Modified Hazard Ranking System for Sites with Mixed Radioactive and Hazardous Wastes - User Manual

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April 1986

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**Pacific Northwest Laboratory
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FOREWORD

The method for ranking hazardous and radioactive waste sites that is described in this document is a combination of two methods separately developed by the MITRE Corporation and Pacific Northwest Laboratory (PNL). The method for ranking hazardous waste sites was developed by The MITRE Corporation under contract to the U.S. Environmental Protection Agency (EPA). It was originally published in the July 16, 1982, Federal Register as "Uncontrolled Hazardous Waste Site Ranking System, A User's Manual (HW-10)." The method for ranking radioactive waste facilities was developed by PNL under contract to the U.S. Department of Energy (DOE).

This document is intended to assist those individuals who are responsible for identifying and evaluating inactive waste sites per the requirements of DOE Order 5480.14. Questions regarding the status of specific DOE facilities under the Comprehensive Environmental Response, Compensation and Liability Act should be directed to:

Dr. Vincent J. DeCarlo
U.S. Department of Energy
Office of Environmental Guidance
Mail Stop EH-23
1000 Indiana Avenue, S.W.
Washington, D.C. 20585

Questions or comments of a technical nature relating to the Modified Hazard Ranking System (mHRS) should be addressed to the authors:

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1.0 INTRODUCTION

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (42 U.S.C. §9601) requires the U.S. Environmental Protection Agency (EPA) to identify the nation's abandoned hazardous waste sites warranting the highest priority for remedial action. To set the priorities, CERCLA requires that criteria be established based on relative risk or danger, taking into account the population at risk, the hazardous 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.

The revised National Oil and Hazardous Substances Contingency Plan (NCP) (1982), mandated by CERCLA and Executive Order 12316 (1981), was promulgated on July 16, 1982. As required by Section 105(8) of CERCLA, the revised NCP establishes criteria for setting priorities for conducting investigative and remedial actions at sites where releases of hazardous wastes have occurred or might occur. Sites may be added based on initiatives from the states or on the basis of the relative potential they exhibit for releases that pose a hazard to health or to the environment. This potential is estimated using the Hazard Ranking System (HRS), which is published as Appendix A to the revised NCP. Scores are assigned to waste sites after considering: 1) if releases of hazardous wastes are known to have occurred or are likely to occur; 2) the toxicity, persistence, and amount of hazardous waste present; and 3) the number of people and the existence of sensitive environments/ecosystems potentially at risk because of the waste site.

The EPA uses the HRS to evaluate hazardous waste sites that fall under the jurisdiction of CERCLA. In its initial application, the HRS was used on sites containing only nonradioactive hazardous wastes. Recently, however, the HRS was used to evaluate federal facilities having waste sites with both chemically hazardous and radioactive constituents (National Oil and Hazardous Substances Contingency Plan 1982). The U.S. Department of Energy (DOE) feels that the HRS does not adequately discriminate between radioactive sites that may pose significant risk and those that do not; consequently, the DOE has developed a method compatible with the EPA's HRS for evaluating the relative

potential hazards of sites containing both radioactive and nonradioactive hazardous wastes. The method utilizes the HRS structure for discriminating chemically contaminated abandoned waste sites that pose no hazard from those that may pose risk to humans and/or the environment.

This modified Hazard Ranking System (mHRS) does not alter the basic HRS ranking philosophy. It simply adds a subcategory to the waste characteristics section of the HRS to allow the system to more accurately reflect the potential hazards of radionuclides at abandoned mixed waste sites. For purely chemical (containing no radionuclides) sites, the mHRS yields identical results to those of the HRS.

The mHRS still has the major deficiencies inherent in a simple ranking system; it cannot account for the myriad site-specific circumstances that ultimately determine if remedial actions are required and what those actions should be. A more comprehensive preliminary modeling system is still required to determine the relative risks of abandoned sites so that they may be prioritized for further investigations. However, as a preliminary screening tool, the mHRS can be useful for determining the potential for hazard from mixed radiological and chemical waste sites.

This document describes both the original HRS and the mHRS as they are to be used in evaluating the relative potential for uncontrolled hazardous substance facilities to cause human health or safety problems or ecological or environmental damage. Detailed instructions for using the mHRS/HRS computer code are provided, along with instructions for performing the calculations by hand. Uniform application of the ranking system will permit the DOE to identify those releases of hazardous substances that pose the greatest hazard to humans or the environment. However, the mHRS/HRS by itself cannot establish priorities for the allocation of funds for remedial action. The mHRS/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. 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 mHRS/HRS assigns three scores to a hazardous facility:

- S_M reflects the potential for harm to humans or the environment from migration of a hazardous substance away from the facility by routes involving ground water, surface water, or air. It is a composite of separate scores for each of the three routes.
- S_{FE} reflects the potential for harm from substances that are explosive or flammable.
- S_{DC} reflects the potential for harm from direct contact with hazardous substances at the facility (i.e., no migration need be involved).

The score for each hazard mode (migration, fire and explosion, and direct contact) or route is obtained by considering a set of factors that characterize the potential of the facility to cause harm (see Table 1.1). Each factor is assigned a numerical value (on a scale of 0 to 3, 5, or 8) according to prescribed guidelines. This value is then multiplied by a weighting factor yielding the factor score. The factor scores are then combined as follows: 1) scores within a factor category are added; then 2) the total scores for each factor category are multiplied together to derive a score for ground water, surface water, air, fire and explosion, and direct contact.

In computing S_{FE} or S_{DC} , or an individual migration route score, the product of its factor category scores is divided by the maximum possible score, and the resulting ratio is multiplied by 100 so that all scores will be on a scale of 0 to 100.

S_M is a composite of the scores for the three possible migration routes:

$$S_M = 1/1.73 \sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$$

where S_{gw} = ground water route score
 S_{sw} = surface water route score
 S_a = air route score

This method of combining the route scores emphasizes the primary (highest scoring) route in aggregating route scores while giving some additional

TABLE 1.1. Comprehensive List of Rating Factors

Hazard Mode	Factor Category	Factors		
		Ground Water Route	Surface Water Route	Air Route
Migration	Route Characteristics	<ul style="list-style-type: none"> • Depth to Aquifer of Concern • Net Precipitation • Permeability of Unsaturated Zone • Physical State 	<ul style="list-style-type: none"> • Facility Slope and Intervening Terrain • One-Year 24-Hour Rainfall • Distance to Nearest Surface Water • Physical State 	
	Containment	<ul style="list-style-type: none"> • Containment 	<ul style="list-style-type: none"> • Containment 	
	Waste Characteristics	<ul style="list-style-type: none"> • Toxicity/Persistence • Hazardous Waste Quantity 	<ul style="list-style-type: none"> • Toxicity/Persistence • Hazardous Waste Quantity 	<ul style="list-style-type: none"> • Reactivity/Incompatibility • Toxicity • Hazardous Waste Quantity
	Targets	<ul style="list-style-type: none"> • Ground Water Use • Distance to Nearest Well/Population Served 	<ul style="list-style-type: none"> • Surface Water Use • Distance to Sensitive Environment • Population Served/Distance to Water Intake Downstream 	<ul style="list-style-type: none"> • Land Use • Population Within 4-Mile Radius • Distance to Sensitive Environment
Fire and Explosion	Containment	<ul style="list-style-type: none"> • Containment 		
	Waste Characteristics	<ul style="list-style-type: none"> • Direct Evidence • Ignitability • Reactivity • Incompatibility • Hazardous Waste Quantity 		
	Targets	<ul style="list-style-type: none"> • Distance to Nearest Population • Distance to Nearest Building • Distance to Nearest Sensitive Environment • Land Use • Population Within 2-Mile Radius • Number of Buildings Within 2-Mile Radius 		
Direct Contact	Observed Incident	<ul style="list-style-type: none"> • Observed Incident 		
	Accessibility	<ul style="list-style-type: none"> • Accessibility of Hazardous Substances 		
	Containment	<ul style="list-style-type: none"> • Containment 		
	Toxicity	<ul style="list-style-type: none"> • Toxicity 		
	Targets	<ul style="list-style-type: none"> • Population Within 1-Mile Radius • Distance to Critical Habitat 		

consideration to the secondary or tertiary routes if they score high. The factor 1/1.73 is used simply for the purpose of reducing S_M scores to a 100-point scale.

The mHRS/HRS does not quantify the probability or magnitude of harm from a facility, although the factors have been selected to approximate both of those risk elements. Rather, the mHRS/HRS ranks facilities in terms of potential threat by describing:

- the manner in which the hazardous substances are contained
- the route by which they would be released
- the characteristics and amount of the harmful substances and
- the likely targets.

The multiplicative combination of factor-category scores is an approximation of the more rigorous approach in which one would express the hazard posed by a facility as the product of the probability of a harmful occurrence and the magnitude of the potential damage.

The ranking of facilities nationally for remedial action will be based primarily on S_M . S_{FE} and S_{DC} may be used to identify facilities requiring emergency attention.

2.0 USING THE MODIFIED HAZARD RANKING SYSTEM - GENERAL CONSIDERATIONS

The HRS (EPA 1982) and the modified HRS (mHRS) were developed to distinguish abandoned waste sites that may pose human health or environmental problems from those that do not. Each waste site is evaluated using a series of standard questions that examine several aspects of the site. Numerical scores are assigned according to prescribed guidelines.

To use the HRS and the mHRS (subsequently referred to as the mHRS/HRS), information on exposure routes must be collected, the characteristics of the waste must be examined, and the potential targets in the vicinity must be assessed. While the system does not provide an absolute assessment of potential risk, it is one of the few tools available for comparing a diverse number of waste sites.

The mHRS/HRS consists of several work sheets that are used to group the site information by potential route of release of (or exposure to) hazardous material from the site. The routes are: migration of the hazardous material through 1) air, 2) surface water, and 3) ground water; exposure by 4) fire or explosion; and exposure by 5) direct contact with material at the site. The work sheets aid in the evaluation of the characteristics of each exposure route (including such things as amount of rainfall and soil permeability), the characteristics of the waste (the degree of hazard presented by the waste), and the targets (people or sensitive environments) near the site. A score is given for each of the five routes of exposure, and an overall site ranking is generated by weighting each of the individual route scores.

Use of the mHRS/HRS requires considerable information about the facility, its surroundings, the hazardous substances present, and the geologic characteristics of the area down to the aquifers that may be at risk. This information, which is the basis of the site scorings, is recorded either by hand or through the use of electronic (computerized) work sheets and documentation pages. Copies of blank work sheets and documentation pages for use in hand calculating mHRS/HRS scores are included in Appendix C to this document. Figure 2.1 illustrates one format for recording by hand the general information on the facility being evaluated. It can also serve as a cover

Phase I portion of the DOE CERCLA effort are not expected to conduct extensive sampling to supplement the available data base. Consequently, where no data are available, the route will be assigned a value of 0 (zero). However, if a factor with no data is the only factor in a category (e.g., containment), then the factor is given a score of 1. If data are lacking for more than one factor in connection with the evaluation of either S_{gw} , S_{sw} , S_a , S_{FE} or S_{DC} , that route score is set at 0.

The following sections give detailed instructions and guidance for rating a facility. Section 3 provides guidance on use of the computerized version of the mHRS/HRS, including details on hardware and software requirements. Sections 4 and 5 describe the hand-calculational techniques for the modified and original ranking systems. Each of those two sections includes the necessary work sheets designed to conform to the sequence of steps required to perform the ratings. Guidance for evaluating each of the factors then follows. Remember: If data are missing for more than one factor in connection with the evaluation of a route, that route score is set at 0 (i.e., there is no need to assign scores to factors in a route that will be set at 0).

For sites with radioactive wastes, there may be circumstances that require additional effort in performing an evaluation. It is important to note that only radionuclides with half-lives greater than one year are evaluated under the mHRS/HRS. Shorter-lived nuclides are not scored.

Many waste sites are situated close to operating nuclear facilities. These facilities may routinely discharge radionuclides into the air and surface water during operations. Sampling data used to rank a waste site must allow for the potential contribution to environmental radioactivity levels from these operating plants. The HRS and mHRS use the term "significantly above background" when determining if environmental measurement data should be considered as evidence of release from a site. "Above background," as used in the mHRS, does not mean that the data are simply above the detection limit of the instrument. Instead, it means the data point in question (with its associated uncertainties) is above the uncertainty range associated with

control (also known as "background") samples. More specifically, to use environmental radioactivity measurements as evidence of release from a site, the data must be unambiguously attributable to the waste site.

3.0 USING THE mHRS/HRS COMPUTER CODE

The mHRS/HRS computer code was developed by Pacific Northwest Laboratory (PNL) to provide a uniform method for DOE facilities to use in performing their CERCLA Phase I mHRS/HRS evaluations. The code removes the tedium and potential for errors associated with searching for information on tables and performing hand calculations. However, since the code is completely interactive in nature, it allows its user the freedom to make the necessary individual site assessment judgments that are vital to a quality mHRS/HRS evaluation.

A simplified flow diagram showing the general operational categories the code uses to receive input information, perform ranking calculations and prepare necessary reports is presented in Figure 3.1. A walk-through of computer prompts generated during an mHRS run is shown in Appendix B.

3.1 HARDWARE REQUIREMENTS

The mHRS/HRS computer code is designed to operate on an IBM PC^(a) microcomputer utilizing either a dual floppy disk drive system or a hard disk storage system. The code requires that the microcomputer have a minimum of 256K random access memory (RAM) memory. A microcomputer system with 512K RAM memory and a hard disk storage system can be configured to operate considerably faster than the system having only 256K RAM memory and either a hard disk or a dual floppy drive system.

The most efficient computer hardware set-up would involve the following hardware:

- IBM PC, IBM XT, or IBM AT with 512K (or more) RAM memory
- 20-megabyte (or more) hard disk storage system
- laser jet printer.

The 512K of RAM memory in the microcomputer will allow the code to be set up with some of the larger, more frequently used modules of the code being transferred into a portion of the RAM configured to operate as an internal disk storage space. This allows the system to operate much faster. The

(a) IBM PC, IBM XT, and IBM AT are trademarks of the International Business Machines Corporation.

FIGURE 3.1. Simplified Flow Diagram of mHRS/HRS Code

20-megabyte (or larger) hard disk storage system is almost essential for large facilities involving several sites to evaluate. The mHRS/HRS code will generate several pages of output information (i.e., cover sheet, applicable score sheets and lengthy justification files) for each site evaluated. Thus, a fast high-quality printer such as a laser jet provides for a more efficient operation.

The mHRS/HRS computer code can be operated using an IBM PC system having only 256K RAM memory and a dual floppy disk storage system. However, such a system will require that a floppy disk be created for each site evaluated. This is necessary because the mHRS/HRS code is so large. The code, as developed to operate on a floppy disk system, utilizes all of the floppy disk space on one drive and more than half of the space on the second drive, leaving less than half of the second disk free for file storage. To allow for this condition, a utility disk called the "mHRS/HRS Code Boot Disk" is provided with the code. The utility disk allows the user to create as many site disks as may be needed to evaluate a facility.

3.2 SOFTWARE REQUIREMENTS

The mHRS/HRS computer code was written in dBASE III^(a) language and utilizes the storage capabilities of the commercial dBASE III data base software. Thus, in order to run the mHRS/HRS code, the user must have the commercial dBASE III software (version 1.1 or higher) installed on their system.

The user may wish to have available one of the commercial word processing software packages. This is not necessary to operate the mHRS/HRS code; however, the code does allow the option of placing all the output information within a single text (ASCII) file. The text file can then be called up under the word processor (assuming it is equipped to handle text files) and used in the development of the CERCLA Phase I document or any other applicable report.

(a) dBASE III is a trademark of Ashton-Tate, Culver City, California.

3.3 INSTALLATION INSTRUCTIONS

A suggested general subdirectory format for installing the mHRS/HRS code onto a microcomputer having a hard disk storage system is as follows:

- DBASE subdirectory (contains the installed dBASE III software)
- MHRSPRG subdirectory (contains the main program module files)
- MHRS subdirectory (contains the data base files and remaining code modules).

Since microcomputer systems can be configured quite differently, it is difficult to offer a generalized installation procedure that will work on each computer system encountered. To respond to this problem, PNL staff will be available for assistance in installing the code on individual systems or for consultation regarding the installation/operation of the code. To obtain assistance with the installation/operation of the code contact:

R. D. Stenner (509-375-2916)
R. A. Peloquin (509-375-3916)

Pacific Northwest Laboratory
P.O. Box 999
Richland, Washington 99352

Operation of the mHRS/HRS code using a microcomputer with a dual floppy disk storage system does not require special installation; however, the mHRS/HRS Boot Disk will have to be used to create the necessary floppy disks for each site to be evaluated. To use the boot disk, simply place it in drive A and perform a soft-boot of the system (press the Ctrl, Alt and Del keys simultaneously), and follow the directions as they appear on the screen. If assistance is needed regarding the operation of the boot disk or code, contact one of the PNL staff listed above.

3.3.1 Operational Instructions

The operating instructions assume that the mHRS/HRS computer code has been installed on the microcomputer system and is properly set up to run utilizing the system as it is configured.

The code is very easy to run once it has been installed. The code can be accessed on the computer by simply selecting the subdirectory that contains

the dBASE III software (for hard disk systems), or placing the dBASE III software disk into the default drive (for dual floppy systems) and typing the following command:

DBASE MHRS

This command calls in both the dBASE III software and the mHRS/HRS code and starts a run of the code. Since the code is completely interactive, all that is necessary to operate the code from this point is to supply the inputs as they are queried on the screen.

The code provides for the option of creating a text (ASCII) file that contains all of the output information (i.e., cover sheet, applicable pathway score sheets and input justification text) resulting from the evaluation of a site. The text file option is provided to allow the user to call it up under a common word processor for editing and inclusion in the development of reports/documents. To retrieve the text file follow the procedures provided with the word processing software for retrieval of text/ASCII files.

3.4 JUSTIFICATION PAGES

A key provision of the mHRS/HRS is the use of "justification" or "documentation" pages. At key points throughout the code the user is instructed to temporarily exit the program and record information in text files, called "justification" pages. The purpose of these text files is to ensure that the data used to score each site is referenced or documented. For example, after waste inventories and constituents are entered into the code, the user will be prompted to document the source of this information. This documentation ensures that the basis for assigning site scores can be justified and verified if necessary. It also provides a referenceable copy for the user.

4.0 HAND CALCULATIONAL METHODS FOR THE mHRS/HRS SCORES

This section contains a guide for using the mHRS/HRS System without the computer code described in Section 3. Before beginning the work described in this section, please read the general instructions given in Sections 1 and 2 of this document. Complete the cover sheet (a copy is included in Appendix C) shown as Figure 2.1 in Section 2. Blank Route Work Sheets and justification pages needed for manual (non-computerized) mHRS/HRS use can be found in Appendix C.

4.1 GROUND WATER MIGRATION ROUTE

Migration of hazardous or radioactive material from the waste site through the ground water is related to many site-specific parameters. These include rainfall, depth to ground water, and several other geologic parameters. The purpose of the Ground Water Route Work Sheet is to evaluate the potential or actual threat from release of material into the environment via this pathway. If no release from the site is known to have occurred, then the potential for a release is determined. If a release to the ground water has been documented, then the actual threat posed by the material is assessed.

4.1.1 Observed Release

If there is direct evidence of release of a substance of concern from a facility to ground water, enter a score of 45 on line 1 of the Ground Water Route Work Sheet (see Figure 4.1). Direct evidence of release must be analytical. If a contaminant is measured (regardless of frequency) in ground water or in a well in the vicinity of the facility at a significantly higher level than the background level (significant in terms of demonstrating that a release has occurred, not in terms of potential effects), then qualitative evidence of a release exists. To be considered qualitative evidence of a release, an existing condition (e.g., an oily or otherwise objectionable taste or smell in well water) must be confirmed to be directly resultant from a release at the facility.

