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Hazard Ranking System (HRS) For Uncontrolled Hazardous Substance Releases; Appendix A of the National Oil and Hazardous Substances Contingency Plan; Proposed Rule

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 300

[FRL-3296-8]

Hazard Ranking System (HRS) for Uncontrolled Hazardous Substance Releases; Appendix A of the National Oil and Hazardous Substances Contingency Plan

AGENCY: Environmental Protection Agency.

ACTION: Proposed rule

SUMMARY: The Environmental Protection Agency (EPA) is proposing revisions to the Hazard Ranking System, the principal mechanism for placing sites on the National Priorities List (NPL). The NPL is a list of releases and potential releases of hazardous substances, pollutants or contaminants that are eligible for Superfund-financed remedial actions. These revisions would change the way EPA evaluates potential threats to public health and the environment from hazardous waste sites and may affect the type and number of such sites included on the NPL. These revisions are designed to make the Hazard Ranking System more accurate in assessing relative potential risk as well as to meet other statutory requirements.

DATES: Comments may be submitted on or before February 21, 1989.

ADDRESSES: Comments may be mailed or delivered to the CERCLA Docket Clerk, Attn: Docket Number, 105NCP-HRS, Mail Code OS-240, Superfund Docket Room, LG-100, U.S. Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460. Please send 4 copies of comments. The public docket for the HRS revisions contains all relevant background material supporting these revisions. Requests for copies of these documents should be made to the CERCLA Docket Office, Waterside Mall Subbasement, U.S. Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460, phone 202-382-3046. The docket is available for viewing by appointment only from 9:00 am to 4:00 pm, Monday through Friday, excluding holidays.

FOR FURTHER INFORMATION CONTACT: Steve Caldwell or Jane Metcalfe, Hazardous Site Evaluation Division, Office of Emergency and Remedial Response, OS-230, U.S. Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460, phone 202-382-3000 or 800-424-9346.

SUPPLEMENTARY INFORMATION:

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I. Background

In 1980, Congress enacted the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. 9601 et seq.), commonly called the Superfund, in response to the dangers posed by uncontrolled releases of hazardous substances, pollutants, or contaminants into the environment.[1] To implement Section 105(8)(A) of CERCLA and Executive Order 12316 (46 FR 42237, August 20, 1981), the Environmental Protection Agency (EPA) revised the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300, on July 16, 1982 (47 FR 31180), with later revisions on September 16, 1985 (50 FR 37624), and November 20, 1985 (50 FR 47912). The NCP sets forth guidelines and procedures for responding to releases or potential releases of hazardous substances, pollutants, or contaminants. Section 105(8)(A) of CERCLA (now section 105(a)(8)(A)) required EPA to establish:

> criteria 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 help set priorities, EPA adopted the Hazard Ranking System (HRS) as part of the revised NCP. The HRS is a scoring system used to assess the relative threat associated with actual or potential releases of hazardous substances from a site. An HRS score is determined for a site by evaluating several migration routes or "pathways," such as water and air. The score for each pathway is obtained by evaluating a set of "factors" that characterize the potential of the facility to cause harm via that pathway. The factors, such as toxicity of the substances at a site, waste quantity, and population, are each assigned a numerical value according to instructions set out in Appendix A to the final NCP (47 FR 31180, July 16, 1982); this value is multiplied by a weighting factor yielding the factor score. The factor scores are then combined within "factor categories"; the total scores for the factor categories are multiplied together to develop a score for the relevant pathway. Finally, the pathway scores are combined according to a mathematical formula to produce the HRS score for the site.

The HRS was designed to be applied uniformly to each site, enabling sites to be evaluated relative to each other with respect to actual or potential hazards. As EPA explained when it 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" (47 FR 31220, July 16, 1982). Although the HRS was designed to assess relative risks, it is not designed to be used as a quantitative risk assessment.

The HRS score is a crucial part of the Agency's program to address the

[1] For the purpose of this rule and preamble, the term "hazardous substances, pollutants, or contaminants" will be referred to simply as "hazardous substances."

identification and cleanup of actual and potential releases of hazardous substances because the HRS is the primary way of determining whether a site is to be included on the National Priorities List (NPL). Each State can also designate a single site to the NPL as a State top priority site regardless of its HRS score and sites may be added in response to a health advisory from the Agency for Toxic Substances and Disease Registry (see NCP, 40 CFR 300.66(b)(4)). The NPL (Appendix B to 40 CFR Part 300) includes those sites that appear to pose the most serious threats to public health and the environment and that appear to warrant remedial investigation and possible cleanup under CERCLA. Only sites on the NPL are eligible for Superfund-financed remedial actions. Emergency removal and enforcement actions can be conducted at any site whether or not it is on the NPL.

Remedial action tends to be long-term in nature and involves response actions that are consistent with a permanent remedy for a release. Removal actions tend to be short-term or temporary in nature and involve cleanup or other actions deemed necessary to prevent or minimize damage to public health and the environment.

In 1986, Congress passed the Superfund Amendments and Reauthorization Act (SARA) (Pub. L. 99–499), which added a 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." Section 105(c)(2) as amended also requires that the HRS appropriately assess the human health risks associated with contamination or potential contamination of surface waters, either directly or as a result of runoff of any hazardous substance. This assessment should take into account the use of these waters for recreation and the potential migration of any hazardous substance through surface water to downstream sources of drinking water.

The Amendments also add two criteria for evaluating sites under section 105(a)(8)(A):

- Evaluation of the damage to natural resources which may affect the human food chain and which is associated with any release or threatened release of hazardous substances.
- The contamination or potential contamination of the ambient air which is associated with a release or threatened release

Section 105(c)(1) states that the revised HRS shall be applied to any site to be newly listed on the NPL after the effective date of the revised HRS. Until the effective date, sites will be scored with the current HRS. In addition, section 105(c)(3) specifies that EPA shall not be required to rescore any site evaluated with the current HRS before the effective date.

CERCLA section 118, added by SARA, requires EPA to give a high priority to facilities where the release of hazardous substances has resulted in the closing of drinking water wells or has contaminated a principal drinking water supply.

CERCLA section 125 (added by SARA) requires revisions to the HRS to address facilities that contain substantial volumes of wastes specified in section 3001(b)(3)(A)(i) of the Solid Waste Disposal Act (Resource Conservation and Recovery Act or RCRA). These wastes include fly ash wastes, bottom ash wastes, slag wastes, and flue gas emission control wastes generated primarily from the combustion of coal or other fossil fuels. Section 125 requires EPA to revise the HRS to assure the appropriate consideration of each of the following site-specific characteristics of such facilities:

1. The quantity, toxicity, and concentrations of hazardous constituents which are present in such waste and a comparison thereof with other wastes.
2. The extent of, and potential for, release of such hazardous constituents into the environment.
3. The degree of risk to human health and the environment posed by such constituents.

II. Hazard Ranking System

The current HRS serves as a screening device to evaluate the relative potential of uncontrolled hazardous substances to cause human health or safety problems or ecological or environmental damage. The pre-remedial portion of the Superfund program—the portion prior to placing sites on the NPL—is intended to identify those sites that represent the highest priority for further investigation and possible cleanup under CERCLA. During site discovery, the first step of the pre-remedial process, possible releases of hazardous substances are listed in the CERCLA Information System (CERCLIS). A preliminary assessment is then conducted for all sites on CERCLIS; this low cost, initial evaluation is meant to give as full and complete a picture of the site as possible using existing information. EPA is currently continuing to screen the approximately 30,000 sites presently in CERCLIS.

If, based on the results of the preliminary assessment, EPA determines that a site warrants further action, the Agency initiates a site inspection as specified in the NCP (40 CFR 300.66). The site inspection may include the collection of a limited number 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 a potential threat to public health or the environment, to determine if there is an immediate threat to people in the area, and to collect sufficient data to enable the site to be scored using the HRS.

As required by CERCLA, EPA has designed the Superfund program to focus its resources on the highest priority sites. 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 has elected to place certain constraints on the complexity of the HRS. The required HRS data should be information that, for most sites, can be collected in a single site visit or that are already available. Thus, the HRS cannot 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 provides a measure of relative rather than absolute risk. Congress, in its Conference Report on SARA, confirmed the appropriateness of this approach when it specified a substantive standard against which HRS revisions could be assessed.

> This standard is to be applied within the context of the purpose for the National Priorities List; i.e., identifying for the States and the public those facilities and sites which *appear* to warrant remedial actions * * *. This standard does not, however, require the Hazard Ranking System to be equivalent to detailed risk assessments, quantitative or qualitative, such as might be performed as part of remedial actions. The standard requires the Hazard Ranking System to rank sites as accurately as the Agency believes is feasible using information from preliminary assessments and site inspections * * *. Meeting this standard does not require long-term monitoring or an accurate determination of the full nature and extent of contamination at sites or the projected levels of exposure such as might be done during remedial investigations and feasibility studies. This

provision is intended to ensure that the Hazard Ranking System performs with a *degree of accuracy appropriate to its role in expeditiously identifying candidates for response actions* (H.R. Rep. No. 962, 99th Cong., 2nd Sess. at 199–200 (1986) (emphasis added)).

EPA wants to emphasize that the HRS was designed to assess relative risk, and, thus, is not designed to be used as a quantitative risk assessment.

Of the approximately 30,000 sites in CERCLIS, approximately 27,000 have received a preliminary assessment. About 9,000 of those have had a site inspection and about 2,000 have been scored using the HRS. To date, there are 1,175 sites on or proposed for the NPL (see 48 FR 40658, September 8, 1983; 49 FR 19480, May 8, 1984; 49 FR 37070, September 21, 1984; 50 FR 6320, February 14, 1985; 50 FR 37630, September 16, 1985; 51 FR 21054, June 10, 1986; 52 FR 2492, January 22, 1987; 52 FR 27620, July 22, 1987; 53 FR 23988, June 24, 1988; and 53 FR 33811, September 1, 1988). SARA provides EPA (see CERCLA sections 116(a) (1) and (2), as amended) with goals for completing preliminary assessments and site inspections. For all sites in CERCLIS as of the date of the enactment of SARA, preliminary assessments should be completed by January 1, 1988, and site inspections, where needed, should be completed by January 1, 1989.

Although the NPL is ordered by HRS scores, EPA puts the sites into groups to emphasize that minor differences in scores do not necessarily indicate significantly different levels of risk.

The revisions being proposed today reflect the Agency's efforts to improve the accuracy of the HRS, addressing the SARA mandate. While this proposed rule, Appendix A to 40 CFR 300 ("proposed rule") would add some new elements, the HRS would still serve its intended purpose as a screening tool. EPA has been careful to balance the potential increased costs in time and resources to collect more data against the goal of improving accuracy, so the revised HRS can list sites correctly without impairing the Agency's ability to evaluate releases quickly.

Current HRS

The current HRS evaluates the relative threat of a site over five pathways—ground water, surface water, air, direct contact, and fire and explosion. The first three of these pathways reflect the risk from migration of hazardous substances from the site. The scores for ground water, surface water, and air are combined into an overall migration score that is the primary consideration in placing a site on the NPL. The last two pathways, direct contact and fire and explosion, may be used to determine if the potential risk is so acute that emergency action is required, but are not included in the overall HRS migration score.

The current HRS uses a structured value analysis approach to scoring sites. This approach assigns values to factors related to or indicative of risk. The basic elements of the current HRS are factors such as toxicity and containment. A scale of numerical rating values is provided for each factor and a value is assigned to each factor based on conditions at the site. Individual values are then weighted. The factors are grouped into three factor categories—observed release/route characteristics, waste characteristics, and targets—and are combined to obtain factor category scores. Each factor category has a maximum value, as does each of the component factors within the category.

The relevant factor category scores are multiplied together within each pathway and normalized to obtain a pathway score. Finally, the pathway scores for ground water, surface water, and air are combined to obtain the HRS migration score.

The pathway scores are combined using a root-mean-square approach to calculate the overall site score; that is, the final HRS score is the square root of the sum of the squares of the pathway scores divided by the square root of three. If all pathway scores are low, the HRS score will be low. However, the final score will be relatively high even if only one pathway score is high. EPA considers this an important requirement for the HRS scoring because some extremely dangerous sites pose threats through only one migration mode. 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.

III. Approach to HRS Revisions

EPA undertook a comprehensive review of the HRS in developing this proposed rule. Based on comments to previous rulemakings, and its own experience scoring sites, EPA prepared or sponsored a series of issue analysis reports that formed the basis for many of the options the Agency considered. These reports covered issues such as methods to evaluate human food chain exposure; methods to evaluate the potential for air release; evaluation of appropriate air and surface water target distance limits; factors to account for environmental attenuation of hazardous substances in ground water and surface water; methodologies for evaluating toxicity; methods for determining direction of ground water flow and issues related to the feasibility of using ground water flow direction measures; and the feasibility of using hazardous substance concentration data as well as evaluating waste quantity on a hazardous constituent basis. These reports and other studies form the basis of the Technical Support Document, available in the Superfund docket for public review, which explains in detail the basis for the options proposed in this revision.

To provide a broad spectrum of technical expertise in developing these revisions, EPA sought information from a number of sources. In 1986, EPA's Office of Emergency and Remedial Response established an EPA work group to guide the revision process. The work group's deliberations addressed not only the broad structure and function of the HRS, but also detailed technical issues.

A. Science Advisory Board

Several scientific questions were referred to the Agency's Science Advisory Board for its review and recommendations. The Science Advisory Board is a public advisory group providing scientific information and advice to the Administrator and other officials of EPA. The Board is structured to provide a balanced expert assessment of scientific issues related to problems facing the Agency. EPA referred three specific issues to the Board: (1) Options for revising the way toxicity of hazardous substances is evaluated and scored in the HRS; (2) the question of whether the HRS is biased against mining waste and other high volume waste sites (including issues related to the use of waste concentration data); and (3) the appropriate air pathway target distance over which population exposure is assessed. EPA developed summary technical documents on these issues and made several presentations to the Science Advisory Board, which prepared a report addressing each issue. The technical documents and Science Advisory Board recommendations are available in the docket. The documents are: (1) "Discussion of Options For Revising the Hazard Ranking System (HRS) Toxicity Factor," ICF, Inc., May 1987; (2) "Analysis of the Air Target Distance Limit in the Hazard Ranking System," EPA, 1987; (3) "The Superfund Hazard Ranking System (HRS): Applicability to Mining Waste Sites," ICF Inc., July 1987; and (4) "The

Superfund Hazard Ranking System (HRS): Feasibility of Using Concentration Data in a Revised HRS," ICF, Inc., July 1987. The Science Advisory Board's recommendations are outlined in "Science Advisory Board Hazard Ranking System Review Subcommittee: Review of the Hazard Ranking System," US EPA, 1988.

B. Review of Alternative Ranking Systems

One of the activities undertaken to develop a revised and improved HRS involved examining alternative site evaluation models chosen from a review of over 30 such systems. EPA evaluated the models to determine: accuracy in predicting potential risk; the extent to which the SARA requirements were addressed by the model; the implementability of the model; the amount of data that would have to be collected to evaluate sites using the model; and the cost and time involved in gathering these data.

In order to better understand the accuracy of these models, EPA tested three of the site evaluation models, along with a draft version of the revised HRS, on 20 sites. Through analysis of these models, EPA hoped to better understand the factors that affect the accuracy of site ranking methodologies, thereby developing insights to guide revisions to the HRS.

The three alternative systems analyzed were the New York State Human Exposure Potential Ranking System, the Air Force Hazard Assessment Rating Methodology II, and the Department of Energy Remedial Action Priority System. These systems were chosen for further testing because they considered site-specific conditions, were either fully developed and tested or in the final stages of development, examined multiple media, and were substantially different from the current HRS. None of them, however, fully met the SARA requirements without some revisions.

EPA convened a site ranking panel of senior EPA staff and managers selected to represent a cross-section of knowledge and specialties. The panel members were to evaluate and rank the 20 sites according to the relative level of risk they perceived the sites posed to human health and the environment. The purpose of this exercise was to obtain expert judgments to serve as a baseline for the comparative evaluations of the site evaluation models and to gain a better understanding of the relative weights of certain factors and exposure pathways in evaluating the threat from a site.

The 20 sites selected for the testing program were not randomly selected and are too small a sample to be statistically representative of the universe of potential Superfund sites. These sites had been investigated under the Superfund program and included NPL and non-NPL sites. The sites were selected to represent a range of different types of sites (landfills, surface impoundments, etc.) and a range of scores above and below 28.50, the cutoff on the current HRS for placing sites on the NPL. EPA also selected sites for which the necessary data were likely to be available. In addition, EPA explicitly selected some sites that contained features the current HRS migration routes could not score (such as human food chain exposures, direct contact exposures, and potential air releases). As a result, caution should be exercised in generalizing the testing results.

The panel used the most complete data available to rank the sites, more information than would normally be available at the time a site is evaluated using the HRS. Remedial investigations or Public Health Evaluations had been performed at most of the sites, providing quantitative risk estimates.

It is important to note that although the testing program provided the Agency with some useful information, this approach to assessing the site evaluation systems had some fundamental limitations. First, only 20 sites were used for the evaluation, and, as discussed above, these sites were not chosen randomly. Second, the panel had access to data that, in some cases, could not be used by (or were unavailable to) one or more of the models. Third, the panel's assessments were based on the subjective conclusions of panel members; although some objective criteria were applied, the same conclusions might not be reached by a second panel. Finally, no firm consensus was reached by the panel at the level of individual sites; rather, a fairly firm consensus on "groupings" of sites was reached, and only after negotiations and discussions among panel members. The limitations of the testing program account for some of the differences between the relative rankings of the expert panel and the rankings of the various models tested.

Despite these limitations, the results of the comparative evaluation of the models indicated that the draft revised HRS best reflected the site ranking panel's consensus ranking. This analysis is discussed in more detail in "Analysis of Alternatives to the Superfund Hazard Ranking System" (Industrial Economics, Inc., November 1988), as are each of the three alternative models tested. Further discussion of the correlations of the model rankings with the site ranking panel rankings and an analysis of the reasons for these correlations are provided in the above-referenced report which is available in the Superfund docket.

The model testing study suggested that the accuracy of the HRS could be improved by ensuring that the model considers a comprehensive set of exposure pathways and that the revised HRS employ a weighting scheme that gives sufficient emphasis to hazardous sites dominated by risks along one or several exposure pathways. In addition, the analysis suggests that the revised HRS should be flexible enough to take evidence of adverse health effects and environmental damage into account in evaluating sites. The analysis points out the sensitivity of site ranking models to the data they employ, and the importance—subject to resource constraints and the need to expeditiously evaluate sites—of providing the revised HRS with the best available data. The revised HRS attempts to implement these recommendations, as is discussed in greater detail later in this preamble.

Based on the evaluation of the HRS in the model testing study, EPA determined that the draft version of the revised HRS met all the statutory requirements, did not require more data than could reasonably be collected within the limited scope of a site inspection, and was cost-effective and implementable.

C. Cutoff Score

The first NPL contained 418 sites. States had the opportunity to designate one site as their single top priority; the remaining sites were included because they had HRS scores of 28.50 or higher. EPA chose the 28.50 cutoff score as a management tool because it yielded an initial NPL of at least 400 sites as required in CERCLA section 105(8)(B) (now CERCLA section 105(a)(8)(B)), not because of any determination that the cutoff represented a threshold of unacceptable risks presented by sites.

In the Conference Report on SARA, Congress asked EPA to address the relationship between risks at NPL sites and the cutoff score. During its revision of the HRS, EPA addressed this and other issues in a number of studies related to the cutoff score. These studies were combined into one report, which is available in the Superfund docket. ("SARA Studies on HRS Scores and Remedial Actions, HRS Scores and Potential Dangers, and the Effect of the 28.50 Cutoff Score," CH2M Hill, September 1988.) Although the study was limited in scope and definitive conclusions are not possible, it did indicate that some sites with scores below the cutoff can also pose potential dangers to human health and the environment. However, the cutoff score was not meant to set a no-risk threshold, but rather to set a level above which a site becomes a priority.[2] Toward that end, the 28.50 cutoff has been useful in identifying high priority sites for further study and possible remedial action and has proven to be an effective management tool. In general, NPL sites with scores exceeding 28.50 present significant risks to public health and the environment, necessitating some form of response. On the other hand, three sites have been deleted from the NPL after completion of a remedial investigation/feasibility study (RI/FS). Based on the remedial investigations, EPA concluded that none of the sites presents a significant threat to public health or the environment and that no removal or remedial action is necessary at those sites (51 FR 7935, March 7, 1986; 53 FR 12680, April 18, 1988).

In the past, EPA considered the effects of both raising and lowering the cutoff score for the NPL relative to the current cutoff. Lowering the cutoff would add more sites to the NPL and would tend to include more sites with lower risks than sites currently on the NPL. EPA is concerned that lowering the threshold might substantially increase the number of NPL sites that are found to present no significant threat to health or the environment after the RI/FS has been completed. Raising the cutoff establishes a higher threshold for newly scored sites and would tend to exclude from the NPL sites that present significant risks to public health and the environment. Since EPA believes that the current cutoff score has been a useful management tool, the Agency is proposing that the cutoff score for the revised HRS be functionally equivalent to the current cutoff.

In light of the rather substantial revisions of the HRS in this proposal, EPA concluded that it is necessary to evaluate the practical effects of keeping the cutoff score at 28.50; that is, whether that score will continue to provide an appropriate set of National Priorities for management purposes. The Agency is examining several approaches for defining "equivalent to 28.50." One alternative is to score sites using both the current and revised systems; EPA would then use statistical analyses to determine what revised HRS score best corresponds to 28.50 on the current HRS. Another alternative would be designed to yield an NPL of the same size as would the current HRS and current cutoff score. That is, EPA would estimate the size of the NPL if the current approach were applied to the known inventory of sites and then identify what cutoff score for the revised HRS would result in the same number of NPL sites. A third alternative involves identifying the quantitative risk levels that on the average correspond to a current HRS score of 28.50 and then determining what revised HRS score best corresponds to that risk level.

EPA specifically requests comment on whether the cutoff score for the revised HRS should be functionally equivalent to the current HRS score of 28.50 and, if so, how to define and determine functional equivalence. The Agency intends to evaluate various cutoff score analyses based on the cost and availability of data.

Although the Agency is proposing that the cutoff be functionally equivalent to the current score of 28.50, it is premature to specify a numerical cutoff score for the revised HRS at this time. As stated previously, every factor in the current HRS has been revised, and new factors have been included. An entirely new exposure pathway, the onsite exposure pathway, has been included in the total site score. Sites with certain characteristics (i.e., human food chain or direct contact problems) may score higher on the revised HRS than under the current HRS. Alternatively, certain sites may score lower under the revised HRS because of factors that allow target populations to be distance and dilution weighted, and due to the addition of mobility factors. Thus, differences in scores are anticipated between the current HRS and the proposed revised HRS. While the Agency expects that the changes will result in increased accuracy in assessing the relative degree of risks to public health and the environment for certain sites, it makes it difficult at this time to identify an appropriate cutoff score. After performing further analyses and reviewing public comments, EPA will select a means of establishing a cutoff score for the revised HRS and will announce that score in the preamble to the final rule.

D. SARA Conference Reports

In the Conference Report on SARA, Congress called on the President to address a number of issues during the review of the HRS (H.R. Rep. No. 962, 99th Cong., 2nd Sess. at 200 (1986)). Thus, in addition to the studies and reviews that EPA performed based on its experience and on comments, the Agency prepared the following:

1. An evaluation of the Preliminary Pollutant Limit Value system used by the Department of Defense and comparison with the HRS.
2. An explanation of how the HRS was developed and the method of determining the relative hazards at different facilities under the system.
3. A study determining the relationship of HRS scores and the potential dangers to human health and the environment.
4. An examination of the effect of establishing a threshold value of 28.50 for facilities to be included on the NPL.
5. A study determining the relationship between HRS scores and the types of remedial actions that are appropriate at such facilities.

These studies are available in the Superfund docket for this proposal. (See "SARA Studies on HRS Scores and Remedial Actions, HRS Scores and Potential Dangers and the Effect of the 28.50 Cutoff Score," CH2M Hill, September 1988; "An Explanation of How the HRS was Developed and the Method of Determining the Relative Hazards at Different Facilities under the System," US EPA, September 1988; and "Comparison of the Preliminary Pollutant Limit Value (PPLV) System and the Hazard Ranking System (HRS)," Versar, September 1988.) In addition, Congress called for a determination of whether a new threshold value should be established for inclusion of facilities on the NPL; this subject is discussed in this preamble in Section III.C.

E. Advance Notice of Proposed Rulemaking

EPA published an advance notice of proposed rulemaking (ANPRM) on April 9, 1987 (52 FR 11513), soliciting comments on the revisions required by SARA as well as on the following technical issues: existing scoring factors; other models for ranking hazardous substance releases; mechanisms for including direct contact in the HRS; and a mechanism for incorporating human food chain exposures into the HRS. On May 7 and 8, 1987, EPA held a public meeting on the HRS. The comments received during the public meeting and in response to the ANPRM have been reviewed and considered in the development of this Notice of Proposed Rulemaking. EPA will respond in detail to all comments when the final rule is promulgated.

[2] It should be noted that although sites scoring below 28.50 have not generally been placed on the NPL, they may be addressed by CERCLA removal or enforcement authorities, or by State and local governments, if response measures appear to be warranted.

IV. Background Documents

The proposed revisions to the HRS are discussed in three primary documents: (1) The proposed rule, (2) this preamble, and (3) the "Technical Support Document: Revised Hazard Ranking System," ("Technical Support Document"). The proposed rule outlines the scoring system, emphasizing the mechanics of scoring sites. This preamble provides an overview of the scoring system, along with concise explanations of why the changes were made.

The Technical Support Document contains a more detailed explanation of the technical basis for the proposed revisions to the HRS, along with descriptions of the options considered. The Technical Support Document follows the same general outline as the preamble, with one section describing revisions that affect more than one pathway (e.g., toxicity), and the remaining sections describing the four pathways of the revised HRS. Each discussion in the Technical Support Document generally contains a description of the current HRS, the options considered, the revisions that are proposed for the revised HRS, and the technical justifications for the option chosen. In addition, the Technical Support Document references other background documents that provide an even greater level of detail on the proposed revisions. These documents, along with the Technical Support Document, are available to the public in the Superfund docket. To facilitate public review, EPA has prepared an index to the proposed rule, the preamble to the proposed rule, and the Technical Support Document with detailed cross referencing of issues. This index will be available in the Superfund docket. See the **ADDRESSES** section of this preamble for further information on the Superfund docket.

V. Discussion of the Proposed Rule

A. Overview

As stated above, the current HRS is incorporated in the NCP as Appendix A to 40 CFR Part 300. Appendix A, which is essentially a user's manual for the HRS, includes the forms as well as instructions for assigning values to each of the factors.

The current Appendix A provides instructions for evaluating five pathways. The surface water, ground water, and air pathways comprise the migration pathways and are used in determining the HRS site score. Direct contact and fire and explosion may be calculated to determine if removal action is warranted. EPA does not believe that the fire and explosion calculation would provide a useful basis for scoring a site for remedial action. The potential for fire and explosion is considered in another part of the Superfund program, the removal program, when determining if a removal action is necessary. Therefore, the proposed HRS would delete the fire and explosion calculations. For the reasons discussed in section V D 4, the current direct contact calculation would also be deleted and replaced by an onsite exposure pathway. This new pathway would be included in the HRS site score.

As can be seen from the diagrams preceding section V D 1 through 4, the essential structural features of the revised HRS would generally remain the same as those of the current HRS. However, every factor has been revised or is new. A few factors would be eliminated, either because they do not discriminate among sites or because they would be replaced by more accurate measures.

The remainder of this preamble discusses the proposed changes to Appendix A. After an overview of the four pathways (both in their current and revised state), section V B presents a general discussion of the major proposed revisions. Following that, section V C describes in detail issues and factor revisions that affect more than one of the pathways. Sections V D 1 through 5 discuss all other changes to each specific pathway. Finally, section V E discusses an issue that has been the subject of special attention, wastes designated as special study wastes under RCRA.

1. Ground Water

The ground water migration pathway in both the current and revised HRS evaluates the likelihood that hazardous substances at a site or facility will migrate through the ground beneath them and contaminate aquifers. If the hazardous substances reach an aquifer, the substances can potentially be transported through the aquifer and contaminate drinking water wells that draw from that aquifer.

If hazardous substances have been released to an aquifer or if the site characteristics make a release likely, the principal questions the ground water pathway evaluates are the impact of releases on the ground water resources and on the people who draw their drinking water from potentially contaminated wells. The revised HRS is designed to reflect the concept that hazardous substances in ground water tend to become increasingly diluted as distance from the site increases.

2. Surface Water

For the purposes of the HRS, surface water is defined as perennial streams, rivers, lakes, oceans, and intermittent streams and ditches in arid and semiarid regions. If contaminated runoff has reached surface water or if the site characteristics make a release to surface water likely, the HRS evaluates the potential for the release to affect people or the environment. The revised HRS would include factors for evaluating flood potential and address the effect of hazardous substances on the human food chain. In addition, the revised HRS would evaluate risks from recreational exposures.

3. Air

The current HRS air pathway is evaluated only if hazardous substances at a site have escaped into the air either as gases or as particulate matter. The revised HRS would also consider the site characteristics to assess the potential for releases to occur even if no release has been documented. Once the likelihood of release has been determined, the main questions are how many people and sensitive environments could be exposed to hazardous substances carried in the air and the inherent hazard associated with potential exposures.

4. Onsite Exposure Pathway

The onsite exposure pathway deals with the possibility that people or sensitive environments will have direct, physical contact with hazardous wastes or contaminated soil. The revised HRS would look at two populations to assess the risk. The resident population consists of those people who live or go to school or day care on land that is contaminated. The nearby population consists of those people who live within a one-mile travel distance of the site and might have access to the site.

B. Major Revisions

The following is a summary discussion of the major revisions being proposed. More detailed specifics of each proposed revision as well as discussions of legal requirements, of options EPA considered, and of the reasons for EPA's decisions are provided in sections C and D, which also give references to the rule and to supporting documents available in the docket.

1. Actual and Potential Contamination

The current HRS evaluates the potential for exposure of populations and does not give additional consideration (i.e., higher scores) to situations where human exposures have been documented. The current HRS is also primarily oriented toward population risk rather than individual risk. EPA is proposing changes in HRS calculations so that the HRS will more accurately reflect the potential risk to individuals and to populations exposed to documented contamination.

In assessing drinking water threats in the proposed revisions, target populations in the ground water and surface water pathways would be divided into four groups: people exposed to documented contamination above health-based benchmarks; people exposed to documented contamination not exceeding health-based benchmarks, but significantly above background concentrations (two groups are defined on the fraction of the benchmark present); and people potentially exposed to contamination from a site. The health-based benchmarks would be based on the National Primary Drinking Water Standards (maximum contaminant levels (MCLs)) (40 CFR 141.11 through 141.16 and 52 FR 25690, July 8, 1987). If no drinking water standard has been developed by the Agency for a substance, the health-based benchmark would then be based on maximum contaminant level goals (MCLGs) for noncarcinogens. For carcinogens and potential carcinogens that have no MCLs, risk-specific concentrations corresponding to an individual cancer risk of 10^{-4} would be used as the benchmark instead of MCLGs. Where contamination above a health-based benchmark occurs, people exposed to this contamination would be weighted most heavily in determining the factor score. (See section V C 5.) The sensitive environments subpathway in the surface water pathway would also be evaluated on actual and potential contamination, using ambient water quality criteria as ecologically-based benchmarks.

Likewise, the human food chain subpathway in the surface water pathway assigns a higher value where a fishery has actually been closed or shows contamination over an action level set by the U.S. Food and Drug Administration (FDA) than where a fishery has not been closed and is not known to be contaminated above action levels. The recreation subpathway assigns a higher value where a recreation area has actual contamination rather than potential contamination.

The potential risk to the maximally exposed individual (MEI) would be represented by the distance to the nearest drinking water well in the ground water pathway, the streamflow at the nearest drinking water intake in the surface water pathway, and the distance to the nearest occupied building in the air pathway. When there is contamination above health-based benchmarks in any well or water intake within the target distance, the MEI factor would be assigned the maximum value in the ground water or surface water pathways to ensure that documented contamination is heavily weighted. (See section V C 9.)

2. Dilution/Distance Weighting

In the current HRS, weighting targets based on dilution/distance is explicitly included only in the air pathway, although such weighting is implicit in some factors in the ground water and surface water pathways. Because, under most circumstances, the concentration of hazardous substances declines as the substances migrate from a site, the revised HRS would apply dilution/distance weighting directly to relevant target category factors to better reflect the differential exposures and risks to targets located at varying distances from a site. The Agency believes such a revision would improve the accuracy of the HRS.

For surface water, the weighting factor would be based on dilution as reflected by the average annual flow; in air and ground water, distance would be used as a surrogate for dilution. The weighting of the population at different distances is based on the results of environmental transport models. In the ground water and surface water pathways, dilution/distance weighting of targets would be used for those populations who do not have actual contamination in their drinking water wells or drinking water intakes, but where the aquifer or surface water body is contaminated or has the potential to be contaminated. In the air pathway, all targets would be distance weighted. In the onsite pathway, the nearby population would be distance weighted, reflecting the likelihood of people visiting the site, not the potential decrease in concentration as hazardous substances migrate from a site. (See section V C 8.)

3. Toxicity

Under the current HRS, the toxicity factor scoring is based primarily on acute toxicity of hazardous substances. However, EPA recognizes that adverse health effects at hazardous waste sites may result from chronic exposures as well as from acute exposures. To include the consideration of such risks, EPA is proposing to change the basis of the toxicity factor score. The current toxicity values are based on either the Sax rating system or the rating system of the National Fire Protection Association. The revised HRS would evaluate hazardous substances and assign scores for three kinds of toxicity: acute toxicity, carcinogenicity, and chronic noncarcinogenic toxicity. The highest of the three scores for a hazardous substance would become the toxicity factor value assigned to that substance. EPA is proposing to score hazardous substances using a system based on Reference Doses for chronic noncarcinogenic toxicity; Cancer Potency Factors combined with qualitative weight-of-evidence for carcinogenicity, or, when the Cancer Potency Factor is not available, the ED_{10}; and LD_{50} or LC_{50} values for acute toxicity. In addition, EPA is proposing to include aquatic toxicity ratings to assess potential risks to aquatic ecosystems. (See section V C 2 and Section V D 2.) Toxicity values for a substance would be combined in a matrix with mobility or persistence factors to calculate the final toxicity/mobility values for the ground water and air pathways or toxicity/persistence values for the surface water pathway.

4. Mobility

The current HRS does not directly consider the properties of substances that affect their ability to be released and migrate through environmental media; therefore, the current HRS may not differentiate well between two highly toxic substances with very different mobilities. The addition of a mobility factor should better reflect the risks from a site. Thus, EPA is proposing to incorporate mobility factors that would combine with toxicity in a matrix calculation in the ground water and air pathways to create a more accurate measure of the likelihood that a particular substance will migrate to ground water or to the atmosphere and expose potential targets; the air pathway would consider the mobility of both gases and particulates. (See sections V D 1 and 3.)

Although the surface water pathway has no mobility factor per se, the persistence factor addresses this issue, as would the proposed bioaccumulation factor in the human food chain calculations and the proposed dose adjusting factor in the recreation calculations. (See section V D 2.)

5. Hazardous Waste Quantity

Hazardous waste, in addition to including some proportion of hazardous substances, almost always includes nontoxic substances. When the current HRS was developed, EPA judged that the cost of reliably determining the amount of hazardous constituents within the hazardous wastes at a site was prohibitive and, in some cases, technically impossible. Therefore, the current HRS was designed to use the total quantity of waste instead of the quantity of hazardous substances in the waste for the calculation of the hazardous waste quantity factor.

EPA is proposing to modify the existing method of calculating the hazardous waste quantity factor to make it a more accurate reflection of relative risk. The proposed tiered approach would allow for the use of calculated amounts of hazardous substances for sites where the contaminant concentrations in a given waste have been determined based on adequate sampling and analytical methods. If these concentrations are not available, waste quantity as deposited could be used, as could source volume or source area. (See section V C 3.)

6. Sensitive Environments

The sensitive environments considered under the current HRS include wetlands and areas that are critical habitats for plants and animals on the Federal endangered species list. EPA is proposing a significant expansion of the sensitive environments eligible to be scored in order to more fully address CERCLA's original mandate to consider threats to both public health and the environment, as well as to respond to the SARA requirement to accurately assess relative risk to human health and the environment, to the maximum extent feasible. In the revised HRS, sensitive environments would include lands and waters that have been legally designated as protected areas by either the Federal government or state governments, as well as areas that have been identified by the Nature Conservancy's National Heritage Program. (See section V C 6.)

7. Onsite Exposure Pathway

The direct contact portion of the current HRS calculates the potential for direct exposure to hazardous substances in a way that essentially parallels the surface water, ground water, and air pathways; however, the calculation is not included in the score used to determine a site's eligibility for the NPL. Currently, the direct contact pathway could be used to determine whether removal action is required at a site. An analysis of decisions on remedial actions indicated that some significant risks from direct contact may not have been completely addressed by removal actions and should be of concern in determining priorities for remedial action. To ensure that the potential for such contact is factored into the HRS score, EPA is proposing to incorporate exposure to onsite wastes and contaminated soils into the HRS migration score by adding a separate pathway. The onsite exposure pathway would be included in the HRS score to better respond to CERCLA's original mandate to take into account the potential for direct human contact in setting priorities, as well as to respond to the requirement in SARA to accurately assess relative risk to the maximum extent feasible.

The proposed onsite exposure pathway would separately assess two populations, those people who live or attend school or day care on the contaminated site and those who live nearby and have access to the site. Resident children under seven would be considered the high risk population and would be weighted more heavily than adults because of their greater likelihood of ingesting onsite contaminants. (See section V D 4.)

8. Surface Water

In the current HRS, the surface water pathway is primarily concerned with the potential contamination of drinking water and with the population that could be affected by this contamination. A lesser weight is given to the impact of contaminants on sensitive environments in surface water. As required by SARA, EPA has considered other targets and is proposing to evaluate separately the potential contamination of the human food chain (based on fishery contamination) and recreational exposures to contaminated surface water. Sensitive environments would also be assessed separately. In addition, new factors to assess flood potential would be incorporated into the likelihood of release factor category. The factors used to assess route characteristics in the current HRS would be replaced by a new set of factors that better assess overland release potential. (See section V D 2.)

9. Air

The HRS currently evaluates the air pathway solely on the basis of site monitoring data; if no release of contaminants has been documented at the site, the air pathway part of the HRS is assigned a score of zero. In contrast, for the surface water and ground water pathways, the potential for a release to occur is considered where no observed release has been documented.

CERCLA section 105(a)(8)(A), as amended by SARA, specifies that EPA should consider potential releases to the ambient air in revising the HRS. Accordingly, the proposal described in Section V D 3 includes a method to assess potential air releases.

C. Revisions Affecting Multiple Pathways

This section discusses in detail those issues that affect more than one pathway. Although some of these issues were covered in the general discussion in the major revisions section, this discussion reviews these cross-cutting issues in more detail and describes the options EPA considered to resolve these issues. Because the proposed changes are similar in all the pathways affected, to prevent repetition, the specific revisions for each pathway are discussed in this section rather than in the individual pathway discussions in section V D. For most of these issues, detailed descriptions of the options reviewed and the reasons for EPA's choice can be found in the Technical Support Document, available in the Superfund docket. Other related documents and tables for determining some factor values are also available in the Superfund docket.

1. Structure

The proposed HRS would retain the general structure of the current HRS, as described in section II; that is, the structure of the revised HRS would continue to be based on evaluating the relative risk of sites through the use of factors, factor categories, and pathways to obtain a final site migration score.

This structure was retained after a careful evaluation of possible alternative structures to the existing HRS, including alternatives to the entire structure, to factor categories, and to individual factors. During this process, EPA reviewed over 30 available site evaluation systems and over 55 chemical ranking systems, including several systems developed expressly for ranking hazardous waste sites.

Evaluation of Overall Site Migration Score. During the course of this evaluation, EPA considered several methods for revising the way in which pathway scores are combined to calculate the overall HRS site score. EPA evaluated the possibility of adding the pathway scores, but found that with the proposed structure, this approach tends to discount the effects of risks involving only one pathway. The results of testing a system that sums pathway scores are consistent with these findings. Other options considered included selecting the single highest pathway score, using a root-mean-square approach for the two highest pathways, and using the root-mean-square approach for the three highest pathways. The Agency believes, however, that using the root-mean-square approach for all pathways in the revised HRS most appropriately considers the risk through all four pathways, without discounting risks involving only one pathway. Thus, the structure for combining pathway scores into a single site score is the same in both the current HRS and the proposed revisions to the HRS.

Evaluation of Pathways. The major changes to the pathways of the existing HRS are: (1) Elimination of the direct contact route; (2) incorporation of an onsite exposure pathway in the calculation of the total HRS site score; (3) elimination of the fire and explosion route; (4) modification of the surface water pathway; and (5) addition of a potential to release calculation to the air pathway.

For the onsite exposure pathway, EPA is proposing that the maximum score for the entire pathway be equal to the maximum score that could be assigned to either the resident or nearby population (proposed rule, section 5.0). EPA concluded that exposures to either group can represent a reasonable worst case risk and that this case should be reflected in the final migration score.

Four threat categories have been incorporated in the surface water pathway: Drinking water, human food chain, recreational, and environmental. Each of these threats is evaluated, structurally, in a manner consistent with surface water threats in the existing HRS. The four threat scores are added to form a total pathway score.

Evaluation of Factor Categories. In the current HRS, the value for the targets factor category in a pathway is the sum of individual factor values. The maximum factor category value can be obtained only if every factor is assigned its maximum factor value. This means that under the current HRS, a site significantly affecting 10,000 people would not receive a maximum score for the surface water pathway unless sensitive environments are also given a maximum value. Similarly, a site would not receive a maximum score for the air pathway if no one lives within a quarter mile of the site and, for the ground water pathway, a site would not receive a maximum score if there were no intakes or wells within 2,000 feet of hazardous substances.

The proposed rule would modify the method used to add target factor values so that some sites that do not meet the criteria for the maximum value for each target factor could still receive the maximum score for the overall target category. The sum of the available points for each type of exposure would be greater than the number of points allowed for the factor category. Under this approach it is possible to allocate a significant number of points for sensitive environments without reducing the importance of human health risks. One effect of this revised scoring system would be to condense scores at the upper end of the scale and more accurately assess relative risks elsewhere.

As is the case in the current HRS, all factor categories in the revised HRS have the same relative weight. That is, the maximum value for the waste characteristics category has the same weight as the maximum value for the targets category, and each of those has the same weight in the air pathway as in the ground water pathway. This is true despite different factor category values because the values are multiplied and normalized.

Evaluation of Factors. EPA is proposing structural changes in the way some individual factors are evaluated and in the relative scoring of factors within the targets factor category. To put this in context, the relationship of factors within categories must be understood. The relative importance of factors within different factor categories cannot be compared by their maximum factor values alone. Rather, their relative importance depends on the maximum percentage of their category they can account for; e.g., a factor with a maximum value of 50 contributes more to its category if the category maximum is 100 than if it is 200. Within the same factor category in a single pathway, the relative importance of factors is comparable based on their maximum values. In other words, in the surface water pathway the relative importance of drinking water population versus surface water use can be compared based on their maximum factor values. However, the relative importance of drinking water population in surface water versus ground water cannot be compared based on their factor values; their relative importance can only be compared based on the percentage their maximum value contributes to the maximum value of their factor category.

In the current HRS, factors are weighted by assigning a factor value and then applying a specified multiplier. The revised HRS would eliminate the explicit weighting by use of a multiplier and would incorporate a measure of relative importance of the factor to the factor category through the factor values themselves. To assign relative values among factors within factor categories for this proposed revision, EPA combined the results of model testing programs, a review of site ranking experience, and the results of analytical models used to model fate and transport of hazardous substances. In evaluating these data, EPA used two primary considerations for assigning the appropriate value to a given factor: (1) The relative importance of the factor as an indicator of risk and (2) the expected accuracy with which the factor can be measured or estimated based on site inspection data.

Potential Revisions Under Consideration. The Agency is still considering a variety of revisions to the algorithm and factor scales in the revised HRS.

The EPA Science Advisory Board, in addition to its review of specific issues identified by EPA, offered ideas regarding revisions to the algorithm used to calculate the current HRS score and the factor scales. The Board suggested that the Agency assess the current HRS algorithm to determine if changes in the algorithm could provide increased accuracy without increasing data collection costs.

Specifically, the Science Advisory Board suggested that the current HRS algorithm be revised to more closely resemble a quantitative risk assessment, with simplifications made to account for the difficulties of data collection. The Board also suggested that the factor category scales be revised so that the logarithm of the actual number for a factor becomes the factor value. Factor values might then be summed to develop pathway scores.

Another change in the algorithm could include moving the waste quantity factor from the waste characteristics category to the likelihood of release category. Such a move would increase the importance of toxicity and mobility/persistence factors because these would be the only factors remaining in the waste characteristics category. The change might also provide better discrimination among sites based on likelihood of release.

Another change in the structure might involve removing the maximum values from some factors (e.g., waste quantity or population) or from all factors. Scores would not be normalized to a 100 point scale under this approach and there would be no maximum possible score. In addition, EPA may change specific values for certain factors (and/or factor categories) to better reflect their relative importance.

EPA is planning to evaluate and possibly test such changes in the algorithm prior to promulgating a revised HRS. Commenters should consider these and other possible revisions to the algorithm.

2. Toxicity

Toxicity, a factor in the waste characteristics category for all HRS pathways, is intended to represent the relative potential of a substance to cause adverse health effects. The toxicity factor does not provide an absolute assessment of toxicity; each substance is assigned a value based on its relative toxicity, and that value is used to determine the relative toxic potential of substances at sites.

The current HRS approach to scoring toxicity is based on the National Fire Protection Association (NFPA) rating scheme and the toxicity ratings developed by N.I. Sax. Using one of these ratings, both of which place primary emphasis on the acute toxicity of a substance, the HRS assigns a toxicity factor value from 0 to 3. Only the single highest scoring substance available for release in a pathway is used in assigning a value to the toxicity factor for that pathway.

Various rulemakings on the NCP and NPL, the subsequent applications of the HRS to uncontrolled hazardous waste sites, and EPA's request for comments in the ANPRM have raised a number of issues concerning the current method of assessing toxicity. In particular, commenters have questioned whether chronic toxicity and carcinogenic effects are adequately addressed.

As a first step to revising the HRS toxicity factor, EPA reviewed over 55 chemical ranking systems, as well as the toxicity components of over 30 site ranking systems. EPA then evaluated in more detail a number of methods to characterize and score toxicity, and presented several options to the Science Advisory Board, including an option based on Reportable Quantities (RQ); an option based on Reference Doses (RfDs) and Cancer Potency Factors; and an option using modified Acceptable Daily Intakes (ADI) and a modified weight-of-evidence approach. These options are discussed more fully in "Discussion of Options for Revising the Hazard Ranking System (HRS) Toxicity Factor" (ICF, Inc., May 1987), available in the Superfund docket.

EPA developed the RQ ranking system to aid in setting reportable quantities for hazardous substances as required by CERCLA; the system is described in detail in the following Federal Register notices and their supporting material: 50 FR 13456, April 4, 1985; 51 FR 34534, September 29, 1986; and 52 FR 8140, March 16, 1987. In the RQ ranking scheme, each CERCLA hazardous substance is assigned to one of five RQ categories. Each category corresponds to a weight, in pounds, above which releases must be reported. Under the option developed for using the RQ approach in the HRS, three toxicity types would be considered: chronic noncarcinogenic toxicity, carcinogenicity, and acute toxicity.

The RfD/Cancer Potency Factor option would use the two quantitative toxicity parameters for chronic toxicity generally used by EPA in site-specific risk assessments: The RfD for noncarcinogenic effects and the Cancer Potency Factor combined with the qualitative weight-of-evidence for carcinogenicity; acute toxicity would not be considered under this option.

The Agency defines the RfD as an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The determination of the RfD requires scientific judgments as to the appropriate NOAEL (No Observed Adverse Effect Level), uncertainty factors, and modifying factors. Uncertainty factors are reductions in dose rate that are introduced to account for areas of scientific uncertainty such as species extrapolation and variability within the human population. General rules have evolved for determining the overall uncertainty factor to use with various data sets. However, the application of these rules in a particular instance needs to be examined on a case-by-case basis, exercising scientific judgment as to the quality and quantity of the available data. As the magnitude of the uncertainty factor increases, the estimate of the RfD becomes less precise. The RfD is viewed by most toxicologists as a "soft" estimate. While exposures higher than the RfD are associated with increased probability of adverse effects, that probability is not a certainty, since the calculation of a RfD includes consideration of sensitive subgroups. Similarly, while the RfD is seen as a level at which the probability of adverse effects is low, the absence of risk to all people cannot be assured at this level. RfDs, which undergo a formalized Agency-wide peer review and verification process, are derived from available chronic and subchronic toxicity studies.

Cancer Potency Factors, which are developed by EPA's Carcinogen Assessment Group and used to estimate potential carcinogenic risk, are derived from studies on experimental animals or from human epidemiologic data, if available. The weight-of-evidence is defined as the overall strength of the data indicating potential carcinogenicity, based on an evaluation of all relevant studies and the nature and type of responses. Methods for estimating Cancer Potency Factors and evaluating weight-of-evidence are both described in more detail in EPA's Guidelines for Carcinogenic Risk Assessment (51 FR 33992, September 24, 1986).

The modified ADI/modified weight-of-evidence option included three human toxicity types: carcinogenicity, mutagenicity, and teratogenicity (CMT) considered as a group; chronic, non-CMT toxicity; and acute toxicity. All substances would be scored for all three types of toxicity. The modified ADI method for assessing chronic noncarcinogenic toxicity is similar to the RfD method, but the ADI values derived are not subject to Agency-wide peer review and can be based on a wider range of toxicity data (e.g., acute data) than can RfDs.

The Science Advisory Board indicated that all three options that EPA presented seem much better than the Sax rating method and recommended that Sax be replaced. The three options use essentially the same data bases for toxicity, the Board stated, although the data are processed differently. The Board preferred the RfD option for assessing chronic noncancer toxicity.

Based on the Board review and input from the EPA work group, EPA is proposing a scoring method that combines elements of several of the options originally presented to the Board. This combined approach would be based on three toxicity types: carcinogenicity, chronic noncarcinogenic toxicity, and acute toxicity. To evaluate the potential carcinogenicity of substances, the revised HRS would use Cancer Potency Factors combined with the qualitative weight-of-evidence. Where Cancer Potency Factors are not available, ED_{10}s, (i.e., dose at which a 10 percent response is observed) developed to assess carcinogenicity for setting RQs, would be converted to an equivalent scale and used for scoring.

For chronic noncarcinogenic toxicity, the revised HRS would use a method based on verified RfDs because they represent EPA's best scientific data and judgment regarding the potential noncarcinogenic effects of substances. RfDs are currently the most widely used values for evaluating chronic noncarcinogenic toxicity in EPA risk assessments. Acute toxicity scoring would be based on the LD_{50} or LC_{50} of a substance, or the LD_{10} or LC_{10} if LD_{50} and LC_{50} are not available.

In scoring toxicity using the revised HRS, separate toxicity scores would be developed for each HRS pathway, based on the substances relevant to that pathway. Within a pathway, the relevant hazardous substances would be identified—those associated with an actual or potential release to ground water, surface water, or air, or, for the onsite pathway, those associated with onsite exposure potential. For each substance identified, the toxicity rating would be determined using the methodology in the proposed rule (section 2.2.1.1) or a reference table based on that methodology (an example is available in the Docket: See "Example Reference Table for Toxicity and Other Substance-Specific Values", Versar, November, 1988).

Toxicity ratings for individual substances would be integer values on a scale of 0 to 5, with 5 being the most toxic and 0 representing insufficient information to score. If adequate toxicity data are available, each substance would receive three subscores—one for acute toxicity, one for chronic noncarcinogenic toxicity, and one would be the highest subscore. The rating scales developed for the revised HRS give less weight to acute toxicity relative to chronic toxicity because remedial actions are almost always in response to concerns over exposures associated with potential carcinogenicity or chronic toxicity (proposed rule, section 2.2.1.1).

Asbestos and radionuclides are classified as human carcinogens (the highest weight-of-evidence category), but their cancer potency values are not expressed in units directly comparable to most other substances. Therefore, asbestos and radionuclides cannot be evaluated and scored using the proposed system. For purposes of HRS scoring, asbestos and radionuclides would be assigned a 5, the highest toxicity value for carcinogens.

A default value of 3 would be used for a toxicity factor value when appropriate toxicity data for scoring does not exist for all hazardous substances relevant to that pathway or threat, a situation that EPA anticipates would be very rare. EPA solicits comment on this default value, which is the midpoint of the scoring range and approximate median of the substances scored to date by EPA.

The proposed rating scales for the three toxicity types (carcinogenicity, chronic noncarcinogenic toxicity, and acute toxicity) are provided in the proposed rule. A more thorough discussion of the development of these rating scales and the overall toxicity factor is provided in the Technical Support Document, available in the Superfund docket. EPA solicits comment on these rating scales.

The proposed toxicity scoring methodology would use readily available, high quality toxicity data, rely on a data base that is large enough to provide a score for all sites, and be consistent with existing EPA procedures. For the ground water, surface water, and air pathways, the overall toxicity value for each hazardous substance would be combined with its corresponding mobility or persistence value in a matrix to assign a toxicity/mobility or toxicity/persistence value. The highest toxicity/mobility or toxicity/persistence value relevant to a pathway or threat would become the factor value.

A hazardous substance's potential ecosystem toxicity, which would be considered in the surface water pathway, would be evaluated using the following hierarchy of data: EPA chronic water quality criteria, EPA acute water quality criteria, or the lowest LC_{50} value for the substance (proposed rule, section 4.4.2.1.1). (See section V D 2.)

Past commenters have questioned the use of the single highest scoring hazardous substance in each pathway to score toxicity in the current HRS. EPA reviewed a number of options related to the number of hazardous substances scored for a site including (1) retaining the current method of using the highest scoring hazardous substance in each pathway to score toxicity; (2) basing the toxicity value on all hazardous substances known to be at the site; (3) basing the toxicity value on a fixed percentage or number of hazardous substances known to be present at the site; and (4) giving extra points to sites with a large number of hazardous substances. These options are more fully discussed in the Technical Support Document and in the paper presented to the Science Advisory Board: "Discussion of Options for Revising the Hazard Ranking System (HRS) Toxicity Factor" (ICF, Inc., May 1987). Both documents are available in the Superfund docket.

EPA is proposing to retain the current method of scoring the toxicity factor based on the single highest scoring hazardous substance applicable in each pathway or threat because the Agency believes that the single most hazardous substance present in a pathway or threat generally provides an adequate screening level evaluation of relative hazards of the pathways, particularly when coupled with mobility or persistence, as applicable. The sampling conducted during a site inspection probably would not provide sufficient information on the relative quantities or concentrations of hazardous substances at a site. EPA believes that the proposed method will ensure that any site where highly toxic substances are present will receive a high toxicity score. EPA solicits comments on the use of a single hazardous substance per pathway or threat to score toxicity and on the alternatives discussed above.

3. Hazardous Waste Quantity

In the current HRS, hazardous waste quantity is the amount of waste containing hazardous substances (as defined in CERCLA Section 101) present at a site, excluding any wastes that are contained such that they cannot migrate. Values for the hazardous waste quantity factor are combined with values for the toxicity/persistence factor (in the ground water and surface water pathways) or toxicity (in the air pathway) to produce the final waste characteristics category score. If it is not possible to make any determination of the hazardous waste quantity at a site and it is known that hazardous substances are in the waste, a default value of one for hazardous waste quantity is assigned (the range is 0 to 8). EPA has found that about 20 percent of all sites studied are assigned the default value for waste quantity, signifying the absence of data. This finding indicates that even hazardous waste quantity, which is generally easier to estimate than hazardous substance concentration, is still difficult to estimate.

In preparing revisions to the HRS, EPA considered a number of alternatives to the current HRS method of calculating hazardous waste quantity and presented two to the Science Advisory Board: one would require use of hazardous substance concentration data to estimate waste quantity at all sites and the other would be a tiered approach that would use hazardous constituent concentration data, waste quantity, volume, or surface area of the source, in that order. These options are discussed in detail in a paper prepared for review by the Science Advisory Board: "The Superfund Hazard Ranking System (HRS): Feasibility of Using Concentration Data in a Revised HRS" (ICF, Inc., July 1987), and available in the Superfund docket.

In general, having adequate hazardous substance concentration data might enable sites to be evaluated more accurately. However, the cost of obtaining these data at all sites would be substantial. If accurate records of wastes were available and if the concentration of contaminants in the wastes were known, it would be possible to calculate the amounts of hazardous constituents. EPA's experience, however, has been that such waste disposal records are frequently not available at Superfund sites, and when they are available, they are often incomplete and insufficiently detailed to estimate constituent quantities.

The comprehensive site sampling needed to estimate hazardous substance concentrations and amounts with known accuracy would not be feasible on a routine basis, given the resources available and the statutory requirement to expeditiously evaluate sites. Wastes at hazardous waste sites are typically heterogeneous. Depending on the nature and history of the site, very great differences in waste composition may occur over just a few meters, with different sets of constituents appearing and with levels varying by orders of magnitude. Attempting to determine a single representative concentration of a constituent or to estimate the total amount of all hazardous substances would be very difficult at most sites. Temporal variability also diminishes the relevance of any estimate of concentrations. Data from a single sampling provide only a "snapshot" of current conditions. Mobile substances may have already moved into environmental media and only the least mobile may remain at significant levels at the source. Thus, substance concentration data taken only from waste source materials may result in underestimates of waste mass available for transport.

In evaluating alternatives for developing a hazardous waste quantity value, the Agency recognized that, at some sites, sufficient data may be available to determine the concentration of hazardous constituents. At most sites, however, obtaining these data would be difficult and costly. Thus, the Agency is proposing the tiered approach to scoring hazardous waste quantity in the revised HRS (proposed rule, section 2.2.2). As the Science Advisory Board stated, the tiered system "would encourage the use of concentration data, but would also provide the flexibility to use indirect estimates of a constituent's mass when direct measurements of concentration are not available."

The tiered approach involves the development of a single hazardous waste quantity value for each pathway at a site. This factor would be based, in order of preference, on three factors: (1) Hazardous constitutent quantity, (2) site wastestream quantity, (3) site disposal capacity. The hazardous constituent quantity factor represents the actual quantity of hazardous substances deposited on the site. The wastestream quantity factor represents the quantity of hazardous substances potentially deposited on the site based on available information about the nature and quantity of wastes that were deposited on the site. The site disposal capacity factor represents the quantity of hazardous substances potentially deposited on the site based on the available information about the quantity of hazardous substances the site could have received as indicated by the sizes of the sources identified on the site. These three factors are in turn evaluated based on some or all of the following waste quantity measures depending on the quality and completeness of supporting data: (1) The quantity of hazardous substances deposited, (2) the quantity of waste deposited that contain hazardous substances, (3) source volume, (4) source area. The actual approach used in evaluating the hazardous waste quantity factor in terms of the three subsidiary factors and the four waste quantity measures is complex. The approach reflects judgments as to the appropriateness of employing each measure and factor under varying site-specific conditions of data completeness and quality. The hazardous waste quantity factor evaluation is presented in section 2.2.2 of the proposed rule; the basis for the approach is presented in section 2.4 of the Technical Support Document.

EPA has concluded that this tiered approach will make the hazardous waste quantity factor more accurate by using the best available data without imposing significant new costs or demands on resources. The tiered approach would also allow the scoring of the hazardous waste quantity factor at many more sites. In addition, the flexibility of the approach would accommodate a wide variety of data gathering strategies; efforts could be varied so that more resources were devoted to complex sites or to sites suspected of presenting severe health risks.

The proposed revision to the hazardous waste quantity factor is also responsive to the SARA requirement (CERCLA section 125, added by SARA) to consider the quantity, toxicity, concentration of hazardous substances at facilities that contain substantial volumes of waste described in section 3001 (b)(3)(A)(i) of RCRA. The wastes include fly ash wastes and other wastes generated from combustion of coal or other fossil fuels. For a further discussion of these wastes, see section V E.

