IV. CHEMICAL RELEASE AND TRANSFER PROFILE

This section is designed to provide background information on the pollutant releases that are reported by this industry. The best source of comparative pollutant release information is the Toxic Release Inventory System (TRI). Pursuant to the Emergency Planning and Community Right-to-Know Act (EPCRA), TRI includes self-reported facility release and transfer data for over 600 toxic chemicals. Facilities within SIC Codes 20-39 (manufacturing industries) that have more than 10 employees, and that are above weight-based reporting thresholds are required to report TRI on-site releases and off-site transfers. The information presented within the sector notebooks is derived from the most recently available (1993) TRI reporting year (which then included 316 chemicals), and focuses primarily on the on-site releases reported by each sector. Because TRI requires consistent reporting regardless of sector, it is an excellent tool for drawing comparisons across industries.

Although this sector notebook does not present historical information regarding TRI chemical releases over time, please note that in general, toxic chemical releases have been declining. In fact, according to the 1993 Toxic Release Inventory Data Book, reported releases dropped by 42.7 percent between 1988 and 1993. Although on-site releases have decreased, the total amount of reported toxic waste has not declined because the amount of toxic chemicals transferred off-site has increased. Transfers have increased from 3.7 billion pounds in 1991 to 4.7 billion pounds in 1993. Better management practices have led to increases in off-site transfers of toxic chemicals for recycling. More detailed information can be obtained from EPA's annual Toxics Release Inventory Public Data Release book (which is available through the EPCRA Hotline at 1-800-535-0202), or directly from the Toxic Release Inventory System database (for user support call 202-260-1531).

Wherever possible, the sector notebooks present TRI data as the primary indicator of chemical release within each industrial category. TRI data provide the type, amount, and media receptor of each chemical released or transferred. When other sources of pollutant release data have been obtained, these data have been included to augment the TRI information.

TRI Data Limitations

The reader should keep in mind the following limitations regarding TRI data. Within some sectors, the majority of facilities are not subject to TRI reporting because they are not considered manufacturing industries, or because they are below TRI reporting thresholds. Examples are the mining, dry cleaning, printing, and transportation equipment cleaning sectors. For these sectors, release information from other sources has been included.

The reader should also be aware that TRI "pounds released" data presented within the notebooks is not equivalent to a "risk" ranking for each industry. Weighting each pound of release equally does not factor in the relative toxicity of each chemical that is released. The Agency is in the process of developing an approach to assign toxicological weightings to each chemical released so that one can differentiate between pollutants with significant differences in toxicity. As a preliminary indicator of the environmental impact of the industry's most commonly released chemicals, the notebook briefly summarizes the toxicological properties of the top five chemicals (by weight) reported by each industry.

Definitions Associated With Section IV Data Tables

General Definitions

SIC Code -- the Standard Industrial Classification (SIC) is a statistical classification standard used for all establishment-based Federal economic statistics. The SIC codes facilitate comparisons between facility and industry data.

TRI Facilities -- are manufacturing facilities that have 10 or more full-time employees and are above established chemical throughput thresholds. Manufacturing facilities are defined as facilities in Standard Industrial Classification primary codes 20-39. Facilities must submit estimates for all chemicals that are on the EPA's defined list and are above throughput thresholds.

Data Table Column Heading Definitions

The following definitions are based upon standard definitions developed by EPAÕs Toxic Release Inventory Program. The categories below represent the possible pollutant destinations that can be reported.

RELEASES -- are an on-site discharge of a toxic chemical to the environment. This includes emissions to the air, discharges to bodies of water, releases at the facility to land, as well as contained disposal into underground injection wells.

Releases to Air (Point and Fugitive Air Emissions) -- Include all air emissions from industry activity. Point emissions occur through confined air streams as found in stacks, ducts, or pipes. Fugitive emissions include losses from equipment leaks, or evaporative losses from impoundments, spills, or leaks.

Releases to Water (Surface Water Discharges) - encompass any releases going directly to streams, rivers, lakes, oceans, or other bodies of water. Any estimates for stormwater runoff and non-point losses must also be included.

Releases to Land -- includes disposal of waste to on-site landfills, waste that is land treated or incorporated into soil, surface impoundments, spills, leaks, or waste piles. These activities must occur within the facility's boundaries for inclusion in this category.

Underground Injection -- is a contained release of a fluid into a subsurface well for the purpose of waste disposal.

TRANSFERS -- is a transfer of toxic chemicals in wastes to a facility that is geographically or physically separate from the facility reporting under TRI. The quantities reported represent a movement of the chemical away from the reporting facility. Except for off-site transfers for disposal, these quantities do not necessarily represent entry of the chemical into the environment.

Transfers to POTWs -- are wastewaters transferred through pipes or sewers to a publicly owned treatments works (POTW). Treatment and chemical removal depend on the chemical's nature and treatment methods used. Chemicals not treated or destroyed by the POTW are generally released to surface waters or landfilled within the sludge.

Transfers to Recycling -- are sent off-site for the purposes of regenerating or recovering still valuable materials. Once these chemicals have been recycled, they may be returned to the originating facility or sold commercially.

Transfers to Energy Recovery -- are wastes combusted off-site in industrial furnaces for energy recovery. Treatment of a chemical by incineration is not considered to be energy recovery.

Transfers to Treatment -- are wastes moved off-site for either neutralization, incineration, biological destruction, or physical separation. In some cases, the chemicals are not destroyed but prepared for further waste management.

Transfers to Disposal -- are wastes taken to another facility for disposal generally as a release to land or as an injection underground.