Ground Water Route Work Sheet						
Rating Factor	Assigned Value (Circle One)		Multi- plier	Score	Max. Score	Ref. (Section)
1 Observed Release	0	45	1		45	3.1
If Observed Release is Given a Score of 45, Proceed to Line 4 .						
If Observed Release is Given a Score of 0, Proceed to Line 2 .						
2 Route Characteristics						3.2
Depth to Aquifer of Concern	0	1	2	3	2	6
Net Precipitation	0	1	2	3	1	3
Permeability of the Unsaturated Zone	0	1	2	3	1	3
Physical State	0	1	2	3	1	3
Total Route Characteristics Score						15
3 Containment	0	1	2	3	1	3
4 Waste Characteristics						3.4
Chemical						
a. Toxicity/Persistence	0	3	6	9	12	14
Hazardous Waste	0	1	2	3	4	5
Quantity	6	7	8	1		8
Radioactive						
b.1 Maximum Observed	0	1	3	7	11	15
b.2 Maximum Potential	0	1	3	7	11	15
Total Waste Characteristics Score					4a.	26
(Largest of 4a, b.1, b.2.)					4b.	
5 Targets						3.5
Ground Water Use	0	1	2	3	3	9
Distance to Nearest Well/Population Served	0	4	6	8	10	1
	12	16	18	20		
	24	30	32	35	40	
Total Targets Score						49
6 If Line 1 is 45, Multiply 1 x 4 x 5	Chemical					57,330
If Line 1 is 0, Multiply 2 x 3 x 4 x 5	Radioactive					
7 Divide Line 6 by 57,330 and Multiply by 100					$S_{gw}^r \approx S_{gw}^c =$	

FIGURE 4.1. Ground Water Route Work Sheet

If a release has been observed, proceed to line 4 to continue scoring (see Section 4.1.4, Waste Characteristics). If direct evidence is lacking, enter a value of 0 on line 1 and continue the scoring procedure by evaluating Route Characteristics.

4.1.2 Route Characteristics

Depth to aquifer of concern is measured vertically from the lowest point of the hazardous substances to the highest seasonal level of the saturated zone of the aquifer of concern (Figure 4.2). This factor is one indicator of the ease with which a pollutant from the facility could migrate to ground water. Assign a value as follows:

<u>Distance</u>	<u>Assigned Value</u>
>150 ft	0
76 to 150 ft	1
21 to 75 ft	2
0 to 20 ft	3

Net precipitation (precipitation minus evaporation) indicates the potential for leachate generation at the facility. Net seasonal rainfall (seasonal rainfall minus seasonal evaporation) data may be used if available. If net precipitation is not measured in the region in which the facility is located, calculate it by subtracting the mean annual lake evaporation for the region (obtained from Figure 4.3) from the normal annual precipitation for the region (obtained from Figure 4.4). Assign a value as follows:

<u>Net Precipitation</u>	<u>Assigned Value</u>
<-10 in.	0
-10 to +5 in.	1
+5 to +15 in.	2
>+15 in.	3

Permeability of unsaturated zone (or intervening geologic formations) is an indicator of the speed at which a contaminant could migrate from a facility. Assign a value from Table 4.1.

*Treat target and route characteristics factors consistently. For example, if the upper aquifer is the aquifer of concern, then the "depth to aquifer of concern" is 20 feet and the "population served" is 5 persons. If the lower aquifer is "of concern", the "depth" is 120 feet (assuming no known contamination below the indicated "hazardous substance") and the "population" is 5000 persons. If the upper aquifer is contaminated and the lower aquifer is "of concern", the "depth" would be 80 feet (vertical distance between hazardous substance and aquifer of concern) and the population would be 5000 persons.

FIGURE 4.2. Depth to Aquifer of Concern

FIGURE 4.3. Mean Annual Lake Evaporation (inches)
 Source: Climatic Atlas of the United States. 1968.
 U.S. Department of Commerce, U.S. Government
 Printing Office, Washington, D.C.

FIGURE 4.4. Normal Annual Total Precipitation (inches)
 Source: Climatic Atlas of the United States. 1968. U.S. Department
 of Commerce, U.S. Government Printing Office, Washington, D.C.

TABLE 4.1. Permeability of Geologic Materials^(a)

Type of Material	Approximate Range of Hydraulic Conductivity	Assigned Value
Clay, compact till, shale; unfractured metamorphic and igneous rocks	$<10^{-7}$ cm/sec	0
Silt, loess, silty clays, silty loams, clay loams; less permeable limestone, dolomites, and sandstone; moderately permeable till	$10^{-5} - 10^{-7}$ cm/sec	1
Fine sand and silty sand; sandy loams; loamy sands; moderately permeable limestone, dolomites, and fractured igneous and metamorphic rocks, some coarse till	$10^{-3} - 10^{-5}$ cm/sec	2
Gravel, sand; highly fractured igneous and metamorphic rocks; permeable basalt and lavas; karst limestone and dolomite	$>10^{-3}$ cm/sec	3

(a) From: Davis, S. N. 1969. Porosity and Permeability of Natural Materials in Flow-Through Porous Media. R. J. M. DeWiest ed., Academic Press, New York.

Freeze, R. A. and J. A. Cherry. 1979. Groundwater. Prentice-Hall, Inc., New York.

Physical state refers to the state of the hazardous substances at the time of disposal, except that gases generated by the hazardous substances in a disposal area should be considered in rating this factor. Each of the hazardous substances being evaluated is assigned a value as follows:

Physical State	Assigned Value
Solid, consolidated or stabilized	0
Solid, unconsolidated or unstabilized	1
Powder or fine material	2
Liquid, sludge or gas	3

4.1.3 Containment

Containment is a measure of the natural or artificial means that have been used to minimize or prevent a contaminant from entering ground water. Examples of containment include liners, leachate collection systems, and sealed containers. In assigning a value to this rating factor (see Table 4.2) consider all ways in which hazardous substances are stored or disposed of at the facility. If the facility involves more than one method of storage or disposal, assign the highest of all applicable values (e.g., if a landfill has a containment value of 1, and, at the same location, a surface impoundment has a value of 2, assign containment a value of 2).

4.1.4 Waste Characteristics

The mHRS/HRS separately assigns waste characteristics scores for the chemical and radioactive constituents of a site. Scores must be determined for both radioactive and nonradioactive wastes. The procedure for determining the waste characteristics score for chemical wastes is discussed below in section 4.1.4.1, and the procedure for radioactive wastes is presented in section 4.1.4.2. For sites with only one type of waste (i.e., chemical only), follow just the applicable procedure.

4.1.4.1 Chemical Waste Characteristics Score

In determining a chemical waste characteristics score, evaluate the most hazardous substances at the facility that could migrate to ground water (i.e., if scored, containment is not equal to zero). The substance with the highest score will be representative of the potential hazard from chemical waste. Note that the substance that may have been observed in the release category can differ from the substance used in rating waste characteristics. Where the total inventory of substances in a facility is known, only those present in amounts greater than the reportable quantity (see CERCLA Section 102 for definition) may be evaluated.

Toxicity and persistence have been combined in the matrix below because of their important relationship. To determine the value of this combined

TABLE 4.2. Containment Value for Ground Water Route

Assign containment a value of 0 if: 1) all the hazardous substances at the facility are underlain by an essentially nonpermeable surface (natural or artificial) and adequate leachate collection systems and diversion systems are present; or 2) there is no ground water in the vicinity. The value "0" does not indicate no risk. Rather, it indicates a significantly lower relative risk when compared with more serious sites on a national level. Otherwise, evaluate the containment for each of the different means of storage or disposal at the facility using the following guidance.

Description	Assigned Value	Description	Assigned Value
A. Surface Impoundment:		C. Piles:	
Sound run-on diversion structure, essentially nonpermeable liner (natural or artificial) compatible with the waste, and adequate leachate collection system	0	Piles uncovered and waste stabilized; or piles covered, waste unstabilized, and essentially non permeable liner	0
Essentially nonpermeable compatible liner with no leachate collection system; or inadequate freeboard	1	Piles uncovered, waste unstabilized, moderately permeable liner, and leachate collection system	1
Potentially unsound run-on diversion structure; or moderately permeable compatible liner	2	Piles uncovered, waste unstabilized, moderately permeable liner, and no leachate collection system	2
Unsound run-on diversion structure; no liner; or incompatible liner	3	Piles uncovered, waste unstabilized, and no liner	3
B. Containers:		D. Landfill:	
Containers sealed and in sound condition, adequate liner, and adequate leachate collection system	0	Essentially nonpermeable liner, liner compatible with waste, and adequate leachate collection system	0
Containers sealed and in sound condition, no liner or moderately permeable liner	1	Essentially nonpermeable compatible liner, no leachate collection system, and landfill surface precludes ponding	1
Containers leaking, moderately permeable liner	2	Moderately permeable, compatible liner, and landfill surface precludes ponding	2
Containers leaking and no liner or incompatible liner	3	No liner or incompatible liner; moderately permeable compatible liner; landfill surface encourages ponding; no run-on control	3

factor, evaluate each factor individually as discussed below. Match the individual values assigned with the values in the matrix for the combined rating factor. Evaluate several of the most hazardous substances at the facility independently. Enter only the highest scoring hazardous substance in the matrix on the work sheet.

Value for Toxicity	Value for Persistence			
	0	1	2	3
0	0	0	0	0
1	3	6	9	12
2	6	9	12	15
3	9	12	15	18

Persistence of each hazardous substance is evaluated on its biodegradability as follows:

Substance	Assigned Value
Easily biodegradable compounds	0
Straight chain hydrocarbons	1
Substituted and other ring compounds	2
Metals, polycyclic compounds and halogenated hydrocarbons	3

More specific information is given in Tables 4.3 and 4.4.

Toxicity of each hazardous substance being evaluated is given a value using the rating scheme of SAX (Table 4.5) or the National Fire Protection Association (NFPA) (Table 4.6), along with the following guidance:

Toxicity	Assigned Value
SAX level 0 or NFPA level 0	0
SAX level 1 or NFPA level 1	1
SAX level 2 or NFPA level 2	2
SAX level 3 or NFPA level 3 or 4	3

Table 4.3 presents values for some common compounds. Detailed information on waste characteristics values for common chemicals is given in Appendix A.

TABLE 4.3. Waste Characteristics Values for Some Common Chemicals

CHEMICAL/COMPOUND	REACTIVITY			
	1	2	3	4
Acetaldehyde	3	0	3	2
Acetic Acid	3	0	2	1
Acetone	2	0	3	0
Aldrin	3	3	1	0
Ammonia, Anhydrous	3	0	1	0
Aniline	3	1	2	0
Benzene	3	1	3	0
Carbon Tetrachloride	3	3	0	0
Chlordane	3	3	0*	0*
Chlorobenzene	2	2	3	0
Chloroform	3	3	0	0
Cresol-O	3	1	2	0
Cresol-M&P	3	1	1	0
Cyclohexane	2	2	3	0
Endrin	3	3	1	0
Ethyl Benzene	2	1	3	0
Formaldehyde	3	0	2	0
Formic Acid	3	0	2	0
Hydrochloric Acid	3	0	0	0
Isopropyl Ether	3	1	3	1
Lindane	3	3	1	0
Methane	1	1	3	0
Methyl Ethyl Ketone	2	0	3	0
Methyl Parathion in Xylene Solution	3	0*	3	2
Naphthalene	2	1	2	0
Nitric Acid	3	0	0	0
Parathion	3	0*	1	2
PCB	3	3	0*	0*
Petroleum, Kerosene (Fuel Oil No. 1)	3	1	2	0
Phenol	3	1	2	0
Sulfuric Acid	3	0	0	2
Toluene	2	1	3	0
Trichlorobenzene	2	3	1	0
α -Trichloroethane	2	2	1	0
Xylene	2	1	3	0

¹ Sax, N. I., Dangerous Properties of Industrial Materials, Van Nostrand Reinhold Co., New York, 4th ed., 1975. The highest rating listed under each chemical is used.

² JES Associates, Inc., Methodology for Rating the Hazard Potential of Waste Disposal Sites, May 5, 1980.

³ National Fire Protection Association, National Fire Codes, Vol. 13, No. 49, 1977.

* Professional judgment based on information contained in the U.S. Coast Guard CHRIS Hazardous Chemical Data, 1978.

Δ Professional judgment based on existing literature.

TABLE 4.4. Persistence (Biodegradability) of Some Organic Compounds

VALUE = 3 HIGHLY PERSISTENT COMPOUNDS	
aldrin	heptachlor
benzopyrene	heptachlor epoxide
benzothiazole	1,2,3,4,5,7,7-haptachloronorborene
benzothiophene	hexachlorobenzene
benzyl butyl phthalate	hexachloro-1,3-butadiene
bromochlorobenzene	hexachlorocyclohexane
bromoforn butanal	hexachloroethane
bromophenyl phenyl ether	methyl benzothiazole
chlordane	pentachlorobiphenyl
chlorohydroxy benzophenone	pentachlorophenol
bis-chloroisopropyl ether	1,1,3,3-tetrachloroacetone
m-chloronitrobenzene	tetrachlorobiphenyl
DDE	thiomethylbenzothiazole
DDT	trichlorobenzene
dibromobenzene	trichlorobiphenyl
dibutyl phthalate	trichlorofluoromethane
1, 4-dichlorobenzene	2,4,6-trichlorophenol
dichlorodifluoroethane	triphenyl phosphate
dieldrin	bromodichloromethane
diethyl phthalate	bromoforn
di(2-ethylhexyl)phthalate	carbon tetrachloride
dihexyl phthalate	chloroform
di-isobutyl phthalate	chloromochloromethane
dimethyl phthalate	dibromodichloroethane
4,6-dinitro-2-aminophenol	tetrachloroethane
dipropyl phthalate	1,1,2-trichloroethane
endrin	

VALUE = 1 SOMEWHAT PERSISTENT COMPOUNDS	
acetylene dichloride	limonene
benenic acid, methyl ester	methyl ester of lignoceric acid
benzene	methane
benzene sulfonic acid	2-methyl-5-ethyl-pyridine -
butyl benzene	methyl naphthalene
butyl bromide	methyl palmitate
ε-caprolactam	methyl phenyl carbinol
carbon-disulfide	methyl stearate
o-cresol	naphthalene
decane	nonane
1,2-dichloroethane	octane
1,2-dimethoxy benzene	octyl chloride
1,3-dimethyl naphthalene	pentane
1,4-dimethyl phenol	phenyl benzoate
dioctyl adipate	phthalic anhydride
n-dodecane	propylbenzene
ethyl benzene	1-terpineol
2-ethyl-n-hexane	toluene
o-ethyltoluene	vinyl benzene
isodecane	xylene
isopropyl benzene	

VALUE = 2 PERSISTENT COMPOUNDS	
acenaphthylene	cis-2-ethyl-4-methyl-1,3-dioxolane
atrazine	trans-2-ethyl-4-methyl-1,3-dioxolane
(diethyl) atrazine	guaiacol
barbital	2-hydroxyadiponitrile
borneol	isophorone
bromobenzene	indene
camphor	isoborneol
chlorobenzene	isopropenyl-r-isopropyl benzene
1,2-bis-chloroethoxy ethane	2-methoxy biphenyl
b-chloroethyl methyl ether	methyl biphenyl
chloromethyl ether	methyl chloride
chloromethyl ethyl ether	methylindane
3-chloropyridine	methylene chloride
di-t-butyl-p-benzoquinone	nitroanisole
dichloroethyl ether	nitrobenzene
dihydrocarvone	1,1,2-trichloroethylene
dimethyl sulfoxide	trimethyl-trioxo-hexahydro-triazine
2,6-dinitrotoluene	isomer

VALUE = 0 NONPERSISTENT COMPOUNDS	
acetaldehyde	methyl benzoate
acetic acid	3-methyl butanol
acetone	methyl ethyl ketone
acetophenone	2-methylpropanol
benzoic acid	octadecane
di-isobutyl carbinol	pentadecane
docosane	pentanol
eicosane	propanol
ethanol	propylamine
ethylamine	tetradecane
hexadecane	n-tridecane
methanol	n-undecane

TABLE 4.5. SAX Toxicity Ratings

0 - No Toxicity* (None)**

This designation is given to materials which fall into one of the following categories:

- (a) Materials which cause no harm under any conditions of normal use.
- (b) Materials which produce toxic effects on humans only under the most unusual conditions or by overwhelming dosage.

1 - Slight Toxicity* (Low)**

- (a) *Acute Local*. Materials which on single exposures lasting seconds, minutes, or hours cause only slight effects on the skin or mucous membranes regardless of the extent of the exposure.
- (b) *Acute systemic*. Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce only slight effects following single exposures lasting seconds, minutes, or hours, or following ingestion of a single dose, regardless of the quantity absorbed or the extent of exposure.
- (c) *Chronic Local*. Materials which on continuous or repeated exposures extending over periods of days, months, or years cause only slight and usually reversible harm to the skin or mucous membranes. The extent of exposure may be great or small.
- (d) *Chronic systemic*. Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce only slightly usually reversible effects extending over days, months, or years. The extent of the exposure may be great or small.

In general, those substances classified as having "slight toxicity" produce changes in the human body which are readily reversible and which will disappear following termination of exposure, either with or without medical treatment.

2 - Moderate Toxicity* (Mod)**

- (a) *Acute Local*. Materials which on single exposure lasting seconds, minutes, or hours cause moderate effects on the skin or mucous membranes. These effects may be the result of intense exposure for a matter of seconds or moderate exposure for a matter of hours.
- (b) *Acute systemic*. Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and produce moderate effects following single exposures lasting seconds, minutes, or hours, or following ingestion of a single dose.
- (c) *Chronic Local*. Materials which on continuous or repeated exposures extending over periods of days, months, or years cause moderate harm to the skin or mucous membranes.
- (d) *Chronic systemic*. Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce moderate effects following continuous or repeated exposures extending over periods of days, months, or years.

Those substances classified as having "moderate toxicity" may produce irreversible as well as reversible changes in the human body. These changes are not of such severity as to threaten life or to produce serious physical impairment.

3 - Severe Toxicity* (High)**

- (a) *Acute Local*. Materials which on single exposure lasting seconds or minutes cause injury to skin or mucous membranes or sufficient severity to threaten life or to cause permanent physical impairment or disfigurement.
- (b) *Acute systemic*. Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which can cause injury of sufficient severity to threaten life following a single exposure lasting seconds, minutes, or hours, or following ingestion of a single dose.
- (c) *Chronic Local*. Materials which on continuous or repeated exposures extending over periods of days, months, or years can cause injury to skin or mucous membranes of sufficient severity to threaten life or cause permanent impairment, which disfigurement, or irreversible change.
- (d) *Chronic systemic*. Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which can cause death or serious physical impairment following continuous or repeated exposures to small amounts extending over periods of days, months, or years.

*Sax, N.I. Dangerous Properties of Industrial Materials. Van Nostrand Reinhold Company, New York, 4th Edition, 1975.

**Sax, N.I. Dangerous Properties of Industrial Materials. Van Nostrand Reinhold Company, New York, 5th Edition, 1979.

TABLE 4.6. NFPA Toxicity Ratings^(a)

Value	Explanation
0	Materials which on exposure under fire conditions would offer no health hazard beyond that of ordinary combustible material.
1	Materials only slightly hazardous to health. It may be desirable to wear self-contained breathing apparatus.
2	Materials hazardous to health, but areas may be entered freely with self-contained breathing apparatus.
3	Materials extremely hazardous to health, but areas may be entered with extreme care. Full protective clothing, including self-contained breathing apparatus, rubber gloves, boots and bands around legs, arms and waist should be provided. No skin surface should be exposed.
4	A few whiffs of the gas or vapor could cause death, or the gas, vapor, or liquid could be fatal on penetrating the fire fighters' normal full protective clothing, which is designed for resistance to heat. For most chemicals having a Health 4 rating, the normal full protective clothing available to the average fire department will not provide adequate protection against skin contact with these materials. Only special protective clothing designed to protect against the specific hazard should be worn.

(a) National Fire Protection Association. 1977. National Fire Codes, Vol. 13, No. 49.

Hazardous waste quantity includes all hazardous substances at a facility (as received) except those with a containment value of 0. Do not include amounts of contaminated soil or water; in such cases, the amount of contaminating hazardous substance may be estimated.

On occasion, it may be necessary to convert data to a common unit to combine them. In such cases, 1 ton = 1 cubic yard = 4 drums and for the purposes of converting bulk storage, 1 drum = 50 gallons. Assign a value as follows:

<u>Tons/yd³</u>	<u>No. of Drums</u>	<u>Assigned Value</u>
0	0	0
1-10	1-40	1
11-62	41-250	2

<u>Tons/yd³</u>	<u>No. of Drums</u>	<u>Assigned Value</u>
63-125	251-500	3
126-250	501-1000	4
251-625	1001-2500	5
626-1250	2501-5000	6
1251-2500	5001-10,000	7
>2500	>10,000	8

4.1.4.2 Radioactive Waste Characteristics Score

The determination of a waste characteristics score for radioactive waste requires information on the kind and quantity of radionuclides that were disposed at the site. Scores are assigned based on an estimate of relative radiation dose. Two scores are calculated for the radioactive waste constituents. These are: 1) a value assigned for the maximum observed concentration of radionuclides in the ground water; and 2) a value assigned based on an estimate of the maximum potential concentration. The higher of these two is used in calculating the ground water route score for radioactive material.

Information on the maximum observed concentration of radionuclides in ground water (pCi/L) and the radionuclide inventory of the waste site is required. If no radioactivity has been observed in ground water, then the waste characteristics score for part 4B of the Ground Water Route Work Sheet (Figure 4.1) must be determined by calculating the potential ground water concentration, as described later in this section.