The hazardous waste quantity factor in the onsite pathway would be calculated differently (proposed rule, section 5.2.1.1). In the other pathways, the hazardous waste quantity factor reflects the magnitude and duration of potential releases. In the onsite pathway, the question is not the release and migration of the hazardous substances, but rather the potential for direct contact with the contaminated area. For this reason, the hazardous quantity factor for the onsite pathway would be based primarily on the total surface area of the known sources at the site. If the original source of the contamination is unknown, the waste quantity factor would be based on the area of soil contaminated at levels significantly above background.

4. Observed Release/Concentration of Hazardous Substances in the Environment

The current HRS scores an observed release if the measured concentration of the hazardous substance is significantly above the background level and if that concentration can reasonably be attributed to the site. The current HRS gives little consideration to the specific concentrations of hazardous substances in the environment nor does it consider the relationship between the concentrations and health standards.

Some commenters to previous rulemakings have stated that only concentrations exceeding health-based benchmarks should be used in determining whether an observed release has occurred. Other commenters have stated that if a substance is detected at a level above a health-based benchmark it should receive a higher score than if the benchmark is not exceeded. Incorporating an assessment of environmental concentrations into the HRS would, in the opinion of some commenters, more accurately define the nature and degree of potential risk.

EPA evaluated several approaches for directly using environmental concentration data to assess potential risk as part of the HRS. One approach would have based the observed release value on the highest measured concentrations of hazardous substances in the environment, using this level as a measure of potential exposure. The Agency, however, concluded that site inspection personnel would generally be unable to identify areas where maximum contamination could be found. The temporal and spatial variance of contaminants makes it difficult to identify the most contaminated location on a site during a limited investigation. Furthermore, the maximum concentrations may not yet have occurred at the time of the sampling.

Another approach studied was the use of simple fate and transport models to predict concentrations at the receptor. Fate and transport models combine movement in the transport medium (e.g., water) with the fate of the substance in the medium. For example, one substance may immediately dissolve in water and persist indefinitely while another may precipitate out of water and biodegrade within hours. However, using fate and transport models in this manner would require the accurate characterization of the source of contaminants and the media through which the contaminants must travel. Given the limited scope of the site inspection, it would be difficult to characterize the source and the media adequately enough to predict concentration levels accurately.

Knowledge of the concentrations and release rates of constituents at the source is essential to predicting levels at more distant points. As discussed in the section on waste quantity, EPA has concluded that at most sites it cannot dependably characterize the constituents of a waste source during the site inspection. Therefore, the Agency is not proposing to include a factor that would be scaled according to measured concentrations in releases.

EPA is retaining the current approach to scoring observed releases, but is proposing to specify better, more precisely defined criteria for determining when a release is significantly above background (proposed rule, sections 2.1.1, 3.1.1, 4.1.1.1, and 5.0.1). The proposed criteria for significant releases are as follows:

- If no background concentration is detected, a significant release is three or more times the detection limit.
- If the background concentration is greater than or equal to the detection limit but less than two times that limit, a significant release is greater than or equal to three times the applicable background concentration or greater than or equal to four times the detection limit, whichever is less.
- If the background concentration is greater than or equal to twice the detection limit, a significant release is greater than or equal to twice the applicable background concentration.

The detection limit could be the minimum of the EPA contract-required quantitation or detection limit specified in EPA's Contract Laboratory Program, the method detection limit for a given analytical procedure or instrument (or in the case of real time field instruments, the detection limit of the instrument used in the field), or the actual detection limit achieved by the laboratory for the set of samples in question. Negative sampling results would not necessarily form the basis for refuting an observed release that is based on a separate valid sampling and analysis because releases may be episodic in nature.

As mentioned above, commenters have suggested that a release at a concentration below a known health-based benchmark should not be considered significantly above background. When the current HRS was proposed, EPA explained that finding an observed release indicates that the likelihood of a release is 100 percent. The release of some substances into the environment is a good indication that substances from the site can escape and increases the likelihood of subsequent releases. Data on frequency and quantity of actual releases would require long-term monitoring, which is not feasible at the site inspection stage. In addition, the results of limited sampling may not be representative; higher concentrations than those detected when the sampling was done may exist or may occur at other times. EPA has concluded that the proposed criteria provide a reasonable definition of an observed release.

EPA has also concluded that limited environmental concentration data cannot be used to demonstrate that concentrations will remain below health-based benchmarks. Such an approach would most likely lead to the omission of some high risk sites from the NPL.

EPA is, however, proposing to use environmental concentration data in evaluating and scoring target populations as discussed below in section V C 5. This scoring method would weight any population actually exposed to documented contamination more heavily than those potentially exposed.

5. Use of Health-Based Benchmarks in Evaluating Target Populations

In assessing target populations in the current HRS, people actually exposed to contamination do not count more than people potentially exposed, nor is the level of exposure considered. Under Section 118, added by SARA, EPA is required to give high priority to sites that have led to the closing of drinking water wells or the contamination of principal drinking water supplies. To respond to this mandate, EPA considered an option of weighting closed wells higher than operating wells. Such a factor, however, would create other problems, such as how to weight contaminated wells that should be closed, but are not, and wells that may be closed in the future. Instead of including closed wells, EPA decided to give greater weight to known exposures using two other mechanisms. First, as discussed in section V C 9, factors reflecting risks to the MEI would be added to the revised HRS. Second, populations whose wells or intakes show documented drinking water contamination would receive higher weightings than those of populations only potentially exposed.

To improve the accuracy of the scoring system by giving increased weighting to populations based on their actual exposure, the Agency is proposing to expand the evaluation of exposed populations in both the ground water and surface water pathways to include weighting factors based on health-based benchmarks.

However, even though the Agency is attempting to consider concentrations of contaminants in drinking water in the proposed revisions to the HRS, it is important to remember that these data are from limited site investigations, and are used, in the HRS, simply to make initial screening decisions. Health-based benchmarks and cancer risk numbers are not used in the HRS to identify levels of risk from drinking contaminated water, but rather to provide added weight to populations actually exposed to site contaminants in determining pathway scores.

For the ground water and surface water pathways, the health-based benchmarks that EPA is proposing to use would be the Federal primary drinking water standards (maximum contaminant levels or MCLs) proposed or promulgated under the Safe Drinking Water Act (SDWA). Where no MCL has been proposed or finalized for a substance, the health-based benchmark for noncarcinogens would be the proposed maximum contaminant level goal (MCLG) [3]; for carcinogens or potential carcinogens, where the proposed MCLG has been set at zero, a concentration corresponding to specified individual lifetime cancer risks would be used as the health-based benchmarks.

MCLGs are health-based levels at which no adverse health effects would arise with a margin of safety. They are not enforceable under the SDWA. MCLs are enforceable limits under the SDWA and are set as close to the MCLGs as possible, taking several factors into account, including the effectiveness of treatment by the best available

[3] This proposed rule discusses "proposed" MCLGs only because MCLGs and MCLs will be finalized concurrently and, for the purposes of the proposed HRS, the final MCL will supercede the final MCLG.

technologies, detectability, and practical quantitation limits. For known or probable human carcinogens, MCLGs are set at zero. MCLs for carcinogens will never be set at zero, but are expected to be set so that the risk of drinking water at the MCL falls within the range of 10^{-4} to 10^{-7} individual lifetime cancer risk. These cancer risk numbers assume that the individual is a 70 kg (150 lb) person consuming 2 liters of water a day for 70 years.

Using these health-based benchmarks in assessing drinking water threats, the target population factor in the surface water and ground water pathways would be divided into four population groups:

(1) Level 1: The population drinking from wells or intakes that are contaminated with hazardous substances at concentrations greater than:

Proposed or final MCLs;

Proposed MCLGs (for noncarcinogens with no proposed or final MCL); or

A 10^{-4} individual lifetime cancer risk (for carcinogens and potential carcinogens with no proposed or final MCL).

The population drinking water at these concentrations would be weighted 100 times as much as the population drinking water at Level 3 concentrations.

(2) Level 2: The population drinking water from wells or intakes that are contaminated with hazardous substances at concentrations significantly above background, but within the following ranges:

Greater than 1/1000 of the proposed or final MCL but less than or equal to the proposed or final MCL;

Greater than 1/1000 of the proposed MCLG but less than or equal to the proposed MCLG (for noncarcinogens with no proposed or final MCL); or

Greater than 10^{-7} but less than or equal to 10^{-4} individual lifetime cancer risk (for carcinogens or potential carcinogens with no proposed or final MCL).

The population drinking water at these concentrations would be weighted 10 times as much as the population drinking water at Level 3 concentrations. Level 2 would also include any hazardous substance that shows up in a drinking water well or intake at concentrations that are significantly above background, but has no proposed or final MCL or MCLG, or cancer risk number.

(3) Level 3: The population drinking from wells or intakes that are contaminated with hazardous substances at concentrations significantly above background, but less than or equal to:

1/1000 of the proposed or final MCL;

1/1000 of the proposed MCLG (for noncarcinogens with no proposed or final MCL); or

10^{-7} individual lifetime cancer risk (for carcinogens with no proposed or final MCL).

These populations would not be given any additional weight.

(4) Potential contamination: The population whose wells or intakes are not known to be contaminated, but the ground water or surface water is already contaminated or has the potential to be contaminated. Only populations who use drinking water from within the target distance limit would be counted as potentially exposed. This potentially exposed population would be distance-weighted in the ground water pathway and dilution-weighted in the surface water pathway.

In all groups, the population counted would be the people whose drinking water is drawn from wells or intakes within the target distance limit; the populations would not have to live or work within the target distance limit.

The weighting of these groups was chosen to give high priority to sites where exposures to contamination attributable to the site were known to be occurring. Where Level I concentrations exist, only 200 people would need to be exposed to the contamination for the population factor to be assigned the maximum score.

The specific health-based benchmarks used in determining this factor were chosen to be consistent with other Agency programs. The range of individual lifetime cancer risks of between 10^{-4} and 10^{-7} was chosen to be consistent with the approach currently taken by the Superfund program in determining cleanup levels. For noncarcinogens, a three order of magnitude range of concentrations would be used in the Level 2 concentrations group to be more consistent with the way carcinogens are treated in Level 2. EPA has chosen to count populations drinking from wells or intakes contaminated at concentrations significantly above background but at concentrations less than or equal to the MCL or MCLG (or with an individual lifetime cancer risk of less than or equal to 10^{-7}) because some contamination, albeit low, has been detected, and may be the leading edge of a contaminant plume. Moreover, the concentration found in a well or intake during a site inspection is only a one-time picture of the contamination. During a remedial investigation/feasibility study, the Agency does extensive sampling to determine the extent of the contamination at a site.

MCLs have been developed for relatively few hazardous substances. More hazardous substances have MCLGs and cancer risk numbers. However, of the hundreds of hazardous substances found at Superfund sites, most currently have no health-based benchmarks. To be protective, the Agency has decided that populations exposed to hazardous substances with no health-based benchmarks should be included in Level 2 if the substances are found in the drinking water at concentrations significantly above background and are attributable to the site. The Agency solicits comments on this approach.

If more than one substance is present in the drinking water at levels significantly above background but not above the MCL, MCLG, or 10^{-4} individual lifetime cancer risk, for each such substance, the percentage of its health-based benchmark at which it is present would be calculated. If the total sum of the percentages exceeds 100, the concentration in the drinking water would be considered Level 1 concentrations (proposed rule, sections 3.3.2.1. and 4.1.3.2.1) and the population using that contaminated water would be weighted as Level 1 concentrations. If the sum of the percentages is greater than 0.1 and less than or equal to 100, the population using that contaminated water would be weighted as Level 2 concentrations. Finally, if the sum of the percentages is less than or equal to 0.1, the population using that contaminated water would be considered as a Level 3 population.

This proposal for summing benchmark ratios would give higher scores to those sites where several hazardous substances are found in the drinking water at concentrations near their benchmarks. The Agency analyzed other methods for achieving this, including evaluating hazardous substances individually against their benchmarks and basing the determination of target population weighting levels on the single substance found in the drinking water with the highest benchmark ratio. The Agency would like comment on the appropriateness of both these approaches to scoring multiple substances detected in drinking water, as well as any alternative approaches.

The Agency solicits comment on the proposed population groups, on the weightings assigned to these groups, and on the health-based benchmarks used to define these groups. In addition, the Agency solicits comment on the risk range (10^{-4} to 10^{-7}) used to define the proposed levels. Specifically, EPA would like comment on whether a risk range should be used in the context of the HRS and, if so, whether it should be 10^{-4} to 10^{-7} (as is used in the proposed rule) or 10^{-4} to 10^{-6}.

EPA is proposing the system described above for considering health-based benchmarks in the HRS; however, the Agency has evaluated a variety of alternatives. Three are discussed in this preamble. (See the Technical Support Document, available in the Superfund docket, for further detail.)

Alternative I is a three-tiered system that would use only proposed or final MCLs as the health-based benchmarks. The populations drinking water contaminated with hazardous substances at concentrations that exceed a proposed or final MCL would be included in the first tier, which would be weighted 100 times as much as the potentially exposed population. The population in the second tier would include those people drinking water at concentrations at or below a proposed or final MCL, but significantly above background, and those people drinking water containing hazardous substances for which proposed or final MCLs do not exist; this population would be weighted 10 times as much as the potentially exposed population. The third tier would include those people potentially exposed to contamination; this population would be distance- or dilution-weighted.

Alternative I would be considerably simpler than the one proposed and would be based solely on proposed or final MCLs, health-based benchmarks developed by the Agency for use in evaluating drinking water contamination, rather than MCLGs or cancer risk numbers. However, since MCLs have been developed for only a handful of chemicals, the Agency believes this approach may not accurately assess the relative degree of hazard and therefore does not discriminate among sites as well as the proposed approach.

Alternative 2 would weight target populations using benchmarks similar to those used in the proposed option—MCLs, MCLGs, and cancer risk numbers. However, Alternative 2 contains three tiers instead of four, and uses a single cancer risk number of 10^{-6} rather than a risk range to delineate the different tiers. The target population would be divided into the following three tiers:

(1) Level 1: The population exposed to concentrations greater than the proposed or final MCLs, the proposed MCLGs (for noncarcinogens with no MCLs), or a 10^{-6} individual lifetime cancer risk (for carcinogens with no MCLs) would be weighted 100 times as much as the people potentially exposed.

(2) Level 2: The population exposed to concentrations less than or equal to the proposed or final MCLs, the proposed MCLGs (for noncarcinogens with no proposed or final MCL), or a 10^{-6} individual lifetime cancer risk (for carcinogens with no MCLs), but significantly above background, would be weighted 10 times as much as the people potentially exposed.

(3) Potential Contamination: The population whose wells or intakes are not known to be contaminated, but the ground water or surface water from which these wells draw is already contaminated or has the potential to be contaminated. This potentially exposed population would be distance-weighted in the ground water pathway and dilution-weighted in the surface water pathway.

In all groups, the people counted would be those whose drinking water is drawn from wells or intakes within the target distance limit; the people would not have to live or work within the target distance limit.

The evaluation of multiple substances under this alternative would be similar to the proposed approach, in that, for each substance the percent of its health-based benchmark at which it is present would be calculated. As in the proposed option, if the total sum of the percentages is greater than 100, the concentration would be considered to be above the benchmark and the populations exposed to the contaminated water would be weighted as Level 1 contamination. If the concentration is significantly above background but not above the health-based benchmarks, the people exposed to the contaminated water would be weighted as Level 2 contamination.

The weighting of the three groups was considered so that sites where exposures to contamination above health-based benchmarks were known to be occurring would be given high priority. This approach is simpler than the proposed approach, and may be appropriate given the limited data available at the site inspection stage, and the purpose of the HRS as a screening tool (rather than a risk assessment).

The third alternative would be identical to Alternative 2, except a 10^{-4} individual lifetime cancer risk level, instead of a 10^{-6} risk level, would be used to differentiate between Level 1 and Level 2 contamination.

The Agency requests comment on these alternative approaches to assessing actual drinking water exposures in the HRS.

EPA is not proposing at this time to incorporate health-based benchmarks for the air and onsite pathways due to a number of unresolved technical issues. These include selection of the point at which samples would be taken to demonstrate exposure, the length of the monitoring period, and interpretation of data in light of the extreme temporal and spatial variability of air releases. EPA is considering ways to evaluate observed human exposure in the air pathway and solicits comments on how these technical issues could be addressed. It should be noted that the onsite pathway would be evaluated only if there is documented contamination at the site. In addition, the varying exposure to the non-resident population would depend more on the frequency of contact than on the level of contamination. For this reason, the nearby population would be distance-weighted.

The surface water pathway would apply ecologically-based benchmarks to the sensitive environment targets factor as well (proposed rule, sections 4.4.3.1.1, 4.4.3.1.2, and 4.4.3.1.3). This would be similar to the health-based benchmark system in terms of the relative weights or groups, except that there would be three levels instead of four. The ecological benchmarks are based on ambient water quality criteria. In the human food chain subpathway and the recreation subpathway, actual observed contamination would also be weighted more heavily than potential contamination.

6. Consideration of Hazards to the Environment

CERCLA section 105 required EPA to create an NPL of at least 400 sites. At the time of enactment, EPA realized that thousands of sites posed potential public health and environmental threats. The Agency believed that, given the need to set priorities for the expenditure of limited monies, the HRS should place greater weight on sites that posed threats to public health rather than those that posed risks to the environment.

CERCLA section 105 mandated that EPA consider both threats to public health and to the environment when it developed the NPL. Although SARA did not specifically require EPA to take any particular action regarding threats to the environment, consideration of the impact that waste sites have on sensitive environments is emphasized in SARA's addition of section 105(c)(1), which requires the HRS "to the maximum extent feasible to accurately assess the relative risk to human health and the environment." EPA's experience with many potential Superfund sites suggests that a number of sites posing a serious threat to the environment are not scoring high enough to be placed on the NPL and addressed under CERCLA. Therefore, the Agency has determined that overall accuracy would be improved, in certain cases, by placing on the NPL sites that have significant impact on the environment, even when the sites pose less of a threat to human health.

Although the proposed HRS was designed to give greater weight to environmental impacts than the current

HRS, the scores related to the relative risks to human health would still be weighted more heavily than sensitive environments. If sensitive environments, but no people, are affected by a site, the score would not reach the maximum for the targets category. EPA does, however, intend to assign a sufficiently high value to sensitive environments so that the most serious environmental impacts in the absence of any public health risks would have scores above the NPL cutoff. EPA would like comments on the relative weightings of the two types of impacts.

EPA is proposing to modify several features of the current sensitive environment factors. In the current HRS, if more than one sensitive ecosystem exists within the target distance, only the one with the highest score is included. The proposed HRS would base the sensitive environment factor in the surface water and air pathways on the sum of the values for all appropriate ecosystems within the target distance, with each ecosystem generally weighted for distance or dilution (proposed rule, sections 2.3.4 and 4.4.3). This proposed change is intended to provide a more accurate assessment of the potential risk to sensitive environments.

The primary ecosystems considered in the current HRS are wetlands of greater than five acres and habitats of Federally designated endangered species. The land use factor in the air pathway also evaluates other ecosystems, such as wildlife reserves. The revised HRS expands significantly the list of sensitive environments to include those environments that are protected under Federal or State designations. The full list of the proposed sensitive environments is Table 2–18 of the proposed rule. These environments include marine sanctuaries, National Parks, designated Wilderness Areas, National Monuments, National Seashore Recreational Areas, and National or State Wildlife Refuges. The final item on the list covers particular areas, often relatively small in size, that are important to the maintenance of unique biotic communities. EPA wants to specify the particular communities in the final rule and requests comments on which such communities should be listed.

In revising the sensitive environments factor, the Agency evaluated several ecological ranking models that were either in use or were in the latter stages of development. From this work, and from comments received in response to the ANPRM, the Nature Conservancy's National Heritage Program was identified as having the potential to supplement the sensitive environments list in the revised HRS. When the National Heritage Program is used in conjunction with the expanded list, EPA will be able to identify not only sensitive environments that have been formally designated by State or Federal agencies, but also those environments that score high on the National Heritage Program's database, which ranks a site according to its rarity and vulnerability.

The proposed sensitive environments factors could be assigned values based on their inclusion on the list of protected areas or on their rating under the National Heritage Program (see Table 2–19 of the proposed rule). If the values assigned for the type of area and for its National Heritage Program ranking differ, the higher of the values would be used.

Sensitive environments considered in the air pathway would be distance-weighted so that those closest to the site would have higher values than those at increasing distances up to the target distance limit. In the surface water pathway, sensitive environments that have been subject to actual contamination would receive a score based on whether the contamination was above or not exceeding ecological benchmarks. Where no actual contamination has been documented, the scores assigned would be dilution-weighted. In the onsite pathway, only terrestrial sensitive environments with observed contamination would be considered since the exposure is presumed to be from direct contact with the hazardous substances, not from the migration of hazardous substances.

7. Consideration of Effects on the Human Food Chain

SARA (see CERCLA section 105(a)(8)(A), as amended) requires EPA to consider, in revising the HRS, the effects of hazardous waste sites on the human food chain. When EPA developed the current HRS, the Agency decided that it could not apportion human food chain effects according to population risks, but it did deal with the effects qualitatively in the land and water use factors. In addition, the risks to the human food chain from using potentially contaminated water for irrigation are reflected in the current procedure for estimating the target population; an additional 1.5 people per acre are added to the population total for each acre of irrigated food or forage crops.

In revising the HRS, EPA has determined that the most significant, measurable human food chain risks are those associated with the aquatic food chain. Therefore, in the HRS surface water pathway, EPA is proposing to evaluate the potential risk to the human food chain based on potential or observed contamination of aquatic food chain organisms. Details of the proposed method the Agency would use to incorporate human food chain effects in the scoring of surface water are discussed in the section on the surface water pathway (section V D 2).

The potential exists for some sites to adversely affect the human food chain via other pathways. These pathways would primarily affect the terrestrial food chain (deposited air pollutants migrating to the edible portion of plants, ground water or surface water used to water animals or irrigate crops). EPA considered ways to account for terrestrial food chain effects in the revised HRS. However, the Agency decided that because the terrestrial food chain was more complex and not as well understood as the aquatic food chain, it was impractical to include a detailed assessment in the HRS. Rather, points are assigned to the ground water and surface water use factors if the water is used for irrigation of commercial food or forage crops, for commercial livestock watering, or for commercial food preparation. In the ANPRM, EPA asked for comments on methods of incorporating human food chain effects into the HRS and is continuing to seek comments on whether food chain contamination by hazardous substances in air and soil should be included in scoring either the air or ground water pathway and if so, the basis for estimating human health risks from such food chain exposure.

8. Dilution/Distance Weighting of Targets

The current HRS directly weights the population factor by dilution/distance only in the air pathway. The ground water pathway combines the total population using water drawn from the area within the target distance limit in a matrix with distance to the nearest drinking water well. The surface water pathway uses a matrix to combine the distance to an intake and the population using that intake. The greater the distance, the lower the HRS value for any population category.

In reviewing ways to account for the greater risks to populations close to sites, EPA considered using analytical models that would require data such as wind speed and temperature in the air pathway to calculate the rate of dispersion for a particular substance at a specific site and data such as ground water flow direction and gradients and dispersion to calculate dilution for the ground water pathway. EPA decided, however, that the reliability of the results, given the limited data available from site inspections, was not great enough to consider using such models and equations for each site.

The revised HRS would use distance- and dilution-weighting factors in calculating the scores for certain populations and environments that are potentially exposed to contamination from sites. The weighting factors would reflect the diminishing risk as substances disperse or dilute and were generally developed using analytical models. For each prescribed distance (e.g., a quarter to a half mile from the site) or for the appropriate flow characteristics of the surface water, the potentially affected population in the area would be multiplied by a weighting factor. The target population would be the sum (subject to the maximum) of the distance or dilution weighted groups plus any populations exposed to documented contamination.

Although EPA did not design the revised HRS to be an analytical model, the Agency did use models to help develop the scales of values and weights for distance weighting. These models are more fully explained in the Technical Support Document, available in the Superfund docket. EPA concluded that this distance and dilution weighting approach uses the best elements of analytical models without requiring site-specific data and thus represents a significant increase in accuracy without a major increase in data collection costs. In reviewing the effects of air emissions on populations surrounding Superfund sites, the Science Advisory Board supported the weighting of population according to distance from a site.

The proposed distance weighting factors for ground water (proposed rule, sections 3.3.1 and 3.3.2) are derived from a three-dimensional fate and transport model that determines relative concentrations as a function of distance from a site. Those relative concentrations provide the basis for the weighting factors. An exception to the distance weighting would occur when the aquifer is a karst aquifer. (See section V D 1 and proposed rule, section 3.3.2 for a discussion of karst aquifers.)

The air pathway distance weighting factors are based on the effects of atmospheric diffusion and were calculated using a simple Gaussian plume model (proposed rule, sections 2.3.1 and 2.3.2). The surface water pathway would not use distance weighting, but would instead employ dilution weighting. The extent of the dilution would be considered a function of the flow characteristics of the water available for dilution (proposed rule, sections 4.1.3.1 and 4.1.3.2).

For the onsite pathway, EPA is proposing a distance weighting factor for the nearby population that lives within one mile travel distance of the area of contamination (proposed rule, section 5.2.3), but does not live where contamination is present. This factor would be set based on the relative frequency with which an individual could travel to the site, which, in turn, is assumed to be based on the distance between the person's residence and the site. EPA has not identified any studies that provide estimates of incursion rates into contaminated land areas or the relationships between frequency of incursions and distance from a site. EPA is proposing a factor based on distance and solicits comments on how frequency of incursion might be taken into account in the onsite pathway.

9. Population Risks and Risk to the Maximally Exposed Individual

Maximally exposed individuals (MEIs) are those individuals in the exposed population that are expected to be exposed to the highest ambient concentration (and thus receive the highest dose) of the hazardous substance in question. Population risk would be the effect on the exposed population over an extended period of time, usually assumed to be 70 years.

The current HRS incorporates both concepts in developing target population scores. For example, the total population is evaluated at distances around a site, and the population scores are either distance weighted (air) or combined in a matrix with distance to the nearest well (ground water) or distance to the intake (surface water).

Although the HRS was not designed to be a risk assessment, the Agency believed that an explicit factor based on potential MEI risks should be added to improve the overall assessment of potential risks to human health within the HRS and to make the revised HRS more consistent with general Agency risk assessment approaches. Usually, EPA evaluates both MEI risks and exposed populations as part of its risk assessments to provide a better overall indication of potential threats. Consequently, several proposed changes related to MEI and population risks are included in the revised HRS. Population scores would be weighted based on known or potential exposure to contaminants (see health-based benchmarks in section V C 5). Factors reflecting the risks to the MEI via the ground water, surface water, and air pathway would be included in the revised HRS.

For ground water, the MEI risk would be assessed through a factor based on the distance to the nearest well (proposed rule, section 3.3.1). This measure was chosen because it is likely that, all other things being equal, the well closest to the site would have the highest level of contamination. Since contamination usually decreases with distance, the farther the nearest well is from the site, the lower the assigned value would be, with three exceptions. First, if any well has documented contamination above health-based benchmarks attributable to the site, the MEI factor would be assigned the maximum value. Second, if the site overlies a karst aquifer, the MEI factor would be assigned the maximum value if any well draws drinking water from the karst aquifer within the target distance limit. This reflects the potentially shorter travel time within such aquifers. Third, different distance weighting factors would be applied to wells in karst and wells not in karst to reflect differences in dilution.

For the surface water pathway, the risk to the MEI from drinking water would be represented by a value based on the flow characteristics of the body of water at the nearest intake (proposed rule, section 4.1.3.1). This method was selected because the flow characteristics of surface water are a major factor in determining the concentration of contaminants;, i.e., the greater the volume of water, the greater the dilution, and therefore the lower the potential risk. The assigned value for the MEI factor would be a multiple of the dilution weighting factors for the different flow characteristics of surface water. If any drinking water intake has documented contamination above health-based benchmarks attributable to the site, the factor would be assigned the maximum value. The human food chain, recreation and environmental subpathways do not contain an MEI factor.

For the air pathway, the risk to the MEI would be based on the distance from the emission sources on the site to the nearest individual, using the distance to the closest residence or regularly occupied building or area (proposed rule, section 2.3.1). Values would be assigned for distances of up to two miles from the site. Values beyond two miles would be zero due to the distance weights beyond two miles.

Because the onsite pathway is not a migration pathway and because of the nature of the exposure, the onsite pathway does not lend itself to an MEI factor. EPA is seeking comments on whether such a factor should be incorporated and if so, how to do so.

10. Scoring on the Basis of Current Conditions

Under the current HRS, EPA generally scores the air, ground water, and surface water pathways based on the present condition of the site excluding any response action that has been taken ("initial conditions"), rather than on the present condition of the site, taking into account response action ("current conditions"). The Agency has used this approach for a number of technical and programmatic reasons explained at 47 FR 31187 (July 16, 1982), and discussed below. In conjunction with revising the HRS, the Agency decided to review this policy. The Agency believes it may, in some situations, be appropriate to evaluate the site based on current conditions and to consider prior responses in calculating a HRS score. The Agency intends to determine under what conditions prior response actions should or should not be considered, to ensure that this results in a more feasible and accurate assessment of potential risk to human health and environment. EPA is, therefore, requesting comment on the following issues and approaches under consideration by the Agency.

CERCLA section 105(c), as added by SARA, requires EPA to amend the HRS, and states that, "Such amendments shall 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 and facilities subject to review." The Agency believes that, to the extent that risks at a site are reduced due to response actions, it may be appropriate to base the HRS score on that reduced risk. In addition, EPA believes that if properly devised, such a policy may encourage a bias toward action that protects human health and environment without distorting the HRS' ability to assess the relative risk of sites. Furthermore, the Agency believes that the current, rather than initial, conditions generally may represent a more accurate basis of scoring. Nonetheless, EPA recognizes that certain situations exist where implementing this policy may not be practical or technically feasible.

The existing policy of evaluating sites based on initial conditions was based on three principal concerns associated with considering current conditions. The first concern was that including consideration of current conditions would create undesirable incentives at hazardous waste sites that may be eligible for the NPL. For instance, some private parties may only take action sufficient to lower the score so the site would not be listed on the NPL, but the site could still pose a potential threat to public health or the environment. Those types of score changes could be accomplished by such actions as removing wells from service to lower target scores, or by removing wastes from a site to lower waste quantity scores; however, in both cases contaminated ground water would still exist at the site.

Another undesirable incentive may be to cause public agencies to be reluctant to perform removals if such actions could lower the score and thereby prevent the site from being included on the NPL. Only sites listed on the NPL are eligible for remedial action using Superfund monies. These early response actions are important to address immediate problems posed by the site. The Agency is concerned that if prior removal actions were considered in the calculation of the HRS score, public agencies may delay responding to threats to public health and the environment in order to ensure listing on the NPL, and the resulting availability of long term remedial response funding under Superfund.

The second issue of concern was that the ability of the HRS to approximate risk at a given site is based on a number of presumed relationships between various factors considered in calculating the HRS score. When partial response actions are taken into account in site scoring, the validity of these relationships for the purpose of approximating risk posed by the site might be affected. For example, the hazardous waste quantity factor, in combination with toxicity and likelihood of release, helps predict the relative risk of a given release. For a site that has been in existence for some time, hazardous substances may have migrated to the ground water or surface water. If the hazardous materials on the surface are removed and the site is scored according to conditions existing after the removal ("current conditions"), the site could be assigned a low value for waste quantity, even though an unknown quantity of the hazardous material may be in the soil on the site and remain a potential threat to public health or the environment via the ground water, surface water, or air pathways. Thus, EPA was concerned that if a site were scored to reflect conditions after a response, the expected reduction in the HRS score based on current conditions might not reflect a commensurate reduction in the level of risk presented by the site, because the Agency may not be able to determine, at the time of site inspection, the extent of contamination that has occurred.

Finally, the Agency considered the programmatic issue of how to define "current conditions" when conditions may be changing between the time of initial data collection and final listing. Response actions often are ongoing at sites during the evaluation process, and it would be unduly burdensome to continually recalculate scores to reflect such actions.

The Agency is considering two approaches to incorporate current site conditions in the HRS score while minimizing the concerns discussed above. Under either approach, EPA would only consider removals prior to a site inspection, as EPA cannot continuously update the score of a site to reflect ongoing cleanup activity. The first approach involves consideration of removal actions for certain pathways or specific factors where appropriate. The second approach is to consider current conditions routinely, but to identify and exempt situations where current conditions will not lead to a more accurate assessment of risks.

Under the first approach, EPA would identify for each pathway (i.e., ground water, surface water, air and onsite) and for non-target factors (e.g., likelihood of release and waste characteristics) and target factors (e.g., population and distance to nearest well) whether scoring based on current conditions is appropriate. In scoring sites using the current HRS, the migration pathways have generally been scored on the basis of initial conditions for non-target factors and current site conditions for target factors. However, there are some exceptions. For example, targets have not been scored on current conditions where a site has contaminated soils of a residential area such that it is advisable for people to relocate.

Under this first approach, the Agency would score all factors for the onsite pathway based on current conditions at the time of the site inspection or equivalent because potential exposure in that pathway is based on direct contact with contaminated materials (proposed rule, section 5.0.1). The Agency believes that this is a better approach for measuring relative risk under those circumstances, and generally it is more feasible to determine whether a threat to health in the onsite pathway has been addressed than in the other pathways. For example, if the contaminated soils have been removed and permanently disposed, the risks through direct contact are probably no longer significant.

The Agency believes there may also be certain non-target factors for which scoring on the basis of current conditions could give a more accurate indication of risks at the site e.g., flood potential and potential air releases. The flood potential factor in the surface water pathway is evaluated based on the site's location in a flood plain and on the source's containment. If the site has not been flooded since the disposal and if all wastes have been removed by an interim action, the Agency believes this factor could be evaluated based on current site conditions. In the potential air release factor, for example, if a site had a surface impoundment with volatile toxic substances, releases to air may occur. If, however, prior to the site inspection, the impoundment is drained and any remaining sludge is adequately capped, the threat of a release of volatiles is mitigated by the response action, and the Agency believes this factor could also be evaluated on current site conditions.

Unlike the situation in the air pathway, it may be much more difficult to determine whether response actions have mitigated the potential for a site to release to ground water or surface water. For example, removal of a waste pile or draining a surface impoundment stops adding to the source of contamination, but does not ensure that other potential sources of contamination (e.g., contaminated soils) or impacts (e.g., contaminated ground water) have been addressed.

Generally, target factors (e.g., population and distance to receptors), have been scored on initial conditions. For example, when a temporary drinking water supply has been provided, the initial target conditions may better represent the adverse impacts caused by the site. The same would be true when people have been relocated due to contamination, in which case scoring on the basis of initial conditions may better reflect the seriousness of the problem.

The Agency believes that the approach of taking response actions into account for more HRS pathways and factors than in the current HRS would provide a more accurate assessment of the risks at sites. Such an approach would also provide incentives for both public and private parties to perform responsible response actions. For both target and non-target factors, the Agency requests comment on additional factors that may be appropriately scored on the basis of current conditions.

The second approach the Agency is considering is to score all factors based on current conditions at the time of the site inspection, except for situations where this is not appropriate or feasible. For example, as just discussed, if a temporary drinking water supply has been provided or residents relocated, initial site conditions will be more appropriate. Also, under this approach, removals performed by non-Federal public agencies should not be considered, as their actions are a recognition of the site's threat to public health or the environment, and the public agency should not be discouraged from taking early action when appropriate.

In consideration of the concern about accurately assessing hazardous waste quantity when the vast majority has been removed, EPA has identified two alternatives under this approach. One method for making such determinations would be to require additional soil and ground water samples if a removal has occurred. This could add significantly to the cost of a site inspection, as sampling and analysis tend to be the highest cost components of performing the site inspection. Alternatively, EPA could develop a factor to modify hazardous waste quantity based on quantity removed and storage time at the site. This would be less accurate, but because it would be an objective model, it could be more simply and consistently applied, and would cost significantly less and be significantly faster than site specific sampling. The Agency specifically requests comment on these two approaches to assessing hazardous waste quantity after a removal has occurred.

The Agency believes that this second approach to incorporating current conditions in the HRS score could be more successful in assessing risk at the site than the first approach, if the hazardous waste quantity issue is satisfactorily resolved. This approach also maintains incentives for public and private sector removals to the same extent as the first alternative.

EPA specifically seeks comment on the two approaches to scoring sites, and on specific factors and situations that should be evaluated on initial conditions. The Agency is also interested in recommendations on other ways to consider removal actions that would allow recognition of the site's current conditions without encouraging incomplete solutions that reduce the HRS score below the cutoff and possibly leave significant health threats unaddressed, or significantly affect the cost of performing a site inspection. Finally, the Agency requests comment on how to evaluate the effectiveness of a response action to account for wastes that may have migrated to the soil, ground water, or surface water and may be posing a potential threat to public health and the environment.

11. Low Density Populations

In the current HRS, the population close to a site must be quite large (1,000 to 10,000 people generally within one to two miles) before the score for the targets category will approach the maximum. Commenters on previous NPL rulemakings have pointed out that this requirement for large populations prevents some dangerous sites from being listed and disproportionately affects certain groups. They have stated that hazardous waste sites on or near Indian tribal lands or in isolated, rural areas usually do not obtain high scores because the population density is low.

EPA is proposing to establish high values in the revised HRS for MEIs and for populations actually exposed to contamination, especially where health-based benchmarks are exceeded in drinking water. EPA believes that this will place greater weight on dangerous sites in isolated or rural areas, and allow such sites to be listed. EPA is seeking comments on this issue and suggestions for other ways to consider it in the HRS.

12. Standby Wells and Surface Water Intakes

In the current HRS, EPA generally does not differentiate between wells or intakes used as primary water sources and those which are used as standby water sources. Such an approach tends to emphasize the value of the drinking water resources, based on the rationale that standby water resources are often indispensable during periods of peak demand or drought. However, treating standby intakes and wells the same as primary water sources does not recognize the significant difference in the use of standby and primary intakes and wells, and the difference in potential risk based on this difference in exposure. To improve the ability of the HRS to distinguish between sites, EPA is proposing to differentiate between primary and standby water sources. EPA is considering three alternative approaches. One alternative involves assigning values to a standby water source based on the percentage of the system it supplies or the percentage of the year the source is used. Such an approach could more accurately assess the relative risks to public health from chronic exposure by better evaluating the relative degree of exposure through drinking water. A second alternative would involve considering as targets. only wells or intakes that are regularly maintained and are used more than some specified annual amount. Such an approach would be simpler than the above option, but it would not be as accurate. A third alternative approach is to give standby wells and intakes a fraction of the value of a primary water source. This alternative would not reflect exposure from a site, but would distinguish between primary and standby sources and be easier to implement. Aspects of the second and third alternative are incorporated in the proposed rule in the MEI, population, and drinking water use factors. EPA specifically requests comment on how standby wells and intakes should be evaluated under the targets category, and would like specific comments on the three alternatives and what the particular cutoff levels or fraction should be.

D. Individual Pathway Revisions

Sections V D 1 through 4 detail the specific proposed revisions to the ground water, surface water, air, and onsite exposure pathways. A diagram that compares the current and the proposed structure precedes each section, except for the onsite exposure pathway where there is no current pathway for comparison. Each of the pathway discussions is organized in the same way: after a brief summary of the most significant proposed revisions and a discussion of any general considerations such as the distance over which risk is evaluated, the specific proposed revisions are grouped within the three factor categories—likelihood of release (likelihood of exposure for onsite exposure), waste characteristics, and targets. Where the revisions have already been specified in section V C, those discussions are referenced. Section 5 discusses the fire and explosion pathway. As with the issues covered in section V C, a more detailed discussion of the options EPA considered and the reasons for the proposed revisions can be found in the Technical Support Document, available in the Superfund docket.

1. Ground Water Pathway

As can be seen in Figure 1, the revised ground water migration pathway would retain the same structure as in the current HRS. In both versions, the likelihood of ground water contamination is evaluated by assessing the actual or potential release of hazardous substances to aquifers. The likelihood of release is then combined with the characteristics of the hazardous wastes and with the targets to obtain a pathway score. EPA is proposing revisions to every factor of the ground water pathway, the most significant of which are in the targets category. As already discussed, population would be assessed by how far drinking water wells subject to potential contamination are from a site (distance weighted) and by whether people are drinking from a well with contaminants above or below health-based standards. In addition, the proposed revisions would change the distance (target distance limit) within which drinking water wells are considered. In the waste characteristics category, EPA is proposing to combine toxicity with mobility rather than with persistence as is done in the current HRS. A new factor, sorptive capacity, would be added to the potential to release calculations.

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Figure 1

Ground Water Migration Pathway

Current HRS

Release X	Waste Characteristics X	Targets
Observed Release or Route Characteristics ❑ Depth to Aquifer of Concern ❑ Net Precipitation ❑ *Permeability of Unsaturated Zone* ❑ *Physical State* ❑ Containment	❑ Hazardous Waste Quantity ❑ Toxicity/*Persistence*	❑ Ground Water Use ❑ *Distance to Nearest Well*/Population Served

Revised HRS

Likelihood of Release X	Waste Characteristics X	Targets
Observed Release or Potential to Release ❑ Depth to Aquifer/ HYDRAULIC CONDUCTIVITY ❑ Net Precipitation ❑ SORPTIVE CAPACITY ❑ Containment	❑ Hazardous Waste Quantity* ❑ Toxicity/MOBILITY	❑ Ground Water Use* ❑ Population* ❑ MAXIMALLY EXPOSED INDIVIDUAL ❑ WELL HEAD PROTECTION AREA

Items in italic under Current HRS have been dropped or replaced.
Items in caps under Revised HRS are new. Most items not in caps have been revised significantly.

****Factor based on several sub-factors.***

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General Considerations. Target Distance. EPA is proposing to extend the target distance limit within which the target factors are evaluated from three to four miles; where there is documented contamination attributable to the site beyond the four-mile target distance limit, wells with such contamination would be considered to be within the target distance for the evaluation of all target factors. In deciding on the change from three to four miles, the Agency used a combination of empirical data and modeling estimates. The empirical data consist of documented plume distances of greater than three miles in length. The modeling studies provided estimates of contaminant travel times for a variety of hydrogeological conditions. The Technical Support Document, available in the Superfund docket, contains further information on these studies.

In addition to increasing the target distance limit, the proposed HRS would change the locations from which the target distance would be measured (proposed rule, section 3.0.1.1) and would distance weight the population drinking from wells within the target distance except where there is documented contamination in these wells. In the revised HRS, the locations from which the distance is measured would be the sources of contamination at the site, not the extent of contamination as is done in the current HRS. The Agency would also incorporate a distance weighting factor for evaluating the potentially exposed population. (See section V C 8.) Thus, the population drawing from wells located between three and four miles from a site would be counted least heavily unless the wells they are drinking from show documented contamination. Extending this target distance limit to four miles is not expected to result in overestimating the target population because the distance weighting factors will be used to adjust the weights of populations as a function of distance from the site, unless those populations use drinking water from wells with documented contamination.

Aquifers Considered. The current HRS designates a single aquifer as the aquifer of concern; this aquifer is the aquifer that produces the highest ground water pathway score. The targets counted are only those that use that aquifer. In the revised HRS, if more than one aquifer is present, a migration score would be calculated for each of the aquifers and the aquifer with the highest score would be used to evaluate the site. In calculating the targets value for an aquifer, both the population using water from that aquifer and the population using water from all overlying aquifers must be considered, except when the hazardous substances were placed directly in the aquifer (proposed rule, section 3.0). The inclusion of targets from overlying aquifers is based on the assumption that contaminants must migrate through the shallower aquifers before reaching a deeper aquifer.

Aquifer Interconnections. In the current HRS, multiple aquifers can be considered a single aquifer if they function as a single hydrological unit within a three-mile radius of the site. Because specific determination of the degree of aquifer interconnection may require professional judgment to evaluate the site, EPA has developed guidance for applying such judgments in determining that multiple aquifers constitute a single hydrologic unit (proposed rule, sections 3.0.1.2 and 3.0.1.2.1).

At present, both the target distance limit and the distance over which the aquifer interconnections are determined extend for a three-mile radius from the extent of known contamination, except where a lateral discontinuity exists. EPA would reduce both the distance over which geologic conditions are evaluated for the potential to release and the distance over which aquifer interconnections are evaluated from three miles to two miles, except where contamination attributable to the site extends beyond two miles; areas underlying this contamination are included in the evaluation. This reflects EPA's belief that the geologic conditions near the site will, in most cases, be of primary importance in affecting the release of contaminants to an aquifer and from upper aquifers to lower aquifers. EPA requests comments on the two-mile radius.

Aquifer Discontinuities. Aquifer discontinuities (proposed rule, section 3.0.1.2.2) result when a geologic, topographic, or other structure or feature completely transects an aquifer, significantly disrupting water from flowing out of or into the aquifer. If the discontinuity exists within the target area, any part of an aquifer beyond the discontinuity is not counted in the aquifer unless the discontinuity does not entirely transect the target area. If multiple aquifers are considered as a single unit, any discontinuity must entirely transect the boundaries of the single unit before the area beyond the discontinuity is discounted. EPA is proposing to extend the distance for considering aquifer discontinuity from the current three-mile radius to a four-mile radius to keep it consistent with the distance over which population factors are evaluated.

Karst Aquifers. Karst aquifers are those associated with karst terrain, which refers to a type of topography formed in limestone, dolomite, or gypsum by dissolution by rain and ground water. Karst aquifers often have very high ground water flow velocities. Currently, sites in karst terrain are not given any special consideration in the HRS. (See proposed rule, section 3.0.1.3 for a further definition of karst.) In the several factors in the proposed revisions, karst aquifers would be scored differently than other types of aquifers (proposed rule, sections 3.1.2 and 3.3.1). The proposed revisions would reflect the high potential for contaminants to migrate through karst aquifers with little reduction in the concentration of the hazardous substance through dispersion, dilution, or attenuation. Karst aquifers would be treated differently than other aquifers in the depth to the aquifer/ hydraulic conductivity factor, the sorptive capacity factor, the maximally exposed individual factor, and the population potential contamination factor. For more detail, see the Technical Support Document, available in the Superfund docket. EPA also considered scoring other types of aquifers, such as fractured bedrock, differently for similar reasons. The Agency solicits comments on how the HRS could reflect the special characteristics of those types of aquifers.

Ground Water Flow Direction. The current HRS does not consider the direction of ground water flow in determining which populations or environments may be affected by the migration of hazardous substances at the site. The target factors give equal weight to the entire population within a three-mile radius from the site. In adopting the current HRS, EPA decided that the time and level of effort required to obtain sufficient geohydrologic information to determine ground water direction accurately over the entire three-mile radius would be inconsistent with the goal of expeditiously scoring sites. A reasonably accurate determination of the flow direction requires extensive geohydrological investigation because the direction of flow may be altered by seasonal variations, long-term historical changes, and the effects of pumping wells. In addition, when considering the migration of hazardous substances in ground water, other problems arise; for example, immiscible liquids may migrate in a direction other than the primary direction of the ground water flow, making ground water flow direction an inaccurate surrogate for the direction of contaminant flow.

In the ANPRM, EPA sought comments on the question of using ground water flow direction measures. Most of the commenters supported using ground water flow direction, at least under certain conditions. EPA investigated several options for considering ground water or contaminant flow direction, including the following.

• Estimating the direction of ground water flow from piezometric measurements and dividing the target population into upgradient and downgradient categories. The two population categories would be evaluated differently.

• Determining population categories based on the direction(s) of observed contaminant migration rather than on direction(s) of ground water flow. The direction of ground water flow is a surrogate measure for evaluating the most probable direction of contaminant migration and is a less direct means of identifying the population at risk. As in the above option, the population would be divided based on location with respect to the direction of contaminant migration. Various alternatives were considered for how the two population categories might be evaluated.

• Retaining the current system that does not consider either the direction of ground water flow or contaminant migration flow in determining the target population.

To evaluate these options, EPA considered both the technical feasibility and the cost of obtaining reliable information. See the Technical Support Document (available in the Superfund docket) for a more detailed discussion of the options considered.

EPA is proposing to retain the current system, which does not directly consider ground water flow direction, in evaluating the population potentially exposed to contaminants. However, where there is known contamination in wells, the populations normally using those wells would be weighted higher than those only potentially exposed. Based on its review of technical feasibility, EPA determined that even if the general direction of the flow around the site could be defined, the localized direction of the flow may not be consistent with the general flow. Accurately determining the local flow within the target distance would require extensive geohydrologic investigations. EPA concluded that the considerable expenditure of time and public funds that would be required for geohydrological investigations is justified only at the nation's highest priority sites, i.e., those on the NPL. The revised HRS would indirectly take substance migration direction into account by using the MEI factor and by assigning weights to people drinking contaminated water either above or below health-based benchmarks.

Likelihood of Release. The proposed revisions provide the same general structure as the current HRS for assessing the likelihood of contaminants to migrate from a site to an aquifer—observed release and potential for release (formerly route characteristics/containment) (proposed rule, section 3.1).

Observed Release. As discussed in Section V C 4, the proposed HRS would include general criteria to define when a release can be considered significantly above background levels (proposed rule, section 3.1.1).

Potential to Release. The proposed potential to release factor category (proposed rule, section 3.1.2) is comparable in intent to the route characteristics/containment portion of the current HRS. The name would be changed to clarify that the factor represents the potential of the site to release contaminants to an aquifer rather than the potential for the contaminants to migrate once they enter the aquifer.

EPA is proposing a number of changes in how potential releases are scored. The current HRS has four route characteristics factors—depth to the aquifer, net precipitation, permeability, and physical state. The values for these factors are added together, then multiplied by the containment factor value. The proposed HRS would use four factors—depth to aquifer/hydraulic conductivity, net precipitation, sorptive capacity, and containment. The release potential would be calculated as the sum of the values of the first three factors multiplied by the value for containment (proposed rule, section 3.1.2.5).

In the proposed HRS, the depth to aquifer would be combined in a matrix with hydraulic conductivity (proposed rule, section 3.1.2.3). Considered together, the two factors provide an indication of the relative travel time required for hazardous substances to reach the underlying aquifer. In the current HRS depth of aquifer factor, aquifers deeper than 150 feet are assigned a value of zero. The depth to aquifer factor would be modified in the revised HRS to include aquifers with depths up to and exceeding 800 feet. Values would be assigned using a matrix that combines depth with hydraulic conductivity. This change in the depth reflects both the fact that aquifers are known to be used at depths exceeding 800 feet and that documented contamination has been found in deeper aquifers. See the Technical Support Document for further detail.

For HRS scoring purposes, the hydraulic conductivity factor would be calculated by deriving a thickness-weighted average hydraulic conductivity, a measure that combines the hydraulic conductivity of each layer of geologic material between the contaminant source and the aquifer with the thickness of that layer (proposed rule, section 3.1.2.3.2). The one exception is when the layer consists of karst; karst aquifers would always be assigned a thickness of zero feet regardless of their actual thickness. The hydraulic conductivity factor is a renaming of the permeability factor; the proposed addition of the thickness component would make the new hydraulic conductivity factor a more accurate measure of travel time and, therefore, a more accurate reflection of the potential for migration. As with aquifer interconnections, hydraulic conductivity would be examined within a two-mile radius of the site, except as noted in the proposed rule (section 3.1.2.3). EPA requests comments on this distance.

The net precipitation factor, which indicates the amount of water potentially available for infiltration to ground water, would be revised. Under the proposed HRS, the net precipitation factor value (proposed rule, section 3.1.2.2) would be based on a new method of estimating annual net precipitation rather than seasonal or annual net precipitation as determined in the current HRS. In addition, the factor value would be based on the sum of the months in which there is a positive net precipitation. This will better reflect the potential of hazardous substances to migrate to aquifers. A map providing net precipitation values for specific areas will be included in the final rule.

When the HRS was adopted, some commenters objected because it did not consider geochemical removal mechanisms. At the time, EPA did not believe that the data regarding these mechanisms were sufficiently broad to warrant inclusion in the HRS. In response to these comments, and to similar comments on the ANPRM, EPA is proposing to add a new factor to the ground water potential to release category, sorptive capacity. Sorptive capacity measures the potential of geologic materials to sorb contaminants and thereby retard their migration to aquifers (proposed rule, section 3.1.2.4). The sorptive capacity factor is intended to reflect relative differences in the ability of various types of geologic materials to inhibit the migration of contaminants. A table of sorptive capacity values is provided in the proposed rule. Sorptive capacity would be evaluated based on the clay and organic carbon content of the geologic materials that occur between the hazardous substances and the aquifer within a two-mile radius of the site (except as noted in the proposed rule), consistent with the way other geologic factors are evaluated. EPA requests comments on the sorptive capacity factor and the distance over which it is evaluated.

The containment factor (proposed rule, section 3.1.2.1) is a measure of the means taken to minimize or prevent the release of hazardous substances from a site to ground water. The containment factor would be revised in the proposed HRS to provide a greater range of assigned values and more detailed descriptions of each type of containment. These changes would make the determination of conditions and of the adequacy of containment more objective.

Certain ground water containment elements (e.g., liners, cover thickness, and permeability) cannot be examined visually during a site inspection. In the past, the Agency has relied principally on the records of site owners and operators to determine the adequacy of such containment measures. In the absence of such records, EPA has assumed that no such containment measures were undertaken. EPA proposes to retain this same approach when determining containment.

The physical state affects the potential of the waste to migrate from a site or, alternatively, for it to be contained at a site. Physical state can, therefore, be used as a component of either waste containment or waste migration potential. Physical state is used in the current HRS as a measure of waste migration potential in the ground water and surface water pathways. EPA is proposing to eliminate the physical state factor used in the current HRS because experience has shown that it seldom provides meaningful discrimination among sites. Most sites scored with the current HRS contained at least some liquids, therefore receiving the maximum value for physical state. In the proposed revisions, physical state has been integrated into the containment factor to better reflect the interrelationship of the two in the release of hazardous substances from a source area. EPA seeks comment on eliminating the physical state as a separate factor.

Waste Characteristics. The current waste characteristics factor category (proposed rule, section 3.2) includes hazardous waste quantity and toxicity/persistence factors. EPA is proposing a number of changes in the calculation of waste characteristics for all pathways. The toxicity factor and hazardous waste quantity factor would be revised as discussed in sections V C 2 and 3. In addition, for the ground water pathway, the toxicity factor would be combined in a matrix with mobility rather than with persistence as is done in the current HRS (proposed rule, section 3.2.1). EPA decided to eliminate the persistence factor because the method currently used to evaluate persistence is based on biodegradability and is generally not applicable to ground water.

The Science Advisory Board, as part of its review of the applicability of the HRS to mining waste sites, supported the incorporation of a mobility factor in the HRS. The Board indicated that mobility would more accurately reflect the potential for a substance to migrate through the ground water to a target population than does persistence.

The Board suggested that speciation of metals was an important consideration in evaluating mobility. However, to accurately assess the mobility of a specific metal, the various metal species present must be determined, both in the waste and in the subsurface environment. This, in turn, requires knowledge of the concentrations of anions, cations and dissolved organic materials; pH; redox potential; and adsorption characteristics of the geologic material. In evaluating options for mobility, EPA believed that it was not feasible to obtain reliable measures of these parameters given the temporal and spatial variations and the difficulty in sampling. Furthermore, the Agency concluded that the mobility factors added to the proposed HRS will increase the accuracy of the waste characteristics assessment.

The proposed mobility factor (proposed rule, section 3.2.1.2) would be a measure of the tendency of a hazardous substance to become mobile in the aqueous phase. Mobility would be evaluated for all hazardous substances that are available to migrate to ground water. Any substance documented in an observed release at a facility would be assigned the maximum value because its presence is an indication that it is sufficiently mobile at that facility to pose a hazard. For other substances, a mobility tendency value would be assigned to specific organic and inorganic contaminants based on water solubility, and to inorganic cations and anions based on each ion's coefficient of aqueous migration value. The coefficient of aqueous migration reflects the mobility of uncombined or free inorganic substances under geochemical conditions that maximize their mobility. For a more detailed discussion see the Technical Support Document in the Superfund docket.

The purpose of this new mobility measure is to increase the accuracy of the waste characteristics factor category by taking into account the differing abilities of substances to migrate and, therefore, increasing the accuracy of the scoring system. Mobility would be considered in a matrix with toxicity and thus would play a role in the selection of the substance used to assign the toxicity/mobility value (proposed rule, section 3.2.1.3). Combining mobility and toxicity would lead to selecting the contaminant that poses the most significant threat, thus increasing the accuracy of the HRS.

The toxicity/mobility factor value would be added to the hazardous waste quantity value to obtain a waste characteristics score.

Ground Water Targets. The ground water targets factor category (proposed rule, section 3.3) reflects the human population and resources potentially at risk from an actual or potential release of hazardous substances from the site to an aquifer. Currently, the ground water targets factor category includes two factors—a use factor and a factor derived from a matrix that combines distance to the nearest well with the population served by ground water. These factors are evaluated for drinking water and irrigation wells drawing from the aquifer of concern within the target distance of the site.

Four factors would be added together to derive a value for the targets category under the proposed rule: Ground water use, the presence of high priority ground water areas, the MEI, and population.

Ground Water Use. Currently, the ground water use factor takes into account four possible conditions and uses of the ground water drawn from the aquifer within the three-mile radius: drinking water with no unthreatened alternative source; drinking water with alternative sources or commercial, industrial or irrigation uses without alternatives; commercial, industrial or irrigation uses with alternatives, or not used but usable water; and unusable water. Only the ground water use with the highest value is used to assign a value to the factor. The proposed revisions (proposed rule, section 3.3.3) to the HRS would divide this factor into two subfactors—drinking water use and other water use. The drinking water use factor reflects the use and value of the ground water and would consider whether the drinking water wells are private, public, or standby, parameters the current HRS does not consider (proposed rule, section 3.3.3.1). (Private wells are defined as wells that have less than 15 connections and serve less than 25 people.) The other water use factor would assign values if the wells are used for specified agricultural, commercial, or industrial purposes (proposed rule, section 3.3.3.2). The ground water use factor value would be the sum of the highest value assigned for drinking water use and for other water use, subject to a maximum (proposed rule, section 3.3.3.3). Expanding the ground water use factor to consider these additional uses would provide increased discrimination.

The ANPRM specifically asked for comments on modifying the ground water use factor to account for future use. The Agency received comments for and against this concept. Those favoring the addition of future use stated that unused aquifers should be considered resources to be protected. These commenters suggested mechanisms to predict future use, such as town planning documents. Those opposed to considering future use stated that the factor would be subjective and conjectural and that communities would develop unrealistic plans so their sites would receive higher HRS scores.

The proposed HRS would continue to place a high priority on current use. EPA has increased the relative weight of the revised ground water use factor among the factors in the target category. EPA concluded that the size of the target distance area, the consideration of alternative water supplies, and the high value placed on the resources give appropriate consideration to future use because it is likely that resources being heavily used at present will continue to be heavily used. In addition, the drinking water use factor assigns points for aquifers that are not used, but usable. However, the Agency recognizes that this approach may not account for a drastic increase in future use. The Agency has not identified a method for accurately and uniformly predicting such future changes in land and water resource use. Therefore, the Agency requests comment on two issues: (1) Can local population changes, land use changes, or changes in ground water use patterns be reliably predicted within the context of the HRS? and (2) how should the Agency weight sites where ground water resources have been degraded, regardless of whether these resources are presently used?

Population. The population factor (proposed rule, section 3.3.2) is an indicator of the number of people actually or potentially at risk from exposure to hazardous substances in drinking water as well as a measure of the value of the potentially affected resources. In the current HRS, all the people who drink water drawn from wells within three miles of the site are counted equally. The total population is then combined in a matrix with distance to the nearest well to assign a single factor value. In the proposed HRS, these factors would be separated to more clearly reflect MEI risks and resource value/population risk.

As discussed in sections V C 5 and 8, the population served by ground water factor would be divided into four possible groups with the first three groups based on how the concentration in the drinking water well compares to the health-based benchmarks (MCLs, MCLGs, or unit cancer risk numbers). The last group represents the population whose wells may not be contaminated, but the aquifer itself is contaminated, or has the potential to be contaminated. This last group would be distance-weighted. The population factor value would be the sum of the four population factor values, subject to a maximum (proposed rule, section 3.3.2.4).

