Hazard Ranking System Issue Analysis: Indoor Air Contamination

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ABSTRACT

This report presents an option for revising the air pathway of the EPA Hazard Ranking System (HRS) to address situations of indoor air contamination arising from uncontrolled hazardous waste sites. The HRS is used by EPA to rank uncontrolled waste sites based on their relative threat to human health and the environment. Highly ranked sites are placed on the National Priorities List for further investigation and possible remedial action. The revision option is structurally similar to the current HRS air pathway. The revision option can be used to assess sites based on the degree of contamination detected in the indoor air, relative to human-health-based benchmark concentrations, and on the size of the population potentially affected by the contamination.

Suggested Keywords: Superfund, Hazard ranking, Hazardous waste, Indoor air contamination.

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1.0 INTRODUCTION

1.1 Background

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (PL 96-510) requires the President to identify national priorities for remedial action among releases or threatened releases of hazardous substances. These releases are to be identified based on criteria promulgated in the National Contingency Plan (NCP). On July 16, 1982, EPA promulgated the Hazard Ranking System (HRS) as Appendix A to the NCP (40 CFR 300; 47 FR 31180, 12 July 1982). The HRS comprises the criteria required under CERCLA and is used by EPA to estimate the relative potential hazard posed by releases or threatened releases of hazardous substances.

The HRS is a means for applying uniform technical judgment regarding the potential hazards presented by a release relative to other releases. The HRS is used in identifying releases as national priorities for further investigation and possible remedial action by assigning numerical values (according to prescribed guidelines) to factors that characterize the potential of any given release to cause harm. The values are manipulated mathematically to yield a single score that is designed to indicate the potential hazard posed by each release relative to other releases. This score is one of the criteria used by EPA in determining whether the release should be placed on the National Priorities List (NPL).

During the original NCP rulemaking process and the subsequent application of the HRS to specific releases, a number of technical issues have been raised regarding the HRS. These issues concern the desire for modifications to the HRS to further improve its capability to estimate the relative potential hazard of releases. The issues include:

- Review of other existing ranking systems suitable for ranking hazardous waste sites for the NPL.
- Feasibility of considering ground water flow direction and distance, as well as defining "aquifer of concern," in determining potentially affected targets.
- Development of a human food chain exposure evaluation methodology.
- Development of a potential for air release factor category in the HRS air pathway.
- Review of the adequacy of the target distance specified in the air pathway.
- Feasibility of considering the accumulation of hazardous substances in indoor environments.
- Feasibility of developing factors to account for environmental attenuation of hazardous substances in ground and surface water.
- Feasibility of developing a more discriminating toxicity factor.
- Refinement of the definition of "significance" as it relates to observed releases.
- Suitability of the current HRS default value for an unknown waste quantity.
- Feasibility of determining and using hazardous substance concentration data.

- Feasibility of evaluating waste quantity on a hazardous constituent basis.
- Review of the adequacy of the target distance specified in the surface water pathway.
- Development of a sensitive environment evaluation methodology.
- Feasibility of revising the containment factors to increase discrimination among facilities.
- Review of the potential for future changes in laboratory detection limits to affect the types of sites considered for the NPL.

Each technical issue is the subject of one or more separate but related reports. These reports, although providing background, analysis, conclusions and recommendations regarding the technical issue, will not directly affect the HRS. Rather, these reports will be used by an EPA working group that will assess and integrate the results and prepare recommendations to EPA management regarding future changes to the HRS. Any changes will then be proposed in Federal notice and comment rulemaking as formal changes to the NCP. The following section describes the specific issue that is the subject of this report.

1.2 Issue Description

Several issues relevant to the HRS air pathway have been raised by Congress and by public comments on the NPL and NPL rulemaking actions. An analysis of these issues and the options developed for revising the air pathway as a result of the analysis are presented in Wolfinger, 1987. One of these issues relates to the applicability of the HRS to assessing sites which may pose significant indoor air contamination problems. These indoor air contamination sites arise as a result of the migration of air contaminants from an uncontrolled waste site through the ground or air, and the eventual accumulation of the contaminants in the air within buildings. The waste site from which the contaminants originated may or may not be readily identifiable. The present HRS evaluation of the air pathway is applicable only to the release of contaminants directly into the open air, subsequent transport in the atmosphere, and eventual human exposure and other environmental effects. Implicitly, the evaluation assumes a relatively high population, generally low concentration average exposure situation. The structure and rating factor values used in the current HRS targets category reflect this assumption. However, the phenomenon of contaminant migration into the confined atmosphere of buildings is somewhat inconsistent with these assumptions. Transport of contaminants from a source in such cases may be through the ground, as well as through the atmosphere, and may result in relatively low population, high concentration exposure situations.

