or part-time, evaluate that worker as being full-time. Divide the number of full-time workers by 3 and the number of part-time workers by 6, and then sum these products with the number of other individuals for each structure or subunit.

4. Sum this combined value for all structures, or subunits, within areas of observed exposure and multiply this sum by 10.

Assign the resulting product as the combined population factor value subject to Level I concentrations for the site. Enter this value in line 9a of Table 5–11.

5.2.1.3.2.2 *Level II concentrations.* Assign the population subject to Level II concentrations as follows:

1. Identify all exposed individuals regularly present in an eligible structure, or if the structure has subunits, identify those regularly present in each subunit, located in an area of observed exposure subject to Level II concentrations as described in sections 5.2.0 and 5.2.1.3.1. Identify only once per structure those exposed individuals that are using more than one eligible subunit of the same structure (*e.g.,* using a common or shared area and other parts of the same structure).

2. Do not include exposed individuals already counted under the Level I concentrations factor.

3. For each structure or subunit(s), count the number of individuals residing in or attending school or day care in the structure, or subunit, subject to Level II concentrations.

4. Count the number of full-time and part-time workers in the structure or subunit(s) subject to Level II concentrations. If information is unavailable to classify a worker as full- or part-time, evaluate that worker as being full-time. Divide the number of full-time workers by 3 and the number of part-time workers by 6, and then sum these products with the number of other individuals for each structure or subunit.

5. Sum the combined population value for all structures within the areas of observed exposure for the site.

Assign this sum as the combined population value subject to Level II contamination for this factor. Enter this value in line 9b of Table 5–11.

5.2.1.3.2.3 *Population within area(s) of subsurface contamination.* Assign the population in area(s) of subsurface contamination factor value as follows, unless available information indicates otherwise (see sections 5.2.0 and 5.2.1.3.1):

1. Identify the regularly occupied structures with a structure containment value greater than zero and the eligible population associated with the structures or portions of structures in each area of subsurface contamination:

- For each regularly occupied structure or portion of a structure in an area of subsurface contamination, sum the number of all individuals residing in or attending school or day care, in the structure or portion of the structure in the area of subsurface contamination.
- Count the number of full-time and part-time workers regularly present in each structure or portion of a structure in an area of subsurface contamination. If information is unavailable to classify a worker as full- or part-time, evaluate that worker as being full-time. Divide the number of full-time workers by 3 and the number of part-time workers by 6. Sum these products with the number of individuals residing in or attending school or day care in the structure.
- Use this sum as the population for the structure.

2. Estimate the depth or distance to contamination at each regularly occupied structure within an area of subsurface contamination based on available sampling data, and categorize each eligible structure based on the depth or distance to contamination and sampling media as presented in Table 5–20. Weight the population in each structure using the appropriate weighting factors in Table 5–20. If samples from multiple media are available, use the sample that results in the highest weighting factor.

3. Sum the weighted population in all structures within the area(s) of subsurface contamination and assign this sum as the population subject subsurface contamination factor value. Enter this value in line 9c of Table 5–11.

TABLE 5–20—WEIGHTING FACTOR VALUES FOR POPULATIONS WITHIN AN AREA OF SUBSURFACE CONTAMINATION

Eligible populations [a] in structures [b] within an area of subsurface contamination	Population weighting factor
Population in a structure with levels of contamination in a semi-enclosed or enclosed crawl space sample meeting observed release criteria *or* Population in a subunit of a multi-story structure within an area of subsurface contamination located directly above a level in an area of observed exposure or a gaseous indoor air sample meeting observed release criteria	0.9
Population in a structure where levels of contaminants meeting observed release criteria are found in any sampling media at or within five feet horizontally or vertically of the structure foundation	0.4
Population occupying a structure where levels of contaminants meeting observed release criteria are found or inferred based on any underlying non-ground water subsurface sample at a depth less than or equal to 30 feet *or* Population in a structure within an area of subsurface contamination where levels of contaminants meeting observed release criteria are inferred based on semi-enclosed or enclosed crawl space samples in surrounding structures	0.2
Population in a structure where levels of contaminants meeting observed release criteria are found or inferred based on underlying ground water samples greater than five feet from the structure foundation *or* Population in a structure where levels of contaminants meeting observed release criteria are found or inferred based on any underlying sample at depths greater than 30 feet	0.1

[a] Eligible populations include residents (including individuals living in, or attending school or day care in the structure), and workers in regularly occupied structures (see HRS Section 5.2.1.3).