Several other changes would affect the population factor. EPA would clarify its definition of which wells may be considered in determining target populations. In evaluating each aquifer, EPA would consider the population drawing drinking water from the aquifer being evaluated and those drawing from overlying aquifers except when the hazardous substances have been introduced directly into that aquifer (proposed rule, section 3.3). EPA would also consider populations drawing from a well beyond four miles if that well has contamination attributable to the site. In addition, EPA would use county census data when there is no actual population count available rather than using a conversion factor of 3.8 people per residence as in the current HRS (proposed rule, section 3.3.2). As explained in section V C 7, EPA has not been able to identify a reliable way of consistently evaluating terrestrial contamination effects on the human food chain. Therefore, the revised HRS would delete the conversion of agricultural acreage to equivalent population in the current HRS.

Maximally Exposed Individual. The current distance to the nearest well factor would be treated as a separate factor in the proposed revisions and would be used to indicate the risk to the MEI, as discussed in section V C 9. If the concentration of a substance (or substances) at any drinking water well exceeds health-based benchmarks and that contamination is attributable to the site under evaluation, then the MEI factor would be assigned the maximum factor value (proposed rule, section 3.3.1). In addition, any well drawing drinking water from a karst aquifer that underlies the site would also be assigned the maximum value. This factor addresses the concerns of section 118 of SARA, which requires EPA to give high priority to wells closed because of contamination.

High Priority Ground Water Areas. CERCLA section 118(a), as amended by SARA, requires the Agency to give a high priority to sites that have contaminated a principal drinking water supply. The use of health.based benchmarks in weighting target populations (see section V C 5) is one way the revised HRS gives greater weight to sites where actual contamination has occurred in a drinking water well. For example, a site responsible for contaminating wells or a water supply has the population factor increased, depending on how the level of contamination compares with health-based benchmarks. The use of the health-based benchmarks ensures that sites where actual contamination has occurred are given greater weight.

The Agency proposes adding a new factor to the target score to take into account the presence of a Wellhead Protection Area (WHPA) designated under section 1428 of the Safe Drinking Water Act (SDWA). This factor would address CERCLA section 118(a), as amended by SARA. This factor, which receives a maximum value if the source or hazardous substance released from the source is located within a WHPA or zero if the source and its hazardous substances are not located within a WHPA, would increase the target score when a hazardous waste site could endanger a WHPA. The Agency specifically requests comment on the weighting that should be given to a source located in a WHPA.

Section 1428 of the SDWA, which sets out the requirements for the WHPAs, requires each State to develop and submit for EPA approval, a program to protect wellhead areas supplying public water systems from contaminants that may have an adverse effect on human health. WHPAs are further defined as "the surface and subsurface area surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield." It is estimated that less than six percent of the land area of the U.S. will likely be included within such areas. Therefore, the WHPA designation would likely discriminate among sites where a principal drinking water supply is threatened. One disadvantage to the approach of using WHPAs is that currently no States have established WHPA programs. Section 1428(a) of the amendments requires each State to adopt and submit to EPA by June 19, 1989, a program designed to protect wellhead areas. Section 1428(g) requires each State to make every reasonable effort to implement the State wellhead protection program within two years of submitting the program to EPA.

The Agency considered using the presence of a sole source aquifer (SSA) rather than a WHPA to fulfill section 118(a). An SSA is established pursuant to section 1424(e) of the SDWA. The Agency decided against using the SSA designation because the criteria for SSA designation are not very selective, i.e., the primary test is whether 50 percent or more of the current population are served by ground water. Although there are currently relatively few designated sole source aquifers in the country, the criteria could potentially allow much more of the land area of the U.S. to be designated as SSAs than would the WHPA designations. If this were the case, assigning a maximum value to the target score if an SSA exists within the target distance limit would result in little discrimination among sites.

EPA's Office of Ground Water Protection has available the following guidance documents dealing with wellhead protection and sole source aquifers:

(1) Sole Source Aquifer Designation Petitioner Guidance, US EPA, February 1987.

(2) Guidelines for Delineation of Wellhead Protection Areas, US EPA, June 1987.

(3) Guidance for Applicants for State Wellhead Protection Program Assistance Funds Under the Safe Drinking Water Act, US EPA, June 1987.

Comment is requested on whether the Agency should use the WHPA designation in meeting the requirements of SARA Section 118. Comment is also requested on the desirability and mechanisms for incorporating other high priority areas in a State, such as those formally recognized within a State ground water classification system.

Ground Water Migration Score. The ground water migration score is the product of the likelihood of release value, the waste characteristics value, and the targets value, divided by a normalizing factor. A ground water migration score would be calculated for each aquifer underlying a site (proposed rule, section 3.4). The highest ground water score for an aquifer would be used as the ground water pathway score (proposed rule, section 3.5).

2. Surface Water Pathway

As can be seen in Figure 2, EPA is proposing major changes in the surface water pathway. As required by CERCLA Section 105 (as amended), EPA has assessed several potential effects of surface water contamination and is proposing to revise the surface water pathway to better consider the threats to human health through drinking water, the human food chain, and recreational water use. EPA is also proposing to revise the environmental component of the surface water pathway. Each of these threats would be evaluated separately for likelihood of release, waste characteristics, and targets. The pathway score would be the sum of the scores of the threats or subpathways. This revised structure provides a relatively simple way to account for the different substances and targets that may be important for the different types of potential exposure in the surface water pathway. The structure allows the HRS to take into account aquatic toxicity for sensitive environments, mammalian toxicity in drinking water, mammalian toxicity and bioaccumulation in the food chain, and mammalian toxicity, dermal permeability, and mass flux dilution for recreation.

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Figure 2

Surface Water Migration Pathway

Current HRS

Release X	Waste Characteristics X	Targets
Observed Release or Route Characteristics ❑ *Facility Slope/ Intervening Terrain* ❑ *One Year, 24 Hour Rainfall* ❑ *Physical State* ❑ Distance to Nearest Surface Water ❑ Containment	❑ Hazardous Waste Quantity ❑ Toxicity/Persistence	❑ Surface Water Use ❑ Population Served/ *Distance to Nearest Intake Downstream* ❑ Distance to a Sensitive Environment

Revised HRS

Drinking Water Threat

Likelihood of Release X	Waste Characteristics X	Targets
Observed Release or Potential to Release OVERLAND FLOW ❑ Containment ❑ RUNOFF* ❑ Distance to Surface Water POTENTIAL TO RELEASE BY FLOOD ❑ CONTAINMENT (FLOOD) ❑ FLOOD FREQUENCY	❑ Hazardous Waste Quantity* ❑ Toxicity/Persistence	❑ Surface Water Use* ❑ Population* ❑ MAXIMALLY EXPOSED INDIVIDUAL

Human Food Chain Threat

Likelihood of Release X	Waste Characteristics X	Targets
(same as above)	❑ Hazardous Waste Quantity* ❑ Toxicity/Persistence/ BIOACCUMULATION	❑ FISHERY USE ❑ POPULATION*

Recreational Threat

Likelihood of Release X	Waste Characteristics X	Targets
(same as above)	❑ Hazardous Waste Quantity* ❑ Toxicity/Persistence/DOSE ADJUSTING FACTOR	❑ POPULATION*

Environmental Threat

Likelihood of Release X	Waste Characteristics X	Targets
(same as above)	❑ Hazardous Waste Quantity* ❑ ECOSYSTEM TOXICITY/Persistence	❑ Sensitive Environments

Items in italic under Current HRS have been dropped or replaced.
Items in caps under Revised HRS are new. Most items not in caps have been revised significantly.

**Factor based on several sub-factors.*

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If hazardous substances could migrate from the site to surface water in more than one watershed, each of the threats would be evaluated over each watershed and the final pathway score would be the sum of the scores of the watersheds (proposed rule, section 4.0.1). In evaluating a threat to a watershed, only the information (waste quantity, observed release, etc.) appropriate for that watershed would be used. The same wastes, for example, would not be used to score more than one watershed except where it is not feasible to determine the locations of those wastes relative to the watershed boundaries.

Target Distance. In the current HRS, the target distance is measured from the probable point where the contaminated water enters the surface water to a point three miles downstream of the farthest observed contamination (one mile in static water such as a lake). EPA is proposing to extend the target distance limit to 15-stream-miles from the probable point of entry (a 15-mile arc for lakes and oceans). If an observed release is based on sediment samples, as opposed to water or benthic samples, the target distance would extend 15 miles beyond the farthest sediment sample showing contamination attributable to the site. This distinction is made because contaminated sediments may serve as a continuing source of contamination as particles become resuspended. In addition, if there is observed release based on water or benthic samples beyond the 15-mile limit, drinking water intakes, fisheries, or sensitive environments up to the point of observed contamination would be used to evaluate targets (proposed rule, section 4.0.2).

To derive the 15-mile limit, EPA analyzed how far contaminants could travel before being attenuated to the point where they were no longer considered important in characterizing risk. More information concerning this analysis is provided in the Technical Support Document, available in the Superfund docket. Based on this analysis, the Agency concluded that 15 miles provides a reasonable balance between ensuring that all potential receptors are evaluated and limiting the data collection effort to a reasonable level. The current and proposed target distance limits should not be directly compared. The current HRS indirectly includes distance and dilution weighting factors by assigning a value based on the distance between the probable point of entry of the contaminants into the surface water and the intake or sensitive environment. The proposed revisions explicitly include dilution weighting factors that are dependent upon the volume of flow. In the ANPRM, EPA requested comments on the target distance limit for surface water. The Agency would like comments on this proposed revision to the target distance.

Likelihood of Release. The current HRS evaluates the likelihood of release as an observed release or as a potential to release. This basic structure has been retained in the revised HRS. Because the likelihood of release factor category value would be calculated once and used in evaluating each of the applicable threats (drinking water, human food chain, recreation, and sensitive environments) at a site, it is discussed here without reference to the threat calculations.

Observed Release. An observed release would be scored when it can be demonstrated that a site has released hazardous substances to surface water. Either aquatic, benthic, or sediment sampling or direct observation of the release could be used to demonstrate that an observed release to surface water has occurred (proposed rule, section 4.1.1.1). (See section V C 4 for a discussion of the observed release criteria.)

Potential to Release. The current HRS calculates the potential to release factor category by multiplying the route characteristics by the containment. Route characteristic factors are the facility slope and the slope of intervening terrain; the one-year, 24-hour rainfall; the distance to the nearest surface water; and the physical state of the waste. These factors are added together.

The proposed HRS would replace the potential to release factors with two new groups of factors, overland flow and potential to release by flood, which would be added together to obtain the potential to release category score (proposed rule, section 4.1.1.2). The proposed overland flow factors are comparable to the route characteristics times containment portion of the current HRS. The name has been changed to reflect that the factors represent the potential of the site to release hazardous substances to surface water rather than the potential for hazardous substances to migrate once they enter the surface water body. Although both the current and revised factors measure the potential for a site to release hazardous substances, the revised factors would emphasize total releases rather than just peak releases.

In the current HRS, if the distance to the surface water is more than two miles, the distance to surface water factor is assigned a value of zero but the rest of the potential to release factors are evaluated and scored. Under the revised HRS, if the distance to surface water is greater than two miles, overland flow would be assigned a value of zero. In addition, if no overland segment can be defined (e.g., the site is in a topographic depression) the overland flow is assigned a value of zero. Flood potential would still be evaluated, however, as would the rest of the factors in the pathway.

Overland Flow. Overland flow is the sum of the runoff and the distance to surface water factors, multiplied by the overland containment factor (proposed rule, section 4.1.1.2.1.4). As stated above, the maximum distance from the site to the surface water would remain at two miles, but the scale of assigned rating values for interim distances would be modified to include more distance ranges, thus expanding the scale of possible values to better reflect the threat posed by the overland flow pathway (proposed rule, section 4.1.1.2.1.3).

The runoff factor, the measure of runoff available for carrying hazardous materials from a site to surface water, would include three components: (1) Rainfall, (2) runoff curve number, and (3) drainage area. The rainfall factor considers the potential for storms to cause surface water contamination as a result of runoff—as reflected by the two-year, 24-hour rainfall. The runoff curve number reflects the ability of the soil types present and of the predominant land surface to facilitate or impede runoff. The runoff curve number would be obtained from a matrix of hydrologic soil groups and the predominant land use (e.g., cultivated land, forests, streets) within the drainage area. The drainage area of interest is a new factor that considers the size of the drainage area and provides an additional measure of the amount of runoff available for hazardous substance migration. The area of interest refers only to the area contributing runoff from the site into the overland migration pathway. It includes the site and any area upgradient of the site that sends water through the site.

EPA chose this method of calculating runoff because it more accurately assesses runoff from the site. The precipitation value would be based on two-year, 24-hour rainfall data rather than the current one-year, 24-hour rainfall because of data availability. For more detail, see the Technical Support Document, available in the Superfund docket.

The sum of the runoff factor value and distance to surface water factor value would be multiplied by the overland containment factor value. The containment factor is a measure of the means taken to minimize or prevent the release of hazardous substances from a site to surface water. The containment factor would be revised in the proposed HRS to provide a greater range of assigned values and more detailed descriptions of each type of containment (proposed rule, section 4.1.1.2.1.1). These changes would make the determination of conditions and of the adequacy of containment more objective.

EPA proposes to eliminate the current physical state and facility slope and intervening terrain factors. Most sites scored with the current HRS contained at least some liquids, thus scoring the maximum for physical state. Consequently, the physical state of the waste does not provide meaningful discrimination among sites. In the proposed revisions, physical state has been integrated into the containment factor to better reflect the interrelationship of the two in the release of hazardous substances from a source area. EPA seeks comment on eliminating the physical state as a separate factor.

Facility slope and slope of intervening terrain would be eliminated in part because of the difficulty in estimating these factors with sites commonly having irregular slopes or, in the case of a lagoon, having no slope but still posing a threat of release from a dike failure, from leakage, or from overtopping due to an inadequate freeboard.

Potential to Release by Flood. The current HRS accounts for flooding at hazardous waste sites only by assigning an observed release if a site has been inundated by a flood. The Agency is concerned that certain sites, such as those near the banks of a river, could release hazardous substances during a flood and that the threat of such a release is not adequately accounted for in the current HRS. The proposed potential to release by flood factor would better reflect the potential for a site to release hazardous substances if a site is flooded.

In determining the value for potential to release by flood, each source on a site is evaluated separately for the flood plain in which it lies, and the highest value calculated for any source would be the value for the factor. For each source, a value would be calculated by multiplying the flood frequency value for each flood plain in which the source lies by the containment (flood) value for that source for each specific flood plain (e.g., 10-year, 100-year) (proposed rule, section 4.1.1.2.2.3).

Flood frequency (proposed rule, section 4.1.1.2.2.2) would be based on available flood plain information. A value greater than zero would be assigned to a source for each flood plain in which the source is located; that is, if a source is in a 10-year and 100-year flood plain, a value would be assigned to the source for each. Flood containment for the source (proposed rule, section 4.1.1.2.2.1) would be scored on an all or nothing basis for each flood plain in which the source is located. If a source is in a flood plain (e.g., a 10-year flood plain) and a professional engineer certifies that the containment will prevent a release of hazardous substances from that source under such a flood, the containment factor for that flood plain would be assigned a value of zero for that source. If the containment would not prevent a release, the containment flood factor would be assigned the maximum value. Containment would be evaluated for each flood plain in which a source is located. EPA requests comments on the inclusion of flood potential and criteria to be used for determining flood containment.

In addition to the overland and flood mechanisms, EPA considered adding a mechanism to evaluate a site's potential to contaminate surface water through ground water discharges. EPA was not able to develop a system for reliably predicting such releases based on site inspection data. The Agency is concerned that discharges of contaminated ground water can be significant sources of hazardous substances in surface waters and would consider including a mechanism for evaluating such potential releases if reasonable. EPA solicits comments on how such a potential could be evaluated within the context of the HRS. Releases of contaminated ground water to surface water are addressed as observed releases where they can be documented.

Drinking Water Threat. Waste Characteristics. The current HRS evaluates the characteristics of the hazardous substances actually or potentially released to the surface water pathway by adding a value from a matrix of toxicity and persistence to a value based on hazardous waste quantity. These factors are retained in the proposed revisions, but evaluated differently. Scoring of toxicity and hazardous waste quantity would be revised as discussed in sections V C 2 and 3.

The persistence factor in the current HRS is based on biodegradation. To better account for actual, substance-specific attenuation processes, the persistence factor would be revised to include five decay processes: biodegradation, hydrolysis, photolysis, volatilization, and free-radical oxidation. In evaluating how the HRS handles the mobility of hazardous substances, the Science Advisory Board supported using attenuation measures for surface water because they most closely approximate what actually happens in the environment. In the proposed rule, four levels of persistence would be defined by a measure of the half-life of the substance, that is, the time it takes the concentration of the substance to be reduced by half (proposed rule, section 4.1.2.1.2). The persistence value would then be assigned based on the half-life of the hazardous substances and the type of the surface water, which together represent the time the hazardous substance will take to travel through the water. Of substances studied by the Agency for purposes of revising this factor, about 90 percent receive the maximum value for persistence in rivers, oceans, and the Great Lakes.

In cases where persistence data do not exist, the revised HRS would assign default values specific to the types of hazardous substances and to the types of surface water affected by a release. For example, hazardous substances that are metals would be assigned a default value of three for all surface water bodies; all other hazardous substances released to a river or stream would be assigned a default value of two, while a default value of one would be assigned for releases to lakes based on the longer travel time. A more detailed discussion of the persistence factor can be found in the Technical Support Document.

For each substance actually or potentially releasable from the site, persistence would be combined with toxicity in a matrix. The substance with the highest toxicity/persistence value would be used in calculating the drinking water waste characteristics factor category value (proposed rule, sections 4.1.2.1.3 and 4.1.2.3).

The value for toxicity/persistence would be added to the value for hazardous waste quantity to derive a waste characteristics score.

Targets. The drinking water target category reflects the humans and resources potentially at risk from exposure to hazardous substances in drinking water obtained from surface water sources (intakes). In the current HRS, two factors are used to evaluate the population potentially affected: surface water use and population served by drinking water intakes that are within the target distance from the probable point of entry of releases from the site to the surface water. Currently, the population factor is combined in a matrix with distance to an intake to produce a single assigned value. The drinking water targets category in the revised HRS retains the surface water use and population factors, but substantially modifies them. The distance to an intake would be replaced with an MEI factor that would be evaluated separately. These three factors (surface water use, population, and MEI) would be added together to obtain a value for the drinking water targets.

The surface water use factor takes into account the value of the resource and the use of the water taken from surface water intakes within the target distance limit. In the current HRS, the use is evaluated based on whether the water is used for drinking; for irrigation, commercial food preparation, or recreation; for commercial/industrial purposes or is not used. Only the surface water use with the highest value is used to assign a value to the factor. The proposed revisions (proposed rule, section 4.1.3.3) to the HRS would divide this factor into two subfactors—drinking water use and other water use. The drinking water use factor would take into account whether the drinking water is a public or private water supply, whether reasonable alternative supplies exist, whether available alternatives are unthreatened by the site, whether the water is a standby source, whether the water has been designated for water use but is not used, and whether it is not used or is not usable for some reason unconnected with the site (proposed rule, section 4.1.3.3.1). These new considerations would provide a better method for evaluating the threat posed by the site to the surface water resource. As in the current HRS, other surface water uses (such as commercial food preparation, commercial livestock watering, or commercial crop irrigation) would also be assigned values (proposed rule, section 4.1.3.3.2). The surface water use value would be the sum of the highest values assigned for drinking water use and for other water use, subject to a maximum (proposed rule, section 4.1.3.3.3), allowing both types of use to be reflected in the score.

The population factor is an indicator of the number of people actually or potentially at risk from exposure to hazardous substances in drinking water. In the current HRS, population is combined in a matrix with distance downstream to the surface water intake to obtain a single factor value. No distinction is made between actual and potential contamination. As explained in section V C 5, EPA has decided that those people actually exposed to contaminated drinking water should be weighted more heavily than those potentially exposed. For this reason, in the revised HRS, the population factor would be determined using four population groups. The first three groups are based on how the concentrations at the drinking water intakes compare with health-based benchmarks (MCLs, MCLGs, or unit cancer risk numbers). The last of these four population groups would represent the population whose intakes are not known to be contaminated, but have the potential to be contaminated. This last group would be dilution-weighted. Where actual population counts are not available, population figures would be derived from county census data instead of being based on an assumption of 3.8 people per residence as in the current HRS (proposed rule, section 4.1.3.2). The emphasis on the risk to individuals exposed to actual as opposed to potential contamination is consistent with the ground water approach.

EPA is also proposing to use the dilution weighting factor at the nearest drinking water intake in assigning a value to the maximally exposed individual factor, as discussed in section V C 9. The dilution weighting factor would be assigned based on the average flow at the intake, and would be multiplied by 50 to obtain the value for the MEI factor, subject to a maximum of 50. If the concentration at any drinking water intake within the target distance limit exceeds a health-based benchmark and the hazardous substances can be attributed to the site, then the maximum value would be assigned to the MEI factor (proposed rule, section 4.1.3.1). Because mixing of hazardous substances depends on the characteristics of the body of water, EPA is proposing a three-mile zone of mixing for quiet flowing rivers with an average annual flow of greater than 50 cubic feet per second. Any intake within the mixing zone would be assigned a higher value than intakes on a similar size river that are not in the mixing zone.

Human Food Chain Threat. CERCLA section 105 (as amended by SARA), required EPA to consider the possible effects of hazardous substance releases on the human food chain in revising the HRS. In the ANPRM, EPA specifically sought comments on the addition of human food chain factors; most commenters supported the inclusion of factors in the HRS to assess the impact on the human food chain.

To develop the human food chain threat, EPA evaluated other ranking systems that considered human food chain effects. All the systems essentially used the same factors for determining exposure through the human food chain: a bioconcentration-type factor coupled with an estimate of the amount of food ingested. EPA has included these factors in the proposed human food chain threat.

The likelihood of release would be calculated as explained earlier. In evaluating exposure via the human food chain, a single hazardous substance would be selected on the basis of its bioaccumulation potential and its toxicity and persistence. The same hazardous substance would be used to evaluate all the waste characteristics and target factors for the human food chain exposure calculations, but would not necessarily be the same hazardous substances used in evaluating drinking water or recreational uses or sensitive environments. All hazardous substances known to be at the site and not contained in such a way as to prevent migration to the surface water would be eligible to be assessed for bioaccumulation. Each eligible hazardous substance would be assigned a bioaccumulation potential value and the hazardous substance with the highest value would be used in assessing human food chain exposure; if more than one hazardous substance has the highest value, the one with the highest toxicity/persistence value would be chosen (proposed rule, section 4.2.2.1.4). EPA specifically requests comments on the use of a single hazardous substance to score the human food chain threat.

The data that would be used to determine bioaccumulation potential are, in order of preference, bioconcentration, the logarithm of the octanol-water partition coefficient, and water solubility. Because, for the purpose of the HRS, EPA considers that bioconcentration provides the best measure of bioaccumulation (see the Technical Support Document for further detail), bioconcentration values are proposed as the principal means of evaluating the potential for hazardous substances to increase in concentration in an organism (proposed rule, section 4.2.2.1.1). Bioconcentration values would be assigned based on either EPA Water Quality Criteria Documents or on peer-reviewed literature.

If bioconcentration data are not available, the logarithm of the octanol-water partition coefficient data could be used as a surrogate. The logarithm of the octanol-water partition coefficient has been found to have a statistically significant linear correlation with the logarithm of the bioconcentration factor of organic chemical compounds. If bioconcentration and log octanol-water partition coefficient data are not available or if the log octanol-water partition coefficient exceeds 6.0, water solubility data could be used because they also have a statistically significant correlation with the bioconcentration factor for organic compounds.

If a hazardous substance biomagnifies—that is, if the tissue concentration of the bioaccumulated hazardous substance increases at each step in the human food chain—the assigned value would increase by one in all cases, subject to a maximum. The bioaccumulation value would be employed to select the hazardous substance used in evaluating the toxicity/persistence factor, except as mentioned above when two substances have the highest bioaccumulation value. In addition, the bioaccumulation value would be used to evaluate targets. Therefore, the same hazardous substance has to be used for both calculations.

Waste Characteristics. Hazardous waste quantity and the toxicity/persistence factors would be calculated in the same way as in the drinking water waste characteristics factor, except that the predominant water category used to assign the persistence factor would be based on the type of water (e.g., lake, river) between the probable point of entry and the nearest fishery (proposed rule, section 4.2.2.1.3) as opposed to the predominant water category between the probable point of entry and the nearest water intake. The waste characteristics score is the sum of the hazardous waste quantity factor and the toxicity/persistence factor values (proposed rule, section 4.2.2.3).

Targets. This category would reflect the threat to people from consumption of aquatic food chain organisms taken from the surface water migration path. Human food chain organisms are not limited to finfish, but could include other species used as human food. The human population exposed to hazardous substances through the aquatic food chain may be distinctly different from the local population, particularly if contaminated fish are caught for nonlocal commercial distribution. The potentially wide distribution of contaminated fish makes direct counting of the people who consume the fish infeasible. Furthermore, the direct counting or estimation of the population involved in local recreational or subsistence fishing is also not feasible. Thus, EPA is proposing a surrogate approach: the target population would be estimated based on the amount of food chain products harvested from the contaminated surface water body and the bioaccumulation of the hazardous substance. Two factors would be summed to obtain the human food chain targets value: population and fishery use.

The population factor value would be the sum of two factors: potential human food chain contamination and actual human food chain contamination (proposed rule, section 4.2.3.1.3). Actual contamination would be used to score a fishery only if, within the limits of the observed release, there is a closed fishery (or a portion of a closed fishery) and the hazardous substance(s) that caused the closing have been documented in an observed release from the site; or, a tissue sample from a fishery exceeds an FDA action level and the hazardous substance(s) that exceeds the action level has been documented in an observed release from the site. If either of these conditions apply, the actual human food chain contamination (population) score for the fishery would be based on the human food chain population value, which is derived from a matrix of the bioaccumulation potential value and the human food chain production values (proposed rule, sections 4.2.3.1 and 4.2.3.1.2).

The human food chain production is the annual production (in pounds) of human food chain organisms from within the fishery under evaluation. Human food chain production would be estimated from actual data on yield, where available. If actual data are not available, actual data on productivity should be used, and, if these are not available, default values for the standing crop of the water body should be used. If the standing crop data are used, they would be converted to pounds and then multiplied by 0.2 to convert the standing crop data to human food chain production yield. This conversion factor represents an assumed ratio between the amount of aquatic organisms caught and the amount of aquatic organisms within the surface water body.

The value for the actual human food chain contamination would be the sum of the human food chain population values for each fishery, subject to a maximum. EPA is soliciting comments on the use of 0.2 to convert standing crop data to catch in estimating human food chain production.

If the conditions for actual human food chain contamination are not met, scoring of the fishery would be based on potential contamination (proposed rule, section 4.2.3.1.1). The potential human food chain contamination (population) score would be calculated in the same manner as actual human food chain population, except that for each fishery, it would be multiplied by a dilution weighting factor based on the flow, and would be divided by 100, similar to the approach taken to evaluate potential contamination for the drinking water threat.

The fishery use factor would reflect the nature and utility of the fishery area. The surface water in question would be assigned values according to whether it is used for commercial fishing for human consumption, subsistence fishing, or recreation or sport fishing (proposed rule, section 4.2.3.2). This factor would be a means of putting a high value on the resource and therefore protecting both the resource and the human users.

Either the drinking water use factor or the fishery use factor would be assigned a value of zero so as to assign only the highest overall use value to the surface water and prevent double counting of surface water use. The method used to determine which factor would be assigned the nonzero value is specified in the proposed rule, section 4.2.3.2.

Recreation Threat. The current HRS does not consider the significance of possible recreational exposures to hazardous substances occurring at or near Superfund sites except as a subfactor of surface water use. No mechanism is included to estimate relative risks from recreational exposure to hazardous substances. In response to the SARA requirement (see CERCLA section 105(c)(2), as amended) that risks from recreation in contaminated surface water be appropriately assessed, the Agency performed an analysis to estimate potential risks to swimmers and fishermen (exclusive of any food chain risks) who might use surface water near selected current NPL sites. EPA concluded that health risks from recreational surface water exposures may be potentially significant at some sites. In addition, EPA has confirmed that some surface waters near NPL sites are used for recreation. Consequently, EPA is proposing a method of evaluating such risks as part of the surface water pathway.

EPA's efforts have focused on methods of evaluating waste characteristics and target category factors; the likelihood of release category would be the same as in the drinking water threat.

Waste Characteristics. In the waste characteristics factor category, two factors would be included: toxicity/

persistence and hazardous waste quantity. In evaluating toxicity/persistence, a dose adjusting factor would be assigned. The dose adjusting factor represents the ratio of the dose to an individual that would be obtained via recreation to that dose that would be obtained via consumption of the same water (proposed rule, section 4.3.2.1.1). The dose adjusting factor makes use of a dermal permeability constant that accounts for dermal exposures and a mass flux dilution factor that accounts for inhalation exposures, and is explained in more detail in the Technical Support Document.

From the set of hazardous substances with the highest dose adjusting factor, the substance with the highest toxicity/persistence value would be selected. The toxicity and persistence values would be determined by the same procedures used in the drinking water subpathway, as would hazardous waste quantity (proposed rule, sections 4.3.2.1.4 and 4.3.2.2.). The toxicity/persistence value would be added to the hazardous waste quantity factor value to obtain the recreation threat waste characteristics value.

Targets. The targets factor category reflects the population potentially at risk from an actual or potential release of hazardous substances from the site to surface waters used for recreation (swimming or fishing). The targets category has one factor, population, which would be evaluated for each recreation area within the target distance limit based on whether the recreation area is subject to actual contamination or potential contamination.

Only those people who use recreational areas within the limits of an observed release would be considered in the actual contamination factor. The recreation population value would be determined for each recreation area using appropriate distance categories and distance multipliers, an accessibility/attractiveness factor, and a recreational dose adjusting factor. Actual counts of the number of people who live within set distances (0–5 miles, 5–10 miles, etc.) from the recreational area would be multiplied by the distance category multipliers for each distance. Where actual population counts are not available, census data would be used. The values for the accessibility/attractiveness factor would be assigned based on the presence of specific improvements such as waterfront parks, boat ramps, designed swimming beaches, etc. (proposed rule, section 4.3.3.1.1.1). The dose adjusting factor value for the substance used to assign the toxicity/persistence value would be used to express the recreational population exposure in terms of an equivalent drinking water population exposure (proposed rule, section 4.3.3.1.1.2). The actual recreation population value for a recreation area would be divided by 10, and the highest value for any recreation area would be used as the value for this factor.

The potential contamination factor would be evaluated for recreational areas within the target distance limit that do not have documented contamination attributable to the site. A human recreation population value would be determined for each recreation area using the same method as for the actual contamination factor. The potential contamination value for a recreation area would be obtained by multiplying the recreation population value for that recreation area by the appropriate dilution weighting factor used for drinking water populations and dividing by 100. The potential contamination factor value would be the highest of the potential contamination values assigned to individual recreation areas within the target distance limit, subject to a maximum (proposed rules, section 4.3.3.1.2).

More detailed discussion of the recreation subpathway can be found in the Technical Support Document, along with other options EPA considered. EPA invites comments on refining these approaches.

The higher of the values for actual contamination and potential contamination would be assigned as the population factor value for the watershed (proposed rule, sections 4.3.3.1.3 and 4.3.4).

Environmental Threat. Sensitive environments are included in the current HRS surface water pathway as a factor in the targets category. The factor is assigned a value based on the distance to the particular type of sensitive environment involved. The revised HRS would place more emphasis on environmental damage and expand the types of environments considered, as discussed in section V C 6.

The likelihood of release would be determined in the same manner as it is in the drinking water subpathway.

Waste Characteristics. The hazardous waste quantity factor would be revised as discussed in section V C 3. Ecosystem toxicity would be combined in a matrix with persistence and would be evaluated for all hazardous substances at the site that are available to migrate to surface water. The final ecosystem toxicity/persistence score would be determined by the substance with the highest assigned value. The Agency requests comments on the appropriateness of using a single substance to evaluate toxicity in sensitive environments.

Because exposure of sensitive environments is more likely to be chronic than acute, the ecosystem toxicity value would be determined by using EPA chronic water quality criteria for the protection of aquatic life, if available. If these data are not available, EPA acute water quality criteria would be used and divided by 100. If EPA acute water quality criteria are not available, the lowest LC_{50} value (median lethal dose value from animal studies) for the hazardous substance would be used and again divided by 100 (proposed rule, section 4.4.2.1.1). The divisors are safety factors used to account for uncertainty.

Ecosystem persistence would be evaluated as described for drinking water, except that the predominant water category between the probable point of entry and the nearest sensitive environment would be used (proposed rule, section 4.4.2.1.2). The final ecosystem toxicity/persistence value would be derived from a matrix to reflect the relationship of these two factors in determining the relative threat posed by hazardous substances (proposed rule, section 4.4.2.1.3).

Hazardous waste quantity would be added to the toxicity/persistence value to obtain a score for the waste characteristics factor category.

Targets. This category reflects the sensitive environments potentially at risk from an actual or potential release of hazardous substances into surface water. The targets category consists of one factor, sensitive environments. Each sensitive environment would be given a value based on an expanded list of sensitive environments or the Natural Heritage Program information (see section V C 6). Each sensitive environment would be placed into three groups: (1) Those with contamination above ecologically-based benchmarks (Level I concentrations); (2) those with contamination not above ecologically-based benchmarks but significantly above background levels (Level II concentrations); and (3) those that could potentially be contaminated (proposed rule, section 4.4.3.1). Weighting factors would be applied to give the greatest weight to those sensitive environments with levels of contamination above the ecologically-based benchmarks; potentially exposed sensitive environments would be dilution weighted. (See discussion of weighting factors and benchmarks in sections V C 5, 6, and 8.)

The values assigned to the sensitive environments within each of these three groups would be added together to determine the environmental threat target factor score (proposed rule, section 4.4.3.1.4).

Surface Water Migration Pathway Score. The score for each threat (drinking water, human food chain, recreational, and environmental) would be the product of the likelihood of release value, the waste characteristics value, and the targets value (proposed rule, sections 4.1.4, 4.2.4, 4.3.4, and 4.4.4). The surface water migration score would be the sum of the scores for the four types of threats, subject to a maximum and normalized. As stated in the introduction to this section, a surface water migration score would be calculated for each watershed at a site (proposed rule, section 4.5). The surface water migration pathway score would be the sum of the watershed scores, subject to a maximum (proposed rule, section 4.6).

3. Air Pathway

As Figure 3 indicates, the proposed air pathway has the same general structure based on the three factor categories as in the current HRS air pathway. However, as stated before, EPA is proposing to revise every factor. The current HRS scores the air pathway using only observed releases; if no release can be documented, the pathway score is zero. The revised HRS would have a factor category to evaluate a site's potential to release substances to the air. In the waste characteristics category, a new mobility factor would be added. The targets category would have a new factor to assess the risk to the MEI.

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Figure 3

Air Migration Pathway

Current HRS

Release X	**Waste Characteristics** X	**Targets**
Observed Release	❏ Hazardous Waste Quantity ❏ Toxicity ❏ *Reactivity and Incompatibility*	❏ Land Use ❏ Population Within 4-Mile Radius ❏ Distance to Sensitive Environment

Revised HRS

Likelihood of Release X	**Waste Characteristics** X	**Targets**
Observed Release or POTENTIAL TO RELEASE ❏ SOURCE TYPE ❏ SOURCE MOBILITY* ❏ SOURCE CONTAINMENT	❏ Hazardous Waste Quantity* ❏ Toxicity/MOBILITY*	❏ Land Use ❏ Population ❏ MAXIMALLY EXPOSED INDIVIDUAL ❏ Sensitive Environments

Items in italic under Current HRS have been dropped or replaced.
Items in caps under Revised HRS are new. Most items not in caps have been revised significantly.

****Factor based on several sub-factors.***

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Likelihood of Release. Observed Release. EPA studied different approaches to monitoring observed releases to the air. As the Science Advisory Board stated in its review of the air pathway: "Because air emissions are often episodic or narrowly focused along a particular wind direction, they are difficult to observe." If weather conditions are unfavorable when sampling occurs (e.g., if there is a high wind), the sampling may result in a false negative. Improving the accuracy of air release observations would have required either substantially more monitoring or monitoring during specific meteorological conditions. Because, for most site inspections, sampling must be conducted during a single visit, which cannot always be scheduled at the optimum time, EPA has decided to retain the current system for scoring observed releases (proposed rule, section 2.1.1). To make the scoring of this factor more consistent, the Agency is proposing more specific criteria discussed in section V C 4.

Potential to Release. SARA (see CERCLA section 105(a)(8)(A) as amended), required EPA to consider potential releases of hazardous substances to the air. Because of the problems in sampling for the air pathway, air releases are often difficult to detect. Furthermore, sites that are not emitting hazardous substances into the atmosphere at the time of sampling may begin to do so at some later date. For these reasons, the Science Advisory Board encouraged the development of a potential to release factor for air. EPA is proposing to modify the HRS to include the potential for release when no observed release can be documented.

The proposed potential to release measure is intended to provide a reliable method for evaluating, in the absence of an observed release, the likelihood that a site will release a potentially significant amount of hazardous substances to the atmosphere (proposed rule, section 2.1.2). The potential for a site to release contaminants to the air is dependent on the physical characteristics of the site, the physical and chemical characteristics of the hazardous substances located at the site, and the ways in which the hazardous substances are contained. In the proposed revisions, three factors that correspond to these characteristics would be used to evaluate a site's potential to release hazardous substances—source type, source mobility, and source containment. Further information on air releases from Superfund sites and the options EPA evaluated in developing the potential to release calculation are provided in the Technical Support Document and in "HRS Issue Analysis: Options for Revising the Air Pathway," (Mitre, 1987) available in the Superfund docket.

A source type value would be assigned to each source at the site that meets a minimum size requirement as specified in the proposed rule, section 2.1.2.2; only sources that contain hazardous substances could be used to calculate size. The six types of sources that would be assigned values are: containers (including tanks); contaminated soil (including land treatment); fire sites; landfills; surface impoundments; and waste piles. The source type values reflect the likelihood that an uncontained source of that type would release a potentially significant amount of relatively immobile hazardous substances to the air.

Source mobility (proposed rule, section 2.1.2.3) reflects the relative propensity of hazardous substances contained in a source to migrate from a source as a gas or as particulates. For a gaseous hazardous substance, the mobility factor would be based on three physical-chemical characteristics of the hazardous substance: its vapor pressure, Henry's constant, and dry relative soil volatility. Gas mobility would be scored as specified in the proposed rule, section 2.1.2.3.1.

Particulate mobility represents the ability of particles contaminated with hazardous substances to escape into the air. Since the moisture content of the soil is a relative measure of particulate mobility, EPA is proposing to use the Thornthwaite Precipitation-Effectiveness (PE) index, a surrogate measure of the relative moisture content of the soil, as the basis for this factor (proposed rule, section, 2.1.2.3.2). The gas mobility factor and the particulate mobility factors would be combined in a matrix to obtain the mobility value for the source (proposed rule, section 2.1.2.3.3). A more detailed discussion of mobility is included in the Technical Support Document, available in the Superfund docket.

The third factor that would be considered to calculate the potential for release to air is the ability of the containment of hazardous substances to inhibit their escape. Containment includes natural and constructed barriers to escape. EPA would assign factor values for both gas containment and particulate containment; the higher of the two values would be used for the source (proposed rule, section 2.1.2.1).

Each source would be assigned a value calculated by adding its source type value and its source mobility value, and multiplying the sum by the containment value (proposed rule, section 2.1.2.4). The release potential value would be the highest of the values assigned to the sources at the site.

This factor approach to assessing potential for release was chosen because the principal alternative approaches, based on emission equations developed for sites regulated under RCRA, were only applicable to certain types of Superfund sites and would have required a substantial expansion of the site inspections. As described above, EPA believes the proposed scoring system will reflect the likelihood that the overall site will release contaminants to the air. EPA is seeking comments on whether these are the most appropriate factors to assess potential to release.

Waste Characteristics. In the waste characteristics category of the current HRS air pathway, the reactivity, incompatibility, and toxicity of the hazardous substances are evaluated, as is the hazardous waste quantity. The proposed HRS includes several revisions to the evaluation of the waste characteristics factor. The changes to toxicity and hazardous waste quantity are discussed in sections V C 2 and 3. The reactivity and incompatibility factors would be deleted because these factors primarily predict the likelihood of sudden releases. While these releases could be important in rare cases, they may not be applicable to the vast majority of Superfund sites. These events are more appropriately assessed when determining the need for removal actions that respond to imminent danger. The waste characteristics score in the proposed HRS would be the sum of the toxicity/mobility factor value and the hazardous waste quantity factor value.

EPA is proposing to add mobility to the waste characteristics category for air (proposed rule, section 2.2.1.2). The mobility factor would measure the tendency of a hazardous substance to migrate as a gas or as particulates. All hazardous substances available to migrate to the air would be evaluated for gas mobility. In addition, if the substance can migrate as a particulate, the site would be evaluated for particulate mobility. If a hazardous substance is present in a documented release, the assigned mobility value for that substance would be the maximum. The mobility of substances not found in observed releases would be calculated in the same way gas and particulate mobility are calculated under potential for release, with the higher of the two scores being used if a substance could migrate as either a gas or particulate.

The purpose of the mobility factor is to increase the accuracy of the waste characteristics factor category by taking into account the differing abilities of substances to migrate and, therefore, the relative threats posed by their release. The mobility and toxicity values for each substance would be combined in a matrix to reflect the importance of both in assessing risk; the substance with the highest toxicity/mobility value would be used to assign the factor value (proposed rule, section 2.2.1.3). Combining toxicity and mobility to select the substance would lead to selecting the substance that poses the most significant threat, thus increasing the accuracy of the HRS.

Targets. The current HRS evaluates three target factors: population within a four-mile radius, distance to a sensitive environment, and land use. The proposed HRS would revise these three factors and add a factor to reflect the risk to the MEI.

Several of the proposed changes to this factor category are discussed in sections V C 6, 8, and 9—the extension of the sensitive areas definition, the distance weighting factors, and the measurement of risk to the maximally exposed individual. In addition, EPA is proposing changes specific to the air pathway target factor category. While the Agency proposes to retain the four-mile target distance limit for humans, the target distance limit for sensitive environments would be extended from one and two miles to four.

Public comments have suggested that the four-mile target distance limit for the air pathway is too large. An EPA study presented to the Science Advisory Board, however, suggested that for sites with large emission rates of potential carcinogens, individual risks may remain of concern even at distances greater than four miles. In this study, EPA used a range of plausible contaminant emission rates from Superfund sites and a range of cancer potency values as input to a Gaussian air dispersion model. The results provided information on the range of risks due to air emissions found at varying distances from Superfund sites. The study—"Analysis of the Air Target Distance Limit in the Hazard Ranking System" (1987)—is available in the Superfund docket.

The Science Advisory Board reviewed the analysis and recommended a dilution weighting scheme that would capture the differences in concentrations at different distances from the site. EPA is proposing to retain the current four-mile target distance limit and would add weighting factors as discussed in section V C 8.

EPA is also proposing to revise the land use factor. The current HRS air pathway considers five categories of land use and assigns values to them depending on their distance from the site. The highest assigned value for any of the relevant land uses becomes the value used for the land use factor. The proposed rule (section 2.3.3) would change this method of determining the land use value in three ways. First, residential land use, now a single category, would be divided into single-family residences and multi-family residences, with the latter being assigned a higher value. Second, the assigned value for land use would be multiplied by the distance weighting factor. Third, the final land use factor would be the sum of all the land uses within the target distance. The inclusion of all land uses would provide better discrimination; the greater range of assigned values and the distance weighting would provide a more accurate assessment of the potential risk.

The sensitive environment factor would be distance weighted and all sensitive environments within four miles would be evaluated and summed (proposed rule, section 2.3.4). EPA would like comments on whether the evaluation of sensitive environments in the air pathway should be limited to terrestrial sensitive environments.

The final score for the targets category would be the sum of the four factors (population, sensitive environments, land use, and MEI) (proposed rule, section 2.3.5).

Air Migration Pathway Score. The air migration pathway score would be the product of the likelihood of release value, the waste characteristics value, and the target value, normalized (Proposed Rule, Section 2.4).

4. Onsite Exposure Pathway

Figure 4 shows the structure of the proposed onsite exposure pathway. There is no current onsite exposure pathway. To parallel the proposed rule, this section discusses the three factor categories for the resident population, then for the nearby population.

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Figure 4

ONSITE EXPOSURE PATHWAY

REVISED HRS*

RESIDENT POPULATION THREAT

LIKELIHOOD OF EXPOSURE	X	WASTE CHARACTERISTICS	X	TARGETS
❏ OBSERVED CONTAMINATION		❏ TOXICITY		❏ HIGH RISK POPULATION ❏ TOTAL RESIDENT POPULATION ❏ TERRESTRIAL SENSITIVE ENVIRONMENTS

NEARBY POPULATION THREAT

LIKELIHOOD OF EXPOSURE	X	WASTE CHARACTERISTICS	X	TARGETS
❏ ACCESSIBILITY/ FREQUENCY OF USE ❏ HAZARDOUS WASTE QUANTITY		❏ TOXICITY		❏ POPULATION WITHIN 1 MILE

***The current HRS includes a direct contact pathway, but that pathway is not used in calculating the overall HRS migration score.**

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CERCLA (section 105(8)(A)) required EPA to take into account the potential for direct human contact in setting priorities for the NPL. When the HRS was promulgated in 1982, EPA explained that hazards from direct contact with hazardous substances would be addressed and controlled by a CERCLA emergency response action prior to remedial action and therefore the direct contact pathway did not need to be included in the HRS migration score. The direct contact portion of the current HRS calculates the potential for direct exposure to hazardous substances in a way that essentially parallels the migration pathways, but is not included in the score used to determine if a site should be on the NPL.

In developing the proposed revisions, EPA analyzed the Records of Decisions (RODs) produced during the first four years of the Superfund program. (A ROD is the documentation of the decision process associated with the selection of a remedy for a site.) This analysis showed that in over 50 percent of the NPL sites, direct contact was listed as one of the considerations in selecting the remedial action. This analysis indicated that some significant risks from direct contact may not have been completely addressed by removal actions and should be of concern in determining priorities for remedial action. The analysis is available in the Superfund docket.

Based on its review and its experience, and in order to better respond to the mandate in CERCLA section 105(8)(A) (now CERCLA 105 (a)(8)(A)), EPA is proposing to add a separate onsite exposure pathway, similar to the direct contact pathway, that would be included in the calculation of the total HRS site score (proposed rule, section 5.0). EPA considered incorporating direct contact exposures in the other migration pathways. However, soil ingestion at sites probably constitutes the most significant direct contact threat. The likelihood of soil ingestion represents a distinctly different mode of exposure than found in the other pathways. Therefore, EPA decided that a separate onsite exposure pathway would more directly and more accurately reflect the potential threat.

The proposed onsite exposure pathway score would consist of two population groups evaluated for the three factor categories (likelihood of exposure, waste characteristics, and targets), and is constructed in a way similar to the surface water threats. The first group is the resident population, including people living on a property where contamination is (or can be inferred to be) significantly above background levels, people attending schools or day care on such property, or sensitive environments that have become contaminated (proposed rule, section 5.1). The second group consists of the nearby population, composed of people who have access to a contaminated area (proposed rule, section 5.2). EPA asks for public comments on this breakdown.

Resident Population Threat. Likelihood of Exposure. The revised HRS would evaluate the resident population likelihood of exposure (proposed rule, section 5.1.1) based on the presence of contamination and not on release potential, as in the other pathways, because no migration of contaminants off-site is necessary for exposure to occur; people live on or attend school or day care on the site, or the contamination is in a terrestrial sensitive environment.

The proposed HRS would require documented, analytic evidence of contamination above background levels in order to assign a score for the pathway. The criteria for contamination would be the same as for the other pathways (see section V C 4); samples would be taken within a specified depth below the surface.

As set forth in the revised HRS, it would be possible to infer that properties are contaminated, even though no soil samples demonstrate contamination on these properties, if surrounding properties show contamination. This approach would also require that the likely mechanisms of transport (overland flow, air, etc.,) be considered along with topography and other factors to determine whether such interpolation of sampling results is reasonable. The Agency considered the alternative approach of only counting targets living on properties where sampling had demonstrated contamination; however, that approach would most likely result in either much higher costs for site inspections due to the increase in soil sampling or in less accuracy, if insufficient samples were taken. While the Agency has proposed the approach of interpolating from soil sampling and other information to demonstrate contamination, comments are solicited both on the approach selected and on guidance for implementing it. The guidance will need to address such issues as methods for establishing background levels of hazardous substances and interpretation of negative sample results within the boundaries of the contaminated area. In addition, the Agency recognizes that the approach of using property boundaries to define contaminated residential land may be problematic in certain situations, such as Federal installations or Indian lands, where residential areas could be within the contaminated "property" and be at considerable distance from the hazardous substances. The Agency is seeking comment on how such situations could be addressed in the revised HRS.

Waste Characteristics. Toxicity would be the only factor in this factor category and would be calculated as discussed in section V C 2.

Targets. The three target subgroups considered in the resident population factor would be children under seven, the total resident population, and sensitive environments (proposed rule, section 5.1.3). These values for these three factors would be added together to obtain the targets category score. Children under seven are considered a high risk subgroup because they have much higher soil ingestion rates than other people. The children counted in the high risk group would include those attending school or day care on contaminated property plus those who live on the contaminated property. Individual children could be counted only once in this factor category. These high risk individuals would be assigned scores five times that of individuals in the rest of the resident population (proposed rule, section 5.1.3.1).

The total resident population would include everyone who lives or goes to school on the property except those individuals already counted under the high risk population (proposed rule, section 5.1.3.2).

A high-risk population of 10 or a total resident population of 50 would be required to assign the maximum target score if there are no affected sensitive environment targets. EPA decided that onsite exposures to a very small number of people warrant assigning a high priority to the site because individual risks can be very high. Also, onsite exposures can lead to an extremely high level of public concern.

The Agency requests comments on the division of the population and on the relative weights. It also requests suggestions on how the high risk population can best be determined.

Any contaminated terrestrial sensitive environments would also be assigned a value (proposed rule, section 5.1.3.3). For this pathway, sensitive environments include only terrestrial environments; aquatic ecosystems would be addressed in the surface water pathway.

The resident population threat score would be calculated by multiplying the likelihood of exposure, waste characteristics, and targets categories (proposed rule, section 5.1.4).

Nearby Population Threat. Likelihood of Exposure. The likelihood of exposure factor category in the revised HRS would evaluate the relative risks a site poses to the nearby population by considering the quantity of hazardous waste on the site and the site's accessibility/frequency of use. The hazardous waste quantity would be evaluated based on the total areal extent of the contamination (proposed rule, section 5.2.1.1). Contaminated area would be used in the onsite exposure pathway for the hazardous waste quantity factor because, for the onsite pathway, this factor evaluates the probability that wastes will be encountered, not the severity of exposures.

The accessibility/frequency of use factor would also evaluate the likelihood that wastes will be encountered. Accessibility refers to natural barriers or measures taken to limit access. Frequency of use is assigned a value based on estimates of use. Documented contamination of school property, parks, etc., would be assigned the maximum value because, by their very nature, the public is attracted to them. Schools onsite are included in this factor because other members of the community besides students use them. The value assigned to other contaminated properties would decline as the numbers of barriers increase, with the lowest value assigned to areas protected by a combination of natural and artificial barriers that completely surround the site and by guards who control entry at all times (proposed rule, section 5.2.1.2). No site would receive a score of zero for this factor because EPA considers that no system can provide a completely effective barrier.

Accessibility/frequency of use and waste quantity would be combined in a matrix to assign a value for the likelihood of exposure factor category (proposed rule, section 5.2.1.3).

EPA specifically requests comments on the appropriateness of basing the estimate of likelihood of exposure for the nearby population on site area and accessibility/frequency of use, the criteria used to assign accessibility/frequency of use, and the scales assigned to site areas.

Waste Characteristics. Toxicity would be the only factor in this category and would be assigned the same value for the nearby population as it would be for the resident population.

Targets. Individuals would be counted in the nearby population if they live or go to school or day care within a one mile travel distance of the contaminated site. As described in section V C 8, the nearby population would be distance weighted. The potential for exposure of nearby populations to contaminated soils and wastes is expected to be significantly less than resident population exposures. The Agency proposes to weight nearby populations at least 20 times lower than resident populations to reflect a reasonable estimate of the relative exposure levels. Individuals farther from the site would be weighted even lower to reflect the assumption that frequency and probability of access decrease with increasing distance from the site (proposed rule, section 5.2.3).

The nearby population targets section does not include a factor for sensitive environments. EPA concluded that relative to the harm measured by the terrestrial sensitive environments factors in the resident populations section and in other pathways, the threats to sensitive environments located near areas of contamination are much less, and therefore inclusion of a sensitive environment factor is not warranted. In addition, sensitive environments would be evaluated in the other pathways.

The nearby population threat score is calculated by multiplying the values for likelihood of exposure, waste characteristics, and targets (proposed rule, section 5.2.4).

Onsite Exposure Pathway Score. The final pathway score would be calculated by adding the resident population score and the nearby population score, subject to a maximum (proposed rule, section 5.3). As discussed above, the maximum for the pathway is also the maximum for either the resident population score or the nearby population score.

5. Fire and Explosion

Although the current HRS evaluates the risk of fire and explosion at sites to determine if removal actions may be required, the score for the fire and explosion pathway is not included in the final HRS migration score. EPA's experience indicates that the fire and explosion pathway would not provide a useful basis for scoring a site for remedial action. The potential for fire and explosion is evaluated in another part of the Superfund program, the removal program, to determine if a removal action is necessary. Therefore, the proposed HRS would not include a fire and explosion pathway.

E. CERCLA Section 125

Section 125, added by SARA, requires EPA, in revising the HRS, to address facilities that contain substantial volumes of waste specified in section 3001(b)(3)(A)(i) of RCRA. These wastes include fly ash wastes, bottom ash wastes, slag wastes and flue gas emission wastes generated from combustion of coal and other fossil fuels. Section 125 requires EPA to revise the HRS in a manner which assures the appropriate consideration of the quantity, toxicity, and concentrations of the hazardous constituents present in such wastes in comparison with other wastes; the extent of, and potential for release of such hazardous constituents; and the degree of risk these hazardous constituents pose to human health and the environment.

The Agency believes that the proposed revisions to the HRS address the requirements of section 125 in a number of different areas. First, the toxicity factor has been revised to include chronic and carcinogenic risks. The revised toxicity factor will provide for a better indication of the comparative toxicity of substances and will provide greater discrimination among sites. Thus, the toxicity of fly ash wastes will be more accurately reflected in HRS scores.

Second, to more fully consider the quantity and concentration of hazardous constituents at fly ash waste sites, the revised HRS will incorporate a tiered approach for calculating the hazardous waste quantity factor. Such a tiered approach would use the best data available at a site to calculate waste quantity, including constituent concentration data, if adequate. The revised HRS would consider the concentration of a hazardous substance in three ways: (1) By assigning a higher score to populations drinking water with contamination that exceeds a health-based benchmark; (2) by outlining specific criteria for determining the significance of an observed release, thus improving the way the HRS evaluates risk; and (3) by distance/dilution weighting targets subject to potential contamination.

Third, the revised HRS will consider the extent of, and potential for, release of hazardous constituents from fly ash waste sites into the environment by the observed release criteria, the revised method for calculating hazardous waste quantity, and the addition of factors that would improve the way the HRS evaluates the potential for hazardous substances to be released. In the ground water pathway, such factors include the revised depth to aquifer/hydraulic conductivity factor, the sorptive capacity factor, and the mobility factor. To improve the potential to release evaluation in the surface water pathway, the revised HRS would replace the current potential to release factors with two new groups of factors, overland flow and potential to release by flood. In addition, the revisions to the persistence factor in the surface water pathway to include mechanisms for attenuation other than biodegradation would provide a more accurate assessment of the potential for hazardous substances to migrate. In the air pathway, the potential for a hazardous substance to be released would be considered by the addition of a potential to release mechanism, which would take into account source type, source size, and the mobility of hazardous substances at the site.

Fourth, the degree of risk to human health and the environment posed by such constituents would be appropriately considered in the revised HRS by:

- Revising the toxicity factor to include chronic toxicity;
- Improving the calculation of hazardous waste quantity by enabling the HRS to use more complete data, if available;
- Adding a mobility factor to the ground water and air pathways that would better assess the potential for contaminants to migrate;
- Revising the evaluation of potential to release in the ground water and surface water pathways;
- Adding a potential to release category in the air pathway;
- Specifying criteria for determining when an observed release is significantly above background;
- Using health-based and ecological benchmarks for weighting the targets actually exposed to contamination; and
- Adding distance and dilution weighting for targets potentially exposed to contamination.

Mining Wastes. Although SARA did not require EPA to revise the HRS with specific reference to mining wastes, the Agency received a number of comments on mining waste issues in response to the previous NPL rulemakings and to the ANPRM. The primary concern of the commenters was that the HRS may be biased against high volume, low concentration wastes because it does not adequately consider quantity, toxicity, and concentration of hazardous constituents.

In considering these issues, EPA evaluated studies conducted by commenters and conducted additional studies to determine whether HRS scores for mining sites versus non-mining sites were too high relative to the potential hazard they posed.

One study was a comprehensive analysis of the HRS scoring patterns of 406 sites on the NPL (mining and non-mining) plus 297 sites considered but not on the NPL at that time. The basic finding was that mining and non-mining NPL sites do not differ significantly in their scoring patterns for observed releases, population/distance scoring, or toxicity/persistence scoring. Mining sites generally do score higher on the hazardous waste quantity factor. However, hazardous waste quantity is a relatively less important determinant of HRS scores than several other factors. In addition, the maximum hazardous waste quantity score in the current HRS (2,500 tons and higher) covers a wide range of quantities reported at sites (e.g., 5,000,000+tons). This large upper category of the scoring range diminishes the relative impact of very large quantities of waste.

A second study provided relevant information on waste and constituent quantities at six high-volume waste sites. For three of the sites, the quantity of hazardous substances present was estimated using site-specific information on constituent concentrations and amounts. For the other three sites, constituent quantities were estimated based on the quantity of hazardous waste reported on HRS scoring sheets for the site and generic constituent concentration ranges for the appropriate mining industry segment/district. The estimated quantity of hazardous constituents present at each site exceeded 2,500 tons, which is the cutoff value for the maximum hazardous waste quantity score. Therefore, these six sites would have received the maximum hazardous waste quantity score even if only the quantity of hazardous constituents present had been evaluated rather than the quantity of waste. In fact, at the six sites, the estimated amount of hazardous constituents exceeded the total amount of hazardous wastes at more than 60 percent of other NPL sites.

A third study compared HRS scores with the results of an analysis of potential dangers for six actual mining waste sites. The sites were chosen primarily on the basis of data availability. Site information relating to potential risks to human health and the environment was compiled for all four migration pathways. Although the six sites were not randomly selected and cannot be construed as representative of all mining waste sites, some conclusions can be drawn. All six sites were associated with a high potential risk rating in at least one exposure route. In addition, they demonstrate that any or all HRS pathways may be associated with significant potential risk at mining waste sites.

Within the six sites, higher HRS scores generally were associated with higher potential danger ratings and also with sites having a large number of potentially dangerous exposure routes. This result gives limited evidence that HRS scores may correlate with potential risk at mining waste sites. While all three studies covered a limited number of sites, they do suggest that the HRS score does not unfairly treat mining waste sites.

