Selection of Industry Sectors, Chemicals and Functions in the Remanufacturing Exclusion:

Background Document in Support of the Definition of Solid Waste Rule

Prepared by:

U.S. Environmental Protection Agency
Office of Pollution Prevention and Toxics
Economic, Exposure and Technology Division
Pollution Prevention Division
1200 Pennsylvania Avenue NW
Washington, DC 20460

June 16, 2011

Introduction

This background document provides the basis for the selection of industries, chemicals, and functions in the Remanufacturing exclusion in the definition of solid waste rule. Companies within these sectors are highly integrated. These chemicals are used because of how they function, and are used within these sectors in the same way – to manufacture a specialty (organic) chemical product – such as a paint, plastic or drug.

The Green Engineering Program within the Office of Chemical Safety and Pollution Prevention (OCSPP) has for several years been studying re-manufacturing scenarios for "once-used" solvents in the pharmaceutical industry sector that use solvents as chemical manufacturing and processing aids. By focusing on the life-cycle (beginning and end of life) impact in their manufacture, and reviewing Toxics Release Inventory Production Related Waste reporting, EPA has found that a large, but often hidden footprint is from the disposal of these solvents. EPA has determined that the environmental impacts from solvents used as manufacturing and processing aids could be significantly reduced if the product life of solvents used for these purposes were extended to more than a single use.[1] (Extension of life)

Why these Sectors?

As stated in the Preamble, EPA selected these sectors as candidates for the re-manufacturing exclusion because they are manufacturing sectors not waste handling sectors, and because they use chemicals serving as chemical manufacturing and processing aids[2]. Sectors that use chemicals in this way are limited to those that make chemicals, and these sectors are relatively few in number. EPA has selected most of the sectors that fall into this group and would welcome comment on its selections. Since readers may well be familiar with numerous additional sectors downstream from chemical manufacturers which combine chemicals to make various end-products, EPA would simply note that they do not share the function of performing actual chemical manufacturing and processing, do not use chemicals in their capacity as manufacturing and processing aids and, thus, cannot be considered under the re-manufacturing exclusion as proposed.

Regarding the sectors selected as candidates for the re-manufacturing exclusion, EPA would like to note a few things. The basic organic chemicals sector makes both polymer resins and specialty chemicals. Polymer resins are the backbone for paints, resins and plastics, whereas specialty chemicals are used to make the complex molecules in the pharmaceutical industry. TRI reporting shows that the facilities within and among each sector are co-located by each other[3] and are customers of one another. Although there are many small facilities within each of these sectors, the highest volumes of material are reported by a few large parent companies that manage the entire supply chain. Also, film-forming agents are resins, but are reported in the paint & coatings sector. Makers of polymers report in both basic organic and plastic & resin

[1] Mass Balance Model is available to estimate emissions reductions from a process change of disposal to recycling. See Tables 8.1 and 8.2, Appendix 4

[2] See discussion and table on "Why these functions?" one page below for TRI evidence of sector-function relationship.

[3] See Map 2, and Figures 6.1 – 6.8, Appendix 2.

sectors. Some makers of specialty chemicals used in and sold to pharmaceutical companies actually report in the pharmaceutical industry.

Why these Chemicals?

EPA has made its best estimate of those chemicals used as chemical manufacturing and processing aides in significant volumes from the list of all chemicals used by the four selected sectors. As noted in the Preamble to the Proposed Rule, "processing aid" solvents assist in the reaction, extraction, purification, and blending of ingredients and reactive products, but are not themselves reacted. These processing aid solvents, once used, can then be re-manufactured to commercial grade again. These higher-value solvents were selected because there are existing markets for all these solvents to be re-manufactured to serve similar purposes to those of the original commercial-grade materials. All these chemicals are solvents (some watery, some oily, some a specialty combination of the two), and TRI reporting indicates these sectors use these solvents in large volumes. EPA would welcome comments on any additions or deletions that could be made to its list of chemicals used as chemical manufacturing and processing aides in the four selected sectors.

Why these Functions?

As noted in the Preamble, EPA has selected two chemical functions that a sector would need to be engaged in to make its chemical(s) eligible for re-manufacturing under the exclusion: (1) the chemical would need to be serving as a chemical manufacturing aid (reacting, extracting, blending and/or purifying chemicals); or, (2) the chemical would need to be serving as a chemical processing aid (extracting, blending and purifying chemicals). EPA chose these functions because solvents used for these functions, when chosen to, can be easily separated readily from the other reaction components. Easy separation can occur because these solvents serve to dissolve other chemicals without bonding to them, in a contaminant-free processing step, after which they are removed as quickly and completely as possible. This is in contrast to a solvent serving in an alternate function as a cleaner or degreaser, where the solvent gets contaminated, is more difficult to separate from grease or other contaminants, and is more likely to be discarded.

EPA is able to discern the functional footprint of the selected solvents in sector facility TRI reports. Sectors that use a chemical in significant volumes as a manufacturing and processing aid have a significantly higher waste-to-release ratio for that chemical (discernable even in aggregate chemical reporting) than sectors that use a chemical for other functions. (See Table 1)

Table 1. 2009 TRI Rank by Waste Reporting [4]

2009 Rank by releases	Industry	Releases (lbs)	Waste (lbs)	Waste Divided by Release	Number of TRI submissions
1	Fossil Fuel Electric Power Generation	790,126,465	1,847,589,379	2.34	5,924
2	Lead Ore and Zinc Ore Mining	746,797,067	783,140,544	1.05	72
3	Gold Ore Mining	187,690,280	285,231,764	1.52	255
4	Copper Ore and Nickel Ore Mining	164,894,245	165,736,271	1.01	156
5	Iron and Steel Mills	132,200,157	576,390,882	4.36	1,156
6	Hazardous Waste Treatment and Disposal	105,000,685	430,593,831	4.10	1,673
7	**All Other Basic Organic Chemical Manufacturing**	**91,230,316**	**2,507,659,432**	**27.49**	**3,230**
15	**Plastics Material and Resin Manufacturing**	**47,759,444**	**1,182,155,225**	**24.75**	**2,472**
18	Petrochemical Manufacturing	35,251,673	1,045,278,191	29.65	1,160
61	**Paint and Coating Manufacturing**	**3,785,958**	**88,569,586**	**23.39**	**2,187**
75	**Pharmaceutical Preparation Manufacturing**	**2,927,669**	**127,941,377**	**43.70**	**376**

A TRI-reporting facility has a high waste-to-release ratio when relatively little is being released on site and relatively more of it is being managed as a waste. Its management as a waste could involve disposal onsite (e.g., burning for energy recovery or flaring) or offsite (e.g., incineration or burning at a cement kiln for energy recovery). By contrast, if a solvent were being used as a degreaser onsite, there would be a higher proportion of releases, since a solvent in use as a degreaser releases fugitive volatile emissions.

The primary reason for this footprint is clear in the analysis. Of the billion pounds reported of the 16 TRI chemicals by these 4 sectors, over half is recycled onsite. The largest 'waste' reporting submissions are in the basic organic chemical industry. When they choose to recycle, virtually all of chemical is recovered. (>99% of total production related waste)[5]. So there are no other releases or wastes associated with over 500 million of our billion pounds. TRI Production Related Waste is reported as a transfer, such as to landfill, underground injection, POTW, energy recovery, treatment and recycling. Any onsite or offsite recycling is reported within the Total Production Related Waste number. So the footprint is clear to discern but not clear in it's meaning, as the top waste submitters are also the top solvent recyclers.[6] A facility in Hopewell VA, (Map 1), has the 2nd and 3rd largest waste submissions in all of TRI reporting. 2008TRI reporting shows that this facility recycles 99.38% of its methanol, over 56,000 tons.

As Map 1 illustrates, Hopewell also reports 168 tons of methanol being transferred to the local wastewater treatment facility. The methanol could be used as a wastewater facility treatment chemical. The use of methanol as a wastewater treatment chemical for reducing nitrate levels in POTWs has been successfully applied.[7]

[4] Adapted from RTKNET.org, 2009TRI Rank by Waste Reporting
[5] See Table 4.4, Appendix 1: Top Waste Reporters / Top Recyclers - By % of Total Waste
[6] Id
[7] Nearly 200 wastewater treatment facilities across the US are currently using methanol in their denitrification process. Blue Plains Wastewater Treatment Facility is the single largest point source of nitrogen for the Bay, at 20 tons of nitrogen per day. Methanol denitrification helped to reduce that number to 10 tons per day, half its original nitrogen discharge. The use of methanol denitrification at Blue Plains has resulted in a 30% drop in nitrogen levels in the Chesapeake Bay, from just one treatment plant. www.methanol.ru/fotos/File/MethanolDenitrification.pdf

Map 1.

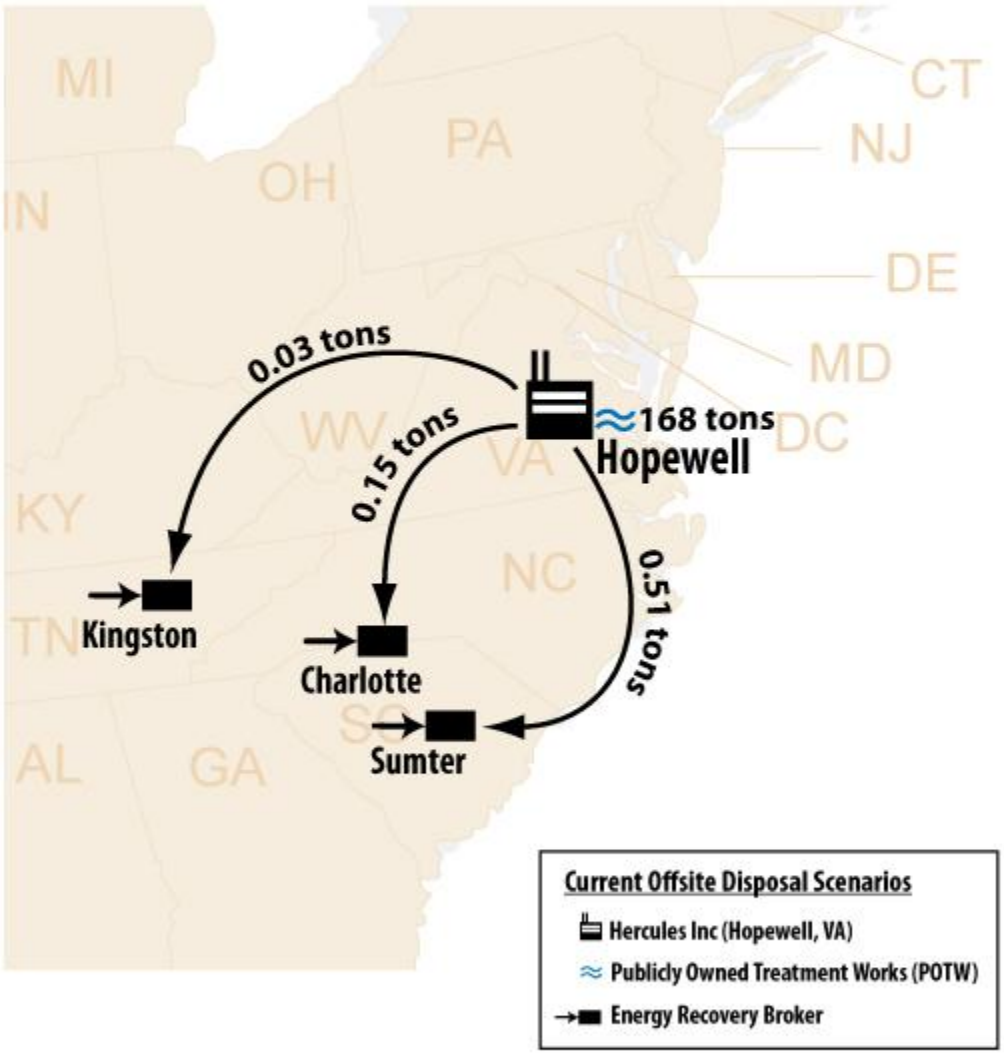
Hercules Inc (Hopewell, VA) Parent Company: Ashland Inc

Methanol Offsite Waste Reporting: (0.5 ton to Energy Recovery, 168 tons to POTW) and Transfer Routes

Methanol Onsite Waste Reporting: Recycling: 56,096 tons

(All TRI ranking sorted by waste: Basic Organic Chemicals: #1 Hercules, Hopewell: #2)

(TRI Facility ID: 23860QLNCM1111H)



Sectors

The following sections further provide the rationale for the selection of the sectors and chemicals.

Pharmaceutical Manufacturing Sector (Pharma): There are 208 submissions of the 16 chemicals accounting for 10% of the billion pounds reported for the 4 sectors. As confirmed by this sector's waste to release ratio, this industry uses, conservatively, 100 kg solvents to make just one kg of Active Pharmaceutical Ingredient.[8] It appears that these companies outsource their 'waste' management. The highest percentage of the waste reported, 35% is going to offsite energy recovery. In the current environment the vast majority of these cleanest materials end up in a cement kiln. There is both on-site recycling (29%) and off-site recycling (9%), with a combined total recycling rate of 38%. (See Table 2 below and Tables 1.1 and 1.2 in Appendix 1)

Table 2. Pharmaceutical Sector Offsite and Onsite Recycling

Pharmaceutical Sector Recycling: Chemical	Offsite Recycling	Onsite Recycling
METHANOL	1,366,677	7,704,629
CHLOROBENZENE	0	7,672,183
DICHLOROMETHANE	4,235,378	6,072,254
N-BUTYL ALCOHOL	0	4,410,529
TOLUENE	1,187,694	3,422,137
CYCLOHEXANE	0	2,511,052
ACETONITRILE	3,386,714	921,646
METHYL ISOBUTYL KETONE	170,000	0
CHLOROFORM	64,651	0
N-HEXANE	18,000	0
METHYL TERT-BUTYL ETHER	12,056	0
XYLENE (MIXED ISOMERS)	3,118	0
N,N-DIMETHYLFORMAMIDE	162	0
1,2,4-TRIMETHYLBENZENE	0	0
CHLOROMETHANE	0	0
ETHYLBENZENE	0	0

Paint & Coating Manufacturing Sector (P&C): There are 991 submissions of the 16 chemicals accounting for 9% of the billion pounds reported for the 4 sectors. As confirmed by the high number of TRI submissions to a relatively low volume, the Paint & Coatings industry has 1000's of products and must be able to turn around an order in a short period of time. As such, they keep a variety of monomers on hand.[9] These monomers are stored in the processing aid solvents so they do not react before their time.[10] The highest percentage of the waste reported, 62% is onsite recycling. Off-site recycling account for 23% of the total reported waste, and, when combined with onsite recycling, this industry has the highest percentage of total waste that is recycled: 85%. (See Table 3 below and Tables 2.1 and 2.2 in Appendix 1)

[8] Preamble footnote 21
[9] Goldschmidt, A., Streitberger, H., BASF handbook of Coating Technology, *Typical Composition of Coatings*, Figure 2.1.1, pg 28, 2003.
[10] Dan Crowl, H. Dow Professor for Chemical Process Safety, Michigan Technical University, email from 4/20 /11

Table 3. Paint & Coating Sector Offsite and Onsite Recycling

Paint & Coating Sector Recycling: Chemical	Offsite Recycling	Onsite Recycling
METHYL TERT-BUTYL ETHER	0	**25,918,934**
DICHLOROMETHANE	52,581	**14,164,696**
CHLOROMETHANE	0	**7,386,339**
N-HEXANE	15,865	**4,760,217**
CYCLOHEXANE	4,574	**4,628,118**
XYLENE (MIXED ISOMERS)	2,424,162	**2,133,971**
CHLOROBENZENE	0	**1,247,171**
CHLOROFORM	0	**146,346**
METHANOL	310,962	**4,876**
N-BUTYL ALCOHOL	514,642	**3,580**
METHYL ISOBUTYL KETONE	2,607,029	**0**
TOLUENE	2,412,244	**0**
ETHYLBENZENE	397,294	**0**
1,2,4-TRIMETHYLBENZENE	70,070	**0**
N,N-DIMETHYLFORMAMIDE	2,018	**0**
ACETONITRILE	0	**0**

Plastic & Resin Manufacturing Sector (P&R): There are 438 submissions of the 16 chemicals accounting for 17% of the billion pounds reported for the 4 sectors. Petroleum refining and synthetic organic chemical manufacturing facilities produce the raw materials used to make plastic resin. Because of integration between the industries, the development of the petrochemical industry has contributed strongly to the growth of the plastic resin industry[11]. The highest percentage of the waste reported, 41%, onsite recycling. Off-site recycling accounts for just 1% of the total reported waste. When combined with onsite recycling, this industry has a total recycling rate of 42%. (See Table 4 below and Tables 3.1 and 3.2 in Appendix 1)

Table 4. Plastic & Resin Sector Offsite and Onsite Recycling

Plastic & Coating Sector Recycling: Chemical	Offsite Recycling	Onsite Recycling
CYCLOHEXANE	0	**22,862,498**
METHANOL	6,949,415	**19,555,731**
XYLENE (MIXED ISOMERS)	1,719,228	**13,599,942**
METHYL ISOBUTYL KETONE	424,332	**7,589,887**
N-HEXANE	2,142,264	**4,343,100**
TOLUENE	193,551	**2,985,022**
ETHYLBENZENE	366,211	**2,171,612**
N,N-DIMETHYLFORMAMIDE	0	**1,863,080**
CHLOROBENZENE	954,563	**404,680**
N-BUTYL ALCOHOL	93,817	**16,514**
1,2,4-TRIMETHYLBENZENE	66,172	**2,662**
DICHLOROMETHANE	0	**0**
CHLOROMETHANE	0	**0**
ACETONITRILE	0	**0**
CHLOROFORM	0	**0**
METHYL TERT-BUTYL ETHER	0	**0**

[11] OECA sector profile notebook on Plastic and Manmade resins. EPA's OECA Sector Notebook: http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/index.html

Basic Organic Chemical Manufacturing Sector (BOM): There are 765 submissions of the 16 chemicals accounting for 63% of the billion pounds reported for the 4 sectors. The organic chemicals industry is broken down into two categories: bulk and specialty. The final product for this sector is an actual chemical so it is inherent within this industry to more effectively manage their chemicals on site. Organic Chemicals facilities, large and small volumes, report over 99% of their total production related waste being recycled on site.[12] These submissions are of high enough volumes to be able to consume all pharmaceutical solvents currently being disposed of in a cement kiln. The highest percentage of the waste reported, 60%, onsite recycling. There is no off-site recycling reported for this industry. (See Table 5 below and Tables 4.1 and 4.2 in Appendix 1)

Table 5. Basic Organic Sector Onsite Recycling

Basic Organic Chemical Manufacturing Recycling: Chemical	Onsite Recycling
METHANOL	**254,012,698**
TOLUENE	**119,123,526**
XYLENE (MIXED ISOMERS)	**14,510,678**
N-BUTYL ALCOHOL	**4,316,302**
METHYL ISOBUTYL KETONE	**3,882,200**
ETHYLBENZENE	**2,777,434**
ACETONITRILE	**2,319,728**
DICHLOROMETHANE	**1,841,486**
CHLOROBENZENE	**1,047,198**
CHLOROMETHANE	**508,485**
N,N-DIMETHYLFORMAMIDE	**436,500**
CHLOROFORM	**350,000**
CYCLOHEXANE	**167,981**
METHYL TERT-BUTYL ETHER	**101,994**
N-HEXANE	**16,251**
1,2,4-TRIMETHYLBENZENE	**14,000**

All Four Manufacturing Sectors Combined: There are 2402 submissions of the 16 chemicals accounting for the billion pounds reported for all 4 sectors. Only 15% of this total mass is going to off-site Energy Recovery (cement kiln) and off-site Thermal Treatment (incinerator). The highest percentage of the waste reported, 53% is onsite recycling. Off-site recycling account for 4% of the total reported waste. When combined with onsite recycling, all four sectors combined have a total recycling rate of 57%. On-site recycling and off-site energy recovery seem to be an 'all' of 'nothing' choice. Pharma, having the highest off-site energy recovery typically has 100% of their total production related waste going to the cement kiln. When BOM chooses to recycle, it is typically at rates of 100% of their total reported waste. (See Table 6 below and Tables 5.1 and 5.2 in Appendix)

[12] See Table 4.4, Appendix 1: Top Waste Reporters / Top Recyclers - By % of Total Waste

Table 6. All Four Sectors Combined: Offsite and Onsite Recycling

All Four Sectors Recycling: Chemical	Offsite Recycling	Onsite Recycling
METHANOL	13,367,148	295,437,754
TOLUENE	5,142,989	132,917,024
XYLENE (MIXED ISOMERS)	4,615,416	54,029,554
CYCLOHEXANE	15,077	25,545,111
METHYL ISOBUTYL KETONE	3,234,301	16,100,205
N-BUTYL ALCOHOL	635,449	9,990,516
ETHYLBENZENE	885,211	9,709,263
CHLOROBENZENE	954,563	9,124,061
DICHLOROMETHANE	5,223,964	7,918,616
N-HEXANE	2,464,066	4,505,697
ACETONITRILE	3,396,731	3,241,374
N,N-DIMETHYLFORMAMIDE	74,830	2,299,580
1,2,4-TRIMETHYLBENZENE	136,244	2,150,633
CHLOROMETHANE	340,000	508,485
CHLOROFORM	75,575	350,000
METHYL TERT-BUTYL ETHER	858,906	101,994

Chemicals

Solvents can be broadly classified into two categories: *polar* and *non-polar*, with polar being 'water-loving' and non-polar being 'water-hating'. **Non-Polar Solvents** facilitate in the addition and removal of Hydrogen (+H) and / or a methyl group (-CH3). **Polar Protic Solvents** facilitate in the addition and removal of a Hydroxide group (-OH) and / or the addition or removal of a methyl group (-CH3). **Polar Aprotic Solvents** facilitate the addition of substances other than the carbon, hydrogen and oxygen.