Radionuclides are grouped according to their potential dose contribution. Table 4.7 contains group assignments for the dose-factor groups developed for each radionuclide of concern. The dose-factor groups developed for each of the routes of exposure relate the estimated dose impact for specific radionuclides. Such groupings can be used when information about the specific radionuclides at a waste site are available. However, in many instances there are incomplete data available on the inventory of a waste site, and the data that are available list inventories in terms of unspecified alpha, beta or

TABLE 4.7. Radionuclide^(a) Group Assignments and Ground Water Transfer Coefficients for Use in Calculating Waste Characteristics Scores

Radionuclide	Air Route	Surface Water	Ground Water	Fire/Explosion	Direct Contact	Ground Water Transfer	Coefficient	Radionuclide	Air Route	Surface Water	Ground Water	Fire/Explosion	Direct Contact	Ground Water Transfer	Coefficient
225Ac	B	E	E	B	C	0		240Pu	A	D	D	A	C	1	
241Am	A	C	C	A	C	3		241+D Pu	C	E	E	C	D	1	
243Am	A	C	C	A	C	3		242Pu	A	D	D	A	C	1	
14C	E	E	E	E	E	100		244Pu	A	D	D	A	C	1	
109Cd	D	E	E	D	D	0		225Ra	B	D	D	B	C	20	
243Cm	A	D	D	A	C	3		226+D Ra	A	A	A	A	C	20	
244Cm	A	D	D	A	C	3		125+D Sb	C	E	E	C	B	20	
60Co	B	D	D	B	A	10		151Sm	E	D	D	E	E	1	
134Cs	C	C	C	C	B	20		90+D Sr	C	B	B	C	D	10	
135Cs	E	D	D	E	E	20		99Tc	D	D	D	D	E	100	
137+D Cs	C	D	D	C	B	20		228+D Th	A	D	D	A	B	1	
152Eu	C	D	D	C	B	1		229+D Th	A	B	B	A	B	1	
154Eu	D	D	D	D	B	1		230+D Th	A	C	C	A	C	1	
55Fe	E	E	E	E	E	10		232+D Th	C	C	C	C	B	1	
3H	F	F	F	F	F	100		233+D U	A	B	B	A	C	20	
129I	C	B	B	C	D	100		234U	A	D	D	A	C	20	
93Mo	D	E	E	D	D	0		235+D U	A	D	D	A	B	20	
22Na	C	D	D	C	B	100		238+D U	A	D	D	A	C	20	
94Nb	B	D	D	B	A	10		240U	E	E	E	E	E	20	
59Ni	E	E	E	E	E	10		U depleted	A	D	D	A	C	20	
63Ni	E	D	D	E	E	10		U enriched	A	D	D	A	B	20	
237+D Np	A	C	C	A	B	2		U natural	A	D	D	A	B	20	
239Np	D	E	E	D	C	2		un id alpha	A	A	A	A	B	20	
210+D Pb	A	B	B	A	C	20		un id beta	B	B	B	B	A	100	
238Pu	A	D	D	A	C	1		un id gamma	B	B	B	B	A	100	
239Pu	A	D	D	A	C	1									

(a) Radionuclides with half-lives less than one year are not evaluated. Those with half-lives greater than one year and which are not found on this list are assessed as "unidentified" radionuclides. Assign their route group based on the predominant mode of decay (e.g., alpha, beta, or gamma).

gamma emitters. For scoring the unidentified radionuclides, the group of the highest scoring identified radionuclide is used. For example, in the air route, unidentified alpha emitting radionuclides would be assumed to be ^{239}Pu and ^{240}Pu . Unidentified beta or gamma emitters would be ^{90}Sr and ^{137}Cs , respectively.

At many DOE facilities, uranium, either natural, depleted, or enriched, may be disposed of at the waste site. Inventory data in terms of picocuries per isotope may be unavailable because it may be listed as grams or curies of natural, depleted, or enriched uranium. For these instances, conversion factors were developed that express the specific activity of these mixtures. Conversion factors are listed for uranium in Table 4.8 and for plutonium isotopes, in Table 4.9. Conversion factors were determined through the use of the following equation:

$$\text{SpA} = [\ln(2) N] / [C \times T_{1/2}]$$

where SpA = specific activity in Ci/gm

$N = 6.023 \times 10^{23}$ / atomic mass

$T_{1/2}$ = radioactive half-life (sec)

$C = 3.7 \times 10^{10}$ disintegrations/sec per Ci

TABLE 4.8. Assumptions and Conversion Factors for Uranium Mixtures

Isotope	Depleted Uranium (wt%)	Natural Uranium (wt%)	Enriched Uranium (wt%)	Specific Activity (Ci/g)
^{234}U	0.003	0.006	0.03	6.16×10^{-3}
^{235}U	0.20	0.72	3.0	2.13×10^{-6}
^{238}U	99.79	99.27	97.0	3.35×10^{-7}
Conversion Factor (Ci/g):	5.2×10^{-7}	7.0×10^{-7}	2.2×10^{-6}	---

Observed Release. If it is known that radionuclides have migrated to the ground water, then, using Table 4.7, determine the dose factor groups for the nuclides measured in ground water. For example, if it is known that

TABLE 4.9. Assumptions and Conversion Factors for Plutonium Mixtures

<u>Isotope</u>	<u>(wt%)</u>	<u>Specific Activity (Ci/g)</u>
^{238}Pu	0.016	17
^{239}Pu	92.6	6.14×10^{-2}
^{240}Pu	6.398	0.22
^{241}Pu	0.039	1.01×10^2
^{242}Pu	0.021	3.92×10^{-3}
^{241}Am	0.647	3.2
<u>Conversion Factor (Ci/g):</u>	1.3×10^{-1}	

tritium (^3H), strontium-90 (^{90}Sr) and iodine-129 (^{129}I) have been released, then determine the appropriate groups as follows:

- ^3H in ground water: Group F
- ^{90}Sr in ground water: Group B
- ^{129}I in ground water: Group B

Calculate the total ground water concentration for each nuclide group by summing the concentrations measured for nuclides within the group. For example, if the known concentrations of radionuclides are as follows:

- ^3H , Group F, 10,000 pCi/L
- ^{90}Sr , Group B, 10 pCi/L
- ^{129}I , Group B, 2 pCi/L

then the total concentrations for the Group F group would be reported as 10,000 picocuries per liter. The total concentration for the Group B radionuclides would be 12 picocuries per liter (from $10 + 2$ pCi/L). If gross alpha, beta or gamma measurements are included, make the following assumptions: 1) gross alpha data are considered Group A nuclides, and 2) gross beta and gross gamma are Group B nuclides. If natural, enriched, or depleted uranium is present, assume it is Group D. Once the nuclide groups have been identified and the total ground water concentration determined for each group, use Table 4.10

TABLE 4.10. Matrix Sheet for Ground Water Waste Characteristics Score for Each Nuclide Group

Nuclide Group	Maximum Ground Water Concentration, pCi/L											
	<10 ⁻³	10 ⁻²	10 ⁻¹	10 ⁰	10 ¹	10 ²	10 ³	10 ⁴	10 ⁵	10 ⁶	10 ⁷	10 ⁸
A	0	1	3	7	11	15	21	26				
B		0	1	3	7	11	15	21	26			
C			0	1	3	7	11	15	21	26		
D				0	1	3	7	11	15	21	26	
E					0	1	3	7	11	15	21	26
F						0	1	3	7	11	15	21

Maximum Observed Release Score: _____

Maximum Potential Release Score: _____

(the matrix table) to determine the waste characteristics score for each nuclide group. To use the matrix table, first select the nuclide group to be scored. Second, using the vertical concentration scale, identify the concentration in ground water that was calculated for this particular group. Using the previous example, if the total concentration of group B nuclides was estimated at 12 picocuries per liter, then a score of 11 would be assigned. The Group F nuclides, at a concentration of 10⁴ picocuries per liter, would be assigned a score of 7. Record the largest value under the maximum observed release score on the matrix sheet. Next, reevaluate the site for maximum potential release, based on the amount of material disposed.

Maximum Potential Release. The maximum potential ground water release from the site is based on the total activity (in Ci) disposed at the facility. The maximum potential ground water concentration for each nuclide disposed at the site is determined using Table 4.7.

To use the table, multiply the activity of each radionuclide disposed at the site by the transport coefficient listed for its element:

$$(Ci) \times (\text{Transport Coefficient}) = (\text{maximum potential}) \text{ pCi/L}$$

As described for the observed release case, use Table 4.7 to determine the dose factor groups represented by these nuclides. Calculate the total potential ground water concentration associated with each nuclide group by summing the potential concentrations calculated for nuclides within the group. If gross alpha, beta or gamma measurements are included, make the following assumptions: 1) gross alpha data are considered Group A with a transport coefficient of 20, and 2) gross beta and gross gamma are Group B with transport coefficients of 100. Once the nuclide groups have been identified, and the total potential ground water concentration determined for each group, use Table 4.10 to determine the waste characteristics score for each nuclide group. Record the largest value under maximum potential release score on the matrix sheet. Compare this value to that derived for the observed (if any) ground water concentration. Record the greater of the two under Section 4b of the Ground Water Route Work Sheet (Figure 4.1).

4.1.5 Targets

Ground water use indicates the nature of the use made of ground water drawn from the aquifer of concern within 3 miles of the hazardous substance, including the geographical extent of the measurable concentration in the aquifer. Assign a value using the following guidance:

<u>Ground Water Use</u>	<u>Assigned Value</u>
Unusable (e.g., extremely saline aquifer, extremely low yield, etc.)	0
Commercial, industrial or irrigation and another water source presently available; not used, but usable	1
Drinking water with municipal water from alternate unthreatened sources presently available (i.e., minimal hookup requirements); or commercial, industrial or irrigation with no other water source presently available	2
Drinking water; no municipal water from alternate unthreatened sources presently available	3

Distance to nearest well and population served have been combined in the matrix below to better reflect the important relationship between the distance of a population from hazardous substances and the size of the population served by ground water that might be contaminated by those substances. To determine the overall value for this combined factor, score each individually, as discussed below. Match the individual values assigned with the values in the matrix for the total score.

Value for Population Served	Value for Distance to Nearest Well				
	0	1	2	3	4
0	0	0	0	0	0
1	0	4	6	8	10
2	0	8	12	16	20
3	0	12	18	24	30
4	0	16	24	32	35
5	0	20	30	35	40

Distance to nearest well is measured from the hazardous substance (not the facility boundary) to the nearest well that draws water from the aquifer of concern. If the actual distance to the nearest well is unknown, use the distance between the hazardous substance and the nearest occupied building not served by a public water supply (e.g., a farmhouse). If the distance between the hazardous substance and all wells drawing from the aquifer is discontinuous, give this factor a score of 0, except where it can be shown that the contaminant is likely to migrate beyond the discontinuity. Figure 4.5 illustrates how the distance should be measured. Assign a value using the following guidance:

Distance	Assigned Value
>3 miles	0
2 to 3 miles	1
1 to 2 miles	2
2001 feet to 1 mile	3
<2000 feet	4

In the situation depicted above, the distance between the hazardous substance and the nearest well (No. 1) is $\frac{1}{4}$ mile. If well No. 1 did not exist, the distance to well No. 2 would be immaterial since there is a discontinuity in the aquifer (surface water) between it and the hazardous substance. Under such circumstances, the factor score would be "0". However, if it could be demonstrated that the contaminant had bridged the discontinuity, then the distance to the nearest well would be 2 miles (assuming well No. 1 does not exist).

FIGURE 4.5. Distance to Nearest Well

Population served by ground water is an indicator of the population at risk, which includes residents as well as others who would regularly use the water, such as workers in factories or offices and students. Include employees in restaurants, motels, or campgrounds but exclude customers and travelers passing through the area in autos, buses, or trains. If aerial photography is used to determine population, assume each dwelling unit has 3.8 residents. Where ground water is used for irrigation, convert to population by assuming 1.5 persons per acre of irrigated land. The well or wells of concern must be within 3 miles of the hazardous substances, including the area of known aquifer contamination, but the "population served" need not be. Likewise, persons within the 3-mile limit who do not use water from the aquifer of concern are not to be counted. Assign a value as follows:

<u>Population</u>	<u>Assigned Value</u>
0	0
1-100	1
101-1,000	2
1,001-3,000	3
3,001-10,000	4
>10,000	5

4.2 SURFACE WATER ROUTE

Migration of the hazardous or radioactive material from the waste site to surface water is dependent on many site-specific parameters. The purpose of this section is to assess the impact from the actual or potential release of material to the environment via the surface water pathway.

4.2.1 Observed Release

Direct evidence of release to surface water must derive from quantitative evidence that the facility is releasing contaminants into surface water. Quantitative evidence could be the measurement of levels of contaminants in surface water, either at the facility or downhill from it, representing a significant increase over background levels (significant in terms of demonstrating that a release has occurred, not in terms of potential effects). If direct evidence of release has been obtained (regardless of frequency),

enter a value of 45 on line 1 of the work sheet (see Figure 4.6) and omit the evaluation of the route characteristics and containment factors. If direct evidence of release is lacking, enter a value of 0 on line 1 and continue with the scoring procedure.

4.2.2 Route Characteristics

Facility slope and intervening terrain are indicators of the potential for contaminated runoff or spills to be transported to surface water at a facility. The facility slope is an indicator of the potential for runoff or spills to leave the facility. Intervening terrain refers to the average slope of the shortest path that would be followed by runoff between the facility boundary and the nearest downhill surface water. This rating factor can be assessed using topographic maps. Table 4.11 shows values assigned to various facility conditions.

One-year 24-hour rainfall (obtained from Figure 4.7) indicates the potential for area storms to cause surface water contamination as a result of runoff, erosion, or flow over dikes. Assign a value as follows:

<u>Amount of Rainfall (in.)</u>	<u>Assigned Value</u>
<1.0	0
1.0-2.0	1
2.1-3.0	2
>3.0	3

Distance to the nearest surface water is the shortest distance from a hazardous substance (not the facility or property boundary) to the nearest downhill body of surface water (e.g., a lake or stream) that is on the course that runoff can be expected to follow and that at least occasionally contains water. Do not include manmade ditches, which do not connect with other surface water bodies. In areas having less than 20 inches of normal annual precipitation (see Figure 4.4), consider intermittent streams. This factor

Surface Water Route Work Sheet									
Rating Factor	Assigned Value (Circle One)				Multi- plier	Score	Max. Score	Ref. (Section)	
1 Observed Release	0		45		1		45	4.1	
If Observed Release is Given a Value of 45, Proceed to Line 4 If Observed Release is Given a Value of 0, Proceed to Line 2									
2 Route Characteristics	4.2								
Facility Slope and Intervening Terrain	0	1	2	3		1	3		
1-yr. 24-hr. Rainfall	0	1	2	3		1	3		
Distance to Nearest Surface Water	0	1	2	3		2	6		
Physical State	0	1	2	3		1	3		
Total Route Characteristics Score							15		
3 Containment	0	1	2	3		1	3	4.3	
4 Waste Characteristics	4.4								
a. Chemical									
Toxicity/Persistence	0	3	6	9	12	15	18	1	
Hazardous Waste Quantity	0	1	2	3	4	5	6	7	
								8	
b. Radioactive									
1 Maximum Observed	0	1	3	7	11	15	21	26	
2 Maximum Potential	0	1	3	7	11	15	21	26	
Total Waste Characteristics Score						4a.		26	
Largest of 4a, b1 or b2						4b.			
5 Targets	4.5								
Surface Water Use	0	1	2	3		3	9		
Distance to a Sensitive Environment	0	1	2	3		2	6		
Population Served/Distance to Water Intake Downstream	0	4	6	8	10		1	40	
	12	16	18	20					
	24	30	32	35	40				
Total Targets Score							55		
6 If Line 1 is 45, Multiply 1 x 4 x 5	Chemical						64,350		
If Line 1 is 0, Multiply 2 x 3 x 4 x 5	Radioactive								
7 Divide Line 6 by 64,350 and Multiply by 100						$S_{sw}^r =$	S_{sw}^c		

FIGURE 4.6. Surface Water Route Work Sheet

TABLE 4.11. Values for Facility Slope and Intervening Terrain

Facility Slope		Intervening Terrain					
		Terrain Average Slope ≤3%; or Site Separated from Water Body by Areas of Higher Elevation	Terrain Average Slope 3-5%	Terrain Average Slope 5-8%	Terrain Average Slope >8%	Site in Surface Water	
Facility is closed basin		0	0	0	0	3	
44	Facility has average slope	≤3%	0	1	1	2	3
	Average slope	3-5%	0	1	2	2	3
	Average slope	5-8%	0	2	2	3	3
	Average slope	>8%	0	2	3	3	3

FIGURE 4.7. 1-Year 24-Hour Rainfall (inches)

Source: Rainfall Frequency Atlas of the United States. 1963.
 Technical Paper No. 40, U.S. Department of Commerce,
 U.S. Government Printing Office, Washington, D.C.

indicates the potential for pollutants flowing overland and into surface water bodies. Assign a value as follows:

<u>Distance</u>	<u>Assigned Value</u>
>2 miles	0
1 to 2 miles	1
1000 feet to 1 mile	2
<1000 feet	3

Physical state is assigned a value using the procedures in Section 4.1.2.

4.2.3 Containment

Containment is a measure of the means that have been taken to minimize the likelihood of a contaminant entering surface water either at the facility or beyond the facility boundary. Examples of containment are diversion structures and the use of sealed containers. If more than one type of containment is used at a facility, evaluate each separately (see Table 4.12) and assign the highest score.

4.2.4 Waste Characteristics

Evaluate the chemical/hazardous wastes using the procedures described in Section 4.1.4.1. Radioactive constituents are to be assessed using the following directions.

Information on the maximum observed concentration of radionuclides in surface water (pCi/L) and the radionuclide inventory of the waste site is required. If no radioactivity has been observed in surface water, determine the waste characteristics score for part 4b of the Surface Water Route Work Sheet (see Figure 4.6) by calculating the potential surface water concentration, as described later in this section.

Observed Release. Using Table 4.7 determine the groups for the nuclides measured in surface water (Section 4.1.4.2 provides examples of determining nuclide groups). Calculate the total surface water concentration for each nuclide group by summing the concentrations of nuclides within the group. If gross alpha, beta or gamma measurements are included, make the following

TABLE 4.12. Containment Values for Surface Water Route

Assign containment a value of 0 if: 1) all the waste at the site is surrounded by diversion structures that are in sound condition and adequate to contain all runoff, spills, or leaks from the waste; or 2) intervening terrain precludes runoff from entering surface water. Otherwise, evaluate the containment for each of the different means of storage or disposal at the site and assign a value as follows:

A. Surface Impoundment

	<u>Assigned Value</u>
Sound diking or diversion structure, adequate freeboard, and no erosion evident	0
Sound diking or diversion structure, but inadequate freeboard	1
Diking not leaking, but potentially unsound	2
Diking unsound, leaking, or in danger of collapse	3

B. Containers

	<u>Assigned Value</u>
Containers sealed, in sound condition, and surrounded by sound diversion or containment system	0
Containers sealed and in sound condition, but not surrounded by sound diversion or containment system	1
Containers leaking and diversion or containment structures potentially unsound	2
Containers leaking, and no diversion or containment structures leaking or in danger of collapse	3

C. Piles

	<u>Assigned Value</u>
Piles are covered and surrounded by sound diversion or containment system	0
Piles covered, wastes unconsolidated, and diversion or containment system not adequate	1
Piles not covered, wastes unconsolidated, and diversion or containment system potentially unsound	2
Piles not covered, wastes unconsolidated, and no diversion or containment or diversion system leaking or in danger of collapse	3

D. Landfill

Landfill slope precludes runoff, landfill surrounded by sound diversion system, or landfill has adequate cover material	0
Landfill not adequately covered and diversion system sound	1
Landfill not covered and diversion system potentially unsound	2
Landfill not covered and no diversion system present, or diversion system unsound ponding; no run-on control	3

assumptions: 1) gross alpha data are considered Group A nuclides, and 2) gross beta and gross gamma are Group B nuclides. Once the nuclide groups have been identified and the total surface water concentration determined for each group, use Table 4.13 to determine the waste characteristics score for each nuclide group. Record the largest value under maximum observed release score on the matrix sheet (Section 4.1.4.2 discusses how to use the matrix tables). Then reevaluate the site for maximum potential release, based on the amount of material disposed.