EPA requested the assistance of the Science Advisory Board regarding the applicability of the HRS in scoring mining waste sites. The studies discussed above are summarized in a report prepared for the Science Advisory Board deliberations entitled "The Superfund Hazard Ranking System (HRS): Applicability to Mining Wastes Sites" (ICF, Inc., July 1987). The report and the studies are available in the Superfund docket. The Board examined the scientific issues pertinent to waste and site characteristics and past HRS experience scoring mining waste sites. The Board concluded that, based on past experience, there is no evidence to demonstrate that the HRS is biased against these sites. However, the Board cautioned that the current HRS has the potential for bias when calculating a score based on potential to release. The Board suggested ways to improve the HRS in regard to large volume waste sites, including modifying the toxicity factor to reflect characteristics of metals, incorporating concentration and mobility factors, and adding transformation parameters. The new mobility factors in air and ground water, the revised persistence factor in surface water, and the new sorptive capacity factor in ground water will improve the accuracy of the revised HRS in evaluating the potential risk posed by mining waste sites.

The Agency also requested the Science Advisory Board's assistance on a related subject—the feasibility of using concentration data in determining the hazardous waste quantity factor. The report presented to the Science Advisory Board—"The Superfund Hazard Ranking System (HRS): Feasibility of Using Concentration Data in a Revised HRS" (ICF, Inc., July 22, 1987)—is available in the Superfund docket.

In response to the issue of using concentration data in calculating the hazardous waste quantity factor, the Board analyzed two options besides the current method (see section V C 3). The proposed tiered approach is based on the Board's recommendation. From comments it has received, EPA expects that sufficient data may be available at certain types of sites, which could allow these sites to be scored using the highest tier in calculating the waste quantity factor.

The Board's conclusions and recommendations are available in the Superfund docket.

VI. Required Analyses

A. Executive Order No. 12291

Under Executive Order No. 12291, the Agency must judge whether a regulation is "major" and thus subject to the requirement of a Regulatory Impact Analysis. The notice published today is not major because the rule will not result in an effect on the economy of $100 million or more, will not result in increased costs or prices, will not have significant adverse effects on competition, employment, investment, productivity, and innovation, and will not significantly disrupt domestic or export markets.

An initial economic analysis entitled "Economic Impact Analysis in Support of the Proposed Revisions to the Hazard Ranking System" (U.S. EPA, January, 1988) was prepared to estimate the incremental costs associated with alternatives to the current HRS. This analysis compared the estimated cost of the revised HRS with the current HRS and with two alternative ranking systems—the Department of Energy's Remedial Action Priority System, the model that, with the revised HRS, did well in the site ranking panel review, and the revised HRS with a direction of ground water flow factor included. The analysis indicates that the revised HRS will cost more than the current HRS, but would be less costly than either of the other alternatives. The results of evaluating sites using the current HRS or any other alternative model are those costs incurred to collect the data and score a site. The best estimate of the average cost of the current HRS is $58,200 per site. The best estimates for the average cost per site for the alternatives are $147,600 for the proposed revised HRS, $217,000 for the revised HRS plus ground water flow direction, and $261,700 for the Remedial Action Priority System. The economic impact analysis is available for inspection in the Superfund docket.

Based on the results of the economic analysis, EPA has concluded that the proposed HRS is not a major rule under Executive Order No. 12291. The proposed HRS is expected to impose total costs of $56.0 million and expected to impose costs on society of $9.0 million over current HRS expenditures, well below the $100 million annual effect on the economy that defines a major rule. At this point, it is impossible to predict whether the revised HRS would result in more or fewer sites being included on the NPL.

This proposed rule has been submitted to the Office of Management and Budget (OMB) for review as required by Executive Order No. 12291.

B. Regulatory Flexibility Act

In accordance with the Regulatory Flexibility Act of 1980, Federal agencies must evaluate the effects of a rule on small entities and examine alternatives that may reduce these effects. EPA certifies that the proposed HRS will not have a significant impact on a substantial number of small entities.

Small businesses generally do not pay for HRS activities and therefore, most firms will not be affected by the proposed changes. In some cases, a responsible party may be required to pay HRS costs. EPA prepared an analysis of the potential impact the revised HRS would have on firms required to pay for HRS activities. The results of the financial analysis demonstrate that four out of five sample small firms had the assets or income to enable them to finance HRS action. (See Appendix A of the economic report.)

C. Paperwork Reduction Act

The information collection requirements in this proposed rule have been submitted for approval to the Office of Management and Budget under the *Paperwork Reduction Act,* 44 U.S.C. 3501 *et seq.* An Information Collection Request document has been prepared by EPA (ICR No. 1488) and a copy may be obtained from Carl M. Koch, Information Policy Branch, EPA, 401 M St., SW. (PM-223), Washington, DC 20460 or by calling (202) 382-2739.

The public reporting burden for this collection of information is estimated to vary from 1280 to 1500 hours, with an average of 1390 hours per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Chief, Information Policy Branch, PM-223, U.S. Environmental Protection Agency, 401 M St., SW., Washington, DC 20460; and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503, marked "Attention: Desk Officer for EPA." The final rule will respond to any OMB or public comments on the information collection requirements contained in this proposal.

List of Subjects in 40 CFR Part 300

Air pollution controls, Chemicals, Hazardous materials, Intergovernmental relations, Natural resources, Oil pollution, Reporting and recordkeeping requirements, Superfund, Waste treatment and disposal, Water pollution control, Water supply.

Date: November 15, 1988.

Lee M. Thomas,
Administrator.

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

PART 300—NATIONAL OIL AND HAZARDOUS SUBSTANCE POLLUTION CONTINGENCY PLAN

1. The authority citation for Part 300 is revised to read as follows:

Authority: 42 U.S.C. 9605, 9618, 9625(a); 33 U.S.C. 1321(c)(2); E.O. No. 11735, 38 FR 21243; E.O. No. 12580, 52 FR 2923.

2. Part 300, Appendix A is revised to read as follows:

Appendix A to Part 300—The Hazard Ranking System

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1.0 Introduction

The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) (Pub. L. 96-510) required the President to identify at least 400 facilities in the nation which appear to warrant remedial investigation and possible cleanup under CERCLA. In order to set the priorities, CERCLA required that criteria be established based on relative risk or danger to public health, welfare or the environment, taking into account the population at risk; the hazard potential of the substances at a facility; the potential for contamination of drinking water supplies, for direct human contact, and for destruction of sensitive ecosystems; and other appropriate factors. To meet these requirements, EPA developed the Hazard Ranking System (HRS).

The HRS is a means of applying uniform technical judgment regarding the relative potential of releases of hazardous substances to threaten human health and the environment. The evaluation of sites for inclusion on the National Priorities List (NPL) is based primarily on HRS scores. The HRS does not, however, address the feasibility, desirability, or degree of cleanup required. Neither does it deal with the readiness or ability of a State to carry out such remedial action as may be indicated, or to meet other conditions prescribed in CERCLA.

The Superfund Amendments and Reauthorization Act of 1986 (SARA) (Pub. L. 99-499) requires the President to revise 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" (CERCLA section 105(c)(1), as amended). The revisions must ensure that human health risks associated with the contamination or potential contamination of surface waters are appropriately assessed where such waters can be used for recreation or drinking water. The revisions must also provide for consideration of damage to natural resources which may affect the human food chain, and releases or threats of releases which may affect the ambient air. CERCLA section 118, added by SARA, also requires that a high priority be given "to facilities where the release of hazardous substances or pollutants or contaminants has resulted in the closing of drinking water wells or has contaminated a principal drinking water supply." Finally, CERCLA section 125, added by SARA, requires the revisions to the HRS to consider the following characteristics for facilities (not included or proposed for inclusion on the NPL on the date of enactment of SARA) which contain substantial volumes of wastes described in section 3001(b)(3)(A)(i) of the Solid Waste Disposal Act: (1) The quantity, toxicity, and concentrations of hazardous constituents which are present in such wastes and comparison thereof with other wastes, (2) the extent of, and the potential for, release of such hazardous constituents into the environment, (3) the degree of risk to human health and the environment posed by such constituents.

This Appendix describes the HRS, as revised pursuant to SARA. Under this rule, an HRS score is determined for a site by evaluating four pathways:

- Air migration.
- Ground water migration.
- Surface water migration.
- Onsite exposure.

The score for each pathway is obtained by first evaluating a set of factors (e.g., observed release, waste quantity, and maximally exposed individual) that characterize the potential for the site to cause harm via that pathway. Each factor is assigned a numerical value according to the instructions in sections 2 through 5 of this document. All factor values assigned must be rounded to the nearest integer, except where otherwise noted.

The factor values are then combined within factor categories (e.g., likelihood of release, waste characteristics, and targets). The values for the factor categories within a pathway are combined and the resultant value divided by the maximum possible score for that pathway. This ratio is multiplied by 100 to obtain the pathway score, subject to a maximum score of 100.

The HRS site score (S) is a composite of the four possible pathway scores:

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

where:

S_a = Air migration pathway score.
S_{gw} = Ground water migration pathway score.
S_{sw} = Surface water migration pathway score.
S_{os} = Onsite exposure pathway score.

The effect of this means of combining the pathway scores is to emphasize the primary (highest scoring) pathway in aggregating pathway scores while giving some additional consideration to the other pathways.

The HRS score does not quantify the probability of harm from a facility nor the magnitude of the harm that could result, although the factors have been selected in order to approximate both those elements of risk. The HRS is a procedure for ranking facilities relative to each other in terms of the potential threat they pose.

The following definitions apply to the HRS:

- The term "hazardous substance" refers to CERCLA hazardous substances, pollutants and contaminants as defined in CERCLA Sections 101(14) and 101(33), as amended.
- A "source" is any area where a hazardous substance has been deposited, stored, disposed, or placed. If there is a release of hazardous substances (e.g., a ground water plume), but no known source of the release, the source is defined for HRS purposes by the known extent of the release.
- A "site" is one or more sources that have been aggregated for the purpose of applying the HRS.
- HRS "factors" represent the primary rating elements internal to the HRS.
- An HRS "factor category" consists of a set of HRS factors.
- An "HRS pathway" consists of a set of factor categories.
- The "HRS site score" is a composite of the four pathway scores.

2.0 Air migration pathway.

The air migration pathway addresses the relative risks, to the people, resources, and the environment surrounding a site, that are associated with actual or threatened releases of hazardous substances from the sources on the site to the atmosphere. Three factor categories are included in the air migration pathway:

- Likelihood of Release (LR).
- Waste Characteristics (WC).
- Targets (T).

Figure 2-1 indicates the factors included within each of these factor categories. The evaluation of the factors and factor categories is discussed in the following sections.

Likelihood of Release (LR)		Waste Characteristics (WC)		Targets (T)
Observed Release or Potential to Release ● Source Containment - Gaseous Emissions - Particulates ● Source Mobility - Source Gas Mobility --Vapor Pressure --Henry's Constant --Dry Relative Soil Volatility - Particulate Mobility --Thornthwaite P-E Index ● Source Type	X	Toxicity/Mobility ● Toxicity - Acute - Chronic - Carcinogenic ● Mobility - Gaseous Substances --Vapor Pressure --Henry's Constant --Dry Relative Soil Volatility - Particulate Substances --Thornthwaite P-E Index Hazardous Waste Quantity ● Hazardous Constituent Quantity ● Wastestream Quantity ● Site Disposal Capacity	X	Maximally Exposed Individual Population Land Use Sensitive Environments ● Sensitive Environment Ranking ● National Heritage Program Ranking

FIGURE 2-1
OVERVIEW OF THE AIR MIGRATION PATHWAY

The air migration pathway score is calculated in terms of the factor category values as follows:

$$S_a = \frac{LR \times WC \times T}{SF}$$

where S_a is the air migration pathway score and SF is a scaling factor used to normalize the score to a scale of 0 to 100. This calculation procedure is outlined in Table 2-1.

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TABLE 2-1
AIR MIGRATION PATHWAY SCORESHEET

Factor Categories and Factors	Maximum Value	Value Assigned	
Likelihood of Release			
1. Observed Release	450	____	
2. Potential to Release (Highest value assigned to any source evaluated)	390	____	
3. Likelihood of Release (Higher of Lines 1 or 2)	450		____
Waste Characteristics			
4. Toxicity/Mobility	100	____	
5. Hazardous Waste Quantity	100	____	
6. Waste Characteristics (Lines 4 + 5)	200		____
Targets			
7. Maximally Exposed Individual	50	____	
8. Population	235	____	
9. Land Use	10	____	
10. Sensitive Environments	100	____	
11. Targets (Lines 7 + 8 + 9 + 10, subject to a maximum of 235)	235		____
Air Pathway Migration Score			
12. Pathway Score (S_a) [(Lines 3 x 6 x 11)/2.115 x 10^5]	100		____[1]

[1] S_a is not to be rounded to the nearest integer.

Figure 2–2 illustrates the process for developing an air migration pathway score.

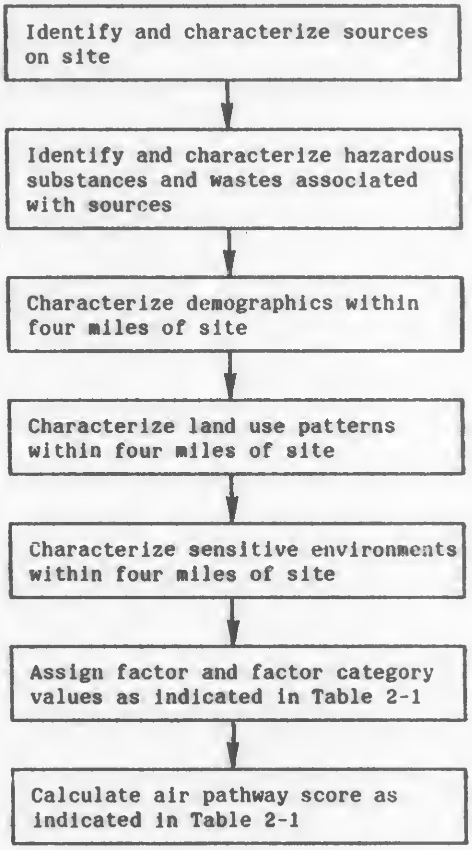

FIGURE 2-2
PROCESS FOR DEVELOPING AIR PATHWAY SCORE

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2.1 Likelihood of release.

The likelihood of release refers to the likelihood that the site has released, is releasing, or will release a potentially significant quantity of hazardous substances to the ambient air. The factor category value is determined in terms of an observed release factor and a potential to release factor.

2.1.1 Observed release.

An observed release to the atmosphere is established whenever it can be demonstrated that a site has released a hazardous substance to the atmosphere. This demonstration can be based on either direct observation of the release or indirect observation (i.e., the analysis of air samples).

In the case of direct observation, material (e.g., particulates) from the site must be seen entering the atmosphere directly. Further, available information must indicate that the material observed entering the atmosphere contained one or more hazardous substances. Such information should include an analysis of the hazardous substances contained in samples of the material or other similar documentation of the content of the material.

In the case of indirect observation, the samples must indicate that a significant increase in ambient hazardous substance concentration has occurred relative to the background concentration for the site (as described below). Further, the available information must support the attribution of some portion of the increase to the site. Attribution can be based on sampling information such as the location of the samplers or other source apportionment techniques.

A significant increase is determined by comparing atmospheric samples, one of which must be a background sample. The background sample should be chosen to reflect, as completely as possible, the concentration of the hazardous substance in the atmosphere exclusive of the contribution of any possible releases from the site. Further, the samples must be taken under the same atmospheric conditions (i.e., wind speed, wind direction, temperature, relative humidity, and any other conditions that might significantly affect sampling results).

The ambient concentration of a hazardous substance is considered to be significantly above background levels under the conditions presented in Table 2-2. The detection limit referred to in Table 2-2 may be the minimum of the actual detection limit achieved by the laboratory for the set of samples in question, the method detection limit achieved by the laboratory for a given analytical procedure (or, in the case of real-time field instruments, the detection limit of the instruments as used in the field), or, with one exception, the EPA contract-required quantitation limit (CRQL) or the EPA contract-required detection limit (CRDL) for the EPA Contract Laboratory Program. The exception is that the CRQL (or the CRDL) must not be used if the method detection limit or actual detection limit achieved is known and exceeds the CRQL (or the CRDL) or if the analysis is not performed under the EPA Contract Laboratory Program. The selection of the detection limit to be used may be done hierarchically, starting with the highest of the applicable detection limits. For example, when the CDRL is higher than the method detection limit achieved and use of the CRDL does not yield an observed release, then the method detection limit achieved can be used to evaluate an observed release.

TABLE 2-2—CONDITIONS NECESSARY TO DOCUMENT AN OBSERVED RELEASE

If background concentration is:	Observed release occurs if detected concentration is:
Not detected	Greater than or equal to 3 times the detection limit.
Greater than or equal to the detection limit, but less than 2 times the detection limit.	Greater than or equal to 3 times the applicable background concentration or greater than or equal to 4 times the detection limit, whichever is less.
Greater than or equal to 2 times the detection limit.	Greater than or equal to 2 times the applicable background concentration.

If an observed release can be established, then assign an observed release factor value of 450. If no observed release can be established, assign an observed release factor value of zero. Enter the value assigned on Table 2-1.

2.1.2 Potential to release.

Evaluate potential to release if an observed release has not been established. Potential to release assesses the likelihood of a site releasing a potentially significant amount of hazardous substances to the atmosphere. The potential to release factor is evaluated for the site by first evaluating the potential to release from each of the sources on the site. Three factors are evaluated in determining the potential to release from a source: source containment, source type, and source mobility.

Determine the potential to release value for each source as illustrated in Table 2-3. Use the highest of the source potential to release values as the value for the site potential to release factor.

TABLE 2-3—AIR PATHWAY POTENTIAL TO RELEASE EVALUATION

Source	Source type [1]	Source containment factor value [2]	Source type factor value [3]	Source mobility factor value [4]	Sum	Emission source value
		A	B	C	(B+C)	Ax(B+C)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
Potential to release factor value (Select highest emission source value)						

[1] Source Type from Table 2-6.
[2] Source Containment Factor Value from Section 2.1.2.1.
[3] Source Type Factor Value from Table 2-6.
[4] Source Mobility Factor Value from Table 2-10.

2.1.2.1 Source containment. Containment refers to the physical characteristics of a source that act to restrict emissions of hazardous substances from the source. Assign, to each source, factor values for both gaseous and particulate containment, using Tables 2-4 and 2-5. Select the higher of the gaseous and particulate containment factor value for that source.

TABLE 2-4—SOURCE CONTAINMENT FACTOR—GASEOUS EMISSIONS

Source type/gas containment descriptions	Assigned value
Container (including tanks)	
Below ground/buried containers	Evaluate as a landfill, etc.
Intact, sealed containers protected from the weather by a maintained cover	0
Intact, sealed containers not protected from the weather by a maintained cover	1
Open, unsealed, or nonintact containers: waste totally covered with an essentially impermeable, maintained cover	0
Open, unsealed, or nonintact containers: waste partially covered with an essentially impermeable, maintained cover	1
Open, unsealed, or nonintact containers: waste totally covered with an essentially impermeable, unmaintained cover	2
Open, unsealed, or nonintact containers: waste otherwise covered or uncovered	3
Other	1
Fire Site	
Former fire site	Evaluate as a landfill, etc.
Active above-ground fire site	3
Active below-ground fire site: uncontaminated [1] soil cover in excess of two feet	1
Active below-ground fire site: uncontaminated [1] soil cover less than two feet, soil resistant to gas migration.[2]	2
Active below-ground fire site: uncontaminated [1] soil cover less than two feet, soil not resistant to gas migration.[2]	3
Other	1
Landfill, Contaminated Soil (including Land Treatment), or Waste Pile.	
Functioning gas collection system	0
Existing, nonfunctioning gas collection system	3
Intact synthetic cover plus uncontaminated soil cover over 0.5 inches in depth.[1]	1
Totally covered with an intact synthetic cover: surface soil contaminated.[1]	3
Totally covered with a nonintact synthetic cover: surface soil contaminated.[1]	3
Uncontaminated soil cover [1] in excess of six inches	0
Uncontaminated soil cover [1] greater than one inch and less than six inches: cover soil resistant to gas migration.[2]	1
Uncontaminated soil cover [1] less than six inches: cover soil type unknown	1
Uncontaminated soil cover [1] greater than one inch and less than six inches: cover soil not resistant to gas migration [2]	2
Uncontaminated soil cover [1] less than one inch: cover soil resistant to gas migration.[2]	2
Uncontaminated soil cover [1] less than one inch: cover soil not resistant to gas migration [2]	3
Covering soil contaminated [1] with waste constituents at surface and no synthetic cover between surface and bulk of waste materials	3
Totally enclosed in a structurally intact building	1
Totally enclosed in a nonintact building	2
Waste uncovered or exposed	3
Other	1
Surface Impoundment	
Dry surface impoundment	Evaluate as a landfill, etc.
Wet enclosed [3] impoundment: impoundment totally covered with a maintained, essentially impermeable cover	0
Wet enclosed impoundment: impoundment totally covered with an unmaintained, essentially impermeable cover	1
Wet enclosed impoundment: impoundment partially covered with a maintained, essentially impermeable cover	1
Wet enclosed impoundment: impoundment partially covered with an unmaintained, essentially impermeable cover	2
Wet enclosed impoundment: uncovered, surface completely open to atmosphere	3
Wet nonenclosed impoundment: impoundment totally covered with a maintained, essentially impermeable cover	0
Wet nonenclosed impoundment: impoundment totally covered with an unmaintained, essentially impermeable cover	1
Wet nonenclosed impoundment: impoundment partially covered with a maintained, essentially impermeable cover	2
Wet nonenclosed impoundment: impoundment partially covered with an unmaintained, essentially impermeable cover	3
Wet nonenclosed impoundment: uncovered, surface completely open to atmosphere	3
Other	1
Other	0

[1] Lacking contrary evidence, covering soils are assumed to be uncontaminated.

[2] USGS soil types GC, ML, CL and CH are considered resistant to gas migration. Source: Adapted from Lutton, R. J., "Evaluating Cover Systems for Solid and Hazardous Wastes," (EPA-530/SW-867c), United States Environmental Protection Agency, Washington, D.C., September 1980.

[3] An enclosed impoundment is one with a freeboard exceeding two feet in height or one that is substantially surrounded by a wall, fence, trees or other adequate windbreak.

TABLE 2-5—SOURCE CONTAINMENT FACTOR—PARTICULATES

Source type/particulate containment descriptions	Assigned value
Container (including tanks):	
Below ground/buried containers	Evaluate as a landfill, etc.
Intact, sealed containers protected from the weather by a maintained cover	0
Intact, sealed containers not protected from the weather by a maintained cover	1
Open, unsealed, or nonintact containers: waste totally covered with a maintained cover	0
Open, unsealed, or nonintact containers: waste partially covered with a maintained cover	1
Open, unsealed, or nonintact containers: waste totally covered with an unmaintained cover	2
Open, unsealed, or nonintact containers: waste otherwise covered or uncovered	3
Other	1
Landfill, contaminated soil (including land treatment), fire site, or waste pile:	
Site covered with an essentially impermeable and maintained cover or heavily vegetated with no exposed soil or waste-bearing liquids (e.g., paved-over)	0
Site substantially vegetated or totally covered with a maintained non-water-based dust suppressing fluid. Little exposed soil or waste-bearing liquids	1
Site lightly vegetated or partially covered with a maintained nonwater-based dust suppressing fluid. Much exposed soil or waste-bearing liquids	2
Site substantially devoid of vegetation with a large percentage of exposed soil or waste-bearing liquids. No other cover	3
Totally enclosed in a structurally intact building	1
Partially enclosed in a structurally intact building	2
Totally enclosed in an nonintact building	2
Partially enclosed in an nonintact building	3
Substantially surrounded with windbreak (e.g., mesh or other fence, trees, etc.)	2
Active fire site	3
Other	1
Surface impoundment:	
Enclosed [1] impoundment: impoundment totally covered with a maintained cover	0
Enclosed impoundment: impoundment totally covered with an unmaintained cover	1
Enclosed impoundment: impoundment partially covered with a maintained cover	1
Enclosed impoundment: impoundment partially covered with an unmaintained cover	2
Enclosed impoundment: uncovered, surface completely open to atmosphere	3

TABLE 2-5—SOURCE CONTAINMENT FACTOR—PARTICULATES—Continued

Source type/particulate containment descriptions	Assigned value
Nonenclosed impoundment: impoundment totally covered with a maintained cover	1
Nonenclosed impoundment: impoundment totally covered with an unmaintained cover	2
Nonenclosed impoundment: impoundment partially covered with a maintained cover	2
Nonenclosed impoundment: impoundment partially covered with an unmaintained cover	3
Nonenclosed impoundment: uncovered, surface completely open to atmosphere	3
Other	1
Other	1

¹ An enclosed impoundment is one with a freeboard exceeding two feet in height or one that is substantially surrounded by a wall, fence, trees or other adequate windbreak.

2.1.2.2 Source type. For purposes of defining and evaluating sources, consider emission sources with all of the following characteristics as a single source:

- Sources of the same type.
- Sources containing the same hazardous substances.
- Sources with the same containment characteristics.

Assign to each emission source on the site that meets a minimum size requirement a source type factor value, using Table 2-6. The minimum size requirement is based on the source disposal capacity factor value defined in section 2.2.2. A source is considered to meet the minimum size requirements if, in evaluating that source, the source would receive a source disposal capacity factor value of one or more (using the rounding criteria in section 1.0). If no source meets the minimum size requirement, use only the descriptor "other" in Table 2-6 and assign a factor value of zero.

TABLE 2-6—SOURCE TYPE EVALUATION TABLE

Type of source ¹	Assigned value
Container (including tanks)	40
Contaminated Soil (including land treatment)	70
Fire Site	50
Landfill	60
Surface Impoundment	80
Waste Pile	30
Other	0

¹ Source must meet minimum size requirements as specified in section 2.1.2.2 in order to be used in the evaluation of the potential to release.

2.1.2.3 Source mobility. Source mobility refers to the propensity of the hazardous substances to migrate to the surface of the source area and escape into the atmosphere, based on their physical-chemical characteristics. The source mobility factor is evaluated using two mobility factors, one addressing gaseous hazardous substances, the other addressing particulate hazardous substances.

2.1.2.3.1 Source gas mobility. The source gas mobility factor reflects the potential of hazardous substances in a source to migrate to the surface/air interface and escape as a gas. The value assigned to gas mobility for a specific hazardous substance is based on three physical-chemical characteristics of the hazardous substance: vapor pressure, Henry's constant, and dry relative soil volatility.

For a specific hazardous substance, assign values for vapor pressure, Henry's constant and dry relative soil volatility using Table 2-7. Sum these three values, and assign a gas mobility value for the hazardous substance, based on this sum, as indicated in Table 2-8.

TABLE 2-7—GAS MOBILITY COMPONENT VALUES

	Assigned value
Vapor pressure:	
Above 10 torr ¹	3
Above 10–3 to 10 torr	2
10–5 to 10–3 torr	1
Less than 10–5 torr	0
Henry's constant: ²	
Above 10–3	3
Above 10–5 to 10–3	2
10–7 to 10–5	1
Less than 10–7	0
Dry relative soil volatility: ³	
Above 1	3
Above 10–3 to 1	2
10–6 to 10–3	1
Less than 10–6	0

¹ Torr is a unit of pressure equal to 1/760 of an atmosphere (i.e., 1 mm Hg).

² Henry's constant in terms of atm-m³/mol.

³ Dry relative soil volatility is a measure of the propensity of a gas to move through the air spaces in dry soil, as defined in U.S. Environmental Protection Agency, "Properties and Categorization of RCRA Wastes According to Volatility," EPA-450/3-85-007, U.S. Environmental Protection Agency, Office of Air Quality, Planning and Standards, Research Triangle Park, North Carolina, 1985. (Report prepared by Versar Inc., Springfield, VA, under EPA Contract 68-03-3041; report available through National Technical Information Service, Springfield, VA, as PB85-204527.) Dry relative soil volatility is determined by experimentation or, alternately if no such data exists, as $P_{vp}/MW^{1/4}$ where P_{vp} equals the vapor pressure of the substance at 25 °C and MW equals the molecular weight of the substance.

TABLE 2-8—SUBSTANCE GAS MOBILITY FACTOR VALUE

Sum of gas mobility component values	Assigned value
0 to 2	0
3 to 4	1
5 to 6	2
7 to 9	3

Calculate the source gas mobility factor value as the average of the substance gas mobility factor values (from Table 2-8) for three hazardous substances associated with the source. If fewer than three hazardous substances can be associated with a source, then use all of the hazardous substances that can be associated with the source. If more than three hazardous substances can be associated with a source, then use the three with the highest substance gas mobility values. Hazardous substances whose location on a site cannot be determined may be used to evaluate the source gas mobility for any source on the site into which the hazardous substances could have been deposited. However, a hazardous substance that can be associated with a source must be used in preference to a hazardous substance whose location is unknown in assessing the gas mobility of that source.

2.1.2.3.2 Particulate mobility. The particulate mobility factor reflects the potential for particles on the surface of a source to be entrained in the atmosphere, thereby escaping from the site. The moisture content of the surface material is a measure of the relative mobility of particulates. The Thornthwaite precipitation effectiveness (P-E) index ¹ is a surrogate measure of the relative moisture content of the surface material and is used to assign a value to particulate mobility.

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¹ Thornthwaite, C. Warren, "The Climates of North America According to a New Classification," Geographical Review, Vol. 21, 1931, pp. 633–655.

FIGURE 2-3
MAP OF P-E INDEX FOR STATE CLIMATIC DIVISIONS

Source: Cowherd, Chatten, Jr. et al., Rapid Assessment of Exposures to Particulate Emissions from Surface Contamination Sites. EPA-600/8-85-002, U.S. Environmental Protection Agency, Washington, DC, 1985.

FIGURE 2-3 (Concluded)

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The Thornthwaite P-E index can be read directly from Figure 2-3. For sites not located in areas on Figure 2-3, and for sites which are near the Thornthwaite P-E index boundary points on Figure 2-3 and for which the assigned factor value would differ on opposite sides of the boundary, the Thornthwaite P-E index may be calculated using the following equation:

$$PE = \sum_{i=1}^{12} 115 \times [P_i/(T_i-10)]^{10/9}$$

where:

PE=Thornthwaite P-E index.

P_i=Mean monthly precipitation for month i in inches.

T_i=Mean monthly temperature for month i in degrees Fahrenheit; for any month in which the mean monthly temperature is less than 28.4 °F, use 28.4 °F.

Using the applicable value for the Thornthwaite P-E index, determine the source particulate mobility factor value as indicated on Table 2-9. As the particulate mobility factor value does not depend on distinct characteristics of the different sources, the same factor value applies to each source on the site.

TABLE 2-9.—PARTICULATE MOBILITY FACTOR EVALUATION TABLE

Thornthwaite PE index	Particulate mobility value
Greater than 150	0
85 to 150	1
50 to less than 85	2
Less than 50	3

2.1.2.3.3 Source mobility factor value. Once the source gas mobility factor value and the particulate mobility factor value have been calculated, determine the source mobility factor value using Table 2-10.

TABLE 2-10.—SOURCE MOBILITY FACTOR VALUE

	Source gas mobility factor value			
	0	1	2	3
Source particulate mobility factor value:				
0	0	10	20	30
1	10	20	30	40
2	20	30	40	50
3	30	40	50	50

2.1.2.4 Calculation of potential to release factor value. Determine the potential to release value for each source as illustrated on Table 2-3. Specifically, for each source, sum the source type factor value and the source mobility factor value and multiply this sum by the source containment factor value. The resulting value is the potential to release value for the source. Select the highest source potential to release value assigned to a source on the site. Assign that value as the potential to release factor value for the site. Enter this value on Table 2-1.

2.1.3 Calculation of likelihood of release category value.

If an observed release is established, assign the observed release factor value as the likelihood of release value. Otherwise, assign the potential to release factor value as the likelihood of release value. Enter the value assigned to likelihood of release on Table 2-1.

2.2 Waste characteristics.

This factor category reflects the rate, duration, and relative toxicity of potential hazardous substances releases from the site to the atmosphere. Two factors are included: toxicity/mobility and hazardous waste quantity.

The hazardous substances at the site that are to be considered in the evaluation of waste characteristics are restricted to those that are available to migrate to the atmosphere. Those hazardous substances available to migrate include hazardous substances establishing an observed release to the atmosphere as well as all hazardous substances found or documented to have been deposited at the site in a source that could be assigned a source containment factor value greater than zero. (See section 2.1.2.1 for descriptions of source containment factor values.) Also, hazardous substances whose locations on a site cannot be determined but that could have been deposited in any source whose source containment factor value is greater than zero are considered available to migrate to the atmosphere. Hazardous substances whose location on the site cannot be determined shall be assumed to have been placed in all sources on the site, except those sources for which there is definitive information that indicates that the hazardous substances were not or cannot have been deposited in the source.

2.2.1 Toxicity/mobility.

In determining the toxicity/mobility value for the air migration pathway at a site, evaluate all hazardous substances that are available to migrate to the atmosphere. For each such hazardous substance, a toxicity value and a mobility value is assigned as described below. The procedure for combining these values into a single toxicity/mobility value for each hazardous substance and for selecting the toxicity/mobility value for the site is described in section 2.2.1.3.

2.2.1.1 Toxicity. Hazardous substances are rated on a 5-point scale for each of three toxicity types: acute toxicity, chronic noncarcinogenic toxicity, and carcinogenicity. If comprehensive toxicity data are available, a hazardous substance is assigned three values, one for each toxicity type. The overall toxicity factor value for a hazardous substance is equal to the highest of the assigned values for the three toxicity types. If available information for a substance is inadequate for developing a value for a particular toxicity type, a value of zero is assigned and the substance's overall toxicity rating is based on the other types of toxicity. If available information for a hazardous substance is inadequate for developing a value for all three toxicity types, a value of zero is assigned as the overall toxicity rating for that hazardous substance, and other hazardous substances must be used to evaluate a pathway. In the event that all hazardous substances available to migrate to a particulate pathway have a zero toxicity rating (i.e., insufficient toxicity data to evaluate them), a default value of 3 is used as the toxicity factor value for the pathway. Table 2-11 provides the rating scales used to derive the values for each toxicity type.

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TOXICI

Acut

Oral LD_{50} (mg/kg)	Dermal LD_{50} (mg/kg)
---	---
$LD_{50} < 5$	$LD_{50} < 2$
$5 \leq LD_{50} < 50$	$2 \leq LD_{50} < 20$
$50 \leq LD_{50} < 500$	$20 \leq LD_{50} < 200$
$500 \leq LD_{50}$	$200 \leq LD_{50}$
Information not available	Information not available

Chron

RfD (mg/k
RfD
$0.0005 \leq$ RfD
$0.005 \leq$ RfD
$0.05 \leq$ RfD
$0.5 \leq$ RfD
Informatio availab

TABLE 2-11
CITY FACTOR EVALUATION TABLES

cute Toxicity Factor Values

)	LC_{50} Dust or Mist (mg/l)	LC_{50} Gas or Vapor (ppm)	Assigned Value
	---	---	5
	$LC_{50} < 0.2$	$LC_{50} < 20$	4
0	$0.2 \leq LC_{50} < 2$	$20 \leq LC_{50} < 200$	3
00	$2 \leq LC_{50} < 20$	$200 \leq LC_{50} < 2000$	2
	$20 \leq LC_{50}$	$2000 \leq LC_{50}$	1
t	Information not available	Information not available	0

onic Toxicity Factor Values

/kg-day)	Assigned Value
fD < 0.0005	5
fD < 0.005	4
fD < 0.05	3
fD < 0.5	2
fD	1
ion not able	0

TABL

Carcinog

Weight-of-Evidence[a]/q_1^*	
A	B
$0.5 \leq q_1^*$	$5 \leq q_1^*$
$0.05 \leq q_1^* < 0.5$	$0.5 \leq q_1^* < 5$
$q_1^* < 0.05$	$0.05 \leq q_1^* < 0$
---	$q_1^* < 0$
---	---
Information not available	Information n available

[a]A, B, and C refer to EPA weight-of-evid
of-evidence of D (inadequate evidence o
carcinogenicity) are assigned a carcino

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BLE 2-11 (Concluded)

nogenicity Factor Values

q_1^* (mg/kg-day)$^{-1}$		
	C	Assigned Value
	$50 \le q_1^*$	5
5	$5 \le q_1^* < 50$	4
0.5	$0.5 \le q_1^* < 5$	3
0.05	$q_1^* < 0.5$	2
	---	1
not e	Information not available	0

idence categories (see text). Substances with a weight- of carcinogenicity) or E (evidence of lack of nogenicity factor value of 0.

The value for acute toxicity is based on the median lethal dose value from animal studies (LC_{50} or LD_{50}). Acute toxicity is scored using separate scales for oral, dermal and inhalation routes of exposure. Sources for LC_{50} or LD_{50} data for hazardous substances include the Technical Background Document for the Reportable Quantity rule (or later versions as available):

- Environmental Monitoring and Services, Inc., 1985. "Technical Background Document to Support Rulemaking Pursuant to CERCLA Section 102, Volume 1." Prepared for Releases Control Branch, Office of Research and Development; and Emergency Response Division, Office of Solid Waste and Emergency Response; U.S. Environmental Protection Agency. Under Contract 68–03–3182.
- Environmental Monitoring and Services, Inc., 1986. "Technical Background Document to Support Rulemaking Pursuant to CERCLA Section 102, Volume 2." Prepared for Releases Control Branch, Office of Research and Development and Emergency Response Division, Office of Solid Waste and Emergency Response; U.S. Environmental Protection Agency. Under Contract 68–03–3182.
- C–E Environmental, Inc., 1987. "Technical Background Document to Support Rulemaking Pursuant to CERCLA Section 102, Volume 3." Prepared for Releases Control Branch, Office of Research and Development; and Emergency Response Division, Office of Solid Waste and Emergency Response; U.S. Environmental Protection Agency. Under Contract 68–03–3452.

If no LC_{50} or LD_{50} data are available for a hazardous substance, but an LD_{lo} or LC_{lo} value is available, these latter values should be used in Table 2–11 in place of the LD_{50} or LC_{50} value in assigning a rating value. These values are similar to LC_{50} or LD_{50} values except they represent a concentration or dose that is fatal to only a low percentage of the population (e.g., 10 percent) instead of 50 percent. The LD_{50} and LD_{lo} are not identical but have been treated the same here because of uncertainty in how to convert from one to the other. This approach is the same as that used in setting Superfund Reportable Quantities for hazardous substances.

For hazardous substances having usable toxicity data for multiple exposure routes (e.g., inhalation, ingestion), use the highest route-specific rating value in assigning the acute toxicity value.

To determine a value for chronic noncarcinogenic toxicity, the Reference Dose (RfD) for a hazardous substance is used. An RfD is the amount of a substance to which an individual can be exposed on a daily basis over an extended period of time (usually a lifetime) without appreciable risk of deleterious noncancer effects. RfDs are derived from available chronic and subchronic toxicity studies and undergo a formalized EPA-wide peer review and verification process. RfDs for a number of CERCLA hazardous substances can be found in the U.S. EPA Integrated Risk Information System (IRIS) or in the appendices to the "Superfund Public Health Evaluation Manual," U.S. Environmental Protection Agency, October 1986, EPA 540/1–86/060 (or later as available).

The carcinogenicity value for a hazardous substance is based on one of two measures, its Cancer Potency Factor (q_1^*) or ED_{10}, combined with its qualitative weight-of-evidence rating. Cancer Potency Factors are used preferentially to ED_{10} values; for substances that do not have a Cancer Potency Factor, the ED_{10} is used. Cancer Potency Factors are developed by EPA's Carcinogen Assessment Group and are derived from studies in experimental animals or from human epidemiologic data, if available. Cancer Potency Factors and weight-of-evidence classifications for a number of hazardous substances can be found in IRIS and in the appendices to the "Superfund Public Health Evaluation Manual." ED_{10}s for a number of hazardous substances can be found in the appendices to the "Superfund Public Health Evaluation Manual."

The ED_{10} method for assessing carcinogenicity was developed by the Carcinogen Assessment Group as a means of setting Reportable Quantities for potentially carcinogenic hazardous substances, as required by CERCLA sections 102 and 103. ED_{10}s are calculated based on dose-response data derived from the primary literature. The ED_{10} is the estimated dose associated with a lifetime increased cancer risk of 10 percent. The ED_{10} method for assessing carcinogenicity is described more fully in the March 16, 1987 Federal Register (52 FR 8140). Empirical analysis of potential carcinogens shows that $1/ED_{10}$ is closely related to q_1^*, and is on average 6 times the q_1^*. Use this relationship between ED_{10} and q_1^* to estimate a q_1^* value from an ED_{10} value in the case when q_1^* data are not available.

The weight-of-evidence is defined as the overall strength of the data indicating potential carcinogenicity based on an evaluation of all relevant studies and the nature and type of responses. EPA has adopted a system for classifying weight-of-evidence for carcinogenicity into five major categories. The weight-of-evidence is used to increase or decrease a carcinogenicity value. Only those hazardous substances with weight-of-evidence classifications of A, B, or C shall be evaluated as carcinogens in the HRS. Those hazardous substances in categories D and E (not classified or with no evidence of carcinogenicity) shall not be evaluated as carcinogens. The Cancer Potency Factor and the weight-of-evidence classification are more fully described in EPA's Guidelines for Carcinogen Risk Assessment (51 FR 33992–34003, September 24, 1986).

Asbestos and radionuclides are classified as Group A human carcinogens (the highest weight-of-evidence category), but their cancer potency values are not expressed in units comparable to most other substances. Therefore, asbestos and radionuclides cannot be evaluated and assigned values using Table 2–11. For purposes of HRS scoring, assign a toxicity value of 5 for carcinogenicity to asbestos and to radionuclides.

Determine an acute toxicity value, a chronic toxicity value and a carcinogenicity value for each hazardous substance using Table 2–11. For each hazardous substance, select the highest of the three values and assign it as the overall toxicity factor value for that hazardous substance. For example, if a hazardous substance has a value of 2 for acute toxicity, 3 for chronic noncarcinogenic toxicity and no data for carcinogenicity, its overall toxicity value for HRS scoring purposes would be 3. If a pathway, aquifer (see section 3), or watershed (see section 4) has only hazardous substances without adequate toxicity data for developing a rating, assign a toxicity value of 3 as a default for each hazardous substance available to migrate to that pathway, aquifer, or watershed.

2.2.1.2 Mobility. In determining the mobility value, evaluate all hazardous substances that are available to migrate to the atmosphere. For any hazardous substance that establishes an observed release to the atmosphere, assign that hazardous substance the maximum mobility factor value of 3. For each gaseous hazardous substance not establishing an observed release, assign the hazardous substance a mobility factor value using the evaluation procedure described in section 2.1.2.3.1 (Tables 2–7 and 2–8). For particulate hazardous substances not establishing an observed release, assign the hazardous substance the particulate mobility factor value assigned in section 2.1.2.3.2 (Figure 2–3 and Table 2–9). (All such particulate hazardous substances are assigned this same value.) For a hazardous substance potentially present in both gaseous and particulate forms, select the higher of the factor values for substance gas mobility and particulate mobility for that hazardous substance and assign that value as the mobility factor value for the hazardous substance.

2.2.1.3 Calculation of toxicity/mobility value. Based on the overall toxicity value and the mobility value, assign a toxicity/mobility value to each hazardous substance available to migrate to the atmosphere using Table 2–12. Use the value for the hazardous substance with the highest toxicity/mobility value as the value for this factor for the air migration pathway. Enter this value on Table 2–1.

TABLE 2-12.—TOXICITY/MOBILITY FACTOR VALUE

	Mobility factor value			
	0	1	2	3
Toxicity factor value:				
0	0	0	0	0
1	10	27	43	60
2	20	37	53	70
3	30	47	63	80
4	40	57	73	90
5	50	67	83	100

2.2.2 Hazardous waste quantity.

The hazardous waste quantity factor reflects the quantity and duration of potential hazardous substances releases from the site by this pathway. The hazardous waste quantity factor is evaluated considering three factors: hazardous constituent quantity, site wastestream quantity, and site disposal capacity.

The method used to evaluate each of these factors and to derive the hazardous waste quantity factor value from them is presented in Table 2-13 and is summarized below. The method varies depending on the completeness of the data available for the following measures: the quantity of hazardous substances deposited on the site, the quantity of wastes deposited on the site that contain hazardous substances, source volumes, and source areas.

TABLE 2-13.—HAZARDOUS WASTE QUANTITY FACTOR EVALUATION METHODOLOGY AND WORKSHEET

Part A—Hazardous Constituent Quantity Factor

1. Hazardous Substances Quantity:
   1a. Quantity of hazardous substances (in pounds) deposited on the site (HSQ)
   1b. Assigned value from Table 2-14 for HSQ [1]
2. Is information on HSQ complete for the site? (Enter "yes" or "no")
   2a. If "yes", go to line 17 and enter value from line 1b on line 17. (Do not evaluate Parts B and C.)
   2b. If "no" and the value on line 1b is the maximum factor value of 100, go to line 17 and enter "100" on line 17. (Do not evaluate Parts B and C.)
   2c. If "no" and value on line 1b is less than 100, go to Part B

Part B—Site Wastestream Quantity Factor

Complete lines 3 through 7 for each wastestream (use additional sheets as necessary).

3. Wastestream identification:
4. Wastestream Hazardous Substances Quantity:
   4a. Quantity of hazardous substances (in pounds) present in this wastestream (WHSQ)
   4b. Is information on WHSQ complete for this wastestream? (Enter "yes" or "no")
   4c. Assigned value from Table 2-14 for this WHSQ [1]
5. Wastestream Quantity as Deposited:
   5a. Quantity of materials in this wastestream (in pounds) that contain hazardous substances (WQD)
   5b. Is information on WQD complete for this wastestream? (Enter "yes" or "no")
   5c. Assigned value from Table 2-14 for this WQD [1]
6. Wastestream Quantity Factor Value:
   6a. If line 4b is "yes", go to line 6c and enter value from line 4c on line 6c
   6b. If line 4b is "no", select the higher of the values from lines 4c and 5c and enter that value on line 6c
   6c. Watestream Quantity Factor Value
7. Site Wastestream Quantity Factor Value: Sum the wastestream quantity factor value (from line 6) for each wastestream evaluated and enter this sum on this line [2]
8. Is information on wastestream quantity as deposited complete for the site? (Enter "yes" or "no")

TABLE 2-13.—HAZARDOUS WASTE QUANTITY FACTOR EVALUATION METHODOLOGY AND WORKSHEET—Continued

   8a. If "yes", enter "10" or the value from line 7, whichever is higher, on this line; go to line 17 enter the value from line 8a on line 17. (Do not evaluate Part C.)
   8b. If "no" and the value on line 7 is the maximum factor value of 100, enter "100" on this line; go to line 17 and enter "100" on line 17. (Do not evaluate Part C.)
   8c. If "no" and value on line 7 is less than 100, go to Part C

Part C—Site Disposal Capacity Factor

Complete lines 9 through 14g for each source (use additional sheets as necessary).

9. Source type and identification (e.g., landfill #1):
10. Source Hazardous Substances Quantity:
   10a. Quantity of hazardous substances (in pounds) deposited in this source (SHSQ)
   10b. Is information on SHSQ complete for this source? (Enter "yes" or "no")
   10c. Assigned value from Table 2-14 for this SHSQ [1]
11. Source Waste Quantity as Deposited: [3]
   11a. Quantity of wastes deposited in this source (in pounds) that contain hazardous substances (SWQD)
   11b. Is information on SWQD complete for this source? (Enter "yes" or "no")
   11c. Assigned value from Table 2-14 for this SWQD [1]
12. Source Volume: [3]
   12a. Volume of this source (in cubic yards); if volume is not available, enter "not available"
   12b. Assigned value from Table 2-14 for this volume for this type of source [1]
13. Source Area: [3]
   13a. Area of this source (in square feet); if area is not available, enter "not available"
   b. Assigned value from Table 2-14 for this area for this type of source. [1]
14. Source Disposal Capacity Factor Value:
   14a. If line 10b is "yes", go to line 14g and enter value from line 10c on line 14g. (Do not evaluate lines 14b through 14f.)
   14b. If line 10b is "no", select the higher of the values from lines 10c and 11c and enter the value on this line. (Continue to line 14c.)
   14c. If line 11b is "yes", go to line 14g and enter the value from line 14b on line 14g. (Do not evaluate lines 14d through 14f.)
   14d. If line 11b is "no" and line 12a has a volume entered, select the higher of the values from lines 14b and 12b and enter the value of this line. Go to line 14g and enter this higher value on line 14g. (Do not evaluate lines 14e and 14f.)

TABLE 2-13.—HAZARDOUS WASTE QUANTITY FACTOR EVALUATION METHODOLOGY AND WORKSHEET—Continued

   14e. If line 11b is "no" and line 13a has an area entered, select the higher of the values from lines 14b and 13b and enter the value on this line. Go to line 14g and enter this higher value on line 14g. (Do not evaluate line 14f.)
   14f. If line 11b is "no" and lines 12a and 13a indicate "not available", enter the value from line 14b on line 14g.
   14g. Source Disposal Capacity Factor Value
15. Site Disposal Capacity Factor Value: Sum the source disposal capacity factor value (from line 14g) for each source evaluated.[2] Go to Part D

Part D—Hazardous Waste Quantity Factor Value

16. If a value is entered on both lines 7 and 15, enter "10" or the value from line 7 or 15, whichever is highest, on this line; go to line 17 and enter the value from line 16 on line 17
17. The Hazardous Waste Quantity Factor Value is the value that has been entered on this line. This factor value is subject to a maximum value of 100. Enter this value on Table 2-1

[1] All values assigned from Table 2-14 are subject to a maximum value of 100.

[2] This sum is subject to a maximum value of 100.

[3] If this information is not needed to obtain the source disposal capacity factor value (see lines 14a through 14g), this section (11, 12, or 13) does not need to be completed for this source.

Throughout the evaluation, consider only those sources that can be assigned a containment factor value greater than zero for the pathway and only those wastes, wastestreams,[2] and hazardous substances that can be associated (either directly or indirectly) with such a source. The source containment value to be associated with wastes, wastestreams, or hazardous substances is that of the source into which each was deposited, or, if the source is unknown, those of the sources into which each could have been placed.

The hazardous constituent quantity factor is evaluated as described in Part A of Table 2-13, using the available data on the following measure: the quantity of hazardous substances that have been deposited on the site. A value is assigned to the quantity of hazardous substances deposited using Table 2-14. If the available data on the quantity of hazardous substances deposited on the site are complete (i.e., the total amount of hazardous substances deposited on the site has been fully quantified) or if the hazardous constituent quantity factor is assigned the maximum value of 100, then the other two factors are not evaluated. In this case the hazardous waste quantity factor value is based solely on the hazardous constitutent quantity factor value.

[2] Wastestreams are those portions of a waste which can be separately evaluated based on available information. (The following is an example of what is meant by wastestreams. For example, assume that 50 drums have been deposited together on a site. For 5 of these drums, complete hazardous substance quantity data are available. For 10 of these drums, hazardous substance quantity data are not available, but data are available on the amount of hazardous waste [e.g., 30 gallons] present in each drum when deposited. For the other 35, the only data available are that the 35 drums were deposited on the site and contained hazardous substances. The set of 5 drums, the set of 10 drums, and the set of 35 drums may each be considered a different wastestream for purposes of evaluating this factor.)

TABLE 2-14.—HAZARDOUS WASTE QUANTITY FACTOR EVALUATION EQUATIONS

Measure (X)	Units	Equation for assigning value [1]
Hazardous Constituent Quantity Factor:		
Hazardous substances quantity (HSQ)	lbs	HSQ/10
Wastestream Quantity Factor: [2]		
Wastestream hazardous substances quantity (WHSQ)	lbs	WHSQ/10
Wastestream quantity as deposited (WQD)	lbs	WQD/50,000
Source Disposal Capacity: [3]		
Source hazardous substances quantity (SHSQ)	lbs	SHSQ/10
Source waste quantity as deposited (SWQD)	lbs	SWQD/50,000
Source Volume (SV):		
Landfill	yd^3	SV/25,000
Surface Impoundment	yd^3	SV/25
Drums [3]	gallons	SV/5,000
Nondrum Containers	yd^3	SV/25
Contaminated Soil	yd^3	SV/25,000
Pile	yd^3	SV/25
Other	yd^3	SV/25
Source Area (SA):		
Landfill	ft^3	SA/25,700
Surface Impoundment	ft^2	SA/112.5
Land Treatment	ft^3	SA/8,100
Pile [4]	ft^2	SA/25.7
Contaminated Soil	ft^2	SA/337.500

[1] Maximum value to be assigned is 100.
[3] Use the following volume to mass conversions when necessary: 1 ton = 2,000 lbs = 1 cubic yard = 4 drums = 200 gallons.
[3] If the actual volume of the drum is unavailable, assume a conversion value of 1 drum = 50 gallons.
[4] Use the land surface area under the pile, not the surface area of the pile.

If the data for evaluating the hazardous constituent quantity factor are not complete and the maximum factor value of 100 is not assigned, the site wastestream quantity factor is evaluated as described in Part B of Table 2–13. It is evaluated by first assigning a wastestream quantity factor value to each wastestream deposited on the site and then summing the wastestream quantity factor value assigned to each wastestream. The wastestream quantity factor is evaluated for each wastestream using the available data on the following measures: the quantity of hazardous substances present in the wastestream and the quantity of materials present in the wastestream that contain hazardous substances (i.e., the wastestream quantity as deposited). If the available data on the wastestream quantity as deposited is complete for the site (i.e., the total amount of wastes deposited on the site that contain hazardous substances has been fully quantified) or if the site wastestream quantity factor is assigned the maximum value of 100, then the site disposal capacity is not evaluated. In this case the hazardous waste quantity factor value is based solely on the site wastestream quantity factor value.

If the data for evaluating both the hazardous constituent quantity factor and the site wastestream quantity factor are not complete and the maximum factor value of 100 has not been assigned, the site disposal capacity factor is evaluated as described in Part C of Table 2–13. It is evaluated by first assigning a source disposal capacity factor value to each source on the site and then summing the source disposal capacity factor value assigned to each source. The source disposal capacity factor is evaluated for each source using the available data on the following measures: the quantity of hazardous substances deposited in the source (i.e., the source hazardous substances quantity), the quantity of wastes deposited in the source that contain hazardous substances (i.e., the source waste quantity as deposited), the source volume, and the source area.

The hazardous waste quantity factor is then assigned a value as described in Part D of Table 2–13. If complete data are available for the hazardous constituent quantity factor or if the maximum factor value is assigned, then the hazardous waste quantity factor is evaluated based solely on that factor. In this case the hazardous waste quantity factor value is subject to a maximum value of 100 and a minimum value of zero. If complete data are not available for the hazardous constituent quantity factor, but if complete data are available for the site wastestream quantity factor or if the maximum factor value is assigned, then the hazardous waste quantity factor is evaluated based solely on the site wastestream quantity factor. In this case the hazardous waste quantity factor value is subject to a maximum value of 100 and a minimum value of 10. If complete data are not available for either of these two factors and the maximum factor value has not been assigned, then the hazardous waste quantity factor is determined by considering both the site wastestream quantity factor and the site disposal capacity factor. In this case, the hazardous waste quantity factor value is also subject to a maximum value of 100 and a minimum value of 10.

2.2.3 Calculation of waste characteristics value.

Sum the toxicity/mobility factor value and the hazardous waste quantity factor value. Assign this sum as the waste characteristics value. Enter this value on Table 2–1.

2.3 Targets.

The targets factor category reflects the human populations, resources, and environments potentially at risk from an actual or threatened release of hazardous substances from the site to the atmosphere. This factor category includes two factors primarily related to human health (maximally exposed individual (MEI) and population), one factor primarily related to resources (land use), and one factor primarily related to the environment (sensitive environments).

2.3.1 Maximally exposed individual.

The maximally exposed individual factor is evaluated based on the distance from any on-site emission source to the nearest individual (either on-site or off-site, as applicable). This distance to the nearest individual is determined as the shortest distance to the closest residence or regularly occupied building or area, as measured from any on-site emission source. Based on this shortest distance, assign the MEI factor a value using Table 2–15. Enter this value on Table 2–1.

TABLE 2-15—MEI FACTOR VALUES

Distance to nearest individual (miles)	Assigned value
0 to ⅛	50
Greater than ⅛ to ¼	13
Greater than ¼ to ½	4
Greater than ½ to 2	1
Greater than 2	0

2.3.2 Population.

The population factor value reflects the population actually or potentially exposed to air emissions from the site. Calculate the population factor value as follows, subject to a maximum value of 235.

For each of the distance categories defined on Table 2–16, determine the number of people within that distance category. The distance for an individual is measured as the shortest distance from any on-site emission source to the place at which the individual is located (e.g., place of residence or work). The population count should include persons residing within the distance categories specified as well as others who would regularly be present, such as students and workers. Exclude transient populations such as customers and travelers passing through the area in autos, buses, or trains.

TABLE 2-16—Distance Weighting Factors

Distance category	Distance (miles)	Distance weight [1]
1	On-site	5.265
2	Greater than 0 to ¼	1.0
3	Greater than ¼ to ½	0.1751
4	Greater than ½ to 1	0.0517
5	Greater than 1 to 2	0.0171
6	Greater than 2 to 3	0.0083
7	Greater than 3 to 4	0.0054
8	Greater than 4	0

[1] These distance weights are not be rounded to the nearest integer.

In counting population, use exact population counts where possible. If actual residential population figures are not available, the population for a distance category should be estimated by determining the number of residences located within the distance category and multiplying each residence by the most recent U.S. Census factor for number of persons per residence for the county in which the residence is located.

Based on the information described above, assign a population factor value (PI) using the following equation, subject to a maximum value of 235:

$$PI = \frac{1}{100} \sum_{i=1}^{8} D_i P_i$$

where:

P_i=Number of people within distance category i.

D_i=Distance weighting factor associated with distance category i.

Enter this calculated value on Table 2-1.

2.3.3 Land use.

The land use factor value is determined based on the shortest distance between an on-site emission source and each of the types of land use listed on Table 2-17.

TABLE 2-17—LAND USE FACTOR VALUES

Type	Definition	Assigned value
1	Commercial/Industrial/ Institutional.	5
2	Single Family Residential [1]	8
3	Multi-Family Residential [2]	10
4	Parks	5
5	Prime Agricultural	7
6	Nonprime Agricultural	5

[1] An area is considered to be "single family residential" whenever the residences are solely single family residences.

[2] An area is considered to be "multi-family residential" whenever it contains multi-family residences such as apartment buildings.

Using the applicable distance category for each land use, assign the appropriate distance weighting factor for Table 2-16 to each of the land uses. Assign a value to each type of land use from Table 2-17. Calculate the land use factor value (L) using the following equation, subject to a maximum value of 10:

$$L = \sum_{i=1}^{6} D_i V_i$$

where:

V_i=Value of land use type i.

D_i=Distance weighting factor associated with land use i.

Enter this calculated value on Table 2-1.

2.3.4 Sensitive environments.

The sensitive environment factor value is determined based on the shortest distance from any on-site emission source to each of the applicable sensitive environments located wholly or partially within four miles of the source. Using the applicable distance category for each sensitive environment, assign a distance weighting factor from Table 2-16 to each sensitive environment. Assign value(s) to each sensitive environment using either Table 2-18 or 2-19. If a sensitive environment can be assigned values from both tables, use the table that assigns the higher value to the sensitive environment. Calculate the sensitive environments factor value (ES) as follows, subject to a maximum value of 100:

$$ES = (1/10) \sum_{i=1}^{n} D_i S_i$$

where:

n=The number of sensitive environments identified.

S_i=Value(s) assigned to sensitive environment i.

D_i=Distance weighting factor associated with sensitive environment i.

Enter this calculated value on Table 2-1.

