Refining the Degree of Hazard Ranking Methodology for Illinois Industrial Waste Stream

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Reprinted October 1991
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Prepared for

The Illinois Hazardous Waste Research and Information Center
HWRIC Project Number 87031

Fifth Printing October 1991

Printed by Authority of the State of Illinois 91/150
This report is part of HWRIC's Research Report Series and as such has been subject to the Center's external scientific peer review. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.
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ABSTRACT

This project was conducted by the Institute for Environmental Studies of the University of Illinois at Urbana-Champaign under contract to the Hazardous Waste Research and Information Center (HWRIC), Illinois Department of Energy and Natural Resources. This research was a continuation of the project entitled Assigning a Degree of Hazard Ranking to Illinois Waste Streams (Plewa et al., 1986). Currently the Illinois Pollution Control Board is mandated to implement a degree of hazard system to evaluate Illinois Special Waste Streams by December 1989. The objectives of this project were, 1) to define a rational and empirically defendable foundation for the accumulative toxicity scoring graphs, 2) to transfer the database management system for degree of hazard evaluation from R:BASE 5000 to R:BASE System V, 3) to generate a series of interactive menu templates for entering data and conducting the degree of hazard evaluation, and, 4) to devise a formal procedure to employ national, toxicology and chemical databases for the periodic revision of the HWRIC Degree of Hazard Database. The results of this study clearly demonstrate that a degree of hazard evaluation can be conducted using IEPA Special Waste applications. The computerized Application Data Form is user-friendly. The program scans the application information and determines if a degree of hazard analysis can be conducted. The output indicates whether additional information is required or if the application is properly completed. The computer identifies the specific data deficiencies so that the waste generator is able to amend the application. When sufficient information is present, a degree of hazard evaluation is automatically conducted. If the hazard category database contains sufficient information, a degree of hazard rank would be assigned to the Special Waste Stream. If the hazard category database does not contain the appropriate information, then the specific types of required information would be listed. This information would be provided to the waste generator as well as to the appropriate Illinois governmental agency so that staff could search the national databases and/or scientific literature and update the HWRIC Degree of Hazard Database. The objectives of this study have been completed and the system is available for implementation by the Illinois Pollution Control Board. A degree of hazard evaluation can be conducted in a consistently fair manner with a high degree of accuracy. Those waste streams that pose a significant threat to the public health or the environment would have to be treated and disposed of in an appropriate manner. Those waste streams that pose a low hazard could be candidates for deregulation. The degree of hazard approach permits an estimate of hazard based on scientific evidence. The degree of hazard evaluation as described in this study has the added benefit of being relatively rapid while reducing subjectivity in the decision-making process. Finally, the evaluation can be economically positive in that those waste streams that demand more costly disposal techniques may be identified and separated from those waste streams that pose little hazard to human health and the environment.
EXECUTIVE SUMMARY

E1 INTRODUCTION

This project was conducted by the Institute for Environmental Studies of the University of Illinois at Urbana-Champaign under contract to the Hazardous Waste Research and Information Center, Illinois Department of Energy and Natural Resources. This research was a continuation of the project entitled Assigning a Degree of Hazard Ranking to Illinois Waste Streams (Plewa et al., 1986; 1988). Two degree of hazard studies demonstrated that the degree of hazard classification system provided a competent basis for classifying Illinois Special Wastes (Reddy, 1985; Plewa et al., 1986). The term Special Waste included all federally regulated hazardous wastes - defined by the Resource Conservation and Recovery Act (RCRA) - as well as industrial process wastes and pollution control wastes as defined by the State of Illinois (non-RCRA wastes).

The information contained in the Plewa et al. (1986) report indicated two immediate deficiencies in the degree of hazard methodology. They were

• the arbitrary basis upon which some of the hazard categories were defined (Reddy, 1985), and,

• the non-interactive computerized data management system used to conduct the degree of hazard evaluation (Plewa et al. 1986).

This research project was contracted by HWRIC to address these deficiencies and to make other improvements in the degree of hazard methodology.

Currently the Illinois Pollution Control Board is mandated to implement a degree of hazard system as stated in the Environmental Protection Act, Illinois Revised Statutes, ch. 111 1/2.

§22.9b. Following the completion of the Department’s study, (DENR) but not later than September 1, 1988 (extended to December 1989), the Pollution Control Board shall, pursuant to Title VII of the Act, adopt regulations that establish standards and criteria for classifying special wastes according to the degree of hazard1 or an alternative method.

1Italics added.
§22.9c. The Board shall adopt regulations by September 1, 1988, (extended to December 1989) establishing the standards and criteria by which the Agency may determine upon written request by any person that a waste or class of waste is not a special waste.

E2 OBJECTIVES

The objectives of this project were

- to define a rational and empirically defendable foundation for the accumulative toxicity scoring graphs,
- to transfer the database management system for degree of hazard evaluation from R:BASE 5000 to R:BASE System V,
- to generate a series of interactive menu templates for entering and conducting the degree of hazard evaluation, and
- to devise a formal procedure to employ national, toxicology and chemical databases for the periodic revision of the HWRIC Degree of Hazard Database.

E3 MODIFICATIONS TO THE DEGREE OF HAZARD SYSTEM

The primary purpose of this study was to refine the methodology presented in Assigning a Degree of Hazard Ranking to Illinois Waste Streams (Plewa et al., 1986). The degree of hazard evaluation process was based on a Special Waste screen and a series of hazard categories. The degree of hazard evaluation system was based upon five hazard categories of the waste stream: 1) toxicity (as modified by the environmental fate), 2) disease, 3) fire, 4) leaching agents, and 5) biological. However, the primary emphasis was on the potential toxicity hazard of a waste stream.

E3.1 Changes Incorporated for the 1988 Degree of Hazard System

A series of modifications were incorporated in the process that was used in the 1986 study. These modifications are described in some detail below.

E3.1.1 Removal of the Special Waste Screen

Plewa et al. (1986) recommended the removal of the Special Waste screen since it was an unnecessary exercise in a computerized degree of hazard system. The original purpose
of the Special Waste screen was to facilitate the manual processing of waste stream applications.

E3.1.2 Modifications in the Toxic Hazard Category

Since the degree of hazard system is driven primarily by the degree of toxic hazard, alterations introduced in this hazard category can have a profound influence on the final degree of hazard rankings of waste streams.

E3.1.2.1 Component Equivalent Toxicity

The equivalent toxic concentrations were calculated, with each waste stream component concentration normalized to an amount representing the same relative hazard/toxicity as a reference substance. The accumulative toxic concentration of the waste stream was the sum of the calculated proportional concentration of each component.

Our approach to the toxicity weighting was a variation, as well as a significant improvement, to that proposed by Reddy (1985). The method outlined by Reddy (1985) was based on a step function with definite boundaries, both high and low, on the toxicity measurements evaluated, as proscribed by his definitions.

The mathematical approach that we used to calculate the equivalent toxicity for individual components is presented below:

\[
\text{Component Equivalent Toxic Concentration} = \frac{\%Ck_2}{k_1T}
\]

Where: \(\%C\) is the concentration of the component as a percentage of the waste stream, 
\(T\) is a measure of the toxicity of the component (LD_{50}, LC_{50}), \(k_1\) is a proportional factor to enable comparisons among types of measurements of toxins (oral, inhalation, etc.), and \(k_2\) is a factor to provide a ratio in relation to a reference substance.

The presence of the proportional factor \((k_2/k_1)\) serves a dual purpose:

- to normalize different kinds of toxicity measurements from various toxicity assays (inhalation and dermal) to a standard level of toxicity (oral), and,
- to calculate a ratio of the component toxic hazard to that of a reference substance.
There is no lower boundary established on toxicity, so highly toxic compounds in trace quantities cannot "fall off the graph" (i.e., low levels of dioxin). Instead, their high relative toxicity can be more accurately represented. The above formula is based on a continuous function without the requirement of setting arbitrary levels.

E3.1.2.2 Waste Stream Equivalent Toxicity

The calculation of the waste stream equivalent toxicity was conducted by summing the equivalent toxicity values for all of the components of the waste stream. The equation that defines the waste stream equivalent toxicity is presented below:

\[
\text{Waste Stream Equivalent} = \sum \frac{\%C k_2}{T k_1 T}
\]

Where: \(\%C\) is the concentration of the component as a percentage of the waste stream, \(T\) is a measure of the toxicity of the component (LD_{50}, LC_{50}), \(k_1\) is a proportional factor to enable comparisons among types of measurements of toxins (oral, inhalation, etc.), and \(k_2\) is a factor to provide a ratio in relation to a reference substance. The equivalent toxic concentrations for each component of the waste stream were summed to calculate the waste stream equivalent toxic concentration.

The presence of the proportional factor \((k_2/k_1)\) serves a dual purpose:

- to factor different kinds of toxicity measurements from various toxicity assays (inhalation and dermal) to a standard level of toxicity (oral), and,
- to calculate a ratio of the component toxic hazard to that of a reference substance.

E3.1.2.3 Toxic Hazard Scoring Graph

We calculated the accumulative toxicity scoring graphs based on the hazard posed by a well-defined reference substance. The boundaries of the regions assigning the hazard levels should be drawn to reflect those situations where small changes in dose significantly alter the toxic effect on the test animal (e.g., lethality versus chronic illness; acute effect versus no effect). Thus, the value boundaries generated in the scoring graphs would represent real differences among hazard levels rather than the fact that our commonly used
numeric system is based on the number ten. However, due to insufficient information on all toxicity measurements for any selected reference compound, the research team decided to retain the order of magnitude relationship between regions of the scoring graph.

By establishing a ratio of the concentration of a waste stream component to a reference standard, the accumulative toxicity scoring graphs employ the reference toxins as objective standards based on the scientific literature for scoring actual risk. The objective of altering the accumulative toxicity scoring graphs was to base on scientific data the assessment of the toxic hazard posed by the components of a waste stream rather than base it on some arbitrary weight or volume criterion as was used in previous studies (Reddy, 1985; Plewa et al., 1986).

E3.1.2.4 Environmental Fate

The Environmental Fate Weighting Table was significantly modified from that used by Plewa et al. (1986). The source and rationale of the solubility values were not defined (Reddy, 1985). We devised and incorporated new definitions for the solubility terms based on data from United States Pharmacopeia and the solubility limits parallel the bioaccumulation/logP and persistence/half-life values.

We eliminated the environmental fate scoring graph that was based on the waste stream size because size is factored in with the toxicity of the waste stream. The environmental level values (EnvLev) for a waste stream were used to modify the accumulated toxicity score similar to that used in Reddy (1985) and Plewa et al. (1986). A step function is used in the EnvLev Table, while a continuous function is used in the toxicity weighting factor. Since environmental containments for waste streams at disposal sites are divided into classes based on the length of time of containment, a step function is a more useful application.

E3.1.2.5 Incorporation of the Carcinogen Potency Database, TD$_{50}$ Values

In order to improve the sensitivity of the degree of hazard system for dealing with carcinogenic agents, we implemented the use of the Carcinogenic Potency Database (Gold et al., 1984; 1986). This NIH-sponsored database contains data on approximately 3,000 long-term chronic animal experiments with approximately 800 chemicals. The numerical index of carcinogenic potency, the TD$_{50}$, is defined as "that dose rate (in mg/kg body weight/day) which, if administered chronically for a standard lifespan of the species, will halve the probability of remaining tumorless throughout that period." The working definition of TD$_{50}$ is that "for a given target site(s), if there are no tumors in control animals, then TD$_{50}$ is that chronic dose rate in mg/kg body weight/day which would induce tumors in half of the test animals at the end of the standard lifespan for the species (Gold et al., 1984). Using the previous degree of hazard methodology (Plewa et al., 1986) a waste stream component that is defined as a carcinogen is automatically rated as a high toxic hazard. No difference in the carcinogenic potency of a waste component was accounted for in the 1986 degree of hazard system. In this study the method was enhanced by directly
relating the TD₅₀ values and the rat-oral LD₅₀ values for the determination of the degree of toxic hazard (Zeise et al., 1984). Since both of these values are based on toxicity after oral exposure, the direct relationship is considered the best method to date.

E3.1.3 Modifications in the Disease Hazard Category

If a disease hazard was present in a waste stream, it was usually not evident in the application. Therefore, the disease hazard category was removed from the degree of hazard calculations and placed instead in the computerized input form as a "yes" or "no" entry. The definition of the disease hazard should be included in the application instructions to aid the applicant in making the correct waste management decision. Since the disease rating is independent of waste stream size, the degree of hazard program issues a ranking of "high" to those waste streams that pose a disease hazard.

3.1.4 Modifications in the Fire Hazard Category

The flash point of 140°F is required for a liquid waste to be regulated under RCRA. A fire hazard under the degree of hazard system requires a flash point between 141°F and 200°F for liquids; ≤130°F for solids. The fire hazard is determined by flash point only.

3.1.5 Modifications to the Leaching Hazard Category

The current degree of hazard system uses the limits of pH 4 and pH 10; however, in the 1986 report we used pH limits of ≤4 or ≥10 (Plewa et al., 1986). For clarity these limits have been established to pH confines of <4 or >10.

3.1.6 Modifications to the Biological Hazard Category

For the 1988 degree of hazard system, the Biological Hazard Category was eliminated because we were unable to establish a legal or scientific basis for this hazard category.

3.2 Computerized Database Management System Modifications

All of the degree of hazard computer programs were completely rewritten. This was done to incorporate the enhanced capabilities of the R:BASE for DOS. The computer programs required for the 1988 degree of hazard system are illustrated in Figure 1.

One of the objectives of this project was the development of a menu-driven format to enter information on the characteristics of a waste stream and the "real-time" generation of a degree of hazard ranking. The basis of the interactive design is the R:BASE System V application program referred to as DoHaz.App. DoHaz.App generates the menus for selection by the operator.
The main menu of DoHaz.App displays the following attributes.

- The ability to change or recover permit application forms.
- The option to add permit applications.
- The option to print the applications.
- The ability to add or change the substance information (toxicological, chemical and physical) to the database.
- The option to list the substances or unidentified components in the database.
- The ability to backup or copy a database.
- The option to exit the menu.

The modifications to the 1986 degree of hazard system (Reddy, 1985; Plewa et al., 1986) that are incorporated in this project have significantly simplified the degree of hazard evaluation system and reduced the computer time required to generate a ranking for a waste stream. These temporal improvements are essential in creating a truly interactive degree of hazard system that can be efficiently employed by State agencies and industry in the evaluation and regulation of Illinois Special Wastes.

E3.3 Summary of the Effect of the System Modifications to the Degree of Hazard Distribution of Ranks

A concise comparison of the effect of the modifications to the current degree of hazard system is presented in Figure 2. For comparison, three degree of hazard evaluations were performed. These evaluations were based on the level of comprehensiveness of the data set for the waste streams. The three degree of hazard evaluations were the degree of toxic hazard; the degree of hazard that included the toxic, fire and leach hazard categories; and the evaluation that included all hazard categories. Each degree of hazard evaluation has two views. The first view represents a control distribution that was generated using the Plewa et al. (1986) methods with the updated 1988 Toxicity Database. View two represents the composite of modifications that we implemented with this study. With the limited non-RCRA Special Waste database that was available to us, the degree of toxic hazard probably is the most informative distribution to illustrate the efficacy of the new degree of hazard system modification. While the Special Waste applications scoring "High" remain unaffected, a substantial broadening of the distribution in the other hazard ranks was observed with the 1988 modified version. The degree of hazard system was vastly improved in terms
of its simplicity, speed, verification, and operator ease; the sensitivity of the system was improved without inducing radical changes in the hazard rankings as compared to Plewa et al. (1986).

Figure 1 FLOW DIAGRAM OF THE COMPUTER PROGRAMS FOR THE DEGREE OF HAZARD PROJECT.
E4 CONCLUSIONS

We conclude that a degree of hazard evaluation of Illinois Special Waste Streams is an appropriate method to determine the impact of these wastes on public health and the environment. The degree of hazard system is quantitative in nature. To conduct a degree of hazard evaluation of Special Waste Streams it is necessary to have quantitative data of high quality. Although the quality of information contained in the Illinois 1984 Special Waste applications was generally poor, the data in recent Illinois Environmental Protection Agency Special Waste applications show a significant improvement.

It is our opinion that if the Illinois Environmental Protection Agency (IEPA) Special Waste Application forms were redesigned to accommodate our suggestions, the degree of hazard system would evolve into an exceedingly useful tool for State regulators as well as for industry. The degree of hazard system that we present here is designed to assist the regulatory and industrial communities in determining the best management approach for Illinois industrial Special Waste Streams. In addition, this report describes a system that can be used to evaluate the degree of hazard posed by Illinois Special Waste Streams as defined by State statutes. The degree of hazard system is now at the implementation stage, based on the realization that it is an evolving system that can adapt to an expanding database of increasing sophistication.

Figure 2. A comparison between the hazard rank distributions: 1986 (View 1), 1988 (View 2)
E5 RECOMMENDATIONS

E5.1 Methodology

Specific recommendations to modify the degree of hazard methodology as defined by Plewa et al. (1986) include the following.

- Applications that score an "Unknown" in hazard categories must be identified, and the information needed to assign a hazard rank obtained either by a more thorough description of the waste stream or by additional analysis of the hazardous properties of specific components.

- More rigorous attention must be paid to the proper typing of information on the IEPA Special Waste Application Forms and to proper spelling. The degree of hazard interactive computer system will identify some errors and notify the operator.

- The key components of a waste stream should approach 100%. Running the degree of hazard system will indicate when the waste stream does not comply with the above requirement. Also, regulators can adjust the level of error or unknown components within a waste stream that they feel is appropriate.

- Components of the waste stream must be listed individually rather than in groups. For all defined chemical components, the use of Chemical Abstract Service (CAS) numbers is necessary.

- Industry-wide toxicity standards should be developed for the evaluation of complex mixtures or for the components of complex mixtures. These standards will allow the use of defined generic names as specific components in the degree of hazard analysis.

- If toxicity data for specific components are not available from studies on laboratory rats and/or rabbits, any relevant data from any mammalian species should be used in the degree of hazard evaluation.

E5.2 IEPA Special Waste Application Form

The key to a competent degree of hazard evaluation is the quantity and quality of information that is required by the IEPA Special Waste Application. No evaluation strategy, no matter what its level of sophistication, can satisfactorily define the hazard to human health and the environment if the information on the application is inadequate or of poor quality. The Illinois Pollution Control Board is mandated to employ a degree of hazard evaluation of industrial waste streams. To facilitate this end, the IEPA Special
Waste Application Form must be redesigned so the information necessary for the degree of hazard evaluation can be provided by the waste generator. The HWRIC Degree of Hazard Application Data Form was designed to interface with the IEPA form (see Chapter 5).

Implementation of the following recommendations would reduce the number of waste streams ranked as "Unknown."

- Greater precision in component names is necessary. A requirement that each specific component name be listed with its CAS or Registry of Toxic Effects of Chemical Substances (RTECS) numbers is necessary for a degree of hazard analysis. The implementation of this recommendation would reduce the mistakes in identifying components, reduce the use of vague names by waste generators, and accelerate information retrieval.

- Allow for the inclusion of more than six components in a Special Waste application.

- Increase the space available on applications for individual component names.

- The application should have a "Yes"/"No" statement to indicate if the waste stream poses a disease hazard.

E5.3 Computerization of the Degree of Hazard System

The success of this study in analyzing the degree of hazard evaluation was based in large measure on the establishment of an interactive, menu-driven microcomputer database management system. Specific questions about and modifications to the degree of hazard process could be tested using the random sample of the Illinois non-RCRA Special Waste Streams used in the previous study (Plewa et al., 1986). To implement this system, the HWRIC Degree of Hazard Database must be expanded to include all of the components that make up the Illinois industrial waste streams.

The computerized Application Data Form is user-friendly. The program scans the application information and determines if a degree of hazard analysis can be conducted. The output indicates whether additional information is required or if the application is properly completed. The computer identifies the specific data deficiencies so that the waste generator is able to amend the application. When sufficient information is present, a degree of hazard evaluation is automatically conducted. If the hazard category database contains sufficient information, a degree of hazard rank would be assigned to the Special Waste Stream. If the hazard category database does not contain the appropriate information, then the specific types of required information would be listed so that staff
could search the national databases and/or scientific literature and update the HWRIC Degree of Hazard Database.