Maximum Potential Release. The maximum potential surface water release from the site is based on the activity (in Ci) disposed at the facility. Using Table 4.7, determine the dose factor groups represented by the nuclides contained at the site. Calculate the total Ci quantity for each nuclide group by summing the activities of the nuclides within the group. If gross alpha, beta or gamma measurements are included, make the following assumptions: 1) gross alpha data are considered Group A, and 2) gross beta and gamma are

TABLE 4.13. Matrix Sheet for Surface Water Route Waste Characteristics Score for Each Nuclide Group

Nuclide Group	Maximum Surface Water Concentration, pCi/L												
	<10 ⁻³	<10 ⁻²	<10 ⁻¹	<10 ⁰	<10 ¹	<10 ²	<10 ³	<10 ⁴	<10 ⁵	<10 ⁶	<10 ⁷	<10 ⁸	<10 ⁹
A	0	1	3	7	11	15	21	26					
B		0	1	3	7	11	15	21	26				
C			0	1	3	7	11	15	21	26			
D				0	1	3	7	11	15	21	26		
E					0	1	3	7	11	15	21	26	
F						0	1	3	7	11	15	21	26

Maximum Observed Release Score: _____
 Maximum Potential Release Score: _____

Group B. Use the following equation to calculate the maximum potential surface water concentration for each group:

$$\frac{(1 \text{ E-4}) (C_i \text{ disposed}) \times (1 \text{ E+12})}{(\text{Flow, L/yr})} = \text{pCi/L}$$

where C_i disposed = the total number of C_i of a specific radionuclide group

1 E-4 = the fractional release rate from the site in years⁻¹

1 E+12 = the conversion factor from C_i to pCi

Flow = the average annual flow of the nearest surface stream

In cases where the nearby streams are intermittent and the average flow cannot easily be estimated, a value can be calculated using a modified version of the Rational Method (Gray 1970). The flow is estimated using the following equation:

$$Q = cRAk$$

where A = area of the watershed (acres)

k = unit conversion factor (10^5)

R = annual rainfall (in./yr)

and where Q = flow (L/yr)

$c = (1 - c_1 - c_2 - c_3)$, or $(1 - c_{\text{tot}})$ with the values for c_1 , c_2 , c_3 , c_{tot} derived from Table 4.14

Once the nuclide groups have been identified and the maximum potential surface water concentration determined for each group, use Table 4.13 to determine the waste characteristics score for each nuclide group. Record the largest value under maximum potential release score on the matrix sheet. Compare this value to the maximum observed release score, if a value has been derived for the concentration observed in surface water. Record the greater of the two under Section 4b of the Surface Water Route Work Sheet (see Figure 4.6).

TABLE 4.14. Contributions to the Runoff Coefficient

c_n	Type of Area	Value
<u>Agricultural</u>		
c_1	Flatland, with average slopes of 1-3 ft per mi	0.3
	Rolling land, with average slopes of 15-20 ft per mi	0.2
	Hilly land, with average slopes of 150-250 ft per mi	0.1
c_2	Tight impervious clay	0.1
	Medium combinations of clay and loam	0.2
	Open sandy loam	0.4
c_3	Cultivated lands	0.1
	Woodlands	0.2
<u>Urban</u>		
c_{tot}	Flat, residential, with about 30% of area impervious	0.4
	Moderately steep, residential, with about 50% of area impervious	0.65
	Moderately steep, built-up, with about 70% impervious	0.8

4.2.5 Targets

Surface water use is the use being made of surface water downstream from the facility. The use or uses of interest are those associated with water taken from surface waters within a distance of 3 miles from the location of the hazardous substance. Assign a value as follows:

Surface Water Use (Fresh or Salt Water)	Assigned Value
Not currently used	0
Commercial or industrial	1
Irrigation, economically important resources (e.g., shellfish), commercial food preparation, or recreation (e.g., fishing, boating, swimming)	2
Drinking water	3

Distance to a sensitive environment refers to the distance from the hazardous substance (not the facility boundary) to an area containing an important biological resource or to a fragile natural setting that could suffer an especially severe impact from pollution. Table 4.15 provides guidance on assigning a value to this rating factor.

Population served by surface water with water intake within 3 miles downstream from facility (or 1 mile in static surface water such as a lake) is a rough indicator of the potential hazard exposure of the nearby population served by potentially contaminated surface water. Measure the distance from the probable point of entry to surface water, following the surface water flow (stream miles). The population includes residents as well as others who would regularly use the water, such as workers in factories or offices and students. Include employees in restaurants, motels, or campgrounds but exclude customers and travelers passing through the area in autos, buses and trains. The distance is measured from the point at which the hazardous substance is observed, including observations in stream or sediment samples, and regardless of facility boundaries. Where only residential houses can be counted (e.g., from an aerial photograph), and residents are known to be using surface water, assume 3.8 individuals per dwelling unit. Where surface water is used for irrigation, convert to population by assuming 1.5 persons per acre of land irrigated. Assign a value as follows:

<u>Population</u>	<u>Distance to Surface Water</u>				
	<u>>3 mi</u>	<u>2-3 mi</u>	<u>1-2 mi</u>	<u>2001 ft to 1 mi</u>	<u>0-2000 ft</u>
0	0	0	0	0	0
1-100	0	4	6	8	10
101-1000	0	8	12	16	20
1001-3000	0	12	18	24	30
3001-10,000	0	16	24	32	35
>10,000	0	20	30	35	40

TABLE 4.15. Values for Sensitive Environment (Surface Water)

ASSIGNED VALUE =	0	1	2	3
<u>Distance to Wetlands</u> ^(a) (5 acre minimum)				
Coastal	>2 mi	1 - 2 mi	$\frac{1}{2}$ - 1 mi	< $\frac{1}{2}$ mi
Fresh Water	>1 mi	$\frac{1}{4}$ - 1 mi	100 ft - $\frac{1}{4}$ mi	<100 ft
<u>Distance to Critical Habitat</u> (of endangered species) ^(b)	>1 mi	$\frac{1}{4}$ - 1 mi	$\frac{1}{4}$ - $\frac{1}{2}$ mi	< $\frac{1}{4}$ mi

(a) Wetland is defined by EPA in the Code of Federal Regulations 40 CFR Part 230, Appendix A, 1980.

(b) Endangered species are designated by the U.S. Fish and Wildlife Service.

4.3 AIR ROUTE

The impact of release of hazardous or radioactive material to the air from a waste site is evaluated only if such a release has occurred. Otherwise, this route is assigned a 0.

4.3.1 Observed Release

The only acceptable evidence of release for the air route is data that show contaminant levels that significantly exceed background levels at or in the vicinity of the facility, regardless of the frequency of occurrence. If such evidence exists, enter a value of 45 on line 1 of the Air Route Work Sheet (Figure 4.8); if not, assign line 1 a 0 value and then $S_a = 0$. Record the date, location, and the sampling protocol for monitoring data on the work sheet. Data based on transitory conditions due to facility disturbance by investigative personnel are not acceptable. Similarly, at waste sites that are situated in close proximity to operating facilities, only data that can be unambiguously attributed to the waste site should be used.

4.3.2 Waste Characteristics

Separately determine a waste characteristics score for the chemical and radioactive waste at the site using the guidance provided below. Record the values on the work sheet as directed.

4.3.2.1 Chemical Waste Characteristics

The hazardous substance that was observed for scoring the release category may be different from the substance used to score waste characteristics.

Reactivity and incompatibility, measures of the potential for sudden releases of concentrated air pollutants, are evaluated independently, and the highest value for either is recorded on the work sheet.

Reactivity provides a measure of the fire/explosion threat at a facility. Assign a value based on the reactivity classification used by NFPA (see Table 4.16). Reactivity ratings for a number of common compounds are given in Table 4.3 and in Appendix A.

Air Route Work Sheet									
Rating Factor	Assigned Value (Circle One)				Multi- plier	Score	Max. Score	Ref. (Section)	
1 Observed Release	0	45			1		45	5.1	
Date and Location:									
Sampling Protocol:									
If Line 1 is 0, the $S_a = 0$. Enter on Line 5.									
If Line 1 is 45, Then Proceed to Line 2.									
2 Waste Characteristics									5.2
a. Chemical									
Reactivity and Incompatibility	0	1	2	3		1	3		
Toxicity	0	1	2	3		3	9		
Hazardous Waste Quantity	0	1	2	3	4	5	6	7	8
						1	8		
b. Radioactive									
	0	2	5	8	12	16	20	1	20
Total Waste Characteristics Score						2a.		20	
						2b.			
3 Targets									5.3
Population Within 4-Mile Radius	0 9 12 15 18				1	30			
	21 24 27 30								
Distance to Sensitive Environment	0	1	2	3		2	6		
Land Use	0	1	2	3		1	3		
Total Targets Score							39		
4 Multiply 1 x 2 x 3						Chemical Radioactive	35,100		
5 Divide Line 4 by 35,100 and Multiply by 100						$S_a = S_a^c =$			

FIGURE 4.8. Air Route Work Sheet

TABLE 4.16. NFPA Reactivity Ratings

	<u>NFPA Level</u>	<u>Assigned Value</u>
0	Materials that are normally stable even under fire exposure conditions and which are not reactive with water.	0
1	Materials which in themselves are normally stable but may become unstable at elevated temperatures and pressures or that may react with water with some release of energy but not violently.	1
2	Materials that in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Includes materials that can undergo chemical change with rapid release of energy at normal temperatures and pressures or that can undergo violent chemical change at elevated temperatures and pressures. Also includes those materials that may react violently with water or that may form potentially explosive mixtures with water.	2
3	Materials that in themselves are capable of detonation or of explosive decomposition or of explosive reaction but that require a strong initiating source or that must be heated under confinement before initiation. Includes materials that are sensitive to thermal or mechanical shock at elevated temperatures and pressures or that react explosively with water without requiring heat or confinement.	3
4	Materials which in themselves are readily capable of detonation or of explosive decomposition or explosive reaction at normal temperatures and pressures. Includes materials that are sensitive to mechanical or localized thermal shock.	3

Incompatibility provides a measure of the increased hazard when hazardous substances are mixed under uncontrolled conditions, leading to production of heat, pressure, fire, explosion, violent reaction, toxic dusts, mists, fumes or gases, or flammable fumes or gases. Table 4.17 provides examples of incompatible combinations of materials. Additional information can be

TABLE 4.17. Incompatible Materials

In the lists below, the mixing of a Group A material with a Group B material may have the potential consequence as noted.

Group 1-A	Group 1-B	Group 4-A	Group 4-B
Acetylene sludge Alkaline caustic liquids Alkaline cleaner Alkaline corrosive liquids Alkaline corrosive battery fluid Caustic wastewater Lime sludge and other corrosive alkalies Lime wastewater Lime and water Spent caustic	Acid sludge Acid and water Battery acid Chemical cleaners Electrolyte acid Etching acid liquid or solvent Pickling liquor and other corrosive acids Spent acid Spent mixed acid Spent sulfuric acid	Alcohols Aldehydes Halogenated hydrocarbons Nitrated hydrocarbons Unsaturated hydrocarbons Other reactive organic compounds and solvents	Concentrated Group 1-A or 1-B wastes Group 2-A wastes
Potential consequences: Heat generation; violent reaction.		Potential consequences: Fire, explosion, or violent reaction.	
Group 2-A	Group 2-B	Group 5-A	Group 5-B
Aluminum Beryllium Calcium Lithium Potassium Sodium Zinc powder Other reactive metals and metal hydrides	Any waste in Group 1-A or 1-B	Spent cyanide and sulfide solutions	Group 1-B wastes
Potential consequences: Fire or explosion; generation of flammable hydrogen gas.		Potential consequences: Generation of toxic hydrogen cyanide or hydrogen sulfide gas.	
Group 3-A	Group 3-B	Group 6-A	Group 6-B
Alcohols Water	Any concentrated waste in Groups 1-A or 1-B Calcium Lithium Metal hydrides Potassium SO ₂ Cl ₂ , SOCl ₂ , PCl ₂ , CH ₃ , SiCl ₃ Other water-reactive waste	Chlorates Chlorine Chlorites Chromic acid Hypochlorites Nitrates Nitric acid, fuming Perchlorates Permanganates Peroxides Other strong oxidizers	Acetic acid and other organic acids Concentrated mineral acids Group 2-A wastes Group 4-A wastes Other flammable and combustible wastes
Potential consequences: Fire, explosion, or heat generation; generation of flammable or toxic gases.		Potential consequences: Fire, explosion, or violent reaction.	

Source: Hazardous Waste Management Law, Regulations, and Guidelines for the Handling of Hazardous Waste. California Department of Health, Sacramento, California, February 1975.

obtained from A Method for Determining the Compatibility of Hazardous Wastes, H. K. Hatayama, et al. 1980. Assign a value using the following guidance:

<u>Incompatibility</u>	<u>Assigned Value</u>
No incompatible substances are present	0
Present but do not pose a hazard	1
Present and may pose a future hazard	2
Present and posing an immediate hazard	3

Toxicity should be rated for the most toxic of the substances that can reasonably be expected to be transported away from the facility via the air route. Using the information given in Tables 4.3, 4.5, and 4.6, assign values as follows:

<u>Toxicity</u>	<u>Assigned Value</u>
SAX level 0 or NFPA level 0	0
SAX level 1 or NFPA level 1	1
SAX level 2 or NFPA level 2	2
SAX level 3 or NFPA levels 3 or 4	3

Hazardous Waste Quantity should be assigned a value as described in Section 4.1.4.1.

4.3.2.2 Radioactive Waste Characteristics

Information on the maximum observed concentration of radionuclides in air (pCi/m^3) at the site is required. Wherever possible, the air route data should be evaluated by individual nuclide. If no concentration of atmospheric radioactivity significantly above background has been observed, set the waste characteristics score for Part 2b of the Air Route Work Sheet (Figure 4.8) at 0. The total waste characteristics score for Part 2 of the Air Route Work Sheet is then derived solely from the score of the hazardous chemical constituents.

Using Table 4.7, determine the dose-factor groups for the nuclides that have been measured in air. Calculate the total concentration for each nuclide group by summing the concentrations of nuclides within the group. If gross alpha, beta or gamma measurements are included in the data, make the following assumptions: 1) gross alpha data are Group A nuclides, and 2) gross beta and gross gamma are Group B nuclides. If natural, enriched, or depleted uranium is present, assume it is a Group A nuclide. Use the conversion factors provided in Tables 4.8 and 4.9 to convert units as needed. With the radionuclide groups identified, and the maximum concentration for each calculated, use Table 4.18 (the matrix table) to determine the waste characteristics score for each nuclide group. Record the largest value under Section 2b of the Air Route Work Sheet (Figure 4.8). Record both values under the total waste characteristics score.

4.3.3 Targets

Population within a 4-mile radius is an indicator of the population that may be harmed should hazardous substances be released to the air.

The distance is measured from the location of the hazardous substances, not from the facility boundary. The population to be counted includes persons residing within the 4-mile radius as well as transients such as workers in

TABLE 4.18. Matrix Table for Air Route Waste Characteristics Score

Nuclide Group	Maximum Observed Air Concentration, pCi/m ³												
	<10 ⁻³	<10 ⁻²	<10 ⁻¹	<10 ⁰	<10 ¹	<10 ²	<10 ³	<10 ⁴	<10 ⁵	<10 ⁶	<10 ⁷	<10 ⁸	<10 ⁹
A	0	1	2	5	8	12	16	20					
B		0	1	2	5	8	12	16	20				
C			0	1	2	5	8	12	16	20			
D				0	1	2	5	8	12	16	20		
E					0	1	2	5	8	12	16	20	
F						0	1	2	5	8	12	16	20

factories, offices, restaurants, motels, or students. It excludes travelers passing through the area. If aerial photography is used in making the count, assume 3.8 individuals per dwelling unit. Select the highest value for this rating factor as follows:

<u>Population</u>	<u>Distance to Population from Hazardous Substance</u>			
	<u>0-4 mi</u>	<u>0-1 mi</u>	<u>0-1/2 mi</u>	<u>0-1/4 mi</u>
0	0	0	0	0
1-100	9	12	15	18
101-1000	12	15	18	21
1001-3000	15	18	21	24
3001-10,000	18	21	24	27
>10,000	21	24	27	30

Distance to sensitive environment is an indicator that a region that contains important biological resources or that is characterized by a fragile natural setting would suffer serious damage if hazardous substances were to be released from the facility. Assign a value from Table 4.15.

Land use indicates the nature and level of human activity in the vicinity of a facility. Assign highest applicable value from Table 4.19.

4.4 COMPUTING THE MIGRATION HAZARD MODE SCORE, S_M

To compute S_M , complete the work sheet (Figure 4.9) using the values of S_{gw} , S_{sw} and S_a obtained from the previous sections.

4.5 FIRE AND EXPLOSION

Compute a score for the fire and explosion hazard mode, S_{FE} , when either a state or local fire marshal has certified that the facility presents a significant fire or explosion threat to the public or to sensitive environments or there is a demonstrated fire and explosion threat based on field observations (e.g., combustible gas indicator readings). Document the threat.

TABLE 4.19. Values For Land Use (Air Route)

ASSIGNED VALUE =	0	1	2	3
Distance to Commercial- Industrial	>1 mile	$\frac{1}{2}$ - 1 mile	$\frac{1}{4}$ - $\frac{1}{2}$ mile	< $\frac{1}{4}$ mile
Distance to National/State Parks, Forests, Wildlife Reserves, and Residential Areas	>2 miles	1 - 2 miles	$\frac{1}{4}$ - 1 mile	< $\frac{1}{4}$ mile
Distance to Agricultural Lands (in Production within 5 years)				
Ag Land	>1 mile	$\frac{1}{2}$ - 1 mile	$\frac{1}{4}$ - $\frac{1}{2}$ mile	< $\frac{1}{4}$ mile
Prime Ag Land*	>2 miles	1 - 2 miles	$\frac{1}{2}$ - 1 mile	< $\frac{1}{2}$ mile
Distance to Historic/Landmark Sites (National Register of Historic Places and National Natural Landmarks)				within view of site or if site is subject to significant im- pacts

*Defined in the Code of Federal Regulations, 7 CFR 657.5, 1981.

	s	s ²
Groundwater Route Score (S _{gw})		
Surface Water Route Score (S _{sw})		
Air Route Score (S _a)		
$S_{gw}^2 + S_{sw}^2 + S_a^2$		
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$		
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2} / 1.73 = S_M$		

FIGURE 4.9. Worksheet for Computing S_M

4.5.1 Containment

Containment is an indicator of the measures that have been taken to minimize or prevent hazardous substances at the facility from catching fire or exploding. Normally it will be given a value of 3 on the work sheet (Figure 4.10). If no hazardous substances that are individually ignitable or explosive are present and those that may be hazardous in combination are segregated and isolated so that they cannot come together to form incompatible mixtures, assign this factor a value of 1.

4.5.2 Waste Characteristics

Direct evidence of ignitability or explosion potential may exist in the form of measurements. If so, assign this factor a value of 3; if not, assign a value of 0.

Ignitability is an indicator of the threat of fire at a facility and the accompanying potential for release of air contaminants. Assign this rating factor a value based on the NFPA classification scheme (Table 4.20).

Fire and Explosion Work Sheet												
Rating Factor	Assigned Value (Circle One)								Multi- plier	Score	Max. Score	Ref. (Section)
1 Containment	1 3								1		3	7.1
2 Waste Characteristics												7.2
Direct Evidence	0 3								1		3	
Ignitability	0 1 2 3								1		3	
Reactivity	0 1 2 3								1		3	
Incompatibility												
	Subtotal										12	
a. Chemical												
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8								1		8	
b. Radioactive												
Waste Characteristics	0 1 2 3								1		8	
Total Waste Characteristics Score									2C		20	
(2C = 2a + Subtotal, 2R = 2b + Subtotal)									2R			
3 Targets												
Distance to Nearest Population	0 1 2 3 4 5								1		5	
Distance to Nearest Building	0 1 2 3								1		3	
Distance to Sensitive Environment	0 1 2 3								1		3	
Land Use												
Population Within 2-Mile Radius	0 1 2 3 4 5								1		3	
Buildings Within 2-Mile Radius	0 1 2 3 4 5								1		5	
Total Targets Score											24	
4 Multiply 1 x 2 x 3									Chemical		1,440	
									Radioactive			
5 Divide Line 4 by 1,440 and Multiply by 100									S_{FE}^T	S_{FE}^C	=	

FIGURE 4.10. Fire and Explosion Work Sheet

Table 4.3 gives values for a number of common compounds. Assign values as follows:

<u>Ignitability</u>	<u>Assigned Value</u>
Flashpoint 200°F, or NFPA level 0	0
Flashpoint 140°F to 200°F or NFPA level 1	1
Flashpoint 80°F to 140°F or NFPA level 2	2
Flashpoint 80°F or NFPA levels 3 or 4	3

TABLE 4.20. NFPA Ignitability Levels and Assigned Values

<u>NFPA Level</u>	<u>Assigned Value</u>
Very flammable gases, very volatile flammable liquids, and materials that in the form of dusts or mists readily form explosive mixtures when dispersed in air.	
Liquids which can be ignited under all normal temperature conditions. Any material that ignites spontaneously at normal temperatures in air.	3
Liquids which must be moderately heated before ignition will occur and solids that readily give off flammable vapors.	2
Materials that must be preheated before ignition can occur. Most combustible solids have a flammability rating of 1.	1
Materials that will not burn.	0

Reactivity. Assign values as in Section 4.3.2.1.