[b] Eligible structures may include single- or multi-tenant structures where eligible populations reside, attend school or day care, or work. These structures may also be mixed use structures.

5.2.1.3.2.4 *Calculation of population factor value.* Sum the factor values for Level I concentrations, Level II concentrations, and population in the area(s) of subsurface contamination. Assign this sum as the population factor value. Enter this value in line 9d of Table 5–11.

5.2.1.3.3 *Resources.* Evaluate the resources factor as follows:

• Assign a value of 5 if a resource structure (*e.g.,* library, church, tribal facility) is present and regularly occupied within either an area of observed exposure or area of subsurface contamination.

• Assign a value of 0 if there is no resource structure within an area of observed exposure or area of subsurface contamination.

Enter the value assigned in Table 5–11.

5.2.1.3.4 *Calculation of targets factor category value.* Sum the values for the exposed individual, population, and resources factors. Do not round to the nearest integer. Assign this sum as the targets factor category value for the subsurface intrusion component. Enter this value in Table 5–11.

5.2.2 *Calculation of subsurface intrusion component score.* Multiply the factor category values for likelihood of exposure, waste characteristics and targets and round the product to the nearest integer. Divide the product by 82,500. Assign the resulting value, subject to a maximum of 100, as the subsurface intrusion component score and enter this score in Table 5–11.

5.3 Calculation of the soil exposure and subsurface intrusion pathway score: Sum the soil exposure component score and subsurface intrusion component. Assign the resulting value, subject to a maximum of 100, as the soil exposure and subsurface intrusion pathway score (S_{sessi}). Enter this score in Table 5–11.

6.0 Air Migration Pathway

* * * * *

TABLE 6–14—HEALTH-BASED BENCHMARKS FOR HAZARDOUS SUBSTANCES IN AIR

• Concentration corresponding to National Ambient Air Quality Standard (NAAQS).
• Concentration corresponding to National Emission Standards for Hazardous Air Pollutants (NESHAPs).
• Screening concentration for cancer corresponding to that concentration that corresponds to the 10^{-6} individual cancer risk for inhalation exposures.
• Screening concentration for noncancer toxicological responses corresponding to the Reference Concentration (RfC) for inhalation exposures.

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7.0 Sites Containing Radioactive Substances

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TABLE 7-1. HRS FACTORS EVALUATED DIFFERENTLY FOR RADIONUCLIDES

Ground Water Pathway	Status [a]	Surface Water Pathway	Status [a]	Soil Exposure Component of SESSI Pathway	Status [a]	Subsurface Intrusion Component of SESSI Pathway	Status [a]	Air Pathway	Status [a]
Likelihood of Release		***Likelihood of Release***		***Likelihood of Exposure***		***Likelihood of Exposure***		***Likelihood of Release***	
Observed Release	Yes	Observed Release	Yes	Observed Contamination	Yes	Observed Exposure	Yes	Observed Release	Yes
Potential to Release	No	Potential to Release	No	Attractiveness/ Accessibility to Nearby Residents	No	Potential for Exposure	Yes	Gas Potential to Release	No
Containment	No	Overland Flow Containment	No	Area of Contamination	No	Structure Containment	No	Gas Containment	No
Net Precipitation	No	Runoff	No			Depth to Contamination	Yes	Gas Source Type	No
Depth to Aquifer	No	Distance to Surface water	No			Vertical migration	No	Gas Migration Potential	No
Travel Time	No	Flood Frequency	No			Vapor Migration Potential	No	Particulate Potential to Release	No
		Flood Containment	No					Particulate Containment	No
								Particulate Source Type	No
								Particulate Migration Potential	No
Waste Characteristics		***Waste Characteristics***		***Waste Characteristics***		***Waste Characteristics***		***Waste Characteristics***	
Toxicity	Yes	Toxicity/ Ecotoxicity	Yes/Yes	Toxicity	Yes	Toxicity/ Degradation	Yes	Toxicity	Yes
Mobility	No	Persistence/ Mobility	Yes/No	Hazardous Waste Quantity	Yes	Hazardous Waste Quantity	Yes	Mobility	No
Hazardous Waste Quantity	Yes	Bioaccumu-lation Potential	No					Hazardous Waste Quantity	Yes
		Hazardous Waste Quantity	Yes						
Targets		***Targets***		***Targets***		***Targets***		***Targets***	
Nearest Well	Yes [b]	Nearest Intake	Yes [b]	Resident	Yes [b]	Exposed	Yes [b]	Nearest	Yes [b]