The Polarity Index of the solvent provides a measure of a solvent's polarity. Water has a Polarity Index of 10. Solvents with a polarity index of less than 3 are generally considered to be non-polar.[13] As a rule of thumb, polar solvents dissolve polar compounds best and non-polar solvents dissolve non-polar compounds best: "like dissolves like". Strongly polar compounds like salt dissolve only in very polar solvents like water, while strongly non-polar compounds like oil dissolve only in very non-polar organic solvents like hexane. Similarly, water and hexane (or vinegar and vegetable oil) do not mix with each other and will quickly separate into two layers even after being shaken well.

Non-Polar Solvents: Non-polar chemicals are made of carbon and hydrogen. Hexane, derived directly from crude oil, has a polarity index of 0. Reactions using these solvents must be in water and oxygen free environments as components from these materials interfere with the chemical reaction. Primary functions facilitate in the addition and removal of Hydrogen (+H) (hydrogenation / dehydrogenation) and the addition or removal of a methyl group (-CH3) (alkylation / dealkylation). These solvents comprise six chemicals on our list: hexane, (1, 2, 4) trimethylbenzene, cyclohexane, ethylbenzene, toluene and xylene.

Polar Protic Solvents: On the opposite scale of the non-polar solvents are the polar protic solvents. Water (H-O-H) is a polar protic solvent. Polar protic solvents contain carbon, hydrogen and oxygen. They differ from non-polar as their primary function is the addition and removal of a hydroxide group, (–OH). Similar to non-polar is the addition and removal of the methyl group (-CH3). Methanol is CH3-OH. Three of our chemicals on the list are polar protic: methanol, ethanol and n-butyl alcohol.

Polar Aprotic Solvents: These solvents have a broad range of polarities and are used in reactions with both polar protic and non-polar solvents. These are specialty chemicals made in batch processes several stages downstream from the starting building blocks and intermediate materials. Polar aprotics involve addition of other non-organic substances, such as ammonia / nitrogen and salt / chlorine used to make acetonitrile and chloromethane. Chemical formulations contain carbons and hydrogen, often contains oxygen, and often contains another element such as nitrogen or chlorine. There are 9 polar protic solvents: acetonitrile, chlorobenzene, chloroform, chloromethane, dichloromethane, methyl tert-butyl ether (MTBE), Methyl isobutyl ketone (MIK), n,n- dimethylformamide, and tetrahydrofuran (THF).

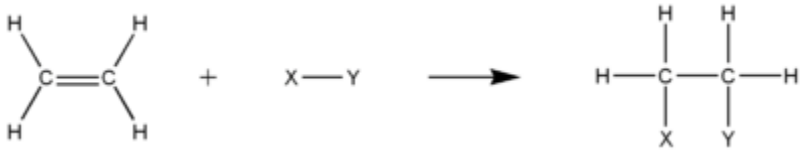
[13] See Table 7: Solvent Polarity with Health Effects

Functions

Dow Chemical describes the function of these chemicals as. . "*A special task in that they merely provide assistance during the processing of....[chemical] materials. When this task is done, they should be removed again as quickly and completely as possible."* [14] This is what allows these materials to be readily remanufactured.

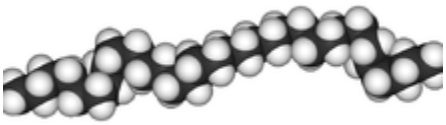
Two primary categories are manufactured using processing aid solvents in this function:
1 - Specialty Chemicals: Multi–stage batch processing reactions where a chemical is 'built' onto a backbone, and
2 – Resins: The monomer, polymers, and film forming agents that must be dissolved before they can be reacted.

Used in making another Chemical: High temperatures break or 'crack' the carbon double bond, allowing component, x---y to be reacted onto the backbone.



Functions include enabling x-y to attach with the molecule, removing x or y from the reacted molecule, and removing x or y from the solvent itself so that it may be reused. The more complex the chemical, such as a specialty chemical or a pharmaceutical, the more steps it takes to get there. Our solvents are used in each step.

Used in making a (polymer) Resin Dow Chemicals terms the types of monomers used in chemical reactions to make polymers as 'functional monomers'. A functional monomer will continue to create its own polymer chain, as aided by the solvent, by feeding in more of the functional monomer. Illustrated, again, with ethylene (C2H4) → polyethylene (C2nH4n):



The studied solvents are universally used to control the reaction conditions, i.e. – keep the chemical from reacting and controlling the reaction of the chemical. There are a relatively small

[14] Yocum and Nyquist, (ed), Functional Monomers: Their Preparation, Polymerization, and Application, 1973.

subset of solvents used for this function that correspond with a broad range of double-carbon bonded functional groups[15] and functional monomers.

Health Effects

Risk is a function of hazard and exposure,[16] and, from a hazard perspective, all of these chemicals have suspected or recognized hazardous health effects associated with their manufacture, processing, and use. (Table 1) Although EPA and industry have been working to find substitutes for the more hazardous of these solvents, or find ways to use less of them, this has not yet been achieved. In addition, some of these solvents are building block and primary intermediate chemicals, making them difficult to replace. Until lower-risk substitutes for these solvents are found, it is helpful from a health risk standpoint to minimize the volume of solvents manufactured and to limit exposure to those already manufactured.

The exclusion can help reduce exposure to these solvents in three ways. First, the exclusion would extend the useful life of existing solvents, which would reduce the health risks associated with their manufacture by slowing the rate at which they are manufactured. Second, the exclusion would reduce exposure to solvents already manufactured by reducing the fuel blending of spent solvent. [17] Re-manufacturing a spent solvent will eliminate the need for blending it with another spent solvent to satisfy the fuel-ratio requirements of incinerators and cement kilns. This, in turn, will reduce the fugitive emissions associated with unloading and loading containers of volatile solvents at fuel-blending facilities. All solvents are volatile, and virtually all spent solvents must go through the fuel-blending process prior to disposal. Third and finally, the exclusion can reduce the potential exposure from any transportation incidents, since it is likely spent solvents can be transported shorter distances for re-manufacturing purposes than they can for disposal purposes.[18]

.

[15] The theory and application of breaking a double carbon bond of a smaller molecule to make other chemicals is very broad. A series of books on chemistry edited by Patai include a double volume (1343 pgs) on "*The chemistry of double-bonded functional groups.*"
[16] Allen, D., Shonnard, D, *Green Engineering: Environmentally Conscious Design of Chemical Processes, Risk Concepts*, chapter 2, pgs 35-62, Austin, S., US EPA Editor, Published by Prentice-Hall, 2001.
[17] See 7.6 & 7.7, Appendix 3: Environmental Release and Exposure from Fuel Blending
[18] See Map 2 and Figures 6.1 – 6.8, Appendix 2, Regional Maps.

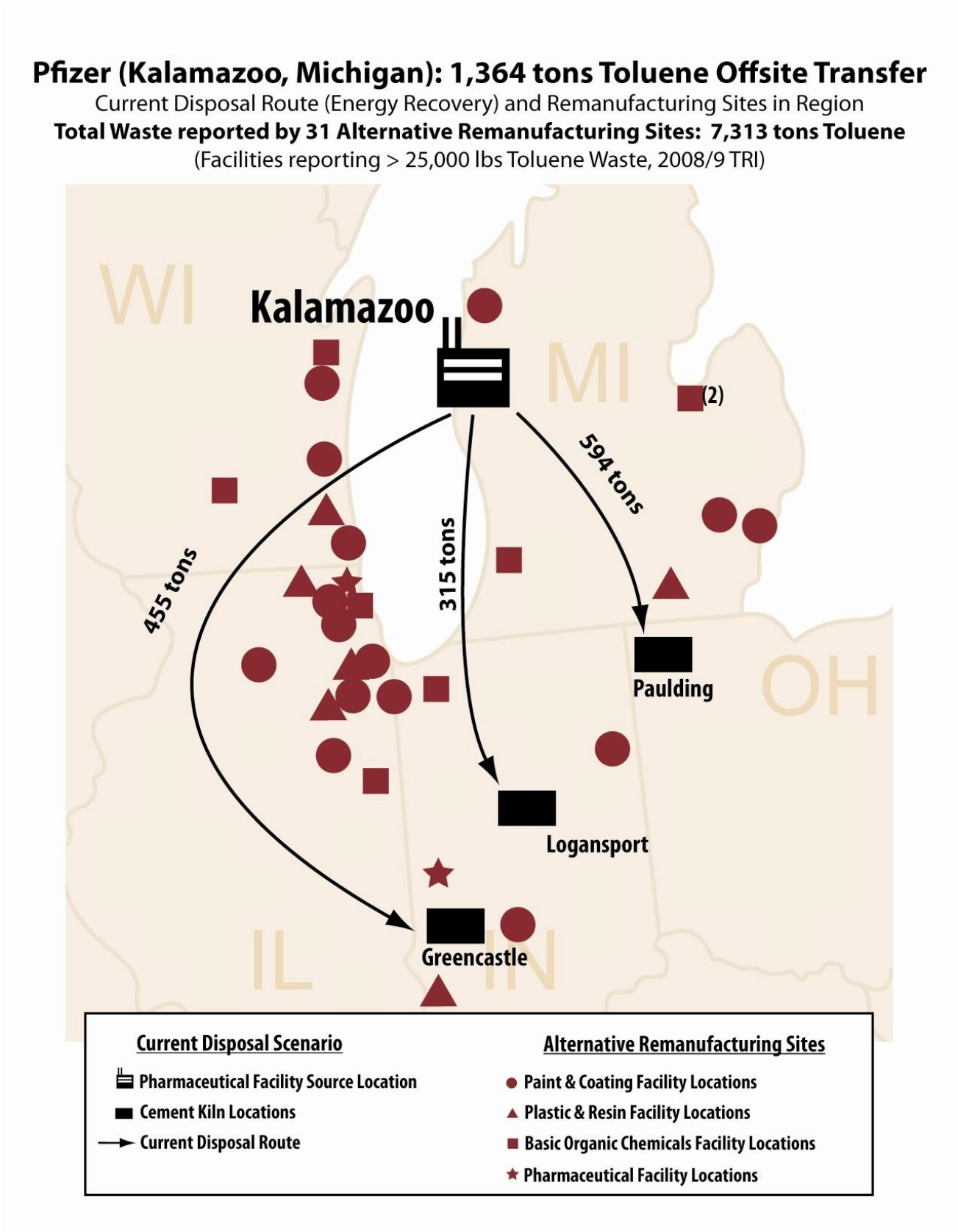
Table 7: Solvents by Polarity Index[19] with Health Effects[20]

Solvent	Chemical formula	Polarity Index	Health Hazard – Recognized or Suspected
Non-polar solvents			
Hexane	CH_3-CH_2-CH_2-CH_2-CH_2-CH_3	0.0	Sus: DT, NT, RepT, ResT
Cyclohexane	C_6H_{12}	0.2	Sus: NT
1,2,4 Trimethylbenzene	C_6H_5-CH_3-CH_3-CH_3	0.8	Sus: BT, NT, ResT
Toluene	C_6H_5-CH_3	2.4	Rec: DT Sus: BT, GT, IT, KT, NT RepT, ResT, ST
Ethylbenzene	C_6H_5-CH_2-CH_3	2.4	Rec: CT Sus: BT, DT, ET, GT, KT, RepT, ResT, ST
Xylene	CH_3CH_2-O-CH_2-CH_3	2.5	Sus: BT, DT, GT, IT, KT, NT, RepT, ResT, ST
Polar aprotic solvents			
Methyl t-Butyl Ether (MTBE)	C_5H_{12}-O	2.5	Sus: CT, GT, KT, NT, ResT, ST
Chlorobenzene	C_6H_5-Cl	2.7	Sus: BT, DT, GT, KI, MT, NT, RepT, ST
Dichloromethane	CH_2Cl_2	3.1	Rec: CT Sus: BT, ET, GT, KT, NT, RepT, ResT
Chloroform	$CHCl_3$	4.1	Rec: CT Sus: BT, T, ET, GT, KT, NT, RepT, ResT
Methyl Isobutyl Ketone	$(CH_3)_2CHCH_2C(O)CH_3$	4.0	Sus: DT, GT, KT, NT, ResT, ST
Tetrahydrofuran (THF)	/-CH_2-CH_2-O-CH_2-CH_2-\	4.0	Sus: BT, DT, ET, GT, NT, ResT
Acetonitrile (MeCN)	CH_3-C≡N	5.8	Sus: BT, DT, GT, KT, HT, RepT, ResT
Dimethylformamide (DMF)	H-C(=O)N$(CH_3)_2$	6.4	Sus: DT, GT, KT, NT, RepT, ResT, ST
Polar protic solvents			
Butyl Alcohol	CH_3-CH_2-CH_2-CH_2-OH	3.9	Sus: BT, GT, NT, ResT, ST
Methanol	CH_3-OH	5.1	Sus: DT, GT, KT, NT, ResT, ST
Ethanol	CH_3-CH_2-OH	5.2	Sus: CT, BT, DT, ET, GT, NT, RepT, ResT, ST
Water	H-O-H	10	Sus: GT, NT

Carcinogen:	CT
Cardiovascular or blood Toxicant:	BT
Developmental Toxicant:	DT
Endocrine Toxicant:	ET
Gastrointestinal or liver Toxicant:	GT
Immunotoxicant:	IT
Kidney Toxicant:	KT
Muscular Skeletal Toxicant:	MT
Neurotoxicant:	NT
Reproductive Toxicant	RepT
Respiratory Toxicant	ResT
Skin or Sense Organ Toxicant	ST

[19] A Charles M. Hansen Hansen solubility parameters: a user's handbook CRC Press, 2007, ISBN 0849372488
[20] Scorecard.org / chemical profiles / health hazards

MAP 2



APPENDIX 1: Sector Characterization: Each Sector and All 4 Sectors Combined

[21] US Sector Maps: Facilities in United States reporting Toluene > 25,000 lbs waste.

APPENDIX 2: Regional Maps:[22] Transportation and co-located Potential Remanufacturing Facilities

APPENDIX 3: New Chemicals Assessment: Release and Exposure from Toluene Fuel Blending

APPENDIX 4: Mass Balance Model and Embedded Emissions Modules

[22] Regional Maps: Facilities in Region reporting toluene > 25,000 lbs waste. Includes current offsite disposal routes and locations of potential remanufacturing facilities.

APPENDICES

Selection of Industry Sectors, Chemicals and Functions in the Remanufacturing Exclusion: Background Document in Support of the Definition of Solid Waste Rule

APPENDIX 1: Sector Characterization: Each Sector and All 4 Sectors Combined

[1] US Sector Maps: Facilities in United States reporting Toluene > 25,000 lbs waste.

APPENDIX 2: Regional Maps:[2] Transportation and co-located Potential Remanufacturing Facilities

APPENDIX 3: New Chemicals Assessment: Release and Exposure from Toluene Fuel Blending

APPENDIX 4: Mass Balance Model and Embedded Emissions Modules

[2] Regional Maps: Facilities in Region reporting toluene > 25,000 lbs waste. Includes current offsite disposal routes and locations of potential remanufacturing facilities.

Table 1.1: TRI Production Related WASTE Reporting - Offsite

Pharmaceutical Manufacturing

Pharma NAICS 325412		Waste Category (lb) (2008 TRI)						
		Off Site						
Chemical	Number of TRI Submissions	Total Underground Injection	Total Landfill	Total Other Management and Disposal	Total Recycling	Total Energy Recovery (Cement Kiln)	Total Thermal Treatment (Incinerator)	Total Other Treatment (not POTW or wastewater)
1,2,4-TRIMETHYLBENZENE	1	0	0	0	**0**	**352**	**1,487**	0
ACETONITRILE	27	0	188	12,533	**3,386,714**	**2,522,096**	**2,151,060**	49,794
CHLOROBENZENE	2	0	0	0	**0**	**49,887**	**263,287**	0
CHLOROFORM	6	0	0	453	**64,651**	**266,498**	**246,513**	0
CHLOROMETHANE	1	0	0	0	**0**	**0**	**0**	0
CYCLOHEXANE	4	0	50	0	**0**	**395,945**	**18,997**	0
DICHLOROMETHANE	35	0	276	0	**4,235,378**	**2,020,446**	**5,739,976**	908,140
ETHYLBENZENE	2	0	0	0	**0**	**39,100**	**0**	0
METHANOL	51	0	1,085	44,063	**1,366,677**	**20,959,681**	**1,030,964**	1,413,242
METHYL ISOBUTYL KETONE	3	0	0	0	**170,000**	**179,618**	**29,343**	500
METHYL TERT-BUTYL ETHER	12	0	100	4,862	**12,056**	**1,220,686**	**302,115**	33,033
N,N-DIMETHYLFORMAMIDE	15	0	56	0	**162**	**3,747,336**	**69,504**	301,891
N-BUTYL ALCOHOL	2	0	0	0	**0**	**510,000**	**758**	0
N-HEXANE	8	0	50	0	**18,000**	**180,647**	**43,184**	91,622
TOLUENE	31	0	1,592	31,176	**1,187,694**	**7,732,219**	**1,578,672**	467,040
XYLENE (MIXED ISOMERS)	8	0	10	1,258	**3,118**	**105,775**	**119,979**	0
Totals	**208**	0	3,407	94,345	**10,444,450**	**39,930,286**	**11,595,839**	3,265,262
Relative to Sum of all Categories (%)	--	0.00	0.00	0.08	**9.2**	**35.2**	**10.2**	2.9
Total All Four Sectors:					1,075,879,320	1,075,879,320	1,075,879,320	
% of Total All Four Sectors:					**1.0%**	**3.7%**	**1.1%**	

Table 1.1

Table 1.2: TRI Production Related WASTE Reporting - Offsite

Pharmaceutical Manufacturing

Pharma NAICS 325412	Waste Category (lb) (2008 TRI)						
	On Site						
Chemical	Total Underground Injection	Total Landfill	Energy Recovery	**Recycling**	Treatment	**Total**	Relative to Sum of all Chemicals (%)
1,2,4-TRIMETHYLBENZENE	0	0	0	**0**	0	1,839	0.0
ACETONITRILE	2,800	0	547	**921,646**	2,576,581	11,623,959	10.2
CHLOROBENZENE	0	0	0	**7,672,183**	97,855	8,083,212	7.1
CHLOROFORM	0	0	0	**0**	107,984	686,099	0.6
CHLOROMETHANE	0	0	0	**0**	39,870	39,870	0.0
CYCLOHEXANE	0	0	0	**2,511,052**	250,524	3,176,568	2.8
DICHLOROMETHANE	8,500	0	66,256	**6,072,254**	2,034,702	21,085,928	18.6
ETHYLBENZENE	0	0	0	**0**	0	39,100	0.0
METHANOL	13,000	5	19,736	**7,704,629**	6,265,808	38,818,890	34.2
METHYL ISOBUTYL KETONE	0	0	0	**0**	3,305	382,766	0.3
METHYL TERT-BUTYL ETHER	0	0	0	**0**	198,721	1,771,573	1.6
N,N-DIMETHYLFORMAMIDE	330,000	0	2	**0**	813,006	5,261,957	4.6
N-BUTYL ALCOHOL	0	0	0	**4,410,529**	1,080,644	6,001,931	5.3
N-HEXANE	0	0	16,988	**0**	44,180	394,671	0.3
TOLUENE	0	0	0	**3,422,137**	1,389,984	15,810,514	13.9
XYLENE (MIXED ISOMERS)	0	0	0	**0**	16,476	246,616	0.2
Off Site Total (lb) 65,333,589	354,300	5	103,529	**32,714,430**	14,919,640	**113,425,493**	
On Site Total (lb): 48,901.904	0.31	0.00	0.09	**28.8**	13.2	% of All Four Sectors	
Onsite to Offsite Ratio: 81%				1,075,879,320		1,075,879,320	
				3.0%		**10.5%**	

Table 1.2

Pharmaceutical Manufacturing Facilities
24 Facilities reporting 7,882 tons Toluene Waste
20 US Facilities: 5,566 tons and 4 PR Facilities: 2,316 tons
(Facilities Reporting > 25,000 lbs Toluene Waste, 2008 TRI)