Such a hazard evaluation could be conducted in a consistent manner with a high degree of accuracy while reducing subjectivity in the decision-making process. Those waste streams that pose a significant threat to the public health or the environment would be disposed of in a highly controlled manner. Those waste streams that pose a low hazard could be candidates for deregulation. Thus, the degree of hazard system may serve to identify waste streams that should be delisted or exempted from regulations as Special Wastes. The degree of hazard approach permits an estimate of hazard based on scientific evidence. The degree of hazard evaluation as described in this study has the added benefit of being a rapid system. Finally, the evaluation can be economically positive in that those waste streams that demand more controlled disposal techniques may be identified and separated from those waste streams that pose little hazard to human health and the environment.
CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

1.1.1 Review of the 1986 Degree of Hazard Ranking Project

In 1986 a project entitled *Assigning a Degree of Hazard Ranking to Illinois Waste Streams* was conducted by the Institute for Environmental Studies at the University of Illinois at Urbana-Champaign under contract to the Hazardous Waste Research and Information Center, Illinois Department of Energy and Natural Resources (Plewa et al., 1986). This project encompassed an evaluation of a randomized sample of the 1,952 Resource Conservation Recovery Act (RCRA) Special Wastes and the 3,060 non-RCRA Special Wastes manifested for disposal in 1984 in Illinois to determine if a degree of hazard analysis could be implemented. The research team evaluated and modified the existing methodology contained in the report, *Special Waste Categorization Study* (Reddy, 1985) and implemented a degree of hazard evaluation. The term "Special Waste" includes all federally-regulated hazardous wastes as well as industrial process wastes and pollution control wastes as defined by the State of Illinois (non-RCRA wastes). A criticism that some have of the present Illinois regulatory system is that all Special Wastes have similar requirements for applications that allow their transport and disposal. The current system does not address the different environmental and health risks posed by these waste streams.

We concluded that the degree of hazard approach was an appropriate method to determine the impact of Illinois Special Waste streams upon the public health and environment. To conduct a degree of hazard evaluation of Special Waste streams it was necessary to have quantitative data of high quality. Unfortunately, the quality of information contained in the 1984 Illinois Environmental Protection Agency applications for waste disposal was poor. However, since our 1986 report was published, a significant improvement in the IEPA format and in the reporting of information is now included in the Special Waste applications (Appendix A). The revised Illinois Environmental Protection Agency application forms will have a positive effect on the implementation of the degree of hazard approach in Illinois.

Of singular importance is the fact that the Illinois Pollution Control Board is mandated to implement a degree of hazard (or a suitable alternative). As stated in the Environmental Protection Act, Illinois Revised Statutes, ch. 111 1/2.

§22.9b. Following the completion of the Department’s study, (DENR) but not later than September 1, 1988, (extended to December 1989) the Pollution Control Board shall, pursuant to Title VII of the Act, adopt regulations that establish standards
and criteria for classifying special wastes according to the degree of hazard\textsuperscript{2} or an alternative method.

§22.9c. The Board shall adopt regulation by September 1, 1988, (extended to December 1989) establishing the standards and criteria by which the Agency may determine upon written request by any person that a waste or class of waste is not a special waste.

The studies referred to in the Environmental Protection Act §22.9 refer to Reddy (1985) Plewa et al. (1986) and Plewa et al. (1988). In addition we (D. Ades-McInerney and M. Plewa) testified on behalf of HWRIC on the degree of hazard system before the Illinois Pollution Control Board on May 26, 1987 (Chicago) and on May 29, 1987. With the completion of the current project, we refined the degree of hazard system to the point that it can be implemented as required by the Illinois Pollution Control Board.

This report incorporates our improvements in the degree of hazard process (Plewa et al., 1986) and documents the effect that these alterations have on the sample of 1984 applications of non-RCRA Special Wastes.

1.1.2 Degree of Hazard Methodology

The degree of hazard evaluation as developed by Plewa et al. (1986) was conducted on the applications that were rated as having sufficient data by the binary screen and had passed the Special Waste screen. These screens were defined in Plewa et al. (1986). The applications were then processed by the database management system using a set of modifications that included the best estimate of component concentration, complex mixtures and the extended mammalian toxicity data range. The general approach of the Plewa et al. (1986) degree of hazard process is illustrated in Figure 3. The 1986 degree of hazard process served as the starting point for this project. The fundamental goals of the current project were, to define and document the scientific and/or legal basis for the hazard categories and to calibrate and improve the efficiency of the degree of hazard evaluation system.

In the 1986 report (Plewa et al., 1986) the degree of hazard analysis was conducted in two parts to ensure a reasonable database size. First a degree of hazard evaluation was conducted for applications in which a toxicity hazard ranking was known plus any other available hazard category. Secondly, an overall degree of hazard evaluation was conducted for applications that had a complete hazard ranking available.

\textsuperscript{2}Italics added.
1.1.2.1 Degree of Hazard Evaluation in which Only the Toxicity Hazard Category was Required

Two hundred and twelve RCRA Special Waste applications passed the binary screen and were processed through the Special Waste screen. Two hundred and two RCRA Special Waste applications contained sufficient data to determine their toxicity hazard, contained some data in the other hazard categories and were available for the degree of toxic hazard evaluation. Thus, 95.3% of the RCRA applications were suitable for analysis at this level of evaluation. The applications were aligned into three hazard ranks.
"Unknown", "High" and "Moderate" with percentages of 40.6%, 56.4% and 3.0%, respectively (Figure 4).

One hundred and sixty-eight non-RCRA Special Waste applications passed the binary screen and were processed through the Special Waste screen, with 135 applications designated as having some hazard and requiring a degree of hazard evaluation. Those applications that did not proceed through the degree of toxic hazard evaluation included four applications that had "No" scores in all hazard categories, and 29 applications that contained one or more "Unknown" scores in the hazard categories. Thus, 80.4% of the non-RCRA applications were suitable for analysis at this level of evaluation. Four hazard ranks were populated by the non-RCRA applications. The largest percentage of non-RCRA applications were ranked as "Unknown" (59.3%) followed by the hazard level ranks of "High" (32.6%), "Moderate" (8.1%), and, "None" (2%) (Figure 5).

1.1.2.2 Degree of Hazard Evaluation in which All Hazard Categories were Required

For the RCRA applications that were involved in the complete degree of hazard evaluation, 82.2% were ranked as "Unknown" hazard, 15.3% were ranked as "High" hazard and 2.5% were ranked as "Moderate" hazard. None of the applications were ranked as "Low," "Negligible" or "No" hazard (Figure 4).
A similar pattern for the complete degree of hazard evaluation for the non-RCRA applications occurred. The hazard rank that contained the largest percentage of applications was the "Unknown" hazard rank with 67.4%, followed by the "High" hazard rank with 24.4%, the "Moderate" hazard rank with 8.1%, and the "No" hazard rank with 2.4% (Figure 5). This distribution of the degree of hazard ranking for the non-RCRA sample applications is the control for the comparative analysis of the effect of the modifications that we instituted in the degree of hazard process. For every major modification in the degree of hazard process that we conducted in this study, a comparison of the resulting distribution was analyzed with the control distribution.

1.1.2.3 Deficiencies in the 1984 Applications Database

In Plewa et al. (1986), the high level of data deficiencies lead to an unsatisfactorily high frequency of the non-RCRA samples to be ranked as "Unknown." The information presented in Figures 6 and 7 was derived from the data published in Plewa et al. (1986). Note the distribution of the missing data component for the specific hazard categories (Figure 6) and for the type of toxicity data (Figure 7). The major difficulty in assigning a degree of hazard ranking for Illinois waste streams was the lack of basic descriptive data. We attempted to resolve some of these problems by determining the need for each data type in the degree of hazard procedure and by offering suggestions in the use of defined generic names to describe waste stream components.
With the high percentage of applications that rank as "Unknown" in the complete degree of hazard evaluation, it is clear that a limitation exists with the quantity and quality of information that is available on the Illinois Special Waste applications.

The data deficiencies were classified into three categories: 1) missing information that was required on the Special Waste application form, 2) data that were necessary for the degree of hazard evaluation but not requested on the Special Waste application form (Figure 6), and 3) data on specific components of a waste stream that were necessary for the toxicity hazard category but were not available in the published scientific literature (Figure 7).

1.2 DESCRIPTION OF PROJECT

1.2.1 Introduction

This research was a continuation of the Plewa et al. (1986) study. Two degree of hazard studies demonstrated that the degree of hazard classification system provided a competent basis for classifying wastes (Reddy, 1985; Plewa et al., 1986).
The information contained in the Plewa et al. (1986) report indicated two immediate deficiencies in the degree of hazard methodology. They are

- the arbitrary basis upon which some of the hazard categories were defined (Reddy, 1985), and,
- the non-interactive computerized data management system used to conduct the degree of hazard evaluation (Plewa et al. 1986).

This research project was contracted by HWRIC to address these deficiencies and to make other improvements in the degree of hazard methodology.

![Figure 7](image)

**Figure 7** Data deficiencies in the 1986 study samples for information that was required for the toxic hazard category.
1.2.2 Objectives

The objectives of this project were

- to define a rational and empirically defendable foundation for the accumulative toxicity scoring graphs,

- to transfer the database management system for degree of hazard evaluation from R:BASE 5000 to R:BASE System V,

- to generate a series of interactive menu templates for entering and conducting the degree of hazard evaluation,

- to devise a formal procedure to employ national, toxicology and chemical databases for the periodic revision of the HWRIC Degree of Hazard Database.
CHAPTER 2: THE DEGREE OF HAZARD EVALUATION PROCESS

2.1 1986 DEGREE OF HAZARD PROCESS

The primary purpose of this study was to refine the methodology presented in Assigning A Degree of Hazard Ranking to Illinois Waste Streams (Plewa et al., 1986). The degree of hazard evaluation process was based on a Special Waste screen and a series of hazard categories.

2.1.1 Special Waste Screen

Reddy (1985) employed a Special Waste screen prior to conducting their version of the degree of hazard evaluation. The purpose of the Special Waste screen was to provide a rapid means for determining whether a waste stream was of negligible hazard and thus, not subject to the degree of hazard evaluation. The same information required to conduct the Special Waste screen was also needed to perform the degree of hazard evaluation. The Special Waste screen was a qualitative analysis while the degree of hazard evaluation was a quantitative analysis.

The degree of hazard evaluation required information based on characteristics of the waste stream as a whole and on each of the identifiable individual components of the waste stream. With the large number of applications evaluated, a database management system was required to control the extensive information base. The database management system, R:BASE 5000 by Microrim, was used with an IBM-AT microcomputer. Using the database management system, a set of five different tables was prepared that contain information used in the different elements of the degree of hazard study. These database tables were designed to interact with each other based on a common feature, such as authorization number or component name.

2.1.2 Hazard Categories

The degree of hazard evaluation system was based upon five hazard categories of the waste stream: 1) toxic hazard (as modified by the environmental fate), 2) disease hazard, 3) fire hazard, 4) leaching agent hazard, and 5) biological hazard. However, the primary emphasis was on the potential toxicity hazard of a waste stream.

2.1.2.1 Toxic Hazard Category

Reddy (1985) established three criteria for the evaluation of the toxicity hazard. These criteria are:
1) Chronic toxicity.
   • The identification of a carcinogenic or mutagenic component in the waste stream.

2) Environmental toxicity.
   • The aquatic toxicity measured as LC$_{50}$ (fish) after 48 hours or 96 hours of exposure.

3) Acute toxicity.
   • The oral LD$_{50}$ for rats,
   • the inhalation LC$_{50}$ for rats, and
   • the dermal LD$_{50}$ for rabbits.

To evaluate the toxicity of a waste stream component, data are required for at least one component of each of the three criteria.

A component of a waste stream was considered to be a carcinogen if it was listed in The Annual Report on Carcinogens published by the National Toxicology Program, National Institute for Environmental Health Sciences. Similarly, a waste component was labeled as a mutagen if it was determined to be positive or weakly positive on any of five tests for mutagenicity annually reported by the National Toxicology Program in the National Toxicology Annual Plan. In addition, the mutagenicity screening results published in Environmental and Molecular Mutagenesis and in the Genotoxicology Section of Mutation Research were used to identify mutagens.

The criteria employed for the environmental and acute toxicity evaluation were searched from a series of reference materials. The primary source was the National Library of Medicine Toxicology Data Network (1986). This network included the databases of the National Institute for Occupational Safety and Health (NIOSH, 1983; 1985), Registry of Toxic Effects of Chemical Substances (RTECS), ToxNet and additional sources. Information on the carcinogenic properties of components was obtained from the National Toxicology Program (NTP, 1983; 1985). A serious effort was made in the search for toxicity data for those components which were not listed in the national databases or for which the databases did not contain data on the specific criteria required by Reddy (1985). Additional sources searched were: Sax's sixth edition of Dangerous Properties of Industrial Materials (1984), the Chemical Hazard Response Information System Hazardous Chemical Data VII, Chemical Engineers' Handbook (Perry, 1973), The Merk Index (1983), Handbook of Chemistry and Physics (1972), Handbook of Environmental Data on Organic Chemicals (1983), and Chemical Abstracts.
The toxicity data obtained for each component were adjusted according to the sensitivity of the response into one of five weighting factor levels. The levels were spaced by one order of magnitude in the toxicological response. The toxicity weighting factor levels developed by Reddy (1985) and used by Plewa et al. (1986) and in this study are presented in Table 1.

Table 1. Toxicity Weighting Table

<table>
<thead>
<tr>
<th>Weighting Factor Level</th>
<th>Chronic Toxicity</th>
<th>Aquatic LC_{50} ppm</th>
<th>Oral-Rat LD_{50} mg/kg</th>
<th>Inhalation mg/l</th>
<th>Dermal-Rabbit LD_{50} mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 1.0 Carcinogens Mutagens</td>
<td>&lt;0.1</td>
<td>&lt;0.5</td>
<td>&lt;0.02</td>
<td>&lt;2</td>
<td></td>
</tr>
<tr>
<td>B 0.1</td>
<td>0.1-1</td>
<td>0.5-5</td>
<td>0.02-0.2</td>
<td>2-20</td>
<td></td>
</tr>
<tr>
<td>C 0.01</td>
<td>1-10</td>
<td>5-50</td>
<td>0.2-2</td>
<td>20-200</td>
<td></td>
</tr>
<tr>
<td>D 0.001</td>
<td>10-100</td>
<td>50-500</td>
<td>2-20</td>
<td>200-2000</td>
<td></td>
</tr>
<tr>
<td>E 0.0001</td>
<td>100-1000</td>
<td>500-5000</td>
<td>20-200</td>
<td>2000-20000</td>
<td></td>
</tr>
</tbody>
</table>

With the methodology described by Reddy (1985), components for which no data were available for any of the three toxicity criteria would be placed in the highest weighted toxicity level, "A". This conservative approach insured that unknown, yet potentially hazardous components received an appropriate toxicity ranking. This approach also resulted in higher degree of hazard rankings for those waste streams that contained innocuous components for which there were no toxicity values available. In Plewa et al. (1986), unknown components were not assigned to the "A" toxicity level but were labeled as "unknown". The ranking of unknowns as "High" would mask the actual distribution of waste streams into the various categories of the degree of hazard evaluation.

The toxic equivalent concentration was calculated for each waste stream according to the formula presented by Reddy (1985). The toxic equivalent concentration was expressed as a percentage for all components in a waste stream. The summation of each toxicity level was divided by the weighting factor and these adjusted concentrations were summed to calculate the percent toxic equivalent concentration. The toxic equivalent concentration was calculated by the following equation:

\[
\text{Tox. Equiv. Conc.}(\%) = \sum A\% + \frac{\sum B\%}{10} + \frac{\sum C\%}{100} + \frac{\sum D\%}{1,000} + \frac{\sum E\%}{10,000}
\]
All of the calculations were performed by computer.

The accumulative toxicity scoring was also calculated automatically by computer. The accumulative toxicity graphs were divided into four areas of potential toxicity (Figure 8). The accumulative toxicity scoring graph was divided into areas on an arbitrary basis (Reddy, 1985).

![Accumulative Toxicity Scoring Graph](image)

**Figure 8** The stringent interpretation of the accumulative toxicity scoring graph (Reddy, 1985).

The environmental fate determination was designed to modify the toxicity ranking determined by the accumulative toxicity graph. There were four toxicity scores, 0, 1, 2, and 3. Waste streams that scored a "0" on the accumulative toxicity graph were automatically ranked in the low hazard category and were not subjected to the environmental fate scoring. Waste streams scoring a "3" on the toxicity graph were ranked "high" and were not subjected to environmental fate scoring. Waste streams that received intermediate scores were evaluated by the environmental fate determination and, thus, were subject to having their degree of hazard ranking modified.

For the environmental fate determination, waste stream components were rated according to three criteria.

- Bioaccumulation. Measured as the log 10 of the n-octanol/water partition coefficient (log P).
- Persistence. Measured as the half-life of the chemical in soil or water (T½).
- Solubility. Measured as ppm in water.

The environmental fate score was calculated similarly to the toxicity score. Each component was assigned a weighting factor as presented in Table 2. The environmental fate equivalent concentration was added using the equation:

\[ \text{Environ. Fate Equiv. % Conc.} = \Sigma A\% + \Sigma B\%/10 + \Sigma C\%/100 + \Sigma D\%/1,000 + \Sigma E\%/10,000 \]

This value, along with the weight of the waste stream, was plotted on the corresponding environmental fate scoring graph (Reddy, 1985).

Data were required on at least one of the three criteria to perform the environmental fate determination. The data define a weighting factor level used for determining an environmental fate equivalent concentration. Reddy (1985) provided an alternate weighting table which was used to estimate persistence for components for which no data on the three criteria were found (Table 3).

The accumulative environmental fate scoring was also performed by computer analysis by relating the waste stream quantity with its environmental fate equivalent concentration.

Table 2. Environmental Fate Weighting Table from the Special Waste Categorization Study (Reddy, 1985)

<table>
<thead>
<tr>
<th>Level</th>
<th>Bioaccumulation log P</th>
<th>Persistence Half Life</th>
<th>Solubility ppm in Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>≥6</td>
<td>≥10 yrs</td>
<td>500+</td>
</tr>
<tr>
<td>B</td>
<td>5-6</td>
<td>1 yr-10 yrs</td>
<td>100-499</td>
</tr>
<tr>
<td>C</td>
<td>4-5</td>
<td>1 month-1 yr</td>
<td>50-99</td>
</tr>
<tr>
<td>D</td>
<td>3-4</td>
<td>3 days-1 month</td>
<td>10-49</td>
</tr>
<tr>
<td>E</td>
<td>&lt;3</td>
<td>&lt;3 days</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>
Table 3. Alternate Weighting Table for Persistence from the Special Waste Categorization Study (Reddy, 1985).

<table>
<thead>
<tr>
<th>Waste Stream Components</th>
<th>Persistence Half Life in Soil or Water</th>
<th>Weighting Factor Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy metals, inorganic oxides, inorganic salts, asbestos, clays, plastics, polymers</td>
<td>≥10 yrs</td>
<td>A</td>
</tr>
<tr>
<td>Pesticides, biphenyls, resins, halogenated hydrocarbons, oils, fats, greases, pigments, paper products, phthalate esters, polyaromatic hydrocarbons.</td>
<td>1-10 yrs</td>
<td>B</td>
</tr>
<tr>
<td>Simple nonhalogenated benzenes, nonhalogenated cyclic hydrocarbons, nonhalogenated straight chain and branched hydrocarbons (&gt;10 carbons).</td>
<td>1 month-1 yr</td>
<td>C</td>
</tr>
<tr>
<td>Nonhalogenated straight chain and branched hydrocarbons (≤10 carbons).</td>
<td>3 days-1 month</td>
<td>D</td>
</tr>
<tr>
<td>Nonhalogenated, oxygen containing simple hydrocarbons (1-4 carbons).</td>
<td>≤3 days</td>
<td>E</td>
</tr>
</tbody>
</table>

Following the toxicity evaluation each waste stream was then evaluated by four additional characteristics. These hazard categories were: disease hazard, fire hazard, leaching hazard and biological hazard.