The purpose of this paper is to present a preliminary air pathway evaluation mechanism applicable to indoor air contamination sites, compatible with the current structure of the HRS. This mechanism is designed to be incorporated into the HRS. Alternately, it could be adapted for use to screen sites for further monitoring in support of possible NPL listing (e.g., as a result of a health advisory).

The evaluation mechanism presented is preliminary. Thus, a number of questions that arise in the approach remain to be answered. Of greatest importance are those questions associated with monitoring requirements, the sources of detected contaminants, and the distance at which targets are included in the evaluation. Since similar questions are under study in respect to the other HRS pathways, these questions could not be resolved as part of this effort.

1.3 Organization of Report

Section 2 presents background information on the Hazard Ranking System (HRS). Section 3 presents an overview of the phenomena of indoor air pollution from uncontrolled waste sites. The mechanism for evaluating indoor contamination sites within the context of the HRS is also discussed in Section 3. Section 4 discusses the implication for program costs and NPL listing that might arise if the evaluation mechanism were adopted as part of the HRS.

2.0 BACKGROUND ON THE HAZARD RANKING SYSTEM

The HRS is designed to screen uncontrolled waste sites based on the information compiled in a site investigation. The HRS addresses three hazard modes: migration, fire, and explosion, and direct contact. The migration mode site score (HRS score) is used to determine whether the site is to be placed on the NPL for further investigation and possible remedial action. The latter two mode scores are not used in computing the HRS score but are included in the HRS as indicators of the need for emergency response.

The migration mode consists of three potential migration pathways representing the major routes of environmental transport common to uncontrolled hazardous waste sites: ground water, surface water, and air. Each pathway is structured similarly using three factor categories: release, waste characteristics, and targets.

The release category reflects the likelihood that the site has, is, or will release contaminants to the environment. If available monitoring data indicate that the site is releasing or has released contaminants, then an "observed release" has been demonstrated. If no such observed release can be demonstrated, then the release category is evaluated using route characteristics and containment factors. These factors are largely physical characteristics of the sites and their surrounding environments. It is important to note that the ground water and surface water routes contain factors for route characteristics and containment while the air route does not.

This permits sites to be evaluated for their potential to release contaminants to these two pathways in cases where documentation of an observed release is lacking. The current HRS requires that ambient air monitoring data support a conclusion that the site is, or has been, emitting contaminants before the site can receive a nonzero air route score. Wolfinger (1987) discusses options for adding factors to the HRS air pathway that reflect the potential of a site to release air contaminants.

The waste characteristics category reflects the inherent hazard of the contaminants that have been or might be released. The factors included in the waste characteristics categories address qualitative and quantitative characteristics of the wastes and waste contaminants found on the sites. The targets category constitutes a measure of the population and resources that might be adversely affected by the release. The factor categories and the rating factors contained in them are illustrated in Table 1.

For each pathway, the site is assigned a value for each applicable factor. The factor values are then multiplied by weighting factors and summed within factor categories. The resulting factor category scores are then multiplied and normalized to form a route score. Thus, for each site, three route scores are produced, each on a scale of 0 to 100. These route scores are referred to as follows:

TABLE 1

HRS SCORING FACTORS

Factor Category	Pathway: Ground Water	Pathway: Surface Water	Pathway: Air
Release	Monitoring data or Depth to aquifer of concern Net precipitation Permeability Physical state Physical state Containment	Monitoring data Facility slope and terrain Rainfall Distance to receiving water Physical state Physical state Containment	Monitoring data or
Waste Characteristics	Toxicity/persistence Quantity	Toxicity/persistence Quantity	Reactivity/ incompatibility Toxicity Quantity
Targets	Ground water use Distance/population	Surface water use Distance/population Distance to sensitive environment	Land use Distance/population Distance to sensitive environment

- Ground water migration route score (S_{gw})
- Surface water migration route score (S_{sw})
- Air migration route score (S_a)

The overall site migration score, or HRS score, (S_m) then is calculated as the root mean square (RMS) of the pathway scores:

$$S_m = (1/1.73)[(S_{gw})^2 + (S_{sw})^2 + (S_a)^2]^{1/2}$$

The RMS procedure was chosen to emphasize the highest scoring route while giving some consideration to secondary and tertiary routes. This procedure is illustrated in Figure 1. (For a more detailed discussion of the HRS see 40 CFR 300 or 47 FR 31180, 12 July 1982.)