IV.A. EPA Toxic Release Inventory for the Electronics/Computer Industry

The follow section provides TRI data for the semiconductor, printed wiring board (PWB) and cathode ray tube (CRT) industries. The manufacture of these products results in the release of similar substances, including solvents, acids, and heavy metals. The commonly released solvents include acetone, xylene, and methanol. Commonly released acids include sulfuric, hydrochloric, and nitric. A significant amount of ammonia is also released by the electronics/computer industry.

IV.A.1. TRI Data for Semiconductor Industry

The following exhibits present TRI data pertaining to semiconductor manufacturing. Exhibit 18 presents the top ten facilities in terms of TRI releases. Many of these companies are also among the top companies in terms of sales. Exhibit 19 presents the top TRI releasing facilities for all of electronics and other electric facilities. Exhibit 20 displays the number of TRI-reporting semiconductor manufacturing facilities per State. As expected, California and Texas contain the largest number of semiconductor manufacturing facilities.

The TRI database contains a detailed compilation of self-reported, facility-specific chemical releases. The top reporting facilities for this sector are listed below. Facilities that have reported only the SIC codes covered under this notebook appear on the first list. The second list contains additional facilities that have reported the SIC code covered within this report, and one or more SIC codes that are not within the scope of this notebook. Therefore, the second list includes facilities that conduct multiple operations Ñ some that are under the scope of this notebook, and some that are not. Currently, the facility-level data do not allow pollutant releases to be broken apart by industrial process.

Exhibit 18
Top 10 TRI Releasing Semiconductor Manufacturing Facilities (SIC 3674)

Rank	Total TRI Releases in Pounds	Facility Name	City	State
1	225,840	Micron Semiconductor Inc.	Boise	ID
2	203,120	Motorola Inc.	Mesa	AZ
3	159,465	Intel Corp.	Hillsboro	OR
4	142,256	Texas Instruments Inc.	Dallas	TX
5	138,950	AT&T Microelectronics	Reading	PA
6	134,208	Intel Corp.	Rio Rancho	NM
7	112,250	Advanced Micro Devices Inc.	Austin	TX
8	82,854	IBM Corp. E. Fishkill Facility	Hopewell Junction	NY
9	81,719	Dallas Semiconductor Corp.	Dallas	TX
10	80,545	Sgs-Thomson Microelectronics Inc.	Carrollton	TX

Source: US EPA, Toxics Release Inventory Database, 1993.

Exhibit 19
Top 10 TRI Releasing Electronics/Computer Industry Facilities

SIC Codes	Total TRI Releases in Pounds	Facility Name	City	State
3671	861,508	Zenith Electronics Corp. Rauland Div.	Melrose Park	IL
3671	378,105	Philips Display Components Co.	Ottawa	OH
3469, 3674, 3089, 3694	297,150	Delco Electronics Corp. Bypass	Kokomo	IN
3672, 3471	274,950	Photocircuits Corp.	Glen Cove	NY
3671	257,954	Toshiba Display Devices Inc.	Horseheads	NY
3672	255,395	IBM Corp.	Endicott	NY
3674	225,840	Micron Semiconductor Inc.	Boise	ID
3674	203,120	Motorola Inc.	Mesa	AZ
3672	193,720	Hadco Corp. Owego Div.	Owego	NY
3674	159,465	Intel Corp.	Hillsboro	OR

Source: US EPA, Toxics Release Inventory Database, 1993.

Note: Being included on this list does not mean that the release is associated with non-compliance with environmental laws.

Exhibit 20
TRI Reporting Semiconductor Manufacturing Facilities (SIC 3674) by State

State	Number of Facilities	State	Number of Facilities
AZ	9	OR	7
CA	56	PA	7
CO	4	PR	1
FL	2	RI	1
ID	3	SC	1
MA	9	TX	20
MD	2	UT	3
ME	1	VT	1
MN	4	WA	1
MO	1	WI	1
NC	2		
NH	2		
NM	2		
NY	6		
OH	4		

Source: US EPA, Toxics Release Inventory Database, 1993.

Exhibits 21 and 22 show the chemical releases and transfers for the semiconductor industry. Sulfuric acid and hydrochloric acid, two of the most commonly-released chemicals, are used during etching and cleaning processes. Solvents such as acetone, glycol ethers, xylene, and Freon 113 are used during photolithography and cleaning processes. 1,1,1-trichloroethane is used during oxidation and ammonia is used during photolithography and cleaning. A significant amount of methyl ethyl ketone is released during the degreasing and cleaning processes. Most of these solvents are released into the air. Facilities with zero releases of certain chemicals are reported here because transfers of the chemical may have been reported.

Exhibit 21
Releases for Semiconductor Manufacturing Facilities (SIC 3674) in TRI, by Number of Facilities (Releases Reported in Pounds/Year)

