

SOLVENTS STUDY

**** CONTAINS NO CONFIDENTIAL BUSINESS INFORMATION ****

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U.S. Environmental Protection Agency
Office of Solid Waste
Hazardous Waste Identification Division (5304W)
Washington, DC 20460

Solvents Study

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- Appendix D: List of rationale for removing industries from further study as solvent users.
- Appendix E: RCRA 3007 Preliminary Survey of Solvent Use
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- Appendix G: Preliminary Questionnaire Data for All Responders By SIC Code
- Appendix H: RCRA 3007 Survey of Solvent Use
- Appendix I: Tables of Waste Generation, Characterization, and Management, by Solvent

1.0 Study Background

1.1 Legislative and Judicial Background

1.1.1 Existing Solvent Listings and the Regulatory Definition of Solvent

As part of the Hazardous and Solid Waste Amendments (HSWA) of 1984, EPA was required to make determinations as to whether certain wastes are hazardous under RCRA. Among these are solvent wastes. Five hazardous waste listings for solvent wastes have been promulgated to date at 40 CFR §261.31(a). These are shown below, and the basis for listing these solvents, toxicity (T) or ignitability (I) is shown in parentheses after the listing description.

- F001: The following spent halogenated solvents used in degreasing: Tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride, and chlorinated fluorocarbons; all spent solvent mixtures/blends used in degreasing containing, before use, a total of ten percent or more (by volume) of one or more of the above halogenated solvents or those solvents listed in F002, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures. (T)
- F002: The following spent halogenated solvents: Tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, ortho-dichlorobenzene, trichlorofluoromethane, and 1,1,2-trichloroethane; all spent solvent mixtures/blends containing, before use, a total of ten percent or more (by volume) of one or more of the above halogenated solvents or those listed in F001, F004, or F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures. (T)
- F003: The following spent non-halogenated solvents: Xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclohexanone, and methanol; all spent solvent mixtures/blends containing, before use, only the above spent non-halogenated solvents; and all spent solvent mixtures/blends containing, before use, one or more of the above non-halogenated solvents, and, a total of ten percent or more (by volume) of one or more of those solvents listed in F001, F002, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures. (I)
- F004: The following spent non-halogenated solvents: Cresols and cresylic acid, and nitrobenzene; all spent solvent mixtures/blends containing, before use, a total of ten percent or more (by volume) of one or more of the above non-halogenated solvents or those solvents listed in F001, F002, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures. (T)
- F005: The following spent non-halogenated solvents: Toluene, methyl ethyl ketone, carbon disulfide, isobutanol, pyridine, benzene, 2-ethoxyethanol, and 2-nitropropane; all spent solvent mixtures/blends containing, before use, a total of ten percent or more (by volume) of one or more of the above non-halogenated solvents or those solvents listed in F001, F002, or F004; and still bottoms from the recovery of these spent solvents and spent solvent mixtures. (I,T)

The existing solvent listings in 40 CFR 261.31 apply to spent solvents that are used for their "solvent properties," as defined in the December 31, 1985 Federal Register (50 FR 53316). This definition

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of "solvent use" was included in the RCRA §3007 Solvent Use Questionnaire used to obtain information to support the solvent investigation:

"Solvents are used for their "solvent" properties -- to solubilize (dissolve) or mobilize other constituents. Examples of such solvent use include degreasing, cleaning, and fabric scouring, use as diluents, extractants, and reaction and synthesis media, and for other similar uses. This definition is discussed in the listing determination for F001-F005 solvents, 50 FR 53316, December 31, 1985. A chemical is not used as a solvent if it is used only for purposes other than those described above.

1.1.2 Summary of EDF Settlement Agreement

The Environmental Defense Fund (EDF) and EPA entered into a consent decree to resolve most of the issues raised in a civil action undertaken by the Environmental Defense Fund (EDF v. Browner, Civ. No. 89-0598 (D.D.C.)), in which the Agency agreed, among other things, to a schedule for making a listing determination and a study on spent solvents. The consent decree was approved by the court on December 9, 1994. As modified, the consent decree provides that the listing determination is scheduled to be proposed for public comment on or before July 31, 1996 and promulgated on or before May 31, 1997. This listing determination includes the use following spent solvents, still bottoms from the recovery of the following solvents, and spent solvent mixtures thereof: cumene, phenol, isophorone, acetonitrile, furfural, epichlorohydrin, methyl chloride, ethylene dibromide, benzyl chloride, p-dichlorobenzene, 2-methoxyethanol, 2-methoxyethanol acetate, 2-ethoxyethanol acetate, and cyclohexanol.

For an additional set of solvents, EPA agreed to conduct a study, in lieu of a listing determination, and issue a final report. The study is scheduled to be issued by August 30, 1996. This study is to discuss the wastes associated with the use of the materials as solvents, the toxicity of the wastes, and a description of the management practices for the wastes. These additional chemicals are: diethylamine, aniline, ethylene oxide, allyl chloride, 1,4-dioxane, 1,1-dichloroethylene, and bromoform.

1.2 Industry Identification Process

The solvents investigation undertaken to support this study covered spent solvents, still bottoms from the recovery of spent solvents, and mixtures of spent solvents. Spent solvents are solvents that have been used and are no longer fit for use without being regenerated, reclaimed, or otherwise processed (50 FR 53316, December 31, 1985). The Agency also investigated the residuals generated by processes that use the solvents of interest. Residuals include spent solvents, residuals generated during solvent recovery, and any residuals generated after the solvent has been introduced into the process that might include some concentration of spent solvent. The solvents under investigation included the seven chemicals for which EPA must make a listing determination as well as the seven solvent study chemicals that are the subject of this report.

EPA's solvents investigation did not consider processes where the constituents of interest are used as raw materials or principally sold as commercial products (i.e., where the constituent is not used for its solvent properties). This approach is similar to discussions in the December 31, 1985 Federal Register notice for existing listings, which noted that "...process wastes where solvents were used as reactants or ingredients in the formulation of commercial chemical products are not covered by the listing." Examples of the use of solvents as reactants or ingredients are the use of solvents in the manufacture of paints and coatings. It is important to note, however, that solvents added as a thinner to product paints and coatings after purchase are being used for their solvent properties and, after use, will meet any applicable spent solvent listings.

1.2.1 Research to Identify Potential Uses of Solvents

As stated above, the solvents investigation is unique in that it focuses on facilities using chemicals *for their solvent properties*. Unlike a traditional industry investigation, which would focus on a specific waste generated in a process unique to one industry, the solvents investigation focussed on the activities of *all* users of these solvents. The immediate challenge to the program was the identification of industries using the chemicals as solvents. To address this challenge, significant background research was conducted on each chemical to determine its probable solvent uses.

Literature searches were conducted to identify industries using the chemicals as solvents. Initial sources searched included *Chemical Engineering Handbook*, the *Industrial Solvents Handbook*, and the SRI *Chemical Economics Handbook* to obtain basic information on production and potential solvent uses. Chemical Abstracts were searched for a four- to twelve-year period for abstracts on potential uses of each of the seven chemicals as a solvent. The number of years searched depended on the number of references available on a specific chemical. Each abstract was reviewed a team of chemists and chemical engineers to determine whether the use constituted a potential solvent use (as defined by EPA/OSW) and to relate the use to industries that may employ the solvent in their processes. Chemical Abstracts provided background on specific solvent uses and were used to determine potential users by Standard Industrial Classification (SIC) code. These efforts produced a list of SIC codes for industries suspected of using the chemicals for their solvent properties. The final memorandum on the Chemical Abstract search is included in Appendix A. The results of the search are summarized in Tables 1-1 through 1-7. Where SIC codes are followed by a question mark (e.g., 2833? for diethylamine use), the potential use of the chemical by facilities in these SIC codes is highly questionable based on the Chemical Abstracts. They are included for completeness.

Table 1-1 Potential Allyl Chloride Users Identified from Chemical Abstracts

2911	Petroleum Refining
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Table 1-2 Potential Aniline Users Identified from Chemical Abstracts

2865	Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments
2999	Products of Petroleum and Coal, Not Elsewhere Classified

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Table 1-3 Potential Bromoform Users Identified from Chemical Abstracts

1311	Crude Petroleum and Natural Gas
2899	Chemicals and Chemical Preparations, Not Elsewhere Classified

Table 1-4 Potential Diethylamine Identified from Chemical Abstracts

2611	Pulp Mills
2819	Industrial Inorganic Chemicals, Not Elsewhere Classified
2823	Cellulosic Manmade Fibers
2833?	Medicinal Chemicals and Botanical Products
2836	Biological Products, Except Diagnostic Substances
2865	Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments
3089	Plastic Products, Not Elsewhere Classified

Table 1-5 Potential 1,4-Dioxane Users Identified from Chemical Abstracts

1311	Crude Petroleum and Natural Gas
2295	Coated Fabrics, Not Rubberized
2611	Pulp Mills
2621	Paper Mills
2679	Converted Paper and Paperboard Products, Not Elsewhere Classified
2752	Commercial Printing
2759	Commercial Printing, Not Elsewhere Classified
2821	Plastics Materials, Synthetic Resins, and Nonvulcanizable Elastomers
2822	Synthetic Rubber (Vulcanizable Elastomers)
2823	Cellulosic Manmade Fibers
2824	Manmade Organic Fibers, Except Cellulosic
2833	Medicinal Chemicals and Botanical Products
2834	Pharmaceutical Preparations
2842	Specialty Cleaning, Polishing, and Sanitation Preparations
2865	Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments
2869	Industrial Organic Chemicals, Not Elsewhere Classified
2879	Pesticides and Agricultural Chemicals, Not Elsewhere Classified
2899	Chemicals and Chemical Preparations, Not Elsewhere Classified
2911	Petroleum Refining
3291	Abrasive Products

Table 1-6 Potential Ethylene Oxide Users Identified from Chemical Abstracts

None	One probable solvent use identified over 12 year Chemical Abstracts search could not be linked to a SIC Code.
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Table 1-7 Potential Vinylidene Chloride Users Identified from Chemical Abstracts

None	No probable solvent uses were identified over 12 year Chemical Abstracts search.
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The Toxic Release Inventory (TRI) database was searched for addresses of facilities reporting releases of the 7 chemicals. The TRI initially was used to develop a baseline of SIC codes for solvents that were reported "as otherwise used". This use classification most paralleled EPA's definition of solvent use. However, some limitations apply. The TRI did not provide complete coverage of the affected industries for

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a number of reasons. Not all of the 7 solvents under investigation are included in the TRI reporting list; diethylamine is not on the list of TRI chemicals. The TRI has a reporting threshold of 10,000 pounds. Facilities using less than that quantity are not required to complete TRI reports (i.e., are not included in the TRI database) and, therefore, would not have been identified as potentially subject to the solvents listing determination. Finally, the TRI is limited to facilities in SIC Codes 20-39, which encompass manufacturing industries. Appendix B to this report contains the instructions from the *Toxic Release Inventory Reporting Form R and Instructions* booklet.

Given the TRI limitations, Chemical Abstract SIC codes were cross-referenced with the TRI SIC codes to develop a final SIC Code list. TRI does not specify that a chemical is used as a solvent, rather, it notes "as otherwise used" (i.e., as a chemical processing aid, as manufacturing aid, or ancillary or other use). Where a chemical was reported to the TRI by facilities in a SIC Code group as otherwise used, but did not correspond to any suspected or known solvent use from Chemical Abstracts research, the SIC Code was dropped. For example, the TRI indicated that the Leather Tanning and Finishing Industry (SIC Code 3111) potentially utilized phenol, 2-methoxyethanol, and acetonitrile as solvents. Chemical literature searches indicated that these chemicals were part of formulations and, therefore, did not meet the solvent definition. Subsequently, SIC Code 3111 was dropped from further study. Appendix C to this report presents two lists of industries and chemicals these industries use, by SIC Code. The first list is SIC Codes potentially affected by the listing determination/study and the second is SIC Codes removed from further study. Appendix D presents two lists, the first relating industries to solvent uses identified and the second detailing the rationale for removing industries from further study as solvent users.

By identifying the potential solvent uses of each chemical, it was possible to link uses to specific industries. Once industries were identified, a final facility address list could be developed. The TRI was the primary source of facility information for the solvents pre-questionnaire mailing list. In order to ensure the broadest and most complete list of potentially affected facilities, additional data sources were consulted. These sources include:

- Trade associations, such as the Pharmaceutical Research and Manufacturers of America, provided their membership list. EPA also conducted discussions with trade groups representing potentially affected industries such as the Chemical Manufacturers Association, the Semiconductor Manufacturers Association, the Chemical Distributor's Association, and the Synthetic Organic Chemical Manufacturers Association.
- The databases supporting EPA's development of two effluent guidelines were searched for facility addresses. The effluent guideline databases searched included Pharmaceuticals I and II, and the Organic Chemicals, Plastics, and Synthetic Fibers.
- The National Air Toxics Inventory of Chemical Hazards (NATICH) was accessed for facility addresses.
- The address list developed for the RCRA §3007 Questionnaires for petroleum refinery facilities was used.
- Addresses for pulp and paper mills developed during a study of Subtitle D disposal of pulp and paper mill sludge was used.
- Addresses for users of solvents were obtained from the Toxic Substances Control Act (TSCA) Office of Pollution Prevention and Toxics (OPPT) at EPA. These addresses resulted from OPPT's evaluation of solvents under the Source Reduction Review Project (SRRP).