Incompatibility. Assign values as in Section 4.3.2.1.

Hazardous Waste Quantity. Assign values as in Section 4.3.2.1.

4.5.3 Radioactive Waste

Information needed to complete this section includes the maximum concentration of waste at the site (pCi/m^3) and the area (m^2) of the site. If the maximum waste concentration is unavailable, divide the total number of picocuries (of each nuclide group) by the volume of the waste site and multiply by 1,000.

Using Table 4.7, determine the groups for the nuclides. If gross alpha, beta or gamma measurements are included, make the following assumptions: 1) gross alpha data are considered a Group A nuclide, and 2) gross beta and gross gamma are Group B nuclides. Calculate the total concentration associated with each nuclide group by summing the concentrations of the nuclides within the group. With the radionuclide groups identified and their maximum concentration calculated, use Table 4.21 (the matrix table) to determine the waste characteristics score for each nuclide group. If the site is less than one hectare, then use the area correction factors shown in Table 4.22 to modify the radionuclide concentration. Record the value of the largest radioactive waste characteristics under Section 2 of the Fire/Explosion Route Work Sheet (Figure 4.10).

4.5.4 Targets

Distance to nearest population is the distance from the hazardous substance to the nearest building or area in which one or more persons is likely to be located, either for residential, educational, business, occupational, or recreational purposes. It is an indicator of the potential for harm to humans from fire and explosion. The building or area need not be off site. Assign values as follows:

<u>Distance</u>	<u>Assigned Value</u>
>2 mi	0
1 mi - 2 mi	1
1/2 mi - 1 mi	2
201 ft - 1/2 mi	3
51 ft - 200 ft	4
0 - 50 ft	5

TABLE 4.21. Matrix Table for Fire/Explosion Waste Characteristics Score

Nuclide Group	Maximum Radioactive Waste Concentration, pCi/m ³												
	<10 ⁻⁵	10 ⁻⁵ -10 ⁻⁴	10 ⁻⁴ -10 ⁻³	10 ⁻³ -10 ⁻²	10 ⁻² -10 ⁻¹	10 ⁻¹ -10 ⁰	10 ⁰ -10 ¹	10 ¹ -10 ²	10 ² -10 ³	10 ³ -10 ⁴	10 ⁴ -10 ⁵	10 ⁵ -10 ⁶	10 ⁶ -10 ⁷
A	0	1	1	2	3	5	6	8					
B		0	1	1	2	3	5	6	8				
C			0	1	1	2	3	5	6	8			
D				0	1	1	2	3	5	6	8		
E					0	1	1	2	3	5	6	8	
F						0	1	1	2	3	5	6	8

TABLE 4.22. Site Area Correction Factors for Fire and Explosion Route

Site Area, m ²	Correction Factor ^(a)
>1000	1.0
500 - 1000	0.8
500 - 300	0.6
300 - 100	0.4
<100	0.2

(a) Multiply correction factor by nuclide group concentration. Use this value to determine the waste characteristics area corrected score.

Distance to nearest building is an indicator of the potential for property damage as a result of fire or explosion. Assign a value as follows:

Distance	Assigned Value
>1/2 mi	0
201 ft - 1/2 mi	1
52 - 200 ft	2
0 - 50 ft	3

Distance to nearest sensitive environment is measured from the hazardous substances, not from the facility boundary. It is an indicator of potential harm to a sensitive environment from fire or explosion at the facility. Select the highest value using the guidance provided in Table 4.23, except assign a value of 3 where fire could be expected to spread to a sensitive environment even though that environment is more than 100 feet from the hazardous substance.

Land Use. Assign values as in Section 4.3.3.

Population within 2-mile radius (measured from the location of the hazardous substance, not from the facility boundary) is a rough indicator of the population at risk in the event of fire or explosion at a facility. The population to be counted includes those residing within the 2-mile radius as well as people regularly in the vicinity, such as workers in factories, offices, or students. It does not include travelers passing through the area. If aerial photography is used in making the count, assume 3.8 individuals per dwelling. Assign values as follows:

<u>Population</u>	<u>Assigned Value</u>
0	0
1 - 100	1
101 - 1,000	2
1,001 - 3,000	3
3,001 - 10,000	4
>10,000	5

TABLE 4.23. Values for Sensitive Environments (Fire and Explosion)

<u>Assigned Value</u>	<u>Distance to Wetlands^(a)</u>	<u>Distance to Critical Habitat^(b)</u>
0	>100 ft	>1/2 mi
1	--	1,000 ft - 1/2 mi
2	--	100 - 1,000 ft
3	<100 ft	<100 ft

- (a) Wetland is defined by EPA in the Code of Federal Regulations 40 CFR Part 230, Appendix A, 1980.
 (b) Designated by the U.S. Fish and Wildlife Service.

Number of buildings within 2-mile radius (measured from the hazardous substance, not from the facility boundary) is a rough indicator of the property damage that could result from fire and explosion at a facility. Assign values to this factor as follows:

<u>Number of Buildings</u>	<u>Assigned Value</u>
0	0
1 - 26	1
27 - 260	2
261 - 790	3
791 - 2600	4
>2600	5

4.6 DIRECT CONTACT

The direct contact hazard mode refers to the potential for injury by direct contact with hazardous substances at the facility.

4.6.1 Observed Incident

If a confirmed instance of contact with hazardous substances at a facility has caused injury, illness, or death to humans or domestic or wild animals, enter a value of 45 on line 1 of the work sheet (Figure 4.11) and proceed to line 4 (toxicity). Document the incident giving the date, location and pertinent details. If no such instance is known, enter "0" on line 1 and proceed to line 2.

4.6.2 Accessibility

Accessibility to hazardous substance refers to the measures taken to limit access by humans or animals to hazardous substances. Assign a value using the following guidance:

Direct Contact Work Sheet						
Rating Factor	Assigned Value (Circle One)		Multi- plier	Score	Max. Score	Ref. (Section)
1 Observed Incident	0	45	1		45	8.1
If Line 1 is 45, Proceed to Line 4 If Line 1 is 0, Proceed to Line 2						
2 Accessibility	0	1 2 3	1		3	8.2
3 Containment	0	15	1		15	8.3
4 Waste Characteristics						8.4
a. Chemical Toxicity	0	1 2 3	5 (a)		15	
b. Radioactive	0	1 2 4	1 (b)		15	
Waste Characteristics	6	9 12 15				
5 Targets						8.5
Population Within a 1-Mile Radius	0	1 2 3 4 5	4		20	
Distance to a Critical Habitat	0	1 2 3	4		12	
				Total Targets Score		32
6 If Line 1 is 45, Multiply 1 x 4 x 5				Chemical	21,600	
If Line 1 is 0, Multiply 2 x 3 x 4 x 5				Radioactive		
7 Divide Line 6 by 21,600 and Multiply by 100				$S_{DC}^r = S_{DC}^c =$		

FIGURE 4.11. Direct Contact Work Sheet

<u>Barrier</u>	<u>Assigned Value</u>
A 24-hour surveillance system (e.g., television monitoring or surveillance by guards or facility personnel) which continuously monitors and controls entry onto the facility; or an artificial or natural barrier (e.g., a fence combined with a cliff) which completely surrounds the facility; and a means to control entry, at all times, through the gates or other entrances to the facility (e.g., an attendant, television monitors, locked entrances, or controlled roadway access to the facility).	0
Security guard, but no barrier	1
A barrier, but no separate means to control entry	2
Barriers do not completely surround the facility	3

4.6.3 Containment

Containment indicates whether the hazardous substance itself is accessible to direct contact. For example, if the hazardous substance at the facility is in surface impoundments, containers (sealed or unsealed), piles, tanks, or landfills with a cover depth of less than 2 feet, or has been spilled on the ground or other surfaces easily contacted (e.g., the bottom of a shallow pond or creek), assign this rating factor a value of 15. Otherwise, assign a value of 0.

4.6.4 Waste Characteristics

Chemical Toxicity. Assign a value as in Section 4.1.4.1.

Radioactive Waste. Information needed to complete this section includes the maximum concentration of waste at the site (pCi/m^3) and the area (m^2) of the site. If the maximum waste concentration is unavailable, divide the total number of picocuries (of each nuclide group) by the volume of the waste site and multiply by 1,000.

Using Table 4.7 determine the dose factor groups for the nuclides. If gross alpha, beta or gamma measurements are included, make the following assumptions: 1) gross alpha data are considered Group B nuclides, and 2) gross beta and gross gamma are Group A nuclides. Calculate the total

concentration for each nuclide group by summing the concentrations of the nuclides within the group. With the radionuclide groups identified and their maximum concentration calculated, use Table 4.24 (the matrix table) to determine the waste characteristics score for each nuclide group. If the site is less than one hectare, use the area correction factors shown in Table 4.25 to modify the radionuclide concentration.

TABLE 4.24. Matrix Sheet for Direct Contact Route Waste Characteristics Score

Maximum Waste Concentration, pCi/m ³														
Nuclide Group	<10 ⁻³	10 ⁻²	10 ⁻¹	10 ⁰	10 ¹	10 ²	10 ³	10 ⁴	10 ⁵	10 ⁶	10 ⁷	10 ⁸	10 ⁹	
A	0	1	2	4	6	9	12	15						
B		0	1	2	4	6	9	12	15					
C			0	1	2	4	6	9	12	15				
D				0	1	2	4	6	9	12	15			
E					0	1	2	4	6	9	12	15		
F						0	1	2	4	6	9	12	15	

TABLE 4.25. Site Area Correction Factors for Direct Contact Route

Site Area, m ²	Correction Factor ^(a)
>1000	1.0
500 - 1000	0.8
500 - 300	0.6
300 - 100	0.4
<100	0.2

(a) Multiply correction factor by nuclide group concentration. Use this value to determine the waste characteristics area corrected score.

Record the value of the largest radioactive waste characteristics under Section 2 of the Direct Contact Route Work Sheet (Figure 4.11).

4.6.5 Targets

Population within a 1-mile radius is a rough indicator of the population that could be involved in direct contact incidents at an uncontrolled facility. Assign a value as follows:

<u>Population</u>	<u>Assigned Value</u>
0	0
1 - 100	1
101 - 1,000	2
1,001 - 3,000	3
3,001 - 10,000	4
>10,000	5

Distance to a critical habitat (of an endangered species) is a rough measure of the probability of harm to members of an endangered species through direct contact with a hazardous substance. Assign a value as follows:

<u>Distance</u>	<u>Assigned Value</u>
>1 mi	0
1/2 to 1 mi	1
1/4 to 1/2 mi	2
<1/4 mi	3

5.0 HAND CALCULATIONAL METHODS FOR THE ORIGINAL (UNMODIFIED) HRS

It may become desirable or necessary to obtain scores for DOE sites using the original HRS. If the waste sites contain only chemicals, the guidance given in Section 4 will provide scores that are completely compatible with the original HRS. However, for sites with radionuclides, some modifications are required. To calculate HRS scores for these sites, ignore the "radioactive waste characteristics" instructions given in Sections 4.1.4.2, 4.2.4.2, 4.3.2.2, 4.5.3, and 4.6.5. Instead, use the guidance given for the hazardous wastes, but assign toxicity, persistence, and other values, as shown in Table 5.1.

TABLE 5.1. Waste Characteristics Values for Radionuclides

Element	Isotope	Toxicity	Persistence	Ignitability	Reactivity	Incompatibility	Incompatibility
Ac	225	3	0	1	1	0	0
Am	241	3	3	1	1	0	0
Am	243	3	3	1	1	0	0
C	14	3	3	1	1	4-A	0
Cd	109	3	1	1	1	6-B	0
Cm	243	3	2	1	1	0	0
Cm	244	3	2	1	1	0	0
Co	60	3	1	1	2	6-B	1-B
Cs	134	3	1	3	2	3-B	6-B
Cs	135	3	3	3	2	3-B	6-B
Cs	137+D	3	2	3	2	3-B	6-B
Eu	152	3	2	1	1	0	0
Eu	154	3	1	1	1	0	0
Fe	55	3	1	2	1	6-B	0
H	3	3	2	3	3	6-B	0
I	129	3	3	0	0	6-A	0
Mo	93	3	3	2	1	6-B	0
Na	22	3	1	3	3	SAX	0
Nb	94	3	3	2	1	6-B	0
Ni	59	3	3	0	0	6-B	2-B
Ni	63	3	2	0	0	0	2-B
Np	237+D	3	3	1	1	0	0
Np	239	3	0	1	1	6-B	0
Pb	210+D	3	2	2	1	4-B	0
Pu	238	3	2	0	0	4-B	3-B
Pu	239	3	3	0	0	4-B	3-B
Pu	240	3	3	0	0	4-B	3-B
Pu	241+D	3	3	0	0	4-B	3-B
Pu	242	3	3	0	0	4-B	3-B
Pu	244	3	3	0	0	0	3-B
Ra	225	3	0	0	0	0	0
Ra	226+D	3	3	0	0	6-B	0
Sb	125+D	3	1	2	1	4-B	0
Sm	151	3	2	2	2	6-B	3-B
Sr	90+D	3	2	2	2	6-B	3-B
Tc	99	3	3	2	1	6-B	0
Th	238+D	3	1	2	2	6-B	0
Th	229+D	3	3	2	2	6-B	0
Th	230+D	3	3	2	2	6-B	0
Th	232+D	3	3	2	2	6-B	0
U	233+D	3	3	2	2	6-B	3-B
U	234	3	3	2	2	6-B	3-B
U	235+D	3	3	2	2	6-B	3-B
U	238+D	3	3	2	2	6-B	3-B
U	240	3	3	2	2	6-B	3-B
U	depleted	3	3	2	2	6-B	3-B
U	enriched	3	3	2	2	6-B	3-B
U	natural	3	3	2	2	6-B	3-B
un	id alpha	3	3	0	0	0	0
un	id beta	3	3	0	0	0	0
un	id gamma	3	3	0	0	0	0

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APPENDIX A

WASTE CHARACTERISTICS VALUES FOR SOME COMMON CHEMICALS

APPENDIX A

WASTE CHARACTERISTICS VALUES FOR SOME COMMON CHEMICALS (2/13/86)

In- dex	CHEMICAL NAME	Toxi- city Index	Per- sis- tence Index	Igni- tabil- ity Index	React- ivity Index	Incom- pati- bility Index	Incom- pati- bility Index
1	1,1,1-trichloroethane	2	2	1	2 0	0	
2	1,1,2,3,4,4-hexachloro-1,3- butadiene	3	3	1	1 0	0	
3	1,1,2-trichloroethane	3	3	0	1 2-B	0	
4	1,1,3,3-tetrachloroacetone	3	3	0	0 0	0	
5	1,1-dichloro-2-chloro ethylene	3	2	2	1 4-A	0	
6	1,2,2-trichloroethane	1	3	0	1 2-B	0	
7	1,2,3,4,5,6-hexachlorocyclohexane	3	3	1	0 0	0	
8	1,2,4-trichlorobenzene	2	3	1	0 6-B	0	
9	1,2-benzene dicarboxylic acid anhydride	3	1	0	1 6-B	0	
10	1,2-dichloroethane	2	1	3	0 2-B	0	
11	1,2-dichloroethylene	2	1	0	1 0	0	
12	1,2-dimethoxy benzene	2	1	0	1 6-B	0	
13	1,3-dioxophthalan	3	1	0	1 6-B	0	
14	1,3-isobenzofurandione	3	1	0	1 6-B	0	
15	1,3-phthalandione	3	1	0	1 6-B	0	
16	1,4-dichlorobenzene	3	3	1	1 6-B	0	
17	1,4-dicyano butane	3	2	1	1 6-B	0	
18	1,6-hexolactam	3	1	0	0 0	0	
19	1-aminopropane	2	0	3	1 6-B	2-B	
20	1-chloro-2,2-dichloro ethylene	3	2	2	1 4-A	0	
21	1-chloro-3-nitrobenzene	3	3	1	0 6-B	0	
22	1-hydroxy methyl propane	3	0	2	1 4-A	3-A	
23	1-hydroxy-2-methoxybenzene	2	2	1	1 6-B	0	
24	1-phenyl ethanone	3	0	1	1 6-B	0	
25	1-phenyl propane	2	1	2	1 6-B	0	
26	1-phenylbutane	1	1	2	1 6-B	0	
27	1-phenylethanol	3	1	0	1 6-B	0	
28	1-propanol	3	0	3	1 6-B	4-A	
29	1-propyl alcohol	3	0	3	1 6-B	4-A	
30	1-terpineol	1	1	0	0 0	0	
31	2,2-dichloroethyl ether	3	2	2	1 1-A	6-B	
32	2,4,6-trichlorophenol	3	3	0	0 0	0	
33	2,4,6-trinitrotoluene	3	2	2	3 4-A	0	
34	2,6-dimethyl-4-heptanol	2	0	1	1 6-B	0	
35	2,6-dinitrotoluene	3	2	0	0 6-B	0	
36	2-azacycloheptanone	3	1	0	0 0	0	
37	2-bromo-2-methylpropane	3	1	0	0 0	0	
38	2-bromoisobutane	3	1	0	0 0	0	
39	2-butanone	3	0	3	0 6-B	0	

In- dex	CHEMICAL NAME	Toxi- city Index	Per- sis- tence Index	Igni- tabil- ity Index	React- ivity Index	Incom- pati- bility Index	Incom- pati- bility Index
40	2-camphanol	2	2	1	1 6-B	0	
41	2-ethyl-2-methyl-1,3-dioxolane	2	2	0	0 0	0	
42	2-ethylhexyl phthalate	2	3	0	0 0	0	
43	2-hydroxy camphane	2	2	1	1 6-B	0	
44	2-hydroxyanisole	2	2	1	1 6-B	0	
45	2-ketohexamethylenimine	3	1	0	0 0	0	
46	2-methoxy phenol	2	2	1	1 6-B	0	
47	2-methoxy-4-propenyl phenol	2	2	1	1 6-B	0	
48	2-methyl butanol	2	0	2	1 SAX	0	
49	2-methyl butanol-1	2	0	2	1 SAX	0	
50	2-methyl propyl alcohol	3	0	2	1 4-A	3-A	
51	2-methyl-1-propanol	3	0	2	1 4-A	3-A	
52	2-methyl-5-ethyl pyridine	2	1	1	1 6-B	0	
53	2-methyl-5-ethyl-pyridine	2	1	1	1 6-B	0	
54	2-methylpropanol	3	0	2	1 4-A	3-A	
55	2-oxohexamethylenimine	3	1	0	0 0	0	
56	2-pentanol	2	0	2	1 6-B	0	
57	2-perhydroazepinone	3	1	0	0 0	0	
58	2-phenylpropene	3	2	0	1 0	0	
59	2-phenylpropylene	3	2	0	1 0	0	
60	2-propanol	2	0	3	1 6-B	4-A	
61	3,4-dimethyl phenol	1	1	0	1 0	0	
62	3,4-xlenol	1	1	0	1 0	0	
63	3-chlorochlordene	3	3	0	0 0	0	
64	3-ethyl-6-methyl pyridine	2	1	1	1 6-B	0	
65	4,6-dinitro-2-aminophenol	3	3	0	0 0	0	
66	4-propenylguaiacol	2	2	1	1 6-B	0	
67	5,5-diethylbarbituric acid	3	2	0	0 0	0	
68	5-ethyl-2-methyl pyridine	2	1	1	1 6-B	0	
69	5-ethyl-2-picoline	2	1	1	1 6-B	0	
70	5-ethyl-alpha-picoline	2	1	1	1 6-B	0	
71	6-aminohexanoic acid cyclic lactam	3	1	0	0 0	0	
72	6-methyl-3-ethyl pyridine	2	1	1	1 6-B	0	
73	BHC	3	3	0	0 0	0	
74	Celluflex TPP	2	3	1	0 0	0	
75	DDT	3	3	0	0 0	0	
76	DMP	3	3	0	1 6-B	0	
77	DMSO	3	2	0	1 4-A	6-B	
78	DOP	2	3	0	0 0	0	
79	Dow-tri	3	2	2	1 4-A	0	
80	Dowicide 2s	3	3	0	0 0	0	
81	Freon 11	2	3	0	2 2-B	0	
82	Gamasol 90	3	2	0	1 4-A	6-B	
83	Julin's carbon chloride	3	3	0	1 SAX	0	