TABLE 2-18.—SENSITIVE ENVIRONMENTS FACTOR VALUES

Sensitive environment	Assigned value
Critical habitat for Federal designated endangered or threatened species	100
Marine Sanctuary	
National Park	
Designated Federal Wilderness Area	
Areas identified under the Coastal Zone Management Act [1]	
Sensitive areas identified under the National Estuary Program or Near Coastal Waters Program [2]	
Critical areas identified under the Clean Lakes Program [3]	
Water segments designated by State as not attaining toxic water quality standards [4]	
National Monument [5]	
National Seashore Recreational Area	
National Lakeshore Recreational Area	
Habitat known to be used by Federal designated or proposed endangered or threatened species	75
Wetlands (freshwater, estuarine or coastal—five acre minimum) [6]	
National Preserve	
National or State Wildlife Refuge	
Unit of the Coastal Barrier Resources System	
Coastal Barrier (undeveloped)	
Federal land designated for protection of natural ecosystems	
Administratively Proposed Federal Wilderness Area	
Spawning areas critical for the maintenance of a fish species within a river system, coastal embayment, or estuary (e.g., anadromous salmon, alewives, shad)	
Migratory pathways critical for the maintenance of a fish species within a river system, coastal embayment, or estuary	
Feeding areas critical for the maintenance of a fish species within a river system, coastal embayment, or estuary	
National river reach designated as recreational	
Habitat known to be used by State designated endangered or threatened species	50
Habitat known to be used by a species under river as to its Federal endangered or threatened status	
State designated areas for the protection or maintenance of aquatic life (coastal, estuarine, or freshwater area) [7]	
Coastal Barrier (partially developed)	
Federal designated Scenic or Wild River	
State land designated for wildlife or game management	25
State designated Scenic or Wild River	
State designated Natural Areas	
Particular areas, relatively small in size, important to the maintenance of unique biotic communities (e.g., prairie pot holes, buffalo wallows, alligator holes, desert springs)	

[1] Areas identified in State Coastal Zone Management plans as requiring protection because of their ecological value.

[2] National Estuary Program study areas (subareas within estuaries) that are identified in Comprehensive Conservation and Management Plans as requiring protection because they support critical life stages of key estuarine species (section 320 of the Clean Water Act as amended by Pub. L. 100-4). Near Coastal Waters (NCW) sensitive areas are those identified in plans developed under NCW special projects as requiring protection because they support key estuarine or marine coastal, living resources (Sections 104(b)(3), 304(1), 319 and 320 of the Clean Water Act as amended by Pub. L. 100-4).

[3] Clean Lakes Program critical areas (subareas within lakes, or in some cases entire small lakes) that are identified by State Clean Lake Plans as critical habitat (section 314 of the Clean Water Act as amended by Pub. L. 100-4).

[4] Segments of navigable waters not attaining a state of water quality that will assure protection and propagation of a balanced population of shellfish, fish, and wildlife, due to toxic pollutants (section 304(1) of the Clean Water Act as amended by Pub. L. 100-4). This sensitive environment may be considered in evaluating a site only if a substance for which the water quality standard is not attained is deposited on the site.

[5] Use only for air pathway.

[6] Wetlands as defined in 40 CFR Section 230.3.

[7] Table I-1 of Attachment I to this Appendix A presents the State designations for ecological use (Section 305(a), Clean Water Act).

TABLE 2-19.—ALTERNATIVE SENSITIVE ENVIRONMENT RATING FACTORS

Elements of Natural Heritage Program[1]	Assigned value
Element with a national ranking of N1[2]	100
Element with a national ranking of N2	75
Element with a state ranking of S1	75
Element with a national ranking of N3	50
Element with a state ranking of S2	50
Element with a state ranking of S3	25

[1] Information for ranking each element (species, natural community, or another entity of conservation interest) and on the presence of each element along the pathway may be obtained from a Natural Heritage Data Center (The Nature Conservancy, 1987, "Natural Heritage Program Operations Manual," The Nature Conservancy, Arlington, VA; The Nature Conservancy, 1987, "Natural Heritage Data Centers, 1987 Directory," The Nature Conservancy, Arlington, VA).

[2] The rankings are those determined under the Natural Heritage Program. Under that Program, the meaning of these rankings is as follows:

National Element Ranks:

N1=Critically imperiled nationally because of extreme rarity (5 or fewer occurrences nationally or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation from the nation.

N2=Imperiled nationally because of rarity (6 to 20 occurrences nationally or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation throughout the nation.

N3=Rare or uncommon nationally (on the order of 21 to 100 occurrences nationally).

State Element Ranks:

S1=Critically imperiled in state because of extreme rarity (5 or fewer occurrences in state or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation from the state.

S2=Imperiled in state because of rarity (6 to 20 occurrences in state or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state.

S3=Rare or uncommon in state (on the order of 21 to 100 occurrences).

2.3.5 Calculation of targets category value.

Sum the MEI, population, land use, and sensitive environments factor values. Assign this sum as the targets value, subject to a maximum value of 235. Enter this value on Table 2-1.

2.4 Air migration pathway score calculation.

Multiply the values for the likelihood of release, waste characteristics, and targets and divide by 211,500. The resulting score is the air migration pathway score (S_a). Enter this score on Table 2-1.

3.0 Ground water migration pathway.

The ground water migration pathway addresses the relative risks, to the people and resources surrounding a site, that are associated with actual or threatened releases of hazardous substances from the sources on the site to an aquifer. Three factor categories are included in the ground water migration pathway:

- Likelihood of release (LR).
- Waste characteristics (WC).
- Targets (T).

Figure 3-1 indicates the factors included within each of these factor categories. The evaluation of the factors and factor categories is discussed in the following sections.

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Likelihood of Release (LR)

Observed Release

or

Potential to Release
- o Containment
- o Net Precipitation
- o Depth to Aquifer/ Hydraulic Conductivity
- o Sorptive Capacity

X

Waste Ch

Toxicit
- o Toxi
  - Ac
  - Ch
  - Ca
- o Mobi
  - Wa
  - Co Aq

Hazardo
- o Haza Quan
- o Site Quan
- o Site

OVERVIEW OF G

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Characteristics (WC)

ity/Mobility
xicity
Acute
Chronic
Carcinogenic
bility
Water Solubility
Coefficient of
Aqueous Migration
dous Waste Quantity
zardous Constituent
antity
te Wastestream
antity
te Disposal Capacity

X

Targets (T)

Maximally Exposed Individual
Population
o Level I Concentrations
o Level II Concentrations
o Level III Concentrations
o Potential Contamination
Ground Water Use
o Drinking Water Use
o Other Water Use
Wellhead Protection Area

FIGURE 3-1
GROUND WATER MIGRATION PATHWAY

The ground water migration pathway score is calculated in terms of the factor category values as follows:

$$S_{gw} = \frac{LR \times WC \times T}{SF}$$

where S_{gw} is the ground water migration pathway score and SF is a scaling factor used to normalize the score to a scale of 0 to 100. This calculation procedure is outlined in Table 3-1.

BILLING CODE 6560-50-M

TABLE 3-1
GROUND WATER MIGRATION PATHWAY SCORESHEET

Factor Categories and Factors	Maximum Value	Value Assigned	
Likelihood of Release to an Aquifer			
1. Observed Release	500	____	
2. Potential to Release			
2a. Containment	10	____	
2b. Net Precipitation	10	____	
2c. Depth to Aquifer/Hydraulic Conductivity	35	____	
2d. Sorptive Capacity	5	____	
2e. Potential to Release (Lines 2a x (2b + 2c + 2d))	500	____	
3. Likelihood of Release (Higher of Lines 1 or 2e)	500		____
Waste Characteristics			
4. Toxicity/Mobility	100	____	
5. Hazardous Waste Quantity	100	____	
6. Waste Characteristics (Lines 4 + 5)	200		____
Targets			
7. Maximally Exposed Individual	50	____	
8. Population			
8a. Level I Concentrations	200	____	
8b. Level II Concentrations	200	____	
8c. Level III Concentrations	200	____	
8d. Potential Contamination	200	____	
8e. Population (Lines 8a + 8b + 8c + 8d, subject to a maximum of 200)	200	____	
9. Ground Water Use			
9a. Drinking Water Use	50	____	
9b. Other Water Use	20	____	
9c. Ground Water Use (Lines 9a + 9b, with a maximum of 50)	50	____	
10. Wellhead Protection Area	50	____	
11. Targets (Lines 7 + 8e + 9c + 10, subject to a maximum of 200)	200		____

TABLE 3-1

GROUND WATER MIGRATION PATHWAY SCORESHEET (CONCLUDED)

	Maximum Value	Value Assigned
Ground Water Migration Score for an Aquifer		
12. Aquifer Score [(Lines 3 x 6 x 11)/2 x 10^5][1]	100	____
Ground Water Migration Pathway Score		
13. Pathway Score (S_{gw}), (Highest value from Line 12 for all aquifers evaluated)[1]	100	____

[1] These scores are not to be rounded to the nearest integer.

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A ground water migration pathway score is calculated for each aquifer. The score for an aquifer is calculated as the product of the factor category values for likelihood of release to the aquifer, waste characteristics, and targets for that aquifer. In calculating the targets factor category value for an aquifer, both the targets using water from that aquifer and the targets using water from all overlying aquifers must be used, except as noted below. The highest ground water migration pathway score that results for any aquifer is assigned as the ground water migration pathway score for the site. Figures 3–2 and 3–3 illustrate this procedure.

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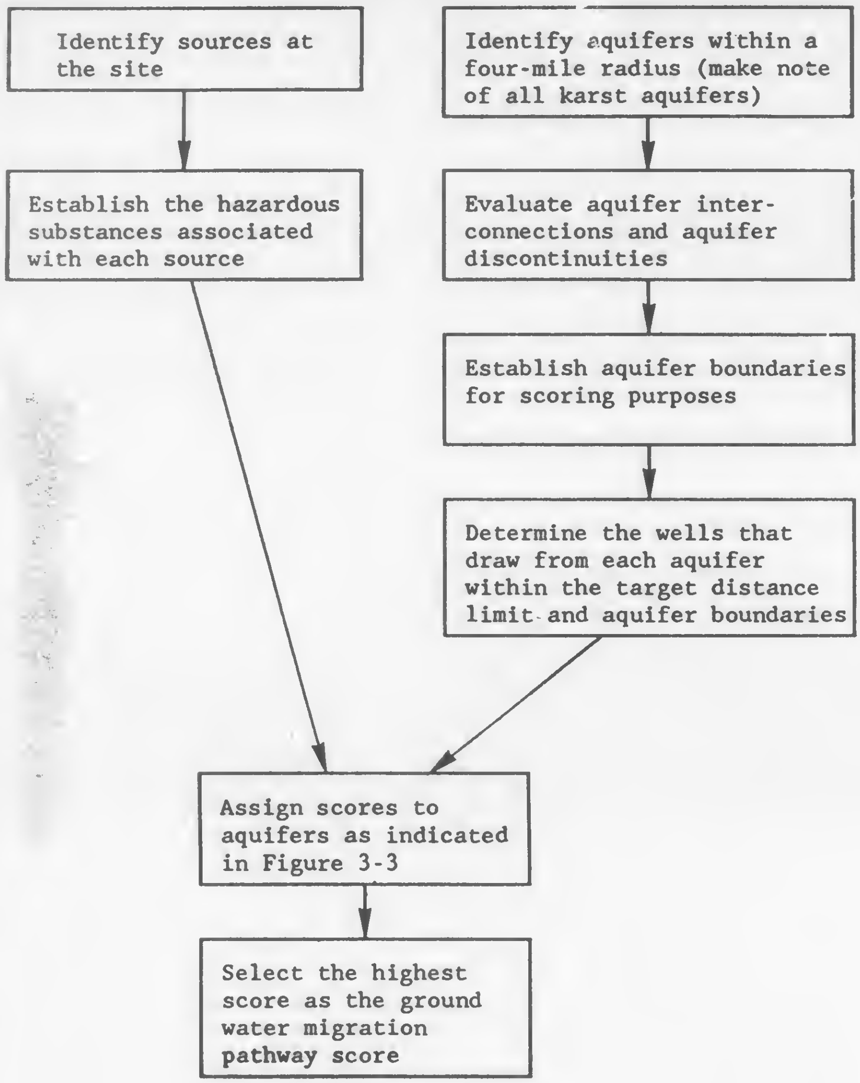
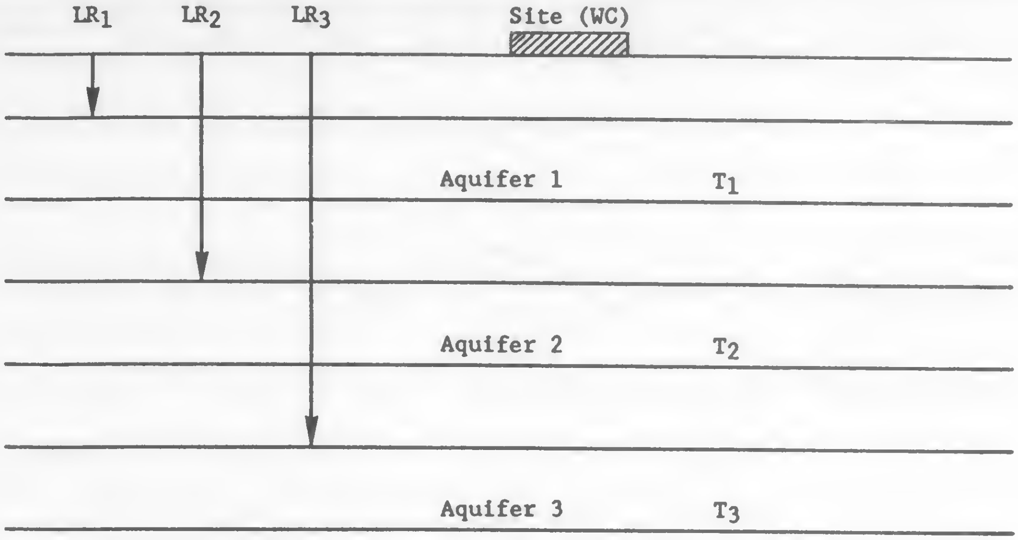


FIGURE 3-2
PROCEDURE FOR EVALUATING GROUND WATER MIGRATION PATHWAY



Aquifer 1 Score = $LR_1 \times WC \times T_1$

Aquifer 2 Score = $LR_2 \times WC \times (T_1$ and $T_2)$

Aquifer 3 Score = $LR_3 \times WC \times (T_1, T_2,$ and $T_3)$

where

LR_i = Likelihood of Release Value for aquifers 1, 2, 3 . . . N

WC = Waste Characteristics Value

T_i = Targets for aquifers 1, 2, 3 . . . N

FIGURE 3-3
CALCULATION OF GROUND WATER MIGRATION SCORE FOR AN AQUIFER

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The above procedure for evaluating all targets associated with the migration of hazardous substances to an aquifer implies that harardous substances, when released, migrate from the surface to the aquifer being evaluated, through all intervening layers. Where there are no sources at the surface and hazardous substances were introduced directly into an aquifer without migrating through overlying layers, the evaluation of the targets for the aquifer that received the hazardous substances is limited to those using water from the aquifer, plus those using water from any additional aquifers where there is an observed release from the aquifer that received the hazardous substances (see section 3.1.1). The evaluation of the targets for each of the other aquifers below the one into which the hazardous substances were directly introduced is limited to those targets using water from the aquifer being evaluated, plus those using water from all overlying aquifers up to and including the one into which the hazardous substances were directly introduced, plus those using water from any additional aquifers where there is an observed release from the aquifer that received the hazardous substances. A ground water pathway migration score is not calculated for any aquifer above the one into which the hazardous substances were directly introduced unless there is an observed release in the aquifer.

Where there are sources at the surface and hazardous substances were also introduced directly into an aquifer, ground water migration scores are calculated as indicated in Figure 3–3 with the following differences. For an aquifer above the one into which the hazardous substances were directly introduced, the hazardous substances that were directly introduced in the lower aquifer must not be considered in calculating the ground water migration score for the upper aquifer unless there is an observed release of these substances from the lower aquifer to the upper aquifer. If there is such an observed release, then these hazardous substances must be considered in calculating the ground water migration score for the aquifers. For the aquifer into which the hazardous substances were introduced and for any aquifers below that aquifer, all hazardous substances (i.e., those in the sources at the surface and those directly introduced) must be considered in calculating the ground water migration score.

3.0.1 Definitions.

3.0.1.1 Ground water target distance limit. The target distance limit defines the maximum distance from a site over which targets are to be considered when evaluating the site. For calculating the ground water migration pathway score, use a target distance limit of our miles, except when aquifer discontinuities apply as noted in section 3.0.1.2.2. Furthermore, any well for which there is an observed release from the site (see section 3.1.1) is considered to lie within the target distance limit of the site, regardless of the well's distance from the site.

Measure the target distance limit from the areas of hazardous waste deposition at a site. These areas do not include the extent of hazardous substance migration at the site. However, for releases that are detected but for which the sources of contamination are unknown, measure the target distance limit from the boundary of the known contamination.

3.0.1.2 Aquifer boundaries. Aquifer boundaries define the extent of an aquifer in the vertical and horizontal directions and are based on the relative difference in the ease of ground water flow in adjacent geologic materials or layers. These boundaries often coincide with boundaries of geologic layers, but may consist of multiple layers or only portions of individual layers. Multiple aquifers may be combined into a single hydrologic unit for scoring purposes when aquifer interconnections for these aquifers can be identified. In contrast, aquifer boundaries must be restricted where aquifer discontinuities can be identified.

3.0.1.2.1 Aquifer interconnections. Aquifer interconnections are areas between aquifers that allow the transfer of ground water or hazardous substances in sufficient amounts to allow the separate aquifers to be treated as a single hydrologic unit. Aquifer interconnections are evaluated within a two-mile radius from the areas of hazardous waste deposition. Where aquifer interconnections can be identified within the two-mile radius, the aquifers with the interconnections may be combined for scoring purposes. If ground water contamination attributable to the site is observed to extend beyond two miles, then any locations within the observed limits of this contamination may also be used to evaluate aquifer interconnections. Where there are insufficient data to identify aquifer interconnections, the aquifers must be evaluated as separate aquifers. Aquifer interconnections can be identified as follows:

- Literature or well logs indicate that no lower relative hydraulic conductivity layer or confining layer separates the aquifers (i.e., a layer with a hydraulic conductivity that is lower by two or more orders of magnitude).
- Literature or well logs indicate that a lower relative hydraulic conductivity layer or a confining layer that separates the aquifers is not continuous throughout the two-mile radius (i.e., hydrogeologic interconnections between the aquifers are identified).
- Withdrawals of water from one aquifer (e.g., pumping tests, aquifer tests, well tests, etc.) affect water levels in another aquifer.
- Migration of constituents from one aquifer to another aquifer has been observed within the two-mile radius. (The mechanism of vertical migration does not have to be defined, and the constituents do not have to be attributed to the site being evaluated.)

In general, two or more layers may be considered a single hydrologic unit when any one of the above conditions are met. However, in conjunction with the above conditions, if conflicting information exists for a geologic setting, the most appropriate information should be used to establish aquifer boundaries. When evaluating a geologic setting, consider that all geologic materials transmit water to a certain degree; therefore, evidence of the leakage of water (not hazardous substances) through a layer of lower relative hydraulic conductivity does not, in itself, indicate that two aquifers should be considered a single hydrologic unit. In addition, identification of aquifer interconnections should include a consideration of the existence and extent of man-made conduits (e.g., composite wells, gravel-packed wells, open boreholes, poorly constructed or damaged wells) and major faults.

3.0.1.2.2 Aquifer discontinuities. Aquifer discontinuities result when a geologic, topographic, or other structure or feature entirely transects an aquifer, thereby creating a continuous boundary to flow within the four-mile radius. Ground water divides and discharge boundaries that reflect ground water flow gradients do not constitute aquifer discontinuities unless they are associated with structures or features which entirely transect an aquifer.

Aquifer discontinuities are evaluated within the four-mile target distance limit. When an aquifier discontinuity is established within the four-mile radius, that portion of the aquifer beyond the discontinuity is not evaluated in the ground water migration pathway, except as noted below. If the migration of hazardous substances across a discontinuity is observed within the four-mile radius, the presence of the discontinuity is not considered for scoring purposes. Where more than one aquifer can be combined into a single hydrologic unit for scoring purposes, an aquifer discontinuity must entirely transect the boundaries of the single hydrologic unit. In general, where an aquifer discontinuity can be present, that portion of the aquifer beyond the apparent discontinuity should be included in the ground water migration pathway evaluation unless definitive information indicates that the discontinuity does actually exist.

3.0.1.3 Karst aquifer. Karst aquifers are aquifers where the predominant water movement occurs through openings in the rock created by dissolution of the rock material. Karst aquifers are given special consideration in the evaluation of two of the potential to release factors (i.e., depth to aquifer/hydraulic conductivity and sorptive capacity) and two of the targets factor (i.e., maximally exposed individual and potential contamination). See sections 3.1.2 and 3.3.

The presence of karst aquifers is often indicated by the occurrence of karst terrains. The following description should be used to identify karst terrains:

Karst is a "terrain with distinctive characteristics of relief and drainage arising from a higher degree of rock solubility in natural waters." [3] The majority of karst occurs in limestones, but karst may also form in dolomite, gypsum, and salt deposits. Dissolution of the rock may occur along joints, bedding planes, or other openings. Continued dissolution results in the formation of conduits that allow for the rapid movement of ground water. Features associated with karst terrains include irregular topography, sinkholes, vertical shafts, abrupt ridges,

[3] Bloom, Arthur L., 1978. "Geomorphology—A Systematic Analysis of Cenozoic Landforms." Prentice-Hall, Inc.

caverns, an abundance of springs, and disappearing streams.[4]

3.1 Likelihood of release.

For an aquifer, the likelihood of release factor category reflects the likelihood of the site releasing hazardous substances to that aquifer. The factor category is evaluated in terms of an observed release factor and a potential to release factor.

3.1.1 Observed release.

An observed release to an aquifer is established whenever it can be demonstrated that a site has released a hazardous substance to the aquifer. This demonstration can be based on either direct observation of the release or indirect observation (i.e., the analysis of samples taken from the aquifer).

In the case of direct observation, material from the site must be known to have entered the aquifer through direct deposition or be seen entering the aquifer through migration. Further, available information must indicate that the material deposited in or observed entering the aquifer contained one or more hazardous substances. Such information should include an analysis of the hazardous substances contained in samples of the material or other similar documentation of the content of the material. Finally, in the case of migration, the available information must indicate that hazardous substances in the material have reached the aquifer. For the hazardous substances to be considered to have reached the aquifer, the samples of the migrating material must be taken near the observed point of entry of the material into the aquifer or the source of the released material must be near the observed point of entry.

In the case of indirect observation, the samples must indicate that a significant increase in ambient hazardous substance concentration has occurred relative to the background concentration for the site (as described below). Further, the available information must support the attribution of some portion of the increase to the site. Attribution can be based on sampling information such as the location of the sampling points or other source apportionment techniques.

A significant increase is determined by comparing aquifer samples, one of which must be a background sample. The background sample should be chosen to reflect, as completely as possible, the concentration of the hazardous substance in the aquifer exclusive of the contribution of any possible releases from the site. The concentration of a hazardous substance is considered to be significantly above background levels under the conditions presented in Table 2-2 of Section 2. See section 2.1.1 for the detection limits to be used in the evaluation.

If an observed release can be established for the aquifer, then assign the aquifer an observed release factor value of 500. If no observed release can be established, assign an observed release factor value of zero.

3.1.2 Potential to release.

Potential to release is evaluated if an observed release has not been established. Potential to release assesses the likelihood of hazardous substances migrating from a site to an aquifer. Four factors are evaluated under potential to release: containment, net precipitation, depth to aquifer/hydraulic conductivity, and sorptive capacity. For a site overlying karst terrain, any karst aquifer within the target distance limit is given special consideration in evaluating depth to aquifer/hydraulic conductivity and sorptive capacity, as discussed below.

3.1.2.1 Containment. Containment refers to the methods (either natural or engineered) that have been used either to restrict the release of hazardous substances from a source (e.g., landfill) to the subsurface or to prevent released substances from entering ground water. Table I-2 of Attachment I to this Appendix A presents the criteria for use in rating the containment of inactive sources for the ground water pathway.

For such containment systems as diking, berms, and run-on control and runoff management systems to be considered present for rating purposes, they must completely surround the source area unless they connect with other natural or engineered barriers that together completely surround the source area. For liners to be considered present for rating purposes, they must be continuous and must cover all earth surrounding the source likely to be in contact with the hazardous substances or leachate containing the hazardous substances.

Assign a containment value to each source at the site using Table I-2 of Attachment I to this Appendix A. The containment factor value for the site is the highest containment value assigned to any of the sources. Enter this value in Table 3-1.

3.1.2.2 Net precipitation. Net precipitation indicates the amount of water that is potentially available, on an annual basis, for infiltration to ground water. This, in turn, is a measure of the amount of water which is potentially available for infiltration to the aquifers underlying the site and for transporting hazardous substances from the site to ground water.

Determine annual net precipitation by summing the monthly net precipitation. Calculate the monthly net precipitation as the difference between monthly precipitation and monthly evapotranspiration. For months where evapotranspiration exceeds precipitation, assign the monthly net precipitation a value of zero.

Calculate net precipitation using local measured averages for precipitation and evapotranspiration. If local data are not available, use data from the nearest National Oceanographic and Atmospheric Administration weather station that is in a similar geographic setting. Data from the same time period must be used for both precipitation and evapotranspiration and must be of a sufficiently long period (20 years) to calculate a meaningful average. Where measured monthly evapotranspiration is not available, calculate monthly potential evapotranspiration as follows:[5]

$$e = 0.6\, F\, (10t/I)^a$$

where:

e = Monthly potential evapotranspiration (inches),
F = latitude adjusting factor for the month (adapted from Criddle [6]).
t = Mean monthly temperature (°C),
$a = 6.75 \times 10^{-7} I^3 - 7.71 \times 10^{-5} I^2 + 1.79 \times 10^{-2} I + .49239$, and
I = Sum of the twelve monthly heat indexes (i) where i (monthly heat index) $= (t/5)^{1.514}$

The latitude adjusting factor (F) for each month is assigned using Table 3-2. For latitudes lower than 50° North or 20° South that are not listed in the table, determine the latitude correction factor by interpolation.

TABLE 3-2.—LATITUDE ADJUSTING FACTOR FOR EACH MONTH FOR USE IN CALCULATING MONTHLY POTENTIAL EVAPOTRANSPIRATION [1]

	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Northern Hemisphere:												
Latitude [3] (deg):												
>50	0.74	0.78	1.02	1.15	1.33	1.36	1.37	1.25	1.06	0.92	0.76	0.70
45	.80	.81	1.02	1.13	1.28	1.29	1.31	1.21	1.04	.94	.79	.75
40	.84	.83	1.03	1.11	1.24	1.25	1.27	1.18	1.04	.96	.83	.81
35	.87	.85	1.03	1.09	1.21	1.21	1.23	1.16	1.03	.97	.86	.85
30	.90	.87	1.03	1.08	1.18	1.17	1.20	1.14	1.03	.98	.89	.88

[4] United States Geological Survey, 1986. "Hydrologic Hazards in Karst Terrain," Open-file Report 85-677, United States Geological Survey, Reston, VA.

[5] Thornthwaite, C.W., 1948. "An Approach Toward a Rational Classification of Climate," Geographical Review 38:55-94. Equation has been modified to convert "e" from centimeters to inches.

[6] Criddle, W.D., 1958. "Methods of Computing Consumptive Use of Water," Proceedings of the American Society of Civil Engineers, Journal of the Division of Irrigation and Drainage, Vol. 84., No. IR1, pp. 1-27.

TABLE 3–2.—LATITUDE ADJUSTING FACTOR FOR EACH MONTH FOR USE IN CALCULATING MONTHLY POTENTIAL EVAPOTRANSPIRATION [1]—Continued

	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
20	.95	.90	1.03	1.05	1.13	1.11	1.14	1.11	1.02	1.00	.93	.94
10	1.00	.91	1.03	1.03	1.08	1.06	1.08	1.07	1.02	1.02	.98	.99
0	1.04	.94	1.04	1.01	1.04	1.01	1.04	1.04	1.01	1.04	1.01	1.04
Southern Hemisphere:												
Latitude [3] (deg):												
0	1.04	.94	1.04	1.01	1.04	1.01	1.04	1.04	1.01	1.04	1.01	1.04
10	1.08	.97	1.05	.99	1.00	.96	1.00	1.02	1.00	1.06	1.05	1.09
20	1.14	.99	1.05	.97	.96	.91	.95	.99	1.00	1.08	1.09	1.15

[1] The latitude adjusting factor is not to be rounded to the nearest integer. The latitude adjusting factor for the Northern hemisphere is adapted from Criddle, W.D., 1958, "Methods of Computing Consumptive Use of Water," Proceedings of the American Society of Civil Engineers, Journal of the Division of Irrigation and Drainage, Vol. 84, No. IR1, pp. 1–27. The latitude adjusting factor for the Southern hemisphere is based on mean monthly daylight hours from "The Astronomical Almanac for the Year 1988," Nautical Almanac Office, U.S. Naval Observatory, 1987.

[2] For latitudes lower than 50° North that are not listed below, determine the latitude adjusting factor by interpolation.

[3] For latitudes lower than 20° South that are not listed below, determine the latitude adjusting factor by interpolation.

Once the annual net precipitation has been calculated, assign a factor value for net precipitation using Table 3–3. Enter this value in Table 3–1.

TABLE 3–3—NET PRECIPITATION FACTOR VALUES

Net Precipitation	Assigned value
0	0
Greater than 0 to 5 inches	1
Greater than 5 to 15 inches	3
Greater than 15 to 30 inches	6
Greater than 30 inches	10

Table I–3 of attachment I of this appendix illustrates the range of the net precipitation for each state as calculated using the above methodology.

3.1.2.3 Depth to aquifer/hydraulic conductivity. Depth to aquifer represents the distance that hazardous substances must travel to an aquifer while hydraulic conductivity represents the potential rate at which geologic materials can transmit ground water. Considered together, these two factors are an indicator of the relative travel time required for hazardous substances to reach an aquifer.

The depth to aquifer/hydraulic conductivity factor is evaluated by determining the depth to an aquifer and by calculating a thickness-weighted average hydraulic conductivity for that depth. In evaluating this factor at a location in karst terrain, the karst aquifer itself, but not other layers or aquifers, is assigned a thickness of zero feet. Depth to aquifer/hydraulic conductivity must be determined at locations within two miles of the areas of hazardous substance deposition, except when ground water contamination attributable to the site is observed to extend beyond two miles; then any locations within the observed limits of this contamination may also be used to evaluate depth to aquifer/hydraulic conductivity for those aquifers not determined to have an observed release. The rating values for depth to aquifer/hydraulic conductivity are given in Table 3–4.

TABLE 3–4—DEPTH TO AQUIFER/HYDRAULIC CONDUCTIVITY FACTOR VALUES

Thickness-weighted hydraulic conductivity (cm/sec)	Depth to aquifer (feet)							
	Greater than 0 to 12	Greater than 12 to 25	Greater than 25 to 50	Greater than 50 to 100	Greater than 100 to 200	Greater than 200 to 400	Greater than 400 to 800	Greater than 800
Greater than or equal to 10^{-3}	35	35	35	35	35	35	35	33
Less than 10^{-3} to 10^{-5}	35	32	30	29	27	26	24	22
Less than 10^{-5} to 10^{-7}	35	21	20	18	17	15	13	12
Less than 10^{-7}	35	10	9	7	6	4	3	1

3.1.2.3.1 Depth to aquifer. Depth to aquifer is measured from the lowest known point of hazardous substances at a site to the top of the aquifer being evaluated.

The distance from the surface to the lowest known point of hazardous substances at a site must be determined at a location where these substances are available to migrate to ground water (i.e., value for ground water containment value is greater than zero). This distance is to be determined from depth of hazardous substance disposal or from depth of hazardous substance migration (subject to the limitation noted in Section 3.0), whichever yields the least depth to the aquifer. For hazardous substances that have been buried, but for which the depth of burial is unknown, assume a deposition distance of six feet below the surface for evaluating only this factor. If any hazardous substances detected in a well is present at a concentration that establishes an observed release, then in evaluating aquifers not determined to have an observed release, the depth of migration below the surface is considered to be the uppermost point at which ground water is capable of entering that well (e.g., top of the well screen).

The distance from the surface to the top of an aquifer is measured to the highest seasonal level of the saturated zone of that aquifer. If this distance from the surface varies throughout an area, use the distance that most closely approximates conditions beneath the site.

Calculate the depth to an aquifer as the distance from the surface to the top of the aquifer minus the distance from the surface to the lowest known point of hazardous substances eligible to be evaluated for that aquifer.

3.1.2.3.2 Hydraulic conductivity. Hydraulic conductivity measures the ability of geologic materials to transmit water.

Evaluate hydraulic conductivity for the geologic materials that occur in the interval between the hazardous substances and the top of the aquifer being evaluated. Evaluate hydraulic conductivity as the thickness-weighted average hydraulic conductivity for all the geological materials that occur within this interval. Determine the thickness-weighted hydraulic conductivity only at those locations where the necessary geologic information (e.g., well logs, borings, stratigraphic columns) is available. Determine the thickness-weighted hydraulic conductivity as follows:

$$\text{Thickness-Weighted Hydraulic Conductivity} = \frac{\sum_{i=1}^{N} Ti}{\sum_{i=1}^{N} \frac{Ti}{HC_i}}$$

where:

T_i = Thickness for layers i = 1, 2, . . . N. (For any layer that is karst, its thickness is considered to be zero feet.)

HC_i = Hydraulic conductivity for layers i = 1, 2, . . . N.

N = Number of layers evaluated.

If, for the interval being evaluated, all layers are karst (and thus the sum of the layer thicknesses is zero), assign the depth to aquifer/hydraulic conductivity factor a value of 35 (the maximum value for this factor). Where the necessary subsurface geologic information is available at multiple locations, determine the thickness-weighted average at each location, and assign a value to each location using Table 3–4. Select the location that yields the highest value for depth to aquifer/hydraulic conductivity. Assign the value for this location as the depth to aquifer/hydraulic conductivity factor value for the aquifer. Enter this value in Table 3–1.

Hydraulic conductivities for individual layers may be determined by in-situ and laboratory tests or may be taken from Table 3–5. However, measured hydraulic conductivity values must be used for any layer where such measured values are available. When multiple measures of hydraulic conductivity are available from a single boring or location for a single layer, the average of the measured hydraulic conductivities should be used.

TABLE 3–5.—HYDRAULIC CONDUCTIVITY OF GEOLOGIC MATERIALS

Type of material	Assigned hydraulic conductivity
Clay; low permeability till (compact, unfractured till); shale; unfractured metamorphic and igneous rocks.	10^{-8} cm/sec.
Silt; 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.	10^{-6} cm/sec.
Sands; sandy silts; sediments that are predominately 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.	10^{-4} cm/sec.
Gravel; clean sand; highly permeable fractured igneous and metamorphic rocks; permeable basalt; karst limestones and dolomites.	10^{-2} cm/sec.

In most cases, information from throughout the two-mile area (or the observed limits of contamination if greater) may be used to calculate the thickness-weighted hydraulic conductivity. However, if the aquifer being evaluated is not continuous throughout this area the thickness-weighted hydraulic conductivity may be determined only at those locations overlying and within the aquifer boundaries (see section 3.0.1.2). In addition, there may be instances where a low hydraulic conductivity layer is not continuous throughout this area but still completely separates the hazardous substances from the aquifer being evaluated (see Figure 3–4). In this instance, migration of hazardous substances from the site to the aquifer must occur through the low hydraulic conductivity layer even though it is not continuous throughout this area. When migration of hazardous substances from the site to an aquifer must occur across a low hydraulic conductivity layer, regardless of its extent, then the location used to determine the thickness-weighted hydraulic conductivity must include this layer.

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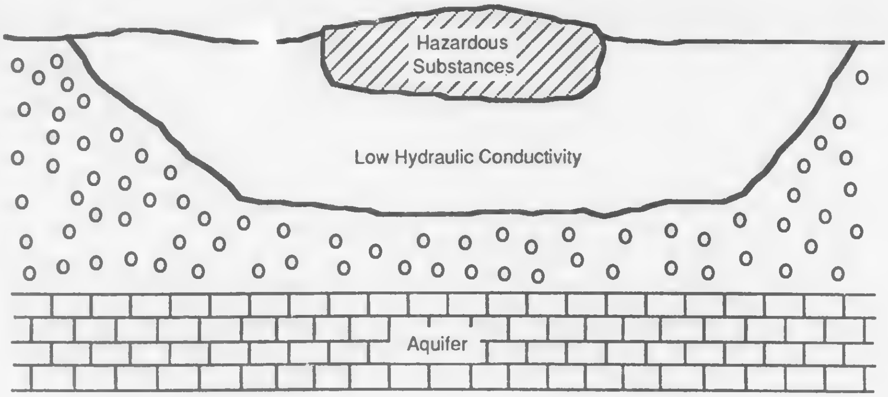

FIGURE 3-4
NONCONTINUOUS LOW HYDRAULIC CONDUCTIVITY
LAYER THAT COMPLETELY SURROUNDS SOURCE

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3.1.2.4 Sorptive capacity. Sorptive capacity reflects the potential for geologic materials to chemically sorb hazardous substances and thereby retard hazardous substance migration.

Sorptive capacity is evaluated for the geologic materials in the interval between the hazardous substances and the top of the aquifer being evaluated. (The depth of this interval is determined as discussed in Section 3.1.2.3.1.) Sorptive capacity is assessed based on the sorbent content of the geologic materials in this interval. Sorbent content is evaluated as the clay and organic carbon content of these geologic materials.

Evaluate sorbent content only at those locations where the necessary geologic information (e.g., well logs, borings, stratigraphic columns) is available. Evaluate sorbent content as follows:

$$\text{Sorbent Content} = \sum_{i=1}^{N} SC_i \cdot T_i/100$$

where SC_i = Average sorbent content (percent clays plus percent organic carbon) for layers i = 1, 2, . . . N.

T_i = Thickness for layers i = 1, 2, . . . N. (For any layer that is karst, its thickness is considered to be zero feet.)

N = Number of layers evaluated.

The average sorbent content (average percent clays plus organic carbon) for individual layers may be measured or taken from Table 3-6. However, measured sorbent contents must be used for any layer where such measured data are available. Use Table 3-7 to assign a value to the sorptive capacity factor based on the calculated sorbent content of the entire interval evaluated. Where the necessary geologic information is available at multiple locations, calculate the sorbent content at each location, and use the location that yields the lowest sorbent content to assign a sorptive capacity factor value for the aquifer. Enter the value assigned in Table 3-1.

TABLE 3-6.—SORBENT CONTENT OF GEOLOGIC MATERIALS

Type of material	Average sorbent content (percent clays plus percent organic carbon)
Coal seams, peat, or organic-rich sediments[1]	77
Clays; silts; till; loesses; tar sands; sediments[1] that are predominantly clay or silt; claystones, mudstones, shales (including oil shales), or siltstones	64
Sands, sediments[1] that are predominantly sands, sandstones, or argillaceous limestones and dolomites	15
Limestones and dolomites, limey sediments[1] or, gravels	6
Clean sands, clean gravels, quartzite sandstones, or metamorphic and igneous rocks	3

[1] Sediments include unconsolidated materials such as soil.

TABLE 3-7.—SORPTIVE CAPACITY FACTOR VALUES

Sorbent Content	Assigned Value
Greater than 100	1
Greater than 10 to 100	3
0 to 10	5

Sorptive capacity must be evaluated at locations within two miles of the areas of hazardous substance deposition, except when ground water contamination attributable to the site is observed to extend beyond two miles; then any locations within the observed limits of the ground water contamination may also be used to evaluate sorptive capacity for those aquifers not determined to have an observed release. However, if the aquifer being evaluated is not continuous throughout this two-mile (or extended) area, sorptive capacity must be evaluated only at locations overlying and within the aquifer boundaries. Furthermore, if migration of hazardous substances from the site to an aquifer must occur across a highly sorptive layer that completely surrounds the site, but is not continuous throughout this area (see hydraulic conductivity example illustrated in Figure 3-4), the interval and location used to calculate sorbent content must include this layer. In addition, if the depth to an aquifer varies throughout an area, use a depth that most closely approximates conditions beneath the site.

3.1.2.5 Calculation of potential to release factor value. Sum the factor values for net preciptation, depth to aquifer/hydraulic conductivity, and sorptive capacity and multiply this sum by the factor value for containment. The resulting value is the value for the potential to release factor for the aquifer. Enter this value in Table 3-1.

3.1.3 Calculation of likelihood of release value.

If an observed release is established for an aquifer, assign the observed release factor value as the likelihood of release value for that aquifer. Otherwise, assign the potential to release factor value for that aquifer as the likelihood of release value. Enter the value assigned in Table 3-1.

3.2 Waste characteristics.

This factor category assesses waste characteristics that reflect the rate, duration, and relative toxicity of potential releases of hazardous substances from the site. Two factors are included: toxicity/mobility and waste quantity.

The hazardous substances at the site that are to be considered in the evaluation of waste characteristics are restricted to those that are available to migrate to ground water. Those hazardous substances available to migrate include hazardous substances establishing an observed release to ground water (subject to the limitation noted in section 3.0) as well as all hazardous substances found or documented to have been deposited at the site in a source that could be assigned a ground water containment factor value greater than zero. (See section 3.1.2.1 for descriptions of ground water containment factor values.) Also, hazardous substances whose location on a site cannot be determined but that could have been deposited in any source with a ground water containment factor value greater than zero are considered available to migrate to ground water. Hazardous substances whose location on the site cannot be determined shall be assumed to have been placed in all sources on the site, except those specific sources for which there is definitive information that indicates that the hazardous substances were not or cannot have been placed in the source.

3.2.1 Toxicity/mobility.

In determining the toxicity/mobility value, evaluate all hazardous substances that are available to migrate to ground water. For each such hazardous substance, assign a toxicity value and a mobility value as described below. The procedure for combining these values into a single toxicity/mobility value for each hazardous substance and for selecting the toxicity/mobility value for the ground water migration pathway is described in section 3.2.1.3.

3.2.1.1 Toxicity. Assign a toxicity value in the same manner as is discussed in Section 2.2.1.1 for each hazardous substance deposited at the site that is considered to be available to migrate to ground water.

3.2.1.2 Mobility. Mobility, a measure of the tendency of a hazardous substance to become mobile in the aqueous phase and to migrate to ground water, is evaluated for all hazardous substances at a site that are available to migrate to ground water.

For any hazardous substance that establishes an observed release to any of the aquifers underlying the site, regardless of the aquifer being evaluated, assign that hazardous substance the maximum mobility factor value of 3. For hazardous substances not establishing an observed release, assign the hazardous substance a mobility value according to Table 3-8 or 3-9, as described below.

Evaluate the mobility of hazardous substances based on water solubility except as noted below. Assign a mobility value to the hazardous substance using Table 3-8. (Water solubility is determined using the method specified in Lyman, Warren J., "Solubility in Water" in the "Handbook of Chemical Property Estimation Methods," Lyman, Warren J., William F. Reehl, and David H. Rosenblatt (authors) McGraw Hill Book Company, New York, New York, 1982.)

TABLE 3-8.—MOBILITY VALUES FOR ORGANIC SUBSTANCES AND FOR INORGANIC SUBSTANCES (OTHER THAN THOSE IN TABLE 3-9)

Water solubility range (mg/l)	Assigned mobility value
Less than or equal to 10	0
Greater than 10 to 100	1
Greater than 100 to 1,000	2
Greater than 1,000	3

For any cation or anion listed in Table 3-9, if the specific compound present at the site has not been identified for that cation or anion, evaluate its mobility based on the coefficient of aqueous migration. Assign a mobility value to such a cation or anion using Table 3-9. (Coefficient of aqueous migration is determined using the method specified in Perel'man, Aleksandr I., "Classification of the Epigenetic Processes Operating in the Supergene Zone," Chapter 9 in "Geochemistry of Epigenesis," Plenum Press, New York, NY, 1967.)

TABLE 3-9.—MOBILITY VALUES FOR CATIONS AND ANIONS

Cations and anions	Coefficient of aqueous migration (K)	Assigned mobility value
Aluminum, Chromium, Thallium, Thorium, Tin	Less than 0.1	1
Barium, Beryllium, Cobalt, Copper, Lead, Manganese, Nickel, Phosphorous	0.1 to 1.0	2
Antimony, Arsenic, Boron, Bromine, Cadmium, Fluorine, Iodine, Magnesium, Mercury, Molybdenum, Radium, Radon, Selenium, Silver, Uranium, Vanadium, Zinc	Greater than 1.0	3

3.2.1.3 *Calculation of toxicity/mobility value.* Based on the overall toxicity value and the mobility value, assign a toxicity/mobility value for each hazardous substance available to migrate to ground water using Table 3-10. Use the value for the hazardous substance with the highest toxicity/mobility value as the value for this factor for the ground water migration pathway. Enter this value in Table 3-1.

TABLE 3-10.—TOXICITY/MOBILITY VALUE

	Mobility value			
	0	1	2	3
Toxicity value:				
0	0	0	0	0
1	10	27	43	60
2	20	37	53	70
3	30	47	63	80
4	40	57	73	90
5	50	67	83	100

3.2.2 *Hazardous waste quantity.*

Assign a hazardous waste quantity factor value in the same manner as is discussed in section 2.2.2 for those wastes deposited at the site that are considered to be available to migrate to ground water. Enter this value in Table 3-1.

3.2.3 *Calculation of waste characteristics value.*

Sum the toxicity/mobility and hazardous waste quantity factor values. Assign this sum as the waste characteristics value. Enter this value in Table 3-1.

3.3 *Targets.*

The ground water targets factor category reflects the human population and resources potentially at risk from an actual or potential release of hazardous substances from the site to an aquifer. Four factors are evaluated for an aquifer: maximally exposed individual, population, ground water use, and wellhead protection area. These four factors are evaluated within the target distance limit defined in section 3.0.1.1 and the aquifer boundaries established according to section 3.0.1.2.

The targets to be considered in evaluating these four factors for an aquifer must include both those targets using water from the aquifer being evaluated and those using water from any overlying aquifers, with the following exceptions. Where there are no sources at the surface and hazardous substances were introduced directly into an aquifer without migrating through overlying layers, the only targets that are to be considered for the aquifer that received the hazardous substances are limited to those using water from that aquifer, plus those using water from any additional aquifers for which an observed release from the aquifer that received the hazardous substances can be established. In this case, when evaluating an aquifer below the one into which hazardous substances were directly introduced, the targets that are considered in evaluating the lower aquifer must include those using water from the aquifer being evaluated, plus those using water from all overlying aquifers up to and including the one into which the hazardous substances were directly introduced, plus those using water from any additional aquifers where there is an observed release from the aquifer into which the wastes were directly introduced.

3.3.1 *Maximally exposed individual.*

This factor reflects the risk to the maximally exposed individual (MEI). The factor is evaluated by measuring the distance from the areas of hazardous waste deposition at a site to the nearest drinking water well within the target distance limit. In determining the nearest well, consider both the wells used for drinking water that draw water from the aquifer being evaluated and the wells that draw water from overlying aquifers, except as noted in section 3.3. Do not consider standby wells in evaluating this factor unless the standby wells are used for supply at least once every year (i.e., annually). Select the nearest well. Assign the appropriate value from Table 3-11 to this nearest drinking water well. This is the value for the maximally exposed individual factor, except as noted below.

TABLE 3-11.—MEI FACTOR EVALUATION

Distance from areas of hazardous waste deposition (miles)	Assigned value
0 to ¼	50
Greater than ¼ to ½	44
Greater than ½ to1	22
Greater than 1 to 2	12
Greater than 2 to 3	7
Greater than 3 to 4	6
Greater than 4	0

If the concentrations of hazardous substances present in a sample (or comparable samples) from any drinking water well considered above (not just the nearest) are at levels that both establish an observed release and, either individually or collectively, exceed a health-based benchmark, then the maximally exposed individual factor is assigned a value of 50. Table 3-12 lists the criteria for determining the health-based benchmarks to be considered. The concentration of a single hazardous substance in a well is considered to be above a benchmark if its concentration detected in at least one sample establishes an observed release and exceeds the benchmark for that hazardous substance. In addition, if more than one hazardous substance is present in a sample (or comparable samples) taken from a well at concentrations that establish an observed release, but all such concentrations are at or below health-based benchmarks, then calculate for each such hazardous substance that establishes an observed release the percentage of its health-based benchmark at which it is present in the sample. (Do not round the calculated percentage to the nearest integer.) If any hazardous substance is present in more than one comparable sample, then use the highest concentration of that hazardous substance in the comparable samples in determining its percentage of the health-based benchmark at which it is present. If the sum of these percentages (without round-off) for these hazardous substances exceeds 100 percent, then the contamination is considered to be above the health-based benchmark for that well. Treat sets of samples that are not comparable separately, calculating sums for each such set. If at least one of these sums exceeds 100 percent, then the contamination is considered to be above the health-based benchmark for that well.

TABLE 3-12.—HEALTH-BASED BENCHMARKS FOR HAZARDOUS SUBSTANCES IN DRINKING WATER

Health-based benchmarks to be used in order of preference: [1]
Carcinogens [2]
● National Primary Drinking Water Regulations [maximum contaminant levels (MCLs)].
● Risk specific concentration corresponding to a 10–4 individual cancer risk.
Other Hazardous Substances [3]
● National Primary Drinking Water Regulations [maximum contaminant levels (MCLs)].
● Maximum contaminant level goals (MCLGs).

[1] If more than one of these benchmarks are specified for a hazardous substance, use the top one in the hierarchy in assigning a value to the factor. If none of these benchmarks are specified for a hazardous substance, that hazardous substance is not used in the comparison of concentrations to the benchmarks.

[2] Includes any hazardous substance with a carcinogen weight-of-evidence classification of A, B, or C (See section 2.2.1.1).

[3] Includes any hazardous substance that does not have a carcinogen weight-of-evidence classification of A, B, or C (See section 2.2.1.1).

Furthermore, if a karst aquifer is one of the aquifers being evaluated and the karst aquifer underlies any portion of the site, assign the MEI factor a value of 50 if there is any well drawing drinking water from the karst aquifer within the target distance limit. If the karst aquifer does not underlie any portion of the site, but there is a well drawing drinking water from the karst aquifer within the target distance limit, then determine the distance from the areas of hazardous waste deposition to the nearest point of the karst aquifer. Use that distance to assign an MEI value from Table 3–11.

Select the highest value assigned above. Use that value as the value for the MEI factor. Enter the value in Table 3–1.

3.3.2 Population.

This factor is an indicator of both the number of people at risk from exposure to hazardous substances in drinking water and the value of the ground water supply. The population count should include persons served by drinking water wells within the target distance limit defined in section 3.0.1.1. (Any wells with observed releases from the site are considered to be within the target distance limit regardless of their distance from the site, as indicated in section 3.0.1.1). For the aquifer being evaluated, include in the population count persons served by wells in the aquifer being evaluated and persons served by wells in overlying aquifers, except as noted in section 3.3. Include residents as well as others who would regularly use the water, such as students and workers. Exclude transient populations such as customers and travelers passing through the area in autos, buses, or trains. In determining the population served by a well, if the water from the well is blended with other water (e.g., water from other wells or surface water intakes), count the population regularly served by the entire blended system as the population served by the well. When a standby well is maintained on a regular basis so that ground water supplies can be withdrawn, treat the standby well as an active well and count the population served by the standby well.

Use exact population counts where possible. If actual residential population figures are not available, the population should be estimated by determining the number of residences and multiplying each residence by the most recent U.S. Census factor for the number of persons per residence for the county in which the residence is located.

The population factor is evaluated as described below from four additional factors: level I concentrations, level II concentrations, level III concentrations, and potential contamination. If there are no samples that establish an observed release for a point of withdrawal, evaluate the point of withdrawal using the potential contamination factor (see section 3.3.2.4). If there are one or more samples that establish an observed release for a point of withdrawal, evaluate that point of withdrawal using the level I, level II, or level III concentrations factor, as appropriate. The determination of which factor applies is made based on a comparison of the concentrations of those hazardous substances that establish an observed release with their health-based benchmarks. Table 3–12 lists the criteria for determining the health-based benchmarks to be considered. The concentrations are to be measured at the point of withdrawal and may be the concentration found in untreated water or the concentrations found in treated water where treatment has not contributed to the levels of the hazardous substances detected. Table 3–13 summarizes the criteria for determining which factor is applicable. The procedure for making the determination is presented below.

TABLE 3-13.—CRITERIA FOR DETERMINING LEVEL OF CONCENTRATION

Sum of percentages [1]	Level
Greater than 100	I
Less than or equal to 100 and greater than 0.1.	II
Less than or equal to 0.1	III
No applicable benchmarks	I or II

[1] This sum is the sum of the ratios of the concentrations to the health-based benchmarks, expressed as percentages, without rounding-off.

Consider only those samples and only those hazardous substances in a sample that establish an observed release. With the exceptions noted below, if one or more such hazardous substances are present in a sample (or comparable samples) taken from a point of withdrawal, then calculate for each such hazardous substance the percentage of its health-based benchmark at which it is present. If any hazardous substance is present in more than one comparable sample, then use the highest concentration of that hazardous substance in the comparable samples in determining the percentage of its health-based benchmark at which it is present. Sum these percentages, without rounding-off. Treat sets of samples that are not comparable separately, calculating separate sums for each such set. Use the highest calculated sum to determine which factor is applicable as follows.

If the highest sum exceeds 100 percent, then the contamination at the point of withdrawal is considered to meet the criteria for level I concentrations. Evaluate such points of withdrawal as described in section 3.3.2.1. If the highest sum is less than or equal to 100 but greater than 0.1, then the contamination at the point of withdrawal is considered to meet the criteria for level II concentrations. Evaluate such points of withdrawal as described in section 3.3.2.2. If the highest sum is less than or equal to 0.1, then the contamination at the point of withdrawal is considered to meet the criteria for level III concentrations. Evaluate such points of withdrawal as described in section 3.3.2.3.

The exception to the above procedure is that if one or more hazardous substances are present in a sample from the point of withdrawal at concentrations that establish an observed release and for which no benchmarks are available, then the contamination at the point of withdrawal is considered to meet the criteria for level II concentrations unless it can be demonstrated that the level I criteria are also met. If the level I criteria are met, they apply.

3.3.2.1 Level I concentrations. This factor represents the total number of people who are exposed to hazardous substances in drinking water at concentrations that both establish an observed release and, either individually or collectively, meet the level I criteria in Table 3–13.

Sum the number of people served by water from points of withdrawal meeting the level I criteria. This sum is the value to be assigned to this factor, subject to a maximum value of 200. Enter this value in Table 3–1.

3.3.2.2 Level II concentrations. This factor represents the total number of people who are exposed to hazardous substances in drinking water which are at concentrations, either individually or collectively, that establish an observed release and that do not meet the level I criteria, but that do meet the level II criteria. Populations counted under the level I concentrations factor are not included in this factor.

Sum the number of people served by water from points of withdrawal meeting the above criteria. This sum divided by 10 is the value for this factor, subject to a maximum value of 200. Enter this value in Table 3–1.

3.3.2.3 Level III concentrations. This factor represents the total number of people who are exposed to hazardous substances in drinking water that are at concentrations which establish an observed release, but that individually or collectively do not meet the level I or II criteria. Populations counted under the level I or level II concentrations factors are not included in this factor.

Sum the number of people served by water from points of withdrawal meeting the above criteria. This sum divided by 100 is the value for this factor, subject to a maximum value of 200. Enter this value in Table 3–1.

3.3.2.4 Potential contamination. This factor represents the population within the target distance limit that is potentially exposed to hazardous substances in ground water. Thus, populations counted in the previous three population factors are not included.

Calculate the value for the potential contamination factor (PC) using the following equation, with a maximum value of 200:

$$PC=\frac{1}{100}\sum_{i=1}^{n} P_i D_i$$

where:

P_i=Population served by ground water from points of withdrawal within evaluation distance i.

D_i=Dilution weighting factor for evaluation distance i.

n=Number of evaluation distances.

The dilution weighting factors to be used are those presented in Table 3–14. The evaluation distances are the distance intervals in Table 3–14. Evaluate populations based on the locations of their water supply wells, not on the location of residences, work places, etc. Enter the value calculated in Table 3–1.

TABLE 3–14.—DILUTION WEIGHTING FACTORS FOR POTENTIALLY EXPOSED POPULATION

Distance from areas of hazardous waste deposition (miles)	Dilution Weighting Factor [3]	
	Karst Aquifer [1]	All Other Aquifers [2]
0 to ¼	1.00	1.00
Greater than ¼ to ½	0.62	0.62
Greater than ½ to 1	0.50	0.32
Greater than 1 to 2	0.50	0.18
Greater than 2 to 3	0.50	0.13
Greater than 3 to 4	0.50	0.08
Greater than 4	0	0

[1] Use this dilution weighting factor for populations drawing drinking water from a karst aquifer that underlies any portion of the site. If the karst aquifer does not underlie any portion of the site, assign the dilution weighting factor for populations drawing drinking water from the karst aquifer in the following manner. Determine the distance from the areas of hazardous waste deposition to the nearest point of the karst aquifer. Call that distance X. Determine the dilution weighting factor applicable to that distance from the "All Other Aquifers" portion of the above table. Call that dilution weighting factor D_x. The dilution weighting factors for the populations drawing drinking water from the karst aquifer are as follows:

Distance from areas of hazardous waste deposition (miles)	Dilution weighting factor [b]
X to X+¼ [a]	1.00 D_x
Greater than X+¼ to X+½ [a]	0.62 D_x
Greater than X+½ to target distance limit	0.5 D_x
Greater than target distance limit	0

[a] If the distance X+¼ or X+½ exceeds the target distance limit, assign a dilution weighting factor only within the target distance limit.

[b] If the dilution weighting factor calculated in this manner is lower than the dilution weighting factor that would be assigned at that distance for an aquifer that underlies the site and that is not a karst aquifer, then use the dilution weighting factor for "All Other Aquifers" instead of the calculated dilution weighting factor.

[2] Use this dilution weighting factor for populations drawing drinking water from "All Other Aquifers" (i.e., other than karst) that underlie any portion of the site. If the site is underlain by a karst aquifer that forms a single hydrologic unit with an aquifer that is not a karst aquifer and does not underlie any portion of the site, assign that latter aquifer a dilution weighting factor in the following manner. Determine the distance from the areas of hazardous waste deposition to the nearest point of the aquifer that is not a karst aquifer. Call that distance Y. Determine the dilution weighting factor applicable to that distance from the "Karst Aquifers" portion of the top table. Call that dilution weighting factor D_y. The dilution weighting factors for the populations drawing drinking water from the aquifer not in karst are as follows:

Distance from areas of hazardous waste deposition (miles)	Dilution weighting factor [d]
Y to Y+¼ [c]	1.00 D_y
Greater than Y+¼ to Y+½ [c]	0.62 D_y
Greater than Y+½ to Y+1 [c]	0.32 D_y
Greater than Y+1 to Y+2 [c]	0.18 D_y
Greater than Y+2 to Y+3 [c]	0.13 D_y
Greater than Y+3 to target distance limit	0.08 D_y
Greater than target distance limit	0

[c] If this distance exceeds the target distance limit, assign a dilution weighting factor only within the target distance limit.

[d] If the dilution weighting factor calculated in this manner is lower than the dilution weighting factor that would be applied at that distance for an aquifer that underlies the site and is not a karst aquifer, then use the dilution weighting factor for "All Other Aquifers" instead of the calculated dilution weighting factor.

[3] The dilution weighting factor is not to be rounded to the nearest integer.

3.3.2.5 *Calculation of population factor value.* Sum the factor values for level I concentrations, level II concentrations, level III concentrations, and potential contamination. Assign this sum as the population factor value for the aquifer, subject to a maximum value of 200. Enter this value in Table 3–1.

3.3.3 *Ground water use.*

Ground water use indicates the use and value of ground water supplies for the aquifer being evaluated and for overlying aquifers, except as noted in section 3.3. Two categories of ground water use are evaluated: drinking water use and other water use.

3.3.3.1 *Drinking water use.* Drinking water use is a measure of the use of ground water for direct human ingestion. Assess this use based on all wells within the target distance limit that draw from the aquifer being evaluated or from any overlying aquifers (except as noted in section 3.3). The drinking water use value for a well is the highest value that can be assigned to any drinking water use of that well. Assign a drinking water use value to the well from Table 3–15. If there are no drinking water wells within the target distance limit, assign a value from Table 3–15 to the target aquifer(s) based on their resource value for drinking water use.