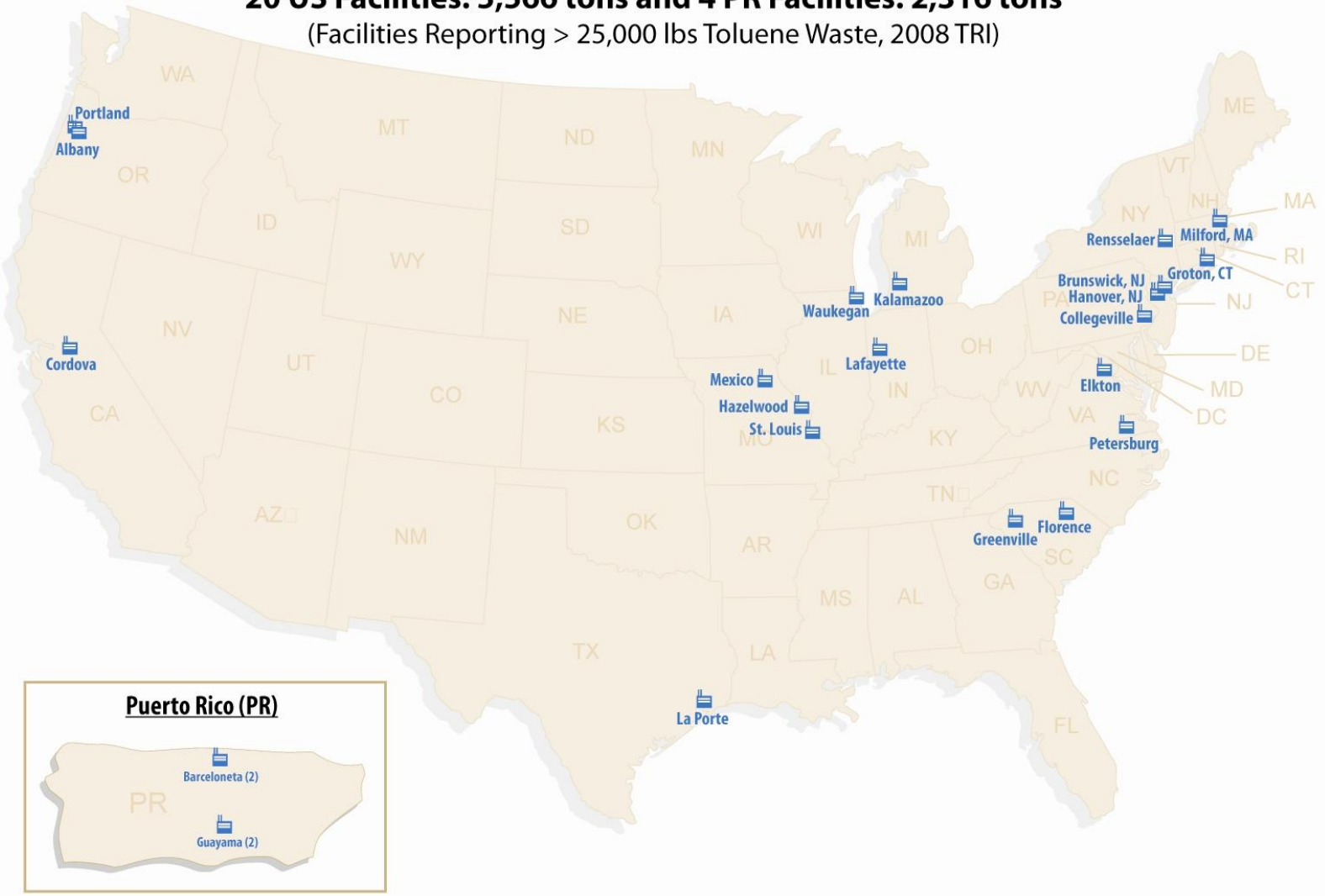


Table 2.1: TRI Production Related WASTE Reporting - Offsite

Paint & Coating Manufacturing

P&C NAICS 325510		Waste Category (lb) (2008 TRI)						
		Off Site						
Chemical	Number of TRI Submissions	Total Underground Injection	Total Landfill	Total Other Management and Disposal	Total Recycling	**Total Energy Recovery (Cement Kiln)**	**Total Thermal Treatment (Incinerator)**	Total Other Treatment (not POTW or wastewater)
1,2,4-TRIMETHYLBENZENE	115	0	2,823	3,706	70,070	**1,333,808**	**59,538**	13,892
ACETONITRILE	0	0	0	0	0	**0**	**0**	0
CHLOROBENZENE	0	0	0	0	0	**0**	**0**	0
CHLOROFORM	0	0	0	0	0	**0**	**0**	0
CHLOROMETHANE	0	0	0	0	0	**0**	**0**	0
CYCLOHEXANE	6	0	525	0	4,574	**18,454**	**405**	255
DICHLOROMETHANE	16	0	0	2,800	52,581	**25,572**	**36,263**	0
ETHYLBENZENE	122	0	1,851	5,846	397,294	**1,804,975**	**194,375**	16,003
METHANOL	66	0	248	9,596	310,962	**604,357**	**351,268**	13,275
METHYL ISOBUTYL KETONE	97	0	235	22,468	2,607,029	**1,397,625**	**265,145**	13,962
METHYL TERT-BUTYL ETHER	1	0	0	0	0	**0**	**0**	0
N,N-DIMETHYLFORMAMIDE	4	0	0	0	2,018	**5,366**	**394**	0
N-BUTYL ALCOHOL	103	0	244	57,174	514,642	**1,004,268**	**133,104**	63,816
N-HEXANE	13	0	0	0	15,865	**33,423**	**0**	151
TOLUENE	196	0	2,479	42,089	2,412,244	**4,248,576**	**568,581**	35,047
XYLENE (MIXED ISOMERS)	252	0	3,748	22,539	2,424,162	**12,057,901**	**932,332**	88,704
Totals	**991**	0	12,153	166,218	8,811,441	**22,534,325**	**2,541,405**	245,105
Relative to Sum of all Categories (%)	--	0.00	0.01	0.17	9.0	**23.1**	**2.6**	0.3
Total All Four Sectors:					1,075,879,320	1,075,879,320	1,075,879,320	
% of Total All Four Sectors:					**0.8%**	**2.1%**	**0.2%**	

Table 2.1

Table 2.2: TRI Production Related WASTE Reporting - Offsite

Paint & Coating Manufacturing

P&C NAICS 325510	Waste Category (lb) (2008 TRI)						
	On Site						
Chemical	Total Underground Injection	Total Landfill	Energy Recovery	**Recycling**	Treatment	**Total**	Relative to Sum of all Chemicals (%)
1,2,4-TRIMETHYLBENZENE	0	5	0	**2,133,971**	38,018	3,655,831	3.7
ACETONITRILE	0	0	0	**0**	0	0	0.0
CHLOROBENZENE	0	0	0	**0**	0	0	0.0
CHLOROFORM	0	0	0	**0**	0	0	0.0
CHLOROMETHANE	0	0	0	**0**	0	0	0.0
CYCLOHEXANE	0	0	0	**3,580**	0	27,793	0.0
DICHLOROMETHANE	0	0	0	**4,876**	0	122,092	0.1
ETHYLBENZENE	0	1	0	**4,760,217**	63,136	7,243,698	7.4
METHANOL	0	0	682,093	**14,164,696**	485,502	16,621,997	17.0
METHYL ISOBUTYL KETONE	0	0	0	**4,628,118**	181,591	9,116,173	9.3
METHYL TERT-BUTYL ETHER	0	0	0	**0**	0	0	0.0
N,N-DIMETHYLFORMAMIDE	0	0	0	**0**	0	7,778	0.0
N-BUTYL ALCOHOL	0	0	7,309	**1,247,171**	167,179	3,194,907	3.3
N-HEXANE	0	0	0	**146,346**	899	196,684	0.2
TOLUENE	0	0	0	**7,386,339**	688,212	15,383,567	15.7
XYLENE (MIXED ISOMERS)	0	0	0	**25,918,934**	714,742	42,163,062	43.1
Off Site Total (lb) 34,310,647	0	6	689,402	**60,394,248**	2,339,279	97,733,582	
On Site Total (lb): 63,422,935	0.00	0.00	0.71	**61.8**	2.4	% of All Four Sectors	
Onsite to Offsite Ratio: 81%				1,075,879,320		1,075,879,320	
				5.6%		**9.1%**	

Table 2.2

Paint & Coating Manufacturing Facilities
65 Facilities reporting 7,410 tons Toluene Waste

(Facilities Reporting > 25,000 lbs Toluene Waste, 2008 TRI)

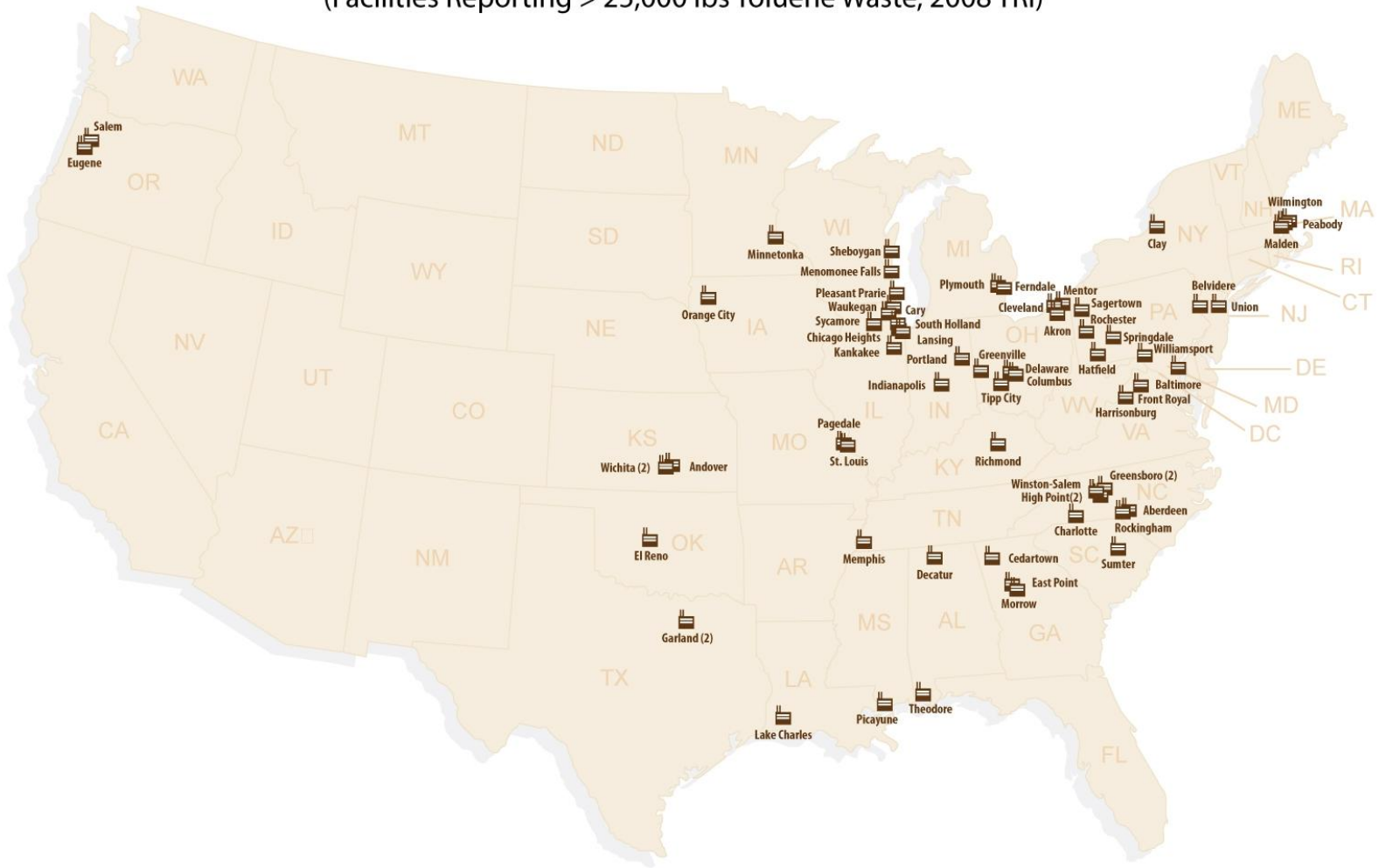


Table 3.1: TRI Production Related WASTE Reporting - Offsite

Plastic & Resin Manufacturing

P & R NAICS 325211		Waste Category (lb) (2008 TRI)						
		Off Site						
Chemical	**Number of TRI Submissions**	Total Underground Injection	Total Landfill	Total Other Management and Disposal	Total Recycling	**Total Energy Recovery (Cement Kiln)**	**Total Thermal Treatment (Incinerator)**	Total Other Treatment (not POTW or wastewater)
1,2,4-TRIMETHYLBENZENE	29	3,700	658	1,020	66,172	**80,194**	**2,856**	6,471
ACETONITRILE	0	0	0	0	0	**0**	**0**	0
CHLOROBENZENE	4	0	1,778	0	954,563	**9,980**	**125,353**	42,299
CHLOROFORM	7	0	1	0	0	**0**	**6,634**	0
CHLOROMETHANE	5	0	4	0	0	**52**	**38,800**	0
CYCLOHEXANE	12	0	594	0	0	**134,697**	**137,719**	2,114
DICHLOROMETHANE	10	0	0	765	0	**55,971**	**27,466**	0
ETHYLBENZENE	54	7,227	553	1,461	366,211	**1,239,529**	**261,407**	9,430
METHANOL	103	2,766,167	25,698	46,386	6,949,415	**5,836,953**	**1,551,445**	43,547
METHYL ISOBUTYL KETONE	20	0	0	0	424,332	**384,521**	**827,116**	2,395
METHYL TERT-BUTYL ETHER	2	0	0	0	0	**0**	**0**	0
N,N-DIMETHYLFORMAMIDE	7	0	0	0	0	**233,042**	**15,735**	0
N-BUTYL ALCOHOL	33	17,200	189	70,156	93,817	**375,477**	**75,907**	9,774
N-HEXANE	20	0	1	1,408	2,142,264	**2,859,306**	**355,981**	114,414
TOLUENE	73	11,377	14,251	18,364	193,551	**4,715,645**	**839,554**	12,225
XYLENE (MIXED ISOMERS)	59	45,082	1,083	2,046	1,719,228	**3,218,715**	**138,334**	54,544
Totals	**438**	2,850,753	44,810	141,606	12,909,553	**19,144,082**	**4,404,307**	297,213
Relative to Sum of all Categories (%)	--	1.56	0.02	0.08	7.1	**10.5**	**2.4**	0.2
Total All Four Sectors:					1,075,879,320	1,075,879,320	1,075,879,320	
% of Total All Four Sectors:					**1.2%**	**1.8%**	**0.4%**	

Table 3.1

Table 3.2: TRI Production Related WASTE Reporting - Offsite

Plastic & Resin Manufacturing

P & R NAICS 325211	Waste Category (lb) (2008 TRI)						
	On Site						
Chemical	Total Underground Injection	Total Landfill	Energy Recovery	**Recycling**	Treatment	**Total**	Relative to Sum of all Chemicals (%)
1,2,4-TRIMETHYLBENZENE	0	30	1	**2,662**	127,985	291,749	0.2
ACETONITRILE	0	0	0	**0**	0	0	0.0
CHLOROBENZENE	0	0	142,870	**404,680**	22,026	1,703,549	0.9
CHLOROFORM	0	0	568,587	**0**	2,765,405	3,340,627	1.8
CHLOROMETHANE	0	0	1,396,519	**0**	2,740,181	4,175,556	2.3
CYCLOHEXANE	8,600	0	0	**22,862,498**	1,670,915	24,817,137	13.6
DICHLOROMETHANE	0	0	0	**0**	433,497	517,699	0.3
ETHYLBENZENE	0	32	1,244,570	**2,171,612**	484,401	5,786,433	3.2
METHANOL	378,818	1,370,036	5,947,159	**19,555,731**	17,476,402	61,947,757	33.8
METHYL ISOBUTYL KETONE	0	0	872,064	**7,589,887**	1,067,378	11,167,693	6.1
METHYL TERT-BUTYL ETHER	0	0	0	**0**	0	0	0.0
N,N-DIMETHYLFORMAMIDE	0	0	3,330,856	**1,863,080**	50,185	5,492,898	3.0
N-BUTYL ALCOHOL	490,519	0	183,408	**16,514**	696,724	2,029,685	1.1
N-HEXANE	0	1,060	5,243,892	**4,343,100**	8,195,184	23,256,610	12.7
TOLUENE	0	23	3,551,694	**2,985,022**	4,142,420	16,484,126	9.0
XYLENE (MIXED ISOMERS)	0	52	1,065,003	**13,599,942**	2,187,602	22,031,631	12.0
Off Site Total (lb) 37,792,324	877,937	1,371,233	23,546,623	**75,394,728**	42,060,305	183,043,150	
On Site Total (lb): 143,250,825	0.48	0.75	12.86	**41.2**	23.0	% of All Four Sectors	
Onsite to Offsite Ratio: 81%				1,075,879,320		1,075,879,320	
				7.0%		**17.0%**	

Table 3.2

Plastic & Resin Manufacturing Facilities
38 Facilities reporting 7,366 tons Toluene Waste

(Facilities Reporting > 25,000 lbs Toluene Waste, 2009 TRI)

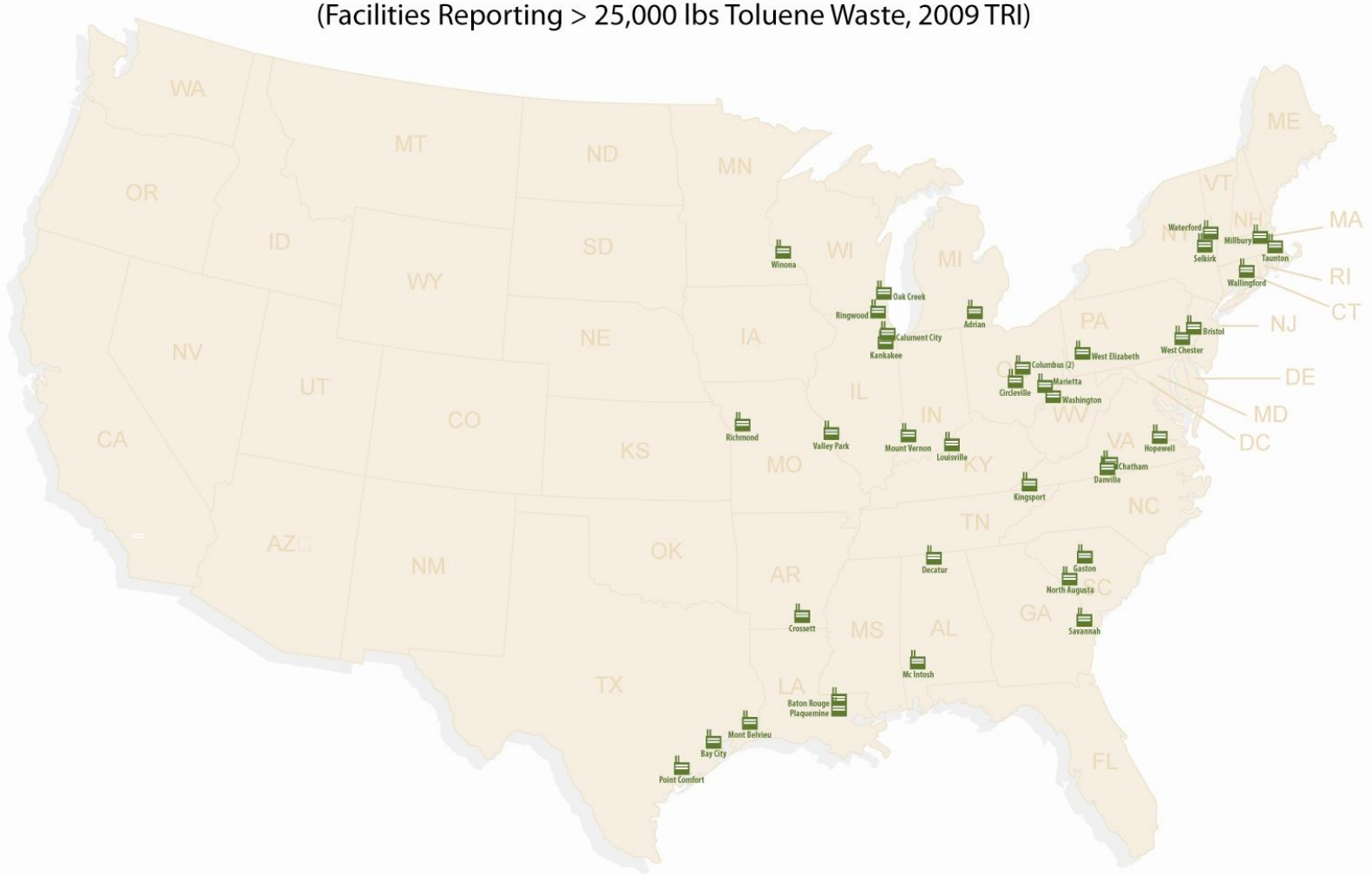


Table 4.1: TRI Production Related WASTE Reporting - Offsite

Basic Organic Chemical Manufacturing

BOM NAICS 325199		Waste Category (lb) (2008 TRI)						
		Off Site						
Chemical	**Number of TRI Submissions**	Total Underground Injection	Total Landfill	Total Other Management and Disposal	**Total Energy Recovery (Cement Kiln)**	**Total Thermal Treatment (Incinerator)**	Total Incineration	Total Other Treatment (not POTW or wastewater)
1,2,4-TRIMETHYLBENZENE	25	231	839	0	**2**	**23,254**	34,730	463
ACETONITRILE	26	0	157	5	**10,017**	**725,207**	331,609	3,118
CHLOROBENZENE	20	0	0	16	**0**	**38,417**	1,085,928	89
CHLOROFORM	20	0	0	250	**10,924**	**86,129**	154,456	0
CHLOROMETHANE	20	0	0	0	**340,000**	**1,402**	151,341	0
CYCLOHEXANE	36	60,579	15	83,066	**10,503**	**949,539**	485,688	0
DICHLOROMETHANE	24	0	67	29	**936,005**	**337,086**	193,868	3,693
ETHYLBENZENE	45	122	12,612	36	**121,706**	**1,537,739**	61,909	2,646
METHANOL	203	196,440	29,206	41,237	**4,740,094**	**18,837,345**	4,367,696	34,615
METHYL ISOBUTYL KETONE	26	0	165	5	**32,940**	**332,951**	30,331	43
METHYL TERT-BUTYL ETHER	17	8,148	15	15,406	**846,850**	**172,196**	18,039	0
N,N-DIMETHYLFORMAMIDE	15	0	658	0	**72,650**	**64,978**	6,157	16,065
N-BUTYL ALCOHOL	65	0	153	0	**26,990**	**1,019,569**	58,909	46
N-HEXANE	55	266	6	56,575	**287,937**	**2,772,254**	828,000	27,210
TOLUENE	99	2,086	62,966	40,403	**1,349,500**	**9,426,573**	4,600,405	21,529
XYLENE (MIXED ISOMERS)	69	139	21,590	187,870	**468,908**	**7,051,002**	354,768	5,523
Totals	**765**	268,011	128,449	424,898	**9,255,026**	**43,375,641**	12,763,834	115,040
Relative to Sum of all Categories (%)	--	0.04	0.02	0.06	**1.4**	**6.4**	1.9	0.0
Total All Four Sectors:					1,075,879,320	1,075,879,320		
% of Total All Four Sectors:					**0.9%**	**4.0%**		