In- dex	CHEMICAL NAME	Toxi- city Index	Per- sis- tence Index	Igni- tabil- ity Index	React- ivity Index	Incom- pati- bility Index	Incom- pati- bility Index
84	MEK	3	0	3	0	6-B	0
85	PCB	3	3	0	0	0	0
86	Seneca oil	3	1	2	0	0	0
87	Shellsol 140	3	1	2	1	6-B	0
88	TNT	3	2	2	3	4-A	0
89	Thompson's Wood Fix	3	3	0	0	0	0
90	Tri-clene	3	2	2	1	4-A	0
91	absolute ethanol	3	0	3	1	4-A	3-A
92	acenaphthylene	2	2	0	0	0	0
93	acetaldehyde	2	0	3	2	4-B	3-B
94	acetic acid	2	0	2	1	6-B	0
95	acetic acid methyl ester	2	1	3	1	6-B	0
96	acetone	2	0	3	0	4-A	0
97	acetophenone	3	0	1	1	6-B	0
98	acetyl benzene	3	0	1	1	6-B	0
99	acetylene dichloride	2	1	0	1	0	0
100	acetylene trichloride	3	2	2	1	4-A	0
101	adipic acid	2	1	0	0	0	0
	bis(2-ethylhexyl)ester						
102	adipic acid dinitrile	3	2	1	1	6-B	0
103	adipic acid nitrile	3	2	1	1	6-B	0
104	adipodinitrile	3	2	1	1	6-B	0
105	adiponitrile	3	2	1	1	6-B	0
106	alcohol	3	0	3	1	4-A	3-A
107	alcohol, anhydrous	3	0	3	1	4-A	3-A
108	alcohol, dehydrated	3	0	3	1	4-A	3-A
109	aldehyde collidine	2	1	1	1	6-B	0
110	aldrin	3	3	1	0	0	0
111	alpha-methylbenzyl alcohol	3	1	0	1	6-B	0
112	alpha-methylstyrene	3	2	0	1	0	0
113	alpha-phenethyl alcohol	3	1	0	1	6-B	0
114	alpha-trichloroethane	2	2	1	0	0	0
115	aminocaproic lactam	3	1	0	0	0	0
116	aminoethane	3	0	3	2	6-B	0
117	ammonia, anhydrous	3	0	1	0	4-A	3-A
118	anhydrol	3	0	3	1	4-A	3-A
119	aniline	3	1	2	0	6-A	1-A
120	aromatic hydrocarbons, mixed	2	1	3	0	6-B	0
121	azotic acid	3	0	0	0	6-A	0
122	barbital	3	2	0	0	0	0
123	baros camphor	2	2	1	1	6-B	0
124	base oil	3	1	2	0	0	0
125	benzene	3	1	3	0	6-B	0
126	benzene carboxylic acid	2	0	0	1	6-B	0
127	benzene hexachloride	3	3	0	0	0	0

In- dex	CHEMICAL NAME	Toxi- city Index	Per- sis- tence Index	Igni- tabil- ity Index	React- ivity Index	Incom- pati- bility Index	Incom- pati- bility Index
128	benzene sulfonic acid	3	1	0	1 0	0	
129	benzoic acid	2	0	0	1 6-B	0	
130	benzopyrene	3	3	0	0 0	0	
131	benzothiazole	3	3	0	0 0	0	
132	benzoyl methide	3	0	1	1 6-B	0	
133	benzyl butyl phthalate	2	3	0	0 6-B	0	
134	beta-phenylpropene	3	2	0	1 0	0	
135	beta-phenylpropylene	3	2	0	1 0	0	
136	beta-trichloroethane	3	3	0	1 2-B	0	
137	bhimsaim camphor	2	2	1	1 6-B	0	
138	bihexyl	3	1	1	1 6-B	0	
139	bis(2-chloroethyl)ether	3	2	2	1 1-A	6-B	
140	bis(2-chloroisopropyl)ether	3	3	1	1 6-B	0	
141	bis(2-ethylhexyl)adipate	2	1	0	0 0	0	
142	bis(2-ethylhexyl)phthalate	2	3	0	0 0	0	
143	bis(beta-chloroethyl)ether	3	2	2	1 1-A	6-B	
144	bis(chloromethyl)ether	3	2	3	3 6-B	0	
145	borneo camphor	2	2	1	1 6-B	0	
146	borneol	2	2	1	1 6-B	0	
147	bornyl alcohol	2	2	1	1 6-B	0	
148	bromobenzene	2	2	2	1 6-B	0	
149	bromodichloromethane	2	3	0	0 0	0	
150	bromoform	3	3	0	0 2-B	4-B	
151	camphor	3	2	1	1 6-B	0	
152	camphor tar	3	1	2	0 6-B	0	
153	caprolactam	3	1	0	0 0	0	
154	carbinol	3	0	3	1 6-B	0	
155	carbolic acid	3	1	2	0 6-B	0	
156	carbon bisulfide	3	1	3	2 6-B	2-B	
157	carbon hexachloride	3	3	2	1 1-B	2-B	
158	carbon sulfide	3	1	3	2 6-B	2-B	
159	carbon tetrachloride	3	3	0	0 SAX	0	
160	carbon-disulfide	3	1	3	2 6-B	2-B	
161	chlordan	3	3	0	0 0	0	
162	chlorobenzene	2	2	3	0 6-B	0	
163	chloroethene	2	2	1	0 0	0	
164	chloroform	3	3	0	0 4-B	2-B	
165	chlorohydric acid	3	0	0	0 1-B	0	
166	chloromethane	3	2	3	2 2-B	6-B	
167	chloromethyl ether	3	2	3	3 6-B	0	
168	chlorothene	2	2	1	0 0	0	
169	cinnamene	3	1	2	1 6-B	4-A	
170	cinnamenol	3	1	2	1 6-B	4-A	
171	coal oil	3	1	2	0 0	0	
172	cologne spirits	3	0	3	1 4-A	3-A	

In- dex	CHEMICAL NAME	Toxi- city Index	Per- sis- tence Index	Igni- tabil- ity Index	React- ivity Index	Incom- pati- bility Index	Incom- pati- bility Index
173	colonial spirit	3	0	3	1 6-B	0	
174	columbian spirits	3	0	3	1 6-B	0	
175	compound 666	3	3	0	0 0	0	
176	crude oil	3	1	2	0 0	0	
177	cyclohexane	2	2	3	0 6-B	0	
178	cyclohexanone iso-oxime	3	1	0	0 0	0	
179	d-limonene	3	1	0	1 SAX	0	
180	decane	3	1	2	1 6-B	0	
181	di(2-ethylhexyl)phthalate	2	3	0	0 0	0	
182	di-2-ethylhexyl adipate	2	1	0	0 0	0	
183	di-isobutyl carbinol	2	0	1	1 6-B	0	
184	di-isobutyl phthalate	3	3	0	1 0	0	
185	di-n-butylphthalate	3	3	0	1 6-B	0	
186	di-n-hexyl phthalate	1	3	1	1 6-B	0	
187	dibutyl phthalate	3	3	0	1 6-B	0	
188	dichlorobromomethane	2	3	0	0 0	0	
189	dichlorodifluoroethane	2	3	0	0 0	0	
190	dichlorodiisopropyl ether	3	3	1	1 6-B	0	
191	dichloroethane	2	1	3	0 2-B	0	
192	dichloroethyl oxide	3	2	2	1 1-A	6-B	
193	dieldrin	3	3	0	0 0	0	
194	diethyl phthalate	3	3	0	0 0	0	
195	diethylbarbitone	3	2	0	0 0	0	
196	diethylmalonylurea	3	2	0	0 0	0	
197	dihexyl	3	1	1	1 6-B	0	
198	dihexyl phthalate	1	3	1	1 6-B	0	
199	dimethyl carbinol	2	0	3	1 6-B	4-A	
200	dimethyl parathion	3	0	3	2 0	0	
201	dimethyl phthalate	3	3	0	1 6-B	0	
202	dimethyl sulfoxide	3	2	0	1 4-A	6-B	
203	dioctyl adipate	2	1	0	0 0	0	
204	dithiocarbonic anhydride	3	1	3	2 6-B	2-B	
205	dryobalanops camphor	2	2	1	1 6-B	0	
206	duodecane	3	1	1	1 6-B	0	
207	e-caprolactam	3	1	0	0 0	0	
208	endrin	3	3	1	0 0	0	
209	epoxy heptachlor	3	3	0	0 0	0	
210	ethanamine	3	0	3	2 6-B	0	
211	ethane hexachloride	3	3	2	1 1-B	2-B	
212	ethane trichloride	3	3	0	1 2-B	0	
213	ethanol	3	0	3	1 4-A	3-A	
214	ethanol 200 proof	3	0	3	1 4-A	3-A	
215	ethers	2	1	9	9 0	0	
216	ethyl alcohol	3	0	3	1 4-A	3-A	
217	ethyl alcohol anhydrous	3	0	3	1 4-A	3-A	

In- dex	CHEMICAL NAME	Toxi- city Index	Per- sis- tence Index	Igni- tabil- ity Index	React- ivity Index	Incom- pati- bility Index	Incom- pati- bility Index
218	ethyl benzene	2	1	3	0	6-B	0
219	ethyl carbinol	3	0	3	1	6-B	4-A
220	ethyl hydrate	3	0	3	1	4-A	3-A
221	ethyl hydroxide	3	0	3	1	4-A	3-A
222	ethyl methyl ketone	3	0	3	0	6-B	0
223	ethylamine	3	0	3	2	6-B	0
224	ethylbenzol	2	1	3	0	6-B	0
225	ethylene acetic acid	2	2	0	0	0	0
226	ethylene hexachloride	3	3	2	1	1-B	2-B
227	ethylene trichloride	3	2	2	1	4-A	0
228	ethylphthalate	3	3	0	0	0	0
229	fannoform	3	0	2	0	6-B	0
230	fermentation alcohol	3	0	3	1	4-A	3-A
231	fermentation butyl alcohol	3	0	2	1	4-A	3-A
232	fluorotrichloromethane	2	3	0	2	2-B	0
233	formaldehyde	3	0	2	0	6-B	0
234	formalin	3	0	2	0	6-B	0
235	formalith	3	0	2	0	6-B	0
236	formic acid	2	0	2	0	6-B	0
237	formic aldehyde	3	0	2	0	6-B	0
238	formol	3	0	2	0	6-B	0
239	formylic acid	2	0	2	0	6-B	0
240	fuel oil	3	1	2	0	0	0
241	gammexane	3	3	0	0	0	0
242	grain alcohol	3	0	3	1	4-A	3-A
243	guaiacol	2	2	1	1	6-B	0
244	guaicol	2	2	1	1	6-B	0
245	hendecane	2	0	1	1	6-B	0
246	heptachlor	3	3	0	0	0	0
247	heptachlor epoxide	3	3	0	0	0	0
248	hexachlorbutadiene	3	3	1	1	0	0
249	hexachloro-1,3-butadiene	3	3	1	1	0	0
250	hexachlorobenzene	3	3	0	1	SAX	0
251	hexachlorocyclohexane	3	3	0	0	0	0
252	hexachloroethane	3	3	2	1	1-B	2-B
253	hexachloroethylene	3	3	2	1	1-B	2-B
254	hexahydro-2-azepinone	3	1	0	0	0	0
255	hexahydro-2H-azepin-2-one)	3	1	0	0	0	0
256	hexahydrobenzene	2	2	3	0	6-B	0
257	hexamethylene	2	2	3	0	6-B	0
258	hexanaphthene	2	2	3	0	6-B	0
259	hexane dioic acid dinitrile	3	2	1	1	6-B	0
260	hexanedinitrile	3	2	1	1	6-B	0
261	hexanedioic acid, bis(2-ethylhexyl)ester	2	1	0	0	0	0

Index	CHEMICAL NAME	Toxicity Index	Per- sistence Index	Igni- tabil- ity Index	React- ivity Index	Incom- pati- bility Index	Incom- pati- bility Index
262	hexanone isoxime	3	1	0	0	0	0
263	hydrochloric acid	3	0	0	0	1-B	0
264	hydrochloride	3	0	0	0	1-B	0
265	hydrogen carboxylic acid	2	0	2	0	6-B	0
266	hydrogen nitrate	3	0	0	0	6-A	0
267	hydroxybenzene	3	1	2	0	6-B	0
268	hypnone	3	0	1	1	6-B	0
269	indene	2	2	0	1	6-B	1-A
270	indonaphthene	2	2	0	1	6-B	1-A
271	isoacetophorone	2	2	1	1	6-B	0
272	isoborneol	2	2	0	1	0	0
273	isobornyl alcohol	2	2	0	1	0	0
274	isobutanol	3	0	2	1	4-A	3-A
275	isobutyl alcohol	3	0	2	1	4-A	3-A
276	isocamphol	2	2	0	1	0	0
277	isocumene	2	1	2	1	6-B	0
278	isohol	2	0	3	1	6-B	4-A
279	isophorone	2	2	1	1	6-B	0
280	isopropanol	2	0	3	1	6-B	4-A
281	isopropenyl benzene	3	2	0	1	0	0
282	isopropyl alcohol	2	0	3	1	6-B	4-A
283	isopropyl carbinol	3	0	2	1	4-A	3-A
284	isopropyl ether	2	1	3	1	6-B	0
285	karsan	3	0	2	0	6-B	0
286	kerosene	3	1	2	0	0	0
287	lindane	3	3	1	0	0	0
288	m-chloronitrobenzene	3	3	1	0	6-8	0
289	m-cresol	3	1	1	0	1-A	0
290	m-methyl phenol	3	1	1	0	1-A	0
291	malayan camphor	2	2	1	1	6-B	0
292	methanal	3	0	2	0	6-B	0
293	methane	1	1	3	0	6-B	0
294	methanoic acid	2	0	2	0	6-B	0
295	methanol	3	0	3	1	6-B	0
296	methenyl tribromide	3	3	0	0	2-8	4-8
297	methyl acetate	2	1	3	1	6-B	0
298	methyl acetone	3	0	3	0	6-B	0
299	methyl alcohol	3	0	3	1	6-8	0
300	methyl aldehyde	3	0	2	0	6-B	0
301	methyl benzene	3	1	3	0	6-B	0
302	methyl benzene carboxylate	2	0	1	1	6-B	0
303	methyl benzoate	2	0	1	1	6-B	0
304	methyl benzol	3	1	3	0	6-B	0
305	methyl benzothiazole	3	3	0	0	0	0
306	methyl carbinol	3	0	3	1	4-A	3-A

Index	CHEMICAL NAME	Toxicity Index	Persistence Index	Ignitability Index	Reactivity Index	Incompatibility Index	Incompatibility Index
307	methyl chloride	3	2	3	2	2-B	6-B
308	methyl chloroform	2	2	1	0	0	0
309	methyl ethyl ketone	3	0	3	0	6-B	0
310	methyl ethyl pyridine	2	1	1	1	6-B	0
311	methyl hydroxide	3	0	3	1	6-B	0
312	methyl naphthalene	1	1	0	1	0	0
313	methyl parathion	3	0	3	2	0	0
314	methyl phenyl carbinol	3	1	0	1	6-B	0
315	methyl phenyl ketone	3	0	1	1	6-B	0
316	methyl phthalate	3	3	0	1	6-B	0
317	methyl propyl carbinol	2	0	2	1	6-B	0
318	methyl sulfoxide	3	2	0	1	4-A	6-B
319	methylene oxide	3	0	2	0	6-B	0
320	methyl naphthalene	1	1	0	1	0	0
321	methyltrichloromethane	2	2	1	0	0	0
322	mixture of p-methenols	1	1	0	0	0	0
323	molasses alcohol	3	0	3	1	4-A	3-A
324	mono-n-propylamine	2	0	3	1	6-B	2-B
325	monofluorotrichloromethane	2	3	0	2	2-B	0
326	monohydroxybenzene	3	1	2	0	6-B	0
327	monohydroxymethane	3	0	3	1	6-B	0
328	moth balls	3	1	2	0	6-B	0
329	moth flakes	3	1	2	0	6-B	0
330	n-butyl benzene	1	1	2	1	6-B	0
331	n-dodecane	3	1	1	1	6-B	0
332	n-nonane	3	1	2	1	6-B	0
333	n-pentadecane	2	0	0	0	0	0
334	n-propanol	3	0	3	1	6-B	4-A
335	n-propyl alcohol	3	0	3	1	6-B	4-A
336	n-propylamine	2	0	3	1	6-B	2-B
337	n-propylbenzene	2	1	2	1	6-B	0
338	n-tridecane	2	0	0	0	0	0
339	n-undecane	2	0	1	1	6-B	0
340	naphthalene	3	1	2	0	6-B	0
341	naphthaline	3	1	2	0	6-B	0
342	naphthene	3	1	2	0	6-B	0
343	niobe oil	2	0	1	1	6-B	0
344	nitrates	2	2	3	3	6-A	0
345	nitric acid	3	0	0	0	6-A	0
346	nitrobenzene	3	2	1	1	4-A	6-B
347	nitrobenzol	3	2	1	1	4-A	6-B
348	o-cresol	2	1	2	0	1-A	0
349	o-dimethoxybenzene	2	1	0	1	6-B	0
350	o-ethylmethyl benzene	1	1	0	1	6-B	0
351	o-ethyltoluene	1	1	0	1	6-B	0

Index	CHEMICAL NAME	Toxicity Index	Persistence Index	Ignitability Index	Reactivity Index	Incompatibility Index	Incompatibility Index
352	o-ethyltoluene	1	1	0	1	6-B	0
353	o-hydroxyanisole	2	2	1	1	6-B	0
354	o-methoxy phenol	2	2	1	1	6-B	0
355	o-methyl phenol	2	1	2	0	1-A	0
356	octane	1	1	3	1	6-B	0
357	octoil	2	3	0	0	0	0
358	octyl adipate	2	1	0	0	0	0
359	oil of vitriol	3	0	0	2	1-B	0
360	omega-caprolactam	3	1	0	0	0	0
361	oxomethane	3	0	2	0	6-B	0
362	oxybenzene	3	1	2	0	6-B	0
363	oxymethylene	3	0	2	0	6-B	0
364	p-cresol	3	1	1	0	1-A	0
365	p-dichlorobenzene	3	3	1	1	6-B	0
366	p-dichlorobenzol	3	3	1	1	6-B	0
367	p-methyl phenol	3	1	1	0	1-A	0
368	paradichlorobenzol	3	3	1	1	6-B	0
369	parathion	3	0	1	2	0	0
370	pentachlorophenol	3	3	0	0	0	0
371	pentachlorophenyl chloride	3	3	0	1	SAX	0
372	pentane	2	1	3	2	6-B	0
373	perchlorobenzene	3	3	0	1	SAX	0
374	perchlorobutadiene	3	3	1	1	0	0
375	perchloroethane	3	3	2	1	1-B	2-B
376	petrohol	2	0	3	1	6-B	4-A
377	petroleum	3	1	2	0	0	0
378	phenic acid	3	1	2	0	6-B	0
379	phenol	3	1	2	0	6-B	0
380	phenyl benzoate	2	1	0	1	0	0
381	phenyl bromide	2	2	2	1	6-B	0
382	phenyl carboxylic acid	2	0	0	1	6-B	0
383	phenyl chloride	2	2	3	0	6-B	0
384	phenyl ethene	3	1	2	1	6-B	4-A
385	phenyl formic acid	2	0	0	1	6-B	0
386	phenyl hydrate	3	1	2	0	6-B	0
387	phenyl hydroxide	3	1	2	0	6-B	0
388	phenyl methyl ketone	3	0	1	1	6-B	0
389	phenyl perchloryl	3	3	0	1	SAX	0
390	phenylethane	2	1	3	0	6-B	0
391	phenylethylene	3	1	2	1	6-B	4-A
392	phenylic acid	3	1	2	0	6-B	0
393	phenylic alcohol	3	1	2	0	6-B	0
394	phenylmethane	3	1	3	0	6-B	0
395	phenylmethylcarbinol	3	1	0	1	6-B	0
396	phenylsulfonic acid	3	1	0	1	0	0