2.1.2.2 Disease Hazard Category

The criteria for determining the disease hazard of a waste stream was defined by Reddy (1985) as the presence of material of human contact in the waste stream (IL Title 35, Subtitle G, Chapter 1, §809.901).

2.1.2.3 Fire Hazard Category

The determination of the fire hazard was dependent on the phase of the waste stream. Liquid waste streams were assessed according to their ignitability. The definition for ignitability was based on the flash point. Since the flash point was listed on the application, the fire hazard of liquid waste streams was easy to assess.
The fire hazard posed by solid waste streams was more difficult to determine. Reddy (1985) delineated seven criteria for assessing the fire hazard of the solid materials. Toxnet was searched for fire potential and decomposition and these two categories encompassed most of the seven criteria. The flash point on the application could be used for determining pyrophoric solids. Much of solid waste stream fire potential was based on component information. The fire potential of liquids was based on the waste stream as a whole. Evaluations based on the entire waste stream can account for the interaction of components and their concentrations. This was preferable to assessing fire potential on a component basis. Ideally, the fire hazard evaluation would be determined by the generator or an outside laboratory and reported on the application.

The fire hazard evaluation was dependent on the waste stream mass (Table 4). Waste streams determined to pose a fire threat and containing a quantity exceeding 1,200 kg a year were ranked as a high degree of hazard, regardless of their previous toxicity ranking. There were 9.2% of non-RCRA and 7.3% of RCRA waste streams which ranked as a high degree of hazard based on their fire hazard evaluation.

### 2.1.2.4 Leaching Hazard Category

The criteria for leaching agent hazard was based upon the pH of the waste stream. Since this information was contained in the application it was readily available and the leaching hazard was easily assessed. The evaluation was also based on waste stream mass. A leaching hazard with a quantity exceeding 1,200 kg was ranked as a moderate hazard. A moderate leaching hazard that also has a moderate toxicity hazard remained in the moderate hazard degree rank.

<table>
<thead>
<tr>
<th>Hazard Category</th>
<th>Mass (kg)</th>
<th>Hazard Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire</td>
<td>&gt;1200</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>&lt;1200</td>
<td>Low</td>
</tr>
<tr>
<td>Leaching Agent</td>
<td>&gt;1200</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>&lt;1200</td>
<td>Low</td>
</tr>
<tr>
<td>Disease</td>
<td>any volume</td>
<td>High</td>
</tr>
<tr>
<td>Biological</td>
<td>&gt;100,000</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>10,000-100,000</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>&lt;10,000</td>
<td>Low</td>
</tr>
</tbody>
</table>
2.1.2.5 Biological Hazard Category

The biological characteristics evaluation was based on four criteria.

- High biological oxygen demand.
- Evolution of methane or hydrogen sulfide gases.
- Attraction of biological vectors.
- Generation of obnoxious odors.

These four criteria were not well defined by Reddy (1985). The suggested source of information was simply from the waste stream application. This information was not sufficient. No specific quantitative measure was given for constituting a BOD value which designated a high hazard ranking.

For each application, the hazard rankings from each hazard category were compared and the highest value was assigned as the overall hazard rank (Figure 3).

2.2 SCIENTIFIC AND/OR LEGAL RATIONALE FOR DEFINITIONS AND RANKINGS FOR THE DEGREE OF HAZARD CATEGORIES

2.2.1 Definitions and Rank Assignments for the Hazard Categories used in the 1986 Degree of Hazard Process

The Illinois Pollution Control Board held two hearings in Chicago and Springfield on May 26 and 29, 1987, respectively, on the implementation of a degree of hazard evaluation system for Illinois industrial waste streams. It was noted that the scientific and legal criteria involved in setting the hazard values for the degree of hazard categories were not well documented. For this project the research team examined the basis for the definition and the limits of components for waste streams for hazard ranks for each hazard category that were used in Reddy (1985).

The Plewa et al. (1986) degree of hazard evaluation process was established using the five hazard categories that were presented in Reddy (1985).

- Toxic Hazard
- Disease Hazard
• Fire Hazard
• Leaching agent Hazard
• Biological Hazard.

2.2.1.1 Toxic Hazard Category

Reddy (1985) provided a table that related oral, dermal, aquatic and inhalation toxicity. The Toxicity Weighting Table (§2.1.2.1, Table 1) was derived from the following sources.

- The factors relating levels of oral, dermal, aquatic and inhalation toxicities came from RCRA, 40CFR, Chapter 1 §261.11 and from the Washington State Dangerous Waste Regulations (1986).
- The oral toxicity value (rat LD$_{50}$) that is considered to be of no hazard was ≤5,000 mg/kg. This value was based on the Washington State Dangerous Waste Regulations (1986).
- The strategy of listing carcinogens and mutagens as derived from the Michigan Priority Ranking System (1983) although a different ranking scheme was used.

The other parts of the Toxicity Hazard Category were derived from the following sources.

- The toxic equivalent concentration formula (§2.1.2.1.2.) was from the Washington State Dangerous Waste Regulations (1986).
- The accumulative toxicity scoring graph was derived from the Washington State Dangerous Waste Regulations (1986). The axes are identical to those used by Washington State (the size of the waste stream (kg/year) versus the toxic equivalent concentration value), however, the boundaries that define the toxicity scores implemented by Reddy (1985) differ.
- The bioaccumulation component of the environmental fate calculations was based on the log-10 of the n-octanol/water partition coefficient and was similar to that used in the Michigan Priority Ranking System (1983).

2.2.1.2 Disease Hazard Category

The disease hazard category was based on the Illinois definition of infectious waste, Title 35, Subtitle G, Chapter 1, §809.901.
2.2.1.3 Fire Hazard Category

The fire hazard rankings were based on the 1984 RCRA Small Generator Exemption where RCRA regulations do not apply to waste generators with waste streams of less than 100 kg per month. The value of 1,200 kgs per year used by Reddy (1985) was derived from this standard. The degree of hazard for a flammable waste is based on the size of the waste stream with a low fire hazard being below 1,200 kg, while the high fire hazard rank is assigned to a waste stream above 1,200 kg.

The flash point for liquid wastes was defined if a fire hazard existed. A liquid waste with a flash point of ≥140°F falls under RCRA regulations (40 CFR, Chapter 1, §261.21). If the flash point was between 140°F and 200°F it was ranked as a fire hazard under the degree of hazard ranking (JRB Associates in their hazard waste evaluation scheme 1982). A liquid waste flash point <200°F was ranked as no fire hazard based on the upper limit of the U.S. Department of Transportation definition of an ignitable liquid. The flash point of <130°F for a solid waste was required for rating as a fire hazard (Department of Transportation definition of a flammable solid).

2.2.1.4 Leaching Hazard Category

The RCRA regulation covers waste streams that have a pH of <2 or >12.5 (40 CFR, Chapter 1, §261.22). The hazard criteria were extended in Reddy (1985) to waste streams with a pH of <4 or >10. The rationale for more stringent criteria were not defined. The degree of hazard ranking was based on the 1984 RCRA Small Generator Exemption of 100 kg per month or ≤1,200 kg per year.

2.2.1.5 Biological Hazard Category

No scientific and/or legal bases for the Biological hazard criteria were found.

2.2.1.6 Summary

The above documentation for the criteria that were used in the hazard categories as defined in Reddy (1985) and used in the 1986 degree of hazard system (Plewa et al., 1986) is presented as a reference for the scientific and/or legal validity of the degree of hazard evaluation process.

2.3 CHANGES INCORPORATED FOR THE 1988 DEGREE OF HAZARD PROCESS

In refining the degree of hazard methodology a series of modifications were incorporated in the process that was used in the 1986 study. The following section details each alteration and the effect of each of the changes is analyzed in Chapter 3.
2.3.1 Removal of the Special Waste Screen

Plewa et al. (1986) recommended the removal of the Special Waste screen since it was an unnecessary exercise in a computerized degree of hazard system. The purpose of the Special Waste screen was to facilitate the manual processing of waste stream applications. With the removal of the screen from the degree of hazard process the computer time to process the 1984 non-RCRA applications was reduced by 50%. Secondly, the number of applications scoring a "no hazard" ranking increased. The grouping of data in the Special Waste screen is different than in the actual degree of hazard system. The Special Waste Screen required qualitative information for three toxicity categories (chronic toxicity—cancer, acute toxicity and aquatic toxicity). The degree of hazard system merges these three classes into a single toxicity category. Thus the lack of information in one toxic characteristic of a waste stream can be related to information present in another toxic characteristic. This alteration caused a few applications that were ranked as "No Hazard—but some unknowns" to simply "No Hazard".

2.3.2 Modifications in the Toxic Hazard Category

Since the degree of hazard system is driven primarily by the degree of toxic hazard, alterations introduced in this hazard category can have a profound influence in the final degree of hazard rankings of waste streams. Therefore each change, however minor, is presented in detail. Also one of the objectives of this project was to address the arbitrary nature of the Equivalent Toxicity Scoring Graph presented in Reddy (1985) and used in the 1986 degree of hazard system (Plewa, et al., 1986).

2.3.2.1 Calculation of Component Equivalent Toxicity

The equivalent toxic concentrations were calculated, where the waste stream component concentration was normalized to an amount representing the same relative hazard/toxicity as a reference substance. The accumulative toxic concentration of the waste stream was the sum of the calculated proportional concentration of each component.

Our approach to the toxicity weighting was a variation, as well as a significant improvement, to that proposed by Reddy (1985). The method outlined by Reddy (1985) is based on a step function with definite boundaries, both high and low, on the toxicity measurements evaluated, as proscribed by the level definitions. The levels were spaced by one order of magnitude in the toxicological response. The level assignments appear to have been adjusted such that the middle level "C" has the same toxicological response as referenced in the RCRA listing criteria (Title 40 CFR, Chapter 1, §261.33). The toxicity weighting factor levels proposed by Reddy (1985) are presented in Table 1.

The equational form that was used to calculate the equivalent toxicity for individual components is presented below:
Component Equivalent = \%C_k_2
Toxic Concentration = [ \ldots ]
k_1T

Where: \%C is the concentration of the component as a percentage of the waste stream, 
T is a measure of the toxicity of the component (LD_{50}, LC_{50}), k_1 is a proportional factor to enable comparisons among types of measurements of toxins (oral, inhalation, etc.), and k_2 is a factor to provide a ratio in relation to a reference substance.

The presence of the proportional factor (k_2/k_1) serves dual purposes, 1) to normalize different kinds of toxicity measurements from various toxicity assays (inhalation and dermal) to a standard level of toxicity (oral) and, 2) to calculate a ratio of the component toxic hazard to that of a reference substance. Reddy (1985) addressed this problem by adjusting the toxicity data obtained for each component according to the sensitivity of the response into one of five weighting factor levels. However, we propose to keep the upper boundary on the toxicity so that components that require huge concentrations before inducing a threat to the environment or human health would not require regulation. There is no lower boundary established on toxicity so highly toxic compounds in trace quantities cannot "fall off the graph" (i.e. low levels of dioxin). Instead their high relative toxicity can be more accurately represented. The above formula advanced in this report is based on a continuous function without the requirement of setting arbitrary levels. The sources that were used in defining this system in which copper sulfate was used as a reference included Boyden (1938), Wiederandders (1968), Gosselin (1976), Seawright (1982), Wagner (1983) and Mukhopadhyay (1984). Figure 9 illustrates the toxicity weighting factors versus the toxicity. The abscissa is the oral toxicity correlation of the waste stream component while the ordinate is the weighting factor or relative toxicity. The process to obtain the toxicity weighting factor uses the following method:

1) Enter all of the toxicity data for the waste component (chronic, acute, aquatic, dermal).
2) Convert the toxicity data into the equivalent oral toxicity using the relationships in Table 1.
3) The database management system selects the lowest, most toxic value of the component (ToxLev of R:BASE System V Table COMPONET).
4) Calculate the relative toxicity of the compound by dividing it into the reference compound toxicity (Relative toxicity = T_{ref}/T_{c} e.g. the smaller the toxicity, the greater the relative toxicity).
2.3.2.2 Calculation of the Waste Stream Equivalent Toxicity

The calculation of the waste stream equivalent toxicity was conducted by summing the equivalent toxicity values for all of the components of the waste stream. The equation that defines the waste stream equivalent toxicity is presented below:

\[
\text{Waste Stream Equivalent Toxicity} = \sum \left( \frac{\%C_k T_k}{k_2} \right)
\]

Where: \(\%C\) is the concentration of the component as a percentage of the waste stream, \(T\) is a measure of the toxicity of the component (\(LD_{50}, LC_{50}\)), \(k_1\) is a proportional factor to enable comparisons among types of measurements of toxins (oral, inhalation, etc.), and \(k_2\) is a factor to provide a ratio in relation to a reference substance. The equivalent toxic concentrations for each component of the waste stream were summed to calculate the waste stream equivalent toxic concentration.
The presence of the proportional factor \((k_2/k_1)\) serves dual purposes, 1) to factor different kinds of toxicity measurements from various toxicity assays (inhalation and dermal) to a standard level of toxicity (oral) and, 2) to calculate a ratio of the component toxic hazard to that of a reference substance.

2.3.2.3 Toxic Hazard Scoring Graph

We calculated the accumulative toxicity scoring graphs based on the hazard posed by a well defined reference substance. The boundaries of the regions assigning the hazard levels should be drawn to reflect those situations where small changes in dose significantly alter the toxic effect on the test animal (e.g. lethality versus chronic illness; acute effect versus no effect). Thus, the value boundaries generated in the scoring graphs would represent real differences among hazard levels rather than the fact that our commonly used numeric system is based on the number ten. However, due to insufficient information on all toxicity measurements for any selected reference compound, the research team decided to retain the order of magnitude relationship between regions of the scoring graph.

The modified Equivalent Toxicity Scoring Graph is presented in Figure 10. The position of the boundary between moderate and High was altered to reflect that mass amount of the reference substance equal to 100% of the reference substance at the RCRA Small Generator limit (100 kg). The other boundaries increased by a factor of 10. The use of waste stream size as a factor in scoring the toxicity of a waste component was desirable to encourage waste volume reduction.

![Equivalent Toxicity Scoring Graph](image-url)
By establishing a ratio of the concentration of a waste stream component to a reference standard the accumulative toxicity scoring graphs employ the reference toxins as objective standards based on the scientific literature for scoring actual risk. The objective of altering the accumulative toxicity scoring graphs was to base the assessment of the toxic hazard posed by the components of a waste stream on scientific data rather than on some arbitrary weight or volume criterion as was used in previous studies (Reddy, 1985; Plewa et al., 1986).

2.3.2.4 Environmental Fate

The Environmental Fate Weighting Table has been significantly modified from that used in the 1986 report (Table 2). The source and rationale of the solubility values in Table 2 were not defined (Reddy, 1985). The solubility values that Reddy (1985) used were not in a log-order relationship as were the bioaccumulation and persistence values. It appears that Reddy (1985) based the solubility values on the JRB Associates report (1982). However, that report used qualitative ratings of, "insoluble, sightly soluble, soluble, very soluble." In Table 5 a quantitative limit of the qualitative descriptions of solubility is presented (United States Pharmacopeia, 1985)

Table 5. Solubility Ranges for the 1988 Environmental Fate Weighting Table.

<table>
<thead>
<tr>
<th>Description</th>
<th>Solvent/Solute</th>
<th>g/l</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
<td>Max</td>
</tr>
<tr>
<td>Very Soluble</td>
<td>--</td>
<td>&lt;1</td>
<td>--</td>
</tr>
<tr>
<td>Freely Soluble</td>
<td>1</td>
<td>10</td>
<td>1000</td>
</tr>
<tr>
<td>Soluble</td>
<td>10</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>Sparingly Soluble</td>
<td>30</td>
<td>100</td>
<td>33.3</td>
</tr>
<tr>
<td>Slightly Soluble</td>
<td>100</td>
<td>1000</td>
<td>10</td>
</tr>
<tr>
<td>Very Slightly Soluble</td>
<td>1000</td>
<td>10000</td>
<td>1</td>
</tr>
<tr>
<td>Practically Insoluble or Insoluble</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;10000</td>
<td>--</td>
<td>&lt;0.1</td>
</tr>
</tbody>
</table>

23
The above United States Pharmacopeia (1985) definitions for the solubility terms were incorporated with the previously defined levels in Table 2. The solubility limits parallel the bioaccumulation/logP and persistence/half-life values. The Revised Environmental Fate Weighting Table is presented in Table 6.

Table 6. Revised Environmental Fate Weighting Table.

<table>
<thead>
<tr>
<th>Level</th>
<th>Bioaccumulation (log P)</th>
<th>Half life (days)</th>
<th>Reddy (1985) ppm</th>
<th>Plewa et al. (1988) ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt;6</td>
<td>&gt;3650</td>
<td>&gt;500</td>
<td>&gt;100000</td>
</tr>
<tr>
<td>B</td>
<td>5-6</td>
<td>365-3650</td>
<td>100-500</td>
<td>10000-100000</td>
</tr>
<tr>
<td>C</td>
<td>4-5</td>
<td>30-365</td>
<td>50-100</td>
<td>1000-10000</td>
</tr>
<tr>
<td>D</td>
<td>4-3</td>
<td>3-30</td>
<td>10-49</td>
<td>100-1000</td>
</tr>
<tr>
<td>E</td>
<td>&lt;3</td>
<td>&lt;3</td>
<td>&lt;10</td>
<td>&lt;100</td>
</tr>
</tbody>
</table>

Since the waste stream size is already factored in with the toxicity of the waste stream, the environmental fate scoring graph using waste stream size was eliminated. The environmental fate (Envlev) is generated from Table 7, a simplified version of Table 6.

Table 7 The Environmental Level Table (Envlev)

<table>
<thead>
<tr>
<th>EnvLev</th>
<th>Effect</th>
<th>Bioaccumulation (log P)</th>
<th>Persistence (days)</th>
<th>Solubility (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Tox + 1</td>
<td>&gt;5</td>
<td>&gt;365</td>
<td>&gt;10,000</td>
</tr>
<tr>
<td>2</td>
<td>--</td>
<td>5-4</td>
<td>30-365</td>
<td>1,000-10,000</td>
</tr>
<tr>
<td>1</td>
<td>Tox - 1</td>
<td>&lt;4</td>
<td>&lt;30</td>
<td>&lt;1,000</td>
</tr>
<tr>
<td>0</td>
<td>-- innocuous substances, no effect --</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The environmental level values (EnvLev) for a waste stream were used to modify the accumulated toxicity score similar to that used in Reddy (1985) and Plewa et al. (1986). A step function is used in the EnvLev Table while a continuous function is used in the
toxicity weighting factor. Since environmental containments for waste streams at disposal sites are divided into classes based on the length of time of containment, a step function is more useful for an application.

2.3.2.5 Incorporation of the Carcinogen Potency Database, TD\textsubscript{so} Values

In order to improve the sensitivity of the degree of hazard system to deal with carcinogenic agents we implemented the use of the Carcinogenic Potency Database (Gold et al. 1984; 1986). This NIH-sponsored database contains data on approximately 3000 long-term chronic animal experiments with approximately 800 chemicals. The numerical index of carcinogenic potency, the TD\textsubscript{so}, is defined as, "that dose rate (in mg/kg body weight/day) which, if administered chronically for a standard lifespan of the species, will halve the probability of remaining tumorless throughout that period." The working definition of TD\textsubscript{so} is that "for a given target site(s), if there are no tumors in control animals, then TD\textsubscript{so} is that chronic dose rate in mg/kg body weight/day which would induce tumors in half of the test animals at the end of the standard lifespan for the species (Gold et al., 1984; 1986). In the degree of hazard analysis a waste stream component that is defined as a carcinogen is automatically rated as a high toxic hazard. No difference in the carcinogenic potency of a waste component was accounted for in the 1986 degree of hazard system.