Table 4.1

Table 4.2: TRI Production Related WASTE Reporting - Offsite

Basic Organic Chemical Manufacturing

BOM NAICS 325199	Waste Category (lb) (2008 TRI)						
	On Site						
Chemical	Total Underground Injection	Total Landfill	Energy Recovery	**Recycling**	Treatment	**Total**	Relative to Sum of all Chemicals (%)
1,2,4-TRIMETHYLBENZENE	0	2	52,918	**14,000**	85,126	211,565	0.0
ACETONITRILE	11,584,152	11	9,163,656	**2,319,728**	3,345,711	27,483,371	4.0
CHLOROBENZENE	25	12	598,199	**1,047,198**	1,150,884	3,920,768	0.6
CHLOROFORM	0	250	68,000	**350,000**	9,786,348	10,456,357	1.5
CHLOROMETHANE	0	0	3,600,851	**508,485**	3,747,316	8,349,395	1.2
CYCLOHEXANE	24,950	4,873	5,318,388	**167,981**	11,516,056	18,621,638	2.7
DICHLOROMETHANE	0	2,579	261	**1,841,486**	2,905,163	6,220,237	0.9
ETHYLBENZENE	0	4,102	2,067,830	**2,777,434**	1,999,578	8,585,714	1.3
METHANOL	4,840,685	14,899	31,275,885	**254,012,698**	64,483,532	382,874,332	56.2
METHYL ISOBUTYL KETONE	4,900	0	672	**3,882,200**	602,330	4,886,537	0.7
METHYL TERT-BUTYL ETHER	0	0	44,067	**101,994**	245,810	1,452,525	0.2
N,N-DIMETHYLFORMAMIDE	0	11,363	0	**436,500**	597,173	1,205,544	0.2
N-BUTYL ALCOHOL	0	5,029	1,920,577	**4,316,302**	12,724,577	20,072,152	2.9
N-HEXANE	0	544	2,669,198	**16,251**	8,116,571	14,774,812	2.2
TOLUENE	0	25,757	4,997,086	**119,123,526**	8,942,758	148,592,589	21.8
XYLENE (MIXED ISOMERS)	0	9,981	631,866	**14,510,678**	727,234	23,969,559	3.5
Off Site Total (lb) 66,330,899	16,454,712	79,402	62,409,454	**405,426,461**	130,976,167	**681,677,095**	
On Site Total (lb): 615,346,196	2.41	0.01	9.16	**59.5**	19.2	All Four Sectors:	
Onsite to Offsite Ratio: 81%				1,075,879,320		1,075,879,320	
				37.7%		**63.4%**	

Table 4.2

Basic Organic Chemicals Manufacturing Facilities
62 Facilities reporting 56,306 tons Toluene Waste
Top 10 Facilities: 50,363 tons Bottom 52 Facilities: 5,947 tons
(Facilities Reporting > 25,000 lbs Toluene Waste, 2009 TRI)

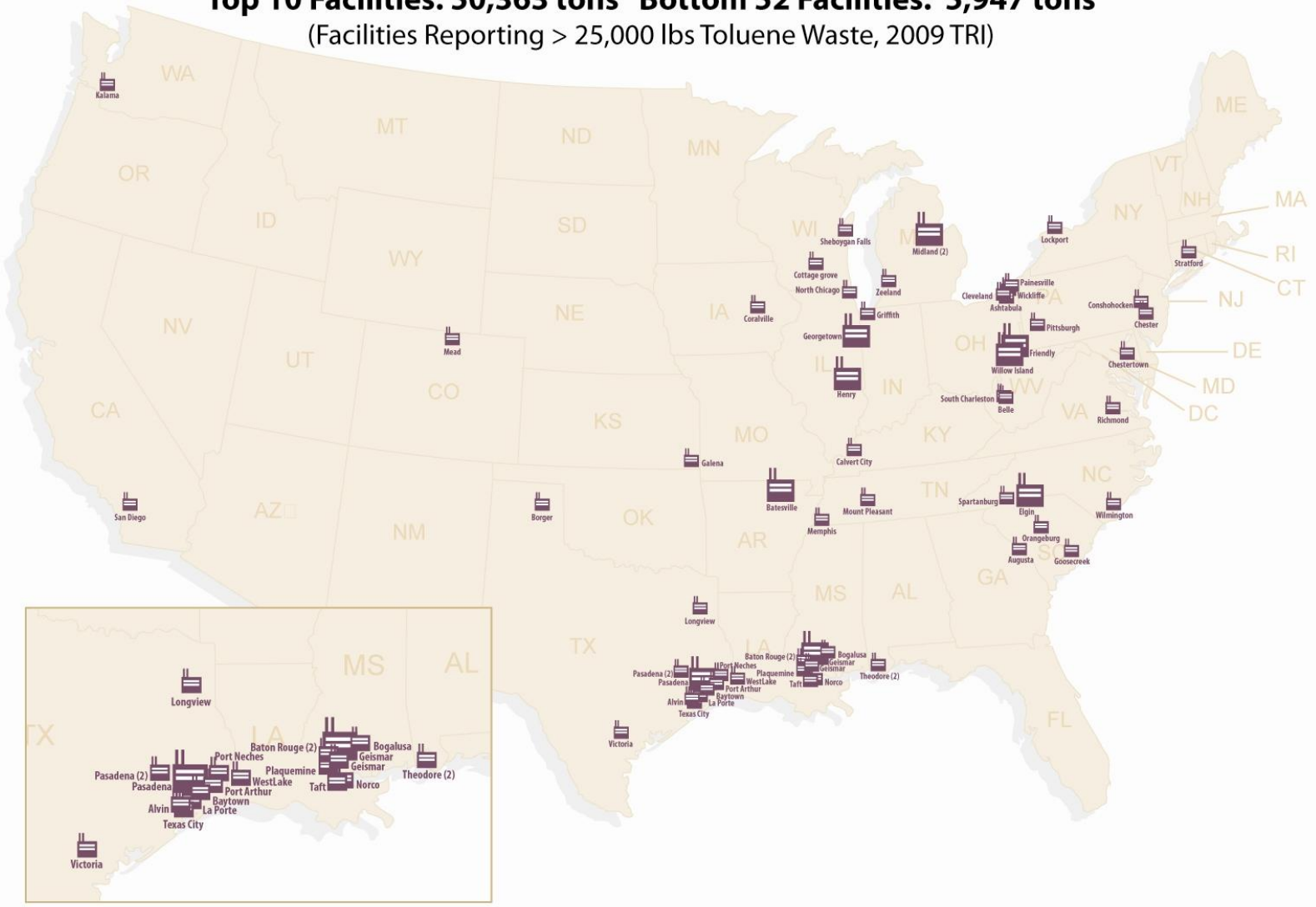


Table 4.4: Top Waste Reporters / Top Recyclers By % of Total Waste **Table 4.4**

Facility Name	Chemical	Releases (lbs)	Waste (lbs)	Waste Divided by Release	Recycled ONSITE (lbs)	%of total waste
U.S. BIOFUELS INC.	**METHANOL**	2,250	6,654,105	2,957	**6,653,105**	99.98%
EMERALD PERFORMANCE MATERIALS LLC	**TOLUENE**	27,775	43,643,511	1,571	**43,600,537**	99.90%
WEYLCHEM US INC	**METHANOL**	120	2,561,945	21,350	**2,558,844**	99.88%
VERTELLUS PERFORMANCE MATERIALS INC	**N-BUTYL ALCOHOL**	539	2,350,563	4,361	**2,347,673**	99.88%
NOVA BIOFUELS SENECA LLC	**METHANOL**	4,485	3,504,760	781	**3,500,086**	99.87%
WEYLCHEM US INC	**METHYL ISOBUTYL KETONE**	11	1,673,973	152,179	**1,671,734**	99.87%
TPC GROUP LLC	**METHANOL**	8,787	25,610,952	2,915	**25,511,849**	99.61%
PRODUCT DEVELOPMENT CENTER	**METHANOL**	109,699	23,032,931	210	**22,901,905**	99.43%
DYNACHEM INC	**TOLUENE**	8,128	1,712,051	211	**1,702,034**	99.41%
ALDRICH CHEMICAL CO INC	**METHANOL**	9,554	1,699,660	178	**1,689,356**	99.39%
HERCULES INC	**METHANOL**	362,314	112,891,979	312	**112,191,940**	99.38%
EMERALD PERFORMANCE MATERIALS LLC	**DICHLOROMETHANE**	14,741	1,633,491	111	**1,618,616**	99.09%
EMERALD PERFORMANCE MATERIALS LLC	**ACETONITRILE**	27,580	2,232,316	81	**2,202,853**	98.68%
CYTEC INDUSTRIES INC	**TOLUENE**	28,800	12,726,000	442	**12,557,000**	98.67%
DIXIE CHEMICAL CO INC	**XYLENE (MIXED ISOMERS)**	492	10,868,088	22,090	**10,700,000**	98.45%
SI GROUP INC	**ETHYLBENZENE**	968	1,320,120	1,364	**1,290,000**	97.72%
LUBRIZOL CORP BAYPORT FACILITY	**METHANOL**	4,427	3,250,502	734	**3,148,503**	96.86%
CYTEC INDUSTRIES INC	**METHYL ISOBUTYL KETONE**	28,920	2,418,820	84	**2,337,000**	96.62%
DIXIE CHEMICAL CO INC	**TOLUENE**	990	2,268,782	2,292	**2,170,000**	95.65%
CIBA CORP	**METHANOL**	2,244	1,440,177	642	**1,376,375**	95.57%
DOW CORNING CORP MIDLAND PLANT	**TOLUENE**	16,296	28,647,278	1,758	**26,915,699**	93.96%
EMERALD KALAMA CHEMICAL LLC	**METHANOL**	1,076	2,068,875	1,923	**1,927,710**	93.18%
WEYLCHEM US INC	**XYLENE (MIXED ISOMERS)**	141	4,805,335	34,080	**4,336,368**	90.24%
AMFINE CHEMICAL CORP	**XYLENE (MIXED ISOMERS)**	1,940	1,781,915	919	**1,603,915**	90.01%
CYTEC INDUSTRIES INC	**METHANOL**	26,830	10,491,630	391	**9,411,000**	89.70%
WEYLCHEM US INC	**TOLUENE**	5,592	3,079,684	551	**2,489,361**	80.83%
TICONA POLYMERS INC	**METHANOL**	132,872	18,898,366	142	**14,822,000**	78.43%
DIXIE CHEMICAL CO INC	**METHANOL**	8,309	2,103,410	253	**1,000,000**	47.54%
SYMRISE INC	**METHANOL**	13,887	1,770,138	127	**467,187**	26.39%
DOW CHEMICAL CO	**CHLOROMETHANE**	11,800	1,271,800	108	**150,000**	11.79%
CHEM FLUER/FIRMENICH INC	**METHANOL**	2,654	1,889,543	712	**65,997**	3.49%
DOW CORNING CORP MIDLAND PLANT	**XYLENE (MIXED ISOMERS)**	8,565	2,940,605	343	**50,724**	1.72%
BASF CORP Freeport TX	**METHANOL**	12,470	22,738,108	1,823	**0**	0.00%
TOTALS:		**885,256**	**365,981,413**	**413**	**324,969,371**	**88.79%**

Table 4.5: Top Waste Reporters / Top Recyclers **By Total Waste** **Table 4.5**

Facility Name	Chemical	Releases (lbs)	Waste (lbs)	Waste Divided by Release	Recycled ONSITE (lbs)	%of total waste
HERCULES INC, Hopewell	**METHANOL**	362,314	112,891,979	312	**112,191,940**	99.38%
EMERALD PERFORMANCE, Henry	**TOLUENE**	27,775	43,643,511	1,571	**43,600,537**	99.90%
DOW CORNING CORP MIDLAND PLANT	**TOLUENE**	16,296	28,647,278	1,758	**26,915,699**	93.96%
TPC GROUP LLC	**METHANOL**	8,787	25,610,952	2,915	**25,511,849**	99.61%
PRODUCT DEVELOPMENT CENTER	**METHANOL**	109,699	23,032,931	210	**22,901,905**	99.43%
BASF CORP	**METHANOL**	12,470	22,738,108	1,823	**0**	0.00%
TICONA POLYMERS INC	**METHANOL**	132,872	18,898,366	142	**14,822,000**	78.43%
CYTEC INDUSTRIES INC	**TOLUENE**	28,800	12,726,000	442	**12,557,000**	98.67%
DIXIE CHEMICAL CO INC	**XYLENE (MIXED ISOMERS)**	492	10,868,088	22,090	**10,700,000**	98.45%
CYTEC INDUSTRIES INC	**METHANOL**	26,830	10,491,630	391	**9,411,000**	89.70%
U.S. BIOFUELS INC.	**METHANOL**	2,250	6,654,105	2,957	**6,653,105**	99.98%
WEYLCHEM US INC	**XYLENE (MIXED ISOMERS)**	141	4,805,335	34,080	**4,336,368**	90.24%
NOVA BIOFUELS SENECA LLC	**METHANOL**	4,485	3,504,760	781	**3,500,086**	99.87%
LUBRIZOL CORP BAYPORT FACILITY	**METHANOL**	4,427	3,250,502	734	**3,148,503**	96.86%
WEYLCHEM US INC	**TOLUENE**	5,592	3,079,684	551	**2,489,361**	80.83%
DOW CORNING CORP MIDLAND PLANT	**XYLENE (MIXED ISOMERS)**	8,565	2,940,605	343	**50,724**	1.72%
WEYLCHEM US INC	**METHANOL**	120	2,561,945	21,350	**2,558,844**	99.88%
CYTEC INDUSTRIES INC	**METHYL ISOBUTYL KETONE**	28,920	2,418,820	84	**2,337,000**	96.62%
VERTELLUS PERFORMANCE MATERIALS INC	**N-BUTYL ALCOHOL**	539	2,350,563	4,361	**2,347,673**	99.88%
DIXIE CHEMICAL CO INC	**TOLUENE**	990	2,268,782	2,292	**2,170,000**	95.65%
EMERALD PERFORMANCE MATERIALS LLC	**ACETONITRILE**	27,580	2,232,316	81	**2,202,853**	98.68%
DIXIE CHEMICAL CO INC	**METHANOL**	8,309	2,103,410	253	**1,000,000**	47.54%
EMERALD KALAMA CHEMICAL LLC	**METHANOL**	1,076	2,068,875	1,923	**1,927,710**	93.18%
CHEM FLUER/FIRMENICH INC	**METHANOL**	2,654	1,889,543	712	**65,997**	3.49%
AMFINE CHEMICAL CORP	**XYLENE (MIXED ISOMERS)**	1,940	1,781,915	919	**1,603,915**	90.01%
SYMRISE INC	**METHANOL**	13,887	1,770,138	127	**467,187**	26.39%
DYNACHEM INC	**TOLUENE**	8,128	1,712,051	211	**1,702,034**	99.41%
ALDRICH CHEMICAL CO INC	**METHANOL**	9,554	1,699,660	178	**1,689,356**	99.39%
WEYLCHEM US INC	**METHYL ISOBUTYL KETONE**	11	1,673,973	152,179	**1,671,734**	99.87%
EMERALD PERFORMANCE MATERIALS LLC	**DICHLOROMETHANE**	14,741	1,633,491	111	**1,618,616**	99.09%
CIBA CORP	**METHANOL**	2,244	1,440,177	642	**1,376,375**	95.57%
SI GROUP INC	**ETHYLBENZENE**	968	1,320,120	1,364	**1,290,000**	97.72%
DOW CHEMICAL CO	**CHLOROMETHANE**	11,800	1,271,800	108	**150,000**	11.79%
TOTALS:		**885,256**	**365,981,413**	**413**	**324,969,371**	**88.79%**

Table 4.6: Top Waste Reporters / Top Recyclers **By Chemical** **Table 4.6**

Facility Name	Chemical	Releases (lbs)	Waste (lbs)	Waste Divided by Release	Recycled ONSITE (lbs)	%of total waste
EMERALD PERFORMANCE MATERIALS LLC	**ACETONITRILE**	27,580	2,232,316	81	**2,202,853**	98.68%
DOW CHEMICAL CO	**CHLOROMETHANE**	11,800	1,271,800	108	**150,000**	11.79%
EMERALD PERFORMANCE MATERIALS LLC	**DICHLOROMETHANE**	14,741	1,633,491	111	**1,618,616**	99.09%
SI GROUP INC	**ETHYLBENZENE**	968	1,320,120	1,364	**1,290,000**	97.72%
HERCULES INC	**METHANOL**	362,314	112,891,979	312	**112,191,940**	99.38%
TPC GROUP LLC	**METHANOL**	8,787	25,610,952	2,915	**25,511,849**	99.61%
PRODUCT DEVELOPMENT CENTER	**METHANOL**	109,699	23,032,931	210	**22,901,905**	99.43%
BASF CORP Freeport TX	**METHANOL**	12,470	22,738,108	1,823	**0**	0.00%
TICONA POLYMERS INC	**METHANOL**	132,872	18,898,366	142	**14,822,000**	78.43%
CYTEC INDUSTRIES INC	**METHANOL**	26,830	10,491,630	391	**9,411,000**	89.70%
U.S. BIOFUELS INC.	**METHANOL**	2,250	6,654,105	2,957	**6,653,105**	99.98%
NOVA BIOFUELS SENECA LLC	**METHANOL**	4,485	3,504,760	781	**3,500,086**	99.87%
LUBRIZOL CORP BAYPORT FACILITY	**METHANOL**	4,427	3,250,502	734	**3,148,503**	96.86%
WEYLCHEM US INC	**METHANOL**	120	2,561,945	21,350	**2,558,844**	99.88%
DIXIE CHEMICAL CO INC	**METHANOL**	8,309	2,103,410	253	**1,000,000**	47.54%
EMERALD KALAMA CHEMICAL LLC	**METHANOL**	1,076	2,068,875	1,923	**1,927,710**	93.18%
CHEM FLUER/FIRMENICH INC	**METHANOL**	2,654	1,889,543	712	**65,997**	3.49%
SYMRISE INC	**METHANOL**	13,887	1,770,138	127	**467,187**	26.39%
ALDRICH CHEMICAL CO INC	**METHANOL**	9,554	1,699,660	178	**1,689,356**	99.39%
CIBA CORP	**METHANOL**	2,244	1,440,177	642	**1,376,375**	95.57%
CYTEC INDUSTRIES INC	**METHYL ISOBUTYL KETONE**	28,920	2,418,820	84	**2,337,000**	96.62%
WEYLCHEM US INC	**METHYL ISOBUTYL KETONE**	11	1,673,973	152,179	**1,671,734**	99.87%
VERTELLUS PERFORMANCE MATERIALS INC	**N-BUTYL ALCOHOL**	539	2,350,563	4,361	**2,347,673**	99.88%
EMERALD PERFORMANCE MATERIALS LLC	**TOLUENE**	27,775	43,643,511	1,571	**43,600,537**	99.90%
DOW CORNING CORP MIDLAND PLANT	**TOLUENE**	16,296	28,647,278	1,758	**26,915,699**	93.96%
CYTEC INDUSTRIES INC	**TOLUENE**	28,800	12,726,000	442	**12,557,000**	98.67%
WEYLCHEM US INC	**TOLUENE**	5,592	3,079,684	551	**2,489,361**	80.83%
DIXIE CHEMICAL CO INC	**TOLUENE**	990	2,268,782	2,292	**2,170,000**	95.65%
DYNACHEM INC	**TOLUENE**	8,128	1,712,051	211	**1,702,034**	99.41%
DIXIE CHEMICAL CO INC	**XYLENE (MIXED ISOMERS)**	492	10,868,088	22,090	**10,700,000**	98.45%
WEYLCHEM US INC	**XYLENE (MIXED ISOMERS)**	141	4,805,335	34,080	**4,336,368**	90.24%
DOW CORNING CORP MIDLAND PLANT	**XYLENE (MIXED ISOMERS)**	8,565	2,940,605	343	**50,724**	1.72%
AMFINE CHEMICAL CORP	**XYLENE (MIXED ISOMERS)**	1,940	1,781,915	919	**1,603,915**	90.01%
TOTALS:		**885,256**	**365,981,413**	**413**	**324,969,371**	**88.79%**

Emerald Performance Materials (Henry, IL) (Predecessor B.F. Goodrich)