Chemical Name	# Facilities Reporting Chemical	Fugitive Air	Point Air	Water Discharges	Under-ground Injection	Land Disposal	Total Releases	Average Releases per Facility
Sulfuric Acid	125	13644	88209	17	250	139	102259	818
Hydrochloric Acid	78	8262	69429	3	0	10	77704	996
Hydrogen Fluoride	71	4940	55479	9902	0	5	70326	991
Phosphoric Acid	69	4039	25674	0	0	5	29718	431
Nitric Acid	57	5403	47628	23	0	5	53059	931
Acetone	53	121794	890290	1460	659	5	1014208	19136
Ammonia	42	42770	101717	42082	17805	8600	212974	5071
Glycol Ethers	27	41317	212900	500	0	82000	336717	12471
Xylene (Mixed Isomers)	25	9952	252661	0	139	0	262752	10510
Ethylene Glycol	16	1688	9316	1600	0	0	12604	788
Methanol	16	31049	135566	0	129	0	166744	10422
Freon 113	10	41211	73335	0	0	0	114546	11455
1,1,1-Trichloroethane	8	1691	82366	0	1	0	84058	10507
Methyl Ethyl Ketone	6	1332	128250	0	0	5	129587	21598
Tetrachloroethylene	4	514	55034	1	0	0	55549	13887
Ammonium Nitrate (Solution)	3	0	0	0	0	0	0	0
Ammonium Sulfate (Solution)	3	250	0	0	0	0	250	83
Lead	3	0	0	0	0	0	0	0
Phenol	3	50	2745	0	0	0	2795	932
Toluene	3	25170	33580	0	0	0	58750	19583
Trichloroethylene	3	14009	21896	0	0	0	35905	11968
Copper	2	0	0	12	0	0	12	6
Ethylbenzene	2	175	1300	0	0	0	1475	738
Methyl Isobutyl Ketone	2	750	9325	0	0	0	10075	5038
1,2-Dichlorobenzene	2	200	49234	0	0	0	49434	24717
1,2,4-Trichlorobenzene	2	0	6519	0	0	0	6519	3260
Antimony Compounds	1	18	5	1	0	0	24	24
Chlorine Dioxide	1	5	5	0	0	0	10	10
Cobalt Compounds	1	5	2	0	0	0	7	7
Isopropyl Alcohol (Manufacturing)	1	0	0	0	0	0	0	0
Lead Compounds	1	0	0	0	0	0	0	0
N-Butyl Alcohol	1	21	84	0	0	0	105	105
Nickel Compounds	1	0	0	0	0	0	0	0
Nitrilotriacetic Acid	1	5	5	0	0	0	10	10
P-Xylene	1	0	430	0	0	0	430	430
Totals	-------	370,264	2,352,984	55,601	18,983	90,774	2,888,606	-------

Source: US EPA, Toxics Release Inventory Database, 1993.

Exhibit 22
Transfers for Semiconductor Manufacturing Facilities (SIC 3674) in TRI, by Number of Facilities (Transfers Reported in Pounds/Year)

Chemical Name	# Reporting Chemical	POTW Discharges	Disposal	Recycling	Treatment	Energy Recovery	Total Transfers	Average Transfer per Facility
Sulfuric Acid	125	147449	500380	1039071	169372	0	1856272	14850
Hydrochloric Acid	78	236415	29599	21664	84745	5	372428	4775
Hydrogen Fluoride	71	11733	198630	525	151929	0	362817	5110
Phosphoric Acid	69	1103	269124	200000	33594	0	503821	7302
Nitric Acid	57	56177	99817	20910	62904	0	239808	4207
Acetone	53	104090	1582	136987	116610	1075656	1442137	27210
Ammonia	42	944298	52771	650	10806	0	1008525	24013
Glycol Ethers	27	30889	3345	139100	56330	1049440	1279104	47374
Xylene (Mixed Isomers)	25	3891	824	31304	127501	728688	892208	35688
Ethylene Glycol	16	458412	2027	15194	623	102016	578272	36142
Methanol	16	14474	0	27715	64502	716413	823104	51444
Freon 113	10	25	592	36937	2435	5660	45649	4565
1,1,1-Trichloroethane	8	263	5	75267	18264	8000	101799	12725
Methyl Ethyl Ketone	6	869	750	0	2105	276109	279833	46639
Tetrachloroethylene	4	0	0	10215	59628	53000	122843	30711
Ammonium Nitrate (Solution)	3	224302	0	0	0	0	224302	74767
Ammonium Sulfate (Solution)	3	1488462	0	122000	0	0	1610462	536821
Lead	3	0	1500	59125	13961	0	74586	24862
Phenol	3	2331	0	0	27	94679	97037	32346
Toluene	3	0	0	0	17000	5970	22970	7657
Trichloroethylene	3	0	0	59736	0	0	59736	19912
Copper	2	0	18	0	166	0	184	92
Ethylbenzene	2	0	146	0	190	16800	17136	8568
Methyl Isobutyl Ketone	2	0	0	0	9300	12190	21490	10745
1,2-Dichlorobenzene	2	10	0	0	2157	93600	95767	47884
1,2,4-Trichlorobenzene	2	1413	0	0	32273	0	33686	16843
Antimony Compounds	1	0	18100	0	0	0	18100	18100
Chlorine Dioxide	1	0	0	0	0	0	0	0
Cobalt Compounds	1	0	3780	0	0	0	3780	3780
Isopropyl Alcohol (Manufacturing)	1	5	0	10165	0	0	10170	10170
Lead Compounds	1	0	6630	0	0	0	6630	6630
N-Butyl Alcohol	1	10430	0	0	0	1433	11863	11863
Nickel Compounds	1	381	0	3574	0	0	3955	3955
Nitrilotriacetic Acid	1	0	0	0	0	0	0	0
P-Xylene	1	0	0	0	10380	0	10380	10380
Zinc Compounds	1	0	267300	0	0	0	267300	267300
Totals	-------	3,737,422	1,456,920	2,010,139	1,046,802	4,239,659	12,498,154	-------

Source: US EPA, Toxics Release Inventory Database, 1993.

IV.A.2. TRI Data for Printed Wiring Board Industry

The following exhibits present TRI data pertaining to PWB manufacturing. Exhibit 23 presents the top ten TRI-reporting PWB manufacturing facilities in terms of TRI releases. IBM is one of these companies which is also among the top ten electronics sales generating companies. Exhibit 24 displays the number of TRI-reporting facilities per State. California has the largest number of PWB manufacturing facilities.