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- Addresses were obtained from Dun and Bradstreet (an industrial address book) or the Thomas Register (a listing of product manufacturers). Industries covered by these sources included rubber manufacture; paper and paperboard products; printing; selected food-related industries; cement, concrete, and gypsum manufacture; iron, steel, copper, and aluminum manufacture; electronics and semiconductors; and medical supply manufacture.
- Finally, facilities that received a RCRA §3007 Chlorinated Aliphatics questionnaire were deleted from the mailing list because solvents questions were included in the questionnaire mailed to that industry.

1.2.2 Development of RCRA 3007 Preliminary Questionnaire Mailing List

From these data gathering activities, 1,497 facilities potentially subject to listing determinations were identified. A copy of the preliminary questionnaire is included in Appendix E to this report. The list of facilities is included in Appendix F to this report. EPA did not include laboratories in the preliminary questionnaire mailing. The Agency attempted to obtain laboratory client lists and the identity of firms purchasing aggregate volumes of solvents from the National Association of Chemical Distributors members; however, such data were not made available. EPA also worked with the American Chemical Society (ACS) and their laboratory network to define the universe of affected laboratories. The Agency presented information on the solvents listing determination and initiated a dialogue with the ACS Task Force on RCRA and Laboratories at their meeting on May 14, 1994 in Washington, D.C.¹ Similar information was presented at the Twelfth Annual College and University Hazardous Waste Conference on August 8, 1994.² Based on these discussions, it is believed that nearly all laboratories dispose of the solvents under investigation as waste rather than recovering them. Further, anecdotal information indicates that the solvents are managed as hazardous, many because they exhibit the characteristic of ignitability. Discussions with ACS and the colleges and universities provided a clearer picture of waste management at universities and further anecdotal information on management of the solvents under investigation.

Of the 1,497 preliminary questionnaires mailed, less than 600 responded that one or more of the solvents were used at that facility. Further investigations (primarily through telephone calls to verify data) eliminated additional facilities³. The definition of "solvent" appeared to be unclear to some respondents, who provided solvents quantities when in fact the compound was part of a formulation or was not used for its solvent properties. For example, 1,4-dioxane is used as a stabilizer in 1,1,1-trichloroethane which is already regulated as hazardous waste codes F001 and F002 when used as a solvent. Many facilities reported 1,4-dioxane use; however, as an additive it is not used for its solvent properties and does not meet the regulatory definition of solvent provided in Section 1.1.1. Hence, data would reflect use of 1,4-dioxane as an additive rather than a solvent, and any residuals generated would already be regulated as RCRA hazardous waste. In addition, a number of facilities did not check the list of solvents carefully and reported volumes for incorrect compounds, such as those who reported diethylamine use when diethanolamine was used. Table 1-8 presents data from the RCRA 3007 Preliminary Solvents Use Questionnaire on potential solvent use in 1992. However, these data include uses reported that subsequently were removed from consideration (e.g., uses reported by TSDs). The use is considered "potential" because there is no means

¹See Docket for Solvents Listing Determination for Briefing Paper (Docket No. F-96-SLDP).

²Ibid.

³Contact sheets documenting these call backs are included in the docket for the Solvents Listing Determination, Docket No. F-96-SLDP.

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to determine with complete certainty that the use reported is truly use as a solvent. To the extent possible, this table reflects totals as revised to eliminate the errors discussed above. Totals shown as greater than (>) or less than (<) reflect totals that do not include confidential business information. Appendix G presents detailed non-CBI data for all responders by SIC code. The facilities making claims of confidential business information (CBI) on their use have been deleted from this list.

The data collected from the Preliminary Solvents Use Questionnaire were limited to the total volume of solvents used in 1991 and 1992. From the information obtained from the preliminary questionnaire, EPA proceeded to develop a detailed solvent use survey to collect process, waste generation, and waste management information, which was under the authority of RCRA Section 3007. Trade associations also were given the opportunity by EPA to review the draft questionnaire for technical accuracy and relevance.

Table 1-8 Total Reporters and Potential Solvent Use, by Chemical
(Source: RCRA §3007 Preliminary Questionnaire of Solvent Use)

Solvent	Number of Responders	Total 1992 Potential Solvent Use (kg)
1,4-Dioxane	126	303,614
Allyl Chloride	4	41
Aniline	58	15,243,149
Bromoform	12	18,254
Diethylamine	44	65,082
Ethylene Oxide	24	<100,000
Vinylidene Chloride	5	24,531

The RCRA §3007 Questionnaire for Solvents Use was based on a new questionnaire design. In addition to traditional questions regarding generation of residuals, residual characterization, and waste management practices, the new format of the questionnaire enabled EPA to collect information on solvent recovery, comanagement of solvents in recycling units, and waste minimization. In addition, respondents were asked to identify all other on-site and captive off-site units in which solvent residuals are managed, the common name and type of unit, the unit's location (on or captive off site), the residual and quantity managed in 1992, other wastes comanaged in the unit, and the permit status of the unit. Finally, facilities are asked to report shipments to off-site facilities and treatment used (if known). The questionnaire was designed to enable EPA to gain a clearer understanding of the residuals generated from the use of the seven chemicals under investigation, their characterization and management, and the management of solvent residuals in specific units.

After approval from all participating Agency parties, the draft Solvents Use Questionnaire was field tested in seven facilities in Pennsylvania, New Jersey, and Texas. The final Solvents Use Questionnaire was revised in response to comments received during field testing and was then mailed to selected positive responders to the preliminary questionnaire. A copy of the Questionnaire is included in Appendix H to this report.

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Of the corrected positive responses to the preliminary questionnaire, a number included small users (e.g., 5 mL per year, 1 gallon per year). Because of the complexity of the full RCRA §3007 Solvent Use Questionnaire, an effort was made to eliminate these very small users of solvents from the mailing list for the Questionnaire. EPA examined the volume of solvents reported and determined that facilities reporting the use of less than 1,200 kilograms per year combined of all seven solvents under investigation could be eliminated from further study. This cutoff corresponds to a monthly use of 100 kilograms or less of the seven solvents under investigation. Table 1-9 presents the breakdown of the number of facilities reporting greater than or equal to 1,200 kilograms per year of all seven chemicals, by solvent. For reference, Table 1-9 also presents the number of facilities reporting use of less than 120 kilograms per year and 120 to less than 1,200 kilograms of an individual solvent.

In all, 157 facilities were sent a Questionnaire. The list of facilities is presented in Figure 1-1. The impact of limiting the study population and its potential impact on the estimation of national solvent residual generation rates is discussed in Section 2.0 of this report.

Table 1-9 Number of Facilities Falling Within Potential Solvent Use Quantities Ranges
(Source: RCRA §3007 Preliminary Questionnaire of Solvent Use)

Solvent	<120 kg	120 - <1200 kg	≥1200 kg
Allyl Chloride	4	0	0
Aniline	48	5	5
Bromoform	11	0	1
Diethylamine	37	4	3
1,4-Dioxane	86	16	24
Ethylene Oxide	17	1	6
Vinylidene Chloride	4	0	1

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Figure 1-1 RCRA 3007 Questionnaire Mailing List, by State

FACILITY NAME	CITY	STATE
M & M CHEMICAL EQUIPMENT CO.	ATTALLA	AL
DU PONT MOBILE PLANT	AXIS	AL
CIBA-GEIGY CORP. MCINTOSH SITE	MC INTOSH	AL
INTEL CORP. - MAIN CHANDLER CAMPUS	CHANDLER	AZ
CONTINENTAL CIRCUITS CORP.	PHOENIX	AZ
OIL AND SOLVENT PROCESS CHEMISTRY	AZUSA	CA
CHIRON CORPORATION	EMERYVILLE	CA
ADVANCED DIELECTRICS INC.	FREMONT	CA
PCA METAL FINISHING INC.	FULLERTON	CA
CHEVRON CHEMICAL CO.	RICHMOND	CA
CHEVRON USA INC. - RICHMOND REFINERY	RICHMOND	CA
UNOCAL SAN FRANCISCO REFINERY	RODEO	CA
NEC ELECTRONICS INC., ROSEVILLE FACILITY	ROSEVILLE	CA
HEWLETT-PACKARD CO.	SAN JOSE	CA
VLSI TECHNOLOGY INC.	SAN JOSE	CA
GENENTECH, INC.	SOUTH SAN FRANCISCO	CA
AMGEN, INC.	THOUSAND OAKS	CA
BACHEM INC.	TORRANCE	CA
NCR CORPORATION	COLORADO SPRINGS	CO
HEWLETT-PACKARD CO.	FORT COLLINS	CO
NCR MICROELECTRONICS	FORT COLLINS	CO
BOEHRINGER INGELHEIM PHARMACEUTICALS, INC.	RIDGEFIELD	CT
SEAFORD FIBERS PLANT	SEAFORD	DE
ZENECA - FAIRFAX SITE	WILMINGTON	DE
PCR INC.	GAINESVILLE	FL
AT&T MICROELECTRONICS-ORLANDO PLANT	ORLANDO	FL
CONTINENTAL CIRCUITS INC.	WINTER SPRINGS	FL
NORTHERN ENGRAVING CORP.	LANSING	IA
ABBOTT LABORATORIES	ABBOTT PARK	IL
ARMOUR PHARMACEUTICAL COMPANY	BRADLEY	IL
ARMSTRONG CONTAINERS INC. METAL DECORATING DIV.	FRANKLIN PARK	IL
BF GOODRICH CO - HENRY PLANT	HENRY	IL
ABBOTT LABORATORIES	NORTH CHICAGO	IL
PFANSTIEHL LABORATORIES	WAUKEGAN	IL
ELI LILLY & CO.	CLINTON	IN
RHONE-POULENC INC.	HAMMOND	IN
ELI LILLY & CO.	INDIANAPOLIS	IN
ELI LILLY & CO.	INDIANAPOLIS	IN
ELI LILLY & CO. - MC RESEARCH	INDIANAPOLIS	IN
C.P. RECYCLING	LOGANSPOUR	IN
GMC, NAO TRUCK FORT WAYNE ASSEMBLY	ROANOKE	IN
ELI LILLY & CO.	SHADELAND	IN
INDUSTRIAL FUELS & RESOURCES, INC.	SOUTH BEND	IN
ASHLAND OIL COMPANY CATLETTSBURG REFINERY	CATLETTSBURG	KY
COMMONWEALTH ALUMINUM CORP.	LEWISPORT	KY
EXXON CHEMICAL AMERICAS-BATON ROUGE CHEMICAL PLANT	BATON ROUGE	LA
UNIROYAL CHEMICAL CO. INC.	GEISMAR	LA
CITGO PETROLEUM CORP. - LAKE CHARLES COMPLEX	LAKE CHARLES	LA
CIBA-GEIGY CORP. - ST GABRIEL PLANT	SAINT GABRIEL	LA
CWM, INC - LAKE CHARLES FACILITY	SULPHUR	LA
ANITEC PRINTING PLATE	HOLYOKE	MA
ANITEC PRINTING PLATE	HOLYOKE	MA

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Figure 1-1 RCRA 3007 Questionnaire Mailing List, by State (continued)