TABLE 7-1. HRS FACTORS EVALUATED DIFFERENTLY FOR RADIONUCLIDES

				Individual		Individual		Individual	
Population	Yes [b]	Drinking Water Population	Yes [b]	Resident Population	Yes [b]	Population	Yes [b]	Population	Yes [b]
Resources	No	Resources	No	Workers	No	Resources	No	Resources	No
Wellhead Protection Area	No	Sensitive Environments	Yes [b]	Resources	No			Sensitive Environments	No
		Human Food Chain Individual	Yes [b]	Terrestrial Sensitive Environments	No				
		Human Food Chain Population	Yes [b]	Nearby Individual	No				
				Population Within 1 Mile	No				

[a] Factors evaluated differently are denoted by "yes"; factors not evaluated differently are denoted by "no".
[b] Difference is in the determination of Level I and Level II concentrations.

* * * * *

* * * These differences apply largely to the soil exposure and subsurface intrusion pathway and to sites containing mixed radioactive and other hazardous substances. * * *

7.1 *Likelihood of release/likelihood of exposure.* Evaluate likelihood of release for the three migration pathways and likelihood of exposure for the soil exposure and subsurface intrusion pathway as specified in sections 2 through 6, except: Establish an observed release, observed contamination, and/or observed exposure as specified in section 7.1.1. When an observed release or exposure cannot be established for a migration pathway or the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, evaluate potential to release as specified in section 7.1.2. When observed contamination cannot be established, do not evaluate the soil exposure component of the soil exposure and subsurface intrusion pathway.

7.1.1 *Observed release/observed contamination/observed exposure.* For radioactive substances, establish an observed release for each migration pathway by demonstrating that the site has released a radioactive substance to the pathway (or watershed or aquifer, as appropriate); establish observed contamination or observed exposure for the soil exposure and subsurface intrusion pathway as indicated below. Base these demonstrations on one or more of the following, as appropriate to the pathway being evaluated:

• Direct observation:

—For each migration pathway, a material that contains one or more radionuclides has been seen entering the atmosphere, surface water, or ground water, as appropriate, or is known to have entered ground water or surface water through direct deposition, or

—For the surface water migration pathway, a source area containing radioactive substances has been flooded at a time that radioactive substances were present and one or more radioactive substances were in contact with the flood waters.

—For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, a material that contains one or more radionuclides has been observed entering a regularly occupied structure via the subsurface or is known to have entered a regularly occupied structure via the subsurface. Also, when evidence supports the inference of subsurface intrusion of a material that contains one or more radionuclides by the site into a regularly occupied structure, demonstrated adverse effects associated with that release may also be used to establish observed exposure by direct observation.

• Analysis of radionuclide concentrations in samples appropriate to the pathway (that is, ground water, soil, air, indoor air, surface water, benthic, or sediment samples):

—For radionuclides that occur naturally and for radionuclides that are ubiquitous in the environment:

▪ Measured concentration (in units of activity, for example, pCi per kilogram [pCi/kg], pCi per liter [pCi/L], pCi per cubic meter [pCi/m3]) of a given radionuclide in the sample are at a level that:

○ Equals or exceeds a value 2 standard deviations above the mean site-specific background concentration for that radionuclide in that type of sample, or

○ Exceeds the upper-limit value of the range of regional background concentration values for that specific radionuclide in that type of sample.

▪ Some portion of the increase must be attributable to the site to establish the observed release (or observed contamination or observed exposure), and

▪ For the soil exposure component of the soil exposure and subsurface intrusion pathway only, the radionuclide must also be present at the surface or covered by 2 feet or less of cover material (for example, soil) to establish observed contamination.

—For man-made radionuclides without ubiquitous background concentrations in the environment:

▪ Measured concentration (in units of activity) of a given radionuclide in a sample equals or exceeds the sample quantitation limit for that specific radionuclide in that type of media and is attributable to the site.