Exhibit 23
Top 10 TRI Releasing Printed Wiring Board Manufacturing Facilities (SIC 3672)

Rank	Total TRI Releases in Pounds	Facility Name	City	State
1	255,395	IBM Corp.	Endicott	NY
2	193,720	Hadco Corp. Oswego Div.	Oswego	NY
3	127,283	Continental Circuits Corp.	Phoenix	AZ
4	120,864	Thomson Consumer Electronics Inc.	Dunmore	PA
5	96,191	Hadco Corp.	Derry	NH
6	79,250	QLP Laminates Inc.	Anaheim	CA
7	74,653	Synthane-Taylor	La Verne	CA
8	68,456	Circuit-Wise Inc.	North Haven	CT
9	67,050	American Matsushita Electronics Corp.	Troy	OH
10	65,088	Pec Viktron	Orlando	FL

Source: US EPA, Toxics Release Inventory Database, 1993.

Exhibit 24
TRI Reporting Printed Wiring Board Manufacturing Facilities (SIC 3672) by State

State	Number of Facilities	State	Number of Facilities
AZ	9	NJ	3
CA	82	NY	8
CO	3	OH	7
CT	7	OK	1
FL	11	OR	6
GA	2	PA	5
IA	2	PR	4
IL	18	SC	2
IN	3	SD	1
KS	1	TX	8
MA	9	UT	4
MD	1	VA	3
MI	1	VT	1
MN	14	WA	6
MO	4	WI	4
NC	1		
NH	9		

Source: US EPA, Toxics Release Inventory Database, 1993.

As seen in Exhibits 25 and 26, the top releases of acids from PWB facilities include sulfuric acid, hydrochloric acid, and nitric acid, all of which are used during cleaning, electroless plating and electroplating operations. Hydrochloric acid is also used during etching. The acids are primarily released to the air or recycled. Glycol ethers are released during image application and cleaning; most of the releases are emitted into the air. Freon 113 is used primarily for flux removal and is released into the air. Nearly all Freon 113 transfers are recycled. Acetone, a solvent used to clean the board before imaging, is released primarily into the air. Ammonium sulfate solution is used during electroplating, imaging, and etching processes and is released to the water or transferred to POTWs. Metals such as lead and copper are commonly used during electroplating, etching, and soldering (i.e., lead) processes. These metals and their compounds are primarily recycled.

Exhibit 25

Releases for Printed Wiring Board Manufacturing Facilities (SIC 3672) in TRI, by Number of Facilities (Releases Reported in Pounds/Year)

Chemical Name	# Facilities Reporting Chemical	Fugitive Air	Point Air	Water Discharges	Under-ground Injection	Land Disposal	Total Releases	Average Release per Facility
Sulfuric Acid	208	25640	98477	0	0	250	124367	598
Ammonia	117	80332	480081	28029	0	0	588442	5029
Copper	89	1345	1860	27	0	8500	11732	132
Copper Compounds	73	6830	7532	1831	0	9739	25932	355
Hydrochloric Acid	70	13268	40342	32189	0	27	85826	1226
Nitric Acid	59	7572	12750	0	0	0	20322	344
Glycol Ethers	25	82099	132118	23057	0	0	237274	9491
Formaldehyde	22	3225	14912	255	0	0	18392	836
Chlorine	16	1545	5992	50	0	0	7587	474
Lead	12	250	750	5	0	3500	4505	375
Acetone	10	117974	70711	0	0	0	188685	18869
Freon 113	9	83258	37550	0	0	0	120808	13423
Lead Compounds	7	760	1260	252	0	0	2272	325
Ammonium Sulfate (Solution)	6	0	0	100000	0	0	100000	16667
Methyl Ethyl Ketone	6	13770	25023	0	0	0	38793	6466
Phosphoric Acid	6	510	505	0	0	0	1015	169
Methanol	5	62978	7394	0	0	0	70372	14074
Dichloromethane	4	51269	125288	5	0	0	176562	44141
1,1,1-Trichloroethane	3	24930	8310	0	0	0	33240	11080
2-Methoxyethanol	3	5000	40960	0	0	0	45960	15320
Hydrogen Fluoride	2	0	250	0	0	0	250	125
Nickel	2	0	0	0	0	0	0	0
Toluene	2	29425	14125	0	0	0	43550	21775
Zinc Compounds	2	750	0	0	0	0	750	375
Ammonium Nitrate (Solution)	1	0	0	0	0	0	0	0
Barium Compounds	1	250	0	0	0	0	250	250
Ethylbenzene	1	250	2600	0	0	0	2850	2850
Ethylene Glycol	1	600	1200	0	0	0	1800	1800

Exhibit 25 (cont'd)
Releases for Printed Wiring Board Manufacturing Facilities (SIC 3672) in TRI, by Number of Facilities (Releases Reported in Pounds/Year)

Chemical Name	**# Facilities Reporting Chemical**	**Fugitive Air**	**Point Air**	**Water Discharges**	**Underground Injection**	**Land Disposal**	**Total Releases**	**Average Releases per Facility**
Isopropyl Alcohol (Manufacturing)	1	0	0	0	0	0	0	0
Methylenebis (Phenylisocyanate)	1	0	0	0	0	0	0	0
Phenol	1	750	750	250	0	0	1750	1750
Silver	1	0	0	.	0	0	0	0
Tetrachloroethylene	1	12900	22300	0	0	0	35200	35200
Trichloroethylene	1	14920	26000	0	0	0	40920	40920
Xylene (Mixed Isomers)	1	1000	16560	0	0	0	17560	17560
1,2-Dichlorobenzene	1	1800	2130	0	0	0	3930	3930
Totals	**-------**	**645,200**	**1,197,730**	**185,950**	**0**	**22,016**	**2,050,896**	**-------**

Source: US EPA, Toxics Release Inventory Database, 1993.