FACILITY NAME	CITY	STATE
SHIPLEY CO. INC.	MARLBOROUGH	MA
AT&T - MERRIMACK VALLEY WORKS	NORTH ANDOVER	MA
POLAROID CORP. - NORWOOD FACILITY	NORWOOD	MA
STAHL USA	PEABODY	MA
POLAROID CORP.	WALTHAM	MA
ANALOG DEVICES	WILMINGTON	MA
KANASCO LTD.	BALTIMORE	MD
TOTAL PETROLEUM INC.	ALMA	MI
NORTRU. INC.	DETROIT	MI
PARKE-DAVIS	HOLLAND	MI
UPJOHN COMPANY	KALAMAZOO	MI
PONTIAC WEST ASSEMBLY	PONTIAC	MI
GMC, TECHNICAL CENTER	WARREN	MI
WARREN TRUCK ASSEMBLY PLANT	WARREN	MI
ZEELAND CHEMICAL PRODUCTS	ZEELAND	MI
3M HUTCHINSON AVTD AND TMD PLANTS	HUTCHINSON	MN
IBM CORP. - ROCHESTER	ROCHESTER	MN
3M CENTER	SAINT PAUL	MN
CEMTECH (SELMA PLANT)	FESTUS	MO
SIGMA CHEMICAL CO.	SAINT LOUIS	MO
MALLINCKRODT SPECIALTY CHEMICALS CO. - ST LOUIS	ST. LOUIS	MO
PACKAGE PRODUCTS SPECIALTY	CHARLOTTE	NC
DU PONT - FAYETTEVILLE WORKS	FAYETTEVILLE	NC
BURROUGHS WELLCOME CO.	GREENVILLE	NC
GLAXO INC.	RESEARCH TRIANGLE PARK	NC
HADCO CORP.	DERRY	NH
POLYCLAD LAMINATES INC.	FRANKLIN	NH
HOECHST CELANESE CORP.	BRANCHBURG TOWNSHIP	NJ
CARTER-WALLACE, INC.	CRANBURY	NJ
SCIENTIFIC DESIGN CO. INC.	LITTLE FERRY	NJ
NAPP CHEMICALS INC.	LODI	NJ
E. R. SQUIBB & SONS	NORTH BRUNSWICK	NJ
HOFFMANN-LA ROCHE INC.	NUTLEY	NJ
MOBIL OIL PAULSBORO REFINERY	PAULSBORO	NJ
SUVAR CORP.	PENNSAUKEN	NJ
BRISTOL-MYERS SQUIBB PHARMACEUTICAL GP	PRINCETON	NJ
MERCK & CO. INC. - RAHWAY SITE	RAHWAY	NJ
CIBA-GEIGY CORP., PHARMACEUTICALS DIV.	SUMMIT	NJ
AMP-AKZO CORP.	AQUEBOGUE	NY
PFIZER, INC.	BROOKLYN	NY
IBM CORP.-ENDICOTT FACILITY	ENDICOTT	NY
IBM CORP. - EAST FISHKILL FACILITY	HOPEWELL JUNCTION	NY
AZON CORP.	JOHNSON CITY	NY
HADCO CORPORATION - OWEGO DIVISION	OWEGO	NY
LEDERLE LABORATORIES DIVISION	PEARL RIVER	NY
STERLING ORGANICS	RENSSELAER	NY
KODAK PARK SITE	ROCHESTER	NY
AYERST LABORATORIES INC.	ROUSES POINT	NY
GE PLASTICS, SELKIRK OPERATION	SELKIRK	NY
BRISTOL-MYERS SQUIBB CO.	SYRACUSE	NY
JOSEPH C. WILSON CENTER FOR TECHNOLOGY, XEROX CORP	WEBSTER	NY
HUKILL CHEMICAL CORPORATION	BEDFORD	OH

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Figure 1-1 RCRA 3007 Questionnaire Mailing List, by State (continued)

FACILITY NAME	CITY	STATE
CHRYSLER MOTORS TOLEDO ASSEMBLY	TOLEDO	OH
CWM RESOURCE RECOVERY, INC.	WEST CARROLLTON	OH
SUN REFINING & MARKETING CO.	TULSA	OK
INTEL CORP.	ALOHA	OR
PRAEGITZER INDUSTRIES INC.	DALLAS	OR
FUJITSU MICROELECTRONICS INC., GRESHAM MANUF. DIV.	GRESHAM	OR
AT&T MICROELECTRONICS - ALLENTOWN	ALLENTOWN	PA
LONZA INC.	CONSHOHOCKEN	PA
HARRIS SEMICONDUCTOR	MOUNTAINTOP	PA
MERCK & CO. INC.	RIVERSIDE	PA
CEMTECH	WAMPUM	PA
WYETH-AYERST LABORATORIES INC.	WEST CHESTER	PA
BAXTER HEALTHCARE CORP. OF PR	ANASCO	PR
STERLING PHARMACEUTICALS INC.	BARCELONETA	PR
UPJOHN MANUFACTURING COMPANY	BARCELONETA	PR
SMITHKLINE BEECHAM PHARMACEUTICALS CO.	CIDRA	PR
SCHERING PLOUGH PRODUCTS	MANATI	PR
ELI LILLY INDUSTRIES INC.	MAYAGUEZ	PR
OCG MICROELECTRONIC MATERIALS	EAST PROVIDENCE	RI
ARKWRIGHT INC.	FISKEVILLE	RI
MOBAY CORP., BUSHY PARK	GOOSE CREEK	SC
FUJI PHOTO FILM INC.	GREENWOOD	SC
DU PONT	CHATTANOOGA	TN
TENNESSEE EASTMAN DIVISION	KINGSPORT	TN
GREAT LAKES CHEMICAL CORP.	NEWPORT	TN
AMOCO CHEMICAL CO. - CHOCOLATE BAYOU PLANT	ALVIN	TX
ARGON MEDICAL	ATHENS	TX
ADVANCED MICRO DEVICES INC.	AUSTIN	TX
IBM	AUSTIN	TX
EXXON	BAYTOWN	TX
EXXON CHEMICAL AMERICAS - BAYTOWN CHEMICAL PLANT	BAYTOWN	TX
MOBIL BEAUMONT REFINERY	BEAUMONT	TX
PHILLIPS 66 CO.	BORGER	TX
SGS-THOMSON MICROELECTRONICS	CARROLLTON	TX
LYONDELL PETROCHEMICAL CO.- CHANNELVIEW COMPLEX	CHANNELVIEW	TX
GOODYEAR TIRE & RUBBER CO. - BEAUMONT CHEM PLANT	CHEEK	TX
OXY CHEM CORPUS CHRISTI PETROCHEMICALS	CORPUS CHRISTI	TX
TEXAS INSTRUMENTS INC. - EXPRESSWAY SITE	DALLAS	TX
ALCON LABORATORIES, INC.	FORT WORTH	TX
HITACHI SEMICONDUCTOR AMERICA	IRVING	TX
VLSI TECHNOLOGY INC.	SAN ANTONIO	TX
GIBRALTAR CHEMICAL RESOURCES INC.	TYLER	TX
NATIONAL SEMICONDUCTOR CORP.	WEST JORDAN	UT
DU PONT	MARTINSVILLE	VA
IBM ESSEX JUNCTION VERMONT	ESSEX JUNCTION	VT
BOEING COMMERCIAL AIRPLANE GRP	EVERETT	WA
IMMUNEX CORPORATION	SEATTLE	WA
POPE & TALBOT WIS INC.	EAU CLAIRE	WI
NORTHERN ENGRAVING CORP., HOLMEN DIV	HOLMEN	WI
SHELL CHEMICAL CO., POINT PLEASANT POLYESTER PLANT	APPLE GROVE	WV
RHONE-POULENC AG CO. - INSTITUTE PLANT	CHARLESTON	WV

2.0 Representativeness of RCRA 3007 Questionnaire Data to National Data

This section describes the preliminary conclusions reached about the coverage of facilities achieved during the solvents industry study for potential listing determinations for residuals generated by the use of the seven chemicals.

EPA is confident that it identified and surveyed all of the large users of these chemicals as solvents and high-end generators of solvent residuals. Most of the seven chemicals are used as solvents for very specific uses by specific industries. Further, most of the seven chemicals included on the lists of chemicals reported in the Toxic Release Inventory. Thus, as discussed below, EPA is confident that large users were identified.

EPA did not pursue an industry study methodology based on random sampling; rather, EPA made a significant effort to identify users of these chemicals as solvents and collect data directly from facilities at which there was a reason for suspected solvent use for at least one of the seven chemicals under study. With the probable exception of 1,4-dioxane, solvent uses of these chemicals of concern are relatively obscure when compared to solvent uses of many F001 - F005 solvents (e.g., methylene chloride and 1,1,1-trichloroethylene). Therefore, it was possible to identify and survey all facilities that might reasonably be expected to use significant quantities (i.e., greater than 1,200 kg per year) of these chemicals as solvents.

This industry study does not claim to have identified all facilities that used these seven chemicals as solvents. However, for most of the seven chemicals of concern, industry study conclusions about the extent of solvent use were confirmed by taking national production and import/export totals for each of the seven chemicals and subtracting out:

- 1) identified nonsolvent uses of these chemicals (identified from other sources such as SRI), and
- 2) total solvent use quantities as identified in RCRA §3007 questionnaire.

For most of the seven chemicals of concern, the industry study concluded that solvent usage is either negligible or limited to a extremely narrow uses by a small number of facilities. The exception to this conclusion is 1,4-dioxane, which is widely used in laboratories. The specific industry study conclusions about issues relating to identification of solvent users and support for those conclusions are discussed below.

2.1 Solvents Industry Study Methodology

Step One: Identification of Industries and Processes Using these Chemicals as Solvents

As described in Section 1.2.1, an extensive literature was undertaken to identify potential uses and users of the seven chemicals as a solvent as defined by EPA. The primary reference source for this literature search was Chemical Abstracts, which is discussed below.

Chemical uses identified from Chemical Abstracts may be limited by the following considerations: (1) solvents uses by many industries may be considered "confidential" and, therefore, not published; (2) solvent use abstracts may not have been identified in the years surveyed, previous years' abstracts may have identified additional uses; (3) abstracts were sometimes ambiguous as to the nature of the activity for the chemical listed (although a conservative approach was taken where ambiguity existed); and (4) solvents used in a particular study may not have been identified in the abstract and, therefore, solvent use went undetected. Although use of Chemical Abstracts to identify uses of the solvents being investigated has its

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drawbacks, no better supplementary source for solvent use identification exists. Even with the limitations inherent in Chemical Abstracts, few, if any, solvent uses for the study chemicals were missed using this extensive literature search.

Step Two: Cross-Referencing of "Target" SIC Code List With Other Data Sources to Identify Specific Facilities

Once the list of SIC codes was developed, several searches were performed to identify specific facilities in those industries that might use one of the chemicals under study. The methodology used to identify specific facilities that might use any of the seven chemicals as solvents is described in Section 1.2.1. Table 2-1 presents a cross-reference of chemicals reported in TRI (the primary source for facility addresses) and the seven chemicals of concern.

Table 2-1 Cross-Reference of TRI Chemicals with Seven Chemicals of Concern

TRI chemicals that coincide with the seven chemicals of interest	Non-TRI chemicals of the seven chemicals of interest
Allyl Chloride Aniline Bromoform 1,4-Dioxane Ethylene Oxide Vinylidene Chloride	Diethylamine

The Agency also conducted meetings with members of the National Association of Chemical Recyclers, however, their membership was not surveyed directly. Rather, some recyclers were identified through other sources, primarily TRI.

Compilation of RCRA §3007 Preliminary Questionnaire Data

In all, a total of 1,497 preliminary questionnaires were distributed to facilities across the country using the methodology described above. These preliminary questionnaires requested information on solvent use quantities only (not solvent residual generation or management, and facilities were not requested to characterize the solvent use).

Responses to the preliminary questionnaire show that some specific chemicals are used as solvents for a very limited number of industries in very small quantities while a few chemicals are used in relatively larger quantities across numerous industries. Of the 1,497 preliminary questionnaires mailed, less than 273 reported any solvent use of one or more of the seven chemicals.

Follow-up phone calls were made to facilities that reported solvent use for several low-volume solvent use chemicals (e.g., vinylidene chloride, bromoform) and data corrections were made in the preliminary questionnaire data set. Information gathered during these follow-up calls revealed that many facilities over-reported solvent use either from 1) a misapplication of the EPA definition of solvent use, 2) general ignorance of the precise use of the chemical at the facility and therefore a report of total amount

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purchased or used at the facility, or 3) mistaken reading of the chemicals queried (e.g., diethanolamine mistaken for diethylamine).

It should be noted, however, that follow-up calls were not made to many facilities that reported solvent use of larger-volume solvents (e.g., 1,4-dioxane). Therefore, based on the results of follow-up phone calls that were made, it can be assumed that preliminary questionnaire use data do overestimate solvent use for a portion of the 1,497 facilities surveyed.

Following tabulation of preliminary questionnaire data, all facilities that reported greater than 1,200 kg of solvent use in the preliminary questionnaire for 1992 (157 facilities) were sent "full" RCRA §3007 questionnaires to obtain detailed information on solvent use, solvent residual generation, and management. Thus, all large-quantity solvent users were captured and were sent a full RCRA §3007 questionnaire if the facility was sent a preliminary questionnaire.

2.2 Confidence Level of Solvents Industry Study Results

EPA focused its efforts during this industry study on identifying the large quantity users of the seven chemicals as solvents and potential large quantity generators of these spent solvent wastes (if listed) using the industry study methodology described above. EPA is confident that the industry study identified and characterized all large quantity solvent users.

In some cases, significant changes in the reported use of a solvent between the 1992 Preliminary Questionnaire and the 1993 Questionnaire can be seen. Overall, the preliminary questionnaire totals included amounts reported by commercial treatment, storage, and disposal (TSD) facilities. In some cases, such as bromoform and vinylidene chloride, management by a TSD accounts for nearly all reported use. These amounts are not reflected in the 1993 totals from the full Questionnaire. Prior to mailing the full RCRA §3007 Questionnaire, EPA attempted to contact all potential recipients of the Questionnaire to confirm the use of the chemical as a solvent. EPA was only partially successful in reaching all facilities prior to mailing the full Questionnaire. However, between the telephone calls prior to mailing and responses to the Questionnaire after the mailing, certain facilities were removed from the mailing list. The facilities removed either had closed (2 facilities), incorrectly reported chemicals used (2 facilities), discontinued use of the chemical (17 facilities), or incorrectly reported the chemical as being used as a solvent (4 facilities).