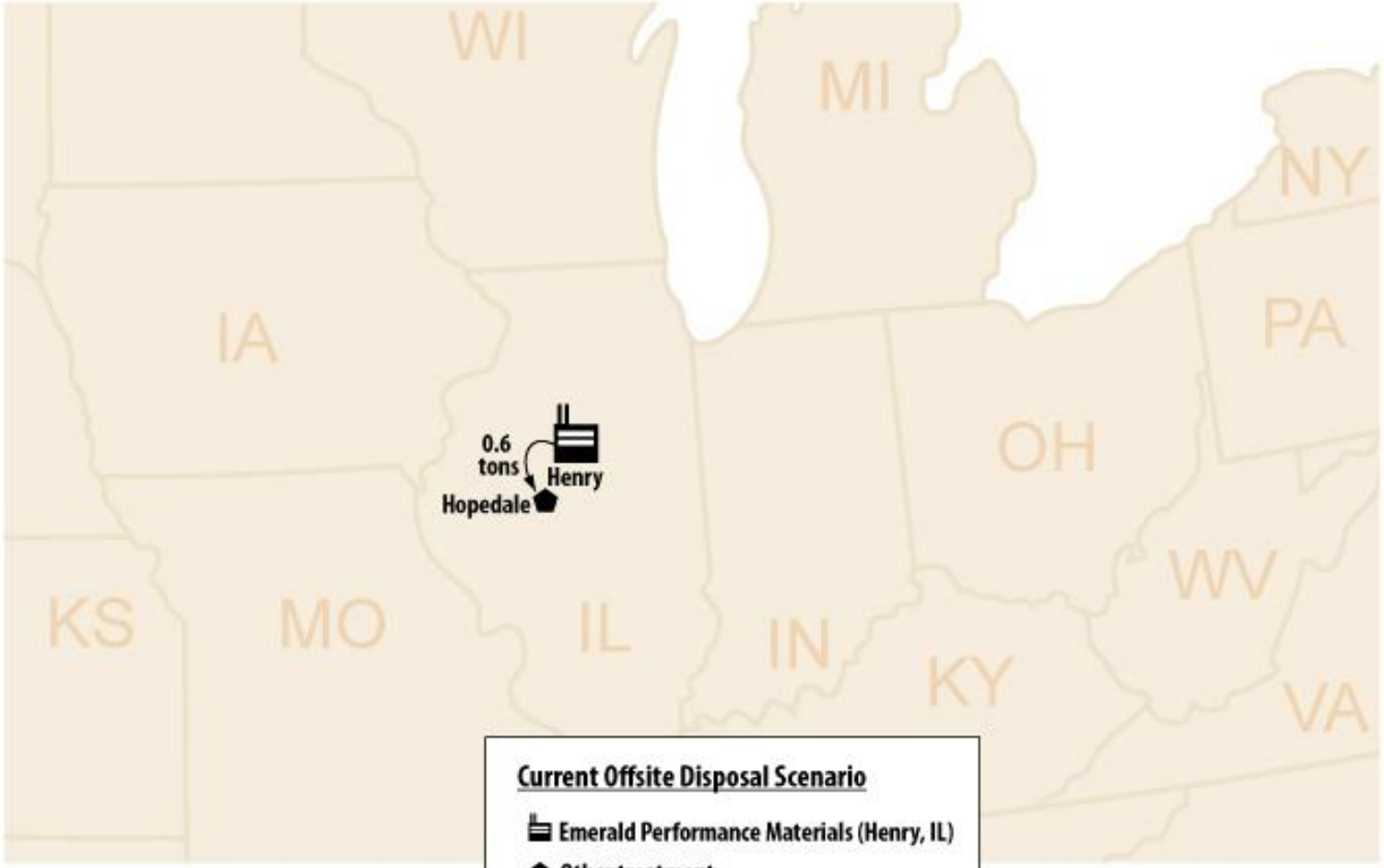
*Product: Good-rite 3114. Invented and patented 1972, produced exclusively at Emerald since the late 1970's**

Toluene Offsite Waste Reporting: (0.6 ton Toluene to 'other') and Transfer Route

Toluene Onsite Waste Reporting: Recycling: 21,500 tons, Treatment: 8 tons

*Annual Purchase: 6,000 gallons Toluene***

(Facility reporting > 25,000 lbs Toluene Waste, 2009 TRI)



* http://www.emeraldmaterials.com/epm/polyadd/micms_doc_admin.display?p_customer=FISPOLYADD&p_name=GR.3114.BROCHURE.PDF

** Discussion with listed technical contact, TRIFID: 61537BFGDRRR1BQ.

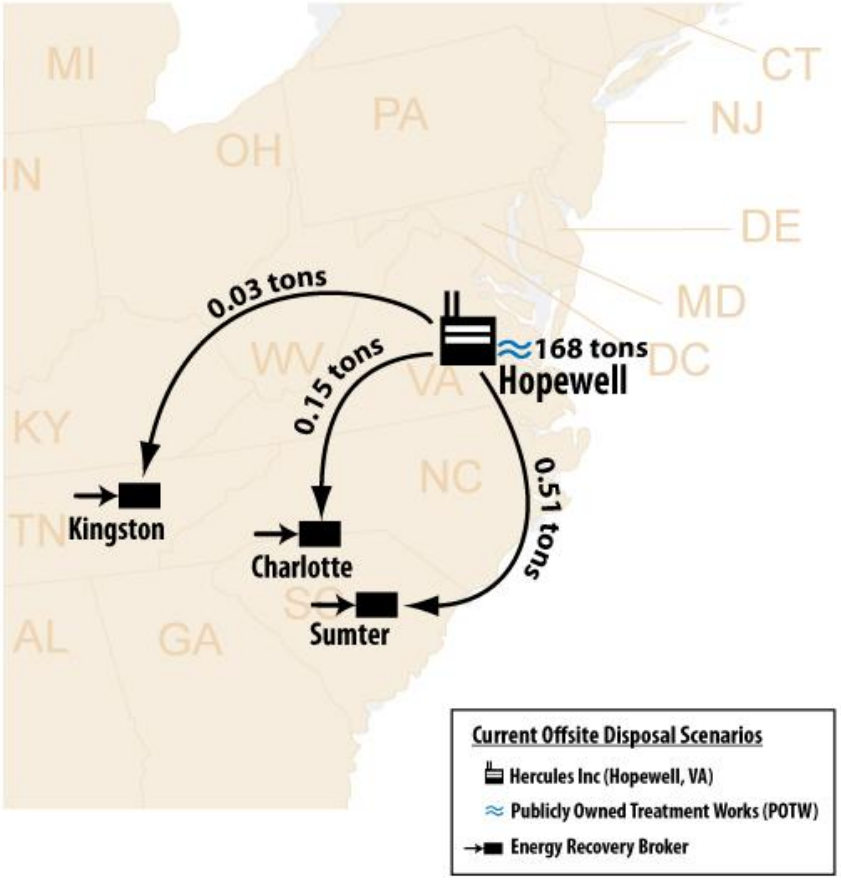
Hercules Inc (Hopewell, VA) Parent Company: Ashland Inc

Methanol Offsite Waste Reporting: (0.5 ton to Energy Recovery, 168 tons to POTW) and Transfer Routes

Methanol Onsite Waste Reporting: Recycling: 56,096 tons

(All TRI ranking sorted by waste: Basic Organic Chemicals: #1 Hercules, Hopewell: #2)

(TRI Facility ID: 23860QLNCM1111H)



Appendix 5.1: All Four Sectors Combined

OFFSITE: Hazardous Waste Treatment and Disposal — 2009TRI Rank by Release: 6th
Rank by Waste: 14th (430,593,831 lbs) — **Number of TRI submissions: 1673**

ONSITE: (*In order of Rank by Waste):* Links below to RTKNet[3].

All Other Basic Organic Chemical Manufacturing — 2009 Rank by Release: 7th
Rank by Waste: 1st (2,507,659,932 lbs) — **Number of TRI submissions: 3230**

Plastics Material and Resin Manufacturing — 2009 Rank by Release: 15th
Rank by Waste: 3rd (1,182,555,225 lbs) — **Number of TRI Submissions: 2472**

Pharmaceutical Preparation Manufacturing — 2009 Rank by Release: 75th
Rank by Waste: low (127,941,376 lbs) — Number of TRI Submissions: 376

Paint and Coating Manufacturing — 2009 Rank by Release: 61st
Rank by Waste: low (88,569,586 lbs) — Number of TRI Submissions: 2187

Pharmaceutical Sector Profile Notebook: [4]
http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/pharma.pdf

Plastic & Resin Sector Profile Notebook: http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/resfibsn.pdf

Basic Organic Chemical Manufacturing Sector Profile Notebook: http://www.cluin.org/download/toolkit/organic.pdf

Paint & Coatings: No sector notebook, but all paints and coatings start with a film-forming agent, which is a resin.

[3] The Right-to-Know Network provides free access to numerous databases and resources on the environment and provided facility information not readily available in the TRI database. www.RTKNET.org

[4] EPA's OECA Sector Notebook series is a unique set of profiles containing information for specific industries and governments. Unlike other resource materials, which are organized by air, water and land pollutants, the Notebooks provide a holistic approach by integrating processes, applicable regulations and other relevant environment information. http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/index.html

Table 5.2: TRI Production Related WASTE Reporting - Offsite

All Four Sectors

NAICS:

325412(Pharma); 325510(P & C); 325199 (BOM); 325211(P & R)		Waste Category (lb) (2008 TRI)						
		Off Site						
Chemical	Number of TRI Submissions	Total Underground Injection	Total Landfill	Total Other Management and Disposal	Total Recycling	Total Energy Recovery (Cement Kiln)	Total Thermal Treatment (Incinerator)	Total Other Treatment (not POTW or wastewater)
1,2,4-TRIMETHYLBENZENE	170	3,931	4,320	4,726	136,244	1,437,608	98,611	20,826
ACETONITRILE	53	0	345	12,538	3,396,731	3,247,303	2,482,669	52,912
CHLOROBENZENE	26	0	1,778	16	954,563	98,284	1,474,568	42,388
CHLOROFORM	33	0	1	703	75,575	352,627	407,603	0
CHLOROMETHANE	26	0	4	0	340,000	1,454	190,141	0
CYCLOHEXANE	58	60,579	1,184	83,066	15,077	1,498,635	642,809	2,369
DICHLOROMETHANE	85	0	343	3,594	5,223,964	2,439,075	5,997,573	911,833
ETHYLBENZENE	223	7,349	15,016	7,343	885,211	4,621,343	517,691	28,079
METHANOL	423	2,962,607	56,236	141,282	13,367,148	46,238,336	7,301,373	1,504,679
METHYL ISOBUTYL KETONE	146	0	400	22,473	3,234,301	2,294,715	1,151,935	16,900
METHYL TERT-BUTYL ETHER	32	8,148	115	20,268	858,906	1,392,882	320,154	33,033
N,N-DIMETHYLFORMAMIDE	41	0	714	0	74,830	4,050,722	91,790	317,956
N-BUTYL ALCOHOL	203	17,200	586	127,330	635,449	2,909,314	268,678	73,636
N-HEXANE	96	266	57	57,983	2,464,066	5,845,630	1,227,165	233,397
TOLUENE	399	13,463	81,288	132,032	5,142,989	26,123,013	7,587,212	535,841
XYLENE (MIXED ISOMERS)	388	45,221	26,431	213,713	4,615,416	22,433,393	1,545,413	148,771
Totals	**2402**	3,118,764	188,819	827,067	41,420,470	124,984,334	31,305,385	3,922,620
Relative to Sum of all Categories (%)	--	0.3	0.0	0.1	3.8	11.6	2.9	0.4
Total All Four Sectors:					1,075,879,320	1,075,879,320	1,075,879,320	
% of Total All Four Sectors:					3.8%	11.6%	2.9%	

Table 5.2

Table 5.3: TRI Production Related WASTE Reporting - Offsite

All Four Sectors

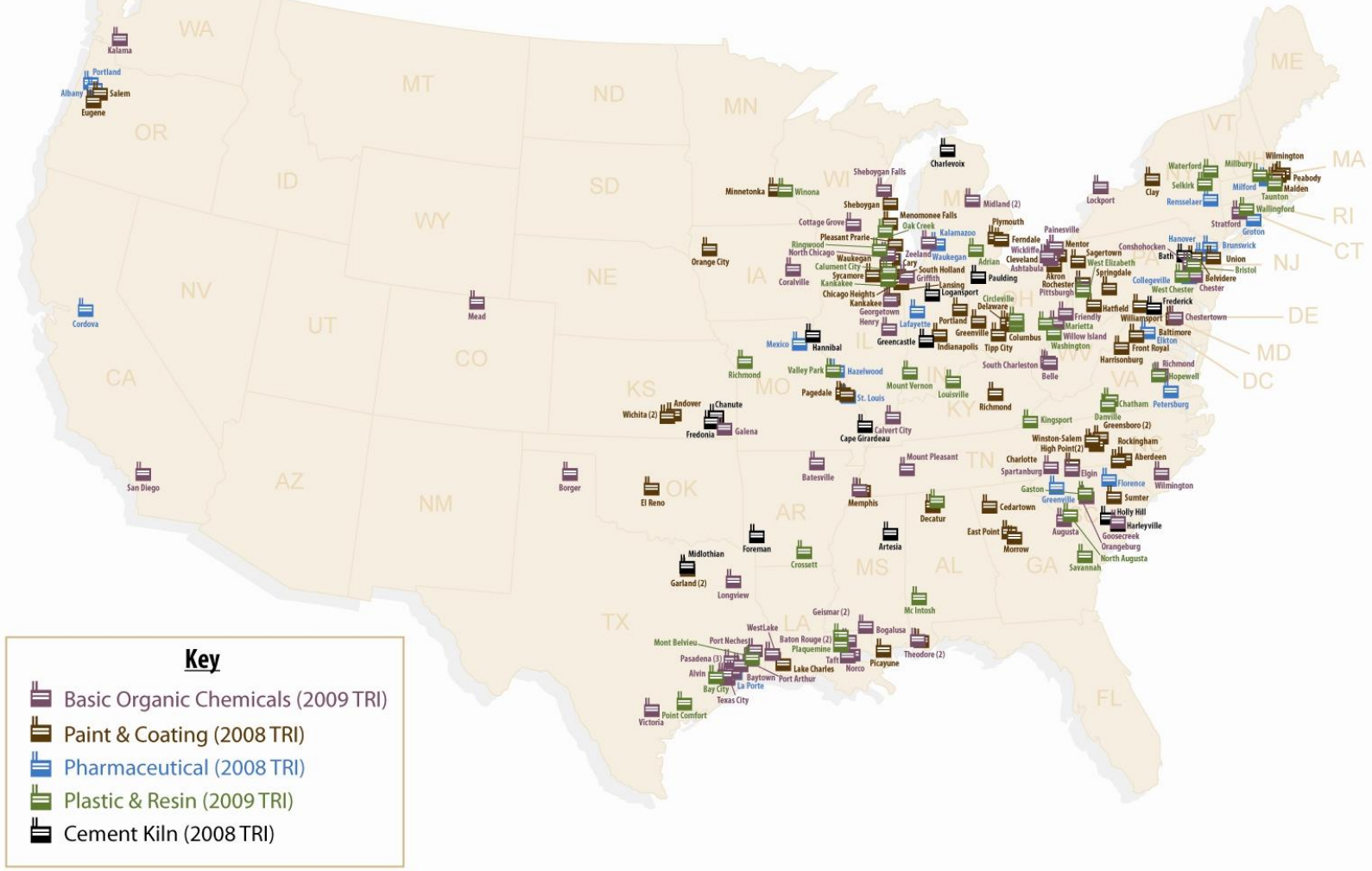
NAICS:

325412(Pharma); 325510(P & C); 325199 (BOM); 325211(P & R)	Waste Category (lb) (2008 TRI) On Site						
Chemical	Total Underground Injection	Total Landfill	Energy Recovery	Recycling	Treatment	**Total**	Relative to Sum of all Chemicals (%)
1,2,4-TRIMETHYLBENZENE	0	37	52,919	2,150,633	251,129	4,160,984	0.4
ACETONITRILE	11,586,952	11	9,164,203	3,241,374	5,922,292	39,107,330	3.6
CHLOROBENZENE	25	12	741,069	9,124,061	1,270,765	13,707,529	1.3
CHLOROFORM	0	250	636,587	350,000	12,659,737	14,483,083	1.3
CHLOROMETHANE	0	0	4,997,370	508,485	6,527,367	12,564,821	1.2
CYCLOHEXANE	33,550	4,873	5,318,388	25,545,111	13,437,495	46,643,136	4.3
DICHLOROMETHANE	8,500	2,579	66,517	7,918,616	5,373,362	27,945,956	2.6
ETHYLBENZENE	0	4,135	3,312,400	9,709,263	2,547,115	21,654,945	2.0
METHANOL	5,232,503	1,384,940	37,924,873	295,437,754	88,711,244	500,262,975	46.5
METHYL ISOBUTYL KETONE	4,900	0	872,736	16,100,205	1,854,604	25,553,169	2.4
METHYL TERT-BUTYL ETHER	0	0	44,067	101,994	444,531	3,224,098	0.3
N,N-DIMETHYLFORMAMIDE	330,000	11,363	3,330,858	2,299,580	1,460,364	11,968,177	1.1
N-BUTYL ALCOHOL	490,519	5,029	2,111,294	9,990,516	14,669,124	31,298,675	2.9
N-HEXANE	0	1,604	7,930,078	4,505,697	16,356,834	38,622,777	3.6
TOLUENE	0	25,780	8,548,780	132,917,024	15,163,374	196,270,796	18.2
XYLENE (MIXED ISOMERS)	0	10,033	1,696,869	54,029,554	3,646,054	88,410,868	8.2
Off Site Total (lb) 235,448,248	17,686,949	1,450,646	86,749,008	573,929,867	190,295,391	1,075,879,320	
On Site Total (lb): 870,111,861	1.6	0.1	8.1	53.3	17.7	% of All Four Sectors	
Onsite to Offsite Ratio: 81%				1,075,879,320		1,075,879,320	
				53.3%		**1216.9%**	

Table 5.3

Basic Organic Chemicals, Paint & Coating, Pharmaceutical, Plastic & Resin, and Cement Kiln Facility Locations

(Facilities Reporting > 25,000 lbs Toluene Waste, 2008/9 TRI)



APPENDIX 2: Regional Maps:[5] Transportation and co-located Potential Remanufacturing Facilities

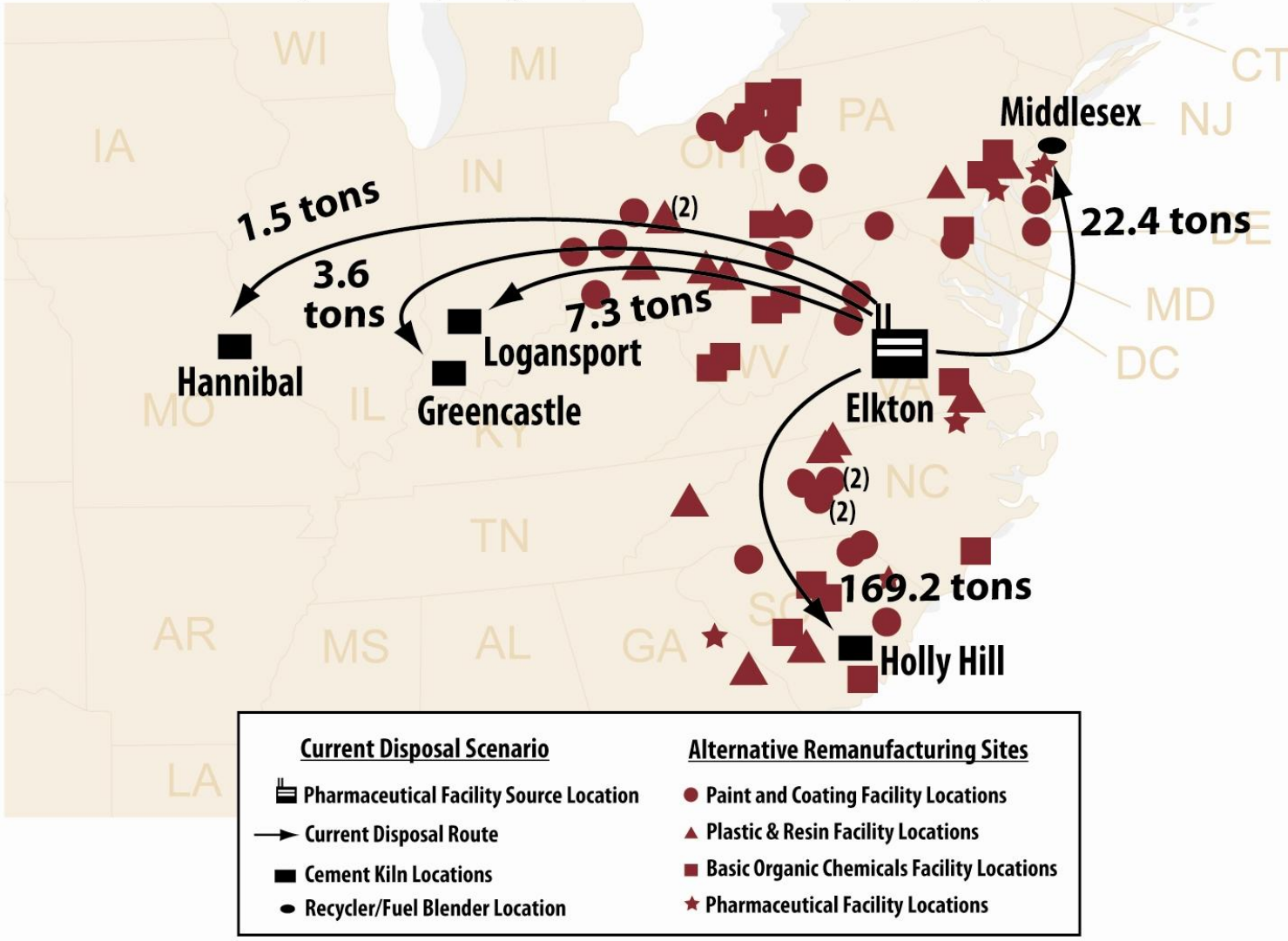
[5] Regional Maps: Facilities in Region reporting toluene > 25,000 lbs waste. Includes current offsite disposal routes and locations of potential remanufacturing facilities.