▪ However, if the radionuclide concentration equals or exceeds its sample quantitation limit, but its release can also be attributed to one or more neighboring sites, then the measured concentration of that radionuclide must also equal or exceed a value either 2 standard deviations above the mean concentration of that radionuclide contributed by those neighboring sites or 3 times its background concentration, whichever is lower.

▪ If the sample quantitation limit cannot be established:

○ If the sample analysis was performed under the EPA Contract Laboratory Program, use the EPA contract-required quantitation limit (CRQL) in place of the sample quantitation limit in establishing an observed release (or observed contamination or observed exposure).

○ If the sample analysis is not performed under the EPA Contract Laboratory Program, use the detection limit in place of the sample quantitation limit.

▪ For the soil exposure component of the soil exposure and subsurface intrusion pathway only, the radionuclide must also be present at the surface or covered by 2 feet or less of cover material (for example, soil) to establish observed contamination.

• Gamma radiation measurements (applies only to observed contamination or observed exposure in the soil exposure and subsurface intrusion pathway):

—The gamma radiation exposure rate, as measured in microroentgens per hour (μR/hr) using a survey instrument held 1 meter above the ground surface or floor or walls of a structure (or 1 meter away from an aboveground source for the soil exposure component), equals or exceeds 2 times the site-specific background gamma radiation exposure rate.

—Some portion of the increase must be attributable to the site to establish observed contamination. The gamma-emitting radionuclides do not have to be within 2 feet of the surface of the source.

For the three migration pathways and for the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, if an observed release or observed exposure can be established for the pathway (or threat, aquifer, or watershed, as appropriate), assign the pathway (or threat, aquifer, or watershed) an observed release or observed exposure factor value of 550 and proceed to section 7.2. If an observed release or observed exposure cannot be established, assign an observed release or observed exposure factor value of 0 and proceed to section 7.1.2.

For the soil exposure component of the soil exposure and subsurface intrusion pathway, if observed contamination can be established, assign the likelihood of exposure factor for resident population a value of 550 if there is an area of observed contamination in one or more locations listed in section 5.1.1; evaluate the likelihood of exposure factor for nearby population as specified in section 5.1.2.1; and proceed to section 7.2. If observed contamination cannot be established, do not evaluate the soil exposure component of the soil exposure and subsurface intrusion pathway.

At sites containing mixed radioactive and other hazardous substances, evaluate observed release (or observed contamination or observed exposure) separately for radionuclides as described in this section and for other hazardous substances as described in sections 2 through 6.

For the three migration pathways and the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, if an observed release or observed exposure can be established based on either radionuclides or other hazardous substances, or both, assign the pathway (or threat, aquifer, or watershed) an observed release or observed exposure factor value of 550 and proceed to section 7.2. If an observed release or observed exposure cannot be established based on either radionuclides or other hazardous substances, assign an observed release or observed exposure factor value of 0 and proceed to section 7.1.2.

For the soil exposure component of the soil exposure and subsurface intrusion pathway, if observed contamination can be established based on either radionuclides or other hazardous substances, or both, assign the likelihood of exposure factor for resident population a value of 550 if there is an area of observed contamination in one or more locations listed in section 5.1.1; evaluate the likelihood of exposure factor for nearby population as specified in section 5.1.2.1; and proceed to section 7.2. If observed contamination cannot be established based on either radionuclides or other hazardous substances, do not evaluate the soil exposure component of the soil exposure and subsurface intrusion pathway.

7.1.2 *Potential to release/potential for exposure.* For the three migration pathways and the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, evaluate potential to release or potential for exposure for sites containing radionuclides in the same manner as specified for sites containing other hazardous substances. Base the evaluation on the physical and chemical properties of the radionuclides, not on their level of radioactivity. For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, if the potential for exposure is based on the presence of gamma emitting radioactive substances, assign a potential for exposure factor value of 500 only if the contamination is found within 2 feet beneath a regularly occupied structure, otherwise assign a potential for exposure factor value of 0.

For sites containing mixed radioactive and other hazardous substances, evaluate potential to release or potential for exposure considering radionuclides and other hazardous substances together. Evaluate potential to release for each migration pathway and the potential for exposure for the subsurface intrusion component of the soil exposure and subsurface intrusion pathway as specified in sections 3 through 6, as appropriate.