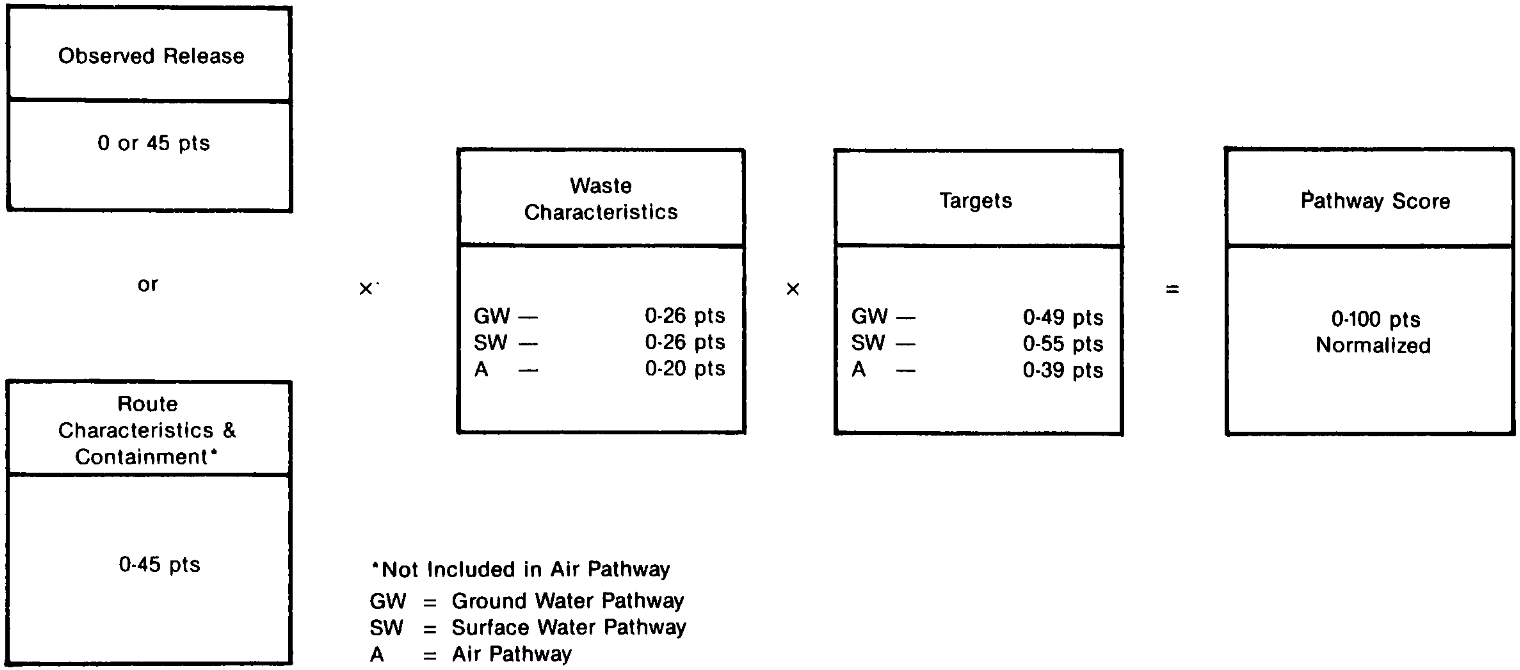

FIGURE 1
BASIC HRS STRUCTURE

3.0 A METHOD FOR EVALUATING INDOOR AIR CONTAMINATION SITES

3.1 Discussion of Indoor Contamination from Uncontrolled Waste Sites

The release of contaminants from an uncontrolled waste site directly into the atmosphere is a common, well known phenomenon. A review of the processes that could result in the release of air contaminants from uncontrolled waste sites leads to the conclusion that nearly all waste sites either currently emit, have emitted, or will emit air pollutants. The exceptions are those sites whose containment is such that it forms (and will continue to form) an impermeable barrier between the contaminants and the atmosphere. Whether the pollutants are emitted in sufficient concentration to cause concern, or even be detected, depends on numerous site-specific factors. A review of the phenomena of contaminant releases from uncontrolled waste sites into the atmosphere can be found in Wolfinger, 1987.