After review of the full Questionnaire responses, the Agency determined that certain uses did not meet EPA's definition of solvent use. For example, 34,484 kg of the ethylene reported was actually used as a sterilant, which does not meet EPA's definition of solvent use. Nearly all of the aniline reported (14,920,877 kg of the 14,978,397 kg reported) was used as a raw material that was consumed in the process. This also does not meet EPA's definition of solvent use. The same is true of diethylamine, where 62,163 kg of the total 64,638 kg reported was actually diethanol amine rather than diethylamine.

Finally, variations in usage are to be expected. In the case of 1,4-dioxane, five facilities reported higher use in 1992 than in 1993. For other solvents, facilities reported either increases or decreases in use between 1992 and 1993 that indicate changes in production schedule or product slate. EPA is confident that all large users of the seven solvents were identified and surveyed as part of the listing determination. The Agency believes that the solvent use reported in response to the full Questionnaire provides a more accurate characterization of solvent use patterns than the Preliminary Questionnaire because of the greater level of detail provided by the respondents. Finally, it is important to recognize that smaller uses of some solvents were captured through facilities reporting larger uses of other solvents. For example, Unocal, Rodeo, CA is a significant user of phenol, but also uses a small amount (3.86 kg) of aniline, thus information on acetonitrile wastes were collected.

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Table 2-2 presents the total reported use, by solvent, for each year along with an explanation of the reasons for the apparent changes in total use. Table 2-3 and Table 2-4 present and discuss the industry study identification and characterization of large-solvent users for each of the seven target chemicals.

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Table 2-2. Total Reporters and Use by Solvent
 (Source: RCRA §3007 Preliminary Questionnaire and §3007 Survey of Solvent Use)

Solvent	Preliminary Questionnaire		RCRA 3007 Questionnaire		Reason for Change from 1992 to 1993
	Number of Responders	Total 1992 Use (kg)	Number of Responders	Total 1993 Use (kg)	
1,4-Dioxane	126	303,614	34	101,565	<ul style="list-style-type: none"> • 68% of facilities used less than 120 kg; most were not sent 3007 Survey; • 147,966 kg reported by eight TSDs/cement kilns; • 15,511 kg reduction in use at 12 facilities; • 57,735 kg use was discontinued from four facilities; • 16,330 kg not used as solvent or discontinued from numerous facilities; • 37,970 kg increased use at five facilities.
Allyl Chloride	4	41	4	12	<ul style="list-style-type: none"> • All identified use is in laboratories; • 36 kg reduction in use by three facilities; • 7 kg use started in 1993 by one facility.

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Solvent	Preliminary Questionnaire		RCRA 3007 Questionnaire		Reason for Change from 1992 to 1993
	Number of Responders	Total 1992 Use (kg)	Number of Responders	Total 1993 Use (kg)	
Aniline	58	15,243,149	9	20	<ul style="list-style-type: none"> 83% of facilities used less than 120 kg for laboratory research; were not sent 3007 Survey; 264,752 kg reported by four TSDs/cement kilns; 14,920,877 kg used as a raw material by one facility, not solvent use; 55,842 kg was misreported - not used as a solvent; 827 kg discontinued or not solvent use; 511 kg reduction by four facilities.
Bromoform	12	18,254	1	<0.001	<ul style="list-style-type: none"> Over 90% used less than 120 kg for laboratory research; 8 of 12 were sent 3007 Survey; 18,098 kg reported by one cement kiln; 155 kg not solvent use or discontinued.
Diethylamine	44	65,082	12	44	<ul style="list-style-type: none"> 84% of facilities used less than 120 kg; most were not sent 3007 Survey; 62,163 kg from two facilities was not for solvent use; 2,087 kg from numerous facilities was discontinued or not for solvent use; 75 kg reduction by two facilities.

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Solvent	Preliminary Questionnaire		RCRA 3007 Questionnaire		Reason for Change from 1992 to 1993
	Number of Responders	Total 1992 Use (kg)	Number of Responders	Total 1993 Use (kg)	
Ethylene Oxide	24	<100,000	4	4.3	<ul style="list-style-type: none"> 71% reported using less than 120 kg; most were not sent a 3007 Survey; 24,021 kg reported by two TSDs/cement kilns; 5,448 kg used as a sterilant, not as a solvent, by one facility; 29,036 kg used as a sterilant/fumigant, not as a solvent, by one facility; 7,337 kg were misreported by one facility; 14,144 kg discontinued or not for solvent use; 84 kg reduction in use by one facility;
Vinylidene Chloride	5	24,532	0	0	<ul style="list-style-type: none"> 24,528 kg reported by two TSDs; 3 kg not used for solvent or discontinued at two facilities; <0.03 kg used at one facility; 3007 Survey was not sent.

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Table 2-3 Solvent Production, Solvent Use, and Survey Results

Chemical	Total Chemical Production (kg)	Production & Import Data Year (SRI)	Quantity Estimated to be Solvent Use from SRI (kg)	Quantity Identified as Solvent Use from 1993 RCRA Survey ¹ (kg)
Allyl Chloride	313,000,000	1990 (capacity)	<31,300,000 ²	12
Aniline	560,187,000	1994 (imports neg)	<18,200,000 ²	20
Bromoform	Unknown	Unknown	None	<0.001
Diethylamine	9,970,000	1990 (no import data)	None	44
1,4-Dioxane	11,000,000 - 14,000,000	1985 (estimated)	None	101,565
Ethylene Oxide	2,812,727,200	1989	None	4.3
Vinylidene Chloride	78,472,000	1995 (no import data)	None	0

¹ All quantities exclude amounts reported by TSDs.

² Represents all "other" uses, which may include solvent use.

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Table 2-4 Solvent Specific Confidence Rationales

Allyl Chloride			
Chemical Production Total (kg) (import quantity unknown)	Quantity Estimated to be Solvent Use from SRI (kg)	Quantity Identified as Solvent Use from 1993 RCRA Survey (kg)	Comments
313,000,000 (SRI, 1990: U.S. capacity only)	<31,300,000 ¹	12	<input type="checkbox"/> Allyl Chloride is a TRI chemical.
			<input type="checkbox"/> An estimated 90 percent (281,700,000 kg) is used as a chemical in the production of epichlorohydrin. The remaining 10 percent is used as a raw material in the synthesis of allyl compounds (esters, ethers, and amines) by substitution of the chlorine and in the high-temperature chlorination of propylene.
			<input type="checkbox"/> Solvent uses could include petroleum refining and pharmaceutical applications, however, no evidence of such current uses are indicated by the data collected from these industries.

¹ Represents all "other" uses, which may include solvent use.

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Aniline			
Chemical Production Total (kg) (import quantity unknown)	Quantity Estimated to be Solvent Use from SRI (kg)	Quantity Identified as Solvent Use from 1993 RCRA Survey (kg)	Comments
560,187,000 (Mansville, 1994)	<18,200,000 ¹	20	<input type="checkbox"/> Aniline is a TRI chemical. <input type="checkbox"/> An estimated 67 percent is used in the production of MDI and rubber. An additional 5 percent is used in agricultural chemicals. Aniline also is a reactant in the dye industry. <input type="checkbox"/> Potential solvent uses include use in dye applications and coal liquefaction. Coal liquefaction facilities reported no aniline solvent use and dye manufacturers report aniline as reactant.

¹ Represents all "other" uses, which may include solvent use.

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Bromoform			
Chemical Production Total (kg) (import quantity unknown)	Quantity Estimated to be Solvent Use from SRI (kg)	Quantity Identified as Solvent Use from 1993 RCRA Survey (kg)	Comments
Unknown. Unavailable from SRI, USITC, Mansville, and TSCA.	None	<0.001	<input type="checkbox"/> Bromoform is a TRI chemical.
			<input type="checkbox"/> Bromoform is used as a chemical in organic syntheses and in medicinal pharmaceuticals as a sedative.
			<input type="checkbox"/> Bromoform potentially can be used as a solvent in mineral separation. No such use was indicated by the TRI or the RCRA 3007 Questionnaire responses.

Diethylamine			
Chemical Production Total (kg) (import quantity unknown)	Quantity Estimated to be Solvent Use from SRI (kg)	Quantity Identified as Solvent Use from 1993 RCRA Survey (kg)	Comments
9,970,000 (USITC, 1990)	None	44	<input type="checkbox"/> Diethylamine is not a TRI chemical.
			<input type="checkbox"/> Non-solvent uses, including production of N,N-diethylaminoethanol, rubber processing chemicals, pesticides, and other chemicals is estimated at 9,305,333 kg.

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1,4-Dioxane			
Chemical Production Total (kg) (import quantity unknown)	Quantity Estimated to be Solvent Use from SRI (kg)	Quantity Identified as Solvent Use from 1993 RCRA Survey (kg)	Comments
11,000,000 to 14,000,000 (SRI, 1985)	None	101,565	<input type="checkbox"/> 1,4-Dioxane is a TRI chemical.
			<input type="checkbox"/> The largest use of 1,4-dioxane is as a stabilizer in 1,1,1-trichloroethane.
			<input type="checkbox"/> 1,4-Dioxane is used in laboratories as an alternative to acetonitrile in chromatography. No attempt was made to survey laboratories separately.

Ethylene Oxide			
Chemical Production Total (kg)	Quantity Estimated to be Solvent Use from SRI (kg)	Quantity Identified as Solvent Use from 1993 RCRA Survey (kg)	Comments
2,812,727,200 (SRI)	None	4.3	<input type="checkbox"/> Ethylene oxide is a TRI chemical.
			<input type="checkbox"/> Ethylene oxide is widely used as a sterilant in medical applications.
			<input type="checkbox"/> Ethylene oxide is used as a raw material in the synthesis of ethylene glycol, diethylene glycol, triethylene glycol, polyethylene glycol, and glycol ethers as well as ethanol amines and non ionic surface active agents. These uses account for over 2.8 billion kg (99.6 % of production and import). An additional 9 million kg is exported.

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Vinylidene Chloride			
Chemical Production Total (kg)	Quantity Estimated to be Solvent Use from SRI (kg)	Quantity Identified as Solvent Use from 1993 RCRA Survey (kg)	Comments
78,472,000 (SRI, 1995)	None	0	<input type="checkbox"/> Vinylidene chloride is a TRI chemical. <input type="checkbox"/> Vinylidene chloride is consumed largely in the production of polyvinylidene chloride (PVDC) copolymers. widely used as a sterilant in medical applications.

3.0 Data Management and Waste Management Practices

3.1 Data Management and Analyses

Data from the questionnaire were managed through a linked database system. From the data, EPA developed spreadsheets detailing residuals as reported by responders for each of the seven chemicals. Each residual stream reported by responders was evaluated to determine whether the residual represented a waste or an in-process stream. Residuals that were returned to the process through a closed loop system were excluded from further analysis.

The Agency completed an enormous task in the data gathering effort. These data helped EPA to identify the major waste generators. The questionnaire asked for very detailed information on waste generation, management, and disposal for these chemicals when they are used as solvents. The questionnaire was sent to larger facilities because 1) only large facilities would be likely to have on-site treatment, storage, and/or disposal for which questionnaire items would be applicable, and 2) many of the solvent uses are peculiar to large chemical industries and are not likely to be used in small companies. Thus, by applying a careful, consistent definition of solvent use and closely examining facilities that use these chemicals as solvent, the Agency identified where these chemicals are used as solvents, and where wastes of interest are generated and managed.

Data submitted by TSDRs indicate that the original use of the chemical was unknown. Therefore, it was not possible to determine whether the residuals managed by TSDRs would be solvent use residuals. EPA noted that in preliminary questionnaire responses and again in full questionnaire responses, TSDRs reported the management of greater quantities of some chemicals than were identified by industry respondents. Generally, EPA believes that this indicates the management of wastes generated from non-solvent uses. Since separation of wastes from solvent and non-solvent uses was not possible at TSDR facilities, EPA could not assess management of these wastes with sufficient confidence in the accuracy of the results. Therefore, the Agency chose not to include residuals reported by TSDR facilities in the assessment of waste generation and management.

The remaining residuals were deemed to be wastes generated as a result of solvent use. Based on the quantity of residual generated and the concentration of the solvent in the residual, EPA determined the loading of the solvent in the residual as

$$\text{Solvent Residual Quantity} \times \text{Solvent Concentration} = \text{Solvent Loading}$$

All residual quantities were converted to kilograms and all solvent loadings were expressed in kilograms as well. Where liquid measurements were provided (e.g., liters or gallons), EPA used the specific gravity of the solvent for conversion of the units. Table 3-1 presents the specific gravities used for these calculations.

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Table 3-1 Specific Gravities of Solvents

Solvent	Specific Gravity (g/cm ³)
Allyl Chloride	0.93700 ⁴
Aniline	1.02000 ⁵
Bromoform	2.89400 ⁶
1,4-Dioxane	1.03200 ⁷
Diethylamine	1.70600 ⁸
Ethylene Oxide	0.87500 ⁹
Vinylidene Chloride	1.21800 ¹⁰

3.2 Identification of Current Waste Management Practices

The current waste management practices were noted, including whether the residual was managed as hazardous at the time of the Questionnaire. Given the information the Agency has collected on these solvents, their uses, waste generation, and management, the Agency has a clear picture of the situation that exists with respect to environmental consequences of current management of these wastes. The Agency also does not believe management practices for these wastes are likely to change for a number of reasons: 1) facilities are not likely to abandon investment in capital equipment such as incinerators, tanks, or wastewater treatment systems, 2) many of these wastes are treated in some ways because they have value (recycling/reuse and BTU value as fuel), 3) facilities have incentives to try to recover more solvent, use a different solvent, or eliminate waste based on cost of solvent and reporting requirements (e.g., TRI), and 4) in the cases where wastes are already hazardous (by characteristic or mixture with a listed waste), the facilities do not have the option of changing to an unregulated management practices. In addition, many states have restrictions on management of liquid wastes in land-based facilities

⁴Shell MSDS, January 1989

⁵Dupont MSDS, August 1992.