In- dex	CHEMICAL NAME	Toxi- city Index	Per- sis- tence Index	Igni- tabil- ity Index	React- ivity Index	Incom- pati- bility Index	Incom- pati- bility Index
397	phthalic acid anhydride	3	1	0	1 6-B	0	
398	phthalic acid methyl ester	3	3	0	1 6-B	0	
399	phthalic anhydride	3	1	0	1 6-B	0	
400	polychlorinated biphenyls	3	3	0	0 0	0	
401	potato alcohol	3	0	3	1 4-A	3-A	
402	propanamine	2	0	3	1 6-B	2-B	
403	propenylguaiacol	2	2	1	1 6-B	0	
404	propyl alcohol	3	0	3	1 6-B	4-A	
405	propylamine	2	0	3	1 6-B	2-B	
406	propylic alcohol	3	0	3	1 6-B	4-A	
407	pyrocatechol dimethyl ether	2	1	0	1 6-B	0	
408	pyroguaiac acid	2	2	1	1 6-B	0	
409	pyroxylic spirit	3	0	3	1 6-B	0	
410	rock oil	3	1	2	0 0	0	
411	s-trinitrotoluene	3	2	2	3 4-A	0	
412	s-trinitrotoluol	3	2	2	3 4-A	0	
413	sec-amyl alcohol	2	0	2	1 6-B	0	
414	sec-butylcarbinol	2	0	2	1 SAX	0	
415	sec-pentyl alcohol	2	0	2	1 6-B	0	
416	sec-propyl alcohol	2	0	3	1 6-B	4-A	
417	sedeval	3	2	0	0 0	0	
418	spirits of wine	3	0	3	1 4-A	3-A	
419	styrallyl alcohol	3	1	0	1 6-B	0	
420	styrene	3	1	2	1 6-B	4-A	
421	sulfuric acid	3	0	0	2 1-B	0	
422	sulphocarbonic anhydride	3	1	3	2 6-B	2-B	
423	sumatra camphor	2	2	1	1 6-B	0	
424	sym-dichloroethyl ether	3	2	2	1 1-A	6-B	
425	sym-dichloroethylene	2	1	0	1 0	0	
426	sym-trinitrotoluene	3	2	2	3 4-A	0	
427	sym-trinitrotoluol	3	2	2	3 4-A	0	
428	tert-butyl bromide	3	1	0	0 0	0	
429	tetrachloroethane	3	3	0	0 0	0	
430	tetradecane	3	0	0	1 6-B	0	
431	tetramethylene cyanide	3	2	1	1 6-B	0	
432	toluene	3	1	3	0 6-B	0	
433	toluol	3	1	3	0 6-B	0	
434	trans-borneol	2	2	1	1 6-B	0	
435	tribromomethane	3	3	0	0 2-B	4-B	
436	trichlorobenzene	2	3	1	0 6-B	0	
437	trichlorobiphenyl	3	3	0	0 0	0	
438	trichloroethylene	3	2	2	1 4-A	0	
439	trichlorofluoromethane	2	3	0	2 2-B	0	
440	trichloromonofluoromethane	2	3	0	2 2-B	0	
441	tridecane	2	0	0	0 0	0	

In- dex	CHEMICAL NAME	Toxi- city Index	Per- sis- tence Index	Igni- tabil- ity Index	React- ivity Index	Incom- pati- bility Index	Incom- pati- bility Index
442	trimethylbromomethane	3	1	0	0 0	0	0
443	trinitrotoluene	3	2	2	3 4-A	0	0
444	triphenyl phosphate	2	3	1	0 0	0	0
445	veratrol	2	1	0	1 6-B	0	0
446	veronal	3	2	0	0 0	0	0
447	vestrol	3	2	2	1 4-A	0	0
448	vinyl benzene	3	1	2	1 6-B	4-A	0
449	vinyl trichloride	3	3	0	1 2-B	0	0
450	vinylbenzol	3	1	2	1 6-B	4-A	0
451	white tar	3	1	2	0 6-B	0	0
452	wood alcohol	3	0	3	1 6-B	0	0
453	wood naphtha	3	0	3	1 6-B	0	0
454	wood spirit	3	0	3	1 6-B	0	0
455	xylene	2	1	3	0 6-B	0	0
456	xlenol	1	1	0	1 0	0	0
457	aluminum fluoride nitrate	3	2	3	3 6-A	0	0
458	aluminum nitrate	3	3	3	3 6-A	0	0
459	ammonium nitrate	1	0	3	3 6-A	0	0
460	cadmium nitrate	3	3	3	3 6-A	0	0
461	calcium nitrate	3	2	3	3 6-A	0	0
462	dibutyl butyl phosphonate	0	2	0	0 0	0	0
463	ferric nitrate	2	2	3	3 6-A	0	0
464	ferrocyanide	1	3	0	0 0	0	0
465	fluorides	3	3	0	0 0	0	0
466	gluconate	0	0	1	0 0	0	0
467	magnesium nitrate	3	2	3	3 6-A	0	0
468	methyl isobutyl ketone	3	0	3	3 6-B	0	0
469	nitrites	3	0	3	3 6-A	0	0
470	oxalate	3	0	1	0 0	0	0
471	paraffin hydrocarbon	2	1	2	0 6-B	0	0
472	phosphates	0	0	0	0 0	0	0
473	sodium aluminate	1	1	1	1 0	0	0
474	sodium dichromate	3	3	0	1 6-A	0	0
475	sodium hydroxide	1	3	0	1 1-A	2-B	0
476	sodium silicate	3	1	0	0 0	0	0
477	sulfates	0	0	0	0 0	0	0
478	tributyl phosphate	2	2	1	0 0	0	0
479	potassium (ion)	0	3	0	0 0	0	0
480	sodium (ion)	0	3	0	0 0	0	0
481	sodium metasilicate	3	1	0	0 0	0	0
482	sodium meta aluminate	3	1	1	1 0	0	0
483	MIBK	3	0	3	3 6-B	0	0
484	HEXONE	3	0	3	3 6-B	0	0

In- dex	CHEMICAL NAME	Toxi- city Index	Per- sis- tence Index	Igni- tabil- ity Index	React- ivity Index	Incom- pati- bility Index	Incom- pati- bility Index
485	disodium metasilicate	3	1	0	0 0	0	0
486	disodium monosilicate	3	1	0	0 0	0	0
487	sodium aluminum oxide	1	1	1	1 0	0	0
488	aluminum sodium oxide	1	1	1	1 0	0	0

APPENDIX B

COMPUTER PROMPTS GENERATED DURING AN mHRS RUN

APPENDIX B

COMPUTER PROMPTS GENERATED DURING AN mHRS RUN

This appendix contains a "work sheet" providing a walk-through of computer prompts generated during an mHRS run. This work sheet shows the same information as that provided in hand-calculational work sheets (see Appendix C). The example "work sheet" is provided to show that the code can be used to develop specifically tailored data-gathering work sheets for use in collecting information on a specific site or groups of sites. The work sheet shown is quite long because it includes questions that would be applicable to a site having releases to the environment from all pathways as well as having every pathway applicable to the site. Work sheets such as the example can best be used in the following manner:

- Group all sites at the facility into categories (e.g., sites with releases to the environment, sites with liquid wastes, remote sites, sites with specific ground water problems, etc.).
- Using the mHRS/HRS code, develop templates (example files) for each of the categories chosen.
- Individually call up the text (ASCII) files from each of the templates developed using a commercial word processor (a word processor that can handle text files) and edit to create a work sheet for each site category.
- When editing a template text file, create blank spaces after the questions that do not have common answers. Leave the answers created during the development of the template for all questions that have common answers.

The work sheet approach is most beneficial at facilities where the sites can be easily divided into categories, with each category containing several sites.

It is not necessary to prepare work sheets to run the code. The work sheet concept is only mentioned as a method that might help in dealing with a

large number of sites within a facility. The mHRS/HRS code is designed to operate as a user-friendly/stand-alone system. Sites can be evaluated by simply having the necessary reference information available and answering the questions as they appear on the screen.

EXAMPLE WORKSHEET WITH RELEASES & ALL PATHWAYS INVOLVED

mHRS Hazardous Ranking System Facility Worksheet

Date:

Site name:

Identification number:

Site index in mHRS dBaseIII file:

Site log file name:

(computer will assign)

(use first 8 characters (letters or numbers) of identification # (or less if # is < 8 characters))

DOE Operations Office and location:

Location:

EPA Region:

Person(s) in charge of facility:

Reviewer:

Type of facility:

Types of hazardous wastes (chemical, radiological, or mixed):

Contamination routes of concern (ground water, surface water, air, fire and explosion, and/or direct contact):

Additional descriptive comments:

Waste storage types (check the category(ies) that are most applicable):

Surface Impoundments

Containers

piles

Landfills

Waste constituents, applicable routes and quantities:

Constituent Name	-----Routes-----					Constituent
	GW	SW	A	FE	DC	Quantity

Chemicals:						
_____	---	---	---	---	---	_____g or Mg
_____	---	---	---	---	---	_____g or Mg
_____	---	---	---	---	---	_____g or Mg
_____	---	---	---	---	---	_____g or Mg
_____	---	---	---	---	---	_____g or Mg
_____	---	---	---	---	---	_____g or Mg
_____	---	---	---	---	---	_____g or Mg
_____	---	---	---	---	---	_____g or Mg
_____	---	---	---	---	---	_____g or Mg
_____	---	---	---	---	---	_____g or Mg
Radionuclides:						
_____	---	---	---	---	---	_____uCi or Ci
_____	---	---	---	---	---	_____uCi or Ci
_____	---	---	---	---	---	_____uCi or Ci
_____	---	---	---	---	---	_____uCi or Ci
_____	---	---	---	---	---	_____uCi or Ci
_____	---	---	---	---	---	_____uCi or Ci
_____	---	---	---	---	---	_____uCi or Ci
_____	---	---	---	---	---	_____uCi or Ci
_____	---	---	---	---	---	_____uCi or Ci
_____	---	---	---	---	---	_____uCi or Ci
_____	---	---	---	---	---	_____uCi or Ci

Inventory Justifications:

REFERENCE(S):

RATIONALE FOR DEFINING PHYSICAL STATE OF SUBSTANCES AT TIME OF DISPOSAL (OR AT
PRESENT TIME FOR GENERATED GASES):

REFERENCE(S):

ADDITIONAL COMMENT(S):

Route: Ground Water

Was there an observed release to ground water?

Was there an observed release of radionuclides?

Radionuclide Name	Observed Release (pCi/L)
-----	-----

Number of population groups considered:

Population group number (complete for each population group):

Distance to nearest well assigned value:

Population served assigned value:

OBSERVED RELEASE JUSTIFICATION INFORMATION

CONTAMINANTS DETECTED (contaminant and concentration):

RATIONALE FOR ATTRIBUTING THE CONTAMINANTS TO THE FACILITY:

DATA SUBSTANTIATING RELEASE (WHAT, WHEN, WHERE, WHY, AND HOW):

REFERENCE(S):

ADDITIONAL COMMENTS (use back if needed):

DISTANCE TO CRITICAL HABITAT OF AN ENDANGERED SPECIES OR NATIONAL WILDLIFE REFUGE, IF 1 MILE OR LESS:

IF NONE OF THE ABOVE DISTANCES APPLY, BRIEFLY DESCRIBE THE SETTING (EMPHASIZING THE TYPE(S) OF ENVIRONMENT LOCATED NEAR THE FACILITY):

REFERENCE(S):

ADDITIONAL COMMENTS:

LAND USE

DISCUSS DISTANCE TO COMMERCIAL/INDUSTRIAL AREA, IF 1 MILE OR LESS:

DISCUSS DISTANCE TO NATIONAL OR STATE PARK, FOREST, OR WILDLIFE RESERVE, IF 2 MILES OR LESS:

DISCUSS DISTANCE TO RESIDENTIAL AREA, IF 2 MILES OR LESS:

DISCUSS DISTANCE TO AGRICULTURAL LAND IN PRODUCTION WITHIN PAST 5 YEARS, IF 1 MILE OR LESS:

DISCUSS DISTANCE TO PRIME AGRICULTURAL LAND IN PRODUCTION WITHIN PAST 5 YEARS, IF 2 MILES OR LESS:

DISCUSS ANY HISTORIC OR LANDMARK SITE (NATIONAL REGISTER OR HISTORIC PLACES AND NATIONAL NATURAL LANDMARKS) WITHIN VIEW OF THE SITE:

REFERENCE(S):

HAZARDOUS WASTE QUANTITY JUSTIFICATION INFORMATION

TOTAL QUANTITY OF HAZARDOUS SUBSTANCES AT THE FACILITY, EXCLUDING THOSE WITH A CONTAINMENT SCORE OF 0 (GIVE A REASONABLE ESTIMATE EVEN IF THE QUANTITY IS ABOVE MAXIMUM):

DESCRIBE AND QUANTIFY THE BREAKDOWN OF THE TOTAL QUANTITY INTO QUANTITY OF CHEMICAL WASTES AND RADIOACTIVE WASTES:

BASIS OF ESTIMATING AND/OR COMPUTING WASTE QUANTITY:

REFERENCE(S):

ADDITIONAL COMMENTS:

MAX. OBSERVED RADIOACTIVE RELEASE INFORMATION

DATA SUBSTANTIATING MEASURED OBSERVED RADIOLOGICAL RELEASE (WHAT, WHEN, WHERE, WHY, AND HOW):

REFERENCE(S):

ADDITIONAL COMMENTS:

GROUND WATER USE INFORMATION

USE(S) OF AQUIFER(S) OF CONCERN WITHIN A 3-MILE RADIUS OF FACILITY:

REFERENCE(S):

ADDITIONAL COMMENTS:

DISTANCE TO THE NEAREST WELL INFORMATION

LOCATION OF NEAREST DRAWING FROM AQUIFER OF CONCERN OR OCCUPIED BUILDING NOT SERVED BY A PUBLIC WATER SUPPLY:

DISTANCE FROM HAZARDOUS SUBSTANCE (NOT THE FACILITY BOUNDARY) TO THE ABOVE WELL OR BUILDING:

REFERENCE(S):

ADDITIONAL COMMENTS:

POPULATION SERVED BY GROUND WATER INFORMATION

IDENTIFIED WATER-SUPPLY WELL(S) FROM AQUIFER(S) OF CONCERN WITHIN A 3-MILE RADIUS AND POPULATIONS SERVED BY EACH:

IF GROUND WATER IS USED FOR IRRIGATION, PROVIDE DETAILS REGARDING THE COMPUTATION OF LAND AREA IRRIGATED BY SUPPLY WELL(S) DRAWING FROM AQUIFER(S) OF CONCERN WITHIN A 3-MILE RADIUS, AND THE RESPECTIVE CONVERSION TO POPULATION (1.5 PEOPLE PER ACRE):

TOTAL POPULATION SERVED BY GROUND WATER WITHIN A 3-MILE RADIUS:

REFERENCE(S):

ADDITIONAL COMMENTS (use back if necessary):

Route: Surface Water

Was there an observed release to surface water?

Was there an observed radiological release to surface water?

Radionuclide Name	Observed Release (pCi/L)
-------------------	--------------------------

Average annual flow of nearest surface water:	liters/yr (or T-liters/yr)
---	-------------------------------

Number of population groups considered:

For each population group:

Distance to nearest well:

Population served:

OBSERVED RELEASE

CONTAMINANTS DETECTED IN SURFACE WATER AT THE FACILITY OR DOWNHILL FROM IT:

RATIONALE FOR ATTRIBUTING THE CONTAMINANTS TO THE FACILITY:

DATA SUBSTANTIATING RELEASE (WHAT, WHEN, WHERE, WHY AND HOW):

REFERENCE(S):

ADDITIONAL COMMENTS (USE BACK FOR ADDITIONAL COMMENTS):

HAZARDOUS WASTE QUANTITY

TOTAL QUANTITY OF HAZARDOUS SUBSTANCE AT THE FACILITY, EXCLUDING THOSE WITH A CONTAINMENT SCORE OF 0 (GIVE A REASONABLE ESTIMATE EVEN IF QUANTITY IS ABOVE MAXIMUM):

DESCRIBE AND QUANTIFY THE BREAKDOWN OF THE TOTAL QUANTITY INTO QUANTITY OF CHEMICAL WASTES AND RADIOACTIVE WASTES:

BASIS OF ESTIMATING AND/OR COMPUTING WASTE QUANTITY:

REFERENCE(S):

ADDITIONAL COMMENTS:

RADIOLOGICAL RELEASE INFORMATION

DATA SUBSTANTIATING MEASURED RADIOLOGICAL RELEASE (WHAT, WHEN, WHERE, WHY, AND HOW):

REFERENCE(S):

ADDITIONAL COMMENTS:

SURFACE WATER USE

USE(S) OF SURFACE WATER WITHIN 3 MILES DOWNSTREAM OF THE HAZARDOUS SUBSTANCE:

IS THERE TIDAL INFLUENCE?

REFERENCE(S):

ADDITIONAL COMMENTS:

DISTANCE TO A SENSITIVE ENVIRONMENT

DISTANCE TO 5-ACRE (MINIMUM) COSTAL WETLAND, IF 2 MILES OR LESS:

DISTANCE TO 5-ACRE (MINIMUM) FRESH-WATER WETLAND, IF 1 MILE OR LESS:

DISTANCE TO CRITICAL HABITAT OF AN ENDANGERED SPECIES OR NATIONAL WILDLIFE REFUGE,
IF 1 MILE OR LESS:

IF NONE OF THE ABOVE DISTANCES APPLY, BRIEFLY DESCRIBE THE SETTING (EMPHASIZING
THE TYPE(S) OF ENVIRONMENT LOCATED NEAR THE FACILITY):

REFERENCE(S):

ADDITIONAL COMMENTS (USE BACK FOR ADDITIONAL COMMENTS):

POPULATION SERVED BY SURFACE WATER INFORMATION

LOCATION OF WATER-SUPPLY INTAKE(S) WITHIN 3 MILES (FREE-FLOWING BODIES) OR 1 MILE (STATIC WATER BODIES) DOWNSTREAM OF THE HAZARDOUS SUBSTANCE AND POPULATION SERVED BY EACH INTAKE:

DISTANCE TO ABOVE-CITED INTAKE(S), MEASURED IN STREAM MILES:

IF SURFACE WATER IS USED FOR IRRIGATION, PROVIDE DETAILS REGARDING THE COMPUTATION OF LAND AREA IRRIGATED BY ABOVE-CITED INTAKE(S) AND THE RESPECTIVE CONVERSION TO POPULATION (1.5 PEOPLE PER ACRE):

TOTAL POPULATION SERVED:

NAME(S)/DESCRIPTION(S) OF SURFACE WATER BODIES LOCATED WITHIN 3 MILES OF FACILITY:

NAME(S)/DESCRIPTION(S) OF CITIES/COMMUNITIES LOCATED WITHIN 3 MILES OF FACILITY:

REFERENCE(S):

ADDITIONAL COMMENTS:

Route: Air

Was there an observed release to air?

Was there an observed radiological release to air?

Radionuclide Name	Observed Release (pCi/L)
-----	-----

Population within 1/4 mi radius:

Population within 1/2 mi radius:

Population within 1 mi radius:

Population within 4 mi radius:

Distance to commercial/industrial complex:

Distance to park, forest, residential areas:

Distance to agricultural lands:

Historic/landmark sites within view?

Historic/landmark sites subject to impacts?

OBSERVED RELEASE

CONTAMINANTS DETECTED:

DATE AND LOCATION OF DETECTION OF CONTAMINANTS:

METHODS USED TO DETECT THE CONTAMINANTS:

RATIONALE FOR ATTRIBUTING THE CONTAMINANTS TO THE SITE:

REFERENCE(S):

ADDITIONAL COMMENTS (use back for additional comments):

INCOMPATIBLE COMPOUNDS

DISCUSS THE RESULTS OF INVESTIGATIONS PERFORMED REGARDING ANY INCOMPATIBLE COMPOUNDS:

REFERENCE(S):

ADDITIONAL COMMENTS:

HAZARDOUS WASTE QUANTITY

TOTAL QUANTITY OF HAZARDOUS WASTE AT THE FACILITY:

DESCRIBE AND QUANTIFY THE BREAKDOWN OF THE TOTAL QUANTITY INTO QUANTITY OF CHEMICAL WASTES AND RADIOACTIVE WASTES:

BASIS FOR ESTIMATING AND/OR COMPUTING WASTE QUANTITY:

REFERENCE(S):

ADDITIONAL COMMENTS (use back for additional comments):

MAX. OBSERVED RADIOACTIVE RELEASE

DATA SUBSTANTIATING MEASURED RADIOLOGICAL RELEASE (WHAT, WHEN, WHERE, WHY, AND HOW):

REFERENCE(S):

ADDITIDNAL COMMENT(S):

POPULATION WITHIN 4-MILE RADIUS

DISCUSS EACH POPULATION GROUP AND INDICATE HOW IT IS INVOLVED (INCLUDE NAMES, LOCATIONS, ETC.):

REFERENCE(S):

ADDITIONAL COMMENTS (use back for additional comments):

DISTANCE TO SENSITIVE ENVIRONMENT

DISTANCE TO 5-ACRE (MINIMUM) COSTAL WETLAND, IF 2 MILES OR LESS:

DISTANCE TO 5-ACRE (MINIMUM) FRESH-WATER WETLAND, IF 1 MILE OR LESS:

DISTANCE TO CRITICAL HABITAT OF AN ENDANGERED SPECIES, IF 1 MILES OR LESS:

IF NONE OF THE ABOVE DISTANCES APPLY, BRIEFLY DESCRIBE THE SETTING (EMPHASIZING THE TYPE(S) OF ENVIRONMENT LOCATED NEAR THE FACILITY:

REFERENCE(S):

ADDITIONAL COMMENTS:

LAND USE

DISCUSS DISTANCE TO COMMERCIAL/INDUSTRIAL AREA, IF 1 MILE OR LESS:

DISCUSS DISTANCE TO NATIONAL OR STATE PARK, FOREST, OR WILDLIFE RESERVE, IF 2 MILES OR LESS:

DISCUSS DISTANCE TO RESIDENTIAL AREA, IF 2 MILES OR LESS:

DISCUSS DISTANCE TO AGRICULTURAL LAND IN PRODUCTION WITHIN PAST 5 YEARS, IF 1 MILE OR LESS:

DISCUSS DISTANCE TO PRIME AGRICULTURAL LAND IN PRODUCTION WITHIN PAST 5 YEARS, IF 2 MILES OR LESS:

DISCUSS ANY HISTORIC OR LANDMARK SITE (NATIONAL REGISTER OR HISTORIC PLACES AND NATIONAL NATURAL LANDMARKS) WITHIN VIEW OF THE SITE?