A less common, but nonetheless well known, phenomena is the transport of gaseous contaminants through the soil and their eventual escape into the interior of buildings. Such inground gas transport can occur directly as the result of pressure gradients or through diffusion processes. Alternately, the gas might be dissolved in, and move through and with, the ground water, eventually volatilizing and escaping into the air. The relative importance of these two basic inground transport pathways is unknown but can be expected to be dependent on the nature of the contaminants and the characteristics of the soil surrounding the waste site. Once the contaminants have escaped from the soil, they can enter the atmosphere directly or, more importantly for this analysis, enter into the basements of buildings near the waste site.

Once inside the buildings, these contaminants may become trapped, resulting in the buildup of contaminant concentrations in the indoor air. Contaminant concentrations in such instances may reach high levels, as shown in Table 2. Pellizzari (1982) indicates that the contaminant concentrations illustrated in this table probably arose from the Love Canal disposal site. Several other researchers have reported elevated concentrations of contaminants in buildings that they believe resulted from uncontrolled waste site releases, many significantly removed in distance from the source (Kim et al., 1980; James, Kinman, and Nutini, 1985; Miller and Beizer, 1985; and Pellizzari, 1982). The weight-of-evidence indicates that these contaminants could probably be traced to uncontrolled waste sites. However, no one has demonstrated conclusively that the contaminant concentrations reported arose from subsurface transport of air contaminants. The contaminants may have arisen from in-house sources or from infiltration of ambient air contaminants. Alternately, as indicated in the analyses of Foster and Chrostowski (1986 and 1987) and others, indoor air contamination can arise from the use of contaminated water for purposes such as showering, cooking, and other household activities. These

TABLE 2

RANGES OF ESTIMATED LEVELS OF ORGANIC VAPORS
IN AMBIENT AIR OF HOUSEHOLD BASEMENTS
IN NIAGARA FALLS, NY

Chemical	Concentration Range (ug/m^3)
Chlorobenzene	ND - 4.2
Dichlorobenzene Isomers (3)[a]	0.65 - 190
Trichlorobenzene Isomers (3)	0.07 - 33
Tetrachlorobenzene Isomers (2)	0.03 - 20
Pentachlorobenzene	T - 0.49
Chlorotoluene Isomers (2)	1.7 - 490
Dichlorotoluene Isomers (3)	0.13 - 370
Trichlorotoluene Isomers (4)	0.06 - 0.157
Tetrachlorotoluene Isomer	0.03 - 4.1
Bromotoluene Isomer	T - 4.4
Chloronaphthalene Isomer	0.08 - 3.4
1,2-Dichloropropane	1.4
Pentachlorobutadiene Isomer	T
1,3-Hexachlorobutadiene	0.03 - 0.41
Benzene	T - 520

[a]Values are the sum of the individual isomers detected.

ND: Not detected.
T: Trace.

Source: Pellizzari, Edo D., "Analysis of Organic Vapor Emissions near Industrial and Chemical Waste Disposal Sites," Environmental Science and Technology, Vol. 16, No. 11, 1982, pp. 781-785.

considerations emphasize the importance of determining the source of detected indoor air contaminants when evaluating sites for possible inclusion on the NPL.

As discussed in Wolfinger, 1987, releases of air contaminants into the atmosphere typically result in low dosage, large population exposure situations. A large number of individuals might each be exposed to a generally low contaminant concentration. The degree of exposure depends on numerous site-specific factors. In contrast, releases of air contaminants into buildings typically result in situations of low population, sometimes high dosage exposure. In such situations, a much smaller number of individuals might be exposed to fairly high contaminant concentrations.

The phenomenon of off-site transport of contaminants through the soil and into buildings is, overall, very different from the more common ambient air transport phenomena addressed in the HRS air pathway. These differences have implications for the structure and assumptions underlying any site evaluation mechanism. First, due to the gaps in current knowledge about inground air contaminant transport phenomena (particularly in the areas of unsteady-state release and transport and contaminant retardation) and difficulties in developing potentially needed data at a site, it would be very difficult to assess the potential of a site to release contaminants into buildings nearby. Thus, no provision is made for a "potential to release" option in the evaluation mechanism discussed below.