Exhibit 26
Transfers for Printed Wiring Board Manufacturing Facilities (SIC 3672) in TRI, by Number of Facilities (Transfers Reported in Pounds/Year)

Chemical Name	**# Reporting Chemical**	**POTW Discharges**	**Disposal**	**Recycling**	**Treatment**	**Energy Recovery**	**Total Transfers**	**Average Transfers per Facility**
Sulfuric Acid	208	34596	15558	85488	456242	28400	620284	2982
Ammonia	117	412348	2513	6102550	212950	0	6730361	57524
Copper	89	18527	77880	5159806	104791	0	5361004	60236
Copper Compounds	73	31441	101998	7949551	263240	0	8346230	114332
Hydrochloric Acid	70	1317	750	1056064	1453601	3100	2514832	35926
Nitric Acid	59	265	8500	169722	202665	0	381152	6460
Glycol Ethers	25	475285	1350	6974	240182	21792	745583	29823
Formaldehyde	22	64501	0	0	2500	0	67001	3046
Chlorine	16	655	0	94152	111000	0	205807	12863
Lead	12	1025	13297	268496	4231	40	287089	23924
Acetone	10	2100	45	3000	1600	188153	194898	19490
Freon 113	9	250	0	77460	1700	5	79415	8824
Lead Compounds	7	1559	14454	92233	5125	0	113371	16196
Ammonium Sulfate (Solution)	6	338933	0	0	0	0	338933	56489
Methyl Ethyl Ketone	6	0	250	0	750	397048	398048	66341
Phosphoric Acid	6	250	0	0	460	0	710	118
Methanol	5	41902	170	0	10746	0	52818	10564
Dichloromethane	4	253	0	71940	2526	38970	113689	28422
1,1,1-Trichloroethane	3	0	0	115750	1410	8180	125340	41780

2-Methoxyethanol	3	0	0	0	0	12250	12250	4083
Hydrogen Fluoride	2	0	0	0	5600	0	5600	2800
Nickel	2	251	0	381	0	0	632	316
Toluene	2	8905	0	0	0	121600	130505	65253
Zinc Compounds	2	4334	10876	0	1087	0	16297	8149
Ammonium Nitrate (Solution)	1	73000	0	0	0	0	73000	73000
Barium Compounds	1	0	500	0	0	0	500	500

Source: US EPA, Toxics Release Inventory Database, 1993.

Exhibit 26 (cont'd)
Transfers for Printed Wiring Board Manufacturing Facilities (SIC 3672) in TRI, by Number of Facilities (Transfers Reported in pounds/year)

Chemical Name	# Reporting Chemical	POTW Discharges	Disposal	Recycling	Treatment	Energy Recovery	Total Transfers	Average Transfer per Facility
Ethylbenzene	1	0	5	0	500	117430	117935	117935
Ethylene Glycol	1	9300	230	0	0	0	9530	9530
Isopropyl Alcohol (Manufacturing)	1	0	3900	0	5460	0	9360	9360
Methylenebis (Phenylisocyanate)	1	0	0	0	16800	0	16800	16800
Phenol	1	0	0	0	10340	22870	33210	33210
Silver	1	0	0	3	0	0	3	3
Tetrachloroethylene	1	0	0	0	1091590	49020	1140610	1140610
Trichloroethylene	1	0	0	0	61600	0	61600	61600
Xylene (Mixed Isomers)	1	0	250	0	2360	559310	561920	561920
1,2-Dichlorobenzene	1	0	0	0	0	109810	109810	109810
Totals	-------	**1,524,043**	**252,526**	**21,253,570**	**4,271,056**	**1,677,978**	**28,976,127**	-------

Source: US EPA, Toxics Release Inventory Database, 1993.

IV.A.3. TRI Data for Cathode Ray Tube Industry

Exhibits 27 present the top ten TRI-reporting CRT manufacturers in terms of releases, and Exhibit 28 presents the number of TRI reporting CRT manufacturing facilities by State. It is not surprising that few facilities are reported in TRI because most manufacturing occurs outside the United States. Exhibits 29 and 30 show TRI releases and transfers per chemical. As expected, a significant amount of lead (used during the frit sealing process) is released, much of which is transferred off-site for disposal and recycling. Zinc compounds are used during the phosphor stripe process and are transferred for recycling. Nitric acid, which is used during tube salvaging, is released into the air. Freon 113 is used as a cleaning agent during panel shadow mask preparation and is also released into the air. Solvents (i.e., acetone, methyl ethyl ketone, toluene, and methanol) are used for cleaning and degreasing and are released primarily into the air or transferred for recycling.

Exhibit 27
Top 10 TRI Releasing Cathode Ray Tube Manufacturing Facilities (SIC 3671)

Rank	Total TRI Releases in Pounds	Facility Name	City	State
1	861,508	Zenith Electronics Corp., Rauland Div.	Melrose Park	IL
2	378,105	Philips Display Components Co.	Ottawa	OH
3	257,954	Toshiba Display Devices Inc.	Horseheads	NY
4	78,756	Varian X-Ray Tube Prods.	Salt Lake City	UT
5	47,000	Richardson Electronics Ltd.	Lafox	IL
6	43,055	Thomson Consumer Electronics	Marion	IN
7	42,323	Varian Assoc. Inc. Power Grid Tube Prods.	San Carlos	CA
8	24,901	Clinton Electronics Corp.	Loves Park	IL
9	21,613	Hitachi Electronic Devices USA Inc.	Greenville	SC
10	6,250	ITT Corp., ITT Electron Technology Div.	Easton	PA

Source: US EPA, Toxics Release Inventory Database, 1993.