Although the inclusion of the Carcinogenic Potency Database was not a contracted objective of this project, it has been integrated in a preliminary manner. By including the Carcinogenic Potency Database, the 1988 degree of hazard system introduces a higher level of sensitivity in the evaluation of the degree of toxic hazard. The components listed in the SUBSTANC Table in the Degree of Hazard Database are identified as carcinogens and mutagens following the definitions given in Plewa et al. (1986). We did not conduct a search for the TD\textsubscript{so} values for all of the components in the SUBSTANC table because of restraints on our resources. The TD\textsubscript{so} values for those listed carcinogens and mutagens in the SUBSTANC table are presented in Table 8.

The TD\textsubscript{so} values and the rat-oral LD\textsubscript{so} values are directly related for the determination of the degree of toxic hazard (Zeise et al. 1984; 1985). Since both of these values are based on toxicity after oral exposure the direct relationship was considered the best method to date. The effect of altering the TD\textsubscript{so} for a carcinogenic waste stream component on the degree of hazard ranking for a set of waste streams is explored in Chapter 3.

2.3.3 Modifications in the Disease Hazard Category

If a disease hazard was present in a waste stream it was usually not evident in the application. Therefore, the disease hazard category has been removed from the degree of hazard calculations and placed instead in the computerized input form as a "yes" or "no" entry. The definition of the disease hazard should be included in the application instructions to aid the applicant in making the correct decision. Since the disease rating is
independent of waste stream size, degree of hazard program issues a ranking of "high" to those waste streams that pose a disease hazard.

Table 8. TD$_{50}$ Values for Carcinogens and Mutagens Listed in the SUBSTANC Table of the Degree of Hazard Database.

<table>
<thead>
<tr>
<th>Name</th>
<th>CAS Number</th>
<th>TD$_{50}$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos</td>
<td>1332-21-4</td>
<td>C</td>
</tr>
<tr>
<td>Chromium</td>
<td>7440-47-3</td>
<td>C</td>
</tr>
<tr>
<td>Diphenylamine</td>
<td>122-39-4</td>
<td>C</td>
</tr>
<tr>
<td>Ethylene glycol</td>
<td>107-21-1</td>
<td>M</td>
</tr>
<tr>
<td>Mineral oil</td>
<td>8012-95-1</td>
<td>C</td>
</tr>
<tr>
<td>Nickel</td>
<td>7440-02-0</td>
<td>C, 1 mg</td>
</tr>
<tr>
<td>Nickel carbonate</td>
<td>3333-67-3</td>
<td>C</td>
</tr>
<tr>
<td>Oil composite</td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>PCB Liquids, Aroclor</td>
<td>1336-36-3</td>
<td>C, 1.04 mg</td>
</tr>
<tr>
<td>Perchloroethylene</td>
<td>127-18-4</td>
<td>M, 75.6 mg</td>
</tr>
<tr>
<td>Phenol</td>
<td>108-95-2</td>
<td>M, 420 mg</td>
</tr>
<tr>
<td>Polyglycol</td>
<td>25322-68-3</td>
<td>M</td>
</tr>
<tr>
<td>Propylene glycol</td>
<td>57-55-6</td>
<td>M</td>
</tr>
<tr>
<td>Tert-butyl perbenzoate</td>
<td>614-45-9</td>
<td>M</td>
</tr>
</tbody>
</table>

2.3.4 Modifications in the Fire Hazard Category

The flash point of 140°F is required for a liquid waste to be regulated under RCRA. A fire hazard under the degree of hazard system requires a flash point between 141°F and 200°F for liquids; ≤130°F for solids. The fire hazard is determined by flash point only.
2.3.5 Modifications to the Leaching Hazard Category

The 1988 degree of hazard system uses the limits of pH 4 and pH 10, however, in the 1986 report we used pH limits of ≤4 or ≥10 this has been altered to pH limits of <4 or >10.

2.3.6 Modifications to the Biological Hazard Category

For the 1988 degree of hazard system the Biological Hazard Category has been eliminated. Neither the Washington State Dangerous Waste Regulations (1986) nor the JRB Associates program (1982) employ a category similar to Biological Hazard. The Michigan Priority Ranking System (1983) has a table for a category that uses odor as a classification. Odor as a hazard classification is a subjective determination. The Biological Hazard Category was removed from the degree of hazard system because it cannot be objectively defined.

2.4 COMPUTERIZED DATABASE MANAGEMENT SYSTEM MODIFICATIONS

2.4.1 R:BASE System V Programs

For the 1988 report all of the degree of hazard programs were completely rewritten as compared to the 1986 report (Plewa et al., 1986). This was done to incorporate the enhanced capabilities of the R:BASE System V database management system as compared to the R:BASE 5000 system that was used for the earlier degree of hazard project (Plewa et al., 1986). Also the rewritten programs incorporate the modifications in the degree of hazard system that were detailed above and can be used interactively.

The degree of hazard computer system in R:BASE System V has been extensively modified and simplified as compared to the Plewa et al. (1986) report. A comparison of the computer programs required for the 1986 degree of hazard system (Figure 3) and those required for the 1988 degree of hazard (Figure 1) illustrates the reduction from a nine program system to a four program system. A description of the 1988 degree of hazard R:BASE System V Programs is presented in Table 9. The source code for each program is included in the Appendix B. The flow diagram (Figure 1) illustrates the relationships among these programs in the generation of the degree of hazard evaluation of a waste stream.
Table 9. A Description of the 1988 Degree of Hazard System Programs in R:BASE System V.

<table>
<thead>
<tr>
<th>Program Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DoHaz.App</td>
<td>R:BASE System V application program to generate and execute menus, and to summon other programs as required.</td>
</tr>
<tr>
<td>ToxLev.Sub</td>
<td>Calculates a toxicity level for all substances in the R:BASE System V SUBSTANC Table.</td>
</tr>
<tr>
<td>Eval.DoH</td>
<td>Generates the degree of hazard evaluation for the designated applications.</td>
</tr>
<tr>
<td>PrtHaz.DoH</td>
<td>Prints the designated degree of hazard ranking and application data.</td>
</tr>
</tbody>
</table>

2.4.2 Development of an Interactive Environment for the Degree of Hazard System

One of the objectives of this project was the development of a menu-driven format to enter information on the characteristics of a waste stream and the "real-time" generation of a degree of hazard ranking. The basis of the interactive design is the R:BASE System V application program DoHaz.App. DoHaz.App generates the menus to allow the operator to select among the features illustrated in Figure 11.

---

**Figure 11** SCREEN FACSIMILE OF THE MAIN MENU OF THE HWRIC DEGREE OF HAZARD DATABASE APPLICATION FORM.

The main menu of DoHaz.App displays the following attributes.

- The ability to change or recover a permit application form(s).
- The option to add permit application(s).
The option to print the application(s).

- The ability to add or change the substance information (toxicological and physical) to the database.

- The option to list the substances or unidentified components in the database (Figure 12).

- The ability to backup or copy a database (Figure 13).

- The option to exit the menu.

Item 5 on the DoHaz.App menu generates a second menu that allows the operator to access the HWRIC degree of hazard database in order to list the unknown compounds, list the substances in the database that contain no data or list components with their data (Figure 12).

<table>
<thead>
<tr>
<th>Compounds in the HWRIC Database</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) List Unknown Components</td>
</tr>
<tr>
<td>(2) List Substances with No Data</td>
</tr>
<tr>
<td>(3) List Cataloged Substances &amp; Data</td>
</tr>
<tr>
<td>(4) EXIT</td>
</tr>
</tbody>
</table>

**Figure 12** SCREEN FACSIMILE OF THE SUBMENU GENERATED WHEN ITEM 5 OF THE MAIN MENU IS SELECTED

Similarly, item 6 of the main menu generates a third menu that is involved in the maintenance of the HWRIC degree of hazard database (Figure 13). The main menu, controlled by the R:BASE System V application program DoHaz.App, allows the operator to choose a specific item. DoHaz.App calls the appropriate program (ToxLev.Sub, Eval.DoH, PrtHaz.DoH) and/or selects the appropriate degree of hazard forms needed to accomplish the operator-selected task. In the 1988 degree of hazard system these tasks are conducted by the operator and the computer interactively. In the 1986 degree of hazard system each task was entered separately into the various R:BASE 5000 tables and all of the applications were processed in a batch mode. Thus the operation of the computer programs is greatly simplified as compared to the 1986 degree of hazard system (Plewa et al., 1986).

The efficiency of the current degree of hazard system was directly affected by the modifications introduced in §2.3. For example by removing the Special Waste Screen from the 1988 degree of hazard system, four programs of the 1986 degree of hazard system were not required and the time for computer processing was reduced by more than 50%.
Additional changes in the computerized database for the 1988 degree of hazard system include the modification of the other 1986 programs. COMPTOX, which rated the toxicities of the waste stream components was changed and renamed to the 1988 program "ToxLev.Sub". Under the current system, the toxicity data for each component listed in the R:BASE System V table, SUBSTANC is evaluated and a toxicity level is stored in that table. This function is analogous to Table 4-1 "Toxicity Weighting Factor" in Reddy (1985).

In the current program the toxicity of a waste stream component is converted to its relative rat-oral LD<sub>50</sub> value. Also ToxLev.DoH assigns an Environmental Fate value. This program reassess all of the compounds in the SUBSTANC table. However, this reassessment is required only if there have been modifications to the SUBSTANC table, not each time the degree of hazard system is run. Item 4 of the DoHaz.App main menu (Add/Change Substance Information, Figure 11) will always call ToxLev.Sub. Examples of screen facsimiles of the input form for acetone and methyl ethyl ketone are presented in Figures 14 and 15.

**Figure 13** SCREEN FACSIMILE OF THE SUBMENU GENERATED WHEN ITEM 6 OF THE MAIN MENU IS SELECTED.

**Figure 14** SCREEN FACSIMILE OF THE COMPONENT INPUT FORM ILLUSTRATING THE DATA FOR ACETONE.

<table>
<thead>
<tr>
<th>Database Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Back Up DataBase onto another Disk</td>
</tr>
<tr>
<td>(2) Restore DataBase from Backup</td>
</tr>
<tr>
<td>(3) Compact DataBase on this Drive (Copies files first)</td>
</tr>
<tr>
<td>(4) Clean up DataBase</td>
</tr>
<tr>
<td>(5) EXIT</td>
</tr>
</tbody>
</table>

---

**CAS #:** 67-64-1  
**NAME:** ACETONE  
**Synonyms:** 2-propanone; dimethyl ketone  
**Toxicity Level = 5000.**  
**Environmental Level = 0.**  
**Calculate Toxicity Level (Y/N)?: Y**  
**carcinogen : N (N=None C=Carcinogen M=Mutagen)**  
**oral LD50 - rat (mg/kg) = 5800. mg/kg if Unknown,**  
**inhalation LD50-rat (mg/L) = -999999. mg/L enter: -999999**  
**dermal LD50- rabbit(mg/kg) = 20000. mg/kg if Innocuous,(eg.water)**  
**Aquatic (LC50 -fish)(mg/L) = 1005. mg/L enter: -1**  
**Solubility (ppm in water) = -0- ppm**  
**Density (grams/liter) = 0.79 gm/L**  
**Half-Life (in days) = -0- days**  
**n-octanol/water partition coefficient (log P) = -0-**

**Data Sources:** ToxNet 5/31/86; CRC den; update dermal 1/11/88 from RTECS online CIS

---

Hit [ESC] when finished......
**Figure 15** SCREEN FACSIMILE OF THE COMPONENT INPUT FORM ILLUSTRATING THE DATA FOR METHYL ETHYL KETONE.

The functions of the other 1986 degree of hazard programs (WTRUN, TOXDEG.RUN and ALLDEG) have been combined into the program Eval.DoH. This program calculates the degree of hazard values for the Fire, Leach, Disease and Toxicity Hazard Categories and selects the highest value as the overall degree of hazard ranking. A significant improvement over the 1986 degree of hazard system is that Eval.DoH conducts a degree of hazard evaluation only on specified applications. To specify an Application, the column "DoIt" must contain a "Y" for yes. DoHaz.App prompts for the Authorization Number, changes DoIt to "Y" for those applications, displays the Application Input Form, then calls Eval.DoH, when menu item 1 (Change/LookUp Permit Applications) or menu item 2 (Add Permit Applications) (Figure 11) are selected. An example of a Special Waste Application Data Input Form screen facsimile is presented in Figure 16.³

³The authorization number was removed to maintain confidentiality.
Illinois Special Waste Application Data

Authorization Number: 000001
Process Name: Demonstration
Generic Name: Improbable Mixture
SIC Code:

pH = 8.0 Flashpoint = 218 °F phase = liquid (solid, liquid, etc)
Quantity = 10000 gals.

Disease Haz. (Y/N): N

Date Entered: 01/20/1988

Component Name | ID # (CAS) | Concentration | Source
--- | --- | --- | ---
ACETIC ACID | 64-19-7 | 20. Yo | Demo
ACETONE | 67-64-1 | 10. Yo | Demo
ALUM SILICATE | 1302-76-7 | 10. Yo | Demo
ALUMINUM SULFATE | 10043-01-3 | 10. Yo | Demo
AMMONIUM HYDROXIDE | 1336-21-6 | 10. Yo | Demo
BORAX | 1303-96-4 | 20. Yo | Demo

Use [F9] key to toggle between Permit data & Component section.
Use [F7](previous) & [F8](next) keys to move thru the Components.

Figure 16 SCREEN FACSIMILE OF A SPECIAL WASTE APPLICATION DATA INPUT FORM.

Authorization Number: 000001

OverAll Hazard Rank: Hi (Hi)

Percent of Components Unknown: 0.

Stress Size: 10000 gals. = 55141.25 Kgs. as liquid

Generic Process Name: Improbable Mixture
Specific Process Name: Demonstration

Use [F9] key to toggle between Permit data & Component section.
Use [F7](previous) & [F8](next) keys to move thru the Components.

Figure 17 PRINTOUT FROM PRTHAZ DoH SHOWING THE DEGREE OF HAZARD RANK FOR A SPECIAL WASTE.
PrtHaz.DoH is a program that prints out the application data and the degree of hazard ranking results for each requested Application separately (Figure 17). A printing program was not included in the 1986 degree of hazard system (Plewa et al., 1986).

The modifications of the 1986 degree of hazard system (Reddy, 1985; Plewa et al., 1986) that are incorporated in this project have significantly simplified the degree of hazard evaluation system and reduced the computer time required to generate a ranking for a waste stream (Figure 1). These temporal improvements are essential in creating a truly interactive degree of hazard system that can be employed by State agencies and industry in the evaluation and regulation of Illinois Special Wastes.

4The authorization number was removed to maintain confidentiality.
CHAPTER 3: ANALYSIS OF THE MODIFIED DEGREE OF HAZARD EVALUATION SYSTEM

Chapter II described the process of defining the scientific and/or legal components of the hazard categories, converting the Degree of Hazard Database from R:BASE 5000 to R:BASE System V, developing menu-driven and interactive computer programs and the simplification of the degree of hazard system. This chapter documents the effects of specific modifications to the degree of hazard system as presented by Plewa et al. (1986).

It must be stressed that this study did not include the addition of data to the HWRIC Degree of Hazard Database generated in the Plewa et al. (1986) study. The distributions of the degree of hazard ranks for the sample of 1984 non-RCRA Special Waste applications were used as the basis of this study. Although some change in the distribution of the degree of hazard ranks was to be expected as the criteria in the degree of hazard system were modified, major shifts in the percentage of applications per rank were not expected or desired. In other words, an application that ranked as "High" in the Plewa et al. (1986) study should have a high probability of retaining that ranking when evaluated with the refined degree of hazard system generated in this study.

3.1 IMPACTS OF THE MODIFICATIONS ON THE HAZARD CATEGORIES

A comparison of the ranking distributions of the three degree of hazard measurements is presented in Table 10. The comparisons are based on the effect on the distributions that the 1988 Toxicity Database update induced as well as the effects caused by the new modifications in the degree of hazard methodology. To determine the consequence of updating the Degree of Hazard Toxicity Database compare the adjacent data columns in Table 10 (e.g. column 1 with column 2; column 3 with column 4). To determine the effect that changes in the degree of hazard methodology had on the ranking distributions, compare column 1 with column 3 and column 2 with column 4 of Table 10.

3.1.1 The Control Distribution

In order to track the effect of specific modifications on the degree of hazard rankings of the non-RCRA Special Waste applications a series of control distributions was taken from the 1986 Plewa et al. study. Three views of the degree of hazard ranking distribution were evaluated. The views represent a degree of hazard ranking system based on the number of hazard categories that were involved in the generation of the degree of hazard ranks. Since the Special Waste applications did not contain sufficient relevant information required by the degree of hazard system, distributions were evaluated for those applications that had complete data for specific hazard categories. Since the degree of hazard system is primarily driven by toxicity, a degree of toxic hazard was employed as the first view. The degree of toxic hazard was used extensively in preparing the Plewa et al. (1986) degree of hazard system. View 2 is a degree of hazard ranking that combined information for the...
Toxicity, Fire and Leaching Hazard Categories. View 3 is a degree of hazard that required complete information for all of the hazard categories. The distribution of the ranks for the three control degree of hazard evaluations is presented in Figure 18. These distributions represent the randomly selected sample of the 1984 non-RCRA Special Waste applications that passed the binary screen (Plewa et al., 1986). The applications that were ranked as "Unknown" would usually be assigned, by default, to the "High" hazard ranking. However, they have been isolated to demonstrate the chronic problem of the lack of relevant data in the Special Waste applications and/or the lack of toxicological, chemical and physical characterization of the waste streams. Also the effects of the modifications can be best visualized by observing the distributions of the different degree of hazard rankings for which the appropriate data exist.

Table 10. The Distribution of the Degree of Hazard Rankings as Affected by Modifications in the Degree of Hazard Analysis.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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<tbody>
<tr>
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<td>13</td>
<td>14</td>
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<tr>
<td>Low</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Moderate</td>
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<td>6</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>High</td>
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<td>Unknown</td>
<td>105</td>
<td>104</td>
<td>105</td>
<td>104</td>
</tr>
</tbody>
</table>

Distribution of the Degree of Hazard Ranking with the Toxic Hazard Category Required.

<table>
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<tr>
<th>Degree of Hazard Rankings</th>
<th>Negligible</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reddy Method</td>
<td>13</td>
<td>1</td>
<td>6</td>
<td>43</td>
<td>105</td>
</tr>
<tr>
<td>Plewa 1986</td>
<td>12</td>
<td>1</td>
<td>6</td>
<td>45</td>
<td>104</td>
</tr>
<tr>
<td>New Tox Scoring Method</td>
<td>13</td>
<td>1</td>
<td>6</td>
<td>43</td>
<td>105</td>
</tr>
<tr>
<td>New Tox Scoring and Env. Fate Methods</td>
<td>14</td>
<td>4</td>
<td>2</td>
<td>44</td>
<td>104</td>
</tr>
</tbody>
</table>

Distribution of the Degree of Hazard Ranking with Toxicity, Fire and Leaching Hazard Categories Required.

<table>
<thead>
<tr>
<th>Degree of Hazard Rankings</th>
<th>Negligible</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Unknown</th>
</tr>
</thead>
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<tr>
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<td>10</td>
<td>43</td>
<td>105</td>
</tr>
<tr>
<td>Plewa 1986</td>
<td>9</td>
<td>0</td>
<td>10</td>
<td>45</td>
<td>104</td>
</tr>
<tr>
<td>New Tox Scoring Method</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>43</td>
<td>105</td>
</tr>
<tr>
<td>New Tox Scoring and Env. Fate Methods</td>
<td>10</td>
<td>1</td>
<td>9</td>
<td>44</td>
<td>104</td>
</tr>
</tbody>
</table>

Distribution of the Degree of Hazard Ranking with all Hazard Categories Required.

<table>
<thead>
<tr>
<th>Degree of Hazard Rankings</th>
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<th>Low</th>
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<th>High</th>
<th>Unknown</th>
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<tr>
<td>Reddy Method</td>
<td>7</td>
<td>0</td>
<td>9</td>
<td>35</td>
<td>117</td>
</tr>
<tr>
<td>Plewa 1986</td>
<td>6</td>
<td>0</td>
<td>9</td>
<td>37</td>
<td>116</td>
</tr>
<tr>
<td>New Tox Scoring Method</td>
<td>7</td>
<td>0</td>
<td>9</td>
<td>35</td>
<td>117</td>
</tr>
<tr>
<td>New Tox Scoring and Env. Fate Methods</td>
<td>7</td>
<td>0</td>
<td>9</td>
<td>36</td>
<td>116</td>
</tr>
</tbody>
</table>
3.1.2 The Degree of Hazard Ranking Distribution after Modifications to the Hazard Categories

The primary changes in the hazard categories that were evaluated included the following.