Second, since each individual is exposed to a generally higher concentration in an indoor contamination situation and there are generally fewer exposed individuals, the population target factor tables currently used in the HRS would be inappropriate for use in assigning values to indoor contamination sites. Rather, the factor tables should reflect a high concentration, low population exposure situation. This implies that the population needed to achieve a given value should be lower than in the current, "outdoor" HRS air pathway.

The third difference is that the interiors of most buildings, particularly residences, may have measurable concentrations of the same contaminants present at waste sites, even when the buildings are not affected by waste sites. Benzene, for example, is a fairly common contaminant found in the basements of houses not affected by waste sites. Benzene may arise from infiltration of outside air, smoking, or from oil or gas heaters. As another example, a household resident may keep an old container of pesticide, such as DDT, for lawn and garden use. The pesticide may escape from the can while it is stored, resulting in a detectable concentration in a garage or basement completely unrelated to any waste site. Because of this, it is generally difficult to determine whether contaminants detected indoors arise from nearby uncontrolled waste sites or from nonwaste related sources such as natural gas furnaces or solvents and pesticides stored indoors. A more complete discussion of the phenomena of building contamination can be found in Pellizzari, 1982; Pellizzari et al., 1985; and Wallace et al., 1984 and 1985.

The following sections describe an HRS-compatible mechanism for evaluating indoor air contamination from uncontrolled hazardous waste sites. This mechanism might be used in place of the current air pathway in those situations where the risk posed by indoor contamination is greater than that posed by outdoor contamination (as indicated by comparing the indoor and "outdoor" pathway scores). In such cases, the score from this indoor air pathway would be used in place of the current air pathway score.

3.2 Overview of the Indoor Air Pathway

The proposed indoor air pathway is structured so as to be compatible with the current HRS air pathway (see Figure 2). The indoor air pathway score is the normalized product of an "observed release" score, a waste characteristics score, and a targets score. "Observed release" has a somewhat different interpretation in the indoor air pathway than in the other HRS pathways. In the current HRS, an "observed release" is said to have occurred whenever available monitoring data indicate that the site has released air contaminants. As a rule of thumb, an order of magnitude elevation above background levels is considered "significant" in evaluating sites using the current HRS, although each set of data is evaluated on its own merits. Alternate criteria for significance are currently under EPA review (see Brown, 1986).

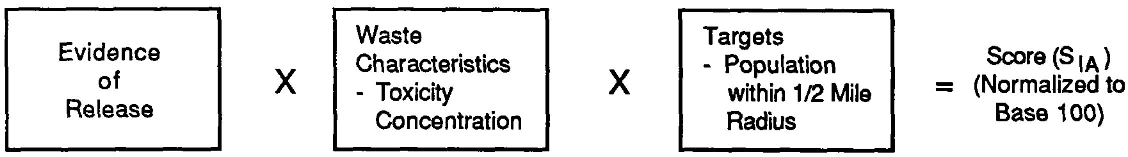

FIGURE 2
STRUCTURE OF THE INDOOR AIR PATHWAY

However, no such "significance" requirement is included in the indoor air pathway for two reasons. First, it is nearly impossible to define a "background" concentration for a building since there is a wide variation in indoor air contaminant concentrations between buildings (Wallace et al., 1984 and 1985). Also, in principle, no data would be available on the "background" concentrations for the particular buildings in question. Second, no such requirement is needed since the concentration factor included in the waste characteristics category of the indoor air pathway precludes the situation in which a site with nonhazardous exposure concentrations would receive an indoor air pathway score (see Section 3.2.2).

In contrast to the current HRS, a very strict quality control requirement needs to be placed on data used to show an "observed release" in the buildings in question. This restriction is necessary to distinguish contaminant concentrations that arise from uncontrolled waste sites from those that arise from other sources, particularly indoor sources. Moreover, as discussed above, the indoor air pathway does not provide for a potential to release option. Thus, the use of the indoor pathway is intentionally restricted to only those sites at which off-site contaminant migration into buildings can be conclusively demonstrated.

Two other significant differences are evident between the indoor air pathway and the current HRS air pathway. First, since high quality contaminant concentration data are required before the pathway may be used, a combined contaminant toxicity-concentration factor is used in the waste characteristics category. Second, the targets category consists only of a population factor. The definition of the population-at-risk and the evaluation approach differ from those in the current HRS air pathway, requiring fewer people at risk to achieve the same factor value.

The following discussion describes these factors in greater detail.