TABLE 3–15.—DRINKING WATER USE—GROUND WATER

Type of use [1]	Assigned value
Public supply, no water from alternate unthreatened sources presently available	50
Private supply, no water from alternate un- threatened sources presently available	40
Public supply, water from alternate unthreatened sources presently available and meets minimum hookup requirements	30
Private supply, water from alternate unthreatened sources presently available and meets minimum hookup requirements	25
Standby well—used less than annually, but within past 10 years	20
Standby well—maintained but not used within past 10 years	10
Not used, but usable	10
Unusable (e.g., extremely saline aquifer as defined in the Safe Drinking Water Act)	0

[1] A well is defined as a public water supply if it is part of a system having at least 15 service connections or regularly serving at least 25 individuals. A well is defined as a private water supply, for HRS purposes, if it is part of a system that does not meet the definition of a public water supply. A standby well, if used for supply at least once every year (i.e., annually), is treated as if it is a public or private water supply and not as a standby well.

Alternate supplies must be capable of meeting current supply demands for extended periods of time and must not require extensive or unconventional treatment. For the aquifer being evaluated, an alternate supply is considered threatened if, within the ground water target distance limit, the alternate supply withdraws water from the aquifer being evaluated or from overlying aquifers (except as noted in section 3.3). An alternate supply is also considered threatened if water from the alternate supply is withdrawn from surface water within the target distance limit of the site under evaluation (see section 4.0.3), providing that a hazardous substance migration path (see section 4.0.1) can be defined for the watershed containing that surface water.

3.3.3.2 *Other water use.* Other water use is a measure of the use of ground water for agricultural, commercial and industrial purposes. Assess this use based on all wells drawing from the aquifer being evaluated and all wells drawing from any overlying aquifers (except as noted in section 3.3) that are within the target distance limit. The other water use value for a well is the highest value that can be assigned to any other water use for that well. Assign an other water use value to the well from Table 3–16.

TABLE 3–16.—OTHER WATER USE—GROUND WATER

Type of use	Assigned value
Used for irrigation (5 acre minimum) of commercial food crops or forage commercial crops	20

TABLE 3-16.—OTHER WATER USE—GROUND WATER—Continued

Type of use	Assigned value
Used for commercial livestock watering	20
Used for commercial food preparation	15
Commercial/industrial purposes other than drinking water	10
Not used for any of the above	0

3.3.3.3 Calculation of ground water use factor value. For all of the wells evaluated (or for the resource use), select the highest value assigned from section 3.3.3.1 and assign the drinking water use factor that value. Enter this value in Table 3–1. Similarly, for all of the wells evaluated (except the one used to assign the drinking water use factor value), select the highest value assigned from section 3.3.3.2 and assign the other water use factor that value.[7] Enter this value in Table 3–1. Sum the drinking water use factor value and the other water use factor value. Assign this sum as the value for the ground water use factor for the aquifer, subject to a maximum value of 50. Enter this value in Table 3–1.

3.3.4 Wellhead protection area.

Determine if either of the following criteria apply for the site:

- There is a source with a ground water containment factor value greater than zero that, either partially or fully, lies within or above a wellhead protection area designated according to Section 1428 of the Safe Drinking Water Act as amended.
- There is a ground water observed release from the site that, either partially or fully, lies within a wellhead protection area designated according to Section 1428 of the Safe Drinking Water Act as amended.

If neither criteria is met for the site, assign this factor a value of 0 for the aquifer being evaluated.

If either criteria is met, assign this factor a value as described below for the aquifer being evaluated. In assigning the factor value, consider the aquifer being evaluated and all overlying aquifers, except as noted in section 3.3. If, within the target distance limit, any of these aquifers are part of the wellhead protection area, assign this factor a value of 50 for the aquifer being evaluated. If, within the target distance limit, none of these aquifers are part of the wellhead protection area, assign this factor a value of 0 for the aquifer being evaluated. Enter the assigned value in Table 3–1.

3.3.5 Calculation of targets factor value.

Sum the MEI, population, ground water use, and wellhead protection area factor values. Assign this sum as the targets value for the aquifer, subject to a maximum value of 200. Enter this value in Table 3–1.

3.4 Ground water migration score for an aquifer.

For the aquifer being evaluated, multiply the values for the likelihood of release, waste characteristics, and targets and divide by 2×10^5. The resulting score is the ground water migration score for the aquifer. Enter this score in Table 3–1.

3.5 Ground water migration pathway score.

A ground water migration score for an aquifer should be calculated for each aquifer underlying a site, as appropriate. Select the highest ground water migration score for an aquifer and assign that score as the ground water migration pathway score (S_{gw}) for the site. Enter this score in Table 3–1.

4.0 Surface water migration pathway.

The surface water migration pathway addresses the relative risks, to the people, resources, and environment surrounding the site, that are associated with releases or threatened releases of hazardous substances from sources on a site to surface water. Four types of threats are evaluated: drinking water threat, human food chain threat, recreational threat, and environmental threat. Each of these threats is evaluated based on three factor categories: likelihood of release, waste characteristics, and targets.

Section 4.0 defines the surface water hazardous substance migration path, the surface water target distance limit, the HRS surface water categories, and the general procedure for calculating the surface water migration pathway score. Sections 4.1 through 4.4 describe the procedures for evaluating the four types of surface water threats.

4.0.1 Definition of the hazardous substance migration path for surface water.

The hazardous substance migration path includes both the overland segment and the in-water segment that hazardous substances would take as they migrate away from the site (Figure 4–1). The overland segment begins at a source and proceeds downgradient to the probable point of entry to surface water. The in-water segment of the hazardous substance migration path begins at this probable point of entry. For streams and rivers, it continues in the direction of the stream flow (including any tidal flows) for the distance established by the target distance limit (section 4.0.2). For lakes or the ocean, no flow direction is presumed and the target distance limit (section 4.0.2) is applied as an arc. If the in-water segment includes both rivers and lakes (or the ocean), the target distance limit then applies to both of their in-water segments combined (see Figure 4–2 for an example.)

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[7] Note that this procedure may be performed in the opposite order (i.e., assign the other water use factor value first) if it results in a higher value being assigned to the ground water use factor.

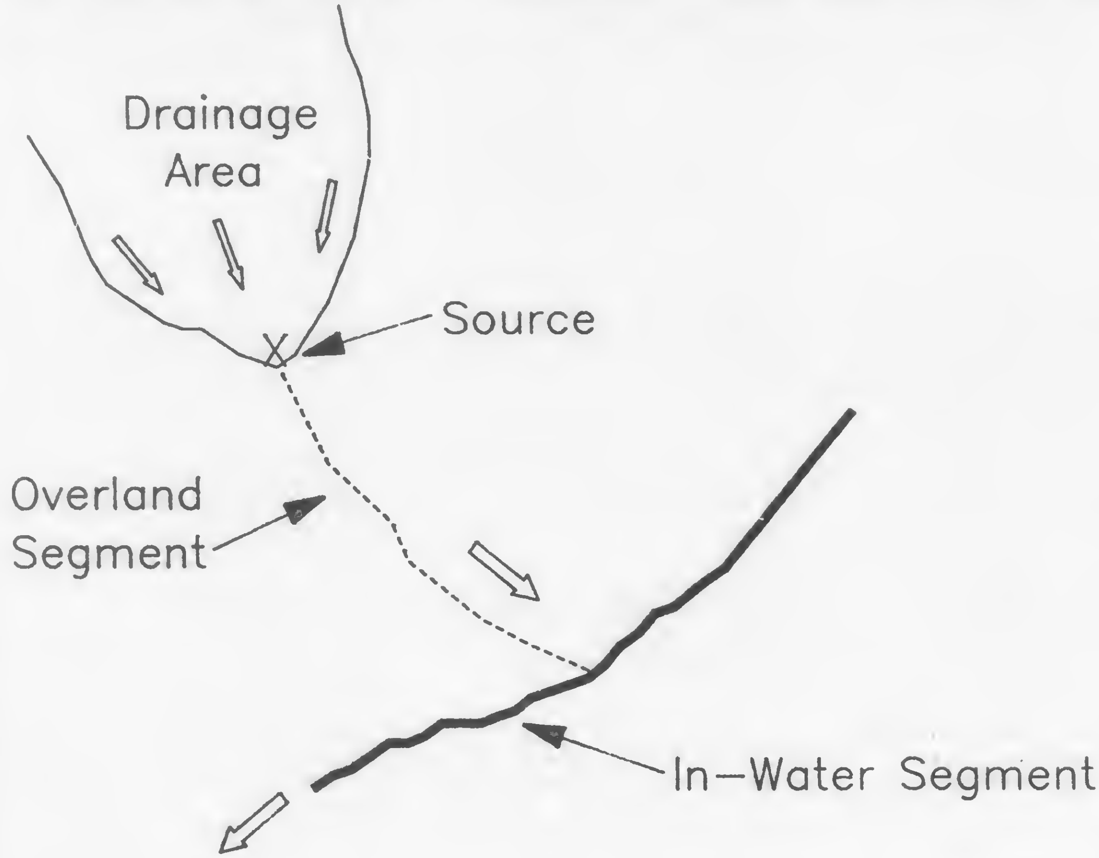

FIGURE 4-1
SURFACE WATER HAZARDOUS SUBSTANCE MIGRATION PATH

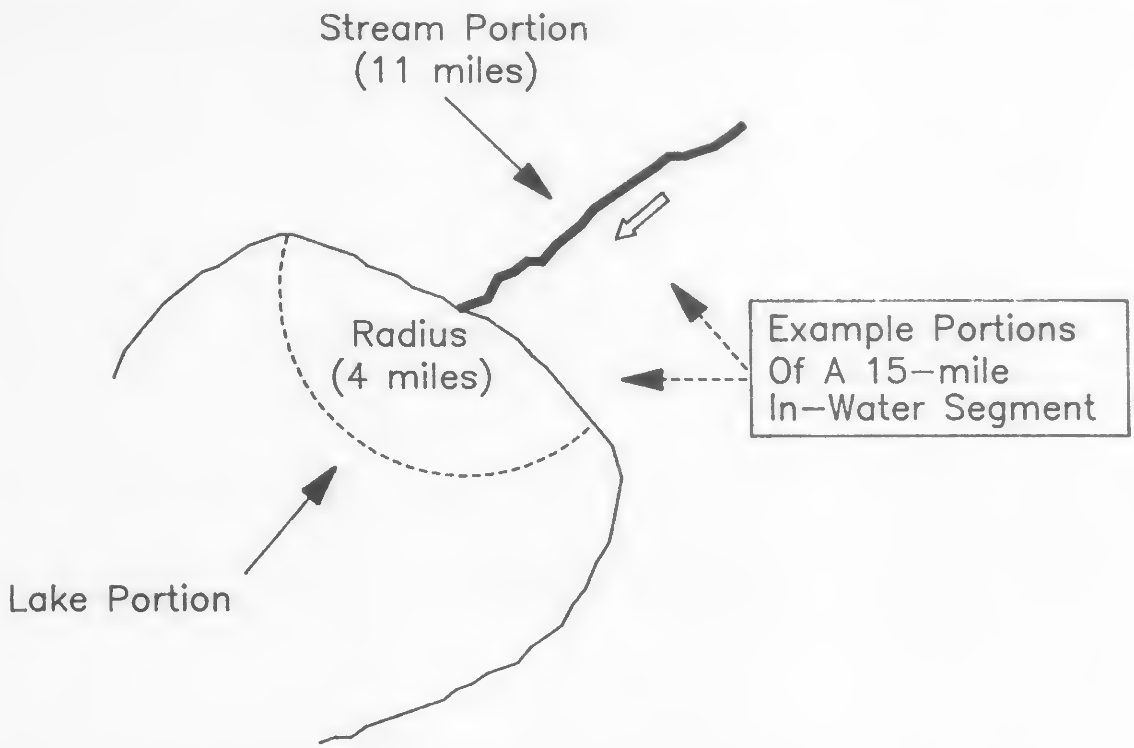

FIGURE 4-2
EXAMPLE OF THE IN-WATER SEGMENT OF A HAZARDOUS SUBSTANCE MIGRATION PATH

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A site is considered to be in on two or more watersheds if there are two or more hazardous substance migration paths from the site that do not reach a common point within the target distance limit downstream. If the site is in more than one watershed, define a separate hazardous substance migration path for each watershed. Evaluate the threat for each watershed separately as described in section 4.0.4.

If for a watershed, overland runoff from the site can reach surface water bodies within that same watershed by two or more overland segments (i.e., there are two or more hazardous substance migration paths for the watershed), select one of these hazardous substance migration path for use in evaluating the threat to that watershed as described in section 4.0.4.

4.0.2 Target distance limit.

The target distance limit is the maximum distance over which targets are to be considered when evaluating the site. If the site is in more than one watershed, a separate target distance limit should be determined for each watershed. The target distance limit for a watershed varies based on whether there is an observed release to the watershed and on the type of samples used to establish the observed release if there is one (see section 4.1.1.1 for the definition of observed release).

If there is no observed release to surface water in the watershed, measurement of the target distance limit for the watershed begins at the probable point of entry to surface water and extends for 15 miles along the water from the point. If there is an observed release to the watershed that is based on aqueous or benthic samples, measurement of the target distance limit for the watershed begins at the probable point of entry; the target distance limit extends either for 15 miles along the water or to the most distant sample point indicating an observed release to that watershed, whichever is greater. If there is an observed release based on sediment samples, the target distance limit for the watershed extends to a distance of 15 miles along the water beyond the most distant sediment sample indicating an observed release to the watershed.

The surface water targets for a site (e.g., intakes, fisheries, recreational areas, sensitive environments) must lie within or be contiguous to the hazardous substance migration path and must be located at or between the probable point of entry and the target distance limit applicable to the watershed to be considered in evaluating the threat for that watershed. Targets located at or between the probable point of entry and any sampling point establishing an observed release to the watershed are considered to be targets subject to actual contamination (defined as either level I, level II, or level III concentrations in section 4.1.3) for that watershed. Targets located within the target distance limit for the watershed, but not at or between the probable point of entry and any sampling point establishing an observed release to the watershed, are considered to be targets subject to potential contamination for that watershed. Populations, resources, and sensitive environments located beyond the target distance limit for any watershed are not considered to be targets in evaluating the site. If flow within the hazardous substance migration path is reversed by tides, for those targets that lie upstream to be considered in the evaluation, documentation is required that the tidal run could carry substances from the site as far as those upstream targets.

4.0.3 Surface water categories.

For the purpose of the HRS, surface water is divided into three categories: rivers, lakes, and oceans. The key feature of these categories is the time necessary to transport hazardous substances over the target distance limit.

For HRS purposes, rivers include:

- Perennially flowing waters from the point of origin to the ocean (including estuaries) and the wetlands contiguous to these flowing waters.
- The aboveground portion of disappearing rivers.
- Man-made ditches only insofar as they perennially flow into other surface water.
- Intermittent streams and contiguous intermittent ditches only in those arid or semi-arid areas with less than 20 inches of mean annual precipitation.

Lakes include:

- Natural and man-made lakes (including impoundments) that lie along rivers, but excluding the Great Lakes.
- Isolated, but perennial, lakes and ponds.
- The wetlands contiguous to lakes.
- Static water channels or oxbow lakes contiguous to rivers.
- Salt water harbors that are largely protected by sea walls.
- Small rivers, without diking, that merge into surrounding perennially inundated wetlands.

Ocean and ocean-like water bodies include:

- Oceans.
- Contiguous bays and wetlands.
- The Great Lakes.

The interface between a river and a lake is frequently defined on the USGS topographic maps. When the definition is unclear (e.g., a river gradually broadens into a lake), surface elevation may be helpful. Although there is flow within lakes, the surface elevation is essentially the same across the lake. Rivers, in contrast, show decreasing elevation with distance. The interface between an estuary and ocean is defined by the most seaward line from landhead to landhead unless otherwise defined by a State.

4.0.4 Evaluation of the surface water migration pathway.

The surface water migration pathway addresses four different types of threat: drinking water threat, human food chain threat, recreational threat and environmental threat. Each of these threats are evaluated for each watershed based on the following three factor categories:

- Likelihood of Release (LR).
- Waste Characteristics (WC).
- Targets (T).

Figure 4–3 indicates the factors included within each of the factor categories for each type of threat. The evaluation of the factors, factor categories, and threats is discussed in the following sections.

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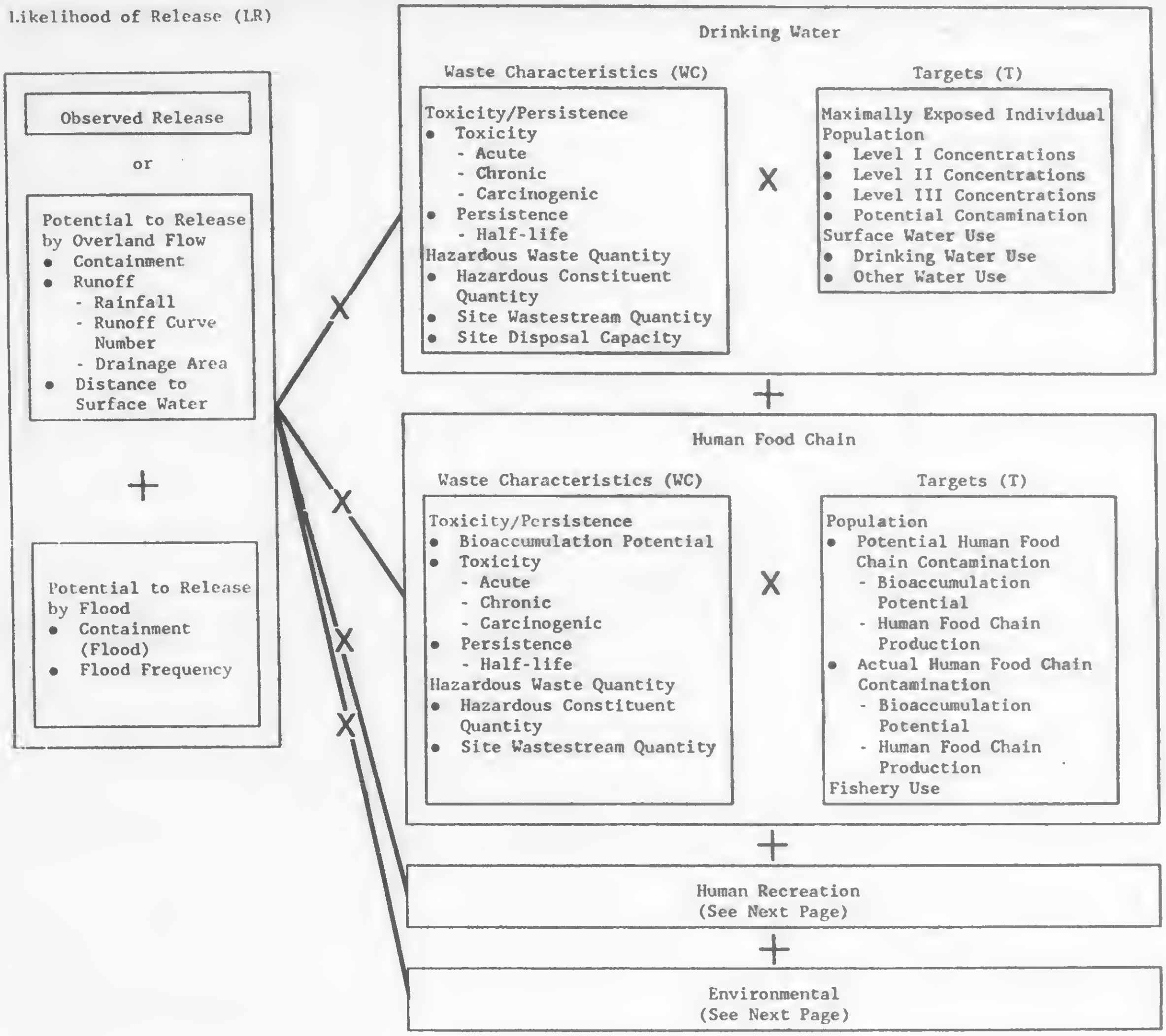

FIGURE 4-3
OVERVIEW OF SURFACE WATER MIGRATION PATHWAY

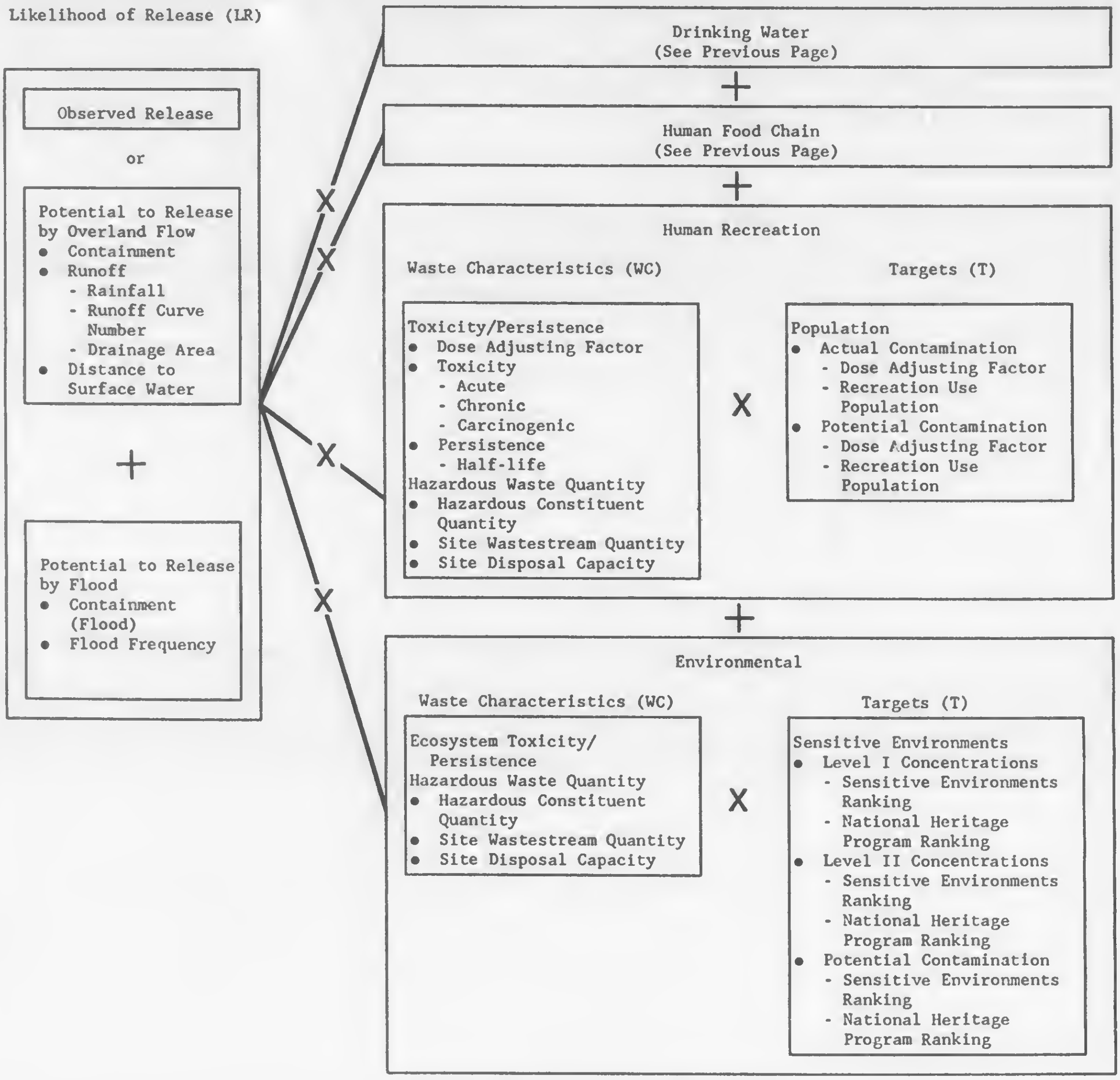

FIGURE 4-3
OVERVIEW OF SURFACE WATER MIGRATION PATHWAY
(Concluded)

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Calculate the surface water migration score for a watershed by multiplying, for each of the four threats, the values assigned to that threat for likelihood of release, waste characteristics and targets. Sum the resultant score for the four threats and normalize to a scale of 0 to 100. The calculation procedure is outlined in Table 4–1.

If there is only one hazardous substance migration path for the watershed (see section 4.0.1), use this score as the surface water migration score for the watershed. If there are two or more hazardous substance migration paths for the watershed, calculate a separate surface water migration score for each hazardous substance migration path for the watershed. For this calculation, include in the evaluation of waste characteristics for each of the hazardous substance migration paths, all those hazardous substances that are available to migrate (see section 4.1.2) along any of these hazardous substance migration paths. Select the highest surface water migration score for these hazardous substance migration paths. Use this score as the surface water migration score for the watershed. If the site is in only one watershed, use the surface water migration score for that watershed as the surface water migration score for the site.

If the site is in more than one watershed, calculate a separate surface water migration score for each watershed, using the likelihood of release, waste characteristics, and targets applicable to each watershed. Use a separate Table 4–1 to record the evaluation of each watershed. Sum the surface water migration score for each watershed. This sum is the surface water migration pathway score for the site, subject to a maximum score of 100. Enter this score on Table 4–1.

Figure 4–4 illustrates this process.

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TABLE 4-1
SURFACE WATER MIGRATION PATHWAY SCORESHEET

Factor Categories and Factors	Maximum Value	Value Assigned	
DRINKING WATER THREAT			
Likelihood of Release			
1. Observed Release	120	____	
2. Potential to Release by Overland Flow			
2a. Containment	10	____	
2b. Runoff	6	____	
2c. Distance to Surface Water	6	____	
2d. Potential to Release by Overland Flow (Lines 2a x (2b + 2c))	120	____	
3 Potential to Release by Flood			
3a. Containment (Flood)	10	____	
3b. Flood Frequency	12	____	
3c. Potential to Release by Flood (Lines 3a x 3b)	120	____	
4 Potential to Release (Lines 2d + 3c, subject to a maximum of 120)	120	____	
5. Likelihood of Release (Higher of Lines 1 or 4)	120		____
Waste Characteristics			
6. Toxicity/Persistence	100	____	
7. Hazardous Waste Quantity	100	____	
8. Waste Characteristics (Lines 6 + 7)	200		____
Targets			
9. Maximally Exposed Individual	50	____	
10. Population			
10a. Level I Concentrations	200	____	
10b. Level II Concentrations	200	____	
10c. Level III Concentrations	200	____	
10d. Potential Contamination	200	____	
10e. Population (Lines 10a + 10b + 10c + 10d, subject to a maximum of 200)	200	____	

TABLE 4-1
SURFACE WATER MIGRATION PATHWAY SCORESHEET (Continued)

Factor Categories and Factors	Maximum Value	Value Assigned	
DRINKING WATER THREAT (Concluded)			
Targets (Concluded)			
11. Surface Water Use			
11a. Drinking Water Use	50	____	
11b. Other Water Use	20	____	
11c. Surface Water Use (Lines 11a + 11b)	50	____	
12. Targets (Lines 9 + 10e + 11c, subject to a maximum of 200)	200		____
Drinking Water Threat Score			
13. Drinking Water Threat (Lines 5 x 8 x 12)	4.8×10^6		____
HUMAN FOOD CHAIN THREAT			
Likelihood of Release			
14. Likelihood of Release (Same Value as Line 5)	120		____
Waste Characteristics			
15. Toxicity/Persistence	100	____	
16. Hazardous Waste Quantity	100	____	
17. Waste Characteristics (Lines 15 + 16)	200		____

TABLE 4-1
SURFACE WATER MIGRATION PATHWAY SCORESHEET (Continued)

Factor Categories and Factors	Maximum Value	Value Assigned	
HUMAN FOOD CHAIN THREAT (Concluded)			
Targets			
18. Population			
18a. Potential Human Food Chain Contamination	200	____	
18b. Actual Human Food Chain Contamination	200	____	
18c. Population (Lines 18a + 18b, subject to a maximum of 200)	200	____	
19. Fishery Use	50	____	
20. Targets (Lines 18c + 19, subject to a maximum of 200)	200		____
Human Food Chain Threat Score			
21. Human Food Chain Threat (Lines 14 x 17 x 20)	$4.8x10^6$		____
HUMAN RECREATION THREAT			
Likelihood of Release			
22. Likelihood of Release (Same value as Line 5)	120		____
Waste Characteristics			
23. Toxicity/Persistence	100	____	
24. Hazardous Waste Quantity	100	____	
25. Waste Characteristics (Lines 23 + 24)	200		____

TABLE 4-1
SURFACE WATER MIGRATION PATHWAY SCORESHEET (Continued)

Factor Categories and Factors	Maximum Value	Value Assigned	
HUMAN RECREATION THREAT (Concluded)			
Targets			
26. Population			
26a. Actual Contamination (Highest value assigned to any recreation area, subject to a maximum of 200)	200	____	
26b. Potential Contamination (Highest value assigned to any recreation area, subject to a maximum of 200)	200	____	
26c. Population (Higher of values on Lines 26a or 26b)	200	____	
27. Targets (Value from Line 26c)	200		____
Human Recreation Threat Score			
28. Human Recreation Threat (Lines 22 x 25 x 27)	4.8×10^6		____
ENVIRONMENTAL THREAT			
Likelihood of Release			
29. Likelihood of Release (Same Value as Line 5)	120		____
Waste Characteristics			
30. Ecosystem Toxicity/Persistence	100	____	
31. Hazardous Waste Quantity	100	____	
32. Waste Characteristics (Lines 30 + 31)	200		____

TABLE 4-1
SURFACE WATER MIGRATION PATHWAY SCORESHEET (Concluded)

Factor Categories and Factors	Maximum Value	Value Assigned	
ENVIRONMENTAL THREAT (Concluded)			
Targets			
33. Sensitive Environments			
33a. Level I Concentrations	120	____	
33b. Level II Concentrations	120	____	
33c. Potential Contamination	120	____	
33d. Sensitive Environments (Lines 33a + 33b + 33c, subject to a maximum of 120)	120	____	
34. Targets (Value from Line 33)	120		____
Environmental Threat Score			
35. Environmental Threat (Lines 29 x 32 x 34)	2.88×10^6		____
SURFACE WATER MIGRATION PATHWAY SCORE FOR A WATERSHED			
36. Watershed Score[1] [(Lines 13 + 21 + 28 + 35)/48,000, subject to a maximum of 100]	100		[ ]
SURFACE WATER MIGRATION PATHWAY SCORE			
37. Pathway Score (S_{sw})[1] (Sum of scores from Line 36 for all watersheds evaluated, subject to a maximum of 100)	100		[ ]

[1]These scores are not to be rounded to the nearest integer.

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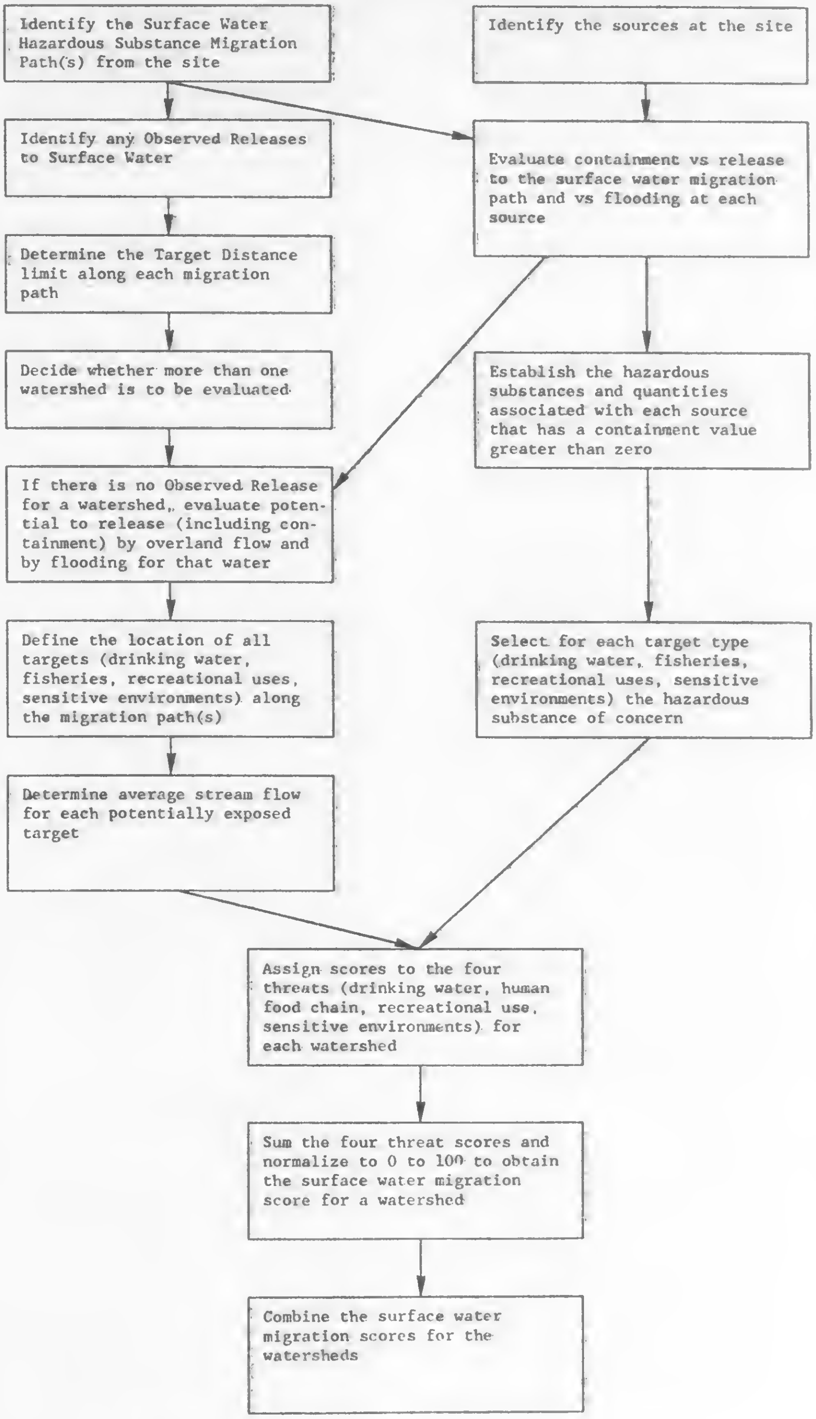

FIGURE 4-4
PROCEDURE FOR EVALUATING THE SURFACE WATER MIGRATION PATHWAY

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4.1 Drinking water threat.

The drinking water threat is used to evaluate the threat associated with the actual or potential release of hazardous substances from a site to drinking water resources. The drinking water threat score for each watershed is the product of the values for three factor categories: likelihood of release, waste characteristics and targets.

4.1.1 Drinking water threat likelihood of release.

The likelihood of release factor category reflects, for a watershed, the likelihood of a site releasing hazardous substances to the surface water in that watershed. The factor category is evaluated for each watershed in terms of an observed release factor and a potential to release factor.

4.1.1.1 Observed release. An observed release to surface water is established for a watershed whenever it can be demonstrated that a site has released a hazardous substance to the surface water in the watershed. This demonstration can be based on either direct observation of the release or indirect observation (i.e., the analysis of samples taken from surface water).

In the case of direct observation, material (e.g., leachate) from the site must be seen entering surface water either through migration or be known to have entered surface water through direct deposition. Further, available information must indicate that the material deposited in or observed entering surface water contained one or more hazardous substances. Such information should include an analysis of the hazardous substances contained in samples of the material or other similiar documentation of the content of the material. In the case of migration the available information must indicate that hazardous substances in the material have reached surface water. For the hazardous substances to be considered to have reached surface water, samples of the migrating material must be taken near the observed point of entry of the material into surface water or the source of the released material must be near the observed point of entry. Finally, documentation both that an area has been flooded at a time that hazardous substances were present and that the hazardous substances were in contact with the flood waters also constitutes an observed release.

In the case of indirect observation, the samples must indicate that a significant increase in ambient hazardous substance concentration has occurred relative to the background concentration for the site (as described below). Further, the available information must support the attribution of some portion of the increase to the site. Attribution can be based on sampling information such as the location of the samplers or other source apportionment techniques.

A significant increase is determined by comparing either surface water, benthic, or sediment samples, one of which must be a background sample for the watershed. The comparisons must be made between similar types of samples (e.g., between two or more surface water samples). The background sample should be chosen to reflect, as completely as possible, the concentration of the hazardous substance in the sample medium exclusive of the contribution of any possible releases from the site. For benthic samples, comparisons must be made between samples of relatively sessile benthic organisms (e.g., macroinvertebates, periphyton) and not between samples of far-ranging organisms (e.g., fish). The comparisons must be between benthic organisms that are similar.

The concentration of a hazardous substance is considered to be significantly above background levels under the conditions presented in Table 2–2 of section 2. See section 2.1.1 for the detection limits to be used in the evaluation.

If an observed release can be established for a watershed, then assign an observed release factor value of 120 to that watershed. If no observed release can be established for the watershed, assign an observed release factor value of zero to that watershed.

4.1.1.2 Potential to release. Potential to release is evaluated for a watershed if an observed release has not been established for the watershed. Potential to release assesses the likelihood for hazardous substances to migrate from a site to surface water in the watershed. Potential to release has two components: potential to release by overland flow (section 4.1.1.2.1) and potential to release by flooding (section 4.1.1.2.2). The sum of these two component values is the value assigned to the potential to release factor for the watershed, subject to a maximum value of 120.

4.1.1.2.1 Overland flow. The potential to release by overland flow for the watershed is based on three factors: containment, runoff, and distance to surface water.

The potential to release by overland flow is assigned a value of zero for the watershed under either of two conditions: no overland segment of the hazardous substance migration path can be defined for the watershed (e.g., the site lies in a topographic depression) or the overland segment of the hazardous substance migration path for the watershed exceeds 2 miles before surface water is encountered. If either of these conditions pertains, enter a value of zero on Table 4–1 for potential to release by overland flow for the watershed and precede to section 4.1.1.2.2 for the evaluation of potential to release by flood.

4.1.1.2.1.1 Containment. Containment for overland flow refers to the methods that have been used either to restrict or prevent the release of hazardous substances from a source (e.g., landfill) to surface water. Table I–4 of Attachment I to this Appendix A presents the criteria for use in rating the containment of inactive sources for the surface water migration pathway.

For such containment systems as diking, berms, and run-on control and runoff management systems to be considered present for rating purposes, they must completely surround the source area unless they connect with other natural or engineered barriers that together completely surround the source area. For liners to be considered present for rating purposes, they must be continuous and must cover all earth surrounding the source likely to be in contact with the hazardous substances or leachate containing the hazardous substances.

Determine the containment factor value for the watershed in the following manner. If, for the watershed, a source is located in surface water, assign the containment factor a value of 10 for the watershed. Otherwise, use Table I–4 of Attachment I to this Appendix A to assign a containment value to each inactive source at the site that can potentially release hazardous substances to the overland segment of the hazardous substance migration path for the watershed. The containment factor value for the watershed is the highest containment value assigned to any of these sources. Record the assigned value on Table 4–1.

4.1.1.2.1.2 Runoff. This factor reflects the potential for overland runoff to convey hazardous substances from a site to surface water downgradient from the site. Three components are evaluated: rainfall, runoff curve number value, and drainage area.

Rainfall. This component considers the potential for area storms to cause surface water runoff. This potential is reflected by the 2-year, 24-hour rainfall. If available, use site specific 2-year, 24-hour rainfall data. However, such site-specific data must be based on at least 20 years of record. If such site-specific data are not available, to obtain the 2-year, 24-hour rainfall appropriate to a site located in Eastern and Central States, use the Rainfall Frequency Atlas of the United States, Technical Paper No. 40, U.S. Department of Commerce, Washington, DC, 1963 (or a later version as available). To obtain this information for sites located in 11 Western States,[8] use the NOAA Atlas II, Precipitation-Frequency Atlas of the Western United States, 1973 (or a later version as available). For sites in Hawaii, use the Rainfall-Frequency Atlas of the Hawaiian Islands, Technical Paper No. 43, U.S. Department of Commerce, 1962 (or a later version as available). For sites in Alaska, use the Probable Maximum Precipitation and Rainfall-Frequency Data for Alaska, Technical Paper No. 47, U.S. Department of Commerce, 1963 (or a later version as available). For sites in Puerto Rico or the Virgin Islands, use the Generalized Estimates of Probable Maximum Precipitation and Rainfall-Frequency Data for Puerto Rico and Virgin Islands, Technical Paper No. 42, U.S. Department of Commerce, 1961 (or a later version as available).

Runoff curve number. The runoff curve number reflects the ability of soils, and the nature of the land surface, to facilitate or retard runoff. Assign a runoff curve number for the watershed according to Table 4–2, based on the predominant land use description (within the drainage area described below) and the hydrologic soil group that is found throughout most of the predominant land use area. The predominant land use is the land use that comprises the largest total area within the applicable drainage area. If a predominant land use area cannot be delineated, use the one in the

[8] These 11 states are Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

drainage area described below that yields the highest curve number, taking into consideration its respective hydrologic soil group. If a predominant soil group cannot be delineated, use the one in the drainage area that yields the highest curve number.

Most of the soils in the U.S. have been classified into the four hydrologic soil groups listed in Table 4–2. For soils, obtain their hydrologic soil group from U.S. Soil Conservation Service, Urban Hydrology for Small Watersheds, Technical Release 55, Appendix A, U.S. Department of Agriculture, Washington, D.C., 1986 (or later as available).

TABLE 4–2.—RUNOFF CURVE NUMBER [1]

Predominant land use	Hydrologic soil group [2]			
	A	B	C	D
Cultivated land:				
With runoff control (e.g., contour farming, sod waterways, terraces)	60	70	80	80
Without runoff control	70	80	90	90
Pasture or range land:				
Poor condition (exposed soil, erosion evident)	70	80	85	90
Good condition	40	60	75	80
Meadow	30	60	70	80
Wood or forest land:				
Thin stand or little soil cover	45	65	75	85
Normal stand or good soil cover	25	55	70	75
Open grass covered areas (lawns, parks, golf courses, cemeteries, etc):				
Good grass cover (75% or more coverage)	40	60	75	80
Poor grass cover (less than 75% coverage)	50	70	80	85
Industrial districts	80	90	90	95
Residential lots	60	75	85	90
Paved lots (parking lots, driveways, large roofs)	100	100	100	100
Streets and roads:				
Paved with curbs and storm sewers	100	100	100	100
Gravel	75	85	90	90
Dirt	70	80	85	90
Landfills:				
Surface composed of clay	—	—	—	90
Surface composed of debris	70	—	—	—
Surface composed of sod:				
Good sod cover (75% or more)	40	—	—	—
Poor sod cover (less than 75%)	50	—	—	—

[1] Curve numbers based on U.S. Soil Conservation Service, Technical Release No. 55, Urban Hydrology for Small Watersheds, U.S. Department of Agriculture, Washington, DC, 1986. Curve numbers have been rounded. (—) indicates soil group not relevant.

[2] The hydrologic soil groups are as follows:

A—Low runoff potential—soils having a high infiltration rate even when thoroughly wetted and consisting chiefly of deep, well-drained to excessively drained sands or gravels.

B—Soils having a moderate infiltration rate when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well-drained to well-drained soils with moderately fine to moderately coarse texture.

C—Soils having a slow infiltration rate when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water or soils with moderately fine to fine texture.

D—High runoff potential—soils having a very slow infiltration rate when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material.

Drainage area. The drainage area reflects the land area which contributes to the runoff from a site that can enter the hazardous substance migration path for the watershed. This drainage area includes both the site area and the area upgradient of the site, but excludes any portion of the drainage area where runoff is diverted away from entering the site by storm sewers or run-on control and/or runoff management systems. Use Table 4–3 to assign the drainage area value for a watershed.

TABLE 4–3.—VALUE FOR SIZE OF DRAINAGE AREA

Size of drainage area in acres	Assigned value
Less than 50 acres	1
50 to 500 acres	2
Greater than 500 acres	3

Calculation of runoff value. Use Table 4–4 to assign a combined rainfall/runoff curve number value for the watershed based on the rainfall and the runoff curve number. Enter this combined value, along with the assigned value for drainage area, into Table 4–5 to determine the runoff factor value for the watershed. Enter the runoff factor value in Table 4–1.

TABLE 4–4.—RAINFALL/RUNOFF CURVE NUMBER VALUE [1]

Rainfall (inches)	Runoff curve No. (CN)															
	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Less than 1.0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	2
1.0 to less than 1.2	0	0	0	0	0	0	0	0	0	1	1	2	2	2	2	3
1.2 to less than 1.4	0	0	0	0	0	0	0	0	1	1	2	2	2	2	2	3
1.4 to less than 1.6	0	0	0	0	0	0	0	1	1	2	2	2	2	2	3	3
1.6 to less than 1.8	0	0	0	0	0	0	0	1	1	2	2	2	2	2	3	3
1.8 to less than 2.0	0	0	0	0	0	0	1	1	2	2	2	2	2	3	3	3
2.0 to less than 2.5	0	0	0	0	1	2	2	2	2	2	2	2	3	3	3	3
2.5 to less than 3.0	0	0	0	1	1	2	2	2	2	2	2	3	3	3	3	3
3.0 to less than 4.0	0	0	1	1	2	2	2	2	3	3	3	3	3	3	3	3
4.0 or greater	0	1	1	2	2	2	2	3	3	3	3	3	3	3	3	3

[1] This table is based on the runoff per unit area estimated using a rainfall/curve number equation (U.S. Soil Conservation Service, Technical Release No. 55, Urban Hydrology for Small Watersheds, U.S. Department of Agriculture, Washington, DC, 1986).

TABLE 4–5.—RUNOFF FACTOR VALUE

Drainage area value	Rainfall/Runoff Curve Number Value			
	0	1	2	3
1	1	2	4	4
2	2	3	5	6
3	3	5	6	6

4.1.1.2.1.3 Distance to surface water. This factor indicates the potential for hazardous substances to flow overland from the site to a surface water body in the watershed. Measure the distance to surface water as the distance along the overland segment from a source to either the mean high water level for tidal waters or the mean water level for other surface waters. Use Table 4–6 to assign a value to the distance to surface water factor for the watershed. Enter the assigned factor value for distance to surface water in Table 4–1.

TABLE 4–6.—DISTANCE TO SURFACE WATER FACTOR VALUES

Distance	Assigned value
Greater than 1.5 miles to 2 miles	1
Greater than 2,500 feet to 1.5 miles	2
Greater than 1,000 feet to 2,500 feet	3
Greater than 500 feet to 1,000 feet	4
100 feet to 500 feet	5
Less than 100 feet	6

4.1.1.2.1.4 Calculation of the factor value for potential to release by overland flow. Sum the factor values for runoff and distance to surface water for the watershed and multiply the sum by the factor value for containment. Enter the result in Table 4–1 as the factor value for potential to release by overland flow for the watershed.

4.1.1.2.2 Potential to release by flood. This factor reflects the potential for hazardous substances to be released to surface water as a result of a site being partially or fully inundated by a flood from surface water in the watershed. The potential for release due to flooding is evaluated for each watershed as the product of containment (flood) and a flood frequency factor.

If a source is located within a specified floodplain, it can become partially or fully submerged during the occurrence of a flood that is equal to or greater than the specified flood. For example, a source located in a 10-year floodplain can be submerged during the occurrence of flood with recurrence period equal to or longer than 10 years. Furthermore, containment that is adequate to prevent any washout of hazardous substances by a flood of a specified recurrence period may not be adequate to prevent washout by a flood with a longer recurrence period. Consequently, each source within the watershed must be evaluated separately for containment (flood) and for flood frequency for each floodplain in which it lies.

4.1.1.2.2.1 Containment (flood). This factor reflects the methods that have been used to prevent the release of hazardous substances from a source if it is partially or fully inundated by a flood. For each source within the watershed, assign from Table 4–7 a value for containment (flood) for each of the floodplains in which the source is partially or fully located (see section 4.1.1.2.2.2 for the applicable floodplains). If the source is not in one or more of the floodplains listed in section 4.1.1.2.2.2, then, for that source, assign a containment (flood) value of zero to each of the listed floodplains in which the source does not lie.

TABLE 4–7.—CONTAINMENT (FLOOD) VALUES

Containment criteria	Assigned value
Certification by a professional engineer that containment at the source is adequate to prevent any washout of hazardous substances by the flood being evaluated	0
Other	10

4.1.1.2.2.2 Flood frequency. This factor reflects the potential for a source or any portion of the source to be inundated by a flood from surface water within the watershed. For each source within the watershed, assign a value for flood frequency for each of the floodplains in which the source is partially or fully located. Assign the values using the criteria in Table 4–8.

TABLE 4–8.—FLOOD FREQUENCY FACTOR VALUES

Floodplain criteria	Assigned value
Source floods annually	12
Source in 10-year floodplain	10
Source in 100-year floodplain	5
Source in 500-year floodplain	1
None of the above	0

4.1.1.2.2.3 Calculation of the factor value for potential to release by flood. For each source within the watershed and for each floodplain in which the source is located, calculate a potential to release by flood value. Calculate this value as the product of the containment (flood) value and the flood frequency value for the floodplain. Select the highest value calculated for these sources. Use this value as the value for the potential to release by flood factor for the watershed. Enter, in Table 4–1, this potential to release by flood value for the watershed as well as the values for containment (flood) and flood frequency that yielded this highest value.

4.1.1.2.3 Calculation of potential to release factor value. Sum the values for the watershed for potential to release by overland flow and potential to release by flood. Assign this sum as the potential to release factor value for the watershed, subject to a maximum value of 120. Enter this value in Table 4–1.

4.1.1.3 Calculation of drinking water threat likelihood to release value. If an observed release is established for the watershed, assign the observed release factor value as the likelihood of release value for the watershed. Otherwise, assign the potential to release factor value for that watershed as the likelihood of release value for the watershed. Enter the value in Table 4–1.

4.1.2 Drinking water threat waste characteristics.

This factor category assesses waste characteristics that reflect the rate, duration, and relative toxicity of potential hazardous substances releases from the site. Two factors are included: toxicity/persistence and hazardous waste quantity.

The hazardous substances at the site that are to be considered in the evaluation of a watershed are restricted to those that are available to migrate via the surface water hazardous substance migration path for the watershed (section 4.0.1). Those hazardous substances available to migrate include hazardous substances establishing an observed release to surface water in the watershed as well as all hazardous substances found or documented to have been deposited at the site in a source that could be assigned a surface water containment value for either overland flow (section 4.1.1.2.1.1) or flood (section 4.1.1.2.2.1) that is greater than zero for the watershed. Also, hazardous substances whose location on the site cannot be determined but that could have been deposited in any source with a surface water containment value greater than zero are considered to be available to migrate to surface water. Hazardous substances whose location on the site cannot be determined shall be assumed to have been placed in all sources on the site, except those specific sources for which there is definitive information that indicates that the hazardous substances were not or cannot have been placed in the source.

4.1.2.1 Toxicity/persistence. In determining the toxicity/persistence value for the watershed, evaluate all hazardous substances that are available to migrate by the hazardous substance migration path for the watershed. For each hazardous substance considered, assign a toxicity value and a persistence value as described in the following sections. Combine these values into a single toxicity/persistence value for each hazardous substance as described in section 4.1.2.1.3.

4.1.2.1.1 Toxicity. Assign a toxicity value in the same manner as is discussed in Section 2.2.1.1 for each hazardous substance that is considered to be available to migrate to surface water in the watershed.

4.1.2.1.2 Persistence. Persistence of hazardous substances in the surface water environment is evaluated based on the expected reduction of the hazardous substance concentration, as a result of decay processes, over the target distance limit. Assess the persistence of hazardous substances in terms of half-life. The half-life is defined as the time to reduce the initial concentration by half as a result of the combined decay processes of biodegradation, hydrolysis, photolysis, volatilization, and free-radical oxidation.

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

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

where $h = (t_{1/2})_h$ = Hydrolysis half-life.
$b = (t_{1/2})_b$ = Biodegradation half-life.
$ox = (t_{1/2})_o$ = Oxidation half-life.
$p = (t_{1/2})_p$ = Photolysis half-life.
$v = (t_{1/2})_v$ = Volatilization half-life.

Estimate the hydrolysis, biodegradation, oxidation, photolysis, and volatization half-lives using the methodology in Attachment II to this Appendix A. If one or more of these five component half-lives cannot be estimated based on available data, delete the component for that half-life from the denominator of the above equation. If none of these five component half-lives can be estimated from available data, a default procedure is used as described below. A separate half-life should be estimated for lakes and for rivers, oceans, and the Great Lakes.

If a half-life can be estimated for a hazardous substance, assign the hazardous substance a persistence value using the appropriate portion of Table 4–9 (i.e., lake; or river, ocean, or Great Lake). If a half-life cannot be estimated from available data for those hazardous substances that are metals (or metalloids), assign a persistence value of 3 to the hazardous substance as a default for all surface water bodies. For other hazardous substances, assign a persistence value of 2 to the hazardous substance as a default for rivers, the ocean, and the Great Lakes, and a persistence value of 1 as a default for lakes.

TABLE 4–9.—PERSISTENCE VALUE

Substance half-life (days)	Assigned value
Persistence in Rivers, the Ocean, and the Great Lakes	
Less than or equal to 0.01	0
Greater than 0.01 but less than or equal to 0.1	1
Greater than 0.1 but less than or equal to 0.5	2
Greater than 0.5	3
Persistence in Lakes	
Less than or equal to 0.02	0
Greater than 0.02 but less than or equal to 2	1
Greater than 2 but less than or equal to 20	2
Greater than 20	3

Select the appropriate portion of Table 4–9 to be used in assigning the persistence value based on the type of surface water body in which the nearest drinking water intake along the hazardous substance migration path is located. If there are no drinking water intakes, then select the appropriate portion of Table 4–9 based on the type of surface water body in which the nearest intake used for any of the other water uses listed in Section 4.1.3.3 is located. If the in-water segment of the hazardous substance migration path between the probable point of entry and the selected nearest intake includes both lakes and other water bodies, use the criteria for lakes only if more than half the distance to this nearest intake lies in the lake(s). Otherwise, use the criteria for rivers, the ocean, and the Great Lakes. In those cases where there is no target intake (e.g., the water is usable but not used), use the criteria for lakes only if more than half the in-water segment of the hazardous substance migration path lies in the lake(s). Otherwise, use the criteria for rivers, the ocean, and the Great Lakes.

4.1.2.1.3 Calculation of toxicity/persistence value. Based on the overall toxicity value and the persistence value, assign a toxicity/persistence value for each hazardous substance available to migration to surface water using Table 4–10. Use the value for the substance with the highest toxicity/persistence value for the watershed as the value for this factor for the watershed. Enter this value in Table 4–1.

TABLE 4–10.—TOXICITY/PERSISTENCE VALUE

	Persistence value			
	0	1	2	3
Toxicity value:				
0	0	0	0	0
1	10	27	43	60
2	20	37	53	70
3	30	47	63	80
4	40	57	73	90
5	50	67	83	100

4.1.2.2 Hazardous waste quantity. Assign a hazardous waste quantity factor value for the watershed in the same manner as is discussed in section 2.2.2 for those wastes deposited at the site that are considered to be available to the hazardous substance migration path for the watershed. Enter the value for the hazardous waste quantity factor for the watershed in Table 4–1.

4.1.2.3 Calculation of drinking water threat waste characteristics value. Sum the toxicity/persistence and hazardous waste quantity factor values for the watershed. Assign this sum as the value for drinking water threat waste characteristics for the watershed. Enter the value in Table 4–1.

4.1.3 Drinking water threat targets.

The targets factor category for the drinking water threat reflects the human population and resources potentially at risk from an actual or potential release of hazardous substances from the site to surface water resources used for drinking water or for agricultural, industrial, or commerical purposes. Three factors are evaluated: maximally exposed individual, population, and surface water use. The values for these three factors are determined as described below for each watershed and summed to obtain the overall value for drinking water threat targets for the watershed, subject to a maximum value of 200.

For two of the factors, maximally exposed individual and population, their evaluation is based on whether the target surface water intakes are considered to be subject to actual or potential contamination as defined in section 4.0.2. The determination of actual contamination can be based on samples taken at the intake or downstream from the intake as discussed in section 4.0.2. The concentrations of those hazardous substances that are present in comparable samples and that are significantly above background levels and attributable at least in part to the site (i.e., those hazardous substance concentrations that establish an observed release) define exposure concentrations for the intake. If there is more than one set of comparable samples, there may be more than one set of exposure concentrations. If the exposure concentrations are measured at the surface water intake, they can be based on the concentrations found in untreated water or treated water where treatment has not contributed to the level of the hazardous substances detected.

Actual contamination at an intake is evaluated as either level I concentrations, level II concentrations, or level III concentrations. The determination of which level applies at the intake is made based on a comparison of the exposure concentrations from comparable samples with their health-based benchmarks. Level I concentrations apply to those intakes at which one or more sets of exposure concentrations, either individually or collectively, exceed health-based benchmarks. Level II concentrations apply to those intakes for which all of the sets of exposure concentrations collectively do not exceed health-based benchmarks but for which at least one set exceeds 0.1 percent of the health-based benchmarks. This level also applies to those intakes for which the level I criteria are not met, but for which there is one or more hazardous substances in an exposure concentration that do not have health-based benchmarks available. Level III concentrations apply to those intakes for which all of the exposure concentrations collectively do not exceed 0.1 percent of health-based benchmarks. Table 3–12 (section 3.3.1) lists the criteria for determining the health-based benchmarks to be used for hazardous substances in drinking water. Table 3–13 (section 3.3.2) summarizes the criteria for determining which level applies at an intake. The procedure for making the determination is presented below.

In determining the level that applies, consider only those samples and only those hazardous substances in a sample that establish an observed release. With the exception noted below, if one or more such hazardous substances are present in a sample (or comparable samples) taken from an intake, then calculate for each such hazardous substance the percentage of its health-based benchmark at which it is present. If any hazardous substance is present in more than one comparable sample, then use the highest concentration of that hazardous substance from the comparable samples as the exposure concentration in determining the percentage of its health-based benchmark at which it is present. Sum these percentages without rounding-off. Treat sets of samples that are not comparable as separate sets of exposure concentrations, calculating separate sums for each such set. Use the highest calculated sum to determine which level is applicable as follows.

If the highest sum exceeds 100 percent, then the actual contamination at the intake is considered to meet the criteria for level I concentrations. If the highest sum is less than or equal to 100 but greater than 0.1, then the actual contamination at the intake is considered to meet the criteria for level II concentrations. If the highest sum is less than or equal to 0.1, then the actual contamination at the intake is considered to meet the criteria for level III concentrations.

The exception to the above procedure is that if one or more hazardous substances are present in a sample from the intake at concentrations that establish an observed release and for which no benchmarks are available, then the contamination at the intake is considered to meet the criteria for level II concentrations unless it can be demonstrated that the level I criteria are also met. If the level I criteria are met, they apply.

4.1.3.1 Maximally exposed individual. This factor reflects the threat to the maximally exposed individual (MEI). The calculation of the factor value requires the assignment of the appropriate dilution weighting factor from Table 4–11 for the nearest drinking water intake (either public or private) along the hazardous substance migration path for the watershed. Do not consider standby intakes in evaluating this factor unless the standby intake is used for supply at least once every year (i.e., annually).

TABLE 4-11.—DILUTION WEIGHTING FACTORS

Surface water characteristic	Average annual flow in cubic feet per second (CFS)	Assigned value[1]
Minimum perennial stream	Less than 5 cfs.	10
Small to moderate stream	5 to 50 cfs.	1
Moderate to large stream	Greater than 50 to 500 cfs.	0.1
Large streams to rivers	Greater than 500 to 10,000 cfs.	0.005
Major rivers	Greater than 10,000 cfs.	0.001
Ocean or the Great Lakes	Not applicable.	0.001
Mixing zone of quiet flowing rivers.	Greater than 50 cfs.	0.5

[1] The dilution weighting factor value is not to be rounded to the nearest integer.

The assignment of a dilution weighting factor requires an estimate of average annual flow sufficient to assign a stream or river to one of five categories in Table 4–11, ranging from minimum perennial stream to major river. The preferred datum is average annual discharge as defined in the U.S. Geological Survey Water Resources Data Annual Report. If this datum is not available, the average annual flow may be established based on other criteria such as annual gauging information for a period of less than five years, stream morphology, watershed area and runoff, or interpolation or extrapolation from points of documented average flow.