- The degree of hazard evaluation in which the Toxicity Hazard Category does not require the Special Waste screen (Reddy, 1985).
- The degree of hazard evaluation in which the new toxic scoring method was used but retaining the Plewa et al. (1986) methods for the environmental fate and scoring graph (§2.3.2.1.).
- The degree of hazard evaluation in which the new toxic scoring and environmental fate scoring methods were used (§2.3.2.1. and §2.3.2.2.).

The distribution of the degree of hazard rankings as a function of the modifications in the hazard categories is presented in Table 10.
3.1.2.1 The Effect on the Distribution of the Degree of Toxic Hazard Rankings

The use of updated toxicity data had little effect on the distributions of the degree of hazard rankings (Figure 19). Since the objectives of this project did not include adding additional Special Waste applications, little change from the distributions illustrated in Figure 18 was expected. In the three views of the degree of hazard analysis - degree of toxic hazard, degree of hazard evaluation that encompassed the Toxicity, Fire and Leaching Hazard Categories, and the Final degree of hazard evaluation - the primary change was a decrease of applications that ranked as "Negligible" and an increase in the those that were ranked as "Unknown".

A comparison of the changes (views) on the degree of toxic hazard rankings is presented in Figure 20. Since the Special Waste applications that ranked as "Unknown" were a constant they were not included in these comparisons. View 1 is the control distribution. View 2 is the same Special Waste applications analyzed with the Plewa et al. (1986) system but incorporating the 1988 toxicity database update. Minor movements in the "Negligible" and "High" rankings were observed. View 3 was the same analysis as presented in the control with the new toxicity scoring method and this change alone did not alter the distribution among the rankings. However, View 4, with its substantial modifications in the toxicity and environmental fate methods, caused a major alteration in the relative frequency of applications ranked as "Low" and "Moderate". As compared to the control, a major shift downward to the "Low" hazard ranking came from applications that were ranked as "Moderate". Those applications that ranked "High" or "Negligible" were unaffected, by the system definition, as the modifications the environmental fate affects only
those waste streams that rank "Low" or "Moderate" for the degree of toxic hazard. Thus, the changes in the distribution of the ranks induced by the modifications encompassed in View 4 increased the efficiency of the degree of hazard system without inducing a major shift in those highly toxic waste streams. An additional indication of the effect that the modifications in determining the environmental fate have on the distribution of these applications can be seen in View 5. In this view the environmental fate calculations have been removed. A distribution of degree of toxic hazard rankings similar to view 2 or 3 resulted. Thus the environmental fate calculations have a substantial effect on waste streams that rank "Moderate" with the tendency to move them toward the "Low" ranking. Note that those waste streams ranked as "Negligible" or "High" were not influenced by the environmental fate calculations.

**Figure 20** Degree of Toxic Hazard Rankings for Five Views of the Non-RCRA Special Waste Applications (Plewa et al., 1986).

**Description of Figure 20.** The degree of toxic hazard rankings for five different views of the non-RCRA Special Waste applications as generated by Plewa et al. (1986). Those Special Waste applications that ranked as "unknown" were not included in these distributions.

- **View 1** - the distribution of ranks for the degree of toxic hazard by the Reddy (1985) approach modified by the removal of the special waste screen and with the toxicology database of Plewa et al. (1986)

- **View 2** - the distribution of ranks for the degree of toxic hazard by the Reddy (1985) approach modified by the removal of the special waste screen and with the updated (1988) toxicology database

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• View 3 - the distribution of ranks for the degree of toxic hazard with the modified (1988) toxic scoring method but retaining the Plewa et al (1986) methodology for calculating the environmental fate and scoring graph.

• View 4 - the distribution of ranks for the degree of toxic hazard with the modified (1988) toxic scoring and environmental fate scoring methods using the updated (1988) toxicity database.

• View 5 - the distribution of ranks for the degree of toxic hazard using data from View 2 without any calculation for environmental fate.

3.1.2.2 The Effect on the Distribution of the Degree of Hazard Rankings that Required Input from the Toxicity, Fire and Leaching Hazard Categories

The distribution of the degree of hazard that required input from the toxicity, fire and leaching hazard categories is presented in Figure 21. The five views are identical as those presented in §3.1.2.1. (Figure 20). The requirement for additional information demanded by these three Hazard Categories caused the elimination of most of the waste streams from the "Low" hazard rank. In Views 1, 2, and 3 none of the applications of the Plewa et al. (1986) sample of the non-RCRA Special Waste streams were ranked as "Low." The percentage of applications that were ranked as "Negligible" decreased across all of the views as compared to the distributions when the degree of toxic hazard ranks were evaluated (Figure 20 versus Figure 21). However, the number of Special Waste applications that ranked "High" remained constant. Thus, those highly toxic and environmentally dangerous Special Wastes were not affected by the constraints imposed by the additional hazard categories. This comparison between the distributions of the degree of toxic hazard and the degree of hazard with three hazard categories illustrate the impact the Toxicity Hazard Category has on the degree of hazard system.

3.1.2.3 The Effect on the Distribution of the Degree of Hazard Rankings that Required Input from all of the Hazard Categories

This final analysis of the distributions of the degree of hazard rankings of the non-RCRA Special Waste applications is illustrated by Figure 22. The trend is toward reducing the number of applications that correspond to the "Low" hazard rank. None of the applications were ranked as "Low" for the four views that monitored the modifications to the degree of hazard system. The additional requirements for information for this degree of hazard evaluation substantially reduced the number of applications that qualified for a ranking. Thus the absolute number of applications that were ranked as "Unknown" increased (Table 10). This fact demonstrates how severely deficiencies in the data compromise the degree of hazard evaluation system.
DEGREE OF HAZARD ANALYSIS MODIFICATIONS

Figure 21 DEGREE OF HAZARD RANKINGS FOR FIVE VIEWS OF THE NON-RCRA SPECIAL WASTE APPLICATIONS THAT REQUIRED DATA FROM THE TOXIC, FIRE AND LEACHING HAZARD CATEGORIES.

Description of Figure 21. The distributions of degree of hazard rankings for five different views of the non-RCRA Special Waste applications as generated by Plewa et al. (1986) that require data from the Toxicity, Fire and Leaching Hazard Categories. Those Special Waste applications that ranked as "unknown" were not included in these distributions.

- View 1 - the distribution of ranks for the degree of hazard by the Reddy (1985) approach modified by the removal of the special waste screen and with the toxicology database of Plewa et al. (1986)


- View 3 - the distribution of ranks for the degree of hazard with the modified (1988) toxic scoring method but retaining the Plewa et al. (1986) methodology for calculating the environmental fate and scoring graph.


- View 5 - the distribution of ranks for the degree of hazard using data from View 2 without any calculation for environmental fate.
Figure 22 DEGREE OF HAZARD RANKINGS FOR FIVE VIEWS OF THE NON-RCRA SPECIAL WASTE APPLICATIONS (PLEWA ET AL, 1986) THAT REQUIRED DATA FROM ALL HAZARD CATEGORIES.

Description of Figure 22. The distributions of degree of hazard rankings for five different views of the non-RCRA Special Waste applications as generated by Plewa et al (1986) that require data from all of the Hazard Categories. Those Special Waste applications that ranked as "unknown" were not included in these distributions.

- View 1 - the distribution of ranks for the degree of hazard by the Reddy (1985) approach modified by the removal of the special waste screen and with the toxicology database of Plewa et al. (1986).


- View 3 - the distribution of ranks for the degree of hazard with the modified (1988) toxic scoring method but retaining the Plewa et al. (1986) methodology for calculating the environmental fate and scoring graph.


- View 5 - the distribution of ranks for the degree of hazard using data from View 2 without any calculation for environmental fate.

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Summary of the Effect of the System Modifications to the Degree of Hazard Distribution of Ranks

A concise comparison of the effect of the modifications to the current degree of hazard system is presented in Figure 23. The three degree of hazard systems (based on the inclusion of the hazard categories) serve as the foundation of the comparison between the control and the modifications instituted by this study. Each degree of hazard evaluation has two views. The first view represents the control distribution derived from the second numerical column in Table 10. View 2 represents the composite of modifications that we implemented with this study and was derived from the fourth numerical column in Table 10. With the limited non-RCRA Special Waste database that was available to us, the degree of toxic hazard probably is the most informative distribution to illustrate the efficacy of the new degree of hazard system modification. While the Special Waste applications scoring "High" remain unaffected, a substantial broadening of the distribution in the other hazard ranks was observed. The degree of hazard system was vastly improved in terms of its simplicity, speed, verification, and operator ease, the sensitivity of the system was improved without inducing radical changes in the hazard rankings as compared to Plewa et al. (1986).

AN ANALYSIS OF THE EFFECT OF THE CARCINOGEN POTENCY DATABASE UPON THE DEGREE OF HAZARD SYSTEM

As was discussed in §2.3.2.3, we suggest the inclusion of the Carcinogenic Potency Database (Gold et al., 1984; 1986) into the Toxicity Hazard Category. We suggest using a 1 to 1 correspondence of the Carcinogenic Potency value (TD$_{50}$) as the equivalent oral toxicity value (LD$_{50}$). Such a change would affect those waste streams that contain a labeled, but very weak carcinogen. Carcinogens express a potency which ranges over several orders of magnitude. Without considering the relative potency of a carcinogenic waste, a waste stream with a component that was highly carcinogenic (i.e. aflatoxin) would be ranked the same as a waste stream that contained an equal amount of a exceedingly weak carcinogen such as saccharin.

To evaluate the effect that TD$_{50}$ values would have on waste streams with a carcinogen, we calculated the degree of hazard ranks for the Special Waste applications using four TD$_{50}$ values. We chose the complex mixture "oil" which is listed as a carcinogen by NTP and the U.S. Environmental Protection Agency (1981) and we assigned TD$_{50}$ values that corresponded to aflatoxin, ethylenedibromide, and saccharin of 0.001, 1 and 1360 mg/kg (Gold et al., 1984). The former value was 0.1 mg/kg (Plewa et al., 1986). All of the Special Waste applications that listed oil as a component were ranked as "High." The effect of varying the TD$_{50}$ values on the degree of hazard ranking distribution is presented in Table 11.
Description of Figure 23. A comparison between "control" degree of hazard distributions generated by using the Plewa et al. (1986) methods with the 1988 Toxicity Database update (Views 1, 3 and 5) and specific modifications made in this study (Views 2, 4 and 6). Those Special Waste applications that ranked as "Unknown" were not included in these distributions.

- The effect of the modifications implemented by this study on the degree of toxic hazard is seen by comparing View 1 with View 2. View 1 represents the distribution of ranks for the degree of toxic hazard as indicated in Table 3-1, data column 2. View 2 illustrates the distribution of ranks for the degree of toxic hazard with the modified (1988) toxic scoring and environmental fate scoring methods using the updated (1988) toxicity database. These data were derived from Table 3-1, data column 4.

- The effect of the modifications on the degree of hazard rankings in which the Toxicity, Fire and Leaching Hazard Categories were required is illustrated by comparing View 3 with View 4. View 3 represents a "control" and shows the distribution of ranks for the degree of toxic hazard as indicated in Table 3-1, data column 2. View 4 demonstrates the distribution of ranks for the degree of hazard with the modified (1988) toxic scoring and environmental fate scoring methods using the updated (1988) toxicity database (Table 3-1, data column 4).
The effect of the modifications on the degree of hazard rankings in which all of the Hazard Categories were required is illustrated by comparing View 5 with View 6. View 5 illustrates the control distribution of ranks for the degree of toxic hazard as indicated in Table 3-1, data column 2. View 6 exhibits the distribution of ranks for the degree of hazard with the modified (1988) toxic scoring and environmental fate scoring methods using the updated (1988) toxicity database.

Table 11  The Effect of Varying TD$_{50}$ Values on the Distributions of the Degree of Hazard Ranks.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Plewa et al. 1986</th>
<th>IES 1988 TD$_{50}$ = 0.001</th>
<th>TD$_{50}$ = 0.1</th>
<th>TD$_{50}$ = 1.0</th>
<th>TD$_{50}$ = 1360</th>
<th>Minus oil value</th>
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<td>2</td>
<td>2</td>
<td>2</td>
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<td>Degree of Hazard with Toxicity, Fire and Leaching Hazard Categories</td>
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<td>Degree of Hazard Employing all Hazard Categories</td>
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<td>116</td>
<td>116</td>
<td>116</td>
<td>116</td>
</tr>
</tbody>
</table>

The impact of a carcinogen on the toxicity value of a waste stream was amended by the TD$_{50}$ values only for those carcinogens that are exceedingly weak. The TD$_{50}$ value for saccharin was the only value that caused a real change in the degree of hazard ranking distribution for waste streams that contained oil as a component. If the oil component of these waste streams had a carcinogenic potency equivalent to the pesticide ethylenedibromide, the effect on the degree of hazard rankings for these applications was zero. However, if the oil component of these waste streams had a carcinogenic potency equivalent to the sugar substitute saccharin, then a substantial movement in the distribution to the lower hazard ranks was seen. By employing TD$_{50}$ values as described above,
additional sensitivity to the toxic effects of carcinogens can be incorporated in the degree of hazard system.

3.3 DISTRIBUTION OF THE PERCENTAGE OF WASTE STREAM APPLICATIONS WITHOUT 100% OF COMPONENTS LISTED.

In the degree of hazard programs prepared for this report, two new variables were added to ensure the quality of the data. The first variable allows the degree of hazard system to accept Special Waste stream applications that vary from the requirement that the percentage of components equal 100. Deviations from this requirement should be an HWRIC or Illinois Environmental Protection Agency decision. Because of additions made to this database using the "best estimate" modification, this variable was rather liberal (Plewa et al. 1986). The second variable sets the percent concentration of unknown components allowed before the Toxicity Hazard Category is declared "Unknown." In this study and the previous one (Plewa et al., 1986) the variable was set at 0% (i.e. the toxicity of all of the listed compounds had to be known). Using the non-RCRA Special Waste stream applications, the cumulative frequency of waste streams that listed 0.1% to 50% of non-described components is presented in Figure 24. Figure 24 illustrates the cumulative number of applications that contained unknown components and/or components for which no toxicological information was available. Although it may be difficult to completely meet the requirement that 100% of the waste stream be accounted for in the Special Waste applications, deviations beyond 1% could seriously compromise the validity of the degree of hazard evaluation system. The high frequency of applications that did not account for all of the components in the waste stream appears to be a serious deficiency in managing components of Special Wastes in Illinois.

3.4 THE SEGREGATION OF A COMPONENT OF WASTE STREAMS TO LOWER THE DEGREE OF HAZARD RANK

Oil, as a representative of a waste stream component that was carcinogenic and a complex mixture, was used to demonstrate the impact of the inclusion of TD_{so} values in the determination of the toxic hazard of the waste stream. Another scenario for the reduction of the degree of hazard ranking of a waste stream would be for the waste generator to segregate one or more components and dispose of them separately. To measure the effect of such an approach, oil was removed as a waste stream component from the application database. The result is presented in the last column of Table 11. Note that in all measurements of the degree of hazard system, the number of waste streams that ranked as "Negligible" increased while the number of those ranked as having a "High" degree of hazard decreased. The number of applications that ranked as "Low" and "Moderate" also increased. Figure 25 illustrates the broadening of the distribution of the lower hazard rankings. From these data it appears that the use of the degree of hazard system may be a useful tool for industry to determine the cost-benefit relationship of altering the composition of waste streams and determine the most economic waste stream composition for a given process.
Figure 24 Cumulative number of applications that contained unknown components and/or components with insufficient toxicological information.

Figure 25 The effect on the degree of hazard ranks when "oil" was removed from all of the special waste applications.
CHAPTER 4: DATA DEFICIENCIES

4.1 INTRODUCTION

A serious impediment of the degree of hazard system is the lack of data on the waste streams. Based on our random sample of RCRA and non-RCRA applications, (Plewa et al., 1986) as well as the experience gained from this project, the data deficiencies fall into one of three categories.

- Deficiencies associated with the Illinois Environmental Protection Agency's Special Waste Application form.
- Deficiencies associated with vague names of waste stream components.
- Lack of toxicological data in the national databases.

4.1.1 Problems Associated with the IEPA's Special Waste Application Form

The primary source of information for a Special Waste stream is the Special Waste Stream Application form issued by IEPA (Appendix A). However, a major source of unknown rankings in the degree of hazard evaluation was the lack of information on the Special Waste Application Forms. The difficulties uncovered in the Plewa et al. (1986) report that were associated with the Special Waste Application Forms were mainly dependent on the incomplete descriptions of the waste streams by waste generators. A large proportion of those Special Wastes that were ranked as "Unknown" were the result of incomplete Special Waste Application Forms. The design of the Special Waste Application Form proved to be the origin of some difficulty in obtaining the necessary information for the degree of hazard system.

The degree of hazard system was developed as a tool to be used by IEPA, and others in the regulatory community, and industry to evaluate the hazards to the environment and the public health that may be associated with Illinois industrial waste streams. The degree of hazard application form was designed to incorporate the data that appeared on the IEPA Special Waste Application Form. This approach is logical as the goals of both forms are similar. Also by incorporating a common form, the burden on industry would not increase due to additional regulatory forms. Ultimately, the benefit of computer transfer of these data from IEPA records should be realized thus avoiding redundant data entry costs. Two items of importance have been added, 1) a specific question regarding a disclosure of the disease hazard of the Special Waste stream, and 2) no restrictions on the numbers of components that comprise a waste stream. The current Special Waste Application Form only has space for six components and their percentage of the waste stream. An added benefit of the degree of hazard application form is that if an operator does not include all of the...
required data, the computer will indicate that a data deficiency exists and it will identify specifically what data are required to fill the form completely.

4.1.2 Deficiencies Associated with Vague Names of Waste Stream Components

A second, critical impediment to the degree of hazard process is the use of vague names in the Special Waste Application Form to describe waste stream components. A list of vague names that were used in the 1984 non-RCRA sample that were catalogued in Plewa et al. (1986) is presented in Table 12.

Table 12. Commonly Used Vague Names on the 1984 Special Waste Application Forms for non-RCRA Waste Streams

<table>
<thead>
<tr>
<th>Vague Names</th>
<th>Number of Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil (all types)</td>
<td>260</td>
</tr>
<tr>
<td>Auto</td>
<td>2</td>
</tr>
<tr>
<td>Crankcase</td>
<td>5</td>
</tr>
<tr>
<td>Cutting</td>
<td>21</td>
</tr>
<tr>
<td>Fuel</td>
<td>4</td>
</tr>
<tr>
<td>Hydraulic</td>
<td>16</td>
</tr>
<tr>
<td>Lubricating</td>
<td>29</td>
</tr>
<tr>
<td>Machine</td>
<td>15</td>
</tr>
<tr>
<td>Miner</td>
<td>5</td>
</tr>
<tr>
<td>Vegetable</td>
<td>6</td>
</tr>
<tr>
<td>Salts (all types)</td>
<td>142</td>
</tr>
<tr>
<td>Inorganic</td>
<td>84</td>
</tr>
<tr>
<td>Na salts</td>
<td>45</td>
</tr>
<tr>
<td>Ca salts only</td>
<td>12</td>
</tr>
<tr>
<td>Ash</td>
<td>18</td>
</tr>
<tr>
<td>Fat</td>
<td>29</td>
</tr>
<tr>
<td>Grease</td>
<td>48</td>
</tr>
<tr>
<td>Paint</td>
<td>40</td>
</tr>
<tr>
<td>Sludge</td>
<td>5</td>
</tr>
<tr>
<td>Pigments</td>
<td>23</td>
</tr>
<tr>
<td>Resin</td>
<td>31</td>
</tr>
<tr>
<td>Steel</td>
<td>6</td>
</tr>
<tr>
<td>Total Number of Permits</td>
<td>547</td>
</tr>
</tbody>
</table>
We propose that a consensus of industry, HWRIC and IEPA personnel agree to adopt a series of "defined generic names." Within an industrial process, a complex mixture usually described by a vague name could be adequately described and a standard for a defined generic name be established. Samples of representative of components listed with defined generic name could be evaluated for the information required in the hazard categories. A standard set of data for these defined generic names could then be used in the degree of hazard system. If no such standard evolves then a rigorous chemical, physical and toxicological analysis must be conducted on each waste stream in order to determine a degree of hazard rank.