* * * * *

7.2.3 *Persistence/Degradation.* In determining the surface water persistence factor for radionuclides, evaluate the surface water persistence this factor based solely on half-life; do not include sorption to sediments in the evaluation as is done for nonradioactive hazardous substances. Assign a persistence factor value from Table 4–10 (section 4.1.2.2.1.2) to each radionuclide based on half-life ($t_{1/2}$) calculated as follows:

$$t_{1/2} = \frac{1}{\frac{1}{r}+\frac{1}{v}}$$

Where:

r = Radioactive half-life.
v = Volatilization half-life.

If the volatilization half-life cannot be estimated for a radionuclide from available data, delete it from the equation. Select the portion of Table 4–10 to use in assigning the persistence factor value as specified in section 4.1.2.2.1.2.

At sites containing mixed radioactive and other hazardous substances, evaluate the persistence factor separately for each radionuclide and for each nonradioactive hazardous substance, even if the available data indicate that they are combined chemically. Assign a persistence factor value to each radionuclide as specified in this section and to each nonradioactive hazardous substance as specified in section 4.1.2.2.1.2. When combined chemically, assign a single persistence factor value based on the higher of the two values assigned (individually) to the radioactive and nonradioactive components.

In determining the subsurface intrusion degradation factor for radionuclides, when evaluating this factor based solely on half-life. Assign a degradation factor value from section 5.2.1.2.1.2 to each radionuclide based on half-life ($t_{1/2}$) calculated as follows:

$$t_{1/2} = \frac{1}{\frac{1}{r}}$$

Where:

r = Radioactive half-life.

At sites containing mixed radioactive and other hazardous substances, evaluate the persistence or degradation factor separately for each radionuclide and for each nonradioactive hazardous substance, even if the available data indicate that they are combined chemically. Assign a persistence or degradation factor value to each radionuclide as specified in this section and to each nonradioactive hazardous substance as specified in sections 4.1.2.2.1.2 and 5.2.1.2.1.2. When combined chemically, assign a single persistence or degradation factor value based on the higher of the two values assigned (individually) to the radioactive and nonradioactive components.

7.2.4 *Selection of substance potentially posing greatest hazard*. For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway and each migration pathway (or threat, aquifer, or watershed, as appropriate), select the radioactive substance or nonradioactive hazardous substance that potentially poses the greatest hazard based on its toxicity factor value, combined with the applicable mobility, persistence, degradation and/or bioaccumulation (or ecosystem bioaccumulation) potential factor values. Combine these factor values as specified in sections 2 through 6. For the soil exposure component of the soil exposure and subsurface intrusion pathway, base the selection on the toxicity factor alone (see sections 2 and 5).

* * * * *

7.2.5.1 *Source hazardous waste quantity for radionuclides* For each migration pathway, assign a source hazardous waste quantity value to each source having a containment factor value greater than 0 for the pathway being evaluated. For the soil exposure component of the soil exposure and subsurface intrusion pathway, assign a source hazardous waste quantity value to each area of observed contamination, as applicable to the threat being evaluated. For the subsurface intrusion component, assign a source hazardous waste quantity value to each regularly occupied structure located within areas of observed exposure or areas of subsurface contamination. Allocate hazardous substances and hazardous wastestreams to specific sources (or areas of observed contamination, area of observed exposure or area of subsurface contamination) as specified in sections 2.4.2 and 5.2.0.

7.2.5.1.1 *Radionuclide constituent quantity (Tier A)*. Evaluate radionuclide constituent quantity for each source (or area of observed contamination or area of observed exposure) based on the activity content of the radionuclides allocated to the source (or area of observed contamination or area of observed exposure) as follows:

- Estimate the net activity content (in curies) for the source (or area of observed contamination or area of observed exposure) based on:
  —Manifests, or
  —Either of the following equations, as applicable:

$$N = 9.1x10^{-7}(V)\sum_{i=1}^{n} AC_i$$

Where:

N = Estimated net activity content (in curies) for the source (or area of observed contamination or area of observed exposure).
V = Total volume of material (in cubic yards) in a source (or area of observed contamination or area of observed exposure) containing radionuclides.
AC_i = Activity concentration above the respective background concentration (in pCi/g) for each radionuclide i allocated to the source (or area of observed contamination or area of observed exposure).
n = Number of radionuclides allocated to the source (or area of observed contamination or area of observed exposure) above the respective background concentrations.

or,

$$N = 3.8x10^{-12}(V)\sum_{i=1}^{n} AC_i$$

Where:

N = Estimated net activity content (in curies) for the source (or area of observed contamination or area of observed exposure).
V = Total volume of material (in gallons) in a source (or area of observed contamination or area of observed exposure) containing radionuclides.
AC_i = Activity concentration above the respective background concentration (in pCi/1) for each radionuclide i allocated to the source (or area of observed contamination or area of observed exposure).
n = Number of radionuclides allocated to the source (or area of observed contamination or area of observed exposure) above the respective background concentrations.