Exhibit 28
TRI Reporting Cathode Ray Tube Manufacturing Facilities (SIC 3671) by State

State	Number of Facilities
CA	1
IL	4
IN	2
KY	1
MA	1
NY	1
OH	1
PA	2
RI	1
SC	1
UT	1

Source: US EPA, Toxics Release Inventory Database, 1993.

Exhibit 29
Releases for Cathode Ray Tube Manufacturing Facilities (SIC 3671) in TRI, by Number of Facilities (Releases Reported in Pounds/Year)

Chemical Name	# Facilities Reporting Chemical	Fugitive Air	Point Air	Water Discharges	Under-ground Injection	Land Disposal	Total Releases	Average Releases per Facility
Hydrochloric Acid	9	359	589	0	0	0	948	105
Acetone	8	121559	102405	0	0	0	223964	27996
Nitric Acid	8	2767	77073	0	0	0	79840	9980
Lead Compounds	7	99	2637	435	0	0	3171	453
Sulfuric Acid	7	1580	152	0	0	0	1732	247
Methanol	6	41906	35307	1550	0	0	78763	13127
Trichloroethylene	6	151543	393048	0	0	0	544591	90765
Barium Compounds	5	6	5	476	0	0	487	97
Hydrogen Fluoride	5	1760	4175	0	0	0	5935	1187
Toluene	5	38856	480286	1681	0	0	520823	104165
Zinc Compounds	4	205	5017	164	0	0	5386	1347
Copper	3	10	255	65	0	0	330	110
Ammonia	2	1069	8411	3103	0	0	12583	6292
Arsenic Compounds	2	0	0	2	0	0	2	1
Freon 113	2	34718	5227	0	0	0	39945	19973
Methyl Ethyl Ketone	2	72778	54045	0	0	0	126823	63412
1,1,1-Trichloroethane	2	1484	35983	5	0	0	37472	18736
Chromium Compounds	1	0	0	146	0	0	146	146
Copper Compounds	1	10	200	5	0	0	215	215
Methyl Isobutyl Ketone	1	139	13777	0	0	01	13916	13916
Methylenebis (Phenylisocyanate)	1	0	0	0	0	0	0	0
Nickel	1	5	5	0	0	0	10	10
Nickel Compounds	1	0	0	50	0	0	50	50
Tetrachloroethylene	1	0	0	0	0	0	0	0
Xylene (Mixed Isomers)	1	70	70418	0	0	0	70488	70488
Totals	-------	**470,923**	**1,289,015**	**7,682**	**0**	**1**	**1,767,620**	-------

Source: US EPA, Toxics Release Inventory Database, 1993.

Exhibit 30
Transfers for Cathode Ray Tube Manufacturing Facilities (SIC 3671) in TRI, by Number of Facilities (Transfers Reported in Pounds/Year)

Chemical Name	# Facilities Reporting Chemical	POTW Discharges	Disposal	Recycling	Treatment	Energy Recovery	Total Transfers	Average Transfers per Facility
Hydrochloric Acid	9	250	0	0	250	0	500	56
Acetone	8	173	0	21712	60	38674	60619	7577
Nitric Acid	8	0	0	0	333274	0	333274	41659
Lead Compounds	7	1175	1924617	487010	137506	0	2550308	364330
Sulfuric Acid	7	0	0	250	20639	0	20889	2984
Methanol	6	202029	0	64240	5000	5820	277089	46182
Trichloroethylene	6	250	0	151155	150000	0	301405	50234

Barium Compounds	5	255	295228	138785	1850	0	436118	87224
Hydrogen Fluoride	5	39347	0	0	215536	0	254883	50977
Toluene	5	81	0	626179	277	106983	733520	146704
Zinc Compounds	4	1397	56654	212504	59710	0	330265	82566
Copper	3	61	279	80492	0	0	80832	26944
Ammonia	2	0	0	0	0	0	0	0
Arsenic Compounds	2	0	7388	7579	0	0	14967	7484
Freon 113	2	0	0	7170	0	0	7170	3585

Source: US EPA, Toxics Release Inventory Database, 1993.

Exhibit 30 (cont'd)
Transfers for Cathode Ray Tube Manufacturing Facilities (SIC 3671) in TRI, by Number of Facilities (Transfers Reported in Pounds/Year)

Chemical Name	# Facilities Reporting Chemical	POTW Discharges	Disposal	Recycling	Treatment	Energy Recovery	Total Transfers	Average Transfers per Facility
Methyl Ethyl Ketone	2	0	0	0	0	15549	15549	7775
1,1,1-Trichloroethane	2	7	0	10845	0	0	10852	5426
Chromium Compounds	1	0	162	2	0	0	164	164
Copper Compounds	1	45	0	68700	0	0	68745	68745
Methyl Isobutyl Ketone	1	0	0	0	0	1722	1722	1722
Methylenebis (Phenylisocyanate)	1	0	4192	0	0	0	4192	4192
Nickel	1	63	0	24146	0	0	24209	24209
Nickel Compounds	1	0	36	40260	0	0	40296	40296
Tetrachloroethylene	1	0	0	0	20600	0	20600	20600
Xylene (Mixed Isomers)	1	0	0	0	0	0	0	0
Totals	**-------**	**245,133**	**2,288,556**	**1,941,029**	**944,702**	**168,748**	**5,588,168**	**-------**

Source: US EPA, Toxics Release Inventory Database, 1993.