⁶Rhone Poulenc MSDS, October 1987.

⁷Ashland 1,4-Dioxane MSDS, August 1992.

⁸Ashland Diethylamine MSDS, August 1992.

⁹Shell MSDS, June 1990.

¹⁰*Handbook of Environmental Data on Organic Chemicals*, 2nd Edition, 1983.

or the construction of surface impoundments (even non-hazardous ones) that make these options highly unlikely to occur.

4.0 Discussion of Solvents Study Chemicals

4.1 Allyl Chloride

Allyl chloride is produced by high-temperature chlorination of propylene, with dichloropropanes and dichloropropenes formed as by-products. Allyl chloride is an intermediate to crude epichlorohydrin, which is used to produce synthetic glycerin or refined to a purer product for synthesis of other products, such as epoxy resins. Other non-solvent uses include use in the pharmaceutical field as a raw material for the production of allyl isothiocyanate (synthetic mustard oil), allyl substituted barbiturates (sedatives) and cyclopropane (anesthetic). Allyl chloride also has been used to prepare allyl esters of starch, which are of some interest on surface coatings, and in the manufacture of speciality resins for water treatment.¹¹

EPA has identified SIC codes through Chemical Abstracts searches that indicated potential use of the chemical as a solvent. These potential uses were cross-referenced with TRI data for this chemical reported to be “otherwise used.” A complete description of this methodology is presented in Section 2.0 of this study. The literature search conducted for this study indicated that allyl chloride can be used in a solvent mixture for removal of deposits from reservoirs and tanks used for storage of heavy petroleum products. TRI data indicated that the Chemical and Allied Products industry may utilize allyl chloride for ancillary purposes. Of three facilities responding to the Preliminary Questionnaire, one confirmed use of solvent for biological research, and the other two could not confirm solvent use.

The 1993 RCRA 3007 Questionnaire reported allyl chloride use as a solvent by four laboratory research and development facilities, totaling 12.0 kg. Allyl chloride was reported as having multiple laboratory uses, including chemicals synthesis by substitution. The use of allyl chloride in a solvent mixture for the removal of deposits from reservoirs and tanks and its use for ancillary purposes, uses identified in the literature search, were not confirmed in the 1993 Questionnaire responses.

Table 4-1 presents the facilities reporting use of allyl chloride as a solvent. Table 4-2 presents solvent use by industry sector.

Table 4-1 Facilities Using Allyl Chloride in 1993 and Industrial Sector

Facility	Location	Industry
Eli Lilly & Co., - MC Research	Indianapolis, IN	Pharmaceuticals
Glaxo Inc.	Research Triangle Park, NC	Pharmaceuticals
PCR Inc.	Gainesville, FL	Industrial Organic Chemicals
3M Center	Saint Paul, MN	Commercial Physical Research

Table 4-2 Use of Allyl Chloride By Industry

¹¹Shell Chemical Co. MSDS, 1/89.

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Industry	Use, kg
Pharmaceuticals	3.64
Industrial Organic Chemicals	7.26
Commercial Physical Research	1.1

4.1.1 Wastes From Use as a Solvent

All of the Wastes generated from the use of allyl chloride as a solvent are small volume, commingled organic laboratory wastes. Only two wastes of the four reported were larger than 3,000 kg/yr (with the largest volume wastes at approximately 12,397 kg/yr and 5,000 kg/yr). The remaining waste quantities were 40.91 kg/yr (with volumes not reported for the remaining waste stream). The total 1993 consumption of allyl chloride reported by each facility ranged from 1.10 kg to 7.26 kg. These low consumption rates result in total allyl chloride loading quantity of less than 12 kg. Table 4-3 presents the residuals generated by waste type.

Table 4-3 Quantity of Allyl Chloride Waste Generated for Each Type Generated

Waste Type	Total Residual Volume (kg/yr)	Solvent Loading (kg/yr)
Organic Wastes Spent Solvents	17,438	9.68

4.1.2 Management Practices

Each of the four organic wastes containing allyl chloride generated from its use as a solvent are managed either by on- or off-site incineration or off-site fuel blending. Most facilities employ on-site storage. The four wastes represent a total waste volume of approximately 17,438 kg and the allyl chloride concentration in the waste streams range from 11 ppm to 1%. The overall loadings was low, totaling less than 12 kg/yr. In all cases the wastes are managed as RCRA hazardous wastes; three of the four wastes are labeled as D001 (ignitable), one is D002 (corrosive), and the remainder consist of D-codes and several F-codes. Prior to final disposal or management, three of the spent solvent waste streams are managed in on-site containers (the fourth being stored off-site). One facility's residual volume and concentration was not reported. However, through conversations between the Agency and the facility, it was determined that the waste is managed as hazardous and sent for offsite fuel blending. An assumption was made that the total amount of allyl chloride used is passed through to the waste loading. Table 4-4 presents the statistics for the residuals, by management practice.

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Table 4-4 Generation Statistics for Allyl Chloride

Management Practice	# of Facilities	# of Streams	# of Streams w/Unreported Volume	Total Volume (kg)	Total Loading (kg)
Incineration	3	3	0.00	17,438	2.42
Fuel Blending	1	1	1	NR	7.26
TOTAL	4	4	1	17,438	9.68

4.1.3 Health Data

Allyl chloride (C₃H₅Cl, CAS No. 107-05-1), is a colorless to yellowish brown liquid with a pungent, unpleasant odor.¹² It is extremely flammable, has a low boiling point (45°C), a flash point of - 25°F (by tag closed cup testing), and vapors that are more dense than air.¹² It hydrolyzes in water with a half-life of 44 hours at 35°C.¹³ Flammable mixtures can be formed at ambient temperatures.¹² Upon combustion, allyl chloride produces hydrogen chloride and/or phosgene and carbon monoxide.¹² Allyl chloride is severely irritating to the eyes, skin, nose, throat, and respiratory tract.¹⁴ If inhaled, allyl chloride can produce liver, kidney, lung, and peripheral nerve damage.¹⁴ If ingested, allyl chloride can result in liver and kidney damage or death.

Based on exposure data, the following exposure limits have been established for allyl chloride. The OSHA PEL and ACGIH TLV is 1 ppm (3 mg/m³).^{15, 16} The OSHA and ACGIH STEL limits are 2 ppm.^{15, 16} The NIOSH IDLH is 250 ppm, and the threshold odor level is 0.2 ppm.¹⁵

Toxicity data indicate that acute exposure to allyl chloride can cause unconsciousness, while chronic exposure can cause cumulative liver and kidney damage.¹⁷ The established LD₅₀ for acute exposure in rats via the oral route is 700 mg/kg and via the inhalation route is 11 gm/m³/2H.¹⁸ Allyl chloride

¹²Material Safety Data Sheet, Shell Chemical Co., January 27, 1989.

¹³Mabey, W., Mill, T., *Journal of Chemical Reference Data*, 1978, Vol. 7, pp. 383-415.

¹⁴Material Safety Data Sheet, Shell Chemical Co., January 27, 1989. Based upon product testing.

¹⁵U.S. Department of Health and Human Services. National Institute for Occupational Safety and Health, *NIOSH Pocket Guide to Chemical Hazards*. Washington D.C. June 1994.

¹⁶American Conference of Governmental Industrial Hygienists. 1995-1996 Threshold Limit Values (TLV's) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs). Cincinnati, OH. 1995.

¹⁷*TheMerck Index*, 11th Edition. Merck and Co., Inc. Rahway, NJ 1989.

¹⁸U.S. Department of Health and Human Resources. Registry of Toxic Effects of Chemical Substances. National Toxicology Program, National Library of Medicine, Bethesda, MD. 1996.

is readily absorbed through the skin and is a possible human carcinogen.¹⁹ The RfC for allyl chloride is 0.001 mg/m³ based on a No Observable Adverse Effects Limit (NOAEL) of 3.6 mg/m³ for rabbits.²⁰ Due to the small number of animals involved in the study and poor reporting of results for NOAEL exposure, EPA has low confidence in the study used as the basis for the RfC.²⁰ Allyl chloride is rated as an EPA Group C (possible) carcinogen.²⁰ Although no human cancer data were found, animal studies show the potential for cancer by gavage and skin painting.²⁰ No RfD has been established. Aquatic toxicity has been estimated at 48 ppm for guppies exposed over a 96-hour period in fresh water.¹⁹

4.2 Aniline

Seventy-four percent of the aniline produced in the U.S. is consumed as an intermediate in production of 4,4-Methylenebis(phenylisocyanate) (MDI). Future demand of aniline is expected to be linked to MDI production, which itself is forecast at a growth rate of 3-5% for 1990-1995.²¹ EPA has identified SIC codes through Chemical Abstracts searches that indicated potential use of the chemical as a solvent. These potential uses were cross-referenced with TRI data for this chemical reported to be "otherwise used." A complete description of this methodology is presented in Section 2.0 of this study.

Literature searches indicate that aniline can be used as a solvent for conversion of coal to a liquid, specifically, for low-temperature coal liquefaction in basic nitrogen compounds; thermal dissolution of Fan-Yagnob coal; and extraction and reaction of coal below 100°C.²² Literature searches indicate that aniline may be used as a solvent in the dye industry to pretreat polyester fibers. The pretreatment is performed at a temperature range of 70 to 100°C in order to increase the dyeability of the fiber. It is assumed that only a portion of the organic solvent used to pretreat the fiber interacts with the fiber and therefore, a spent solvent would result.²³

The 1993 RCRA 3007 Questionnaire reported use of aniline as a solvent by seven facilities totaling 20.38 kg. These facilities include three pharmaceutical manufacturers, one industrial organic chemicals manufacturer, one petroleum refinery, one office machines manufacturer, and one commercial physical and biological research facility. All seven facilities use aniline as a solvent for laboratory purposes, such as acetic acid titration of raw materials, testing properties of hydrocarbon solvents, and as a reaction or synthesis media for a dye intermediate filtrate. The use of aniline as a solvent for the conversion of coal to a liquid or in the dye industry to pretreat fibers, as indicated by the literature search, was not confirmed by the Questionnaire.

Table 4-5 presents the facilities reporting use of aniline as a solvent. Table 4-6 presents the use of aniline as a solvent by industry.

¹⁹Hazardous Chemicals Directory, 1987.

²⁰U.S. EPA Integrated Risk Information System (IRIS) on Allyl Chloride. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH. 1993.

²¹SRI *Chemical Economics Handbook*, 10/91.

²²Chemical Abstracts, various dates.

²³*American Dyestuff Reporter*, 3/92.

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Table 4-5 Facilities Using Aniline in 193 and Industrial Sector

Facility Name	Location	Industry
Eli Lilly & Co., - MC Research	Indianapolis, IN	Pharmaceuticals
Merck & Co., Inc.	Danville, PA	Pharmaceuticals
Glaxo Inc.	Research Triangle Park, NC	Pharmaceuticals
Exxon Chemical Americas-Baytown Chemical	Baytown, TX	Industrial Organic Chemicals
Unocal San Francisco Refinery	Rodeo, CA	Petroleum Refining
Joseph C. Wilson Center for Technology	Webster, NY	Office Machines
3M Center	Saint Paul, MN	Commercial Physical and Biological Research

Table 4-6 Use of Aniline By Industry

Industry	Use, kg
Pharmaceuticals	8.45
Industrial Organic Chemicals	0.20
Petroleum Refining	3.86
Office Machines	0.07
Commercial Physical and Biological Research	7.8

4.2.1 Wastes From Use as a Solvent

All of the wastes generated from the use of aniline as a solvent are small volume commingled organic laboratory wastes. Only two wastes of the seven reported were larger than 3,000 kg/yr (with the largest volume waste approximately 12,397 kg/yr and the second highest approximately 5,000 kg/yr). One facility reported an aniline waste stream of approximately 207 kg/yr, while the remaining estimations were less than 10 kg/yr. The total 1993 consumption rates result in a total aniline loading quantity of less than 14 kg. One facility did not report their residual volume or concentration. An assumption was made that the total amount of solvent used is passed through to the waste loading. Table 4-7 presents data on the generation of aniline residuals, by waste type.