- Estimate volume for the source (or volume for the area of observed contamination or area of observed exposure) based on records or measurements.
- For the soil exposure component, in estimating the volume for areas of observed contamination, do not include more than the first 2 feet of depth, except: For those types of areas of observed contamination listed in Tier C of Table 5–2 (section 5.1.1.2.2), include the entire depth, not just that within 2 feet of the surface.
- For the subsurface intrusion component, in estimating the volume for areas of observed exposure, only use the volume of air in the regularly occupied structures where observed exposure has been documented.
- Convert from curies of radionuclides to equivalent pounds of nonradioactive hazardous substances by multiplying the activity estimate for the source (or area of observed contamination or area of observed exposure) by 1,000.
- Assign this resulting product as the radionuclide constituent quantity value for the source (or area of observed contamination or area of observed exposure).

If the radionuclide constituent quantity for the source (or area of observed contamination or area of observed exposure) is adequately determined (that is, the total activity of all radionuclides in the source and releases from the source [or in the area of observed contamination or area of observed exposure] is known or is estimated with reasonable confidence), do not evaluate the radionuclide wastestream quantity measure in section 7.2.5.1.2. Instead, assign radionuclide wastestream quantity a value of 0 and proceed to section 7.2.5.1.3. If the radionuclide constituent quantity is not adequately determined, assign the source (or area of observed contamination or area of observed exposure) a value for radionuclide constituent quantity based on the available data and proceed to section 7.2.5.1.2.

7.2.5.1.2 *Radionuclide wastestream quantity (Tier B)*. Evaluate radionuclide wastestream quantity for the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination) based on the activity content of radionuclide wastestreams allocated to the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination) as follows:

- Estimate the total volume (in cubic yards or in gallons) of wastestreams containing radionuclides allocated to the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination).
- Divide the volume in cubic yards by 0.55 (or the volume in gallons by 110) to convert to the activity content expressed in terms of equivalent pounds of nonradioactive hazardous substances.

• Assign the resulting value as the radionuclide wastestream quantity value for the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination).

• For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, estimate the total wastestream volume for all regularly occupied structures located within areas of observed exposure with observed or inferred intrusion and within areas of subsurface contamination. Calculate the volume of each regularly occupied structure based on actual data. If unknown, use a ceiling height of 8 feet.

7.2.5.1.3 *Calculation of source hazardous waste quantity value for radionuclides.* Select the higher of the values assigned to the source (or area of observed contamination, area of observed exposure, and/or area of subsurface contamination) for radionuclide constituent quantity and radionuclide wastestream quantity. Assign this value as the source hazardous waste quantity value for the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination). Do not round to the nearest integer.

7.2.5.2 *Calculation of hazardous waste quantity factor value for radionuclides.* Sum the source hazardous waste quantity values assigned to all sources (or areas of observed contamination, areas of observed exposure, or areas of subsurface contamination) for the pathway being evaluated and round this sum to the nearest integer, except: If the sum is greater than 0, but less than 1, round it to 1. Based on this value, select a hazardous waste quantity factor value for this pathway from Table 2–6 (section 2.4.2.2).

For a migration pathway, if the radionuclide constituent quantity is adequately determined (see section 7.2.5.1.1) for all sources (or all portions of sources and releases remaining after a removal action), assign the value from Table 2–6 as the hazardous waste quantity factor value for the pathway. If the radionuclide constituent quantity is not adequately determined for one or more sources (or one or more portions of sources or releases remaining after a removal action), assign a factor value as follows:

• If any target for that migration pathway is subject to Level I or Level II concentrations (see section 7.3), assign either the value from Table 2–6 or a value of 100, whichever is greater, as the hazardous waste quantity factor value for that pathway.