IV.B. Summary of Selected Chemicals Released

The following is a synopsis of current scientific toxicity and fate information for the top chemicals (by weight) that facilities within this sector self-reported as released to the environment based upon 1993 TRI data. Because this section is based upon self-reported release data, it does not attempt to provide information on management practices employed by the sector to reduce the release of these chemicals. Information regarding pollutant release reductions over time may be available from EPA's TRI and 33/50 programs, or directly from the industrial trade associations that are listed in Section IX of this document. Since these descriptions are cursory, please consult the sources referenced below for a more detailed description of both the chemicals described in this section, and the chemicals that appear on the full list of TRI chemicals appearing in Section IV.A.

The brief descriptions provided below were taken from the *1993 Toxics Release Inventory Public Data Release* (EPA, 1994), the Hazardous Substances Data Bank (HSDB), and the Integrated Risk Information System (IRIS), both accessed via TOXNET[2]. The information contained below is based upon exposure assumptions that have been conducted using standard scientific procedures. The effects listed below must be taken in context of these exposure assumptions that are more fully explained within the full chemical profiles in HSDB.

The following chemicals are those released in the greatest quantity by the electronics/computer manufacturing industry:

Acetone
Ammonia
Dichloromethane
Freon 113
Glycol Ethers
Methanol
Methyl Ethyl Ketone
Sulfuric Acid
Toluene
Trichloroethylene
Xylene

Acetone

Toxicity**.** Acetone is irritating to the eyes, nose, and throat. Symptoms of exposure to large quantities of acetone may include headache, unsteadiness, confusion, lassitude, drowsiness, vomiting, and respiratory depression.

Reactions of acetone (see environmental fate) in the lower atmosphere contribute to the formation of ground-level ozone. Ozone (a major component of urban smog) can affect the respiratory system, especially in sensitive individuals such as asthmatics or allergy sufferers.

Carcinogenicity**.** There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate**.** If released into water, acetone will be degraded by microorganisms or will evaporate into the atmosphere. Degradation by microorganisms will be the primary removal mechanism.

Acetone is highly volatile, and once it reaches the troposphere (lower atmosphere), it will react with other gases, contributing to the formation of ground-level ozone and other air pollutants. EPA is reevaluating acetone's reactivity in the lower atmosphere to determine whether this contribution is significant.

Physical Properties. Acetone is a volatile and flammable organic chemical.

Note: Acetone was removed from the list of TRI chemicals on June 16, 1995 (60 FR 31643) and will not be reported for 1994 or subsequent years.

Freon 113 (Trichlorotrifluoroethane)

Toxicity. No adverse human health effects are expected from ambient exposure to Freon 113. Inhalation of high concentrations of Freon 113 causes some deterioration of psychomotor performance (loss of ability to concentrate and a mild lethargy), and an irregular heartbeat. Chronic exposure to Freon 113 caused reversible weakness, pain, and tingling in the legs of one occupationally-exposed woman. There is some evidence of a higher incidence of coronary heart disease among hospital personnel and refrigerant mechanics exposed to fluorocarbons. Exposure to high concentrations of Freon 113 may cause eye and throat irritation.

Fluorocarbons are, however, considerably less toxic than the process materials used in their manufacture (e.g., chlorine). In addition, under certain conditions, fluorocarbon vapors may decompose on contact with flames or hot surfaces, creating the potential hazard of inhalation of toxic decomposition products.

Populations at increased risk from exposure to Freon 113 include people with existing skin disorders, and people with a history of cardiac arrhythmias.

The most significant toxic effect associated with Freon 113 is its role as a potent ozone-depleter. Stratospheric ozone depletion causes an increase in the levels of ultraviolet solar radiation reaching the earth's surface, which in turn is linked to increased incidence of skin cancers, immune system suppression, cataracts, and disruptions in terrestrial and aquatic ecosystems. In addition, increased UV-B radiation is expected to increase photochemical smog, aggravating related health problems in urban and industrialized areas.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. All of the Freon 113 produced is eventually lost as air emissions and builds up in the atmosphere. If released on land, Freon 113 will leach into the ground and volatilize from the soil surface. No degradative processes are known to occur in the soil. Freon 113 is not very water soluble and is removed rapidly from water via volatilization. Chemical hydrolysis, bioaccumulation and adsorption to sediments are not significant fate processes in water.

Freon 113 is extremely stable in the lower atmosphere and will disperse over the globe and diffuse slowly into the stratosphere where it will be lost by photolysis. In this process, chlorine atoms are released that attack ozone.

Glycol Ethers

Due to data limitations, data on diethylene glycol (glycol ether) are used to represent all glycol ethers.

Toxicity. Diethylene glycol is only a hazard to human health if concentrated vapors are generated through heating or vigorous agitation or if appreciable skin contact or ingestion occurs over an extended period of time. Under normal occupational and ambient exposures, diethylene glycol is low in oral toxicity, is not irritating to the eyes or skin, is not readily absorbed through the skin, and has a low vapor pressure so that toxic concentrations of the vapor can not occur in the air at room temperatures.

At high levels of exposure, diethylene glycol causes central nervous depression and liver and kidney damage. Symptoms of moderate 0
diethylene glycol poisoning include nausea, vomiting, headache, diarrhea, abdominal pain, and damage to the pulmonary and cardiovascular systems. Sulfanilamide in diethylene glycol was once used therapeutically against bacterial infection; it was withdrawn from the market after causing over 100 deaths from acute kidney failure.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. Diethylene glycol is a water-soluble, volatile organic chemical. It may enter the environment in liquid form via petrochemical plant effluents or as an unburned gas from combustion sources. Diethylene glycol typically does not occur in sufficient concentrations to pose a hazard to human health.