Table 4-7 Quantity of Aniline Waste Generated for Each Type Generated

Waste Type	Total Residual Volume (kg/yr)	Solvent Loading (Kg/yr)
Organic Wastes Spent solvents	17,614	13.84

4.2.2 Management Practices

Each of the seven organic wastes containing aniline generated from its use as a solvent are managed in one of three ways: 1) stored on-site prior to being incinerated on-or off-site, 2) stored on-site prior to being sent off-site for fuel blending, or 3) in the case of the aniline stream being treated as “non-hazardous”, treated at an on-site in a tank-based waste water treatment system. The seven wastes represent total waste volume of approximately 17,614 kg and the aniline concentration ranges from 23 ppm to 100%. Where high volume waste streams were reported, there were considerably low concentrations of aniline. Conversely, where low volume waste streams were reported, there were relatively high concentrations of aniline. Hence, the overall loadings was considerably low, totaling less than 14 kg/yr. In all but one facility, the wastes are managed as RCRA hazardous wastes: two of the seven wastes are labeled as D001 (ignitable) only; one is D002 (corrosive) only; one is toxic and ignitable; one is a U-listed wastes; and one carries various D- and F-codes. Prior to final disposal or management, the spent solvent wastes are managed in on-site containers or tanks. Table 4-8 presents data on the residuals generated, by management practice.

Table 4-8 Generation Statistics for Aniline

Management Practice	# of Facilities	# of Streams	# of Streams w/Unreported Volume	Total Volume (kg)	Total Loading (kg)
Incineration	5	5	0	17,614	9.47
Fuel Blending	1	1	0	0.51	0.51
WW-Tanks	1	1	1	NR	3.86
TOTAL	7	7	1	17,614.5	13.84

4.2.3 Health Data

Aniline (C₆H₇N, CAS No. 62-53-3) is an oily liquid that is colorless when distilled but darkens to red-brown on exposure to air and light.²⁴ It has a high boiling point (184°C) and a flash point of 169°F (closed cup).²⁵

Various exposure limits have been established for aniline. The OSHA PEL and ACGIH TLV levels for inhalation are 5 ppm and 2 ppm, respectively.^{23, 27} The NIOSH IDLH level is 100 ppm. The threshold odor level is 1 ppm.²⁷

Toxicity data indicate that aniline is poisonous by most routes including inhalation and ingestion. Acute exposure may result in cyanosis and methemoglobinemia.²⁶ Chronic exposure may result in anemia, anorexia, weight loss, and lesions.²⁸ Via the oral route in rats the LD₅₀ for acute exposure is 250 mg/kg.²⁷ Aniline has a carcinogen slope factor (CSF) of 5.7E-03 mg/kg/day and a health-based limit (HBL) of 6E-03 mg/L.²⁸

Toxicity data indicate that acute exposure to aniline can cause unconsciousness, while chronic exposure can cause cumulative liver and kidney damage.²⁸ The established LD₅₀ for acute exposure in rats via the oral route is 250 mg/kg and by inhalation is 250 ppm/4H.²⁹ Aniline is readily absorbed through the skin and is a possible human carcinogen.²⁹ The RfC for aniline is 0.001 mg/m³ based on spleen toxicity in rats.³⁰ Due to the small number of animals and single exposure concentration used in one study and the short duration of a second study, EPA has low confidence in the study used as the basis for the RfC.³⁰ Aniline is rated as an EPA Group B2 (probable) carcinogen.³⁰ Human cancer data are not sufficient to demonstrate that aniline is a carcinogen, but animal studies show the potential for spleen and body cavity tumors.³⁰ No RfD has been established. Aquatic toxicity shows that sunfish exposed at 1020 ppm over a 1-hour period in fresh water were killed.³⁰

4.3 Diethylamine

Fifty percent of diethylamine consumed is used for the production of N,N-Diethylaminoethanol (DEAE). Diethylene amine based rubber accelerators include various N,N-diethyldithiocarbamate salts

²⁴ *Solvents Safety Handbook*.

²⁵ *The Merck Index*, 11th Edition. Merck and Co., Rahway, NJ. 1989.

²⁶ U.S. EPA. *Health and Environmental Effects Profile for Aniline*. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH. 1985.

²⁷ U.S. Department of Health and Human Resources. *Registry of Toxic Effects of Chemical Substances*. National Toxicology Program, National Library of Medicine, Bethesda, MD. 1996.

²⁸ U.S. Environmental Protection Agency. *Integrated Risk Information System*. Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH. 1993.

²⁹ *Hazardous Chemicals Directory*, 1987.

³⁰ *Solvent Safety Handbook*.

from Uniroyal Chemical, RT Vanderbilt, and ARTEL Chemical. Diethylamine is used to produce N,N-diethyl-m-toluamide (DEET). Diethylamine is used as a selective solvent for the removal of impurities from oils, fats, and waxes where its property of hydrating in aqueous solution is utilized.³¹ Diethylamine mixture is used as a mobile phase solvent for the optimization of TLC separations of basic drugs and alkaloids. Diethylamine mixture was used to test the solubility and reactivity of native, mercerized, and regenerative celluloses, as well as dissolution of cellulose in mixtures of N-methylmorpholine N-oxide. A sulfur dioxide/diethylamine/dimethyl sulfoxide mixture is used for viscosity measurements of cellulose to determine the molecular weight of cellulose in wood pulp. Diethylamine mixture is used as a solvent for the preparation of amorphous cellulose by regeneration of cellulose in its solutions. Diethylamine is used as a solvent medium for the preparation of the red-blue a-modification of copper phthalocyanine. [The red-blue pigment is useful for coloring oil varnishes.] A diethylamine mixture is used as a solvent in the reagent to dissolve iron protoporphyrins in fecal occult blood tests. Diethylamine is used for the cleavage of DNA and as a medium to study the dropping Hg electrode polarographic behavior of sulfur solutions.³²

The 1993 RCRA 3007 Questionnaire reported diethylamine use as a solvent by 12 facilities, totaling 41.65 kg. All of the facilities indicated that diethylamine was used only in their laboratories. Eight of these facilities are pharmaceutical laboratories. Three of the pharmaceutical laboratories use diethylamine in chromatography; one uses it in a quality control lab; one uses the chemical as a solvent for amine reactions; and the others have multiple laboratory uses of diethylamine. In the industrial organic chemicals industry, there are two facilities which use the diethylamine for laboratory use. Finally, one laboratory in the office machines industry and one laboratory in the commercial research industry use diethylamine as a solvent. Several of the solvent uses identified in the literature search are being used according to the Questionnaire responses, but at the present time they are only being used on the research/laboratory level.

Table 4-9 presents the facilities reporting the use of diethylamine as a solvent. Table 4-10 presents the solvent use by industry.

³¹*Industrial Solvents Handbook*, 1991.

³²Chemical Abstracts, various dates.

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Table 4-9 Facilities Using Diethylamine in 1993 and Industrial Sector

Facility Name	Location	Industry
Eli Lilly & Co. - MC Research	Indianapolis, IN	Pharmaceuticals
Hoffmann - La Roche Inc.	Nutley, NJ	Pharmaceuticals
Zeneca - Fairfax Site	Wilmington, DE	Pharmaceuticals
Glaxo Inc.	Research Triangle Park, NC	Pharmaceuticals
Carter-Wallace, Inc.	Cranbury, NJ	Pharmaceuticals
Pfizer, Inc.	Brooklyn, NY	Pharmaceuticals
Ayerst laboratories, Inc.	Rouses Point, NY	Pharmaceuticals
Alcon Laboratories, Inc.	Fort Worth, TX	Pharmaceuticals
CIBA-Geigy Corp. McIntosh Site	McIntosh, AL	Industrial Organic Chemicals
PCR Inc.	Gainesville, FL	Industrial Organic Chemicals
Xerox	Webster, NY	Office Machines
3M Center	Saint Paul, MN	Commercial Physical and Biological Research

Table 4-10 Use of Diethylamine By Industry

Industry	Use, kg
Pharmaceuticals	31.07
Industrial Organic Chemicals	7.27
Office Machines	0.02
Commercial Physical and Biological Research	3.29

4.3.1 Wastes From Use as a Solvent

All of the wastes generated from the use of diethylamine as a solvent are small volume commingled organic laboratory wastes. Only three wastes of the 13 reported were larger than 3,000 kg/yr (with the largest volume waste approximately 12,400 kg/yr). All of the remaining waste quantities were less than 210 kg/yr (with volumes not reported for four waste streams). The total 1993 consumption of diethylamine reported by each facility ranged from <0.01 kg to 14.12 kg. These low consumption rates result in a total diethylamine loading quantity of less than 41 kg. Table 4-11 presents data on the diethylamine residuals generated, by waste type.

Table 4-11 Quantity of Diethylamine Waste Generated for Each Type Generated

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Waste Type	Reported Volume kg/yr	Loading kg/yr
Organic Wastes	21,285.91	40.98

4.3.2 Management Practices

Each of the 13 organic wastes containing diethylamine are managed in one of three ways: 1) incineration on-site or off-site, 2) stored on-site prior to being sent off-site for fuel blending, or 3) burned for energy recovery. The 13 wastes represent a total waste volume of approximately 21,286 kg and have an average diethylamine concentration of 543 mg/L. In all cases, the wastes are managed as RCRA hazardous wastes; six of the thirteen wastes are labeled as D001 (ignitable), one is D002 (corrosive), one is F003/F005, two are a combination of D001, D018, and F001-F005, and three are unspecified hazardous wastes. Prior to final disposal or management, the spent solvent wastes are managed in on-site containers or tanks. Table 4-12 presents statistics for diethylamine residuals, by management practice.

Table 4-12 Generation Statistics for Diethylamine

Management Practice	# of Facilities	# of Streams	# of Streams w/Unreported Volume	Total Volume (kg)	Total Loading (kg)
Incineration	7	8	1	21,282	12.25
Fuel Blending	3	3	1	3.90	2.43
Unspecified	2	2	2	NR	19.12
TOTAL	12	13	4	21,285.90	33.80

NR - Not Reported

4.3.3 Health Data

Diethylamine (C₄H₁₁N, CAS No., 109-89-7) is a colorless liquid with a fishy, ammonia-like odor.³³ It is highly volatile (explosive), has a low boiling point (55.5°C) with vapors more dense than air.³⁵ It is harmful if ingested or inhaled and can burn eyes and skin.³⁵

Various exposure limits have been established for diethylamine. The OSHA PEL dermal exposure limit is 25 ppm and the NIOSH IDLH limit is 200 ppm.³⁴ The ACGIH TLV is 5 ppm (15 mg/m³) and the short term TLV is 15 ppm (45 mg/m³).³⁵

³³The Merck Index, 11th Edition. Merck and Co., Inc. Rahway, NJ. 1989.

³⁴U.S. Department of Health and Human Services. National Institute for Occupational Safety and Health, *NIOSH Pocket Guide to Chemical Hazards*. Washington D.C. June 1994.

³⁵American Conference of Governmental Industrial Hygienists. *1995-1996 Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs)*. Cincinnati, OH. 1995.

Toxicity data indicates that diethylamine is a skin and eye irritant; and is moderately toxic by ingestion, inhalation, and dermal contact.³⁶ Data indicate that acute exposure to diethylamine can cause eye, skin, mucous membrane, and respiratory tract irritation; diethylamine is corrosive and can severely damage skin and eyes.³⁸ Chronic exposure can cause tracheitis, bronchitis, preunomitis, and pulmonary edema.³⁸ Via the oral route in rats the LD₅₀ is 540 mg/kg and the LC₅₀ for exposure via the inhalation route is 4,000 ppm/4H.³⁸ A reference dose (RfD), a carcinogen slope factor (CSF), a health based limit (HBL), or a maximum contaminant level (MCL) have been established for diethylamine.³⁷ Aquatic toxicity has been estimated at 85 mg/l for creek chub exposed over a 48-hour period in fresh water.³⁸

4.4 1,4-Dioxane

EPA has identified SIC codes through Chemical Abstracts searches that indicated potential use of the chemical as a solvent. These potential users were cross-referenced with TRI data for this chemical reported to be "otherwise used." A complete description of this methodology is presented in Section 2.0 of this study.

1,4-Dioxane is used as a solvent for extracting animal and vegetable oils and in the formulation of inks, coatings, and adhesives. In the laboratory, 1,4-dioxane is useful as a cryoscopic solvent for molecular mass determinations and as a stable reaction medium for diverse reactions.³⁹ 1,4-Dioxane is used primarily as a solvent in such widely used products as paints, varnishes, lacquers, cosmetics, deodorants, cleaning and detergent preparations, and in scintillating fluids.⁴⁰ Literature searches also indicated the potential for use as a solvent in the processing of crude petroleum, petroleum refining, petrochemicals, pulp and paper, explosives, commercial printing, electroplating/polishing, pesticide and agricultural manufacture, dyes, fiber manufacture, pharmaceuticals, adhesives, semiconductors, electronic components, photographic equipment, magnetic recording media, polymers, plastics, rubber manufacture, and organic and inorganic chemical manufacture.⁴¹

The 1993 RCRA 3007 Questionnaire reported 1,4-dioxane use as a solvent in 27 facilities, totaling 101,577.08 kg. Only one facility in the coated and laminated paper industry indicated the use of 1,4-dioxane. The chemical was used in the dissolution of polymers to produce a coating. Sixteen pharmaceutical facilities reported the use of 1,4-dioxane, fourteen of which use the small amounts of the chemical in laboratory operations such as research and development, quality control of finished goods, and laboratory experiments. The remaining two facilities use 1,4-dioxane as a medium for crystallization and for the distillation and dissolution of an intermediate product.