• If none of the targets for that pathway is subject to Level I or Level II concentrations, assign a factor value as follows:

—If there has been no removal action, assign either the value from Table 2–6 or a value of 10, whichever is greater, as the hazardous waste quantity factor value for that pathway.

—If there has been a removal action:

 ▪ Determine values from Table 2–6 with and without consideration of the removal action.

 ▪ If the value that would be assigned from Table 2–6 without consideration of the removal action would be 100 or greater, assign either the value from Table 2–6 with consideration of the removal action or a value of 100, whichever is greater, as the hazardous waste quantity factor value for the pathway.

 ▪ If the value that would be assigned from Table 2–6 without consideration of the removal action would be less than 100, assign a value of 10 as the hazardous waste quantity factor value for the pathway.

For the soil exposure component of the soil exposure and subsurface intrusion pathway, if the radionuclide constituent quantity is adequately determined for all areas of observed contamination, assign the value from Table 2–6 as the hazardous waste quantity factor value. If the radionuclide constituent quantity is not adequately determined for one or more areas of observed contamination, assign either the value from Table 2–6 or a value of 10, whichever is greater, as the hazardous waste quantity factor value.

For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, if the radionuclide constituent quantity is adequately determined for all areas of observed exposure, assign the value from Table 2–6 as the hazardous waste quantity factor value. If the radionuclide constituent quantity is not adequately determined for one or more areas of observed exposure, assign either the value from Table 2–6 or a value of 10, whichever is greater, as the hazardous waste quantity factor value.

7.2.5.3 *Calculation of hazardous waste quantity factor value for sites containing mixed radioactive and other hazardous substances.* For each source (or area of observed contamination, area of observed exposure, or area of subsurface contamination) containing mixed radioactive and other hazardous substances, calculate two source hazardous waste quantity values—one based on radionuclides as specified in sections 7.2.5.1 through 7.2.5.1.3 and the other based on the nonradioactive hazardous substances as specified in sections 2.4.2.1 through 2.4.2.1.5, and sections 5.1.1.2.2, 5.1.2.2.2 and 5.2.1.2.2 (that is, determine each value as if the other type of substance was not present). Sum the two values to determine a combined source hazardous waste quantity value for the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination). Do not round this value to the nearest integer.

Use this combined source hazardous waste quantity value to calculate the hazardous waste quantity factor value for the pathway as specified in section 2.4.2.2, except: If either the hazardous constituent quantity or the radionuclide constituent quantity, or both, are not adequately determined for one or more sources (or one or more portions of sources or releases remaining after a removal action) or for one or more areas of observed contamination, areas of observed exposure, or areas of subsurface contamination, as applicable, assign the value from Table 2–6 or the default value applicable for the pathway, whichever is greater, as the hazardous waste quantity factor value for the pathway.

7.3 *Targets.* For radioactive substances, evaluate the targets factor category as specified in section 2.5 and sections 3 through 6, except: Establish Level I and Level II concentrations at sampling locations as specified in sections 7.3.1 and 7.3.2 and establish weighting factors for populations associated with an area of subsurface contamination in the subsurface intrusion component of the soil exposure and subsurface intrusion pathway as specified in section 7.3.3.

For all pathways (components and threats), use the same target distance limits for sites containing radioactive substances as is specified in sections 3 through 6 for sites containing nonradioactive hazardous substances. At sites containing mixed radioactive and other hazardous substances, include all sources (or areas of observed contamination, areas of observed exposure, or areas of subsurface contamination) at the site in identifying the applicable targets for the pathway.

7.3.1 *Level of contamination at a sampling location.* Determine whether Level I or Level II concentrations apply at a sampling location (and thus to the associated targets) as follows:

- Select the benchmarks from section 7.3.2 applicable to the pathway (or component or threat) being evaluated.
- Compare the concentrations of radionuclides in the sample (or comparable samples) to their benchmark concentrations for the pathway (or component or threat) as specified in section 7.3.2. Treat comparable samples as specified in section 2.5.1.
- Determine which level applies based on this comparison.
- If none of the radionuclides eligible to be evaluated for the sampling location have an applicable benchmark, assign Level II to the actual contamination at that sampling location for the pathway (or component or threat).
- In making the comparison, consider only those samples, and only those radionuclides in the sample, that meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway, except: Tissue samples from aquatic human food chain organisms may also be used for the human food chain threat of the surface water pathway as specified in sections 4.1.3.3 and 4.2.3.3.