Merck (Elkton, Virginia): 199 tons Toluene Offsite Transfer

Current Disposal Route (Energy Recovery) and Remanufacturing Sites in Region

Total Waste reported by 65 Alternative Remanufacturing Sites: 17,639 tons Toluene

(Facilities reporting > 25,000 lbs Toluene Waste, 2008/9 TRI)

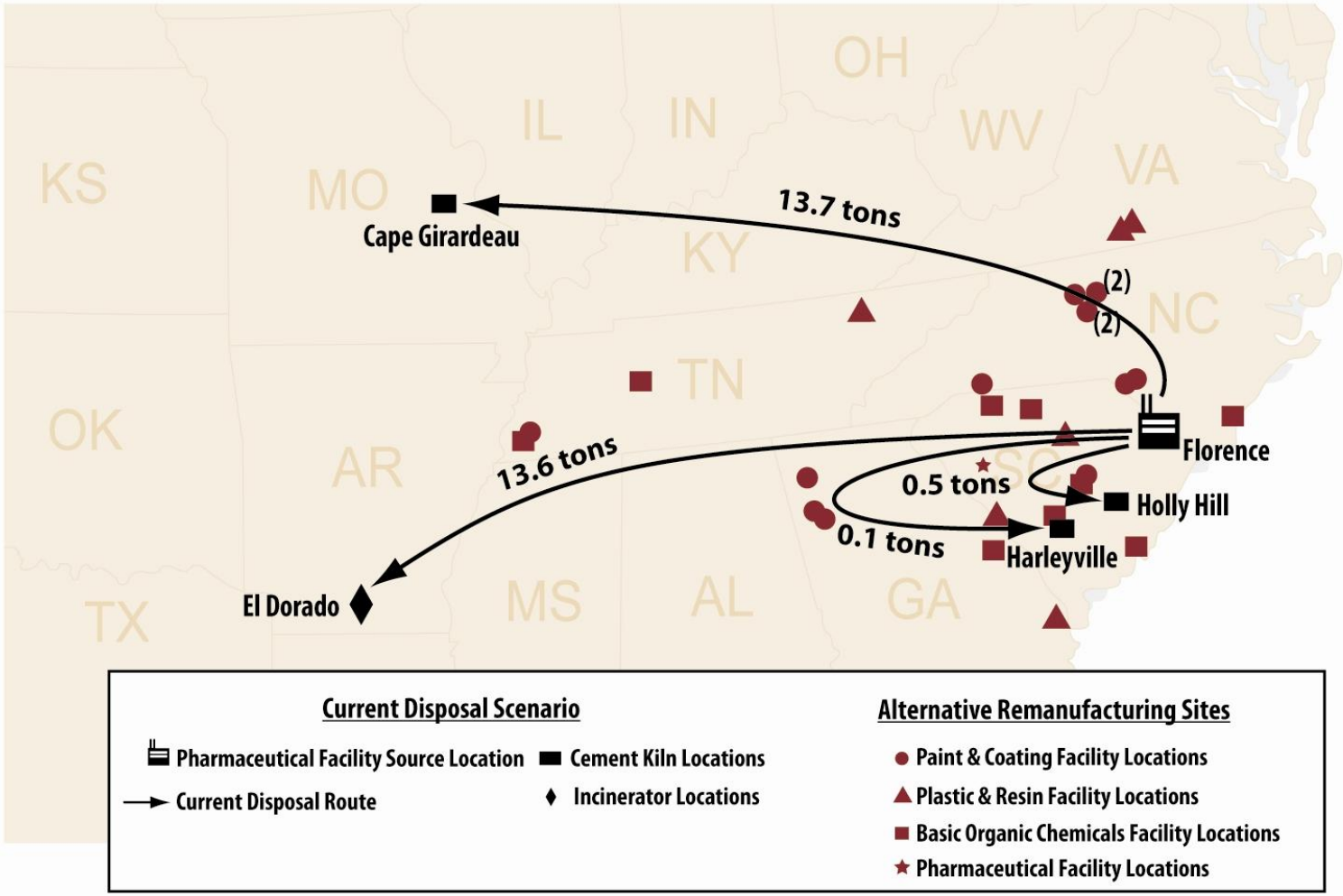


Roche (Florence, South Carolina): 28 tons Toluene Offsite Transfer

Current Disposal Route (Energy Recovery & Incineration) and Remanufacturing Sites in Region

Total Waste reported by 29 Alternative Remanufacturing Sites: 5,334 tons Toluene

(Facilities reporting > 25,000 lbs Toluene Waste, 2008/9 TRI)

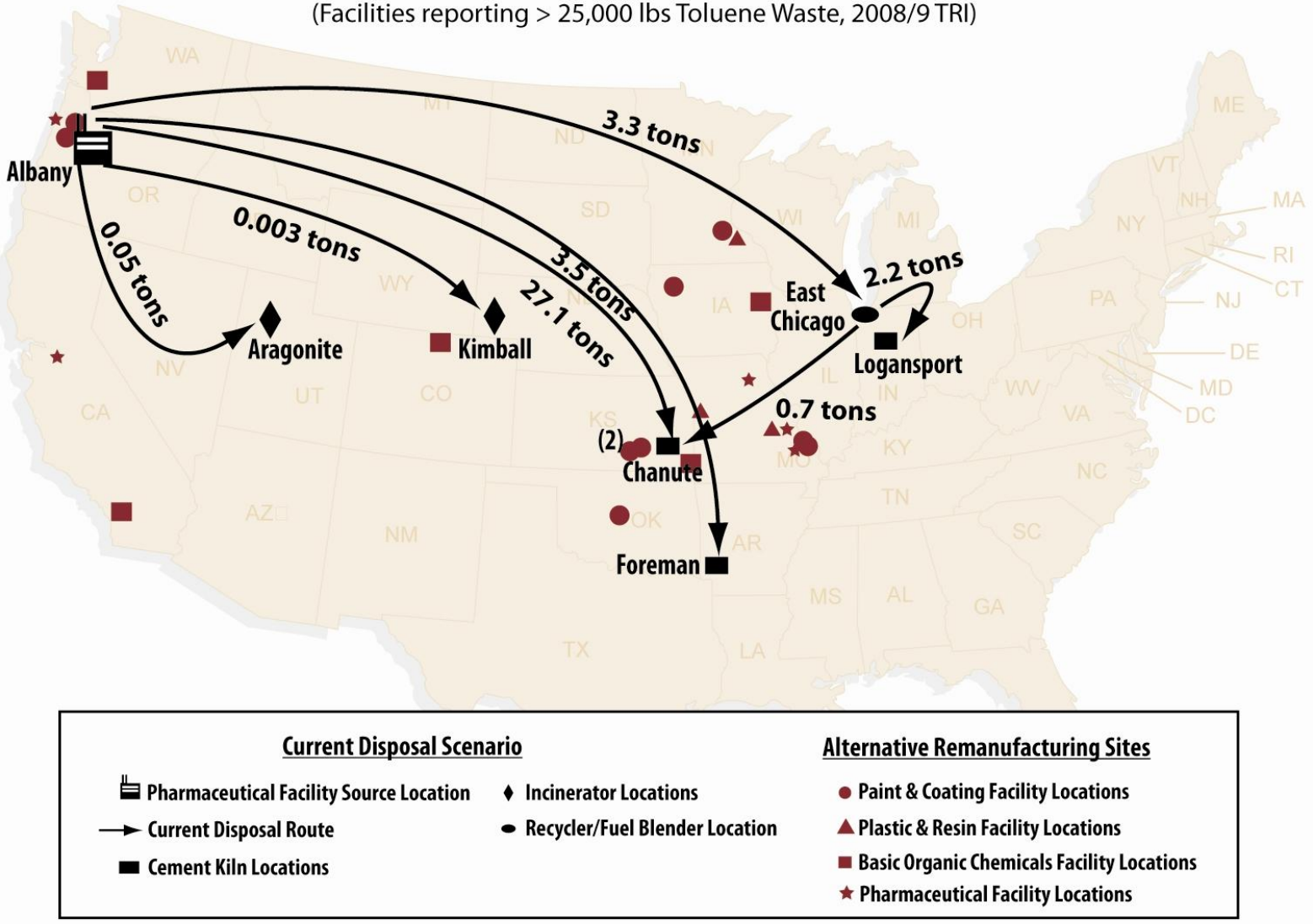


Synthetech (Albany, Oregon): 33 tons Toluene Offsite Transfer

Current Disposal Route (Energy Recovery & Incineration) and Remanufacturing Sites in Region

Total Waste reported by 24 Alternative Remanufacturing Sites: 4,581 tons Toluene

(Facilities reporting > 25,000 lbs Toluene Waste, 2008/9 TRI)



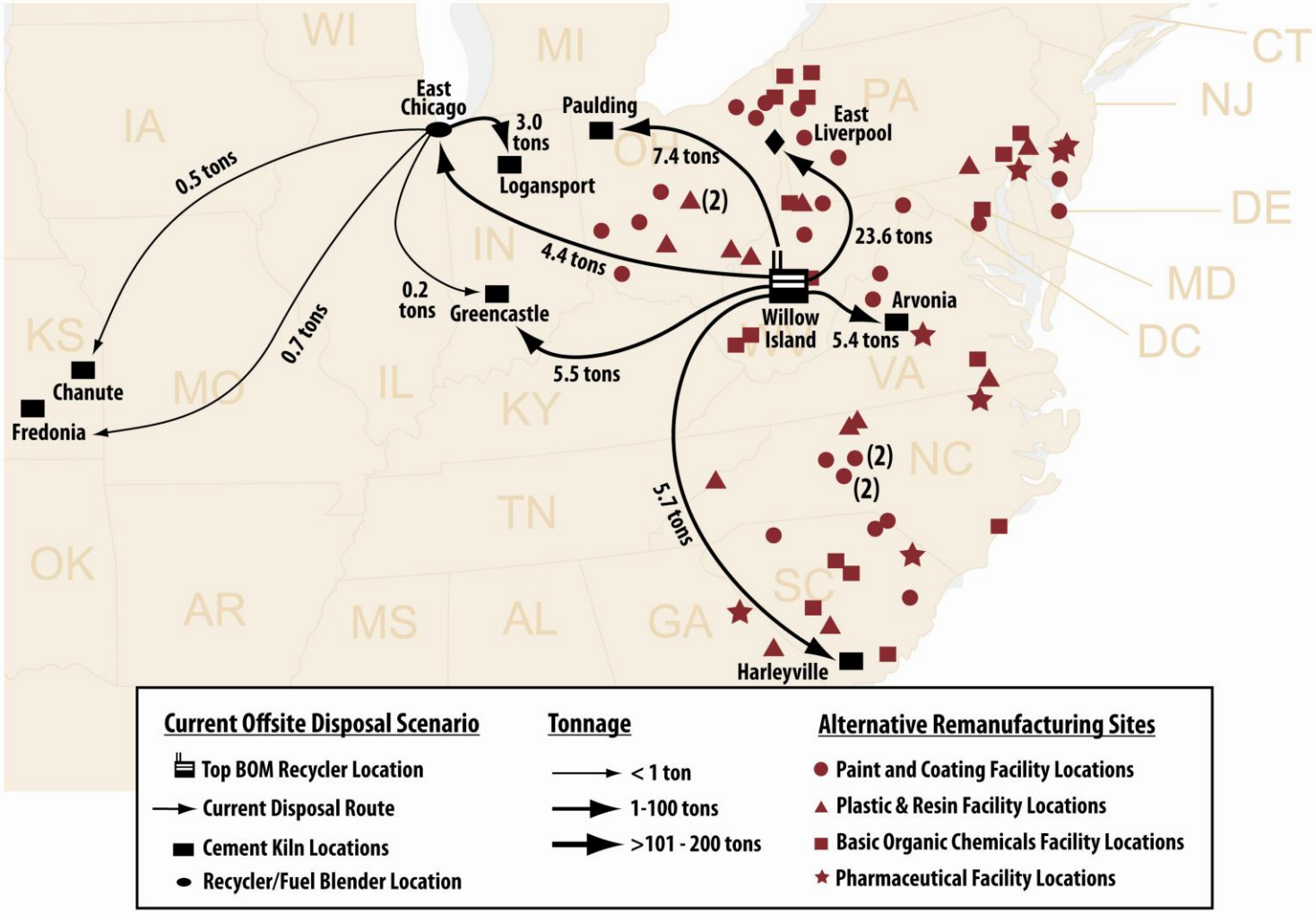
Top 10 Basic Organic Chemical Manufacturer (BOM): CYTEC (Willow Island, West Virginia)

Toluene Waste Offsite Transfers Routes (52 tons) and Remanufacturing Sites in Region

Toluene Waste Onsite Transfers: (Recycling: 6,279 tons, Treatment: 18 tons, Energy Recovery: 0 tons)

Total Waste reported by 65 Alternative Remanufacturing Sites: 17,639 tons

(Four Top 10 BOM that do not produce but recycle (96% of Total Waste) Toluene on-site)



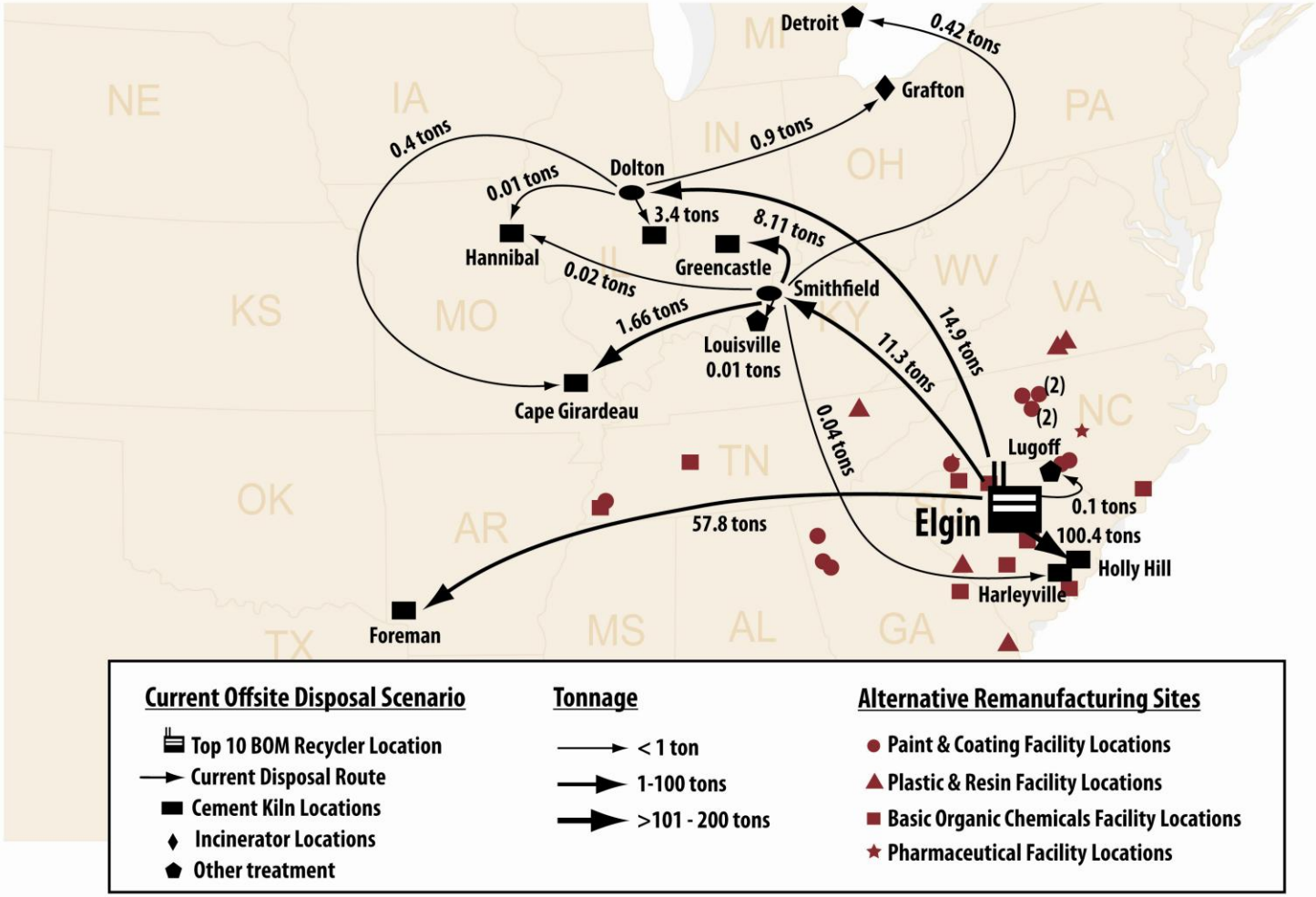
Top 10 Basic Organic Chemical Manufacturer (BOM): WEYLCHEM (Elgin, South Carolina)

Toluene Waste Offsite Transfers Routes (184 tons) and Remanufacturing Sites in Region

Toluene Waste Onsite Transfers: (Recycling: 1,245 tons, Treatment: 108 tons, Energy Recovery: 0 tons)

Total Waste reported by 29 Alternative Remanufacturing Sites: 5,334 tons

(Four Top 10 BOM that do not produce but recycle (96% of Total Waste) Toluene on-site)



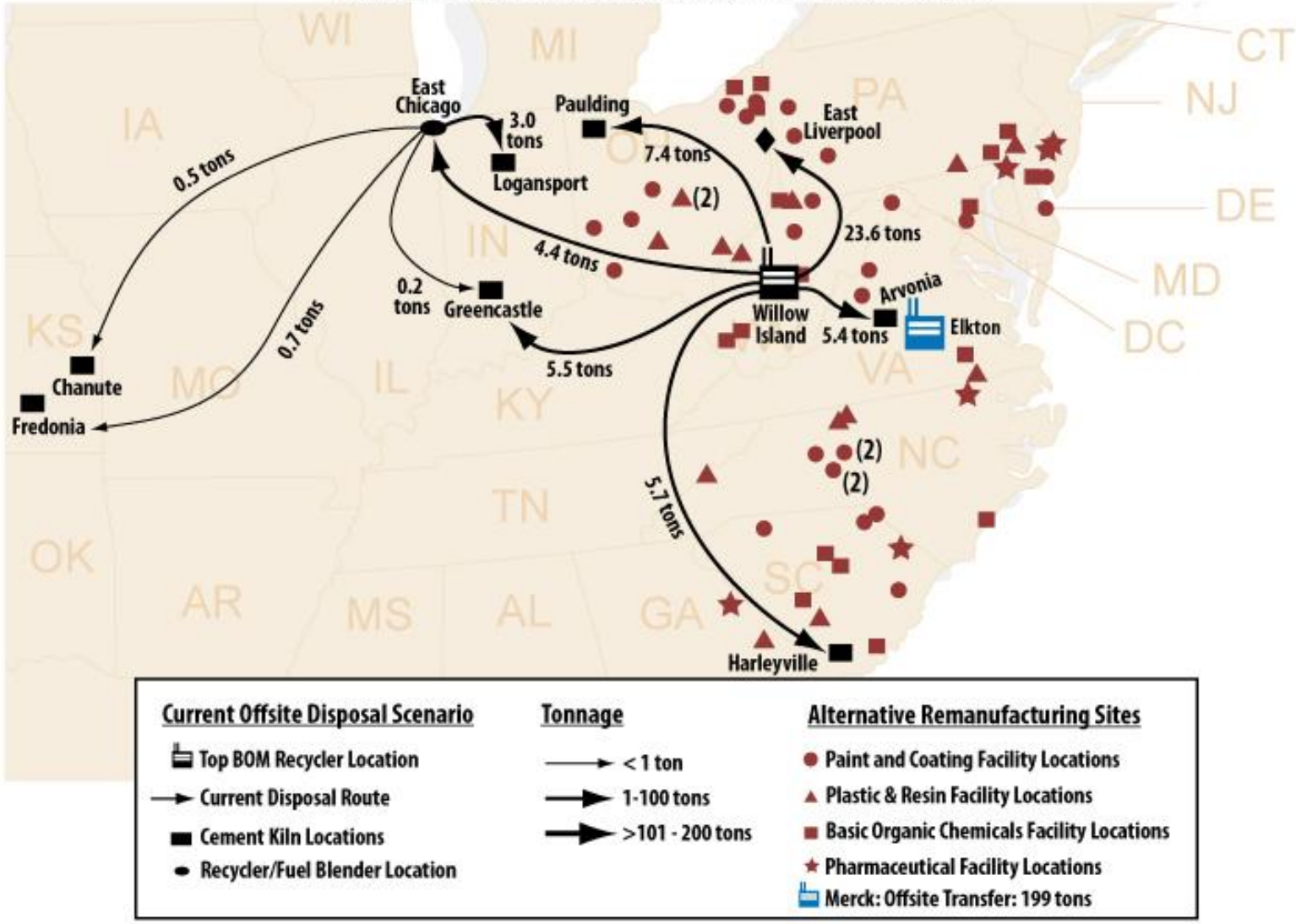
Top 10 Basic Organic Chemical Manufacturer (BOM): CYTEC (Willow Island, West Virginia)

Toluene Waste Offsite Transfers Routes (52 tons) and Remanufacturing Sites in Region

Toluene Waste Onsite Transfers: (Recycling: 6,279 tons, Treatment: 18 tons, Energy Recovery: 0 tons)

Total Waste reported by 65 Alternative Remanufacturing Sites: 17,639 tons

(Four Top 10 BOM that do not produce but recycle Toluene on-site)