³⁶U.S. Department of Health and Human Resources. Registry of Toxic Effects of Chemical Substances. National Toxicology Program, National Library of Medicine, Bethesda, MD. 1996.

³⁷U.S. EPA. *Integrated Risk Information System (IRIS)*. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH 1993.

³⁸*Solvents Safety Handbook*.

³⁹*Ullman's*, 1987.

⁴⁰*Handbook of Environmental Fate and Exposure Data*, 1990.

⁴¹Chemical Abstracts, various dates.

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Three facilities in the organic chemicals industry use 1,4-dioxane. One facility uses small amounts of 1,4-dioxane in a quality assurance laboratory; one facility uses it for distillation and as a reaction/synthesis medium; and the third facility uses 1,4-dioxane for chromatography in polyolefin catalyst synthesis. The largest use of 1,4-dioxane is by a pesticide and agricultural chemical facility. This facility uses the chemical as a polar reaction medium for a nucleophilic displacement reaction. Both the facility in the chemical preparations industry and the petroleum refining industry use minimal amounts of 1,4-dioxane. The chemical preparations facility uses 1,4-dioxane as a reaction medium in the laboratory. The petroleum refining facility uses it at a concentration of 1% in a cleaning solvent. One facility uses 1,4-dioxane in the office machines industry for the dissolution of pigment for an interface spray. In the photographic industry, there are two facilities which use 1,4-dioxane; one facility uses it to dissolve resins and polymers into solution for film coating; the other facility uses 1,4-dioxane as a photochemical reaction/synthesis medium as well as for miscellaneous research and development projects. Finally, one facility in the commercial research industry uses 1,4-dioxane in its laboratories as a solvent in reactions and distillation.

The use of 1,4-dioxane in the processing of explosives, dyes, fiber manufacture, semiconductors, and rubber manufacture, uses identified in the literature search, were not reported in the 1993 Questionnaire responses.

Table 4-12 presents the facilities reporting the use of 1,4-dioxane as a solvent. Table 4-13 presents the use of solvent, by industry.

Table 4-12 Facilities Using 1,4-Dioxane in 1993 and Industrial Sector

Facility Name	Location	Industry
3M Hutchinson AVTD and TMD Plants	Hutchinson, MN	Coated and Laminated Paper
Merck & Co. Inc. - Rahway Site	Rahway, NJ	Pharmaceuticals
Abbott Laboratories	North Chicago, IL	Pharmaceuticals
Eli Lilly - MC Research	Indianapolis, IN	Pharmaceuticals
Hoffman-LaRoche, Inc.	Nutley, NJ	Pharmaceuticals
Merck and Co., Inc.	Danville, PA	Pharmaceuticals
Schering Plough Products	Manati, PR	Pharmaceuticals
Genetech, Inc.	South San Francisco, CA	Pharmaceuticals
Zeneca - Fairfax Site	Wilmington, DE	Pharmaceuticals
Abbott Laboratories	Abbott Park, IL	Pharmaceuticals
Eli Lilly & Co.	Indianapolis, IN	Pharmaceuticals
Eli Lilly & Co.	Shadeland, IN	Pharmaceuticals
Upjohn Company	Kalamazoo, MI	Pharmaceuticals
Glaxo Inc.	Research Triangle Park, NC	Pharmaceuticals

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Facility Name	Location	Industry
Carter-Wallace, Inc.	Cranbury, NJ	Pharmaceuticals
Pfizer, Inc.	Brooklyn, NY	Pharmaceuticals
Ayerst laboratories, Inc.	Rouses Point, NY	Pharmaceuticals
BF Goodrich Co - Henry Plant	Henry, IL	Industrial Organic Chemicals
Sigma Chemical Co.	Saint Louis, MO	Industrial Organic Chemicals
Exxon Chemical Americas	Baytown, TX	Industrial Organic Chemicals
Du Pont Mobile Plant	Axis, AL	Pesticide/Agricultural Chem.
OCG Microelectronic Materials	East Providence, RI	Chemical Preparations
Mobile Beaumont Refinery	Beaumont, TX	Petroleum Refining
Xerox	Webster, NY	Office Machines
Polaroid Corp. - Norwood Facility	Norwood, MA	Photographic
Kodak park Site	Rochester, NY	Photographic
3M Center	Saint Paul, MN	Commercial Research

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Table 4-13 Use of 1,4-Dioxane By Industry

Industry	Use, kg
Pesticides and Agricultural Chemicals	53,852.85
Photographic Equipment and Supplies	20,796.46
Pharmaceutical Preparations	15,940.77
Office Machines	5,686.15
Coated and Laminated Paper	3,850.13
Industrial Organic Chemicals	1,137.69
Commercial Physical and Biological Research	88.98
Chemicals and Chemical Preparations	13.60
Petroleum Refining	0.45

4.4.1 Wastes From Use as a Solvent

The wastes generated from the use of 1,4-dioxane as a solvent are organic wastes, waste waters, and solids. The majority of the waste streams (39 of the 48) are in the form of organic wastes, and they vary from the smallest volume of 0.1 kg to the largest volume of 297,000 kg. These facilities reported 1993 consumptions of 1,4-dioxane in the range of 0.45 kg to 54,000 kg. Seven of the waste streams are wastewaters. The wastewater streams range from 356 kg to 206,000,000 kg. The 1993 use of 1,4-dioxane was between 1 and 54,000 kg for the wastewater streams. Two wastes were reported as solids. The residual volumes were 12,000 kg and 554,000 kg, and the total 1993 1,4-dioxane consumptions were 3,850 kg for both streams. Table 4-14 presents data on the generation of 1,4-dioxane residuals, by waste type.

Table 4-14 Quantity of 1,4-Dioxane Residuals

Waste Type	Reported Volumes kg/yr	Total Loading kg/yr
Waste waters		
Process Waste waters	206,211,494	4,728
Scrubber Waters	8,182	82
Filtrates/Condensates	NR	1,112
Solids	566,337	754
Organic Waste		
Spent Solvents	66,492	2,522
Precipitates, Filtrates, Condensates, Distillates	243,108	2,439
Gases/Vapors	1,508	473
Organic Residues	305,836	2,377

4.4.2 Management Practices

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The wastes containing 1,4-dioxane generated from the use of 1,4-dioxane as a solvent are managed in at least five different ways. The solids and organic wastes are managed in one of three ways: incinerated on-site or off-site, maintained on-site until they are burned off-site for energy recovery, or maintained on-site until they are sent off-site for fuel blending. The majority of the solid and organic wastes are incinerated. In all three cases, the waste streams are managed as RCRA hazardous wastes. There is one exception where a facility has non-hazardous on-site solids incineration. Seven of the 41 waste streams are labeled as D001; 18 are labeled as a combination of D001, D002, D018, D022, D028, D035, D038, F002, F003, F005, U003, U005, U007, and U188; and the remainder are unrecorded or disposed of by some other means. The wastewater streams are either sent to a POTW for treatment or are biologically treated on-site in a WWTP prior to being discharged. The wastewater streams are all managed as non-hazardous wastes and the wastewater treatment systems are tank-based. Table 4-15 presents statistics on the management of 1,4-dioxane residuals, by management practice.

Table 4-15 Generation Statistics for 1,4-Dioxane

Management Practice	# of Facilities	# of Streams	# of Streams w/Unreported Volume	Total Volume (kg/yr)	Total Loading (kg/yr)
Incineration	16	24	0	936,098	5,799
Energy Recovery	2	8	0	4,714	241
Fuel Blending	3	4	0	243,067	2,444
WWT-Tanks	2	2	0	205,917,273	4,200
POTW	1	1	1	NR	1,112
WWT - Surface Impoundment	1	1	0	297,804	596
Unspecified Disposal	2	2	1	2.5	96
TOTAL	27	42	2	207,398,959	14,488

4.4.3 Health Data

1,4-Dioxane (C₄H₈O₂, CAS No., 123-91-1) is a colorless, flammable liquid with a faint, pleasant odor.⁴² It has a moderate boiling point (101°C) and a flash point of 5 to 18°C.⁴⁴ Its vapors are heavier than air.⁴³

Various exposure limits have been established for 1,4-dioxane. The limit for OSHA PEL is 100 ppm (360 mg/m³) with an assigned "skin notation" indicating that this chemical has the potential for dermal absorption.⁴⁴ The ACGIH TLV for dermal exposure is 25 ppm and 90 mg/m for inhalation.⁴⁵ The NIOSH IDLH is 500 ppm.⁴⁶

Toxicity data indicate that acute exposure to 1,4-dioxane can cause respiratory irritation, headache, nausea, vomiting, drowsiness, dizziness, and central nervous system depression.⁴⁶ Chronic exposure can cause liver and kidney damage in animals.⁴⁸ The established LD₅₀ for acute exposure in rats via the oral route is 5,200 mg/kg.⁴⁷ The LC₅₀ for rats via the inhalation route is 46 gm/m³/2H.⁴⁸ 1,4-Dioxane is a probable human carcinogen.⁴⁸ The carcinogen slope factor (CSF) for 1,4-dioxane is 0.011 mg/kg/day and the health based limit (HBL) at 10⁻⁶ risk level is 0.003 mg/L.⁴⁹ A reference dose (RfD) and a maximum contaminant level (MCL) have not been established for 1,4-dioxane.⁵¹ 1,4-Dioxane is rated as an EPA Group B2 (probable) carcinogen.⁵¹ Three epidemiological studies showed no relationship between exposure to 1,4-dioxane and human cancer.⁵¹ Animal studies show the potential for liver and nasal cavity cancer by ingestion.⁴⁸

4.5 Ethylene Oxide

A small fraction of ethylene oxide production (less than 0.5 percent) is consumed by a sterilant or fumigant users. Ethylene oxide is utilized as a sterilant agent by various facets of the health care industry for the sterilization of delicate instruments and heat and moisture sensitive devices. (EPA 49 FR 25734). Such

⁴²*The Merck Index*, 11th Edition. Merck and Co., Inc., Rahway, NJ. 1989.

⁴³SRI Chemical Economics Handbook, 11/91.

⁴⁴U.S. Department of Health and Human Services. National Institute for Occupational Safety and Health, *NIOSH Pocket Guide to Chemical Hazards*. Washington, D.C. June 1994.

⁴⁵American Conference of Governmental Industrial Hygienists. *1995-1996 Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs)*. Cincinnati, OH 1995.

⁴⁶U.S. Department of Health and Human Resources. Registry of Toxic Effects of Chemical Substances. National Toxicology Program, National Library of Medicine, Bethesda, MD. 1996.

⁴⁷Material Safety Data Sheet, BASF. March 14, 1989.

⁴⁸National Institute of Environmental Health Science. *Reasonably Anticipated to be Carcinogen: 1,4-Dioxane (CAS No. 123-91-1)*. ARC/RAC online database.

⁴⁹U.S. EPA. *Integrated Risk Information System (IRIS)*. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH, 1993.

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use does not meet EPA's definition of "solvent use." EPA has identified SIC codes through Chemical Abstracts searches that indicated potential use of the chemical as a solvent. These potential uses were cross-referenced with TRI data for this chemical reported to be "otherwise used." A complete description of this methodology is presented in Section 2.0 of this study.

Potential solvent uses identified through literature searches include use as a solvent/catalyst in catalyst systems subjected to different stages of heat treatments in the skeletal isomerization of cyclohexane to 1-methylcyclopentene and 3-methylcyclopentene.⁵⁰

The 1993 RCRA 3007 Questionnaire reported ethylene oxide use as a solvent by three pharmaceutical research laboratories, totaling 4.29 kg. In these laboratories, ethylene oxide had multiple small-scale solvent uses, such as a reaction or synthesis medium in oxidation and use as a standard for gas chromatography. The use of ethylene oxide as a solvent in catalyst systems in the skeletal isomerization of cyclohexane, a use identified in the literature search, was not reported in the 1993 Questionnaires.

Table 4-16 presents the facilities reporting the use of ethylene oxide as a solvent. Table 4-17 presents the use of ethylene oxide as a solvent by industry.

Table 4-16 Facilities Using Ethylene Oxide in 1993 and Industrial Sector

Facility Name	Location	Industry
Eli Lilly & Co. - MC Research	Indianapolis, IN	Pharmaceutical
Glaxo Inc.	Research Triangle Park, NC	Pharmaceutical
Carter-Wallace, Inc.	Cranbury, NJ	Pharmaceutical

Table 4-17 Use of Ethylene Oxide By Industry

Industry	Use, kg
Pharmaceuticals	4.29

4.5.1 Wastes From Use as a Solvent

Most of the wastes generated from the use of ethylene oxide as a solvent are commingled organic laboratory wastes. The residual volumes reported range from 210 kg to 12,400 kg. The three waste volumes each had concentrations of much less than one percent. This resulted in all three loadings being under 3 kg, totaling 4.3 kg of ethylene oxide. Table 4-18 presents data on the quantity of ethylene oxide residuals, by waste type.