4.1.3 Data Deficiencies Associated with a Lack of Toxicological Information in National Databases

A waste stream may still be ranked as "Unknown" even if it is adequately described. Components that have not been tested for their toxicological properties will be identified as deficiencies in the data. The degree of hazard system will list the agents within a waste stream that are not included in the HWRIC Degree of Hazard Database. Information on such agents will be searched using national on-line databases.

Updating the HWRIC Degree of Hazard Database must be part of maintaining the degree of hazard system. In Plewa et al. (1986) the non-RCRA SUBSTANC table contained information on 117 substances listed as other then innocuous. The majority of data for the SUBSTANC Table was compiled by May 31, 1986. The updated toxicology data search for this project was completed on January 11, 1988, approximately 19 months later. Of the 117 substances, 33 (28%) agents had additional toxicological information, while 84 remained the same. Five substances that were identified in the Plewa et al. (1986) report as containing no toxicity data were found to have such data in the update. The result of these new data allowed the inclusion of 1 additional Special Waste Application to be evaluated by the degree of hazard system. It is important to note that even with this substantial updating of toxicity data (28% of the database) no momentous changes occurred in the distributions of the degree of hazard rankings (compare columns 1 and 2 or 3 and 4 of Table 10).
CHAPTER 5: DEGREE OF HAZARD COMPUTER SYSTEM TUTORIAL

5.1 INTRODUCTION

This tutorial is provided in this report to serve as an independent manual for the operation of the HWRIC Degree of Hazard Evaluation System. The tutorial provides a step-by-step critique of the R:BASE System V application program DoHaz.App in order to generate a degree of hazard evaluation of a demonstration Special Waste application. This tutorial is divided into three task areas:

- Application Processing,
- Substance Table Processing,
- Database Maintenance.

The selections on the main menu for application processing are items 1, 2 and 3; those for substance table processing are items 4 and 5 and database maintenance is main menu selection 6. To exit the HWRIC degree of hazard system use selection items 7 or 8 from the main menu. Selecting number 7 from the main menu "EXIT" will return you to DOS. Using menu item 8 "BREAK" will exit you from the DoHaz.App degree of hazard program without exiting from R:BASE System V. A screen facsimile of the main menu the HWRIC Degree of Hazard Database is presented in Figure 26.

![Figure 26 Tutorial Screen Facsimile of the Main Menu of the HWRIC Degree of Hazard Database.](image)

A note on the convention used in this tutorial. Entries that are to be typed by the operator are enclosed in brackets, [ ]. Data or information within the brackets should be entered (without typing the brackets) onto a specific form on the screen followed by pressing the Enter (Return) key.
5.2 ENTERING INFORMATION FOR A SPECIAL WASTE APPLICATION

To enter the HWRIC Degree of Hazard System, enter the command "DOH" at the DOS prompt (C>), [DOH].

The primary source of information for the degree of hazard system usually originates from the Illinois Environmental Protection Agency Special Waste Application form. The operator will use this form to key in the information necessary for the degree of hazard evaluation of that waste stream. At the main menu select "Add Permit Applications" by entering item 2 [2]. The Special Waste Application Data Form will appear on the screen (Figure 27).

![Figure 27 TUTORIAL SCREEN FACSIMILE OF THE SPECIAL WASTE APPLICATION DATA FORM.](image)

You will enter data for a demonstration waste stream into the Illinois Special Waste Application Data form for this tutorial (Figure 27).

1) Enter the authorization number [000001].
2) Enter the date of entry [??/??/19??]
3) Enter Process Name [Demonstration].
4) Enter Generic Name [Improbable mixture].
5) Enter SIC Code [0].
6) Enter pH [8.0].
7) Enter flash point [218].
8) Enter phase [liquid].
9) Enter quantity [10000].
10) Enter Disease Hazard [N].

After the section on the Permit Data has been entered use the F9 key to toggle to the Component section. The Component section is bounded by a double-lined box and the F9 key toggles movement between the Permit Data section and the Component section. Depressing the Enter key will move the cursor to the next blank data area within the line or to a new line in the Component section. When in the Component section the F7 key will move the cursor to the previous component and the F8 key will move the cursor to the next component. Also the UP and DOWN arrow keys will move the cursor forward or backward through the data within a section.

11) [F9] (if component box does not contain highlight)
12) Enter [Acetic acid] under the component name column.
13) Enter CAS number [64-19-7].
14) Enter % concentration [20].
15) Enter Source [Demo].

Enter the component information as illustrated in Figure 28. If you make an error use the F7 key to return and correct a datum. To proceed forward within the Component section use the F8 key.
The Component section can accommodate only six waste stream components per screen, however, the section will scroll to allow the entry of as many components that make up the waste stream. Enter the additional components of this demonstration as is listed in Figure 29. Figure 29 is a screen facsimile of the data presented in Figure 28 but scrolled up by three lines to include an additional two components. The correct data set of the finished tutorial application should appear as the screen facsimile illustrated in Figure 29.
Illinois Special Waste Application Data

Authorization Number = 1
Process Name: Demonstration
Generic Name: Improbable Mixture
SIC Code: -

pH = 8. Flashpoint = 218. °F
Quantity = 10000. gals.

Previous Haz. Rank: Hi
Tox = Hi
Leach = Nil
Fire = Nil
Disease = Nil

<table>
<thead>
<tr>
<th>Component Name</th>
<th>ID # (CAS)</th>
<th>Concentration</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALUM SILICATE</td>
<td>1302-76-7</td>
<td>10.</td>
<td>% Demo</td>
</tr>
<tr>
<td>ALUMINUM SULPHATE</td>
<td>10043-01-3</td>
<td>10.</td>
<td>% Demo</td>
</tr>
<tr>
<td>AMMONIUM HYDROXIDE</td>
<td>1336-21-6</td>
<td>3.0</td>
<td>% Demo</td>
</tr>
<tr>
<td>BORAX</td>
<td>1303-96-4</td>
<td>20.</td>
<td>% Demo</td>
</tr>
<tr>
<td>CALCIUM HYDROXIDE</td>
<td>1305-62-0</td>
<td>10.</td>
<td>% Demo</td>
</tr>
<tr>
<td>WATER</td>
<td>INNOC</td>
<td>31.0</td>
<td>% Demo</td>
</tr>
</tbody>
</table>

Use [F9] key to toggle between Permit data & Component section.
Use [F7] (previous) & [F8] (next) keys to move thru the Components.

Figure 29  TUTORIAL SCREEN FACSIMILE OF THE COMPONENT INFORMATION SCROLLED UP TO INCLUDE AN ADDITIONAL TWO COMPONENTS.

Information cannot be entered by the operator in the Degree of Hazard Rank listing areas of the form or the date. The degree of hazard evaluation and the date stamp is entered by the computer onto the form after the degree of hazard system programs have run.

After the appropriate data have been entered the degree of hazard can be calculated by pressing the Escape key.

16)  [ESC].

After pressing the ESC key a double-lined box containing a horizontal menu will appear as in the top of Figure 27. Select Quit to indicate that no additional applications are to be entered.

17)  [Q].

If there were further applications to be entered, then one would select the Add command from the menu and proceed to enter the information for the other applications, one application at a time.

After the Quit command has been keyed in, the programs Eval.DoH, and PrtHaz.Doh are automatically executed for the applications that have been entered. When program
Eval.DoH is finished, program PrtHaz.Doh begins by sounding a warning BEEP. A screen request will appear indicating the format of the output - screen or printer. Select P for printer.

18) [P].

Due to the amount of information, the degree of hazard report is wider than the screen. The screen output is for previewing the degree of hazard ranking. A facsimile of a printer output for the demonstration application is presented in Figure 30.

<table>
<thead>
<tr>
<th>Authorization Number:</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>OverAll Hazard Rank:</td>
<td>Hi</td>
</tr>
<tr>
<td>Toxicity=Hi</td>
<td></td>
</tr>
<tr>
<td>Leach=Nil</td>
<td></td>
</tr>
<tr>
<td>Fire=Nil</td>
<td></td>
</tr>
<tr>
<td>Disease=Nil</td>
<td></td>
</tr>
<tr>
<td>Percent of Components Unknown=</td>
<td>0.%</td>
</tr>
<tr>
<td>Note: ALUMINUM SULFATE&lt;&gt;ALUMINUM SULPHATE</td>
<td></td>
</tr>
</tbody>
</table>

| Stream Size: | 10000. gals. = 55141.25 Kgs. as liquid |
| Generic Process Name: | Improbable Mixture |
| Specific Process Name: | Demonstration |
| SIC Code(s): | -0- |
| pH= | 8. |
| Flashpoint= | 218.6°F |
| Disease= | N |

**Waste Stream Components:** (sorted by Eqv.Tox)

<table>
<thead>
<tr>
<th>CAS/RTECS #</th>
<th>NAME</th>
<th>Concentration</th>
<th>Eqv.Tox.</th>
</tr>
</thead>
<tbody>
<tr>
<td>64-19-7</td>
<td>ACETIC ACID</td>
<td>20.%</td>
<td>0.226415</td>
</tr>
<tr>
<td>1336-21-6</td>
<td>AMMONIUM HYDROXIDE</td>
<td>10.%</td>
<td>0.12</td>
</tr>
<tr>
<td>1303-96-4</td>
<td>BORAX</td>
<td>20.%</td>
<td>0.024</td>
</tr>
<tr>
<td>10043-81-3</td>
<td>ALUMINUM SULFATE</td>
<td>10.%</td>
<td>0.024</td>
</tr>
<tr>
<td>1305-62-0</td>
<td>CALCIUM HYDROXIDE</td>
<td>10.%</td>
<td>0.012</td>
</tr>
<tr>
<td>67-64-1</td>
<td>ACETONE</td>
<td>10.%</td>
<td>0.006</td>
</tr>
<tr>
<td>1302-76-7</td>
<td>ALUM SILICATE</td>
<td>10.%</td>
<td>0.</td>
</tr>
<tr>
<td>INNOC WATER</td>
<td></td>
<td>10.%</td>
<td>0.</td>
</tr>
</tbody>
</table>

No Toxicity Data available for: Components unable to be identified:

---

**Figure 30** TUTORIAL SCREEN FACSIMILE OF A PRINTER OUTPUT.

Note that the waste stream was ranked as having a "High" degree of hazard. In the printout, the overall degree of hazard ranking is presented as well as the degree of hazard ranking for each of the hazard categories. The entire data set for the waste stream is also printed out for review. If the components of the waste stream did not equal 100% then the percent of components unknown is given in line 4. This is a useful measurement that indicates if the Special Waste application was properly completed and/or entered into the computer. Also if a waste stream component was entered and the toxicity of the
component was not in the Toxicity Hazard Database, it would be listed. This information would alert HWRIC staff or the waste generator and disposer to attempt to find the required data so that the HWRIC Degree of Hazard Database could be updated.

5.2.1 Summary

A recapitulation of the procedures to generate a degree of hazard evaluation for a waste stream is presented below:

- Enter [R:BASE], while in subdirectory containing database.
- Select main menu item 2.
- Enter information in the permit data section and the component data section of the Illinois Special Waste Application Data form.
- Quit the form by pressing the ESC key.
- If other applications are to be entered select ADD from the horizontal menu.
- If no other applications are to be entered during the current session, select the QUIT command from the horizontal menu.
- Wait until the warning beep is sounded.
- Select output device (screen or printer).
- Obtain output and degree of hazard rank for each application.

5.3 EDITING AN APPLICATION

Editing an application and generating a new degree of hazard evaluation rank is an easy task. This important feature may be used to correct errors on the application or to analyze different hypothetical compositions of a specific waste stream. The latter would allow industrial concerns to conduct economic analysis in which the costs of disposal would be a factor of waste stream composition. In addition the effect of different waste stream reduction scenarios could be evaluated as a function of the degree of hazard rank for each resulting waste stream. In this tutorial we shall alter two component concentrations in our demonstration and then determine the effect that the change has on the degree of hazard rank for the waste stream.
For the demonstration waste stream, the concentrations of two components have been altered to determine the effect of these changes on the degree of hazard rank for the entire waste stream. In the demonstration waste stream, the concentration of acetic acid and ammonium hydroxide were altered to 30% solutions. You want to decrease the percentages of each of these pure components in the demonstration waste stream while increasing the percent water accordingly.

To edit an application, enter R:BASE System V and the DoHaz.App application program. Choose item 1 from the main menu (Change/LookUp Permit Applications) (Figure 26)

1) Main menu [1].

After selecting item 1 from the main menu you are queried for your password. Depending upon the final security arrangements to protect the HWRIC Degree of Hazard System a password or other identification may be required for access to specific applications. Should this degree of hazard system be implemented by the Illinois Pollution Control Board a separate security system would be necessary for the HWRIC Degree of Hazard Database. For this tutorial just press the enter key.

2) [ ].

The second question that appears is a request for the Authorization Number. (Figure 31). The Authorization Number is from the Illinois Environmental Protection Agency's form. Enter the demonstration Authorization Number.

3) Enter [1].

![Figure 31 TUTORIAL SCREEN FACSIMILE OF THE EDITING OF A SPECIAL WASTE APPLICATION DATA FORM.](image)

After entering the Authorization Number a new screen will appear with the Permit Data and Component Data sections (Figure 32a,b). This form is identical to that used in entering the original data for Application Number 1. The cursor control keys are identical
to those used in the original Special Waste Application form. The F9 key is used to toggle between the Permit Data and Component section of the form. Within a section the F7 key will move the cursor to the previous entry and the F8 key will move the cursor to the next entry. The "F" (function) keys are especially useful in editing data. To highlight a certain item for editing, use the F9 key to move the cursor to the appropriate section, then move the cursor to the appropriate item by using the UP and DOWN arrow keys. Type in the correct information over the displayed value.

Direct the cursor to the Acetic acid concentration and change it from 20.0% to 6.0%. Likewise change the concentration of ammonium hydroxide from 10.0% to 3.0%. Increase the water concentration to 31.0%. After you finish the editing press the ESC key.

4) [ESC].

The horizontal menu will appear at the top of the screen. To edit another application, select the QUIT command and then enter the next Application Number at the query. To quit the current program and generate the degree of hazard rank for the demonstration waste stream press the ENTER key after selecting QUIT.

5) Select [QUIT].

6) Press the ENTER key [ ].

Automatically the programs Eval.DoH and PrtHaz.DoH will be run as discussed in §5.2. Select the output to the printer.

7) [p].

The final printout of the new degree of hazard evaluation for the demonstration waste stream is presented in Figure 33. Note that the degree of hazard rank has been reduced to "Moderate."
Authorization Number: 1

Date: 01/30/1988

Overall Hazard Rank: Mod

Toxicity=Mod, Leach=Nil, Fire=Nil, Disease=Nil

Percent of Components Unknown: 0%

Note: -0-

Stream Size: 10000 gals. = 54870 Kgs. as liquid

Generic Process Name: Improbable Mixture

Specific Process Name: Demonstration

SIC Code(s): -0-

pH = 8

Flashpoint = 218°F

Disease = N

Waste Stream Components (sorted by Eqv.Tox):

<table>
<thead>
<tr>
<th>CAS/PTECS #</th>
<th>NAME</th>
<th>Concentration</th>
<th>Eqv.Tox</th>
</tr>
</thead>
<tbody>
<tr>
<td>64-19-7</td>
<td>ACETIC ACID</td>
<td>6.0%</td>
<td>0.06725</td>
</tr>
<tr>
<td>1336-21-6</td>
<td>AMMONIUM HYDROXIDE</td>
<td>3.0%</td>
<td>0.036</td>
</tr>
<tr>
<td>1303-96-4</td>
<td>BORAX</td>
<td>20.0%</td>
<td>0.024</td>
</tr>
<tr>
<td>10043-01-3</td>
<td>ALUMINUM SULPHATE</td>
<td>10.0%</td>
<td>0.024</td>
</tr>
<tr>
<td>1305-62-0</td>
<td>CALCIUM HYDROXIDE</td>
<td>10.0%</td>
<td>0.012</td>
</tr>
<tr>
<td>67-64-1</td>
<td>ACETONE</td>
<td>10.0%</td>
<td>0.006</td>
</tr>
<tr>
<td>1302-76-7</td>
<td>ALUM SULICATE</td>
<td>10.0%</td>
<td>0</td>
</tr>
<tr>
<td>INNOC</td>
<td>WATER</td>
<td>31.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

No Toxicity Data available for:

Components unable to be identified:

Figure 32  TUTORIAL SCREEN FACSIMILE OF EDITING THE APPLICATION AND COMPONENT DATA SECTIONS OF THE SPECIAL WASTE APPLICATION DATA FORM.
Authorization Number: 1

OverAll Hazard Rank: Mod (Mod )
Toxicity=Mod Leach=Nil Fire=Nil Disease=Nil

Percent of Components Unknown= 0.0%

Note: -0-

Stream Size: 100000. gals. = 54870. Kgs. as liquid
Generic Process Name: Improbable Mixture
Specific Process Name: Demonstration
SIC Code(s): -121-
pH= 8. Flashpoint= 218.°F Disease= N

Waste Stream Components:(sorted by Eqv.Tox)

<table>
<thead>
<tr>
<th>CAS/RTECS #</th>
<th>NAME</th>
<th>Concentration</th>
<th>Eqv.Tox</th>
</tr>
</thead>
<tbody>
<tr>
<td>64-19-7</td>
<td>ACETIC ACID</td>
<td>6.0%</td>
<td>0.067925</td>
</tr>
<tr>
<td>1336-21-6</td>
<td>AMMONIUM HYDROXIDE</td>
<td>3.0%</td>
<td>0.036</td>
</tr>
<tr>
<td>1303-96-4</td>
<td>BORAX</td>
<td>20.0%</td>
<td>0.024</td>
</tr>
<tr>
<td>10042-81-3</td>
<td>ALUMINUM SULPHATE</td>
<td>10.0%</td>
<td>0.024</td>
</tr>
<tr>
<td>1305-62-0</td>
<td>CALCIUM HYDROXIDE</td>
<td>10.0%</td>
<td>0.012</td>
</tr>
<tr>
<td>67-64-1</td>
<td>ACETONE</td>
<td>10.0%</td>
<td>0.005</td>
</tr>
<tr>
<td>1302-76-7</td>
<td>ALUM SILICATE</td>
<td>10.0%</td>
<td>0.</td>
</tr>
<tr>
<td>INNOC</td>
<td>WATER</td>
<td>31.0%</td>
<td>0.</td>
</tr>
</tbody>
</table>

No Toxicity Data available for:
Components unable to be identified:

---

Figure 33 TUTORIAL SCREEN FACSIMILE OF THE EDITED FINAL DEGREE OF HAZARD RANK FOR THE DEMONSTRATION WASTE STREAM.

5.3.1 Summary

To edit an application:

- Select main menu item 1.
- Enter the Authorization Number.
- Edit the form.
- Quit the form by engaging the ESC key.


- (To proceed with a second application enter the Authorization after the prompt.)
- Exit the editing mode by pressing the enter key at the Authorization Number query.
- After the warning Beep is sounded select the output device - printer or screen.
- Review output.

5.4 PRINTING APPLICATIONS PREVIOUSLY ENTERED

By selecting item 3 from the main menu, the degree of hazard evaluation of an application that has been previously entered will be printed. After selecting item 3 you will be queried for the Authorization numbers of the applications that you wish to review. By entering a series of Authorization numbers a printout of the degree of hazard for each waste stream will be generated.

5.4.1 Command Summary

To print the degree of hazard evaluations for a series of applications run the following procedure.

- Select main menu item 3.
- Enter the Authorization number.
- (Enter the next Authorization number ...).
- Exit the editing mode by pressing the ENTER key.
- Wait for the beep to sound and select the output device - printer or screen.
- Collect printout.