3.2.1 Release Category

The release category in the indoor air pathway is very simple. If the available data indicate that air contaminants have escaped from an uncontrolled waste site into the interior of surrounding buildings, then a release score of 45 is assigned to the site. If the data do not support such a conclusion, then a score of 0 is assigned. No provision is made for a "potential to release" option within the release category. Regardless of the indoor air pathway score, the site should still be evaluated using the outdoor air pathway to determine if the site could receive a higher HRS score using the current air pathway.

As stated above, it is crucial to determine that the contaminants concentrations detected did not arise from indoor sources or from some other source within or near the building. Rather, the contaminants should be attributable to an uncontrolled waste site. For the purposes of the indoor pathway, a CERCLA contaminant whose presence in the atmosphere of the building in question cannot be attributed to a source other than a possible uncontrolled waste site is considered a "critical" contaminant. The need to ensure that the contaminants arose from a waste site places restrictions on the nature and quality of data used to conclude that an observed release has occurred. Detailed requirements for determining that an observed release has occurred have not yet been developed. These requirements would include restrictions on sampling equipment and protocols and may also include a requirement for an indoor source inventory.

However, the actual location of the waste sites contributing to situations of indoor air contamination may not be known at the time the contamination is investigated. This has occurred several times in the past, in particular, at the Love Canal disposal site. Similar situations have also occurred in the past in cases of ground water contaminant plumes having no readily identifiable source. Several approaches could be used to address the question of source attribution in the indoor air pathway. One approach is to employ a "negative" approach, i.e., if a contaminant cannot be traced to any known source within the building or any known source other than a possible uncontrolled waste site, then the contaminant can be assumed to have escaped from a waste site. This option addresses the question of unknown sources and allows buildings themselves to be declared "sites". An alternate approach would be to require that an uncontrolled waste site that has received wastes containing the critical contaminants be identified within a reasonable distance of the contaminated building before the site is evaluated under this pathway. A third variation would be to require that outside monitoring, such as soil gas or ground water monitoring, indicate the presence of the critical contaminant below the surface.

Alternately, the building in question may be located on the site itself. The indoor air pathway is to be employed, however, only if the building is currently in use, or is vacant and not associated with the waste disposal activity. Thus, data from on-site buildings used to support a waste disposal operation cannot be used in this approach. This restriction is imposed as required in Section 101:22(A) of CERCLA.

3.2.2 Waste Characteristics Category

Two factors are reflected in the waste characteristics category: critical contaminant toxicity and concentration (as measured in the buildings in question). These factors are evaluated for each critical contaminant and the resulting factors values multiplied to form a combined toxicity-concentration value. The maximum calculated toxicity-concentration value is used in evaluating the site score.

Critical contaminant toxicity is evaluated using the same approach as in the outdoor air pathway (see 47 FR 31219-31243, 16 July 1982). Critical contaminant concentration is evaluated using a benchmark approach. In such an approach, the concentration is evaluated based on its relative magnitude in comparison with a given benchmark concentration. Possible benchmark concentrations include Threshold Limit Values (TLV), Short Term Exposure Levels (STEL), and Acceptable Daily Intakes (ADI) via inhalation. Threshold Limit Values and Short Term Exposure Levels are defined in American Conference of Governmental Industrial Hygienists, 1985. Acceptable Daily Intakes for some chemicals have been set by EPA (U.S. Environmental Protection Agency, October 1986).

Critical contaminant concentration is evaluated as follows. If the affected buildings are industrial or commercial, the benchmark concentration of each critical contaminant is the 8-hour average Threshold Limit Value (TLV) of the contaminant. TLVs define the levels below which occupational exposures to each particular contaminant is expected not to pose an undue risk to the worker. The benchmark concentration should reflect the types of exposure situations associated with indoor air contamination. Characteristics of particular interest are the classes of exposed individuals (e.g., children as well as adults), the duration of exposures (e.g., longer-term for children, shorter-term for working adults), and the temporal variations in inhalation rates (sleeping versus waking). An adaptation of the proposed revisions to the HRS toxicity factor discussed in DeSesso et al., 1986, recognizing the different characteristics of indoor versus outdoor exposures, should be investigated.

The critical contaminant concentration value is defined based on the ratio of the maximum detected concentration to the benchmark concentration and using the scale shown in Table 3. If the site contains several buildings of different types, the maximum calculated score should be used. However, the benchmark concentration used in these calculations must be consistent with the type of building affected (i.e., residential versus industrial/commercial). The use of data from a commercial building and a residential benchmark, for example, is not permitted even if residential buildings are also affected.