Table 4-18 Quantity of Ethylene Oxide Waste Generated for Each Type Generated

⁵⁰Chemical Abstracts, various dates.

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Waste Type	Reported Volumes kg/yr	Total Loading kg/yr
Organic Waste	17,611	4.3

4.5.2 Management Practices

Each of the three organic wastes containing ethylene oxide generated from the use of ethylene oxide are managed in one of two ways: onsite storage followed by either incineration or fuel blending. The three wastes represent a total waste volume of 17,611 kg and have concentrations ranging from 11 parts per million to 0.01 percent. In all cases, the wastes are managed as RCRA hazardous wastes and are labeled as D001 (ignitable). One of these three is also labeled D018 and F002/F003/F005. Table 4-19 presents statistics for the management of ethylene oxide residuals by management practice.

Table 4-19 Generation Statistics for Ethylene Oxide

Management Practice	# of Facilities	# of Streams	# of Streams w/Unreported Volume	Total Volume (kg/yr)	Total Loading (kg/yr)
Incineration	2	2	0	17,397	4.3
Fuel Blending	1	1	0	214	0.0005
TOTAL	3	3	0	17,611	4.3005

4.5.3 Health Data

Ethylene oxide (C₂H₄O, CAS No., 75-21-8) is a colorless gas condensing at low temperatures (below 12°C) to a mobile liquid, with a ether-like odor.⁵¹ Ethylene oxide is a highly reactive molecule with vapors that are flammable and explosive.⁵² It hydrolyzes in water with a half-life at 25°C of about 12 days.⁵³ As little as three percent ethylene oxide in air can be flammable.⁵⁴ Ethylene oxide has a very low boiling point (10.6°C) with vapors that are heavier than air.⁵⁴ It may undergo hazardous polymerization upon contact with highly active catalytic surfaces.⁵⁴

Based on exposure data the following exposure limits were established for ethylene oxide. The OSHA PEL limits for TWA and 15 minute excursion are 1 ppm and 5 ppm, respectively.⁵⁴ The ACGIH TLV

⁵¹ *The Merck Index*, 11th Edition. Merck and Co., Inc. Rahway, NJ. 1989.

⁵² Material Safety Data Sheet, Shell Chemical Co., June 6, 1990.

⁵³ Mabey, W., Mill, T., *Journal of Chemical Reference Data*, 1978, Vol. 7, pp. 383-415.

⁵⁴ *NIOSH Pocket Guide to Chemical Hazards*. U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health. Washington, D.C. June 1994.

limits for TWA is 1 ppm.⁵⁵ The ACGIH also reports an odor threshold of 261ppm for perception and 500 to 700 ppm for recognition.⁵⁵ The NIOSH IDLH limit is 800 ppm and the threshold odor level is 1 pm.⁵⁶ The NIOSH TLV limits for TWA and the ceiling are <0.1 ppm and 5 ppm, respectively.

The toxicity data indicate that ethylene oxide is irritating to the skin, eyes, and mucous membranes of respiratory tract.⁵⁶ Toxicity data indicate that acute exposure to ethylene oxide can cause nausea, vomiting, and death.⁵⁷ Chronic exposure can cause irritation of eyes, skin, and mucous membranes, cataracts, and problems in brain function.⁵⁸ Exposure to ethylene oxide may result in lung, liver, and kidney damage.⁵⁸ Via the oral route in rats the LD₅₀ is 72 mg/kg and via the inhalation route, the LC₅₀ is 800 ppm/4H.⁵⁸ Ethylene oxide is rated as a Group B1 (probable) human carcinogen.⁵⁹ The carcinogen slope factor (CSF) is 1.02 mg/kg/day and the health-based limit (HBL) is 3E-05 mg/L.⁶¹ A reference dose (RfD) and a maximum contaminant level (MCL) have not been established for ethylene oxide.⁶¹

4.6 Bromoform

Bromoform is reportedly used in separating mixtures of minerals⁶⁰, as a solvent to selectively extract rare earth metals (e.g., Cs and Rb), and to separate Ekibastuz coal into fractions (benefication).⁶¹ Non-solvent uses of bromoform include use in organic syntheses and in medicinal pharmaceuticals as a sedative.⁶² EPA has identified SIC codes through Chemical Abstracts searches that indicate potential use of the chemical as a solvent. These potential uses were cross-referenced with TRI data for this chemical reported as "otherwise used." A complete description of this methodology is presented in Section 2.0 of this study.

4.6.1 Use as a Solvent

In response to the RCRA 3007 Preliminary Questionnaire, 12 facilities indicated the use of bromoform as a solvent at their site. These facilities reported a total use of 18,254 kilograms in 1992.

⁵⁵American Conference of Governmental Industrial Hygienist. *1995-1996 Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs)*. Cincinnati, OH, 1995.

⁵⁶U.S. Department of Health and Human Resources. Registry of Toxic Effects of Chemical Substances. National Toxicology Program, National Library of Medicine, Bethesda, MD. 1996.

⁵⁷Agency for Toxic Substances and Disease Registry (ATSDR). *Toxicological Profile for Ethylene Oxide*. U.S. Public Health Service, U.S. Department of Health and Human Services. 1990.

⁵⁸U.S. Department of Health and Human Resources. Hazardous Substances Data Base. National Toxicology Program, National Library of Medicine, Bethesda, MD. 1993.

⁵⁹U.S. EPA. *Integrated Risk Information System (IRIS)*. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH, 1993.

⁶⁰*Merck Index*, 1989.

⁶¹Chemical Abstracts.

⁶²Rhone-Poulenc Product Information.

Nearly all of the “use” was reported by TSD facilities that accepted bromoform for thermal treatment. Two facilities reported the use of bromoform in the RCRA 3007 Questionnaire of Solvent Use, one of which erroneously reported its use as a solvent, when in fact it was used as a reactant. The only facility to indicate the use of bromoform as a solvent used a very small amount, 0.001 liters per year. The facility did not report any residuals associated with this use due to the very small quantity involved.

4.6.2 Health Data

Bromoform (CHBr₃, CAS No., 75-25-2) is a colorless to yellow, very heavy liquid (density = 2.9031), with a chloroform-like odor.⁶³ It is toxic by inhalation, ingestion, and skin absorption; is irritating to the skin, eye and respiratory tract.⁶⁵ It is a lachrymator.⁶⁵ It is non-flammable, has low reactivity, and has a moderate boiling point (149°C).⁶⁵

Based on exposure data the following limits have been established for bromoform. The OSHA PEL and the ACGIH TLV are 5 mg/m³ (0.5 ppm) and 5.2 mg/m³ (0.5 ppm), respectively and a “skin notation” has been assigned, which indicates a potential for dermal absorption.^{64, 65} The NIOSH IDLH limit is 850 ppm.⁶⁶

Bromoform is moderately toxic via the oral and subcutaneous routes.⁶⁶ Acute inhalation of small amounts causes irritation, provoking the flow of tears and saliva, and reddening of the face.²² Cumulative exposures cause liver damage and abuse of bromoform can lead to addiction.²² Acute exposure in rats via the oral route has a LD₅₀ of 1,147 mg/kg and an LC₅₀ via the inhalation route of 45 gm/m³/4H.⁶⁸ Bromoform has a reference dose (RfD) of 2E-02 mg/kg/day, a carcinogen slope factor (CSF) of 7.9E-03 mg/kg/day, and a health-based limit (HBL) limit of 4E-03 mg/L at 10⁻⁶ risk level.⁶⁷ An interim maximum contaminant level (MCL) of 0.10 mg/L has been established for total trihalomethanes.⁶⁹ No RfC has been established.⁶⁹

According to IRIS, the inhalation unit risk value is 1.1E-06 (ug/m³)⁻¹, and thus, the concentration in air corresponding to a risk level of 10⁻⁶ is 9E-04 mg/m³.⁶⁹

Toxicity data indicate that acute exposure to bromoform can cause central nervous system depression, while chronic oral exposure can cause liver, kidney, and central nervous system damage in animals.⁶⁸ Bromoform is rated as an EPA Group B2 (probable) carcinogen.⁶⁹ Although no human cancer data were found, animal studies show the potential for liver and intestinal cancer by oral exposure.⁶⁹

⁶³*The Merck Index*, 11th Edition. Merck and Co., Inc., Rahway, NJ. 1989.

⁶⁴U.S. Department of Health and Human Services. National Institute for Occupational Safety and Health, NIOSH Pocket Guide to Chemical Hazards. Washington, D.C. June 1994.

⁶⁵American Conference of Governmental Industrial Hygienists. *1995-1996 Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs)*. Cincinnati, OH. 1995.

⁶⁶U.S. Department of Health and Human Resources. Registry of Toxic Effects of Chemical Substances. National Toxicology Program, National Library of Medicine, Bethesda, MD. 1996.

⁶⁷U.S. EPA. *Integrated Risk Information System (IRIS) on Vinylidene Chloride*. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH. 1993.

4.7 Vinylidene Chloride

Vinylidene chloride's major use is as an intermediate in the production of "vinylidene polymer plastics" such as Saran and Velon. It also is used captively for the production of 1,1,1-trichloroethane. EPA has identified SIC codes through Chemical Abstracts searches that indicated potential use of the chemical as a solvent. These potential uses were cross-referenced with TRI data for this chemical reported as "otherwise used." A complete description of this methodology is presented in Section 2.0 of this study. No solvent uses have been identified due to its reactivity.

4.7.1 Use as a Solvent

Data from the RCRA 3007 Preliminary Questionnaire indicated that five facilities used a total of 24,532 kilograms of vinylidene chloride as a solvent in 1992, which included 24,529 kg reported by two TSDs. An additional 3 kg reported by two facilities did not meet EPA's definitions of "solvent use." One facility used less than 0.03 kg; this use was not continued in 1993. In response to the RCRA 3007 Questionnaire, the only "use" of vinylidene chloride was reported by a TSD facility that accepted vinylidene chloride for treatment. No other facilities reported the use of vinylidene chloride on the RCRA 3007 Questionnaire.

The use of vinylidene chloride as a solvent appears to be very limited, if it even occurs. It is unlikely that it has any industrial solvent use, rather it is used for specialty applications in laboratories.

4.7.2 Health Data

Vinylidene chloride ($C_2H_2Cl_2$, CAS No., 75-35-4) is a colorless, mobile liquid with a sweet, slightly irritating odor resembling that of chloroform.⁶⁸ It is toxic by ingestion or inhalation and is an eye and skin irritant.⁷⁰ It is flammable and may undergo hazardous polymerization with atmospheric oxygen if its inhibitor has been depleted.⁷⁰ It has a low boiling point (31.6°C) and a flash point of -15°C.⁷⁰

Based on exposure data the following limits have been established for vinylidene chloride. The ACGIH TLV and STEL exposure limits are 5 ppm and 20 ppm, respectively.⁶⁹ No exposure limits have been established for the OSHA PEL, NIOSH IDLH, and the threshold odor level.

Toxicity data indicate that the vinylidene chloride is a skin and mucous membrane irritant.⁷⁰ Toxicity data indicate that acute exposure to vinylidene chloride can have adverse respiratory and neurological effects (e.g., central nervous system depression, convulsions, spasms, and unconsciousness).⁷⁰ Chronic exposure can cause cumulative liver and kidney damage.⁷² It has caused liver and kidney injury in experimental animals and is a narcotic at high concentrations.⁷⁰ The established LD_{50} for acute exposure in rats via the oral route is 200 mg/kg and the LC_{50} for inhalation in rats is 6,350 ppm/4H.⁷² Vinylidene chloride is a possible human carcinogen. Vinylidene chloride has a reference dose (RfD) of 0.009 mg/kg/day, a carcinogen slope factor (CSF) of 0.6 mg/kg/day, and a health-based limit (HBL) of 6E-05 (corresponding to

⁶⁸*The Merck Index*, 11th Edition, Merck and Co., Inc., Rahway, NJ. 1989.

⁶⁹American Conference of Governmental Industrial Hygienist. *1995-1996 Threshold Limit Values (TLVs) for Chemical Substances and Physical Agent and Biological Exposure Indices (BEIs)*. Cincinnati, OH 1995.

⁷⁰U.S. Department of Health and Human Resources. Registry of Toxic Effects of Chemical Substances. National Toxicology Program, National Library of Medicine, Bethesda, MD. 1996.

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a risk level of $1E-06$ ⁷¹ and a maximum contaminant level (MCL) of 0.007 mg/L.⁷¹ EPA has medium confidence in the study used as the basis for the RfD.⁷¹ Vinylidene chloride is rated as an EPA Group C (possible) carcinogen.⁷¹ Although no relationship between occupational exposure to vinylidene chloride and human cancer were found, animal studies show the potential for kidney and mammary cancer by inhalation.⁷¹

The concentration in water corresponding to a risk level of $10E-06$ as reported by IRIS is $6E-05$ mg/l. The inhalation unit risk value is $5E-05$ ($\mu\text{g}/\text{m}^3$)⁻¹, and thus, the concentration in air corresponding to a risk level of $10E-06$ is $2E-05$.⁷¹

⁷¹U.S. EPA. Integrated Risk Information System (IRIS). Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH, 1993.