Finally quit the degree of hazard programs and exit from R:BASE System V.
5.5 EDITING THE SUBSTANC TABLE

5.5.1 Modifying the SUBSTANC Table

( CAUTION! MAKE A BACKUP OF THE ORIGINAL SUBSTANC TABLE! )

The SUBSTANC Table contains the toxicity and physical data for the HWRIC Degree of Hazard Database. To modify the SUBSTANC Table address the main menu and select item number 4: "Add/Change Substance Information." A sample menu will appear with the choices: EDIT, ADD, QUIT. Highlight the desired action and press the [enter] key.

5.5.1.1 Edit

To edit the SUBSTANC Table a form will appear on the screen after selecting "EDIT." This form contains all of the toxicity and physical data for one substance. If this agent is not the substance for which the database is to be modified, then select [ESC]. A horizontal menu will appear across the top of the screen (Figure 34). You may scroll through the substance list by using the "NEXT" or "PREVIOUS" commands. The substances are stored by CAS number. After the form with the data for the agent that you want to modify appears, select [EDIT]. The information areas on the form will highlighted as you move through the form. As in the editing of the application forms, the UP, DOWN and ENTER keys may be used to proceed through the form. When you finish with modifying the SUBSTANC Table form, select [ESC] and proceed to the next substance that you wish to modify. Select [QUIT] when you have finished editing.
## Component Toxicity & Physical Data

**CAS #:** 1303-96-4  
**NAME:** BORAX  
**Synonyms:** SODIUM BORATE, DECAHYDRATE;  
**Toxicity Level:** 2500.  
**Environmental Level:** 2.  
**Calculate Toxicity Level (Y/N)?:** Y  
**Carcinogen:** N  
**T050=0-**  
**oral LD50 - rat (mg/kg) = 2660. mg/kg if Unknown,**  
**inhalation LD50-rat (mg/L) = -999999. mg/L enter: -999999**  
**dermal LD50 - rabbit(mg/kg) = -999999. mg/kg if Innocuous,(eg.water)**  
**Aquatic (LC50 -fish)(mg/L) = 500. mg/L enter: -1**  
**Solubility (ppm in water) = 59200. ppm**  
**Density (grams/liter) = 1.7 gm/L**  
**Half-Life (in days) = 190. days**  
**n-octanol/water partition coefficient (log P) = -0-**  

**Data Sources:** ToxNet online database 5/31/86

---

**Figure 34** SUBSTANC TABLE FOR FORM FOR TOXICITY AND PHYSICAL DATA.

5.5.1.1.1 **Summary**

The steps to edit a SUBSTANC Table form for a component that is in the database are as follows.

- Select item 4 from the main menu.
- Choose the desired function, [EDIT].
- Edit the first substance form that you wish to modify.
- Select [ESC] to obtain the menu move through the SUBSTANC Table using the NEXT and PREVIOUS commands.
- After each desired SUBSTANC Table form is located, you may edit them.
- To exit the EDIT mode, select [QUIT] or [ESC] on the SUBSTANC Table menu.

---

66
5.5.1.2 Add

To add data on a new substance into the SUBSTANC Table select [ADD] from the SUBSTANC Table menu. A blank form will appear on the screen. Enter the requested information at each highlighted area, moving through the items after pressing the [ENTER] key. When you have completed the form, depress [ESC]. To add another application, select [ADD]. To exit the ADD mode select [QUIT] or [ESC].

5.5.1.2.1 Summary

The steps to add a component to the SUBSTANC Table are as follows.

- Select item 4 from the main menu.
- Choose the add function, [ADD].
- Complete the form.
- Exit the form by pressing [ESC].
- To add another component repeat the above steps.
- To exit the EDIT mode, select [QUIT] or [ESC] on the SUBSTANC Table menu.

5.5.1.3 Quit

Selecting Quit or ESC will cause the ToxLev.Sub program to run so that all changes will be incorporated and reflected in the ToxLevel and EnvLevel sections of the SUBSTANC Table. After the program has completed its run, the main menu will appear.

5.5.1.3.1 Summary

The steps to exit from the SUBSTANC Table are as follows.

- Select [QUIT].
- Wait for warning beep that indicates that the ToxLev.Sub has finished running.
- Continue at the main menu.
5.5.2 Substance Information Output

From the main menu, item 5 permits a selection of various types of output of the data from the SUBSTANC Table. Selecting item 5 from the main menu generates a second menu with four choices.

1) List unknown components.

2) List substances with no data.

3) List cataloged substances and data.

4) Exit.

Menu items 1, 2, and 3 will output the list to the printer. Item 4 will return you to the main menu.
CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

It is the conclusion of this study that a degree of hazard evaluation of Illinois Special Waste streams is an appropriate method to determine the impact of these wastes upon the public health and environment. The degree of hazard evaluation is quantitative in nature. To conduct a degree of hazard evaluation of Special Waste streams it is necessary to have quantitative data of high quality. Unfortunately, the quality of information contained in the 1984 Illinois Special Waste applications was poor, however, the recent Special Waste applications show a significant improvement.

It is our opinion that if the IEPA Special Waste Application forms were redesigned to accommodate our suggestions, the degree of hazard system would evolve into an exceedingly useful tool for State regulators as well as for industry. The degree of hazard system that we present herein was designed to assist the regulatory and industrial communities in determining the best cost-benefit relationship in controlling the detrimental impacts of Illinois industrial Special Waste streams. In addition, this report describes a system that can be used to evaluate the degree of hazard posed by Illinois Special Waste streams as defined by State statutes. The Illinois Pollution Control Board is mandated to implement a degree of hazard (or a suitable alternative). Industry, State Agencies such as IEPA, DENR and HWRIC with the assistance of the academic community should be able to address the technical problems that currently exist with the degree of hazard. The degree of hazard system is now at the stage for immediate implementation with the realization that it is an evolving system that can adapt to an expanding database of increasing sophistication.

6.2 RECOMMENDATIONS

6.2.1 Methodology

Specific recommendations to modify the degree of hazard methodology as defined by Plewa et al. (1986) include the following.

- Applications that score an "Unknown" in hazard categories must be identified, and the information needed to assign a hazard rank obtained either by a more thorough description of the waste stream or by additional analysis of the hazardous properties of specific components.

- More rigorous attention must be paid to proper typing and spelling of information on the IEPA Special Waste Application Forms. The degree
of hazard interactive computer system will identify some errors and notify the operator.

- The key components of a waste stream must total 100%. Running the degree of hazard system will indicate when the waste stream does not comply with the above requirement. Also, regulators can adjust the level of error or unknown components within a waste stream that they feel is appropriate.

- Components of the waste stream must be listed individually rather than in groups. For all defined chemical components the use of CAS numbers is a necessity.

- Industry-wide toxicity standards must be developed for the evaluation of complex mixtures or for the components of complex mixtures. These standards will allow the use of defined generic names as specific components in the degree of hazard analysis. Another approach would be a toxicological analysis of the composite waste stream or of specific complex mixtures that are defined as specific components of a waste stream.

- If toxicity data for specific components are not available from studies on laboratory rat and/or rabbits, any competent, relevant data from any mammalian species should be used in the degree of hazard evaluation.

6.2.2 Applications

The key to a competent degree of hazard evaluation is the quantity and quality of information on a Special Waste stream that is communicated by the application. No evaluation strategy, no matter its level of sophistication, can satisfactorily define the hazard to human health and the environment if the information on the application is inadequate or of poor quality. The Illinois Pollution Control Board is mandated to employ a degree of hazard evaluation of industrial waste streams. To facilitate this end, the IEPA Special Waste Application Forms need to be redesigned in order that the information necessary for the degree of hazard evaluation can be provided by the waste generator. The HWRIC Degree of Hazard Application Data Form was designed to interface with the IEPA form.

The following recommendations would reduce the number of waste streams ranked as "Unknown."

- Greater precision in component names is necessary. A requirement that each specific component name be listed with its CAS or RTECS numbers is necessary for a degree of hazard analysis. The implementation of this recommendation would reduce the mistakes in identifying components,
reduce the use of vague names by waste generators, and accelerate information retrieval.

- Allow for the inclusion of more than six components in a Special Waste application.
- Increase the space available on applications for individual component names.
- The application should have a "Yes"/"No" statement to indicate if the waste stream poses a disease hazard.

### 6.2.3 Computerization of the Degree of Hazard System

The success of this study in analyzing the degree of hazard evaluation was based in large measure on the establishment of an interactive, menu-driven microcomputer database management system. Specific questions about and modifications to the degree of hazard process could be tested using the random sample of the Illinois non-RCRA Special Waste streams used in the previous study (Plewa et al., 1986). The HWRIC Degree of Hazard system must now have its database expanded and the degree of hazard evaluation system implemented for Illinois Industrial Waste streams.

The results of this study clearly demonstrate that a degree of hazard evaluation can be conducted on Special Waste applications. The computerized Application Data Form is user friendly and the programs scan the application information and determine if a degree of hazard analysis can be conducted. The output indicates whether additional information is required or if the application is properly completed. The computer identifies the specific data deficiencies so that the waste generator is able to amend the application. When sufficient information is present, a degree of hazard evaluation is automatically conducted. If the hazard category database contains sufficient information, a degree of hazard rank would be assigned to the Special Waste stream. If the hazard category database does not contain the appropriate information, then the specific types of required information would be listed so that staff could search the national databases and/or scientific literature.

The objectives of this study have been completed. From results of this study it is apparent that conducting a degree of hazard evaluation on Illinois Special Waste streams is feasible and appropriate. Such a hazard evaluation could be conducted in a consistently fair manner with a high degree of accuracy. Those waste streams that pose a significant threat to the public health or the environment would be disposed of in an appropriate manner. Those waste streams that pose a low hazard could be candidates for deregulation. The degree of hazard approach permits an estimate of hazard based on scientific evidence. The degree of hazard evaluation as described in this study has the added benefit of being relatively rapid while reducing subjectivity in the decision-making process. Finally, the evaluation can be economically positive in that those waste streams that demand more costly
disposal techniques may be identified and separated from those waste streams that pose little hazard to human health and the environment.
LITERATURE CITED


Chemical Information Systems, Inc. RTECS (on-line): Registry of Toxic Effects of Chemical Substances provided by NIOSH. CIS, Baltimore, MD. (revisions through 1/11/88).


APPENDICES

Appendix A. IEPA Special Waste Stream Application Form.

Appendix B. Source Code of Programs Prepared for this Project Written in R:Base System V Language.
ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
DIVISION OF LAND/NOISE POLLUTION CONTROL
SPECIAL WASTE STREAM APPLICATION

<table>
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<tr>
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<th>DATE ENTERED</th>
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<td>8</td>
<td>15 / 7 / 92</td>
<td>15 / 7 / 92</td>
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This application is for waste: (check one)  Storage  Disposal  Treatment

APPLICANT (SITE)

Name: __________________________
Address: __________________________
(County) / (Community) / (State) / (Zip)

APPLICANT ADDRESS

Name: __________________________
Address: __________________________
(County) / (Community) / (State) / (Zip)

Site Contact Name: __________________________
Telephone: __________________________

The undersigned hereby makes application for a supplemental permit for the storage, treatment or disposal of this waste stream and certifies that the information referenced herein is true, correct and current.

Signature: __________________________
(Owner/Authorized Agent)

DATE: __ / __ / __

FOR AGENCY USE

PLANT ADDRESS

Name: __________________________
Address: __________________________
(County) / (Community) / (State) / (Zip)

WASTE GENERATOR INFORMATION

Name: __________________________
Address: __________________________
(County) / (Community) / (State) / (Zip)

Generator IEPA Code: __________
Generator USEPA Code: __________
Generator Contact Name: __________________________
Telephone: __________________________

Process/Operation CODE: __________
Process/Operation Name: __________________________

Process Description: __________________________

Generic Waste Code: __________
Generic Waste Name: __________________________

*INDICATE ULTIMATE DISPOSITION OF TREATMENT RESIDUALS OR WASTES:
WASTE CHARACTERISTICS

This waste is: (check one) Hazardous Non-Hazardous as defined by U.S.E.P.A. in the Resource Conservation and Recovery Act, and regulations adopted thereunder, and the Illinois Pollution Control Board in Title 35 - Subtitle G, Part 721.

USEPA Hazardous Waste Number(s)

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<th>Penetrometer Test</th>
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Transport Frequency __ Waste Class __

1 = ONE TIME 5 = MONTHLY 1 = SOLID
2 = DAILY 6 = BI-MONTHLY 2 = SEMI-SOLID
3 = WEEKLY 7 = QUARTERLY 3 = LIQUID
4 = BI-WEEKLY 8 = SEMI-ANNUALLY 4 = GAS

Reviewed by: __ __ __ / __ / __ (Agency Use) 5 = PONDERS

Flash Point __ °F

Percent Acidity __ Alkalinity __ pH __ Percent Solids __

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<tr>
<th>COMPONENT NAME</th>
<th>PERCENT</th>
<th>COMPONENT NAME</th>
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<td>______________</td>
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Analysis Deletion Field __

LAB MEASUREMENTS

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**OTHER ANALYSIS AS REQUIRED**

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**ADM 1067 (Rev. 10/86)**
8.2. Appendix B. Source Code of Programs Prepared for this Project
Written in R:Base System V Language

**Program DOHAZ**

```r
$COMMAND
DOHAZ
SET MESSAGE OFF
OPEN HWRIC
SET ERROR MESSAGE OFF
SET COLOR BACKGRND BLACK
SET COLOR FOREGRND GRAY
SET BELL OFF
SET VAR PICK1 INT
LABEL STARTAPP
  NEWPAGE
  CHOOSE PICK1 FROM Main IN DOHAZ.APX
  IF PICK1 EQ 0 THEN
    GOTO ENDAPP
  ENDIF
  IF PICK1 EQ 1 THEN
    RUN lookup IN DOHAZ.APX
    GOTO STARTAPP
  ENDIF
  IF PICK1 EQ 2 THEN
    RUN addit IN DOHAZ.APX
    GOTO STARTAPP
  ENDIF
  IF PICK1 EQ 3 THEN
    RUN printit IN DOHAZ.APX
    GOTO STARTAPP
  ENDIF
  IF PICK1 EQ 4 THEN
    RUN subuser IN DOHAZ.APX
    SET VAR PICK2 TEXT
    SET VAR LEVEL2 INT
    SET VAR LEVEL2 TO 0
    WHILE LEVEL2 EQ 0 THEN
      NEWPAGE
      CHOOSE PICK2 FROM subin IN DOHAZ.APX
      IF PICK2 EQ "ESC" THEN
        BREAK
      ENDIF
      IF PICK2 EQ "Edit CAS# " THEN
        RUN casin IN DOHAZ.APX
      ENDIF
      IF PICK2 EQ "Edit Name " THEN
        RUN namein IN DOHAZ.APX
      ENDIF
      IF PICK2 EQ "ADD " THEN
        ENTER SUBDATA
      ENDIF
      IF PICK2 EQ "QUIT " THEN
        BREAK
      ENDIF
  ENDIF
```

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ENDWHILE
CLEAR LEVEL2
CLEAR PICK2
RUN subrun  IN DOHAZ.APX
GOTO STARTAPP
ENDIF
IF PICK1 EQ 5 THEN
SET VAR PICK2 INT
SET VAR LEVEL2 INT
SET VAR LEVEL2 TO 0
WHILE LEVEL2 EQ 0 THEN
   NEWPAGE
   CHOOSE PICK2 FROM submenu IN DOHAZ.APX
   IF PICK2 EQ 0 THEN
      BREAK
   ENDIF
   IF PICK2 EQ 1 THEN
      RUN listunk IN DOHAZ.APX
   ENDIF
   IF PICK2 EQ 2 THEN
      RUN nodata IN DOHAZ.APX
   ENDIF
   IF PICK2 EQ 3 THEN
      RUN idcomps IN DOHAZ.APX
   ENDIF
   IF PICK2 EQ 4 THEN
      BREAK
   ENDIF
ENDWHILE
CLEAR LEVEL2
CLEAR PICK2
GOTO STARTAPP
ENDIF
IF PICK1 EQ 6 THEN
SET USER "hwric "
SET VAR PICK2 INT
SET VAR LEVEL2 INT
SET VAR LEVEL2 TO 0
WHILE LEVEL2 EQ 0 THEN
   NEWPAGE
   CHOOSE PICK2 FROM maintain IN DOHAZ.APX
   IF PICK2 EQ -1 THEN
      NEWPAGE
      DISPLAY dbhelp IN DOHAZ.APX
      WRITE "Press any key to continue "
      PAUSE
   ENDIF
   IF PICK2 EQ 0 THEN
      BREAK
   ENDIF
   IF PICK2 EQ 1 THEN
      RUN backto IN DOHAZ.APX
   ENDIF
ENDWHILE
CLEAR LEVEL2
CLEAR PICK2
GOTO STARTAPP
ENDIF
IF PICK2 EQ 2 THEN
  RUN resbas IN DOHAZ.APX
ENDIF
IF PICK2 EQ 3 THEN
  RUN compact IN DOHAZ.APX
ENDIF
IF PICK2 EQ 4 THEN
  RUN cleanup IN DOHAZ.APX
ENDIF
IF PICK2 EQ 5 THEN
  BREAK
ENDIF
ENDWHILE
CLEAR LEVEL2
CLEAR PICK2
GOTO STARTAPP
ENDIF
IF PICK1 EQ 7 THEN
  GOTO ENDAPP
  GOTO STARTAPP
ENDIF
IF PICK1 EQ 8 THEN
  RUN endit IN DOHAZ.APX
  GOTO STARTAPP
ENDIF
GOTO STARTAPP
LABEL ENDAPP
CLEAR PICK1
RETURN
$MENU
Main
COLUMN HWRIC Degree of Hazard DataBase
Change/LookUp Permit Applications
Add Permit Applications
Print Out Permit Applications
Add/Change Substance Info
List Substances
BackUp DataBase
EXIT
BREAK
$MENU
maintain
COLUMN DataBase Maintenance
Back Up DataBase onto another Disk
Restore DataBase from Backup
Compact DataBase on this Drive (Copies files first)
Clean up DataBase
EXIT
$MENU
submenu
COLUMN Compounds in the HWRIC DataBase
List Unknown Components
List Substances with No Data
List Cataloged Substances & Data
EXIT
$MENU
subin
ROW Modify Substance Table - Toxicity & Physical Info
Edit CAS#
Edit Name
ADD
QUIT
$SCREEN

Back Up Database onto Another Drive:

Compact DataBase on this Drive:
This command compacts the database on the disk by removing
unusable space (which had been occupied by now deleted info).
This needs to be done periodically to keep the database from
wasting too much space on the disk.