REFERENCE(S):

ADDITIONAL COMMENTS:

Route: Fire & Explosion

Volume of the waste site (cubic meters):

Is area of the waste site greater than 1000 square meters?

Quantity of chemical waste considered this route:

Distance to commercial/industrial complex:

Distance to park, forest, residential areas:

Distance to agricultural lands:

Historic/landmark sites within view?

Historic/landmark sites subject to impacts?

CONTAINMENT

BASIS FOR SELECTED CONTAINMENT VALUES:

REFERENCE(S):

ADDITIONAL COMMENTS:

DIRECT EVIDENCE

SUBSTANCES (CHEMICAL OR RADIOACTIVE) INVOLVED:

DISCUSS MONITORING OR SAMPLING/ANALYSIS CONDUCTED TO DETECT SUBSTANCES (PROVIDE DATES, LOCATIONS, AND SUMMARY OF RESULTS):

REFERENCE(S):

ADDITIONAL COMMENTS:

HAZARDOUS WASTE QUANTITY

TOTAL QUANTITY OF HAZARDOUS WASTE AT THE FACILITY:

DESCRIBE AND QUANTIFY THE BREAKDOWN OF THE TOTAL QUANTITY INTO QUANTITY OF CHEMICAL WASTES AND RADIOACTIVE WASTES:

BASIS FOR ESTIMATING AND/OR COMPUTING WASTE QUANTITY:

REFERENCE(S):

ADDITIONAL COMMENTS:

WASTE CONCENTRATION OR SITE SIZE

IF MEASURED CONCENTRATIONS OF RADIONUCLIDES ARE KNOWN, PROVIDE DATA SUBSTANTIATING RELEASE (WHAT, WHEN, WHERE, WHY, AND HOW):

IF MEASURED CONCENTRATIONS OF RADIONUCLIDES ARE NOT KNOWN, WHAT ARE THE DIMENSIONS OF THE WASTE SITE?

REFERENCE(S):

ADDITIONAL COMMENTS:

DISTANCE TO NEAREST POPULATION

IDENTIFY POPULATIONS WITHIN A 2-MILE RADIUS:

REFERENCE(S):

ADDITIONAL COMMENTS:

DISTANCE TO NEAREST BUILDING

IDENTIFY BUILDINGS WITHIN A 2-MILE RADIUS:

REFERENCE(S):

ADDITIONAL COMMENTS:

DISTANCE TO SENSITIVE ENVIRONMENT

DISTANCE TO 5-ACRE (MINIMUM) COSTAL WETLAND, IF 2 MILES OR LESS:

DISTANCE TO 5-ACRE (MINIMUM) FRESH-WATER WETLAND, IF 1 MILE OR LESS:

DISTANCE TO CRITICAL HABITAT OF AN ENDANGERED SPECIES OR NATIONAL WILDLIFE REFUGE,
IF 1 MILE OR LESS:

IF NONE OF THE ABOVE DISTANCES APPLY, BRIEFLY DESCRIBE THE SETTING (EMPHASIZING
THE TYPE(S) OF ENVIRONMENT LOCATED NEAR THE FACILITY):

REFERENCE(S):

ADDITIONAL COMMENTS:

LAND USE

DISCUSS DISTANCE TO COMMERCIAL/INDUSTRIAL AREA, IF 1 MILE OR LESS:

DISCUSS DISTANCE TO NATIONAL OR STATE PARK, FOREST, OR WILDLIFE RESERVE, IF 2
MILES OR LESS:

DISCUSS DISTANCE TO RESIDENTIAL AREA, IF 2 MILES OR LESS:

DISCUSS DISTANCE TO AGRICULTURAL LAND IN PRODUCTION WITHIN PAST 5 YEARS, IF 1
MILE OR LESS:

DISCUSS DISTANCE TO PRIME AGRICULTURAL LAND IN PRODUCTION WITHIN PAST 5 YEARS,
IF 2 MILES OR LESS:

DISCUSS ANY HISTORIC OR LANDMARK SITE (NATIONAL REGISTER OR HISTORIC PLACES AND
NATIONAL NATURAL LANDMARKS) WITHIN VIEW OF THE SITE:

REFERENCE(S):

ADDITIONAL COMMENTS (use back for additional comments):

POPULATION WITHIN 2-MILE RADIUS

DISCUSS EACH POPULATION GROUP AND INDICATE HOW IT IS INVOLVED (INCLUDE NAMES, LOCATIONS, ETC.):

REFERENCE(S):

ADDITIONAL COMMENTS:

BUILDINGS WITHIN 2-MILE RADIUS

DISCUSS EACH BUILDING AND INDICATE HOW IT IS INVOLVED (INCLUDE NAMES, LOCATIONS, ETC.):

REFERENCE(S):

ADDITIONAL COMMENTS:

Route: Direct Contact

Was there an observed incident of direct contact?

Volume of the waste site (cubic meters):

Is area of the waste site greater than 1000 square meters?

ACCESSIBILITY

DESCRIBE BARRIER SYSTEM USED AT THE SITE:

REFERENCE(S):

ADDITIONAL COMMENTS:

WASTE CONCENTRATION OR SITE SIZE

IF MEASURED CONCENTRATIONS OF RADIONUCLIDES ARE KNOWN, PROVIDE DATA SUBSTANTIATING RELEASE (WHAT, WHEN, WHERE, WHY, AND HOW):

IF MEASURED CONCENTRATIONS OF RADIONUCLIDES ARE NOT KNOWN, WHAT ARE THE DIMENSIONS OF THE WASTE SITE?

REFERENCE(S):

ADDITIONAL COMMENT(S):

CONTAINMENT

BASIS FOR SELECTED CONTAINMENT VALUES:

REFERENCE(S):

ADDITIONAL COMMENTS:

POPULATION WITHIN 1-MILE RADIUS

DISCUSS EACH POPULATION GROUP AND INDICATE HOW IT IS INVOLVED (INCLUDE NAMES, LOCATIONS, ETC.):

REFERENCE(S):

ADDITIONAL COMMENTS (use back for additional comments):

APPENDIX C

WORK SHEETS AND HAND CALCULATIONAL RECORDS FOR mHRS/HRS

APPENDIX C

WORK SHEETS AND HAND CALCULATIONAL RECORDS FOR mHRS/HRS

This appendix contains blank work sheets and documentation pages needed for manual (non-computerized) mHRS/HRS use. Information on work sheets and documentation pages is used to calculate mHRS/HRS scores according to prescribed guidelines. Instructions and guidelines for rating a facility are detailed in Section 4.

Facility name: _____	
Location: _____	
EPA Region: _____	
Person(s) in charge of the facility: _____	

Name of Reviewer: _____	Date: _____
General description of the facility:	
(For example: landfill, surface impoundment, pile, container; types of hazardous substances; location of the facility; contamination route of major concern; types of information needed for rating; agency action, etc.)	

Scores: $S_M =$ ($S_{gw} =$ $S_{gw} =$ $S_a =$)	
$S_{FE} =$	
$S_{DC} =$	

FIGURE C.1. HRS Cover Sheet

Ground Water Route Work Sheet									
Rating Factor	Assigned Value (Circle One)				Multi- plier	Score	Max. Score	Ref. (Section)	
1 Observed Release	0		45		1		45	3.1	
If Observed Release is Given a Score of 45, Proceed to Line 4 . If Observed Release is Given a Score of 0, Proceed to Line 2 .									
2 Route Characteristics								3.2	
Depth to Aquifer of Concern	0	1	2	3		2	6		
Net Precipitation	0	1	2	3		1	3		
Permeability of the Unsaturated Zone	0	1	2	3		1	3		
Physical State	0	1	2	3		1	3		
Total Route Characteristics Score							15		
3 Containment	0	1	2	3		1	3	3.3	
4 Waste Characteristics								3.4	
Chemical									
a. Toxicity/Persistence	0	3	6	9	12	14	18	1	18
Hazardous Waste Quantity	0	1	2	3	4	5	6	7	8
Radioactive									
b.1 Maximum Observed	0	1	3	7	11	15	21	26	1
b.2 Maximum Potential	0	1	3	7	11	15	21	26	1
Total Waste Characteristics Score (Largest of 4a, b.1, b.2.)						4a.		26	
						4b.			
5 Targets								3.5	
Ground Water Use	0	1	2	3		3	9		
Distance to Nearest Well/Population Served	0 4 6 8 10 12 16 18 20 24 30 32 35 40					1	40		
Total Targets Score							49		
6 If Line 1 is 45, Multiply 1 x 4 x 5					Chemical		57,330		
If Line 1 is 0, Multiply 2 x 3 x 4 x 5					Radioactive				
7 Divide Line 6 by 57,330 and Multiply by 100						$S'_{gw} = S^c_{gw} =$			

FIGURE C.2. Ground Water Route Sheet

Surface Water Route Work Sheet									
Rating Factor	Assigned Value (Circle One)				Multi- plier	Score	Max. Score	Ref. (Section)	
1 Observed Release	0		45		1		45	4.1	
If Observed Release is Given a Value of 45, Proceed to Line 4 If Observed Release is Given a Value of 0, Proceed to Line 2									
2 Route Characteristics									4.2
Facility Slope and Intervening Terrain	0	1	2	3		1	3		
1-yr. 24-hr. Rainfall	0	1	2	3		1	3		
Distance to Nearest Surface Water	0	1	2	3		2	6		
Physical State	0	1	2	3		1	3		
Total Route Characteristics Score							15		
3 Containment	0	1	2	3		1	3	4.3	
4 Waste Characteristics									4.4
a. Chemical									
Toxicity/Persistence	0	3	6	9	12	15	18	1	18
Hazardous Waste Quantity	0	1	2	3	4	5	6	7	8
b. Radioactive									
b.1 Maximum Observed	0	1	3	7	11	15	21	26	1
b.2 Maximum Potential	0	1	3	7	11	15	21	26	1
Total Waste Characteristics Score Largest of 4a, b1 or b2						4 a. 4 b.	26		
5 Targets									4.5
Surface Water Use	0	1	2	3		3	9		
Distance to a Sensitive Environment	0	1	2	3		2	6		
Population Served/Distance to Water Intake Downstream	0	4	6	8	10		40		
	12	16	18	20					
	24	30	32	35	40				
Total Targets Score							55		
6 If Line 1 is 45, Multiply 1 x 4 x 5						Chemical	64,350		
If Line 1 is 0, Multiply 2 x 3 x 4 x 5						Radioactive			
7 Divide Line 6 by 64,350 and Multiply by 100						$S'_{sw} =$	S^c_{sw}		

FIGURE C.3. Surface Water Route Work Sheet

Air Route Work Sheet									
Rating Factor	Assigned Value (Circle One)				Multi- plier	Score	Max. Score	Ref. (Section)	
1 Observed Release	0		45		1		45	5.1	
Date and Location:									
Sampling Protocol:									
If Line 1 is 0, the $S_a = 0$. Enter on Line 5 . If Line 1 is 45, Then Proceed to Line 2 .									
2 Waste Characteristics									5.2
a. Chemical									
Reactivity and Incompatibility	0	1	2	3		1	3		
Toxicity	0	1	2	3		3	9		
Hazardous Waste Quantity	0	1	2	3	4	5	6	7	8
						1	8		
b. Radioactive	0	2	5	8	12	16	20		
						1	20		
Total Waste Characteristics Score						2a. 2b.	20		
3 Targets									5.3
Population Within 4-Mile Radius	} 0 9 12 15 18 } 21 24 27 30					1	30		
Distance to Sensitive Environment	0	1	2	3		2	6		
Land Use	0	1	2	3		1	3		
Total Targets Score							39		
4 Multiply 1 x 2 x 3						Chemical Radioactive	35,100		
5 Divide Line 4 by 35,100 and Multiply by 100						$S_a = S_a^c =$			

FIGURE C.4. Air Route Work Sheet

Fire and Explosion Work Sheet												
Rating Factor	Assigned Value (Circle One)								Multi- plier	Score	Max. Score	Ref. (Section)
1 Containment	1		3						1		3	7.1
2 Waste Characteristics												7.2
Direct Evidence	0			3					1		3	
Ignitability	0	1	2	3					1		3	
Reactivity	0	1	2	3					1		3	
Incompatibility												
									Subtotal		12	
a. Chemical												
Hazardous Waste Quantity	0	1	2	3	4	5	6	7	8	1	8	
b. Radioactive	0	1	2	3	5	6	8			1	8	
Waste Characteristics	0	1	2	3								
Total Waste Characteristics Score									2C		20	
(2C = 2a + Subtotal, 2R = 2b + Subtotal)									2R			
3 Targets												
Distance to Nearest Population	0	1	2	3	4	5			1		5	
Distance to Nearest Building	0	1	2	3					1		3	
Distance to Sensitive Environment	0	1	2	3					1		3	
Land Use												
Population Within 2-Mile Radius	0	1	2	3					1		3	
Buildings Within 2-Mile Radius	0	1	2	3	4	5			1		5	
Total Targets Score											24	
4 Multiply 1 x 2 x 3									Chemical		1,440	
								Radioactive				
5 Divide Line 4 by 1,440 and Multiply by 100									$S_{FE}^r = S_{FE}^c =$			

FIGURE C.5. Fire and Explosion Work Sheet

Direct Contact Work Sheet							
Rating Factor	Assigned Value (Circle One)		Multi- plier	Score	Max. Score	Ref. (Section)	
1 Observed Incident	0	45	1		45	8.1	
If Line 1 is 45, Proceed to Line 4 If Line 1 is 0, Proceed to Line 2							
2 Accessibility	0	1	2	3	1	3	8.2
3 Containment	0	15		1		15	8.3
4 Waste Characteristics						8.4	
a. Chemical Toxicity	0	1	2	3	5 (a)	15	
b. Radioactive	0	1	2	4	1 (b)	15	
Waste Characteristics	6	9	12	15			
5 Targets						8.5	
Population Within a 1-Mile Radius	0	1	2	3	4	5	20
Distance to a Critical Habitat	0	1	2	3	4		12
Total Targets Score						32	
6 If Line 1 is 45, Multiply 1 x 4 x 5					Chemical	21,600	
If Line 1 is 0, Multiply 2 x 3 x 4 x 5					Radioactive		
7 Divide Line 6 by 21,600 and Multiply by 100					$S_{DC}^r = S_{DC}^c =$		

FIGURE C.6. Direct Contact Work Sheet

DOCUMENTATION RECORDS FOR HAZARD RANKING SYSTEM

INSTRUCTIONS

The purpose of these records is to provide a convenient way to prepare an auditable record of the data and documentation used to apply the modified and original Hazard Ranking System to a given facility. As briefly as possible summarize the information you used to assign the score for each factor (e.g., "Waste quantity = 4,230 drums plus 800 cubic yards of sludges"). The source of information should be provided for each entry and should be a bibliographic-type reference that will make the document used for a given data point easier to find. Include the location of the document and consider appending a copy of the relevant pages(s) for ease in review.

Facility Name _____

Location _____

Sources Cites:

GROUND WATER ROUTE

1. OBSERVED RELEASE

Contaminants detected (5 maximum):

Rationale for attributing the contaminants to the facility:

2. ROUTE CHARACTERISTICS

Depth to Aquifer of Concern

Name/description of aquifer(s) of concern:

Depth(s) from the ground surface to the highest seasonal level of the saturated zone [water table(s)] of the aquifer of concern:

Depth from the ground surface to the lowest point of waste disposal/storage:

Net Precipitation

Mean annual or seasonal precipitation (list months for seasonal):

Mean annual lake or seasonal evaporation (list months for seasonal):

Net precipitation (subtract the above figures):

Permeability of Unsaturated Zone

Soil type in unsaturated zone:

Permeability associated with soil type:

Physical State

Physical state of substances at time of disposal (or at present time for generated gases):

3. CONTAINMENT

Containment

Method(s) of waste or leachate containment evaluated:

Method with highest score:

4. WASTE CHARACTERISTICS

A. Chemical

Toxicity and Persistence

Compound(s) evaluated:

Compound with highest score:

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

Basis of estimating and/or computing waste quantity:

B. Radioactive

Radionuclides disposed with half-lives longer than one year, and curie quantities of each.

Maximum observed radionuclide concentration (include reference).

Maximum potential concentration (show calculation)

5. TARGETS

Ground Water Use

Use(s) of aquifer(s) of concern within a 3-mile radius of the facility:

Distance to Nearest Well

Location of nearest well drawing from aquifer of concern or occupied building not served by a public water supply:

Distance to above well or building:

Population Served by Ground Water Wells Within a 3-Mile Radius

Identified water-supply well(s) drawing from aquifer(s) of concern within a 3-mile radius and populations served by each:

Computation of land area irrigated by supply well(s) drawing from aquifer(s) of concern within a 3-mile radius, and conversion to population (1.5 people per acre):

Total population served by ground water within a 3-mile radius:

SURFACE WATER ROUTE

1. OBSERVED RELEASE

Contaminants detected in surface water at the facility or downhill from it (5 maximum):

Rationale for attributing and contaminants to the facility:

2. ROUTE CHARACTERISTICS

Facility Slope and Intervening Terrain

Average slope of facility in percent:

Name/description of nearest downslope surface water:

Average slope of terrain between facility and above-cited surface water body in percent:

Is the facility located either totally or partially in surface water?

Is the facility completely surrounded by areas of higher elevation?

1-Year 24-Hour Rainfall in Inches

Distance to Nearest Downslope Surface Water

Physical State of Waste

3. CONTAINMENT

Containment

Method(s) of waste or leachate containment evaluated:

Method with highest score:

4. WASTE CHARACTERISTICS

A. Chemical

Toxicity and Persistence

Compound(s) evaluated

Compound with highest score:

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

Basis of estimating and/or computing waste quantity:

B. Radioactive

Radionuclides disposed with half-lives longer than one year, and curie quantities of each.

Maximum observed radionuclide concentration (include reference).

Maximum potential concentration (show calculation).

5. TARGETS

Surface Water Use

Use(s) of surface water within 3 miles downstream of the hazardous substance:

Is there tidal influence?

Distance to a Sensitive Environment

Distance to 5-acre (minimum) coastal wetland, if 2 miles or less:

Distance to critical habitat of an endangered species or national wildlife refuge, if 1 mile or less:

Population Served by Surface Water

Location(s) of water-supply intake(s) within 3 miles (free-flowing bodies) or 1 mile (static water bodies) downstream of the hazardous substance and population served by each intake:

Computation of land area irrigated by above-cited intake(s) and
conversion to population (1.5 people per acre):

Total population served:

Name/description of nearest of above water bodies:

Distance to above-cited intakes, measured in stream miles:

AIR ROUTE

1. OBSERVED RELEASE

Contaminants detected:

Date and location of detection of contaminants:

Methods used to detect the contaminants:

Rationale for attributing the contaminants to the site:

2. WASTE CHARACTERISTICS

A. Chemical

Reactivity and Incompatibility

Most reactive compound:

Most incompatible pair of compounds:

Toxicity

Most toxic compound:

Hazardous Waste Quantity

Total quantity of hazardous waste:

Basis of estimating and/or computing waste quantity:

B. Radioactive

Airborne concentration of each radionuclide (in Ci/m^3) with half-life greater than one year and attributable to the waste site.

3. TARGETS

Population Within 4-Mile Radius

Circle radius used, give population, and indicate how determined:

0 to 4 mi 0 to 1 mi 0 to 1/2 mi 0 to 1/4 mi

Distance to a Sensitive Environment

Distance to 5-acre (minimum) coastal wetland, if 2 miles or less:

Distance to 5-acre (minimum) fresh-water wetland, if 1 miles or less:

Distance to critical habitat of an endangered species, if 1 mile or less:

Land Use

Distance to commercial/industrial area, if 1 mile or less:

Distance to national or state park, forest, or wildlife reserve, if 2 miles or less:

Distance to residential area, if 2 miles or less:

Distance to agricultural land in production within past 5 years, if 1 mile or less:

Distance to prime agricultural land in production within past 5 years, if 2 miles or less:

Is a historic or landmark site (National Register or Historic Places and National Natural Landmarks) within the view of the site?

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