7.3.2 *Comparison to benchmarks.* Use the following media specific benchmarks (expressed in activity units, for example, pCi/l for water, pCi/kg for soil and for aquatic human food chain organisms, and pCi/m3 for air) for making the comparisons for the indicated pathway (or threat):

- Maximum Contaminant Levels (MCLs)—ground water migration pathway and drinking water threat in surface water migration pathway.
- Uranium Mill Tailings Radiation Control Act (UMTRCA) standards—soil exposure component of the soil exposure and subsurface intrusion pathway only.
- Screening concentration for cancer corresponding to that concentration that corresponds to the 10^{-6} individual cancer risk for inhalation exposures (air migration pathway and subsurface intrusion component of the soil exposure and subsurface intrusion pathway) or for oral exposures (ground water migration pathway; drinking water or human food chain threats in surface water migration pathway; and soil exposure and subsurface intrusion pathway).
  —For the soil exposure and subsurface intrusion pathway, include two screening concentrations for cancer—one for ingestion of surface materials and one for external radiation exposures from gamma-emitting radionuclides in surface materials.

Select the benchmark(s) applicable to the pathway (component or threat) being evaluated. Compare the concentration of each radionuclide from the sampling location to its benchmark concentration(s) for that pathway (component or threat). Use only those samples and only those radionuclides in the sample that meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway, except: Tissue samples from aquatic human food chain organisms may be used as specified in sections 4.1.3.3 and 4.2.3.3. If the concentration of any applicable radionuclide from any sample equals or exceeds its benchmark concentration, consider the sampling location to be subject to Level I concentrations for that pathway (component or threat). If more than one benchmark applies to the radionuclide, assign Level I if the radionuclide concentration equals or exceeds the lowest applicable benchmark concentration. In addition, for the soil exposure and subsurface intrusion pathway, assign Level I concentrations at the sampling location if measured gamma radiation exposure rates equal or exceed 2 times the background level (see section 7.1.1).

If no radionuclide individually equals or exceeds its benchmark concentration, but more than one radionuclide either meets the criteria for an observed release (or observed contamination or observed exposure) for the sample or is eligible to be evaluated for a tissue sample (see sections 4.1.3.3 and 4.2.3.3), calculate a value for index I for these radionuclides as specified in section 2.5.2. If I equals or exceeds 1, assign Level I to the sampling location. If I is less than 1, assign Level II.

At sites containing mixed radioactive and other hazardous substances, establish the level of contamination for each sampling location considering radioactive substances and nonradioactive hazardous substances separately. Compare the concentration of each radionuclide and each nonradioactive hazardous substance from the sampling location to its respective benchmark concentration(s). Use only those samples and only those substances in the sample that meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway except: Tissue samples from aquatic human food chain organisms may be used as specified in sections 4.1.3.3 and 4.2.3.3. If the concentration of one or more applicable radionuclides or other hazardous substances from any sample equals or exceeds its benchmark concentration, consider the sampling location to be subject to Level I concentrations. If more than one benchmark applies to a radionuclide or other hazardous substance, assign Level I if the concentration of the radionuclide or other hazardous substance equals or exceeds its lowest applicable benchmark concentration.

If no radionuclide or other hazardous substance individually exceed a benchmark concentration, but more than one radionuclide or other hazardous substance either meets the criteria for an observed release (or observed contamination or observed exposure) for the sample or is eligible to be evaluated for a tissue sample, calculate an index I for both types of substances as specified in section 2.5.2. Sum the index I values for the two types of substances. If the value, individually or combined, equals or exceeds 1, assign Level I to the sample location. If it is less than 1, calculate an index J for the nonradioactive hazardous substances as specified in section 2.5.2. If J equals or exceeds 1, assign Level I to the sampling location. If J is less than 1, assign Level II.

7.3.3 *Weighting of targets within an area of subsurface contamination.* For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, assign a weighting factor as specified in section 5.2.1.3.2.3 except when an area of subsurface contamination is bound by gamma radiation exposure rates meeting observed release criteria with a depth to contamination of 2 feet or less. For those populations residing, working, or attending school or day care in a structure, assign a weighting factor of 0.9.

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