$COMMAND
lookup
set error var errprob
user
set var want integer
fillin want using " What is the Authorization Number? "
while want exists and want NE 0 then
    edit using permdat where authno EQ .want
    change DoIt to "YPr" in HazDeg where authno EQ .want
    clear want
    fillin want using " What is the Authorization Number? "
endwhile
delete rows from componet where compon fails and CAS_No fails
if errprob EQ 0 then; run EVAL.DoH; endif
run PrtHaz.DoH
return

$COMMAND
addit
set error var errprob
user
Enter using PermtDat
set var prob to .errprob
if prob EQ 0 then
    append permit to hazdeg where DoIt fails
    change DoIt to "A" in Permit where DoIt fails
    change DoIt to "Y" in HazDeg where DoIt fails
    change When to .#DATE in Permit where When fails
    delete rows from componet where compon fails and CAS_No fails
run Eval.DoH
run PrtHaz.DoH
else; Write "Access Denied."
endif
return

$COMMAND
printit
compute ToxDate as MAX when from SUBSTANC *(get latest update date)
fillin want using "What is Authorization Number?"
while want exists and want NE 0 then
    set var AppDate to when in HazDeg where authno EQ .want
    if AppDate LT .ToxDate then *(Eval run before Update)
        change DoIt to Y in HazDeg where authno EQ .want
    else; set var Huh to DoIt in HazDeg where authno EQ .want
        change DoIt to (.Huh "Pr") in HazDeg where authno EQ .want
    endif
    clear want
    fillin want using "What is the next Authorization Number?"
endwhile
run Eval.DoH
run PrtHaz.DoH
return

$COMMAND
subuser
set error var errprob
user
return

$COMMAND
subrun
if errprob EQ 0 then
    run ToxLev.SUB ; endif
return

$COMMAND
edit
set messages on
set error messages on
set esc on
break
return

$COMMAND
backto
fillin wantto using "Where do you want this?"
set esc off
output .wantto
backup all
output screen
set esc on
return
$COMMAND
resbas
fillin wherfr using " What is the Drive:\Path\Filename ?"
restore .wherfr
return
$COMMAND
compact
set esc off
fillin wantto using " Where should the copies go? Drive:\Path\ "
set var wantto = .wantto + "HWRIC?.rbf"
copy HWRIC?.rbf .wantto
pack
set esc on
return

$COMMAND
cleanup
write " Relax....this will take a while......."
delete duplicates from permit
delete duplicates from hazdeg
delete duplicates from componet
return

$COMMAND
listunk
*(listunk - to list unk components in COMPONET)
output printer
print unckomp sorted by CAS_NO COMPON where ToxRate EQ -999 and CAS_NO exists
print unckomp sorted by COMPON where ToxRate EQ -999 and CAS_NO fails
output screen
return

$COMMAND
nodata
*(nodata- lists compon from SUBSTANC with no Tox data)
output printer
print lstnodat sorted by compon where ToxLevel LT -1
output screen
return

$COMMAND
idcomps
*(idcomps - lists identified compon from SUBSTANC )
write " Please have Printer in Condensed Font (i.e. >15 cpi). "
pause
output printer
print listsub sorted by COMPON where LevSrc NE I
output screen
write " You can return Printer to 12 pitch (Elite). "
return
$COMMAND
casin
write "What is the CAS Number?"
fillin IDcomp using "use -hyphens--; use * for all) "
edit using SUBDATA sorted by CAS_NO where CAS_NO contains .IDcomp
return

$COMMAND
namein
fillin IDcomp using " What is all or part of the Name? "
edit using SUBDATA sorted by COMPON where compon contains .IDcomp
return
Program ToxLev.Sub

*(ToxLev.Sub-assigns normalized toxicity value to components in )
  *(Substanc by normalizing to oral rat LD50, choosing highest)
  *(tox value )
  *( modified from Reddy method )
  *( written for RBase System V........10/87 )

SET BELL OFF
SET MESSAGES OFF
SET ERROR MESSAGES OFF
SET CLEAR OFF
SET ESCAPE OFF
Write " Assigning Toxicity Levels to Substances......"
Write " this will take a while, say maybe 10 minutes...."

*(PARAMETERS )

*(factors for normalizing toxicities (dermal,aquatic,inhal) to oral)
*(basis:Reddy report HWRIC-RR013, pg.4-19;or RCRA 40CFR ch.1 261.11)
set var InhNorm to 25.0
set var DerNorm to 0.25
set var AqNorm to 5.0

*(maximum toxicity value - value above this calc out to 0 haz)
set var OrMax to 5000.0

  *(basis: )
set var CarNorm to 0.1 *(assume high toxicity for carcinogens)
set var MutNorm to 0.6 *(assume high, but lower, tox for mutagens)

*(factors for normalizing enviroment factors (log P,solubility) to)
*( persistence/halflife; basis: Reddy report pg.4-27)
set var LogPNorm to 2.437708 *( Log P - 2.437708 + log(days) )
set var SolNorm to 27.4 *( Sol_ppm - 27.4 x (days) )

set var STox REAL
set var SEnv REAL
set var ELog REAL
set var ESol REAL

*(loop thru Substanc where not designated as calc by Y)

set pointer #2 p2 for Substanc where LevSrc NE "N" and LevSrc NE "n"
while p2 EQ 0 then
  clear STox TAq TInh TDer CarMut TTD SEnv ELog ESol Env

SET VAR WHAT TO COMPON IN #2
SHOW VAR WHAT
*(Toxicity)*
set var STox to oral in #2
if STox EQ -1 then *(innocuous )
   change ToxLevel to 0.0 in #2
   change EnvLevel to 0.0 in #2
   change LevSrc to "I" in #2
else
   set var TAq to Aquatic in #2 *(is Aquatic tox higher ?)
   set var TAq = (.TAq * .AqNorm)
   if TAq LT .STox and TAq GT 0 and TAq LT 5000 then
      set var STox to .TAq; endif
   if STox LT 0 and TAq GT 0 then
      set var STox to .TAq; endif
   set var Tlnh to inhal in #2 *(is Inhalation tox higher ?)
   set var Tlnh = (.Tlnh * .InhNorm)
   if Tlnh LT .STox and Tlnh GT 0 then
      set var STox to .Tlnh; endif
   if STox LT 0 and Tlnh GT 0 then; set var STox to .Tlnh; endif
   set var TDer to dermal in #2 *(is dermal tox higher ?)
   set var TDer = (.TDer * .DerNorm)
   if TDer LT .STox and TDer GT 0 then
      set var STox to .TDer; endif
   if STox LT 0 and TDer GT 0 then; set var STox to .TDer; endif
   set var CarMut to carcin in #2 *(if carcinogen or mutagen)
   set var TTD to TDSO in #2
   if CarMut NE N and TTD exists then
      set var TCar to .TTD
   else
      if CarMut EQ "M" or CarMut EQ "m" then
         set var TCar to .MutNorm
      else; set var TCar to (.OrMax + 100); endif
      if CarMut EQ "C" or CarMut EQ "c" then
         set var TCar to .CarNorm; endif
   endif
   if TCar LT .STox and TCar GT 0 and TCar LT .OrMax then
      set var STox to .TCar; endif
   if STox LT 0 then *(Unknown Tox)
      change ToxLevel to -999 in #2
      change EnvLevel to -999 in #2
      change LevSrc to "U" in #2
   else; change LevSrc to "Y" in #2
      if STox GT 0 and STox LE .OrMax then
         change ToxLevel to .STox in #2 *(known tox, some haz)
      else
         change ToxLevel to 0.0 in #2 *(known tox, no haz)
         change EnvLevel to 0.0 in #2
   endif
endif; endif

endif

*(Environmental)
if STox GT 0 and STox LE .OrMax then
    set var SEnv to halflife in #2 *(persistence)
    set var ELog to Log_P in #2 *(bioaccumulation)
    set var ESol to sol_ppm in #2 *(solubility)
    if ELog exists and SEnv fails then
        set var SEnv = (10 **(.ELog - .LogPNorm)); endif
    if SEnv fails and ESol exists then
        set var SEnv = (.ESol / .SolNorm); endif
    if SEnv exists then
        if ELog exists then
            set var ELog = (10 **(.ELog - .LogPNorm))
            if SEnv GT .ELog and ELog GT 0 then
                set var SEnv to .ELog; endif
        endif
        if ESol exists then
            set var ESol = (.ESol / .SolNorm)
            if SEnv GT .ESol and ESol GT 0 then
                set var SEnv to .ESol; endif
        endif
        if SEnv fails or SEnv LT 0 then; set var Env to 0
        else; if SEnv LT 30 then; set var Env to 1
            else; if SEnv LT 365 then; set var Env to 2
            else; set var Env to 3; endif
        endif; endif
    else; set var SEnv to -999; endif

    change EnvLevel to .Env in #2 *(EnvLevel in terms of 
days/halflife)
endif

    next #2 p2
endwhile

SET CLEAR ON
SET ESCAPE ON
beep
return
Program Eval.DoH

*(EVALI.DOH - evaluates each hazard category for designated permit)
*( applications & assigns a degree of hazard rating to)
*( each; the overall hazard is then assigned as the )
*(highest rating written for RBase System V.......8/87)
*(modify Env by removing Size & using Stream avg Env as code 0-3)

set bell off
set error messages off
set messages off
set error var errprob
write " I'm evaluating the permit applications for Degree of Hazard."

*(PARAMETERS)

set var QuantoKg = 3.875 *(ratio Kgs to units in Quant in Permit)2
*(3.875 kg/gal = density of water)

set var UnkLimit = 0.0 *(in %, amount of permit allowed to be unk)
set var Off100pc = 200.0 *(in %, amount total conc is ±100%)
set var OffUndpc = (100.0 - .Off100pc)
set var OffOvrc = (100.0 + .Off100pc)
if OffUndpc LE 0 then; set var OffUndpc = 0.0; endif

set var LeachSiz = 1200.0 *(size-KG cutoff between Leach DOH ranks)
set var LeachLo = 4.0 *(pH >cutoff for Leach hazard)
set var LeachHi = 10.0 *(pH <cutoff for Leach hazard)

set var FireSiz = 1200.0 *(size-KG cutoff between Fire DOH ranks)
set var Ignit1 = 140.0 *(liquid waste> flashpt °F limits)
set var Ignit2 = 200.0 *(liquid waste< flashpt °F limits)
set var Flamm = 130.0 *(solid waste <flashpt °F limit)

*(Reference substance which Tox Scoring is based on )
set var RefSub = 300 *(copper sulfate LD50 mg/kg)

set var ToxSc01 = 100.0 *(Toxicity wtKg*conc cutoff for DOH scores)
set var ToxSc12 = 1000.0 *(order of magnitude reduction from ToxSc23=Hi)
set var ToxSc23 = 10000.0 *(basis:100%RefSub at 100kg-'84 RCRA small gen. exempt)

set var EnvSc01 = 1.0 *(Environmental cutoffs)
set var EnvSc23 = 2.0

*(loop thru all permit, evaluate those tagged in col DoIt)
set pointer #2 ptr2 for HazDeg where DoIt contains "Y" or DoIt fails
while ptr2 EQ 0 then
*(initialize)*
clear F D L Size Flag
set var Flag note
set var AuNo to authno in #2
set var prob to .errprob
if prob NE 0 then; goto elfin; endif
show var AuNo
set var F to flash in permit where authno EQ .AuNo
set var L to pH in permit where authno EQ .AuNo
set var State to phase in permit where authno EQ .AuNo
set var D to disease in permit where authno EQ .AuNo
set var Size to quant in permit where authno EQ .AuNo
set var StrDen = 0.0
set var StrTox = 0.0; set var StrEnv = 0.0
set var ToxUnk = 0.0; set var TotConc = 0.0

*(loop thru components for a permit, summing concs, etc)*
set pointer #3 ptr3 for Componet where authno EQ .AuNo
if ptr3 NE 0 then *(if there are no components)*
  set var flag = (.flag & " No Components ")
  set var ToxUnk = 100.0 ; set var StrTox = -999
  set var TDoH = -999; change Toxicity to Unk in #2
  set var StrDen = 1.0; endif
while ptr3 EQ 0 then
  clear Cname Sname CCAS SCAS Cden Ctox Cenv CConc
  set var CCAS text; set var SCAS text; set var Sname text
  set var Cden real
  set var Cname to COMPON in #3
  set var CCAS to CAS NO in #3
  set var CConc to cone in #3
  set var TotConc = .TotConc + .CConc *(100% sum check)

  if CCAS exists and CCAS NE "INNOC" then
    set var SCAS to CAS_NO in Substanc where CAS_NO EQ .CCAS
    set var Sname to compon in Substanc where CAS_no EQ .CCAS
    if SCAS EQ .CCAS then
      set var Cden to density in Substanc where CAS_NO EQ .CCAS
      set var Ctox to ToxLevel in Substanc where CAS_NO EQ .CCAS
      set var CEnv to EnvLevel in Substanc where CAS_NO EQ .CCAS
      GOTO CalcOK
    endif; endif
  endif
endif

if CCAS fails or Sname fails or SCAS NE .CCAS then
  set pointer #1 ptr1 for substanc where compon contains .Cname
  while ptr1 EQ 0 and Sname NE .Cname then
    set var Sname to compon in #1
    set var SCAS to CAS_NO in #1
    if SCAS EQ "INNOC" or SCAS fails then
      set var SCAS to " "; endif
if Sname EQ .Cname or SCAS EQ .CCAS then
    set var Cden to density in #1
    set var CTox to ToxLevel in #1
    set var CEnv to EnvLevel in #1
    GOTO CalcOK
endif

next #1 ptr1
endwhile
endif

*(if name & CAS not matched, then unknown)
set var name to COMPON in #3
set var ToxUnk = .ToxUnk + .CConc
set var Cden = 1.0       *(assume density of water)
change ToxRate to -999 in #3 *(flag in compon table)
change EnvRate to -999 in #3
goto fincomp

label CalcOK       *(calculate values for known components)
if CTox GT 0 then    *(identified components with tox data)
    *(normalize & proportion component tox)
    if CEnv fails or CEnv LT 0 then
        set var CEnv = 0; endif
    set var CTox = (.RefSub/ .Ctox)*(.CConc/100.0)
    set var CEnv = (.CEnv*(.CConc/100.0))
    set var StrTox = (.StrTox + .CTox )
    set var StrEnv = (.StrEnv + .CEnv )
    change ToxRate to .CTox in #3
    change EnvRate to .CEnv in #3
else; set var Cden to 1.0
    if CTox EQ 0 then; change ToxRate to 0 in #3 *(innoc)
        change EnvRate to 0 in #3
    else; change ToxRate to -9 in #3     *(iden.component,no data)
        change EnvRate to -9 in #3
    set var ToxUnk = .ToxUnk + .CConc; endif
endif

if Sname EQ .Cname and CCAS fails then *(permit w/o component CAS #)
    set var Flag to (.Flag & "@" + .Cname + " uses CAS #" + .SCAS)
endif
if Cname fails and SCAS EQ .CCAS then *(permit w/o component names)
    set var Flag to (.Flag & "@"+.CCAS +" assumed is "+.Sname);endif
if Sname NE .Cname and SCAS EQ .CCAS then *(names wrong,but CAS match)
    set var Flag to (.Flag & "@"+ .Cname +"<>"+ .Sname); endif
if Sname EQ .Cname and SCAS NE .CCAS and CCAS NE "INNOC" then
    *(names match, but not CAS#: assume typo in CAS#)
    set var Flag to (.Flag & "@" + .CCAS + "<>" + .SCAS); endif

label fincomp

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if Cden fails then; set var Cden = 1.0; endif
set var StrDen = (.StrDen + (.Cden * .CConc/100.0) )

next #3 ptr3
endwhile
*(end loop thru components)

set var Size to (.StrDen * .Size * .QuantoKg)
change wt_kg to .Size in #2

*( Degree of Hazard calcs where 3=Hi 2=Mod 1=Lo )
*( 0=Neg 0=Nil -999=Unk)

*( LEACH DoH)
if L fails then
  change leach to "Unk" in #2; set var LDoH to -999
else
  if L LE .LeachHi and L GE .LeachLo then
    change leach to "Nil" in #2; set var LDoH to 0
  else
    if Size GE .LeachSiz then
      change leach to "Mod" in #2; set var LDoH to 2
    else
      change leach to "Lo" in #2; set var LDoH to 1
    endif; endif
endif

*( Disease DoH)
if D fails or D contains "U" then
  change disease to "Unk" in #2; set var DDoH to -999
else
  if D contains "Y" or D contains "y" then
    change disease to "Hi" in #2; set var DDoH to 3
  else
    change disease to "Nil" in #2; set var DDoH to 0
  endif; endif

*(Fire DoH)
if F fails or State fails or State contains "Unk" then
  change fire to "Unk" in #2; set var FDoH to -999
else
  if State contains "liq" then
    if F LT .Ignit1 or F GE .Ignit2 then
      change fire to "Nil" in #2; set var FDoH to 0
    if F LT .Ignit1 then; change fire to "RCRA" in #2; endif
  else
    if Size GE .FireSiz then
      change fire to "Hi" in #2; set var FDoH to 3
    else
      change fire to "Lo" in #2; set var FDoH to 1
    endif
  endif
else
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if F GE .Flamm then  
    change fire to "Nil" in #2; set var FDoH to 0  
else  
    if Size GE .FireSiz then  
        change fire to "Hi" in #2; set var FDoH to 3  
    else  
        change fire to "Lo" in #2; set var FDoH to 1  
    endif; endif; endif; endif  

*(Toxicity DOH)  
change ToxUKpc to .ToxUnk in #2  
set var wtconc to (.Size * .StrTox)  
change ToxWtEqv to .wtconc in #2  
if TotConc LE .OffUndpc or TotConc GT .OffOvrpc then  
  *(if component don't add up to close to 100%, don't calc)  
    change toxicity to "Unk" in #2; set var TDOH to -999  
    set var Flag to .Flag & "@ Conc. not Equal to 100% "  
else  
    if ToxUnk GT .UnkLimit then *( don't calc if %Unk too great)  
        change toxicity to "Unk" in #2; set var TDOH to -999  
    else  
        if wtconc GE .ToxSc23 then; set var TDoH to 3; endif  
        if wtconc LT .ToxSc23 and wtconc GE 0 then; set var TDoH to 0; endif  
    endif  
    if wtconc LT .ToxSc12 and wtconc GE .ToxSc01 then; set var TDoH to 1; endif  
    ifwtconc LT .ToxSc12 and wtconc GE .ToxSc01 and wtconc GE 0 then; set var TDoH to 0; endif  
    if TDoH EQ 1 or TDoH EQ 2 then  
        if StrEnv GE EnvSc23 then; set var TDoH to (.TDoH +1)  
        else  
            if StrEnv LT EnvSc01 then; set var TDoH to (.TDoH -1)  
            endif; endif; endif  
    endif  
    if TDoH Lt 0 then; change toxicity to "Unk" in #2; endif  
    if TDoH EQ 0 then; change toxicity to "Neg" in #2; endif  
    if TDoH EQ 1 then; change toxicity to "Lo" in #2; endif  
    if TDoH EQ 2 then; change toxicity to "Mod" in #2; endif  
    if TDoH EQ 3 then; change toxicity to "Hi" in #2; endif  
    endif; endif; endif; endif  

*(OverAll DOH)  
set var AllDoH to "Unk"  
if TDoH EQ 0 or FDoH EQ 0 or DDoH EQ 0 or LDoH EQ 0 then  
    set var AllDoH to "Neg"; endif  
if TDoH EQ 1 or FDoH EQ 1 or DDoH EQ 1 or LDoH EQ 1 then  
    set var AllDoH to "Lo"; endif  
if TDoH EQ 2 or FDoH EQ 2 or DDoH EQ 2 or LDoH EQ 2 then  
    set var AllDoH to "Mod"; endif  

if TDoH EQ 3 or FDoH EQ 3 or DDoH EQ 3 or LDoH EQ 3 then
    set var AllDoH to "Hi"; endif
if TDoH LT 0 then; set var AllDoH to "Unk" ; endif

change OverAll to .AllDoH in #2
if TDoH LT 0 or FDoH Lt 0 or DDoH Lt 0 or LDoH Lt 0 then
    change OverUnk to "Unk" in #2
else; change OverUnk to .AllDoH in #2; endif

change Irreg to .Flag in #2
change DoIt to "DPr" in #2
change When to #DATE in #2

next #2 ptr2  *( end loop thru permits)
endwhile
label elfin
beep
clear all var
return
Program PrtHaz.DoH

*(PrtHaz.DoH - prints out info from Permit & HazDeg if there is a Pr in DoIt. To be run after EVAL.DoH *)

set bell off
set error messages off
set messages off
fillin whereout using "Does this go to the Printer or the Screen? P/S "
if whereout contains "P" then; output printer
  else; output screen; endif

set pointer #2 ptr2 for HazDeg where DoIt contains "Pr"
while ptr2 EQ 0 then
  set var Ano to authno in #2
  print EvalHaz where authno EQ .Ano
  print EvalPerm where authno EQ .Ano
  if whereout contains S then; write "Press any key..."; Pause; endif
  print EvalComp sorted by ToxRate=D where authno EQ .Ano
  if whereout contains S then; write "Press any key..."; Pause; endif
  write " No Toxicity Data available for:"
  select compon CAS_NO cone from Componet where authno EQ .Ano and +
    ToxRate EQ -9
  write " Components unable to be identified:"
  select compon CAS_NO cone from Componet where authno EQ .Ano and +
    ToxRate EQ -999
  write "
  if whereout contains S then; write "Press any key..."; Pause; endif
  new page
  change DoIt to "D" in #2
next #2 ptr2
endwhile

output screen
beep
return