3.2.3 Targets Category

A single target factor is used to reflect the population at risk from the escaped contaminants. For purposes of this calculation, the target population consists of the population residing in the area around the site plus any permanent, nonresident employees working in the area. Distance would be measured from the contaminated buildings, and from the uncontrolled waste site as well, if its location is known, as is currently done in the ground water pathway. Table 4 defines an illustrative population factor evaluation method in terms of the population living or working within a 1/2-mile target distance limit. The distance of 1/2 mile was chosen for illustrative purposes only. A final distance could not be developed since few data are available showing the geographic extent of sub-surface air contaminant transport. This distance is

TABLE 3

CONCENTRATION MULTIPLIER

Ratio of Contaminant Concentration to Benchmark Concentration	Multiplier
Less than 0.1	0
Greater than or equal to 0.1 but less than 1.0	1
Greater than or equal to 1.0 and less than 10	2
Greater than or equal to 10	3

TABLE 4

ILLUSTRATIVE TABLE OF POPULATION FACTOR VALUES

Population On-site or Within 1/2 Mile of Site or Building	Value
0	0
1	1
2 - 10	2
11 - 30	3
31 - 100	4
Greater than 100	5

smaller than the 4-mile target distance limit used in the current HRS air pathway, since no data are available indicating that uncontrolled waste sites affect indoor air at substantial distances from the sites.

An alternate approach is to adapt the current HRS target distance factor value tables used for the ground water pathway. One such adaptation is presented in Table 5. Such an approach might be better than a strict 1/2 mile limit since ground water is considered to be an important transport media in cases of building contamination.

3.2.4 Pathway Score

The score for the indoor air pathway is the product of the release category score, the waste characteristics score and the targets score normalized to a scale of 0 to 100. The greater of this score and the "outdoor" air pathway score could be used as the air pathway score in computing the HRS migration score.

3.3 Step-By-Step Instructions for the Indoor Air Pathway

This section presents preliminary step-by-step instructions for evaluating sites using the indoor air pathway. The instructions are provided to illustrate how a site would be evaluated using the approach described above.

The pathway would be employed only when the available air monitoring data include contaminant concentration data taken indoors and when the contamination cannot be attributed to any nearby source other than a possible waste site.

TABLE 5

ILLUSTRATIVE ADAPTATION OF CURRENT HRS GROUND WATER PATHWAY TARGET POPULATION FACTOR MATRIX

	Value for Distance to Nearest Building From Hazardous Substance				
Population*	0	1	2	3	4
0	0	0	0	0	0
1 - 100	0	4	6	8	10
101 - 1,000	0	8	12	16	20
1,001 - 3,000	0	12	18	24	30
3,001 - 10,000	0	16	24	32	35
10,000+	0	20	30	35	40

*Population within 3 miles.

Distance to Nearest Building	Value
Greater than 3 miles	0
>2 to 3 miles	1
>1 to 2 miles	2
2,000 feet to 1 mile	3
Less than 2,000 feet	4

Step 1: Determine the concentrations of CERCLA contaminants in the building. Record the data on Worksheet 1: Contaminant Record (Table 6). Determine the potential sources of any detected contaminants within the building. Contaminants that cannot be attributed to any nearby or indoor source other than a possible uncontrolled waste site are considered critical contaminants. Documentation of the rational for determining that a contaminant is a critical contaminant must be provided by the analyst evaluating the site. If the concentration of any critical contaminant indicates that an indoor observed release from a waste site has occurred, assign a release value of 45. Otherwise, assign a release value of 0.

Step 2: For each critical contaminant, record the detected concentration on Worksheet 2: Concentration Multiplier (Table 7) and determine the benchmark concentrations as indicated in the preceding discussion.* Record the benchmark values on Worksheet 2.

Step 3: Calculate the ratio of each critical contaminant concentration to its benchmark value, and determine the concentration multiplier as indicated in Table 3. Record the multiplier for each critical contaminant on Worksheet 2 and Worksheet 3: Toxicity-Concentration (Table 8).

*The recommended benchmark for commercial/industrial buildings is the Threshold Limit Value, as determined by the American Conference of Governmental Industrial Hygienists. Benchmarks for residential buildings are under development.