When the target intake being evaluated is located on a river, assign the dilution weighting factor based on the average flow in the river at the target intake. If the intake is on a lake, assign the dilution weighting factor based on the sum of the average flows for the rivers entering the lake up to the point of the intake. In those cases where flow is decreasing with distance, use the highest average flow between the intake and the probable point of entry; however, if the decrease in flow results primarily from evaporation, use the flow at the intake. Assign the ocean and the Great Lakes the same dilution weighting factor as a major river, as indicated in Table 4–11. In those cases where there is flow from a surface water body with a lower dilution weighting factor value to a surface water body with a higher dilution weighting factor value (i.e., flow is from a surface water body with more dilution to one with less dilution), then use the lower dilution weighting factor value as the dilution weighting factor value for the latter surface water body.

Mixing of hazardous substances is rapidly achieved in turbulent rivers (e.g., rocky bottoms, rapids), whereas hazardous substances tend to remain as a slug or plume for longer distances in quiet-flowing rivers (e.g., silted bottom and meandering). A zone of mixing is to be applied to a quiet-flowing river that contains the probable point of entry from the site to surface water. The zone of mixing starts at this probable point of entry and, with one exception, extends for 3 miles from the probable point of entry. The exception is that if the surface water characteristics change to turbulent within this 3-mile distance, the zone of mixing extends only to the point at which the change occurs. Assign a dilution weighting factor value of 0.5 for any intake that lies within the zone of mixing if the quiet-flowing river has an average flow greater than 50 cubic feet per second. Beyond this zone of mixing, assign a quiet-flowing river the same dilution weighting factor value as any other river. For a quiet-flowing river with an average flow less than or equal to 50 cubic feet per second, do not use the river characteristic "mixing zone of the quiet flowing river" in assigning the dilution weighting factor value to any portion of the river.

To calculate the value for the MEI factor for the watershed, multiple the dilution weighting factor for the nearest intake by 50, subject to a maximum MEI factor value of 50. If, however, there is actual contamination at any drinking water intake within the target distance limit for the watershed and the criteria for level I concentrations (as defined in sections 4.0.2 and 4.1.3) are met at any intake, assign the MEI factor a value of 50 for the watershed. Do not consider standby intakes in evaluating the MEI factor unless the standby intake is used for supply at least once a year (i.e., annually). Enter the value assigned in Table 4–1.

4.1.3.2 Population. This factor reflects the number of people at risk from actual or potential contamination of the in-water segment of the hazardous substance migration path for the watershed. The population factor is evaluated, as described below, from four additional factors: level I concentrations, level II concentrations, level III concentrations, and potential contamination. Evaluate the level I concentrations factor described in section 4.1.3.2.1 for each intake meeting the criteria for level I concentrations. Evaluate the level II concentrations factor described in section 4.1.3.2.2 for each intake meeting the criteria for level II concentrations. Evaluate the level III concentrations factor described in section 4.1.3.2.3 for each intake meeting the criteria for level III concentrations. Evaluate the potential contamination factor described in section 4.1.3.2.4 for all other intakes.

The population count to be used in evaluating each of these factors should include persons served by drinking water drawn from intakes (both public and private) that are along the surface water hazardous substance migration path for the watershed (section 4.0.1) and that are within the target distance limits defined in section 4.0.2. Include residents as well as others who would regularly use the water, such as students and workers. Exclude transient populations such as customers and travelers passing through the area in autos, buses, or trains. In determining the population served by an intake, if the water from the intake is blended with other water (e.g., water from other intakes or ground water wells), count the population regularly served by the entire blended system as the population served by the intake. When a standby intake is maintained on a regular basis so that surface water supplies can be withdrawn, treat the standby intake as an active intake and count the population.

Use exact population counts where possible. If actual residential population figures are not available, the population should be estimated by determining the number of residences and multiplying each residence by the most recent U.S. Census factor for the number of persons per residence for the county in which the residence is located.

4.1.3.2.1 Level I concentrations. This factor represents the total number of people who are exposed to hazardous substances in drinking water at concentrations that both establish an observed release and, either individually or collectively, meet the level I criteria (as defined in sections 4.0.2 and 4.1.3). Only count persons in this category who use intakes that are subject to level I concentrations as defined in section 4.1.3.

The population count is the value for this factor, subject to a maximum value of 200. Sum the number of people served by water from intakes that are subject to level I concentrations and enter the value in Table 4–1, subject to the maximum of 200.

4.1.3.2.2 Level II concentrations. This factor represents the total number of people who are exposed to hazardous substances in drinking water which are at concentrations, either individually or collectively, that establish an observed release and that do not meet the level I criteria, but that do meet the level II criteria (as defined in sections 4.0.2 and 4.1.3). Populations counted under the level I concentrations factor are not counted under this factor.

Sum the number of people served by water from intakes that are subject to level II concentrations. This sum divided by 10 is the value for this factor, subject to a maximum of 200. Enter the value in Table 4–1.

4.1.3.2.3 Level III concentrations. This factor represents the total number of people who are exposed to hazardous substances in drinking water that are at concentrations which establish an observed release, but that individually or collectively do not meet the level I or II criteria (as defined in sections 4.0.2 and 4.1.3). Populations counted under the level I or level II concentrations factors are not included in this factor.

Sum the number of people served by water from intakes that are subject to level III concentrations. This sum divided by 100 is the value for this factor, subject to a maximum of 200. Enter the value in Table 4–1.

4.1.3.2.4 Potential contamination. This factor represents the population within the target distance limit for the watershed, that is potentially exposed to hazardous substances in drinking water (i.e., population served by surface water intakes subject to potential contamination as defined in section 4.1.3). Thus, populations counted in the level I, level II, and level III concentrations factors are not included.

Calculate the value for the potential contamination factor (PC) for the watershed as follows, subject to a maximum value of 200:

$$PC = \frac{1}{100} \times \sum_{i=1}^{n} P_i \; D_i$$

where:

P_i=Population using intake i.
D_i=Dilution weighting factor for intake i.
n=Number of intakes.

Determine the appropriate dilution weighting factor for each intake from Table 4–11, as described in section 4.1.3.1. Enter the value for PC in Table 4–1, subject to a maximum of 200.

4.1.3.2.5 Calculation of population factor value. Sum the factor values for level I concentrations, level II concentrations, level III concentrations, and potential contamination. Assign this sum as the population factor value for the watershed, subject to a maximum value of 200. Enter this value in Table 4–1.

4.1.3.3 Surface water use. This factor indicates the use and value of surface water drawn from the in-water segment of the hazardous substance migration path within the target distance limit for the watershed. Two categories of surface water use are evaluated: drinking water use and other water use.

4.1.3.3.1 Drinking water use. Drinking water use is a measure of the use of surface water for direct human ingestion. Assess all intakes drawing drinking water from the in-water segment of the hazardous substance migration path that are within the target distance limit for the watershed. The drinking water use value for an intake is the highest value that can be assigned to any drinking water use for that intake. Assign a drinking water use value to the intake using Table 4–12. If there are no intakes within the target distance limit, assign a value from Table 4–12 to the surface water within the target distance limit for the watershed based on its resource value for drinking water use.

TABLE 4–12.—DRINKING WATER USE—SURFACE WATER

Type of use	Assigned value
DRINKING WATER—PUBLIC WATER SUPPLY [1]	
An adequate alternative supply has not been developed:	
—and no studies have been completed which verify that such a supply is technically and economically feasible	50
—but could be developed, although it would be threatened by the site	45
—but could be developed and would be unthreatened by the site	40
An alternative source is already developed and can be brought into use without major changes in the system:	
—alternate source threatened by the site	35
—alternate source unthreatened by the site	30
The target intake being evaluated is a standby intake for the system:	
—used less than annually, but used within past 10 years	25
—maintained but not used within the past 10 years	20
DRINKING WATER—PRIVATE WATER SUPPLY [1]	
No alternative supply is readily available with minimum hookup requirements	40
An alternative unthreatened supply is readily available with mimimum hookup requirements	15
NOT CURRENTLY USED FOR DRINKING WATER	
Designated by State for drinking water use [2] but not currently used	15
Not currently used and does not meet the criteria for an assigned value of zero	5
Not usable without extensive treatment because of naturally-occurring water quality problems	0

[1] An intake is defined as a public water supply if it is part of a system having at least 15 service connections or regularly serves at least 25 individuals. An intake is defined as private water supply, for HRS purposes, if it is part of a system that does not meet the definition of a public water supply. A standby intake, if used for supply at least once every year (i.e., annually), is treated as if it is a public or private water supply and not as a standby well.

[2] Table I–1 of Attachment I of this Appendix A presents the State designations for drinking water use.

To be defined as adequate in Table 4–12, an alternative supply must be capable of providing sufficient volume and also must not require extensive or unconventional treatment (e.g., for high salinity). Bottled water or water delivered by vehicle is considered for HRS purposes to be a temporary measure rather than an alternative supply. An alternative supply is considered threatened if water from the alternative supply is withdrawn from surface water within the target distance limit of the site, providing that a hazardous substance migration path can be defined for the watershed containing that surface water. An alternate supply is also considered threatened if water from the alternate supply is withdrawn from aquifers within the ground water target distance limit (see section 3.0.1.1) of the site.

4.1.3.3.2 Other water use. Other water use is a measure of the use of surface water for agricultural, commercial and industrial purposes. Assess all intakes drawing water from the in-water segment of the hazardous substance migration path that are within the target distance limit for the watershed. The other water use value for an intake is the highest value that can be assigned to any other water use for that intake. Assign an other water use value to the intake using Table 4–13.

TABLE 4–13.—OTHER WATER USE—SURFACE WATER

Type of use	Assigned value
Used for irrigation (5 acre minimum) of commercial food crops or commercial forage crops	20
Used for commercial livestock watering	20
Used for commercial food preparation	15
Used for commercial/industrial purposes other than drinking water, recreation, fishery, or transportation	10
Not used for any of the above	0

4.1.3.3.3 Calculation of surface water use factor value. For all of the intakes evaluated (or for the resource use), select the highest value assigned from section 4.1.3.3.1 and assign that highest value to the drinking water factor for the watershed. Similarly, for all of the intakes evaluated for the watershed (except the one used to assign the drinking water factor value), select the highest value assigned from section 4.1.3.3.2 and assign the other water use factor that highest value.[9] Sum the assigned values for the drinking water use factor and the other use factor. Assign this sum, not to exceed 50, as the value for the surface water use factor for the watershed.

Note that if the surface water use factor is assigned a nonzero value for the watershed, then the fisheries use factor in section 4.2.3.2 must be assigned a value of zero for the watershed. If the fisheries use factor is assigned a nonzero value for the watershed, then the surface water use factor must be assigned a value of zero for the watershed. The use (surface water use or fisheries use) which results in the higher overall surface water migration pathway score for the watershed should be assigned the nonzero factor value; the other use should be assigned a factor value of zero.[10]

[9] Note that this procedure may be performed in the opposite order (i.e., assign other water use factor value first) if it results in higher value being assigned to the surface water use factor.

[10] Note this determination can be made as follows: Multiply the value for the waste

Continued

Enter the value for drinking water use and the value for other water use for the watershed on Table 4-1. If the fisheries use factor is to be assigned a nonzero value, then enter in Table 4-1 a zero for the surface water use factor. Otherwise, sum the values for drinking water use and other water use and enter the sum, subject to a maximum value of 50, on Table 4-1 as the value for the surface water use factor for the watershed.

4.1.3.4 Calculation of the drinking water threat targets value. Sum the MEI, population and surface water use factor values for the watershed. This sum is the drinking water threat targets value for the watershed, subject to a maximum value of 200. Enter the targets value in Table 4-1.

4.1.4 Calculation of the drinking water threat score for a watershed.

Multiply the values for the likelihood of release (maximum value of 120), waste characteristics (maximum value of 200), and drinking water threat targets (maximum value of 200) for the watershed. The product is the drinking water threat score for the watershed. Enter the score (maximum value of 4,800,000) in Table 4-1.

4.2 Human food chain threat.

The human food chain threat is used to evaluate the threat associated with the actual or potential release of hazardous substances to surface waters containing human food chain organisms. The human food chain threat score for a watershed is the product of the values for three factor categories: likelihood of release, waste characteristics and targets.

4.2.1 Human food chain threat likelihood of release.

Assign the same value for human food chain threat likelihood of release for the watershed as was assigned for drinking water threat likelihood of release for the watershed in section 4.1.1.3. Enter this value in Table 4-1.

4.2.2 Human food chain threat waste characteristics.

This factor category assesses waste characteristics that reflect the rate, duration and relative human toxicity of potential hazardous substances releases from the site to the human food chain. Two factors are included: toxicity/persistence and hazardous waste quantity.

4.2.2.1 Toxicity/persistence. Evaluate toxicity/persistence for the human food chain threat in the same manner as toxicity/persistence is evaluated for the drinking water threat (Section 4.1.2.1) except as discussed below. The major exception relates to the role that bioaccumulation potential plays in the selection of the substance whose toxicity/persistence value is employed in the evaluation for the watershed. The hazardous substances to be considered are all those eligible to be considered for the drinking water threat for the watershed (see section 4.1.2).

4.2.2.1.1 Bioaccumulation potential. Use the following data hierarchy to assign a bioaccumulation potential value to each hazardous substance:

- Bioconcentration factor (BCF) data.
- Logarithm of the n-octanol-water partition coefficient (log Pow) data.
- Water solubility data.

Assign a bioaccumulation potential value to each hazardous substance using Table 4-14.

TABLE 4-14.—BIOACCUMULATION POTENTIAL VALUE

	Assigned value [1]
If BCF data are available, assign a value as follows:	
BCF	
Greater than or equal to 10,000	6
1,000 to less than 10,000	5
100 to less than 1,000	4
10 to less than 100	3
1 to less than 10	2
Less than 1	1
If BCF data are not available, assign a value as follows:	
Log Pow	
5.5 to 6.0	6
4.5 to less than 5.5	5
3.2 to less than 4.5	4
2.0 to less than 3.2	3
0.8 to less than 2.0	2
Less than 0.8	1
If Log Pow data are not available or exceed 6.0, assign a value as follows:	
Water Solubility (mg/l)	
Less than 25	6
25 to 500	5
Greater than 500 to 1500	4
Greater than 1500	1

[1] If the hazardous substance biomagnifies, increase the assigned value by one, except that the assigned value may not exceed 6.

If a BCF is available for any aquatic human food chain organism for the substance being evaluated, use the BCF to assign the bioaccumulation potential value to the hazardous substance. Use the following hierarchy for BCF data:

- BCF values in EPA Water Quality Criteria Documents.
- BCF values from peer reviewed literature.

If, within the same level of the hierarchy, BCFs are available for more than one species or from more than one bioassay of the same species, use the highest reported BCF in assigning a bioaccumulation potential value to the hazardous substance.

If BCF data are not available for the hazardous substance, use log Pow data to assign a bioaccumulation potential value to organic substances. Log Pow data are not to be used to assign a value to inorganic substances. If log Pow data are not available for the hazardous substance or if the log Pow exceeds 6.0, use water solubility data to assign a bioaccumulation potential value. (Use water solubility data as defined in section 3.2.1.2.) If none of these data are available, assign the hazardous substance the minimum bioaccumulation potential value of 1.

If a hazardous substance is reported in EPA Water Quality Criteria documents or peer reviewed literature to biomagnify [11], increase the assigned value by one in all cases, except that a hazardous substance must not be assigned a bioaccumulation potential value higher than 6.

4.2.2.1.2 Toxicity. Select those hazardous substances that have the highest bioaccumulation potential value. Assign a value for toxicity to these hazardous substances using the same procedures described in section 4.1.2.1.1.

4.2.2.1.3 Persistence. Evaluate the persistence of the set of hazardous substances that have the highest bioaccumulation potential value. Assign a value for persistence to each hazardous substance in the set, using the same procedures described in section 4.1.2.1.2, with one exception. In assigning the persistence value, use the predominant water category (i.e., lake; or river, ocean or Great Lake) between the probable point of entry and the nearest fishery (not the nearest drinking water intake) along the hazardous substance migration path for the watershed to determine which portion of the persistence rating table is to be used. The predominant water category is determined based on distance as described in section 4.1.2.1.2.

4.2.2.1.4 Calculation of the toxicity/persistence value, considering bioaccumulation. Bioaccumulation potential is considered in the selection of the substance whose toxicity/persistence value is employed in evaluating the human food chain threat for the watershed. For the set of hazardous substances with the highest bioaccumulation potential value for the watershed, assign a toxicity/persistence value to each hazardous substance in the set, using Table 4-10. Select that hazardous substance with the highest human toxicity/persistence value. Use the toxicity/persistence value of this hazardous substance as the assigned toxicity/persistence factor value for the watershed. The bioaccumulation potential value of this same hazardous substance must also be used in evaluating human exposure for the watershed in section 4.2.3. Enter the value for toxicity/persistence for this hazardous substance in Table 4-1.

4.2.2.2 Hazardous waste quantity. Assign the same factor value for hazardous waste quantity for the watershed as is assigned in section 4.1.2.2. Enter this value in Table 4-1.

4.2.2.3 Calculation of human food chain threat waste characteristics value. Sum the toxicity/persistence and hazardous waste quantity factor value for the watershed. Assign this sum as the value for the human food chain threat waste characteristics for the watershed. Enter this value in Table 4-1.

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characteristics (drinking water) factor category times the value for the surface water use factor, and multiply the value for the waste characteristics (human food chain) factor category times fishery use factor value. For the smaller of the two products, assign its "use" factor the value of zero.

[11] Biomagnification is the process whereby the tissue concentration of a bioaccumulated substance increases at each step in the food chain, as the substance moves through two or more trophic levels.

4.2.3 Human food chain threat targets.

This targets factor category reflects the human population and fishery resources potentially at risk from an actual or potential release of hazardous substances from the site to aquatic human food chain resources. Two factors are evaluated: population and fishery use.

4.2.3.1 Population. The population factor value is determined for the watershed from two factors: potential human food chain contamination and actual human food chain contamination.

The actual human food chain contamination factor is to be used only for those fisheries along the hazardous substance migration path for the watershed at which either of the following apply:

- There is a closed fishery, and the hazardous substance(s) for which the fishery has been closed has been documented in an observed release from the site for the watershed, and at least a portion of the fishery is within the boundaries of the observed release (i.e., probable point of entry to furthest sampling point establishing the observed release).
- A tissue sample from a human food chain organism from a fishery exceeds an FDA action level and the hazardous substance which exceeds the FDA action level has been documented in an observed release from the site, and at least a portion of the fishery is within the boundaries of the observed release.

The potential human food chain contamination factor is to be used for all other fisheries that are partially or fully within the target distance limit for the watershed, including fisheries partially or fully within the boundaries of an observed release for the watershed that do not meet either of the two criteria listed above. If only a portion of a fishery is within the target distance limit, only that portion is considered in the evaluation of the population factor.

4.2.3.1.1 Potential human food chain contamination. This factor reflects the threat to the human population potentially exposed to hazardous substances through the aquatic human food chain. This factor is evaluated only for those fisheries that do not meet the criteria for actual human food chain contamination and that are partially or fully within the target distance limit for the watershed. Calculate the value for the potential human food chain contamination factor (PF) for the watershed as follows, subject to a maximum value of 200:

$$PF = \frac{1}{100} \times \sum_{i=1}^{n} P_i \, D_i$$

where:

P_i = Human food chain population for fishery i.

D_i = Dilution weighting factor for fishery i.

n = Number of fisheries.

Assign the dilution weighting factor a value as indicated in Table 4–7 of section 4.1.3.1, with the following exception: the river characteristic "mixing zone of quiet flowing rivers" is not to be used in assigning a dilution weighting factor. Determine the value for the human food chain population for each fishery, using values assigned to the bioaccumulation potential and to human food chain production as described below. Set boundaries between fisheries at those points where a change in human food chain production results in a different assigned value or where a change in stream flow results in a change in the dilution weighting factor.

In assigning the bioaccumulation potential value, use the bioaccumulation potential value for the same hazardous substance used to assign the toxicity/persistence factor value for this watershed in section 4.2.2.1.4.

The human food chain production is the annual production (in pounds) of human food chain organisms (e.g., fish, shellfish) from within the fishery under evaluation. Estimate human food chain production using the following hierarchy of data:

- Actual data on yield from the surface water body or on the stocking rate for the surface water body.
- Actual data on productivity of the surface water body.
- Default values on standing crop from Table I–5 of Attachment I to this Appendix A.

Convert standing crop data (a common measure of productivity) to pounds of fish per year within the hazardous substance migration path. In addition, multiply the standing crop data by 0.2 to convert the standing crop data to human food chain yield. (Note that each 1 foot section of stream width over a distance of 15 miles is equivalent to 1.82 acres.) Use Table 4–15 to assign human food chain production a value.

TABLE 4–15.—VALUES FOR HUMAN FOOD CHAIN PRODUCTION

Human food chain production (pounds per year)	Assigned value
0	0
Greater than 0 to 10	1
Greater than 10 to 100	2
Greater than 100 to 1,000	3
Greater than 1,000 to 10,000	4
Greater than 10,000 to 100,000	5
Greater than 100,000 to 1,000,000	6
Greater than 10^6 to 10^7	7
Greater than 10^7	8

Based on the values assigned to bioaccumulation potential and human food chain production, determine the value for human food chain population using Table 4–16.

TABLE 4–16.—HUMAN FOOD CHAIN POPULATION VALUE

	Human Food Chain Production Value								
	0	1	2	3	4	5	6	7	8
Bioaccumulation potential factor:									
6	0	160	1,600	16,000	160,000	1.6×10^6	1.6×10^7	[a] 2.0×10^7	2.0×10^7
5	0	16	160	1,600	16,000	160,000	1.6×10^6	1.6×10^7	2.0×10^7
4	0	2	16	160	1,600	16,000	160,000	1.6×10^6	1.6×10^7
3	0	0	2	16	160	1,600	16,000	160,000	1.6×10^6
2	0	0	0	2	16	160	1,600	16,000	160,000
1	0	0	0	0	2	16	160	1,600	16,000

[a] A value of 2.0×10^7 or greater will result in the maximum value for the human exposure factor for all dilution weighting factors.

Calculate the value for the potential human food chain contamination factor for the watershed using the formula for PF in this section. Enter the value, subject to a maximum of 200, in Table 4–1.

4.2.3.1.2 Actual human food chain contamination. This factor is to be used only for those fisheries which meet either of the two criteria in section 4.2.3.1. If these criteria do not apply, assign this factor a value of zero for the watershed, and enter the value in Table 4–1.

If either criteria applies for the watershed, estimate the human food chain population value for each such fishery from Table 4–16, using values assigned to the bioaccumulation potential and to human food production as described below.

In assigning the bioaccumulation potential value, use the bioaccumulation potential value for the same hazardous substance used to assign the toxicity/persistence factor value for this watershed in Section 4.2.2.1.4. Human food chain production is assigned a value as described in Section 4.2.3.1.1, except that for a closed fishery the data on yield, stocking rate, or productivity that are to be considered within the specified data hierarchy are to be the most recent data available for the period prior to closure of the fishery.

Calculate the value for the actual human food chain contamination for the watershed as the sum of the human food chain population values for each fishery, subject to a maximum factor value of 200. Enter the factor value in Table 4–1.

4.2.3.1.3 Calculation of the population factor value. Sum the values for potential human food chain contamination and actual human food chain contamination for the watershed. Assign this sum as the population factor value for the watershed, subject to a maximum value of 200. Enter this factor value in Table 4–1.

4.2.3.2 Fishery use. This factor reflects the nature and utility of the fisheries along the hazardous substance migration path for the watershed. Assign each fishery the highest value applicable from Table 4–17.

TABLE 4–17.—VALUES FOR FISHERY USE

Activity	Assigned Value
Commercial fishing for human consumption (including fish farming)	50
Subsistence fishing	40
Recreation/sport fishing	30
None of the above	0

For all the fisheries evaluated for the watershed, select the highest value assigned to any fishery and assign the fishery use factor that highest value, except as noted below.

If the fishery use factor has an assigned value of zero for the watershed, enter that value on Table 4–1. If the fishery use factor has a nonzero value and the surface water use factor (section 4.1.4) has a value of zero for the watershed, enter the value of the fishery use factor in Table 4–1. If, however, both the fishery use factor and the surface water use factor have a nonzero value assigned for the watershed, one of those values must be set to zero for the watershed. The use (fishery use or surface water use) which results in the highest overall surface water migration pathway score for the watershed should be assigned the nonzero factor value and the other use should be assigned a factor value of zero.[12] Decide which use factor is to be assigned the nonzero value and which is to be assigned the zero value for the watershed. Adjust the value for the surface water use factor in Table 4–1 in this manner if necessary, and enter the value for fishery use in Table 4–1.

[12] Note that this determination can ba made as follows. Multiply the valua for tha waste characteristics (drinking water threat) factor category times the value for the surface water use factor, and multiply the value for the waste characteristics (human food chain threat) times tha value for fishery use factor. For the smaller of tha two products, assign its "use" factor the value of zero. (Note that the maximum value for both drinking water targets and human food chain targets is 200. Consequently, if tha value for the fishery use factor exceeds 200 minus the population factor vaiue assigned in section 4.2.3.1.3, then use a value equal to 200 minus this population factor value in the above calculation in place of the fishery use factor valua. Similary, if the value for the surfaca water use factor exceeds 200 minus the population factor value assigned in section 4.1.3.2.5 minus the MEI factor value assigned in section 4.1.3.1, then use a value equal to 200 minus this population factor value minus this MEI factor valua in the above calculation in place of the surface water use factor value.)

4.2.3.3 Calculation of human food chain threat targets value. Sum the population and fishery use factor values for the watershed. This sum is the human food chain threat targets value for the watershed, subject to a maximum value of 200. Enter the value in Table 4–1.

4.2.4 Calculation of the human food chain threat score for a watershed.

Multiply the human food chain threat values for likelihood of release (maximum value of 120), waste characteristics (maximum value of 200), and targets (maximum value of 200) for the watershed. Assign this product as the human food chain threat score for the watershed. Enter the score (maximum value of 4,800,000) in Table 4–1.

4.3 Human recreation threat.

The human recreation threat is used to evaluate the threat associated with the actual or potential release of hazardous substances to surface water used for human recreation. Recreation is defined, for the evaluation of this threat, as swimming or fishing in surface water. Recreation areas are those in which these activities take place. However, rivers with average annual flows less than 5 cubic feet per second and ponds less than 5 acres in size are excluded from consideration.

The human recreation threat score is the product of the values for three factor categories: likelihood of release, waste characteristics, and targets.

4.3.1 Human recreation threat likelihood of release.

Assign the same value for human recreation threat likelihood of release for the watershed as is assigned in section 4.1.1.3 for drinking water threat likelihood of release for the watershed. Enter this value in Table 4–1.

4.3.2 Human recreation threat waste characteristics.

This factor category assesses waste characteristics that reflect the rate, duration, and relative human toxicity of potential hazardous substances releases from the site to surface waters used for recreation in the watershed. Two factors are included: toxicity/persistence and hazardous waste quantity.

4.3.2.1 Toxicity/persistence. Evaluate toxicity/persistence for the human recreation threat in the same manner that toxicity/persistence is evaluated for the drinking water threat (section 4.1.2.1) except as discussed below. The major exception relates to the role that the dose adjusting factor plays in the selection of the substance whose toxicity/persistence value is employed in the evaluation for the watershed. The hazardous substances to be considered are all those eligible to be considered for the drinking water threat for the watershed (see section 4.1.2).

4.3.2.1.1 Dose adjusting factor. The dose adjusting factor represents the ratio of the dose of a hazardous substance that an individual would obtain via recreation in surface water to the dose that would be obtained via consumption of the same surface water as drinking water. Assign a dose adjusting factor value to each hazardous substance using the following equation and Table 4–18.

$$DF = (0.66 \times D_p) + (0.16 \times MF) + 0.0013$$

where:

DF = Dose adjusting factor.
D_p = Dermal permeability constant for the hazardous substance (cm/hr).
MF = Mass flux dilution factor for the hazardous substance ($1/m^3$).

TABLE 4–18.—DOSE ADJUSTING FACTOR EVALUATION TABLE

Dose Adjusting Factor (DF)	Assigned factor value
Greater than or equal to 0.1	3
0.01 to less than 0.1	2
0.001 to less than 0.01	1

Use values for the dermal permeability constant obtained from peer reviewed literature. If no such data are available, set $D_p = 0$ for that hazardous substance. "Analysis of Human Health Risks of Recreational Exposure to Toxic Pollutants in Surface Waters Near National Priority List (NPL) Sites, Appendix A," (EPA Contract No. 68–01–7090), Versar Inc., Springfield, VA, 1987, describes the method used to obtain the mass flux dilution factor for a hazardous substance.

4.3.2.1.2 Toxicity. Select those hazardous substances that have the highest dose adjusting factor value. Assign a value for toxicity to those hazardous substances using the same procedures described in Section 4.1.2.1.1.

4.3.2.1.3 Persistence. Evaluate the persistence of the set of hazardous substances that have the highest dose adjusting factor. Assign a value for persistence using the same procedures described in section 4.1.2.1.2, with one exception. In assigning the persistence value, use the predominant water category (i.e., lake; or river, ocean or Great Lake) between the probable point of entry and the nearest recreation area (not the nearest drinking water intake) along the hazardous substance migration path for the watershed to determine which portion of the persistence rating table is to be used. The predominant water category is determined based on distance as described in section 4.1.2.1.2.

4.3.2.1.4 Calculation of the toxicity/persistence value, considering the dose adjusting factor. The dose adjusting factor is considered in the selection of the hazardous substance whose toxicity/persistence value is employed in evaluating the human recreation threat for the watershed. For the set of hazardous substances with the highest dose adjusting factor value for the watershed, assign a toxicity/persistence value to each hazardous substance in the set, using Table 4–10. Select that hazardous substance with the highest human toxicity/persistence value. Use the toxicity/persistence value of this hazardous substance as the assigned toxicity/persistence factor value for the watershed. The dose adjusting factor value for this same hazardous substance must also be used in evaluating human recreation targets for the watershed in section 4.3.3. Enter the value for toxicity/persistence for this hazardous substance in Table 4–1.

4.3.2.2 Hazardous waste quantity. Assign the same factor value for hazardous waste quantity for the watershed as is assigned in section 4.1.2.2. Enter this value in Table 4–1.

4.3.2.3 Calculation of human recreation threat waste characteristics value. Sum the toxicity/persistence and hazardous waste quantity factor values for the watershed. Assign this sum as the value for human recreation threat waste characteristics for the watershed. Enter this value in Table 4–1.

4.3.3 Human recreation threat targets.

This targets factor category reflects the human population potentially at risk from an actual or potential release of hazardous substances from the site to surface waters used for recreation. The human recreation targets are evaluated based on one factor: population. (This factor also includes components for evaluating the attractiveness and accessibility of the surface water recreation area.) The evaluation of the population factor is based on whether the surface water recreation areas are considered to be subject to actual or potential contamination as defined in section 4.0.2. The determination of whether a specific recreation area is subject to actual or potential contamination is to be made as described in section 4.1.3.

4.3.3.1 Population. The population factor value for the watershed is determined from two factors: actual contamination and potential contamination.

4.3.3.1.1 Actual contamination. This factor is to be used only for those recreation areas that are subject to actual contamination as defined in sections 4.0.2 and 4.1.3 and that are wholly or partially within the target distance limit for the watershed. If only a portion of the recreation area is within the target distance limit for the watershed, consider only that portion in the evaluation. If there are no recreation areas that meet these criteria, assign the actual contamination factor a value of zero, and enter this value in Table 4–1.

If there are recreation areas that meet the above criteria, a human recreation population value is derived for each such recreation area as described in section 4.3.3.1.1.2. The human recreation population value is derived using values assigned to the dose adjusting factor and to the recreation use population factor for that recreation area. The value for the recreation use population factor for the recreation area is determined as discussed in section 4.3.3.1.1.1. The value for the dose adjusting factor is determined as discussed in section 4.3.2.1.1; use the dose adjusting factor value for the same hazardous substance used to assign the toxicity/persistence factor value for the watershed in section 4.3.2.1.4. Boundaries between recreation areas are set at those points where a change in recreation use population value results in a different assigned value or where a change in stream flow results in a change in the dilution weighting factor.

4.3.3.1.1.1 Recreation use population. To determine the recreation use population factor value for a recreation area, first use Table 4–19 and the criteria discussed below to place the recreation area into a recreation category and then to assign an accessibility/attractiveness factor value to the recreation area based on this recreation category. The accessibility/attractiveness factor value is not to be rounded to the nearest integer.

TABLE 4–19.—ACCESSIBILITY/ATTRACTIVENESS FACTOR[1]

Recreation area category[2]	Accessibility/attractiveness factor value[3]	Distance limit (miles)
Capitol use and access improvements	1.00	125 [4](N=8)
Access improvements only	0.66	80 (N=6)
Observed use only	0.33	40 (N=4)
None of the above criteria apply and access is not restricted	0.08	10 (N=2)

[1] Applies to flowing water bodies (greater than or equal to 5 CFS) and lakes/reservoirs/ponds (greater than or equal to 5 acres).

[2] See text for the specific types of recreation areas within each category.

[3] If more than one category applies, select the highest factor value that applies. The accessibility/attractiveness factor value is not to be rounded to the nearest integer.

[4] N = Number of distance categories in Table 4–20 to be used within the indicated distance limit for evaluating the recreation use population factor for the recreation area.

Assign an accessibility/attractiveness factor value of 1.0 when any one of the following are present at the waterfront for that recreation area: designated swimming beaches and areas, boat ramps or boat rental facilities, public recreation piers, marinas, waterfront parks, waterfront campgrounds, waterfront picnic areas, recreation fish stocking (e.g., trout streams), or designated water-sport recreation areas.

Assign a factor value of 0.66 where the following are present: public land access or roads or bridges that provide waterfront access to the public, but no other capital improvements are present.

Assign a factor value of 0.33 when there are no signs of access or use improvements and the surface water is observed to be in use for recreational activities.

Assign a factor value of 0.08 for other surface waters except those whose access is restricted (e.g., by private, nonresidential property owners). Where access is restricted and none of the other categories apply, assign a factor value of zero.

Next, based on the applicable recreation category, use Table 4–19 to select the maximum distance over which the recreation use population is to be estimated for the recreation area and the number of distance categories (N) to be used in counting the population within this maximum distance limit. Table 4–20 indicates the specific distance categories in which population is to be counted within this maximum distance limit and the distance category multipliers to be applied to the population count within each of these distance categories. The location for centering these distance measurements is defined as the access point of the recreation area nearest the largest population center within the appropriate maximum distance limit determined from Table 4–19; the location for centering these measurements is not the site itself.

TABLE 4–20.—DISTANCE CATEGORY MULTIPLIERS FOR CALCULATION OF RECREATION USE POPULATION

Distance category (miles)	Multiplier[1]
Distance Category Multipliers for Rivers (Greater than or equal to 5 CFS) and Ponds (5 to 500 Acres)	
0 to less than 5	0.45
5 to less than 10	0.15
10 to less than 20	0.074
20 to less than 40	0.037
40 to less than 60	0.022
60 to less than 80	0.016
80 to less than 100	0.012
100 to less than 125	0.010
Distance Category Multipliers for Small Lakes (Greater than 500 to 1,000 Acres)	
0 to less than 5	0.46
5 to less than 10	0.15
10 to less than 20	0.077
20 to less than 40	0.039
40 to less than 60	0.023
60 to less than 80	0.017
80 to less than 100	0.013
100 to less than 125	0.011
Distance Category Multipliers for Medium Lakes (Greater than 1,000 to 5,000 Acres)	
0 to less than 5	0.52
5 to less than 10	0.17
10 to less than 20	0.086
20 to less than 40	0.04
40 to less than 60	0.026
60 to less than 80	0.019
80 to less than 100	0.014
100 to less than 125	0.012
Distance Category Multipliers for Large Lakes (Greater than 5,000 Acres)	
0 to less than 5	0.65
5 to less than 10	0.22
10 to less than 20	0.11
20 to less than 40	0.055
40 to less than 60	0.033
60 to less than 80	0.023
80 to less than 100	0.018
100 to less than 125	0.015

[1] These multipliers are not to be rounded to the nearest integer.

Determine the population residing within each applicable distance category. Use actual population numbers where possible. If such data are not available, use Bureau of Census data (which is available in both noncomputerized form and as part of available computerized population data bases).

Determine a recreation use population value (RU) for a recreation area using the following equation:

$$RU = AAF \times \sum_{i=1}^{n} M_i P_i$$

where:

RU = Recreation use population value.

AAF = Accessibility/attractiveness factor value for the recreation area.

N=Number of distance categories applicable to the recreation area.

M_i=Multiplier associated with distance category i.

P_i=Number of people within distance category i.

Use Table 4–21 to assign a value to the recreation use population factor for each recreation area based on the value of RU calculated above.

TABLE 4–21.—RECREATION USE POPULATION FACTOR VALUES

Recreation use population value (RU)	Assigned factor value
Greater than 1,000,000	7
100,000 to less than 1,000,000	6
10,000 to less than 100,000	5
1,000 to less than 10,000	4
100 to less than 1,000	3
10 to less than 100	2
1 to less than 10	1
0	0

4.3.3.1.1.2 Determination of human recreation population value. Based on the values assigned to the dose adjusting factor and the recreation use population factor, use Table 4–22 to determine the human recreation population value for each recreation area.

TABLE 4–22.—HUMAN RECREATION POPULATION VALUE

	Recreation Use Population Factor Value							
	0	1	2	3	4	5	6	7
Does Adjusting Factor Value:								
3	0	3	25	250	2,500	25,000	250,000	2,500,000
2	0	0	3	25	250	2,500	25,000	250,000
1	0	0	0	3	25	250	2,500	25,000

4.3.3.1.1.3 Determination of actual contamination factor value. Divide the human recreation population value for each recreation area by 10. Use the resulting value as the value for the actual contamination factor for that recreation area. Select the highest actual contamination factor value assigned to any recreation area evaluated for the watershed. Assign the value selected as the value for the actual contamination factor for the watershed, subject to a maximum factor value of 200. Enter this factor value in Table 4–1.

4.3.3.1.2 Potential contamination. This factor reflects the threat to the human population potentially exposed to hazardous substances through aquatic recreation activities. This factor is evaluated only for those recreation areas that are not subject to actual contamination as defined in Sections 4.0.2 and 4.1.3. and that are wholly or partially within the target distance limit for the watershed (see section 4.3.3.1.1). If only a portion of the recreation area is within the target distance limit for the watershed, consider only that portion in the evaluation.

Calculate a human recreation population value as described in sections 4.3.3.1.1.1 and 4.3.3.1.1.2 for each recreation area evaluated for potential contamination for the watershed. Assign a dilution weighting factor value for the recreation area as indicated in Table 4–11 of section 4.1.3.1, with the following exception: the river characteristic "mixing zone of quiet flowing rivers" is not to be used in assigning a dilution weighting factor value. Determine boundaries between recreation areas as described in section 4.3.3.1.1.

Multiply the population value calculated above by the dilution factor value and divide the result by 100. Use the resulting value as the value for the potential contamination factor value for that recreation area. Select the highest potential contamination factor value assigned to any recreation area evaluated for the watershed. Assign the value selected as the value for the potential contamination factor for the watershed, subject to a maximum factor value of 200. Enter this factor value in Table 4–1.

4.3.3.1.3 Calculation of human recreation threat targets value. Assign the higher of the values for the actual contamination and potential contamination factors as the population factor value for the watershed, subject to a maximum value of 200. Enter this value in Table 4–1. Assign this same value to the human recreation threat targets factor category for the watershed and enter the value in Table 4–1.

4.3.4 Calculation of the human recreation threat score for a watershed.

Multiply the human recreation threat values for likelihood of release (maximum value of 120), waste characteristics (maximum value of 200), and targets (maximum value of 200) for the watershed. The product is the human recreation threat score for the watershed. Enter the resulting product (maximum value of 4,800,000) in Table 4–1.

4.4 Environmental threat.

The environmental threat is used to evaluate the threat associated with the actual or potential release of hazardous substances to surface water related sensitive environments. The environmental threat score for the watershed is the product of the values for the following: likelihood of release, waste characteristics, and targets.

4.4.1 Environmental threat likelihood of release.

Assign the same value for environmental threat likelihood of release for the watershed as is assigned for drinking water threat likelihood of release for the watershed in section 4.1.1.3. Enter this value in Table 4–1.

4.4.2 Environmental threat waste characteristics.

This factor category assesses waste characteristics that reflect the rate, duration, and relative ecological toxicity of potential hazardous substances releases from the site to surface water related sensitive environments. Two factors are included: ecosystem toxicity/persistence and waste quantity.

4.4.2.1 Ecosystem toxicity/persistence. The hazardous substances to be considered in evaluating ecosystem toxicity/persistence for the watershed are all those eligible to be considered in evaluating drinking water toxicity/persistence (section 4.1.2.1) for the watershed.

4.4.2.1.1 Ecosystem toxicity. Assign an ecosystem toxicity value to each hazardous substance for the watershed using Table 4–23.

Use the following hierarchy of data in assigning the ecosystem toxicity value:

- EPA chronic water quality criteria for the substance.
- EPA acute water quality criteria for the substance.
- Lowest LC50 value reported in peer reviewed literature for the substance.

TABLE 4–23.—ECOSYSTEM TOXICITY VALUE

	Assigned value
If an EPA chronic water quality criterion is available, assign a value as follows:	
EPA Chronic Water Quality Criterion	
Less than 1 ug/l	5
1 to 10 ug/l	4
Greater than 10 to 100 ug/l	3
Greater than 100 to 1,000 ug/l	2
Greater than 1,000 to 10,000 ug/l	1
Greater than 10,000 ug/l	0
If an EPA chronic water quality criterion is not available, assign a value from the EPA acute water quality criterion/100 as follows:	
EPA Acute Water Quality Criterion/100	
Less than 1 ug/l	5
1 to 10 ug/l	4

TABLE 4-23.—ECOSYSTEM TOXICITY VALUE—Continued

	Assigned value
Greater than 10 to 100 ug/l	3
Greater than 100 to 1,000 ug/l	2
Greater than 1,000 to 10,000 ug/l	1
Greater than 10,000 ug/l	0
If an EPA acute water quality criterion is also not available, assign a value from the $LC_{50}/100$ as follows:	
$LC_{50}/100$	
Less than 1 ug/l	5
1 to 10 ug/l	4
Greater than 10 to 100 ug/l	3
Greater than 100 to 1,000 ug/l	2
Greater than 1,000 to 10,000 ug/l	1
Greater than 10,000 ug/l	0

The EPA water quality criteria refer to water quality criteria for the protection of aquatic life (freshwater and saltwater) as presented in "Quality Criteria for Water 1986", EPA 440/5-86-001 (or later as available). If an EPA chronic water quality criterion is available for the hazardous substance being evaluated, use it to assign the ecosystem toxicity value. If the EPA chronic criterion is not available, use the EPA acute criterion, divided by 100, to assign the ecosystem toxicity value. If neither criterion is available, use the lowest LC_{50} value reported in peer reviewed literature, divided by 100, to assign the ecosystem toxicity value.

If the applicable EPA water quality criterion or LC_{50} value for the hazardous substance is available for both freshwater and saltwater, calculate a separate ecosystem toxicity value for freshwater and saltwater for the hazardous substance. If only a freshwater criterion or LC_{50} value is available, use it for both freshwater and saltwater. If only a saltwater criterion or LC_{50} value is available, use it for both saltwater and freshwater. If all sensitive environments being evaluated for the watershed are in freshwater, assign the hazardous substance the ecosystem toxicity value for freshwater. If all are in saltwater, assign the hazardous substance the ecosystem toxicity value for saltwater. If some are in freshwater and some are in saltwater, assign the hazardous substance the higher of the freshwater or saltwater ecosystem toxicity values.

4.4.2.1.2 Persistence. Assign a value for persistence for each hazardous substance available to the hazardous substance migration path for the watershed using the procedure outlined in section 4.1.2.1.2. However, in assigning the persistence value, use the predominant water category (i.e., lake or river; ocean or Great Lake) between the probable point of entry and the nearest sensitive environment (not the nearest drinking water intake) along the hazardous substance migration path for the watershed to determine which portion of Table 4-9 is to be used. The predominant water category is determined based on distance as described in section 4.1.2.1.2.

4.4.2.1.3 Calculation of toxicity/persistence factor value. Assign a toxicity/persistence value from Table 4-24 to each hazardous substance evaluated for the watershed, using the values assigned to the hazardous substance for ecosystem toxicity and persistence. Use the value for the substance with the highest toxicity/persistence value for the watershed as the value for this factor. Enter this value in Table 4-1.

TABLE 4-24.—ECOSYSTEM TOXICITY/PERSISTENCE VALUE

	Persistence value			
	0	1	2	3
Ecosystem toxicity value:				
0	0	0	0	0
1	10	27	43	60
2	20	37	53	70
3	30	47	63	80
4	40	57	73	90
5	50	67	83	100

4.4.2.2 Hazardous waste quantity. Assign the same factor value for hazardous waste quantity for the watershed as is assigned in section 4.1.2.2. Enter this value in Table 4-1.

4.4.2.3 Calculation of environmental threat waste characteristics value. Sum the toxicity/persistence factor value and the hazardous waste quantity factor value for the watershed. This sum is the environmental threat waste characteristics value for the watershed. Enter this value on Table 4-1.

4.4.3 Environmental targets.

The environmental targets factor category reflects the sensitive environments potentially at risk from an actual or potential release of hazardous substances from the site to surface water. The environmental targets for a watershed are evaluated based on one factor: sensitive environments. The evaluation is based on whether the sensitive environments are considered to be subject to actual or potential contamination as defined in section 4.0.2. Actual contamination is evaluated under a level I concentrations factor (i.e., exposure concentration exceeds ecological-based benchmarks) or a level II concentrations factor (i.e., exposure concentration does not exceed ecological-based benchmarks), as appropriate.

Determine whether a sensitive environment is subject to potential contamination, level I concentrations, or level II concentrations using the general methodology described in section 4.1.3 with the following modifications. Use ecological-based benchmarks (Table 4-25) rather than health-based benchmarks (Table 3-12) in determining if the level I criteria apply. If there is actual contamination and it does not meet the level I criteria, then the contamination is considered to meet the criteria for level II concentrations. In determining the level that applies consider only those samples and only those hazardous substances in a sample that establish an observed release. The samples considered may be taken at any location within the sensitive environment (or adjacent to the sensitive environment if contiguous to the migration path) or downstream from the sensitive environment. Table 4-25 lists the criteria for determining the ecological-based benchmarks to be used for hazardous substances in surface water.

TABLE 4-25.—Ecological-Based Benchmarks for Hazardous Substances in Surface Water

The appropriate ecological-based benchmark is selected from the EPA Water Quality Criteria for the protection of aquatic life (fresh water or salt water) as follows:

- If, within the target distance limit, the sensitive environment being evaluated is in freshwater, use the freshwater criteria as the benchmark.
- If, within the target distance limit, the sensitive environment being evaluated is in saltwater, use the saltwater criteria as the benchmark.
- If, within the target distance limit, the sensitive environment being evaluated is in both freshwater and saltwater, use the lower of the freshwater or saltwater criteria as the benchmark.

In all cases, use the chronic criteria if it is specified; otherwise, use the acute criteria as the benchmark.

4.4.3.1 Sensitive environments. Sensitive environments are determined from three factors: Level I concentrations, level II concentrations, and potential contamination.

4.4.3.1.1 Level I concentrations. This factor represents the sensitive environments along the hazardous substance migration path for the watersheds that are exposed to hazardous substances at exposure concentrations that exceed ecological-based benchmarks (see Table 4-25). Only count sensitive environments that are subject to level I concentrations as defined in section 4.4.3.

Assign values to each sensitive environment using either Table 2-18 or 2-19 in section 2.3.4. If a sensitive environment can be assigned values from both tables, use the table that assigns the higher values to the sensitive environment. Calculate the value (SH) of this factor for the watershed as follows, subject to a maximum value of 120:

$$SH = 10 \times \sum_{i=1}^{n} S_i$$

where:

S_i = Value(s) assigned to sensitive environment i.

n = Number of sensitive environments identified for the level I concentrations factor.

Enter the value in Table 4-1.

4.4.3.1.2 Level II concentrations. This factor represents the sensitive environments along the hazardous substance migration path for the watersheds that are exposed to hazardous substances at exposure concentrations that do not exceed ecological-based benchmarks (see Table 4-25) or for which ecological-based benchmarks do not exist for hazardous substances in the exposure concentration. Count only those environments that are subject to level II concentrations as defined in section 4.4.3. Do not count any sensitive environments that have already been included in the evaluation of the level I concentrations factor for this watershed.

Assign values to each sensitive environment using either Table 2–18 or 2–19 in section 2.3.4. If a sensitive environment can be assigned values from both tables, use the table that assigns the higher values to the sensitive environment. Calculate the value (SL) of this factor for the watershed as follows, subject to a maximum value of 120:

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

where:

S_i=Value(s) assigned to sensitive i.
n=Number of sensitive environments identified for the level II concentrations factor.

Enter the value in Table 4–1.

4.4.3.1.3 Potential contamination. This factor represents the sensitive environments within the target distance limit for the watershed (section 4.0.2) that are potentially exposed to hazardous substances along the surface water hazardous substance migration path. Thus, sensitive environments counted in the level I or level II concentrations factors are not included.

Calculate the value of the potential contamination factor (SP) for the watershed as follows, subject to a maximum value of 120:

$$SP = \frac{1}{10} \sum_{i=1}^{n} S_i D_i$$

where:

S_i=Value(s) assigned to sensitive environment i.
D_i=Dilution weighting factor for sensitive environment i.
n=Number of sensitive environments identified for the potential contamination factor.

Assign values to each sensitive environment using either Table 2–18 or 2–19 in section 2.3.4. If a sensitive environment can be assigned values from both tables, use the table that assigns the higher values to the sensitive environment. Determine the appropriate dilution weighting factor for each sensitive environment from Table 4–11, as described in section 4.1.3.1, with the following exception: the river characteristic "mixing zone of quiet flowing rivers" is not to be used in assigning a dilution weighting factor. If more than one dilution weighting factor can be assigned to the sensitive environment (e.g., a wetland that is contiguous both to a small stream and to the main branch of the river), assign the highest value for the dilution weighting factor from among those that apply.

Enter the value for this factor, subject to a maximum of 120, in Table 4–1.

4.4.3.1.4 Calculation of environmental threat targets factor value. Sum the values for level I concentrations, level II concentrations, and potential contamination for the watershed. This sum is the environmental threat targets value for the watershed, subject to a maximum value of 120.

Enter the value in Table 4–1.

4.4.4 Calculation of environmental threat score for a watershed.

Multiply the environmental threat values for likelihood of release (maximum value of 120), waste characteristics (maximum value of 200), and targets (maximum value of 120) for the watershed. Assign the product as the environmental threat score for the watershed. Enter the resulting product (maximum value of 2,880,000) in Table 4–1.

4.5 Surface water migration pathway score for a watershed.

Sum the scores for the four types of threats for the watershed (drinking water, human food chain, recreation and environmental), subject to a maximum score of 4,800,000, and divide by 48,000. The resulting score is the surface water migration pathway score for the watershed. Enter the result in Table 4–1.

4.6 Surface water migration pathway score.

Sum the surface water migration pathway scores for each watershed. This sum is the surface water migration pathway score for the site, subject to a maximum score of 100. Enter this score in Table 4–1.

5.0 Onsite exposure pathway.

The onsite exposure pathway addresses the relative risks to people and to terrestrial sensitive environments, that are associated with direct contact with soils or wastes containing hazardous substances. These risks are evaluated based on the following: the likelihood of there being exposure through direct physical contact to hazardous substances in soils or sources containing shallow wastes (i.e., wastes on or above the land surface, or those contaminated soils or wastes not more than 2 feet below the land surface), the relative frequency and duration of such exposures, the relative toxicity of the hazardous substances, and the size and composition of the potentially exposed population.

Two types of threats are evaluated: the threat to the resident population and the threat to the nearby population. Both of these threats are evaluated based on three factor catagories:

- Likelihood of Exposure (LE).
- Waste Characteristics (WC).
- Targets (T).

Figure 5–1 indicates the factors included within each factor category for each type of threat.

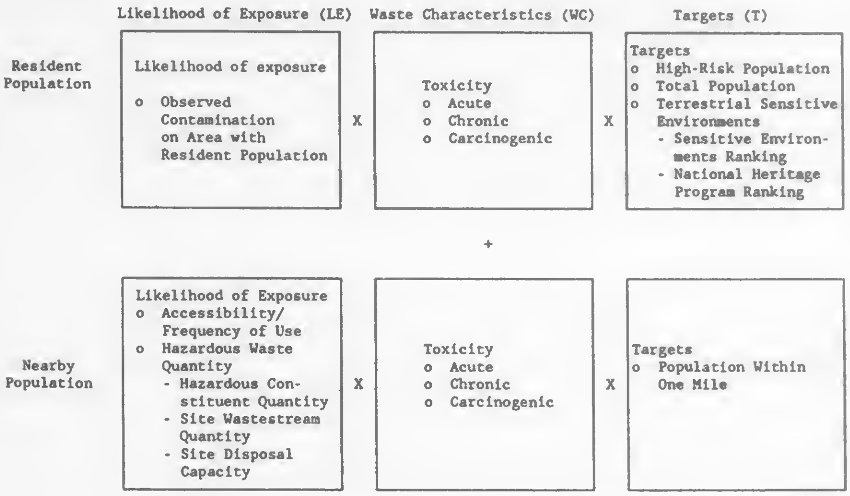

FIGURE 5-1
OVERVIEW OF THE ONSITE EXPOSURE PATHWAY

The onsite exposure pathway score (S_{os}) is calculated by multiplying, for each type of threat, the values for likelihood of exposure, waste characteristics, and targets. The resultant score is summed for the two types of threats and divided by a scaling factor to normalize it to a scale of 0 to 100. This calculation procedure is outlined in Table 5–1.

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TABLE 5-1
ONSITE EXPOSURE PATHWAY SCORESHEET

Factor Categories and Factors	Maximum Value	Value Assigned	
Resident Population Threat			
1. Likelihood of Exposure	100	___	
2. Waste Characteristics	5	___	
3. Targets			
3a. High-Risk Population	100	___	
3b. Total Resident Population	100	___	
3c. Terrestrial Sensitive Environments	25	___	
3d. Targets (Lines 3a + 3b + 3c, subject to a maximum of 100)	100	___	
4. Resident Population Threat Score (Lines 1 x 2 x 3d)	50,000		___
Nearby Population Threat			
5. Likelihood of Exposure			
5a. Waste Quantity	100	___	
5b. Accessibility/Frequency of Use	100	___	
5c. Likelihood of Exposure	100	___	
6. Waste Characteristics	5	___	
7. Targets			
7a. Population Within 1-Mile	100	___	
7b. Targets (Line 7a, subject to a maximum of 100)	100	___	
8. Nearby Population Threat Score (Lines 5c x 6 x 7)	50,000		___
Onsite Exposure Pathway Score			
9. Onsite Exposure Pathway Score (S_{OS}) (Lines [4+8]/500, subject to a maximum of 100)	100		[ ]

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5.0.1 General considerations.

The process for scoring the onsite exposure pathway is diagrammed in Figure 5–2. Observed contamination is considered to be present at locations where analytical evidence shows the presence of hazardous substances, attributable to the site, in soils or sources containing shallow wastes at concentrations significantly above background levels under the conditions presented in Table 2–2 of section 2. See section 2.1.1 for the detection limits to be used in the evaluation. Observed contamination is also considered to be present in areas between the site and the sampling locations that establish observed contamination, providing that these areas are likely to be contaminated by releases from the site based on topography or other surface conditions.

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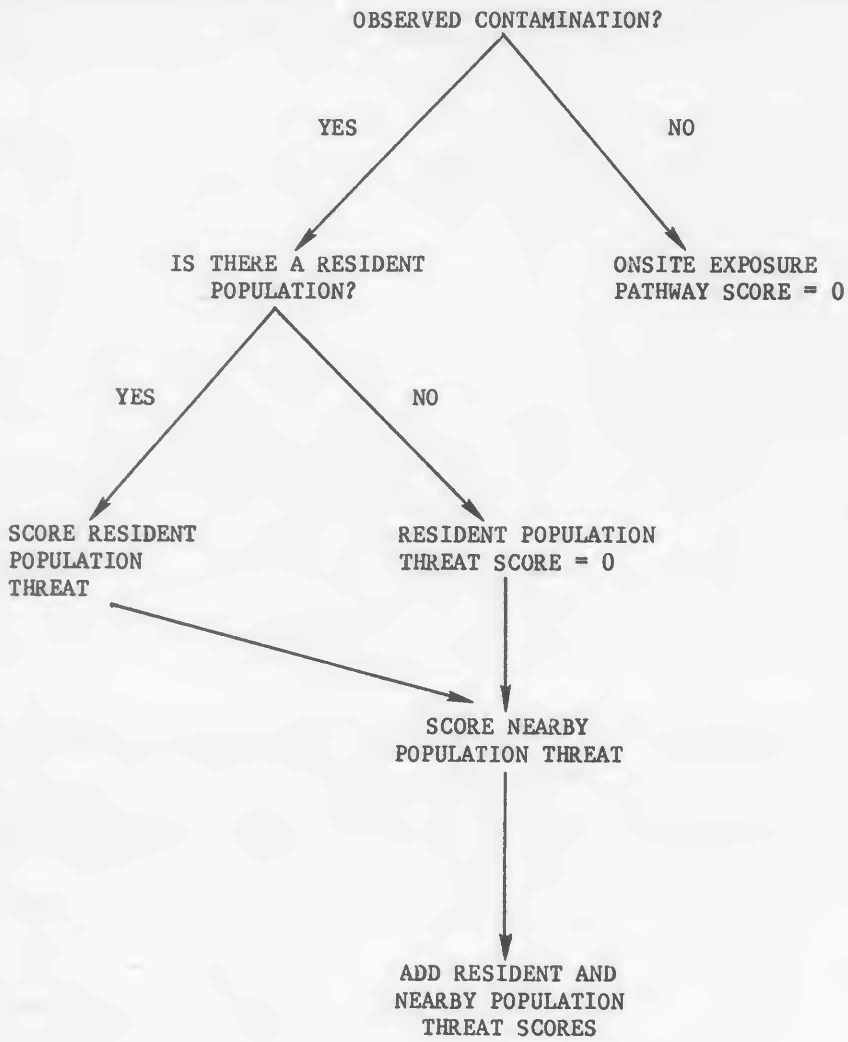

FIGURE 5-2
ONSITE EXPOSURE PATHWAY SCORING PROCESS

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If there is no observed contamination, assign the onsite exposure pathway a score of zero. If there is observed contamination, assign scores for the resident population threat and the nearby population threat as indicated in sections 5.1 and 5.2.

5.1 Resident population threat.

The resident population consists of the following: people living or attending school or day care on property where there is observed contamination; and terrestrial sensitive environments where there is observed contamination. If no people or terrestrial sensitive environments meet these criteria, assign the resident population threat a score of zero.

5.1.1 Likelihood of exposure.

If there is observed contamination on an area containing resident population, assign a value of 100 to the likelihood of exposure factor. Otherwise, assign a value of zero for both this factor and the resident population threat and proceed to the evaluation of the nearby population threat (section 5.2). Enter the value assigned in Table 5–1.

5.1.2 Waste characteristics.

The waste characteristics factor category consists of one factor: toxicity. Toxicity is evaluated for all those hazardous substances attributable to the site that are observed in soils and sources containing shallow wastes at levels significantly above background levels. Assign a toxicity value to these hazardous substances as specified in section 2.2.1.1. The value for this factor category is the highest toxicity value assigned to any of these hazardous substances. Enter this value in Table 5–1.

5.1.3 Targets.

The resident population targets category is based on three factors: high-risk population, total resident population, and terrestrial sensitive environments.

For any of these three populations to be considered in this factor category, one of two criteria must be met:

• There must be observed contamination attributable to the site within the property boundary of a residence, school, or day-care center, or within the boundaries of a terrestrial sensitive environment.

• The property boundary of a residence, school, day-care center, or terrestrial sensitive environment must lie within an area between the site and points of observed contamination attributable to the site and be likely to be contaminated by releases from the site based on topography or other surface conditions.