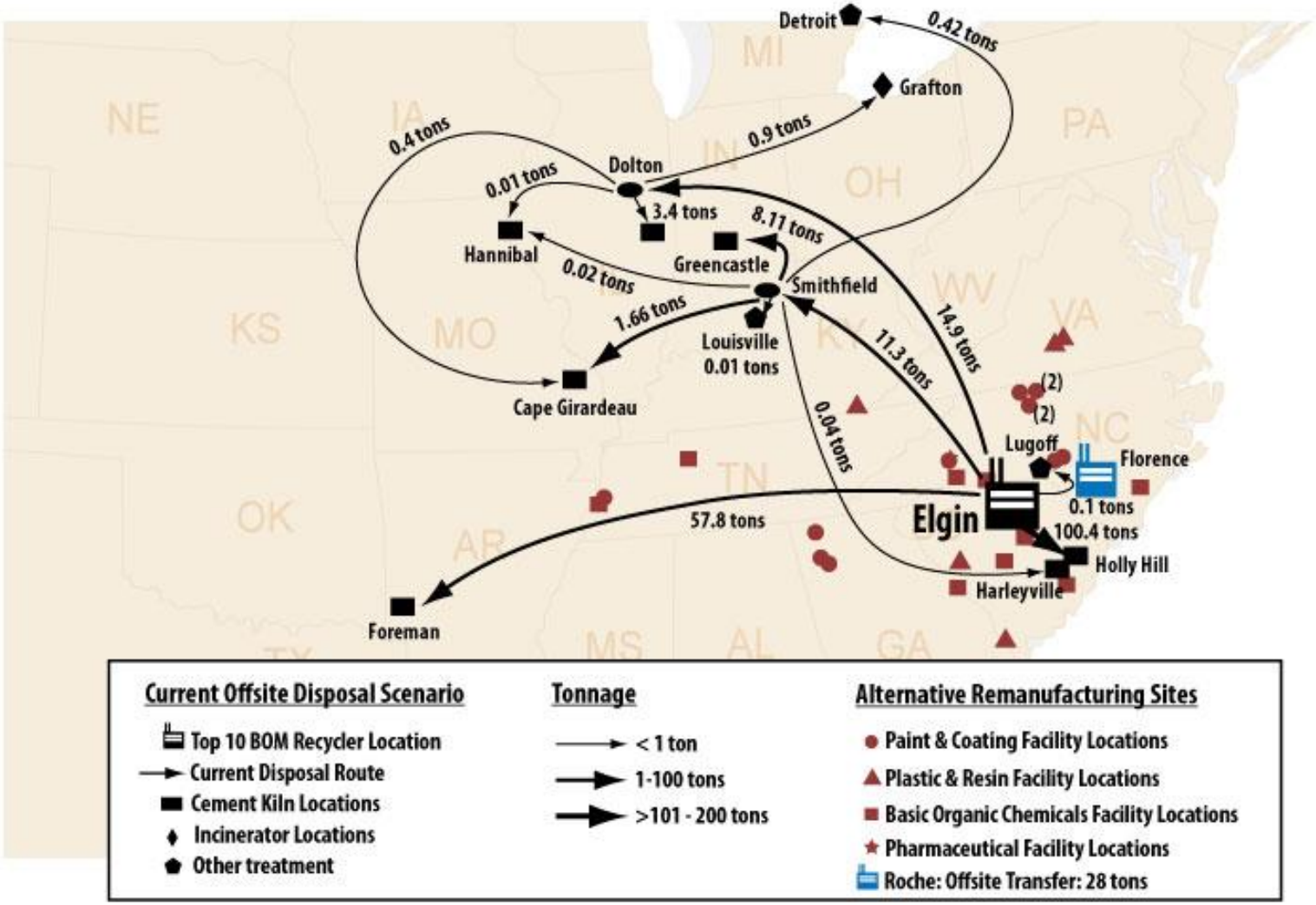
Top 10 Basic Organic Chemical Manufacturer (BOM): WEYLCHEM (Elgin, South Carolina)

Toluene Waste Offsite Transfers Routes (184 tons) and Remanufacturing Sites in Region

Toluene Waste Onsite Transfers: (Recycling: 1,245 tons, Treatment: 108 tons, Energy Recovery: 0 tons)

Total Waste reported by 29 Alternative Remanufacturing Sites: 5,334 tons

(Four Top 10 BOM that do not produce but recycle Toluene on-site)



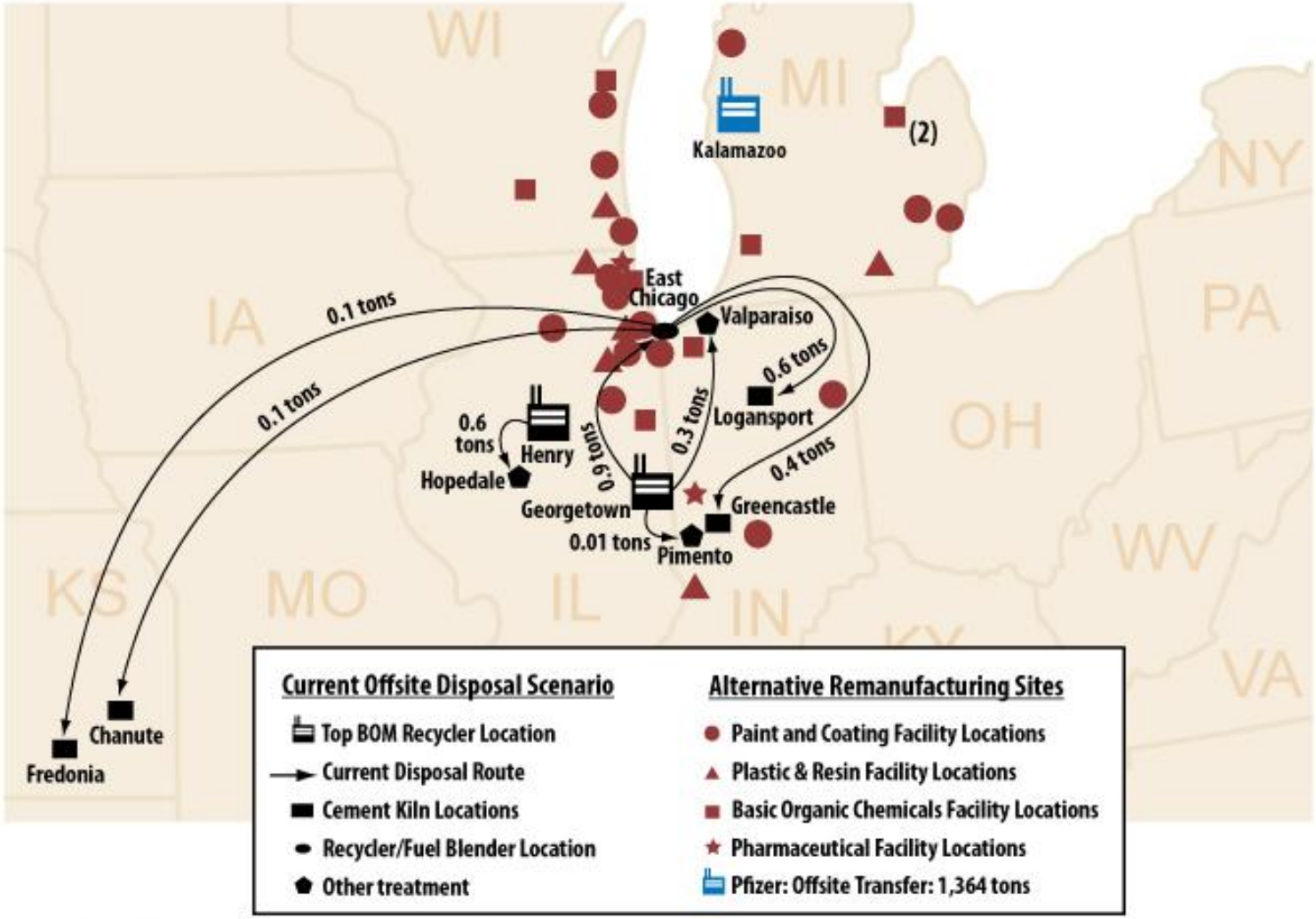
Top 10 Basic Organic Chemical Manufacturer (BOM): DYNACHEM & EMERALD (Georgetown & Henry, IL)

Toluene Waste Offsite Transfers Routes (2 tons) and Remanufacturing Sites in Region

Onsite Transfers: Dynachem (Recycling: 851 tons, Treatment: 931 tons) Emerald: (Recycling: 21,500 tons)*

Total Waste reported by 31 Alternative Remanufacturing Sites: 7,313 tons* (excludes Emerald)

(Four Top 10 BOM that do not produce but recycle Toluene on-site)



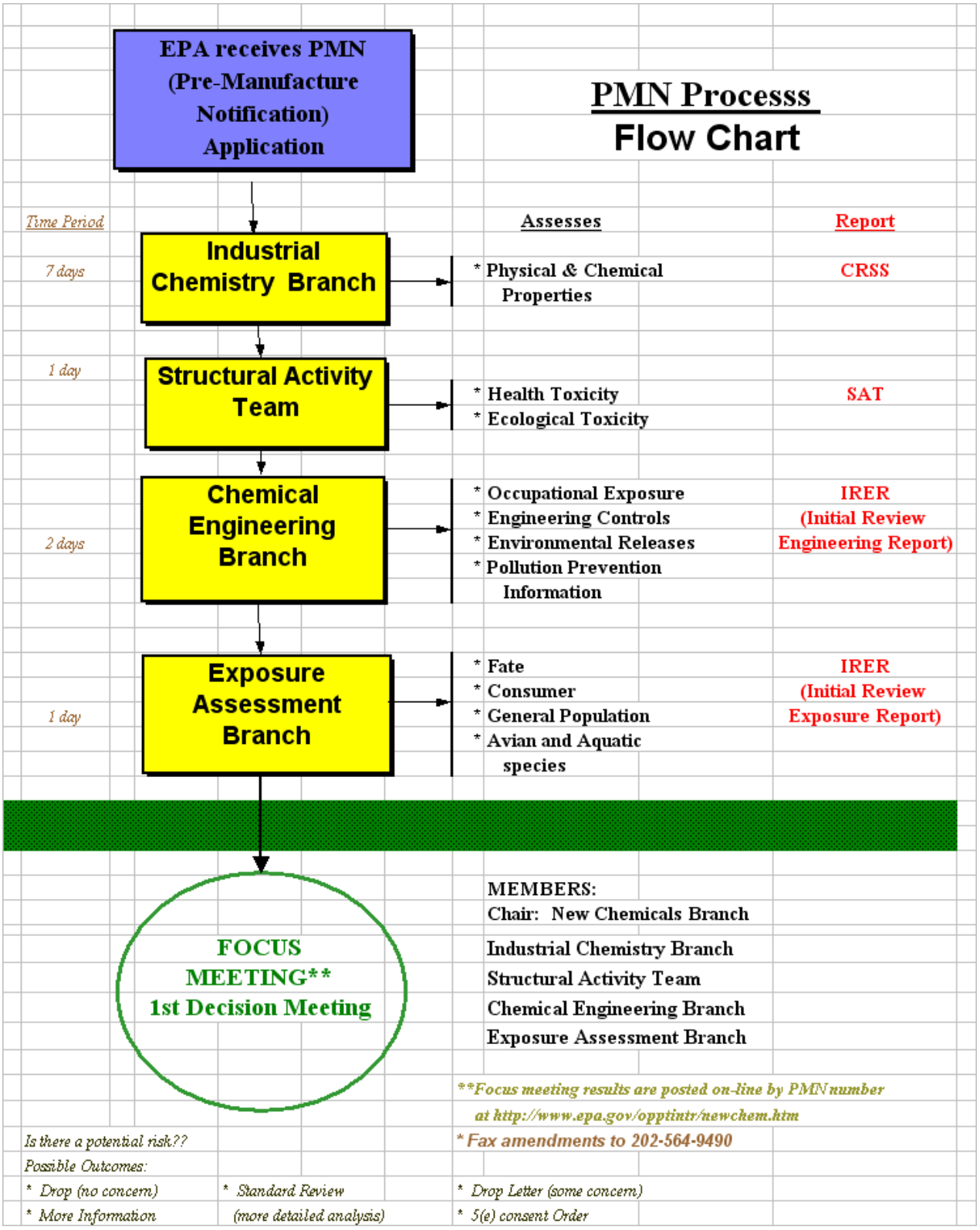
*Emerald is closed loop / currently recovering ~100% toluene waste.

APPENDIX 3: New Chemicals Assessment: Release and Exposure from Toluene Fuel Blending

Appendix 3

7.1: New Chemical assessment and Releases & Exposures from Fuel Blending

A primary responsibility in the Office of Pollution Prevention and Toxics, via the Toxic Substance Control Act (TSCA), is the assessment of a new chemical, known as Premanufacture Notice (PMN). The Chemical Engineering Branch (CEB) estimates the worker exposure and releases for the manufacturing, processing and use of a new chemical substance utilizing the ChemSTEER model.

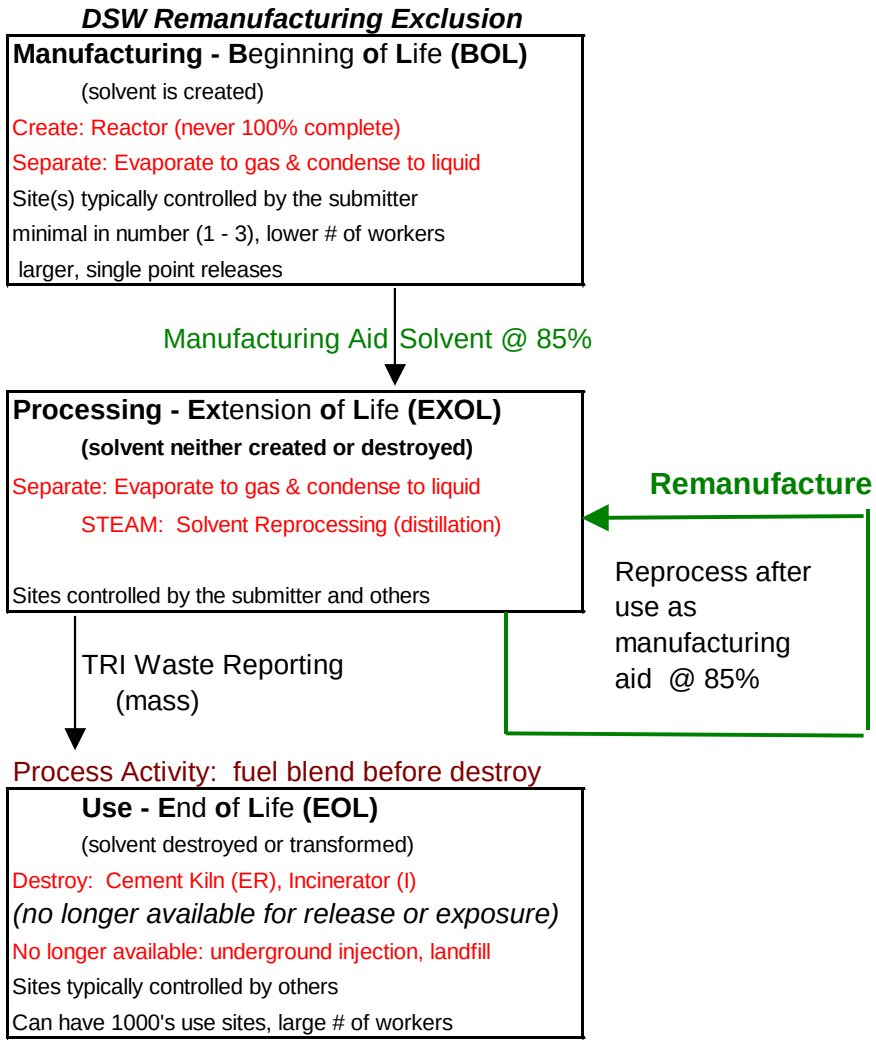


7.2: New Chemical Assessment as it relates to the Remanufacturing Exclusion

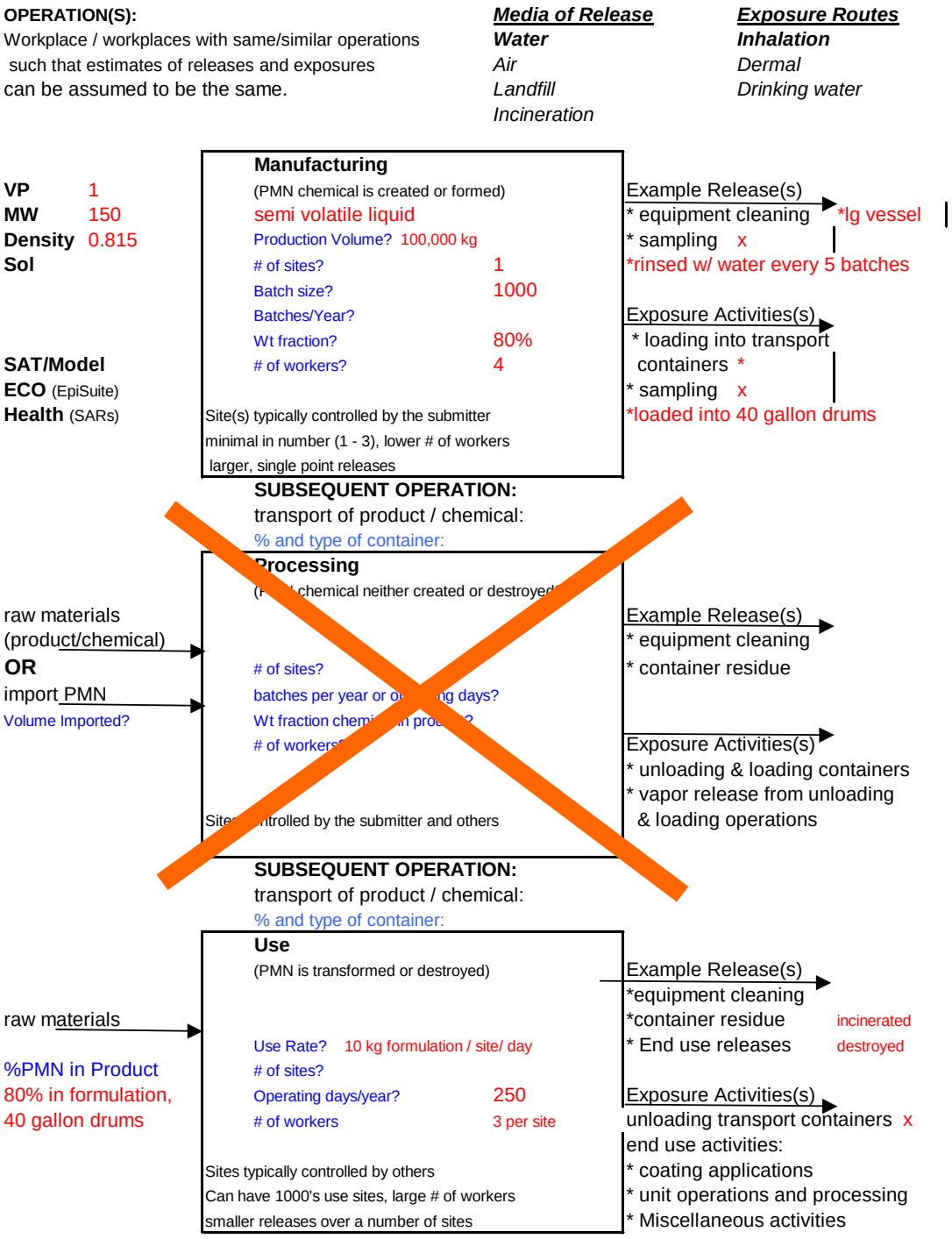
Chemical Screening Tool For Exposures & Environmental Releases

The chemical engineering branch performs worker exposure and environmental release assessments for the manufacture (chemical created), processing (chemical neither created nor destroyed), and use (chemical destroyed or no longer available for release or exposure) of a new chemical substance. Tools and scenarios have been developed to assess further downstream (use operations) in order to fill in blanks of our assessment of nearly 2000 chemicals annually. All that is needed is the amount of material (lbs), basic physical – chemical properties (vapor pressure), and the operation.

In the case of the manufacture of a new chemical, the input mass (production volume) is known. In the case of the Remanufacturing Exclusion, the output mass from processing is known. This is the TRI Production Related Waste reporting – often referred to as 'waste', where a submission reports specific pounds of chemicals to both onsite (chemical industry) and offsite (hazardous waste industry) transfers. Another 'known' or can be modeled are the emissions from particular (unit) operations, as a similar operation will have a similar release and exposure. In addition, we know of the manufacturing emissions to create the solvents. So a partial life cycle assessment can be performed using TRI reported measured flows and modeled emissions. (See Appendix 4, Mass Balance Model) As creation and destruction is the largest footprint, anything to extend the processing life of the solvent has multiple benefits in multiple medias.