TABLE 6

WORKSHEET 1: CONTAMINANT RECORD

	Contaminant CAS Number	Concentration	Units	Critical* Contaminant
1.	________	________	________	________
2.	________	________	________	________
3.	________	________	________	________
4.	________	________	________	________
5.	________	________	________	________
6.	________	________	________	________
7.	________	________	________	________
8.	________	________	________	________
9.	________	________	________	________
10.	________	________	________	________
11.	________	________	________	________
12.	________	________	________	________
13.	________	________	________	________
14.	________	________	________	________
15.	________	________	________	________
		Observed Release Score		________

Rationale for considering contaminants to be critical contaminants (use additional sheets as necessary):

*Contaminants that cannot be attributed to any nearby or indoor source other than a possible uncontrolled waste site are considered critical contaminants. This column is used to indicate that a contaminant is considered by the analyst to be a critical contaminant.

TABLE 7

WORKSHEET 2: CONCENTRATION MULTIPLIER

	Contaminant CAS Number	Contaminant Concentration	Benchmark	Ratio	Multiplier
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					

TABLE 8

WORKSHEET 3: TOXICITY-CONCENTRATION

	Contaminant CAS Number	Toxicity Score	Concentration Multiplier*	Product
1.	______	______	______	______
2.	______	______	______	______
3.	______	______	______	______
4.	______	______	______	______
5.	______	______	______	______
6.	______	______	______	______
7.	______	______	______	______
8.	______	______	______	______
9.	______	______	______	______
10.	______	______	______	______
11.	______	______	______	______
12.	______	______	______	______
13.	______	______	______	______
14.	______	______	______	______
15.	______	______	______	______
	Maximum value calculated		______	

*From Worksheet 2.

Step 4: For each critical contaminant, determine the toxicity value as indicated in the Tables 4, 6, and 7 and page 42 of the HRS User's Manual (47 FR 31219-31243, 16 July 1982). Record the contaminant toxicity values for each contaminant on Worksheet 3.

Step 5: Calculate the product of the toxicity factor value and contaminant multiplier for each critical contaminant as indicated on Worksheet 3. Identify the largest value and record it on Worksheet 3.

Step 6: Record the observed release value from Worksheet 1 and the toxicity-concentration value from Worksheet 3 on Worksheet 4: Score Sheet (Table 9).

Step 7: Evaluate the population exposed using the population factor table (e.g., Table 4) and record the population value on Worksheet 4.

Step 8: Compute the indoor air pathway score as indicated on Worksheet 4.

TABLE 9

WORKSHEET 4: SCORE SHEET

1.	OBSERVED RELEASE VALUE		____
2.	TOXICITY-CONCENTRATION VALUE[a]		____
3.	POPULATION VALUE[b]		____
4.	Multiply lines 1 x 2 x 3		____
5.	Divide line 4 by 2025	S_{ia} =	____

[a]From Worksheet 3.
[b]From Population Scoring Table (e.g., Table 4).

4.0 IMPLICATIONS

The incorporation of this indoor air pathway would have several implications for the HRS. First, since the pathway requires that fairly comprehensive, expensive monitoring data be developed in order to evaluate the site, the potential costs of use of the indoor air pathway may be significant. These costs would arise from the monitoring requirements, as the cost of calculating the waste characteristics and targets scores would be negligible in comparison. Current estimates of the cost to determine the presence of waste site contaminants in indoor air in residential buildings range from $4,000 to $4,500 per house, exclusive of labor costs (personal communication, Turpin, 1986). This cost reflects the minimum necessary under the most favorable conditions. Cost at complex sites (e.g., those with nearby point sources) will be higher.

Second, there are two important differences between the factors used in this indoor air pathway and the other HRS pathways; the lack of a potential to release option and the use of a concentration factor. This first difference is particularly important since the lack of a "potential to release" option in the current HRS air pathway has been identified as a weakness in the current approach. This weakness has been discussed by Congress in its deliberations on CERCLA reauthorization. In response to these concerns, an effort is underway to develop a "potential to release" option for the HRS air pathway (Wolfinger, 1987). Thus, a potential to release option for an indoor air pathway may also be required. Further, the use of a concentration factor in this pathway raises the question of the use of similar factors in the other pathways.

Finally, several technical issues remain to be resolved before this indoor air pathway could be incorporated into the HRS. These include the development of benchmark concentration values for residences, the preparation of monitoring requirements and guidance, and the finalization of the target distance limit.

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