5.1.3.1 High-risk population. The high-risk population is composed of all children less than seven years old, as of the date of the SI or action equivalent to the SI, who meet either of the eligibility criteria for the resident population threat targets factor category as described above. Action equivalent to the SI includes evaluations performed by EPA prior to conducting removal actions, or by States prior to conducting response actions.

Children meeting more than one of the above criteria may be counted only once for this factor. Assign a value to this factor by multiplying the number of children in this high-risk population by ten. Enter this value in Table 5–1.

5.1.3.2 Total resident population. The total resident population is determined by counting all individuals who live or attend school or day care on property that meets either of the eligibility criteria for the resident population threat targets factor category as described above. Children counted for the high-risk population factor are not to be counted in evaluating this factor.

Assign a value to this factor by multiplying the total number of people counted in the resident population by two. Enter this value in Table 5–1.

5.1.3.3 Terrestrial sensitive environments. Assign values from either Table 5–2 or Table 2–19 of section 2.3.4 to each terrestrial sensitive environment that meets either of the eligibility criteria for the resident threat targets factor category as described above. If a sensitive environment can be assigned values from both tables, use the table that assigns the higher values to the sensitive environment. Calculate the value for this factor by dividing the value for the highest scoring sensitive environment by four. Enter this value in Table 5–1.

TABLE 5–2.—TERRESTRIAL SENSITIVE ENVIRONMENTS FACTOR VALUES

Terrestrial sensitive environments	Assigned value
Terrestrial critical habitat for federally designated endangered or threatened species National park Designated Federal wilderness area	100
Terrestrial habitat known to be used by Federally designated or proposed threatened or endangered species National preserve (terrestrial) National or State terrestrial wildlife refuge Federal land designated for protection of natural ecosystems Administratively proposed Federal wilderness area	75
Terrestrial habitat known to be used by State-designated endangered or threatened species Terrestrial habitat known to be used by species under review as to its Federally designated threatened and endangered status	50
State lands designated for wildlife or game management	25

5.1.3.4 Calculation of resident population targets score. Sum the values for the three resident population targets factors. This sum is the resident population targets category value, subject to a maximum value of 100. Enter this value in Table 5–1.

5.1.4 Resident population threat score.

Multiply the values for likelihood of exposure, waste characteristics, and targets for the resident population threat. This product is the resident population threat score. Enter this score in Table 5–1.

5.2 Nearby population threat.

The nearby population consists of individuals who live or go to school within a one-mile travel distance of the site and who do not meet the criteria for the resident population targets (see section 5.1.3).

5.2.1 Likelihood of exposure.

Two factors are included in the nearby population likelihood of exposure factor category: waste quantity and accessibility/frequency of use.

5.2.1.1 Waste quantity. The waste quantity factor for the site is evaluated based on the total areal extent of the site. Only the area covered by sources with wastes either on or above the surface or not more than 2 feet below the surface may be counted for this factor. Use Table 5–3 to assign a value to each source based on its area. For those sources where areal extent is not readily attainable, use the default measures in Table 5–3 applicable to each source type to assign a value to each source by using the following data (in order of preference): quantity of hazardous substances deposited in the source, quantity of waste deposited in the source that contains hazardous substance, source volume. Use a lower measure in the hierarchy only if data are not complete for a higher measure in the hierarchy. If more than one measure is used, assign the source the highest value that results from any of the measures used.

TABLE 5-3.—NEARBY POPULATION WASTE QUANTITY FACTOR VALUES

	Assigned factor value		
	0	1 to 100	100
PRIMARY MEASURE			
Contaminated Area (A) (ft^2)	Less than 5,000	A/5,000	500,000+
DEFAULT MEASURES			
Landfill:			
HSQ [1] (lbs)	Less than 1.95	HSQ/1.95	195+
QWD [2] (lbs)	Less than 9,728	QWD/9,728	972,800+
V [3] (yd^3)	Less than 4,864	V/4,864	486,400+
Surface Impoundment:			
HSQ (lbs)	Less than 444	HSQ/444	44,400+
QWD (lbs)	Less than 2.2×10^6	QWD/2.2×10^6	2.2×10^6+
V (yd^3)	Less than 1,111	V/1,111	111,100+
Land Treatment:			
HSQ (lbs)	Less than 1.5	HSQ/1.5	150+
QWD (lbs)	Less than 7,047	QWD/7,407	740,700+
Waste Pile:			
HSQ (lbs)	Less than 1,946	HSQ/1,946	194,600+
QWD (lbs)	Less than 9.7×10^6	QWD/9.7×10^6+	9.7×10^6+
V (yd^3)	Less than 4,864	V/4,864	486,400+
Contaminated Soil:			
HSQ (lbs)	Less than 0.15	HSQ/0.15	15+
QWD (lbs)	Less than 741	AWD/741	74,100+
V (yd^3)	Less than 370	V/370	37,000+

[1] HSQ: Hazardous Substance Quantity.
[2] QWD: Waste Quantity as Deposited.
[3] V: Volume.

Sum the values assigned to each eligible source within the site. This sum is the value for this factor, subject to a maximum value to 100. Enter this value in Table 5–1.

5.2.1.2 Accessibility/frequency of use. Accessibility refers both to the measures taken to limit access by humans or animals to areas with observed contamination and to natural barriers that may reduce access to such areas. Frequency of use is a measure of the expected level of use based on the characteristics of the areas with observed contamination.

Use Table 5–4 to assign a value for accessibility/frequency of use to areas with observed contamination. Any land used for residences is not considered in assigning a value for the accessibility/frequency of use factor. Select the highest value assigned to any area. This is the value for the acessibility/frequency of use factor. Enter this value in Table 5–1.

TABLE 5-4.—CRITERIA FOR ASSIGNING ACCESSIBILITY/FREQUENCY OF USE VALUES

Accessibility/frequency of use	Assigned value
Observed contamination on the property of a park, playground, school, or other areas designated for use by the public	100
Observed contamination on land (excluding land used for residences) with no continuous barrier to entry or a barrier that has been breached; or observed contamination on lands where there are clear indications of human recreational activity	75
Observed contamination on land (excluding land used for residences) protected by a continuous and effective barrier to entry or monitored by 24-hour surveillance	50

TABLE 5-4.—CRITERIA FOR ASSIGNING ACCESSIBILITY/FREQUENCY OF USE VALUES—Continued

Accessibility/frequency of use	Assigned value
Observed contamination on land (excluding land used for residences) protected by a continuous and effective barrier to entry and 24-hour surveillance	25
Presence of an artificial barrier and a natural barrier combining to restrict access to hazardous substances (e.g., a fence combined with a cliff), which completely surrounds the facility; and a means to control entry, at all times, through gates or other entrances to the facility (e.g., an attendant, television monitors, or controlled roadway access to the facility)	5

5.2.1.3 Likelihood of exposure value. Assign a value for the likelihood of exposure factor using the matrix in Table 5–5, based on the values asigned to the waste quantity and accessibility/frequency of use factors. Enter this value in Table 5–1.

TABLE 5-5.— NEARBY POPULATION LIKELIHOOD OF EXPOSURE MATRIX

	Accessibility/frequency of use factor value				
	100	75	50	25	5
Waste Quantity Factor Value:					
76 to 100	100	100	75	50	25
51 to 75	100	75	50	25	10
26 to 50	75	50	25	10	0
1 to 25	50	25	10	0	0
0	25	10	0	0	0
No observed Contamination	0	0	0	0	0

5.2.2 Waste characteristics.

The waste characteristics factor category consists of one factor: toxicity. For every hazardous substance on the site significantly above background levels, assign a toxicity value as specified in section 2.2.1.1. The value for this factor category is the highest toxicity value assigned to any of these hazardous substances. Enter this value in Table 5–1.

5.2.3 Targets.

The nearby population targets factor category is evaluated based on one factor: population within a 1-mile travel distance from the site.

The population within a 1-mile travel distance from the site includes residents as well as students who attend school within this travel distance. Populations counted in the resident population threat are not counted under this factor. In determining the distance of an individual from the site, measure the overland distance an individual would have to travel. If there are no natural barriers to travel, such as a river, the travel distances from the site to the population are measured along a straight line from the site. If barriers exist, the distance must be measured from the site to the nearest crossing and from there to the individual as shown in Figure 5–3.

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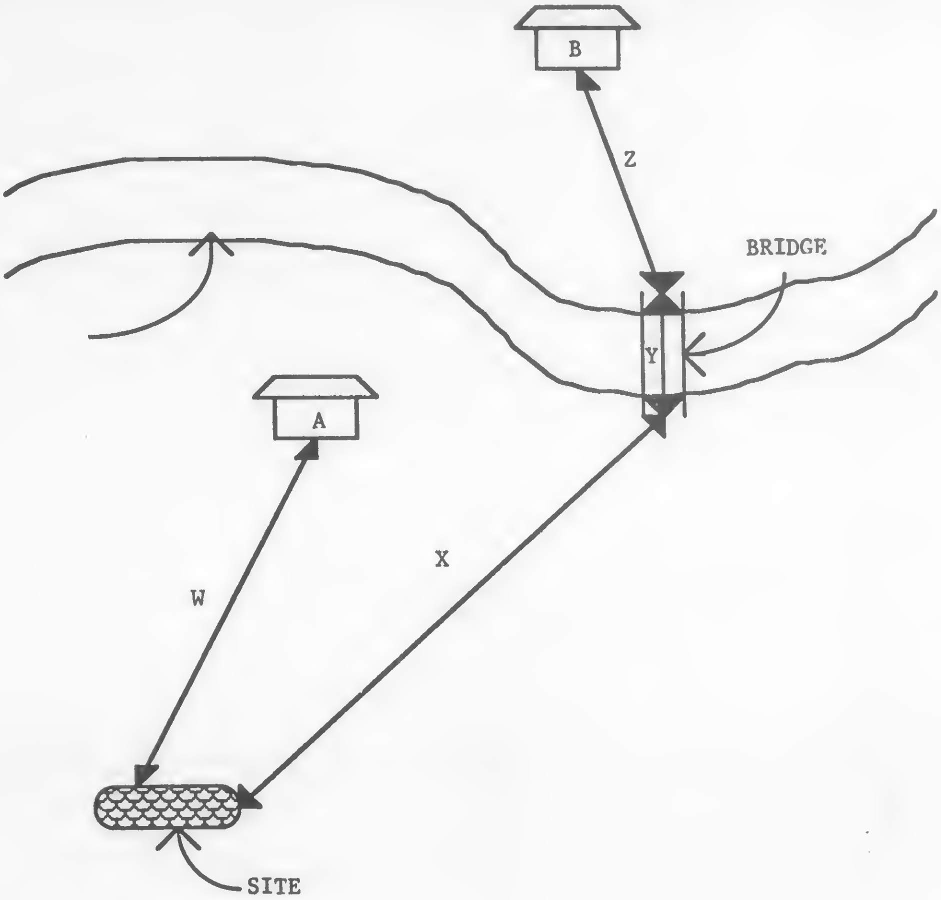

DISTANCE TO A = W

DISTANCE TO B = X + Y + Z

FIGURE 5-3
MEASUREMENT OF DISTANCE TO NEARBY POPULATION

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Calculate the value for this factor (PN) using the following equation, subject to a maximum value of 100:

$$PN = \sum_{i=1}^{3} P_i D_i$$

Where:
P_i = Population within evaluation distance i.
D_i = Distance weighting factor for evaluating distance i.

The distance weighting factors to be used as those presented in Table 5–6. Enter the value calculated in Table 5–1.

TABLE 5–6.—DISTANCE WEIGHTING FACTORS FOR NEARBY POPULATION

Evaluation distance (miles)	Distance weighting factor[1]
0 to ¼	0.1
Greater than ¼ to ½	0.05
Greater than ½ to 1	0.025

[1] This distance weighting factor is not to be rounded to the nearest integer.

5.2.4 Calculation of the nearby population threat score.

Multiply the values assigned to the nearby population likelihood of exposure factor, waste characteristics factor, and targets factor. This product is the nearby population threat score. Enter this score in Table 5–1.

5.3 Calculation of the onsite exposure pathway score.

Sum the resident population threat score and the nearby population threat score and divide the sum by 5. The resulting value, subject to a maximum of 100, is the onsite exposure pathway score. Enter this score in Table 5–1.

Attachment I to Appendix A

TABLE I–1.—STATE WATER USE DESIGNATIONS FOR DRINKING WATER AND ECOLOGY

State	Drinking water	Ecology
1. Alabama	PWS	F & W.
2. Alaska:		
—Fresh Water	A(i)	C.
—Marine Water		C.
3. Arizona	DWS	A & W.
4. Arkansas	Public water supply	Fisheries.
5. California	Domestic water supply	Preservation and enhancement of fish, wildlife, and other aquatic resources or preserves.
6. Colorado	Domestic water supply	Aquatic life.
7. Connecticut:		
—Inland Waters	AA; A	B; C; D.
—Coastal and Marine		SA; SB; SC.
8. Delaware	Public water supply	Fish, Aquatic life, and Wildlife.
9. District of Columbia	D	C.
10. Florida	Class I	Class III.
11. Georgia	Drinking water supply	Fishing, propagation of fish, shellfish, game and other aquatic life; primary trout waters.
12. Hawaii:		
—Inland Waters	1b	1a; 1b; 1c.
—Marine Waters		AA; A.
13. Idaho	Domestic water supply	Cold water biota; warm water biota; salmonid spawning.
14. Illinois	Public and food processing water supply	Secondary contact and indigenous aquatic life waters.
15. Indiana	Domestic and industrial use	Aquatic life; limited use; exceptional use.
16. Iowa	C	B.
17. Kansas	Domestic water supply	Aquatic life use.
18. Kentucky	DWS	WAH; CAH; OWR.
19. Louisiana	D	C; G.
20. Maine:		
—Fresh Waters	A; B–1; B–2	B–1; B–2; C.
—Great Ponds	GP–A; GP–B	GP–B.
—Tidal or Marine		SA; SB–1; SB–2; SC; SD.
21. Maryland	I	I; III.
22. Massachusetts:		
—Inland Waters	A	B; C.
—Coastal or Marine		SA; SB; SC.
23. Michigan	Public water supply	Warmwater fish; other indigenous aquatic life and wildlife; coldwater fish.
24. Minnesota	Domestic consumption	Fisheries and recreation; agriculture and wildlife.
25. Mississippi	Public water supply	Fish and wildlife.
26. Missouri	Drinking water supply	Livestock and wildlife watering; protection of aquatic life.
27. Montana	A–closed; A–1; B–1; B–2; B–3	A–1; B–1; B–2; B–3; C–2; C–3.
28. Nebraska	Public drinking water supply	Aquatic life-coldwater habitat.
29. Nevada	A; B; C	A; B; C; D.
30. New Hampshire	A; B	B; C.
31. New Jersey	FW–2	FW–1; PL; FW–2; SE–1; SE–2; SE–3; SC.
32. New Mexico	Domestic water supply	Coldwater fishery; high quality cold water fishery; marginal coldwater fishery; warmwater fishery; limited warmwater fishery; livestock and wildlife watering.
33. New York:		
—Fresh Surface	AA, A	N; AA; A; B; C.
—Saline Surface		SA; SB; SC.
34. North Carolina:		
—Freshwater	WS–I; WS–II; WS–III	B; C.
—Saltwater		SA; SB; SC.
35. North Dakota	I; IA; II	I; IA; II.
36. Ohio	C(1)	A(1); A(2); A(3); A(4); A(5).
37. Oklahoma	Public and private water supplies; emergency public and private water supplies.	Fish and wildlife propagation.

TABLE I-1.—STATE WATER USE DESIGNATIONS FOR DRINKING WATER AND ECOLOGY—Continued

State	Drinking water	Ecology
38. Oregon	Public domestic water supply; private domestic water supply.	Salmonid fish rearing; salmonid fish spawning; resident fish and aquatic life; wildlife and hunting; anadromous fish and passage.
39. Pennsylvania	PWS	CWF; WWF; MF; AWS; HQ; EV.
40. Puerto Rico	SD	SA; SB; SC; SD; SE.
41. Rhode Island:		
—Freshwater	A; B	B; C; D.
—Sea Water		SA; SB; SC.
42. South Carolina:		
—Freshwaters	AA; A; B	AA; A-trout; A; B-trout; B.
—Tidal salt waters		SAA; SA; SB; SC.
43. South Dakota	Domestic water supply waters	Cold water permanent fish life propagation waters; cold water marginal fish life propagation waters; warmwater permanent fish life propagation waters; warmwater semipermanent fish life propagation waters; warmwater marginal fish life propagation waters; wildlife propagation and stock watering.
44. Tennessee	Domestic water supply	Livestock watering and wildlife; fish and aquatic life; trout waters.
45. Texas	Domestic water supply	Aquatic life.
46. Utah	1A; 1B; 1C	3A; 3B; 3C; 3D.
47. Vermont	A; B	Fish habitat designation.
48. Virginia	Public water supply	
49. Washington	AA; A; Lake class	AA; A; B; C; Lake class.
50. West Virginia	B-1	C-1; C-2.
51. Wisconsin	Public water supply	Fish and aquatic life.
52. Wyoming	Public water supply	Fish and wildlife.

TABLE I-2.—CONTAINMENT FACTORS FOR GROUND WATER MIGRATION PATHWAY

	Assigned value
Landfill:	
Evidence of hazardous substance migration from the landfill; or no liner; or none of the following present: Maintained engineered cover, functioning and maintained run-on control system and runoff management system, or functioning leachate collection and removal system immediately above the liner	10
No evidence of hazardous substance migration from the landfill, a liner, and any one of the following present: Maintained engineered cover, functioning and maintained run-on control system and runoff management system, or functioning leachate collection and removed system immediately above the liner	9
No evidence of hazardous substance migration from the landfill, a liner, and any two of the following present: Maintained engineered cover, functioning and maintained run-on control system and runoff management system, or functioning leachate collection and removal system immediately above the liner	7
No evidence of hazardous substance migration from the landfill; and all of the following present: Liner with functioning leachate collection and removal system immediately above the liner, functioning ground water monitoring system, maintained engineered cover and functioning and maintained run-on control system and runoff management system	5

TABLE I-2.—CONTAINMENT FACTORS FOR GROUND WATER MIGRATION PATHWAY—Continued

	Assigned value
No evidence of hazardous substance migration from the landfill; and single liner with functioning leachate collection and removal system immediately above the liner, functioning ground water monitoring system, no bulk or noncontainerized liquids or materials containing free liquids deposited in the landfill, functioning and maintained run-on control system and runoff management system, and maintained engineered cover	3
No evidence of hazardous substance migration from the landfill; and double liner with functioning leachate collection and removal system above and between such liners, functioning ground water monitoring system, any one deficiency in the physical containment system (i.e., bulk or noncontainerized liquids or materials containing free liquids deposited in the landfill, no or nonfunctioning or nonmaintained run-on control system and runoff management system, or no or nonmaintained engineered cover)	3
No evidence of hazardous substance migration from the landfill; and double liner with functioning leachate collection and removal system above and between such liners, functioning ground water monitoring system, no bulk or noncontainerized liquids or materials containing free liquids deposited in the landfill, functioning and maintained run-on control system and runoff management system, and maintained engineered cover	0

TABLE I-2.—CONTAINMENT FACTORS FOR GROUND WATER MIGRATION PATHWAY—Continued

	Assigned value
Surface impoundment:	
Evidence of hazardous substance migration from the surface impoundment; or no liner; or free liquids present with either no diking, unsound diking, or diking that is not regularly inspected and maintained	10
No evidence of hazardous substance migration from the surface impoundment, free liquids present, a liner, sound diking that is regularly inspected and maintained, and adequate freeboard	9
No evidence of hazardous substance migration from the surface impoundment, free liquids present, a single liner with functioning leachate collection and removal system below the liner, functioning ground water monitoring system, sound diking that is regularly inspected and maintained, and adequate freeboard	[illegible]
No evidence of hazardous substance migration from the surface impoundment, free liquids present, a double liner with functioning leachate collection and removal system between the liners, functioning ground water monitoring system, sound diking that is regularly inspected and maintained, and adequate freeboard	3
No evidence of hazardous substance migration from the surface impoundment and all free liquids eliminated at closure (either by removal of liquids or solidification of remaining wastes and waste residues	(a)

TABLE I-2.—CONTAINMENT FACTORS FOR GROUND WATER MIGRATION PATHWAY—Continued

	Assigned value
Pile:	
Evidence of hazardous substance migration from the pile area (i.e., pile area includes pile and any containment structure that may be present); or no liner; or none of the following present: maintained engineered cover over the pile, functioning and maintained run-on control system and runoff management system, or functioning leachate collection and removal system immediately above the liner	10
No evidence of hazardous substance migration from the pile area, a liner, and one of the following present: Maintained engineered cover, functioning and maintained run-on control system and runoff management system, or functioning leachate collection and removal system immediately above the liner	9
No evidence of hazardous substance migration from the pile area, a liner, and any two of the following present: Maintained engineered cover, functioning and maintained run-on control system and runoff management system, functioning leachate collection and removal system immediately above the liner	7
No evidence of hazardous substance migration from the pile area, a liner, and all of the following present: Maintained engineered cover, functioning and maintained run-on control system and runoff management system, functioning leachate collection and removal system immediately above the liner, and functioning ground water monitoring system	5
No evidence of hazardous substance migration from the pile area; and single liner with functioning leachate collection system immediately above the liner, ground water monitoring system, no bulk or noncontainerized liquids or materials containing free liquids deposited in the pile, functioning and maintained run-on control system and runoff management system, and maintained engineered cover	3
No evidence of hazardous substance migration from the pile area; and double liner with functioning leachate collection and removal system above and between such liners, ground water monitoring system, and any one deficiency in the physical containment system (i.e., bulk or noncontainerized liquids or materials containing free liquids deposited in the pile, no or nonfunctioning or nonmaintained run-on control system and runoff management system, or no or nonmaintained engineered cover)	3
No evidence of hazardous substance migration from the pile area; and double liner with functioning leachate collection and removal system above and between such liners, functioning ground water monitoring system, no bulk or noncontainerized liquids or materials containing free liquids deposited in the pile, functioning and maintained run-on control system and runoff management system, and maintained engineered cover	0
Pile inside or under a maintained structure that provides protection from precipitation so that neither runoff nor leachate is generated, liquids or materials containing free liquids are not deposited in the pile, and functioning and maintained run-on control is present	0
Containers:	
All containers buried	(b)
Evidence of hazardous substance migration from the container area (i.e., container area includes containers and any containment structures that may be present); or no liner (or no essentially impervious base) under the container area; or no diking (or similar structure) surrounding container area; or diking surrounding container area unsound or not regularly inspected and maintained	10
No evidence of hazardous substance migration from the container area, a liner (or essentially impervious base) under the container area, and container area surrounded by sound diking that is regularly inspected and maintained	9
No evidence of hazardous substance migration from the container area; container area surrounded by sound diking that is regularly inspected and maintained; and an essentially impervious base under the container area with a liquids collection and removal system	7
No evidence of hazardous substance migration from the container area, free liquids present, container area surrounded by sound diking that is regularly inspected and maintained, containment system has sufficient capacity to hold total volume of all containers and to provide adequate freeboard, single liner under container area with functioning leachate collection and removal system below the liner, and functioning ground water monitoring system	5
No evidence of hazardous substance migration from the container area; container area surrounded by sound diking that is regularly inspected and maintained; containment system includes an essentially impervious base, a liquids collection system, sufficient capacity to contain 10 percent of the volume of all the containers, and functioning and maintained run-on control; functioning ground water monitoring system; and spilled or leaked hazardous substances and accumulated precipitation removed in a timely manner to prevent overflow of the collection system, at least weekly inspection of containers, hazardous substances in leaking or deteriorating containers transferred to containers in good condition, and containers sealed except when waste is added or removed	5
No evidence of hazardous substance migration from the container area, free liquids present, container area surrounded by sound diking that is regularly inspected and maintained, containment system has sufficient capacity to hold total volume of all containers and to provide adequate freeboard, double liner under container area with functioning leachate collection and removal system between the liners, and functioning ground water monitoring system	3
Containers inside or under a maintained structure that provides protection from precipitation so that neither runoff nor leachate would be generated from any containers that were unsealed or ruptured, liquids or materials containing free liquids are not deposited in any container, and functioning and maintained run-on control is present	0
All containers removed, all containers were sealed and intact, and no evidence of hazardous substance migration from any container	0
No evidence of hazardous substance migration from the container area, containers leaking, and all free liquids eliminated at closure (either by removal or liquids or solidification of remaining wastes and waste residues)	(a)
Tank:	
Below ground tank	(b)

TABLE I-2.—CONTAINMENT FACTORS FOR GROUND WATER MIGRATION PATHWAY—Continued

	Assigned value
Evidence of hazardous substance migration from the tank area (i.e., tank area includes tank, ancillary equipment such as piping, and any containment structures); or tank and ancillary equipment not provided with secondary containment (e.g., liner under tank area, vault system, double wall); or no diking (or similar structure) surrounding tank and ancillary equipment; or diking surrounding tank and ancillary equipment unsound or not regularly inspected and maintained	10
No evidence of hazardous substance migration from the tank area, tank and ancillary equipment provided with secondary containment, and tank and ancillary equipment surrounded by sound diking that is regularly inspected and maintained	9
No evidence of hazardous substance migration from tank area; tank and ancillary equipment surrounded by sound diking that is regularly inspected and maintained; tank and ancillary equipment provided with secondary containment with a leak detection and collection system	7
No evidence of hazardous substances migration from the tank area, tank and ancillary equipment surrounded by sound diking that is regularly inspected and maintained, containment system has sufficient capacity to hold total volume of all tanks within the containment area and to provide adequate freeboard, single liner under that tank area with functioning leachate collection and removal system below the liner, and functioning ground water monitoring system	5
No evidence of hazardous substance migration from the tank area; tank and ancillary equipment surrounded by sound diking that is regularly inspected and maintained; tank and ancillary equipment provided with secondary containment system that detects and collects spilled or leaked hazardous substances and accumulated precipitation and has sufficient capacity to contain 110 percent of the volume of the largest tank within the containment area; spilled or leaked hazardous substances and accumulated precipitation removed in a timely manner; and at least weekly inspection of tank and secondary containment system, and all leaking or unfit-for-use tank systems promptly responded to; and functioning ground water monitoring system	5
No evidence of hazardous substances migration from the tank area, tank and ancillary equipment surrounded by sound diking that is regularly inspected and maintained, containment system has sufficient capacity to hold total volume of all tanks within the containment area and to provide adequate freeboard, double liner under container area with functioning leachate collection and removal system between the liners, and functioning ground water monitoring system	3
Tank is above ground, and inside or under a maintained structure that provides protection from precipitation so that neither runoff nor leachate would be generated from any material released from the tank, liquids or materials containing free liquids are not deposited in any tank, and functioning and maintained run-on control is present	0
Land treatment:	
Evidence of hazardous substances migration from the land treatment zone; or no functioning and maintained run-on control and runoff management system	10
No evidence of hazardous substances migration from the land treatment zone and functioning and maintained run-on control and runoff management system	7
No evidence of hazardous substances migration from the land treatment zone, functioning and maintained run-on control and runoff management system, and vegetative cover established over entire land treatment area	5
No evidence of hazardous substances migration from the land treatment zone and land treatment area maintained in compliance with requirements of 40 CFR 264.280	0
Other types of sources:	
Evidence of hazardous substances migration from the source area; or no liner; or none of the following present: Maintained engineered cover, functioning and maintained run-on control system and runoff management system, or functioning leachate collection and removal system immediately above the liner	10
No evidence of hazardous substances migration from the source area, a liner, and any one of the following present: Maintained engineered cover, or functioning and maintained run-on control system and runoff management system, or functioning leachate collection and removal system immediately above the liner	9
Other types of sources:	
No evidence of hazardous substances migration from the source area, a liner, and any two of the following present: Maintained engineered cover, functioning and maintained run-on control system and runoff management system, or functioning leachate collection and removal system immediately above the liner	7
No evidence of hazardous substances migration from the source area and all of the following present: Liner with functioning leachate collection and removal system immediately above the liner, functioning ground water monitoring system, maintained engineered cover and functioning and maintained run-on control system and runoff management system	5
No evidence of hazardous substances migration from the source area; and single liner with functioning leachate collection and removal system immediately above the liner, functioning ground water monitoring system, no bulk or noncontainerized liquids or materials containing free liquids deposited in the source area, functioning and maintained run-on control system and runoff management system, and maintained engineered cover	3
No evidence of hazardous substances migration from the source area; and double liner with functioning leachate collection and removal system above and between such liners, functioning ground water monitoring system, and any one deficiency in the physical containment system (i.e., bulk or noncontainerized liquids or materials containing free liquids deposited in the source area, no or nonfunctioning or nonmaintained run-on control system and runoff management system, or no or nonmaintained engineered cover)	3
No evidence of hazardous substances migration from the source area; and double liner with functioning leachate collection and removal system above and between such liners, functioning ground water monitoring system, no bulk or noncontainerized liquids or materials containing free liquids deposited in the source area, functioning and maintained run-on control system and runoff management system, and maintained engineered cover	0
Source area inside or under a maintained structure that provides protection from precipitation so that neither runoff nor leachate is generated, liquids or materials containing free liquids are not deposited in the source area, and functioning and maintained run-on control is present	0

a. Evaluate as a landfill without bulk or free liquids deposited.
b. Evaluate as a landfill.

TABLE I-3.—MINIMUM TO MAXIMUM ANNUAL NET PRECIPITATION FOR EACH STATE (IN INCHES) AS DERIVED FROM THE NET PRECIPITATION METHODOLOGY [1]

State	Weather station name	Minimum	Weather station name	Maximum
AL	Montgomery WSO	20	Haleyville	32
AK	Northway FAA AP	2	Little Port Walter	203
AZ	Wellton	0	Junipine	12
AR	Fort Smith WSO	15	Mount Ida 3 SE	26
CA	Blythe	0	Strawberry Valley	69
CO	John Martin Dam	0	Crested Butte	15
CT	Bridgeport WSO	20	Norfolk 2 SW	31
DE	Newark University Farm	17	Wilmington Porter Res	20
FL	Key West WSO	0	Milton Exp Station	26
GA	Fort Stewart	10	Clayton 1 W	43
HI	Lahaina 361	1	Mountain View 91	151
ID	Chilly Barton Flat	2	Wallace Woodland Park	25
IL	Pontiac	11	Rosiclare	21
IN	Hobart	12	Paoli Radio WVAK	22
IA	Hawarden	5	Dubuque WSO	16
KS	Johnson 11 ESE	1	Columbus 6 NNW	13
KY	Ashland	17	Russellville	26
LA	Lake Charles WSO	16	Bunkie	27
ME	Presque Isle	17	Bar Harbor	33
MD	Cumberland 2	14	Oakland 1 SE	24
MA	Birch Hill Dam	20	Blue Hill WSO	28
MI	MIO Hydro Plant	10	Marquette FAA AP	19
MN	Crookston NW Exp Sta	3	Duluth WSO	10
MS	Biloxi City	22	Tupelo 2 WNW	29
MO	Kansas City FAA AP	6	Charleston	23
MT	Opheim 12 SSE	1	Heron 2 NW	21
NE	Mitchell 5 E	1	Falls City	9
NV	Desert Natl WL Range	0	Glenbrook	11
NH	Lebanon FAA Airport	17	Mt. Washington WSO	76
NJ	Shiloh	17	Charlotteburg	27
NM	Carlsbad Caverns	0	Chama	8
NY	Mount Morris 2 W	10	Boonville 2 SSW	36
NC	Asheville	15	Highlands 2 S	55
ND	Parshall	2	Fullerton 1 ESE	5
OH	Put in Bay Perry Mon	11	Chardon	22
OK	Kenton	0	Idabel	20
OR	Burns WSO AP	2	Otis 2 NE	78
PA	Donora 1 SW	13	Pleasant Mount 1 W	26
RI	Block Island WSO	22	Kingston	27
SC	Charleston City WSO	11	Caesars Head 1 NE	53
SD	Camp Crook	2	Lead 1 SE	13
TN	Greeneville Exp Sta	17	Monteagle	34
TX	Alpine	0	Center	20
UT	Capitol Ref Natl Mon	1	Silver Lake Brighton	32
VT	Burlington WSO	14	Readsboro 1 SSE	28
VA	Dale Enterprise	11	Big Meadows	28
WA	Sunnyside	3	Ranier Paradise RS	100
WV	Franklin 2 NE	11	Pickens 1	42
WI	Sponner Exp Farm	7	Lake Geneva	13
WY	Deaver	1	Moran 5 WNW	15

[1] Based on over 3,300 weather stations in the U.S. for which average monthly precipitation and average monthly temperature data are available.

TABLE I-4.—CONTAINMENT FACTORS FOR SURFACE WATER MIGRATION PATHWAY

	Assigned value
Landfill:	
Evidence of hazardous substance migration from the landfill; or none of the following present: maintained engineered cover, functioning and maintained run-on control system and runoff management system, or liner with functioning leachate collection and removal system immediately above the liner.	10
No evidence of hazardous substance migration from the landfill; and any one of the following present: maintained engineered cover, functioning and maintained run-on control system and runoff management system, or liner with functioning leachate collection and removed system immediately above the liner.	9
No evidence of hazardous substance migration from the landfill; and any two of the following present: maintained engineered cover, functioning and maintained run-on control system and runoff management system, or liner with functioning leachate collection and removal system immediately above the liner.	7
No evidence of hazardous substance migration from the landfill; and all of the following present: maintained engineered cover, functioning and maintained run-on control system and runoff management system, and liner with functioning leachate collection and removal system immediately above the liner.	5
No evidence of hazardous substance migration from the landfill; and single liner with functioning leachate collection and removal system immediately above the liner, no bulk or noncontainerized liquids or materials containing free liquids deposited in the landfill, functioning and maintained run-on control system and runoff management system, and maintained engineered cover.	3
No evidence of hazardous substance migration from the landfill; and double liner with functioning leachate collection and removal system above and between such liners and any one deficiency in the physical containment system (i.e., bulk or noncontainerized liquids or materials containing free liquids deposited in the landfill, no or nonfunctioning or nonmaintained run-on control system and runoff management system, or no or nonmaintained engineered cover).	3
No evidence of hazardous substance migration from the landfill; and double liner with functioning leachate collection and removal system above and between such liners, no bulk or noncontainerized liquids or materials containing free liquids deposited in the landfill, functioning and maintained run-on control system and runoff management system, and maintained engineered cover.	0
Surface impoundment:	
Evidence of hazardous substance migration from the surface impoundment; or free liquids present with either no diking, unsound diking, or diking that is not regularly inspected and maintained.	10
No evidence of hazardous substance migration from the surface impoundment, free liquids present, sound diking that is regularly inspected and maintained, and adequate freeboard.	9
No evidence of hazardous substance migration from the surface impoundment, free liquids present, sound diking that is regularly inspected and maintained, adequate freeboard, and a single liner.	7
No evidence of hazardous substance migration from the surface impoundment, free liquids present, sound diking that is regularly inspected and maintained, adequate freeboard, and a single liner with functioning leachate collection and removal system below the liner.	5
No evidence of hazardous substance migration from the surface impoundment, free liquids present, sound diking that is regularly inspected and maintained, adequate freeboard, and a double liner with functioning leachate collection and removal system between the liners.	3
No evidence of hazardous substance migration from the surface impoundment and all free liquids eliminated at closure (either by removal of liquids or solidification of remaining wastes and waste residues).	(a)
Pile:	
Evidence of hazardous substance migration from the pile area (i.e., pile area includes pile and any containment structure that may be present) or neither of the following present: maintained engineered cover, or functioning and maintained run-on control system and runoff management system.	10
No evidence of hazardous substance migration from the pile area and either of the following present: maintained engineered cover, or functioning and maintained run-on control system and runoff management system.	9
No evidence of hazardous substance migration from the pile area and any two of the following present: maintained engineered cover, functioning and maintained run-on control system and runoff management system, or liner with functioning leachate collection and removal system immediately above the liner.	7
No evidence of hazardous substance migration from the pile area and all of the following present: maintained engineered cover, functioning and maintained run-on control system and runoff management system, and liner with functioning leachate collection and removal system immediately above the liner.	5
No evidence of hazardous substance migration from the pile area; and single liner with functioning leachate collection system immediately above the liner, no bulk or noncontainerized liquids or materials containing free liquids deposited in the pile, functioning and maintained run-on control system and runoff management system, and maintained engineered cover.	3
No evidence of hazardous substance migration from the pile area; and double liner with functioning leachate collection and removal system above and between such liners and any one deficiency in the physical containment system (i.e., bulk or noncontainerized liquids or materials containing free liquids deposited in the pile, no or nonfunctioning or nonmaintained run-on control system and runoff management system, or no or nonmaintained engineered cover).	3
No evidence of hazardous substance migration from the pile area; and double liner with functioning leachate collection and removal system above and between such liners, no bulk or noncontainerized liquids or materials containing free liquids deposited in the pile, functioning and maintained run-on control system and runoff management system, and maintained engineered cover.	0
Pile inside or under a maintained structure that provides protection from precipitation so that neither runoff nor leachate is generated, liquids or materials containing free liquids are not deposited in the pile, and functioning and maintained run-on control is present.	0
Container:	
All containers buried.	(b)

TABLE I-4.—CONTAINMENT FACTORS FOR SURFACE WATER MIGRATION PATHWAY—Continued

	Assigned value
Evidence of hazardous substance migration from the container area (i.e., container area includes containers and any containment structures that may be present); no diking (or similar structure) surrounding container area; or diking surrounding container area unsound or not regularly inspected and maintained.	10
No evidence of hazardous substance migration from the container area and container area surrounded by sound diking that is regularly inspected and maintained.	9
No evidence of hazardous substance migration from the container area; container area surrounded by sound diking that is regularly inspected and maintained; and an essentially impervious base under the container area with a liquids collection and removal system.	7
No evidence of hazardous substance migration from the container area; container area surrounded by sound diking that is regularly inspected and maintained; containment system includes an essentially impervious base, a liquids collection system, sufficient capacity to contain 10 percent of the volume of all the containers, and functioning and maintained run-on control; and spilled or leaked hazardous substances and accumulated precipitation removed in a timely manner to prevent overflow of the collection system, at least weekly inspection of containers, hazardous substances in leaking or deteriorating containers transferred to containers in good condition, and containers sealed except when waste is added or removed	5
No evidence of hazardous substance migration from the container area, free liquids present, container area surrounded by sound diking that is regularly inspected and maintained, containment system has sufficient capacity to hold total volume of all containers and to provide adequate freeboard, and single liner under container area with functioning leachate collection and removal system below the liner.	5
No evidence of hazardous substance migration from the container area, free liquids present, container area surrounded by sound diking that is regularly inspected and maintained, containment system has sufficient capacity to hold total volume of all containers and to provide adequate freeboard, and double liner under container area with functioning leachate collection and removal system between the liners.	3
Containers inside or under a maintained structure that provides protection from precipitation so that neither runoff nor leachate would be generated from any containers that were unsealed or ruptured, liquids or materials containing free liquids are not deposited in any container, and functioning and maintained run-on control is present	0
All containers removed, all containers were sealed and intact, and no evidence of hazardous substance migration from any container.	0
No evidence of hazardous substance migration from the container area, containers leaking, and all free liquids eliminated at closure (either by removal or liquids or solidification of remaining wastes and waste residues).	(a)
Tank:	
Below ground tank	(b)
Evidence of hazardous substance migration from the tank area (i.e., tank area includes tank, ancillary equipment such as piping, and any containment structures); no diking (or similar structure) surrounding tank and ancillary equipment; or diking surrounding tank and ancillary equipment unsound or not regularly inspected and maintained	10
No evidence of hazardous substance migration from the tank area, and tank and ancillary equipment surrounded by sound diking that is regularly inspected and maintained.	9
No evidence of hazardous substance migration from tank area; tank and ancillary equipment surrounded by sound diking that is regularly inspected and maintained; tank and ancillary equipment provided with secondary containment (e.g., liner under tank area, vault system, double-wall) with a leak detection and collection system	7
No evidence of hazardous substance migration from the tank area; tank and ancillary equipment surrounded by sound diking that is regularly inspected and maintained; tank and ancillary equipment provided with secondary containment system that detects and collects spilled or leaked hazardous substances and accumulated precipitation and has sufficient capacity to contain 110 percent of the volume of the largest tank within the containment area; spilled or leaked hazardous substances and accumulated precipitation removed in a timely manner; at least weekly inspection of tank and secondary containment system, and all leaking or unfit-for-use tank systems promptly responded to.	5
No evidence of hazardous substances migration from the tank area, tank and ancillary equipment surrounded by sound diking that is regularly inspected and maintained, containment system has sufficient capacity to hold total volume of all tanks within the containment area and to provide adequate freeboard, and single liner under that tank area with functioning leachate collection and removal system below the liner	5
No evidence of hazardous substances migration from the tank area, tank and ancillary equipment surrounded by sound diking that is regularly inspected and maintained, containment system has sufficient capacity to hold total volume of all tanks within the containment area and to provide adequate freeboard, and double liner under container area with functioning leachate collection and removal system between the liners	3
Tank is above ground, and inside or under a maintained structure that provides protection from precipitation so that neither runoff nor leachate would be generated from any material released from the tank, liquids or materials containing free liquids are not deposited in any tank, and functioning and maintained run-on control is present	0
Land Treatment:	
Evidence of hazardous substances migration from the land treatment zone; or no functioning and maintained run-on control and runoff management system	10
No evidence of hazardous substances migration from the land treatment zone and functioning and maintained run-on control and runoff management system	7
No evidence of hazardous substances migration from the land treatment zone, functioning and maintained run-on control and runoff management system, and vegetative cover established over entire land treatment area	5
No evidence of hazardous substances migration from the land treatment zone and land treatment area maintained in compliance with requirements of 40 CFR 264.280	0
Other Types of Sources:	
Evidence of hazardous substances migration from the source area; or neither of the following present: maintained engineered cover, or functioning and maintained run-on control system and runoff management system.	10

TABLE I-4.—CONTAINMENT FACTORS FOR SURFACE WATER MIGRATION PATHWAY—Continued

	Assigned value
No evidence of hazardous substances migration from the source area and either of the following present: maintained engineered cover, or functioning and maintained run-on control system and runoff management system	9
No evidence of hazardous substances migration from the source area and any two of the following present: maintained engineered cover, functioning and maintained run-on control system and runoff management system, or liner with functioning leachate collection and removal system immediately above the liner	7
No evidence of hazardous substances migration from the source area and all of the following present: maintained engineered cover, functioning and maintained run-on control system and runoff management system, and liner with functioning leachate collection and removal system immediately above the liner.	5
No evidence of hazardous substances migration from the source area; and single liner with functioning leachate collection and removal system immediately above the liner, no bulk or noncontainerized liquids or materials containing free liquids deposited in the source area, functioning and maintained run-on control system and runoff management system, and maintained engineered cover	3
No evidence of hazardous substances migration from the source area; and double liner with functioning leachate collection and removal system above and between such liners and any one deficiency in the physical containment system (i.e., bulk or noncontainerized liquids or materials containing free liquids deposited in the source area, no or nonfunctioning or nonmaintained run-on control system and runoff management system, or no or nonmaintained engineered cover)	3
No evidence of hazardous substances migration from the source area; and double liner with functioning leachate collection and removal system above and between such liners, no bulk or noncontainerized liquids or materials containing free liquids deposited in the source area, functioning and maintained run-on control system and runoff management system, and maintained engineered cover.	C
Source area inside or under a maintained structure that provides protection from precipitation so that neither runoff nor leachate is generated, liquids or materials containing free liquids are not deposited in the source area, and functioning and maintained run-on control is present.	0

a. Evaluate as a landfill without bulk or free liquids deposited.
b. Evaluate as a landfill.

TABLE I-5.—STANDING CROP DEFAULT DATA

Habitat	Pounds per acre	Comments
RIVER/STREAM		
COLD		
WI Rivers	14	Bass only.
PA trout stream	24	Trout only.
CA trout stream	41	Trout only.
WI Rivers	26	Pike only.
WY tailwaters	46	Trout only.
Mountain stream	51	Not U.S.
Trout streams	55	Average.
Mt. trout streams	40–226	Average.
MI streams	195	Bass streams.
WI streams	33	Smallmouth bass.
OH streams	11	Smallmouth bass.
MO streams	8	Smallmouth bass.
MD streams	16	Smallmouth bass.
MIDWESTERN		
Chariton River, MO.	53	Channelized.
Chariton River, MO.	304	Unchannelized.
Chariton River, MO.	152	Carp only.
OH streams	56	Average.
MO streams	72	Average.
Midwestern smallmouth stream.	114	Average.
Midwestern largemouth stream.	168	Average.
IN streams	158	Average.
IN streams	124	Largemouth.
IL streams	164	Average.
OK streams	174	Average.
WARM		
Warmwater Streams.	9–43	Average.
Warmwater Streams.	72	Courtois Creek.
Warmwater Streams.	56–90	Ozarks average.
Warmwater Streams.	120	Northern streams.
River backwaters and oxbows.	500	Average.
Tropical rivers	979–1,600	Lagoons.
OTHER		
Upper Mississippi	7–8	All species (1962-1973).
Lower Mississippi borrow pit.	51–3,199	All species.
Lower Mississippi (delta region).	530	Mosey Lake (mostly shad).
Lower Mississippi (delta region).	51–299	Wolf Lake (mostly shad).
RIVER BASIN		
Atchafalaya R.B., LA.	767	Lower basin stations.
Atchafalaya R.B., LA.	495	Upper basin stations.
LAKES		
Backwater lakes	397	Largemouth bass.
NY lake	47	Perch & bass.
Northern lake	51	Suckers.
Cold trout lakes	50	Average.
Lakes & ponds	58	Mixed species.
FL bass lake	97	All fish.
IO lake	123	Bullheads.
MI lakes	46	Slow growing perch.
MI lakes	88	Average diversity.
MI lakes	104	Unusual populations.
Lake Tohopekaliga, FL.	59–127	Before and after drawdown.
Warmwater lakes	125–150	Average.
MS oxbow lakes	202	Average.
Natural lakes	50–150	Average.
KY lakes	49–200	Average.
WI lakes	210	64% are minnows.
Lake Wingra, WI	440	Large fish.
AR lakes	89–445	Average range.
Alpine lakes	0.6–7	Average.
Tropical lakes	45–178	Average.
Atchafalaya Basin	270	Crawfish.
Atchafalaya Basin	624	Finfish.
Floodplain lakes	440	No overflow.
6 oxbow lakes, LA	156–267	Mostly channel cat and centrarchids.
7 backwater lakes	397	Average.
Wallum Lake, RI	14–17	Combined fish species.
Floa Lake, WI	3	Pumpkinseed & bluegill.
IL Lakes	18–36	
Third Sister Lake, MI.	86	Rotenone catch.
Third Sister Lake, MI.	13	Bass (average).
5 Lakes, FL (1-10ha).	7	Bass (average) only legal size.
Backwater lakes, LA.	24	Bass 250mm.
Lower Lock Alpine.	30	Bass.
Wintergreen Lake, MI.	48	Bass.
Cuba lakes, Cove Sampling.	83	Bass (average).
5 Lakes, FL	22–110	Ocala National Forest.
RESERVOIRS		
West VA reservoir	9	Largemouth bass.
IL, artificially heated.	8–18	Bass and carp.
170 reservoirs	23	All bass.
GA reservoir	48	All species.
CO reservoir	82	Average.
LA reservoirs	73	Average.
127 reservoirs	180–186	Average, all species.
Reservoirs and ponds.	200–300	Average.

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TABLE I-5.—STANDING CROP DEFAULT DATA—Continued

Habitat	Pounds per acre	Comments
Impoundments	200–400	Average.
Midwest reservoirs.	400	Average.
Barkley Lake, KY	771	Small bay.
Power plant cooling lake in Texas.	1,000–2,000	Bass & tilapia.
Bobwhite Lake, IA	7	Largemouth bass.
Red Hawk Lake, IA.	24	Largemouth bass.
3 reservoirs, OK	8	Largemouth bass (average).
Carl Blackwell Lake, OK.	1	Largemouth bass.
Buds Lake, IA	3	Largemouth bass.
Lanier Lake, GA	8	Largemouth bass (average).
34 reservoirs TX & MA.	19	Largemouth bass (average).
IA reservoirs	112	Largemouth bass (average).
Fast Osceola, IA	29	Largemouth bass.
Bastrop Lake, TX	33	Largemouth bass.
Ridgelake, IL	49	Largemouth bass (average).
North American Lakes & reservoirs.	15	Bass (average).
Clear Lake	1	Bass.
Clear Lake	15	Bass (average).
68 Gamefish Lakes, MN.	7	Bass (average).
44 Roughfish Lakes, NM.	6	Bass (average).
FL, WI 30 lakes	7	Bass (mean).
Brown's Lake, WI	24	Bass (average).
Cacapon Lake, WV.	9	Bass (average).
14 Lakes, MI (0.3–8.7 ha).	7	Bass (average).
Deep Creek reservoir, MD.	100	Mixed species.
Cherokee Reservoir, TX.	1,550	Mixed species.
PONDS		
Cold ponds	69	Grebe Lake.
Carp ponds	356	Unfertilized.
Bullhead ponds	178	Unfertilized.
Small desert pond	133	Eutrophic.
Kansas pond	168	Channel catfish.
MI ponds	289	Bluegills.
Southern ponds	230–330	Average.
AL ponds	498	Bass & bluegill.
Stocked AL pond	527	Tilapia.
Ashville pond, RI	48	Combined fish sp.
Meshanticut pond, RI.	500	Combined fish sp. Few catchable bass/pickerel.
MA ponds (23)	86	Average.
OK ponds	91	Sunfishes.
IL ponds	88	Smallmouth bass.
NY ponds	18	Smallmouth bass.
IA ponds (balanced).	13	Largemouth bass (avg.).
IA ponds	14	Largemouth bass (avg.) (overpopulated w/bluegill).
IA ponds	23	Largemouth bass (avg.).
IA ponds	2	Largemouth bass (overpopulated w/bass).
MI ponds	21	Largemouth bass.
IL ponds	125	Only "large" bass (avg.).
Ridge Lake, IL	357	Largemouth bass (avg.).
Ridge Lake, IL	48	(Over 254 mm).
Breon's pond, PA	15,771	Largemouth bass all sizes.
Rearing ponds U.S.	18,787	Largemouth bass.
MI ponds	147	Largemouth bass (avg.).
NY ponds	72	Largemouth bass (avg.).
AL pond	255	Largemouth bass.
MO ponds	72	No harvest.
Lake Toho Pekaligo, FL.	43	Littoral zone.
Lake Toho Pekaligo, FL.	46	Limnetic zone.
WV pond	88	Largemouth bass.
AL ponds	2,360	Bass fed.
FERTILIZED PONDS		
Carp & bullhead	1,070	Southern.
3 ponds, IL	447	Largemouth bass (avg.).
3 ponds,IL	69	Largemouth bass (avg.).
3 ponds,IL	60	Only "large" bass (avg.).
COASTAL		
Newport River, NC.	8	Littoral area estuary.
Mystic River, MA	18	Polluted estuary.
Narragansett Bay, RI.	28	Demersal fish.
Gulf of Mexico	54	Avg. Gulf.
Beach canals, LA	3–367	Gulf canals.
LA estuary	351	All estuary fish.
Chesapeake Bay	250	Nearshore-saltwater.
Chesapeake Bay	750	All finfish.
South Atlantic	286	Fish & shellfish.
Gulf Coast	432	Fish & shellfish.
Guadalupe Bay, TX.	11	
CA (3-mi zone)	293	Commercial catch.
OR (3-mi zone)	152	Commercial catch.
WA (3-mi zone)	444	Commercial catch.
AL Coastal	60	Estuary commercial catch.
LA Coastal	314	Estuary commercial catch.
MS Coastal	1011	Estuary commercial catch.
FL Coastal	48	Estuary commercial catch.
GA Coastal	35	Estuary commercial catch.
NC Coastal	128	Estuary commercial catch.
SC Coastal	26	Estuary commercial catch.
TX Coastal	[1] 57–68	Estuary commercial catch.
MA Coastal	1,267	Estuary commercial catch.
NH Coastal	320	Estuary commercial catch.
MA Coastal	1,984	Estuary commercial catch.
RI Coastal	1,209	Estuary commercial catch.
CT Coastal	19	Estuary commercial catch.
NY Coastal	90	Estuary commercial catch.
NJ Coastal	155	Estuary commercial catch.
DE Coastal	14	Estuary commercial catch.
MD Coastal	84	Estuary commercial catch.
VA Coastal	751	Estuary commercial catch.
Laguna Madre, TX	18–337	Range-winter minimum/summer maximum.
Caminada estuary, LA.	649	
LacDes Allemands, LA.	87	Channel catfish.
Barataria-Caminada Bay, LA.	9	Shrimp only (1967–1972).

[1] Includes fish and shellfish.

Attachment II to Appendix A

II.0 Methodology for calculating half-lives.

This section describes the methodology for calculating the hydrolysis half-life, the biodegradation half-life, the free-radical oxidation half-life, the photolysis half-life, and the volatilization half-life.

II.1 Hydrolysis.

The hydrolysis half-life $(t_{1/2})_h$ is calculated as follows:

$$(t_{1/2})_h = 0.693/K_h$$

where K_h is the hydrolysis rate constant.

The hydrolysis rate constant K_h includes contributions from acid-catalyzed hydrolysis, base-catalyzed hydrolysis, and nucleophilic reaction with water (which is often referred to as neutral hydrolysis). The value of K_h is determined as follows:

$$K_h = K_a[H^+] + K_n + K_b\,[OH^-]$$

where:

K_h = Total hydrolysis rate constant, in units of $(time)^{-1}$

K_a = Acid hydrolysis rate constant, in units of $(M)^{-1}(time)^{-1}$ where M is moles per liter.

K_b = Base hydrolysis rate constant, in units of $(M)^{-1}(time)^{-1}$.

K_n = Neutral hydrolysis rate constant, in units of $(time)^{-1}$.

$[H^+]$=Hydrogen ion concentration, in units of M.

$[OH^-]$=Hydroxyl ion concentration, in units of M.

Obtain the values of K_a, K_b, and K_n from peer reviewed literature. If the hydrolysis rates are reported for a temperature (T) other than 25 °C, multiply the reported rates by a temperature adjustment factor of $(1.116)^{T-25}$. This temperature adjustment factor will cause the rate constant to vary by a factor of 3 for each 10 °C change in temperature.

Assume the pH of the water to be in the range of 6 to 9. Calculate the value of K_h at pH 6 (i.e., $[H^+]=10^{-6}$ M and $[OH^-]=10^{-8}$ M) and at pH 9 (i.e., $[H^+]=10^{-9}$ M and $[OH^-]=10^{-5}$ M). Select the lower of the two calculated values. Use this as the value of the total hydrolysis rate constant K_h.

II.2 Biodegradation.

The biodegradation half-life $(t_{1/2})_b$ is calculated as follows:

$(t_{1/2})_b=0.693/K_b$

where K_b is the biodegradation rate constant, in units of $(time)^{-1}$.

Obtain the value of K_b from peer-reviewed literature. If the rate is reported for a temperature (T) other than 25 °C, multiply the reported value by a temperature adjustment factor of $(1.07)^{25-T}$.

In some cases, the biodegradation rate is specified as a second order rate constant (e.g., in units of $(volume)\,(cells)^{-1}\,(time)^{-1}$), rather than as a first order rate constant (i.e., in unit of $(time)^{-1}$). When a second order rate constant is specified, multiply the rate specified by an assumed microorganism concentration of 10^4 cells/ml to obtain the value of K_b.

II.3 Free-radical oxidation.

Oxidation half-life $(t_{1/2})_o$ is calculated as follows:

$(t_{1/2})_o=0.693/K_o$

where K_o is the total oxidation rate constant.

The total oxidation rate includes contributions from oxidation by peroxyl radicals, oxidation by singlet oxygen, and oxidation by other unspecified oxidants. The total oxidation rate constant is calculated as follows:

$K_o=K_R[R]+K_S[S]+K_x[X]$

where:

K_R=Rate constant for oxidation by peroxyl radical.

K_S=Rate constant for oxidation by singlet oxygen.

K_X=Rate constant for oxidation by other oxidants.

[R]=Peroxyl radical concentration $[RO_2\bullet]$.

[S]=Singlet oxygen concentration $[{}^1O_2\bullet]$.

[X]=Other oxidants concentration $[OX\bullet]$.

Obtain the values of K_R, K_S, and K_X from peer reviewed literature. Assume the peroxyl radical concentration to be 10^{-9} M and the singlet oxygen concentration to be 10^{-11} M. Rate constants for oxidation by other oxidants are rarely available and need not be included unless available.

II.4 Photolysis.

The photolysis half-life $(t_{1/2})_p$ is calculated as follows:

$(t_{1/2})_p=0.693/K_p$

where K_p is the photolysis rate.

The photolysis rate K_p used in calculating the photolysis half-life is to be the rate averaged over both a 24-hour day receiving the mean annual sunlight and the depth of the water body.

Obtain the value of the photolysis rate from peer-reviewed literature. If the reported value is for a mid-day near surface situation, multiply the value by $2/\pi$ to convert from a mid-day to a daily average value, and then multiply by 1/30 to convert from near surface to a depth average value. The value of the photolysis rate may also be obtained from existing studies that have estimated the photolysis rate using laboratory data on absorption spectrum and quantum yield in conjunction with the method specified in Burns et al. (1982).[1]

II.5 Volatilization.

The volatilization half-life $(t_{1/2})_v$ is calculated as follows:

$(t_{1/2})_v=0.693/K_v$

where K_v= Volatilization rate, in units of $(time)^{-1}$.

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[1] Burns, L.A., D.M. Cline, and R.R. Lassiter, 1982. Exposure Analysis Modeling System (EXAM): User Manual and System Documentation, U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA.

Estimate the value of K_V using the following equation:

$$K_V = \frac{1}{L} \left(\frac{1}{A} + \frac{RT}{B} \right)^{-1}$$

$$A = K_1^0 \, (D_1^C / D_1^0)^m$$

$$B = H_c \, K_g^W \, (D_g^C / D_g^W)^n$$

where:

L = Mixing depth of the water body in units of cm; assumed it to be 200 cm.

K_1^0 = Liquid phase mass transport coefficient of oxygen in the water body in the units of cm $hour^{-1}$; assumed it to be 8 cm $hour^{-1}$ in rivers and 1.8 cm $hour^{-1}$ in lakes.

D_1^C = Liquid phase diffusion coefficient of the hazardous substance in water, in units of cm^2 sec^{-1}.

D_1^0 = Liquid phase diffusion coefficient of oxygen in water, in units of cm^2 sec^{-1}.

m = Coefficient depending on the liquid phase turbulence; assume it to be 0.7.

R = Gas constant, 62.4 torr $(°K)^{-1}M^{-1}$, or 8.205×10^{-5} m^3 atm $(°K)^{-1}$ mol^{-1}.

T = Temperature in unit of °K; assume it to be 298°K.

H_c = Henry's constant in unit of torr M^{-1} or m^3 atm mol^{-1}.

K_g^W = Gas phase transport coefficient for water in units of cm $hour^{-1}$; assume it to be 2,100 cm $hour^{-1}$.

D_g^C = Gas phase diffusion coefficient of the hazardous substance in air, in units of cm^2 sec^{-1}.

D_g^W = Gas phase diffusion coefficient of water in air, in units of cm^2 sec^{-1}.

n = Coefficient depending on the gas phase turbulence; assume it to be 0.7.

Obtain the value of Henry's constant from peer-reviewed literature. The ratio of the liquid diffusion constants for the hazardous substance and oxygen (D_l^C/D_l^O) is related to the ratio of their molecular weights and is calculated as follows:

$$\frac{D_l^C}{D_l^O} = \left(\frac{W_C}{W_O}\right)^{-2/3} = \left(\frac{W_C}{32}\right)^{-2/3}$$

where: W_C = Molecular weight of hazardous substance.
W_O = Molecular weight of oxygen.

Similarily, the ratio of gas diffusion constants for the chemical and water (D_g^C/D_g^W) is related to the ratio of their molecular weights and is calculated as follows:

$$\frac{D_g^C}{D_g^W} = \left(\frac{W_C}{W_W}\right)^{-2/3} = \left(\frac{W_C}{18}\right)^{-2/3}$$

where: W_W = Molecular weight of water.

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