7.3: ChemSTEER Worksheet – Manufactured and used as an intermediate (destroyed)[6]

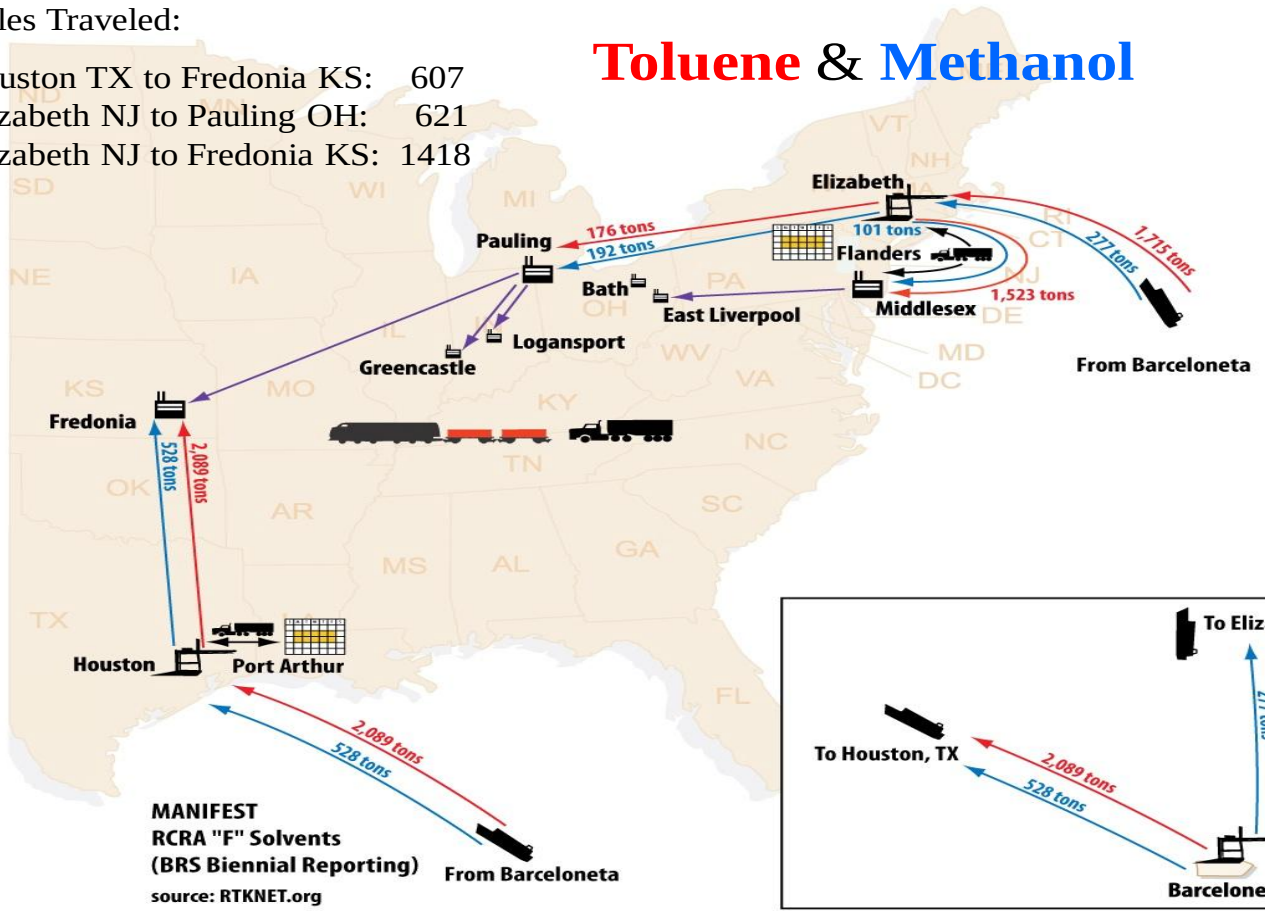


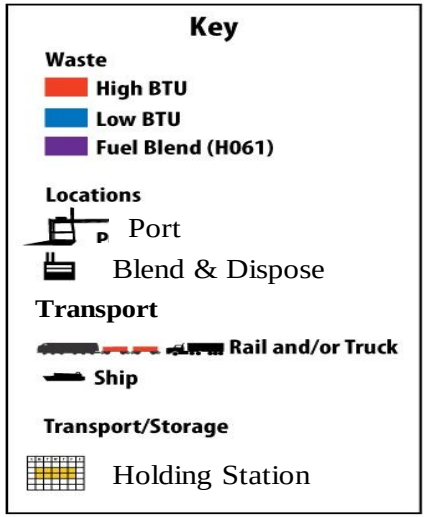
[6] Austin, S., Chicago Completed CS Worksheet, ChemSTEER Training Materials posted on ChemSTEER website and incorporated in all Sustainable Futures training materials.

Miles Traveled:

Houston TX to Fredonia KS: 607
Elizabeth NJ to Pauling OH: 621
Elizabeth NJ to Fredonia KS: 1418

Toluene & Methanol





MANIFEST: Building Block Chemicals

The Trip from Puerto Rico – Basic Building Block Chemicals (Toluene & Methanol)

The High energy value toluene (red line) and low energy value methanol (blue line) arrive at port in Houston or Elizabeth and transported to a holding station such as Port Arthur and Flanders. RCRA regulations limit holding time to 10 days, so some of the HSM is moved around until enough is accumulated for fuel blending (RCRA code HO61 - purple line) in the correct ratios. Fuel blending can occur at permitted recyclers, such as in Middlesex but is regularly done by cement kilns such as Fredonia and Pauling. Fuel blended materials go to incinerators and cement kilns in Greencastle, Logansport, Bath, East Liverpool, and Fredonia.

7.5: ChemSTEER Worksheet – Fuel Blending (unload, blend, load) Activity

OPERATION(S):
Workplace / workplaces with same/similar operations such that estimates of releases and exposures can be assumed to be the same.

Media of Release
Water
Air
Landfill
Incineration

Exposure Routes
Inhalation
Dermal
Drinking water

Toluene
VP 22 Torr
MW
Density
Sol

SAT/Model
ECO (EpiSuite)
Health (SARs)

Manufacturing
(PMN chemical is created or formed)

Production Volume?
# of sites?
Batch size?
Batches/Year?
Wt fraction?
# of workers?

Site(s) typically controlled by the submitter
Minimal in number (1 - 3), lower # of workers
larger, single point releases

Example Release(s)
* equipment cleaning
* sampling

Exposure Activities(s)
* loading into transport containers
* sampling

BARGE to Houston
3804 tons
Pfizer, Puerto Rico
OR
import PMN
Volume Imported?

Processing
(PMN chemical neither created or destroyed0

Source/Activity: Fuel Blending
1 - Unloading (truck)
2 - Blending (tank)
3 - Reloading (truck)

# of sites? 100's?
batches per year or operating days **?**
Wt fraction chemical in product? **??**
# of workers' assumes 1 per activity

Example Release(s)
* equipment cleaning
* container residue
Trucks

Exposure Activities(s)
* unloading & loading containers
* vapor release from unloading & loading operations

SUBSEQUENT OPERATION:
transport of product / chemical:
% and type of container:

raw materials

%PMN in Product

Use
(PMN is **destroyed in Cement Kiln**)

Source/Activity: Unloading

Use Rate? TRI Reporting
# of sites? **14**
Operating days/year? **350**
# of workers

Can have 1000's use sites, large # of workers
smaller releases over a number of sites

Example Release(s)
*equipment cleaning
*container residue
* End use releases

Exposure Activities(s)
unloading transport containers
end use activities:
* coating applications
* unit operations and processing
* Miscellaneous activities

7.6: ENVIRONMENTAL RELEASES ESTIMATE SUMMARY: Toluene Fuel Blending

Water or Incineration
High End: 2.6E+1 kg/site-day over 1 day/yr from 130 sites or 3.4E+3 kg/yr
from: Cleaning Liquid Residuals from Tank Trucks Used to Transport the Raw Material
basis: EPA/OPPT Bulk Transport Residual Model, CEB standard 0.2% residual.

Water or Incineration or Landfill
Conservative: 1.1E+0 kg/site-day over 1 day/yr from 130 sites or 1.4E+2 kg/yr
from: Equipment Cleaning Losses of Liquids from a Single, Large Vessel
basis: EPA/OPPT Single Vessel Residual Model, CEB standard 1% residual. annual tank cleanout. media of release is uncertain.

Air
Output 2: 3.6E-3 kg/site-day over 250 days/yr from 130 sites
from: Equipment Cleaning Losses of Liquids from a Single, Large Vessel
basis: EPA/OPPT Mass Transfer Coefficient Model.

Air
Typical: 8.5E-3 kg/site-day over 250 days/yr from 130 sites
Worst Case: 8.5E-3 kg/site-day over 250 days/yr from 130 sites
from: Loading Liquid Product into Tank Trucks
basis: EPA/OAQPS AP-42 Loading Model.

Air
Typical: 8.5E-3 kg/site-day over 250 days/yr from 130 sites
Worst Case: 8.5E-3 kg/site-day over 250 days/yr from 130 sites
from: Unloading Liquid Raw Material from Tank Trucks
basis: EPA/OAQPS AP-42 Loading Model.

Air
Output 2: 3.3E-5 kg/site-day over 250 days/yr from 130 sites
from: Cleaning Liquid Residuals from Tank Trucks Used to Transport the Raw Material
basis: EPA/OPPT Mass Transfer Coefficient Model.

Incineration
High End: 3.4E+3 kg/yr
from: Cleaning Liquid Residuals from Tank Trucks Used to Transport the Raw Material
basis: EPA/OPPT Bulk Transport Residual Model, CEB standard 0.2% residual.

RELEASE TOTAL
8.1E+3 kg/yr - all sites

7.7: OCCUPATIONAL EXPOSURES ESTIMATE SUMMARY – Toluene Fuel Blending

Total # of workers: 390
Days/yr: 250

Inhalation:

Exposure to Vapor (Class II)
Typical: 1.6E+2 mg/day over 250 days/yr
Worst Case: 4.7E+3 mg/day over 250 days/yr
Number of workers (all sites) with inhalation exposure: 130
Loading Liquid Product into Tank Trucks;
Basis: EPA/OPPT Mass Balance Model**.**
NOTE: The respirator class is: II. Gas/vapor (all substances in the gas form).

Exposure to Vapor (Class II)
Typical: 1.9E+2 mg/day over 250 days/yr
Worst Case: 5.7E+3 mg/day over 250 days/yr
Number of workers (all sites) with inhalation exposure: 130
Unloading Liquid Raw Material from Tank Trucks;
Basis: EPA/OPPT Mass Balance Model.
NOTE: The respirator class is: II. Gas/vapor (all substances in the gas form).

Exposure to Vapor (Class II)
Typical: 9.2E-3 mg/day over 250 days/yr
Worst Case: 8.3E-2 mg/day over 250 days/yr
Number of workers (all sites) with inhalation exposure: 130
Cleaning Liquid Residuals from Tank Trucks Used to Transport the Raw Material;
Basis: EPA/OPPT Mass Balance Model.
NOTE: The respirator class is: II. Gas/vapor (all substances in the gas form).

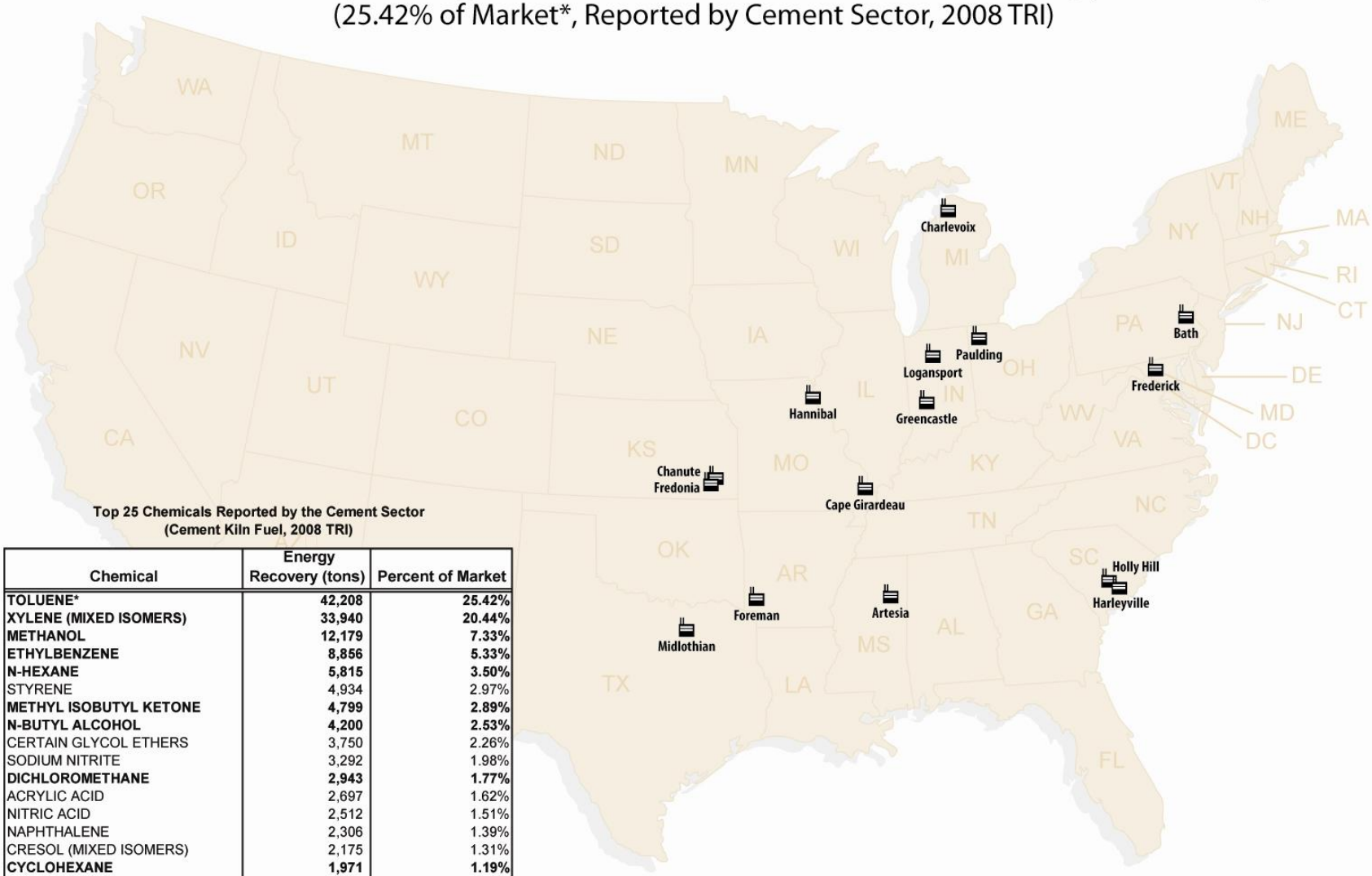
Dermal:

Exposure to Liquid at 82.50% concentration
High End: 1.5E+3 mg/day over 250 days/yr
Number of workers (all sites) with dermal exposure: 390
Loading Liquid Product into Tank Trucks, Unloading Liquid Raw Material from Tank Trucks, and Cleaning Liquid Residuals from Tank Trucks Used to Transport the Raw Material;
Basis: EPA/OPPT 2-Hand Dermal Contact with Liquids Model.

Health Effects[7] of Toluene:
Recognized: Developmental Toxicant
Suspected: Cardiovascular or Blood toxicant, Gastrointestinal of Liver toxicant, Immunotoxicant, Kidney Toxicant, Neurotoxicant, Reproductive Toxicant, Respiratory Toxicant, Skin or Sense Organ Toxicant.

[7] Scorecard is the web's most popular resource for information about pollution problems and toxic chemicals. www.Scorecard.org

Cement Kiln Facilities
15 Facilities reporting 43,308 tons Toluene as Fuel (Energy Recovery)
(25.42% of Market*, Reported by Cement Sector, 2008 TRI)



Top 25 Chemicals Reported by the Cement Sector
(Cement Kiln Fuel, 2008 TRI)

Chemical	Energy Recovery (tons)	Percent of Market
TOLUENE*	**42,208**	**25.42%**
XYLENE (MIXED ISOMERS)	**33,940**	**20.44%**
METHANOL	**12,179**	**7.33%**
ETHYLBENZENE	**8,856**	**5.33%**
N-HEXANE	**5,815**	**3.50%**
STYRENE	4,934	2.97%
METHYL ISOBUTYL KETONE	**4,799**	**2.89%**
N-BUTYL ALCOHOL	**4,200**	**2.53%**
CERTAIN GLYCOL ETHERS	3,750	2.26%
SODIUM NITRITE	3,292	1.98%
DICHLOROMETHANE	**2,943**	**1.77%**
ACRYLIC ACID	2,697	1.62%
NITRIC ACID	2,512	1.51%
NAPHTHALENE	2,306	1.39%
CRESOL (MIXED ISOMERS)	2,175	1.31%
CYCLOHEXANE	**1,971**	**1.19%**
TETRACHLOROETHYLENE	1,798	1.08%
ACETONITRILE	**1,601**	**0.96%**
1,2,4-TRIMETHYLBENZENE	**1,545**	**0.93%**
METHYL TERT-BUTYL ETHER	**1,453**	**0.87%**
PHENOL	1,326	0.80%

**** Remanufacturing Solvents in Bold***

APPENDIX 4
8.1: Mass Balance Model

Emission Type [a, b]	Underground Injection (U) and Landfill (L)		Cement Kiln (ER)	Incinerator (I)	Current Recycling (75% reported in haz waste)		New Recycling (Bottoms - 92% recovery, double steam)			NEW RECYCLING Mnfctring Emissions (ME)	
			ER EOL	I EOL	STEAM Onsite Reported Recycling Mass [f]	Baseline BOL Mnfctring Emissions (ME)	STEAM New Solvent Mass going to Steam [i]	NEW ER EOL Cement kiln	INEW EOL Incinerator	Recovered Solvent (92% [j] of Distilled Mass)	NEW BOL Mnfctring Emissions (ME)
	U	L	Offsite ER EOL (end of life)	Offsite I EOL (end of life)							
2008 Solvent Mass (tonne)											
MASS	9,436	744	56,682	14,111	260,055	239,251	480,450	30,831	7,605	442,014	442,014
Air emission (tonne)											
CO2	--	--	267,961	86,555	58,553	464,619	104,657	130,431	47,577	--	954,213
CH4	--	--	725	284	107	2,716	191	369	162	--	5,368
N2O	--	--	2	0.8	0	5	0	1	0	--	11
CO	--	--	316	71	41	793	73	148	39	--	1,642
NMVOC	--	--	476	117	298	2,208	532	286	61	--	3,953
NOx	--	--	251	88	193	972	344	129	44	--	1,884
SOx	--	--	944	426	256	3,145	458	440	241	--	6,582
Water emission (tonne)											
TOC	--	--	450	120	2	2,287	3	299	66	--	4,170
BOD	--	--	30	14	14	99	26	14	8	--	206
COD	--	--	1,802	480	5	9,190	8	1,201	261	--	16,750
TDS	--	--	6,393	3,056	266	20,131	476	2,863	1,771	--	43,173
Solid waste (tonne)											
Solid waste	--	--	1,684	735	126	5,788	225	786	391	--	11,835
Energy / Carbon											
MMBTU	--	--	3,197,671	757,633	701,940	5,998,413	1,254,640	1,558,942	424,185	--	12,372,487
MTCO2e	--	--	283,707	92,757	60,802	523,253	108,676	138,399	51,114	--	1,070,380

Left side incorporates all current TRI reporting in the four sectors, in which cement and incinerator operations are off-site.
The Right side shifts current off-site disposal to on-site recycling, in which portions are sent to cement and incinerator operations.

APPENDIX 4
8.2: Modules Embedded in Mass Balance Model

One can enter a mass into the mass balance model, which has emission modules embedded into it. Following is the representative module, acronym, and color code that is utilized in the mass balance model.

End of Life (EOL)

- The GlaxoSmithKline (GSK) Life Cycle Assessment Waste Treatment Modules[8],
  - GSK Incinerator (I) models emissions from mass sent to incinerator:
    - the combustion of solvents put in the incinerator 'oven',
    - the manufacturing emissions of the solvents destroyed in the oven,
    - and the Natural Gas used as fuel to heat the oven.

    I (EOL)
  - Energy Recovery (ER) (GSK Adapted) models emissions from mass sent to Cement kiln:
    - solvents burned as fuels to heat the cement kiln,
    - and the manufacturing emissions from the solvents destroyed.

    ER (EOL)

Extension of Life (EXOL)

- GSK Solvent Recovery models emissions from steam needed to evaporate the solvent

STEAM

Beginning of Life (BOL)

- GSK (embedded) and Zurich Institute[9] (adapted) Manufacturing Emissions
  - The GSK solvent recovery model derived manufacturing emissions to all media for 7 of our solvents: dichloromethane, dimethylformamide, hexane, methanol, THF, toluene (& ethanol)
  - The Zurich Institute derived Solvent Production energy numbers. These numbers were derived by ERG[10] to incorporate emissions to all media for Acetonitrile, butanol, cyclohexane, and methyl ethyl ketone.
  - The remaining solvents were derived by ERG[11] using structural properties.

    ME (BOL)

- ERG[12] Natural Gas LCI was used to model emissions from natural gas used as Fuel (EOL & BOL)
  - Incorporated N20 [not in GSK]
  - Incorporated LCI [GSK was LCI but did not have N20]

    Natural Gas

---

[8] Gonzalez, Overcash and Curzons, *Waste Treatment Modules – a Partial Life Cycle Inventory*, Journal of Chemical Technology and Biotechnology, 76: 707-706, 2001

[9] Hungerbuhler, et al,, ETH Zurich Institute for Chemical and Bioengineering, *What is a green Solvent? A comprehensive framework for the environmental assessment of solvents*, Table 2; Results of the life-cycle assssment of 26 organic solvents, Green Chemistry Jounal, pg 927-934, 2007.

[10] The ETH Zurich paper (Capello et al.) only provides the cumulative energy demand (CED) for the production of each solvent. To estimate emissions, it was assumed that the CED is supplied entirely by natural gas. Cradle-to-gate (combustion) life cycle inventory (LCI) data for natural gas were used to estimate the emissions associated with the manufacture of a solvent.

[11] These solvents were assumed to have manufacturing emissions equal to a similar chemical included in the GSK model or a CED equal to a similar chemical included in Capello et al. Chloroform was assumed equal to dichloromethane and methyl *tert*-butyl ether was assumed equal to those of ethyl ether (GSK). Chlorobenzene was assumed equal to ethylbenzene; methyl isobutyl ketone was assumed equal to methyl ethyl ketone; and 1,2,4-trimethylbenzene was assumed equal to xylenes (Capello et al).

[12] Calculated by ERG, based on updates to LCI data available in the U.S.LCI Database.