Methanol

Toxicity. Methanol is readily absorbed from the gastrointestinal tract and the respiratory tract, and is toxic to humans in moderate to high doses. In the body, methanol is converted into formaldehyde and formic acid. Methanol is excreted as formic acid. Observed toxic effects at high dose levels generally include central nervous system damage and blindness. Long-term exposure to high levels of methanol via inhalation cause liver and blood damage in animals.

Ecologically, methanol is expected to have low toxicity to aquatic organisms. Concentrations lethal to half the organisms of a test population are expected to exceed 1 mg methanol per liter water. Methanol is not likely to persist in water or to bioaccumulate in aquatic organisms.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. Liquid methanol is likely to evaporate when left exposed. Methanol reacts in air to produce formaldehyde which contributes to the formation of air pollutants. In the atmosphere it can react with other atmospheric chemicals or be washed out by rain. Methanol is readily degraded by microorganisms in soils and surface waters.

Physical Properties. Methanol is highly flammable.

Methylene Chloride (Dichloromethane)

Toxicity. Short-term exposure to dichloromethane (DCM) is associated with central nervous system effects, including headache, giddiness, stupor, irritability, and numbness and tingling in the limbs. More severe neurological effects are reported from longer-term exposure, apparently due to increased carbon monoxide in the blood from the break down of DCM. Contact with DCM causes irritation of the eyes, skin, and respiratory tract.

Occupational exposure to DCM has also been linked to increased incidence of spontaneous abortions in women. Acute damage to the eyes and upper respiratory tract, unconsciousness, and death were reported in workers exposed to high concentrations of DCM. Phosgene (a degradation product of DCM) poisoning has been reported to occur in several cases where DCM was used in the presence of an open fire.

Populations at special risk from exposure to DCM include obese people (due to accumulation of DCM in fat), and people with impaired cardiovascular systems.

Carcinogenicity. DCM is a probable human carcinogen via both oral and inhalation exposure, based on inadequate human data and sufficient evidence in animals.

Environmental Fate. When spilled on land, DCM is rapidly lost from the soil surface through volatilization. The remainder leaches through the subsoil into the groundwater.

Biodegradation is possible in natural waters but will probably be very slow compared with evaporation. Little is known about bioconcentration in aquatic organisms or adsorption to sediments but these are not likely to be significant processes. Hydrolysis is not an important process under normal environmental conditions.

DCM released into the atmosphere degrades via contact with other gases with a half-life of several months. A small fraction of the chemical diffuses to the stratosphere where it rapidly degrades through exposure to ultraviolet radiation and contact with chlorine ions. Being a moderately soluble chemical, DCM is expected to partially return to earth in rain.

Methyl Ethyl Ketone

Toxicity. Breathing moderate amounts of methyl ethyl ketone (MEK) for short periods of time can cause adverse effects on the nervous system ranging from headaches, dizziness, nausea, and numbness in the fingers and toes to unconsciousness. Its vapors are irritating to the skin, eyes, nose, and throat and can damage the eyes. Repeated exposure to moderate to high amounts may cause liver and kidney effects.

Carcinogenicity. No agreement exists over the carcinogenicity of MEK. One source believes MEK is a possible carcinogen in humans based on limited animal evidence. Other sources believe that there is insufficient evidence to make any statements about possible carcinogenicity.

Environmental Fate. Most of the MEK released to the environment will end up in the atmosphere. MEK can contribute to the formation of air pollutants in the lower atmosphere. It can be degraded by microorganisms living in water and soil.

Physical Properties. Methyl ethyl ketone is a flammable liquid.

Sulfuric Acid

Toxicity. Concentrated sulfuric acid is corrosive. In its aerosol form, sulfuric acid has been implicated in causing and exacerbating a variety of respiratory ailments.

Ecologically, accidental releases of solution forms of sulfuric acid may adversely affect aquatic life by inducing a transient lowering of the pH (i.e., increasing the acidity) of surface waters. In addition, sulfuric acid in its aerosol form is also a component of acid rain. Acid rain can cause serious damage to crops and forests.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. Releases of sulfuric acid to surface waters and soils will be neutralized to an extent due to the buffering capacities of both systems. The extent of these reactions will depend on the characteristics of the specific environment.

In the atmosphere, aerosol forms of sulfuric acid contribute to acid rain. These aerosol forms can travel large distances from the point of release before the acid is deposited on land and surface waters in the form of rain.

Toluene

Toxicity. Inhalation or ingestion of toluene can cause headaches, confusion, weakness, and memory loss. Toluene may also affect the way the kidneys and liver function.

Reactions of toluene (see environmental fate) in the atmosphere contribute to the formation of ozone in the lower atmosphere. Ozone can affect the respiratory system, especially in sensitive individuals such as asthma or allergy sufferers.

Some studies have shown that unborn animals were harmed when high levels of toluene were inhaled by their mothers, although the same effects were not seen when the mothers were fed large quantities of toluene. Note that these results may reflect similar difficulties in humans.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. The majority of releases of toluene to land and water will evaporate. Toluene may also be degraded by microorganisms. Once volatilized, toluene in the lower atmosphere will react with other atmospheric components contributing to the formation of ground-level ozone and other air pollutants.

Physical Properties. Toluene is a volatile organic chemical.

Trichloroethylene

Toxicity. Trichloroethylene was once used as an anesthetic, though its use caused several fatalities due to liver failure. Short term inhalation exposure to high levels of trichloroethylene may cause rapid coma followed by eventual death from liver, kidney, or heart failure. Short-term exposure to lower concentrations of trichloroethylene causes eye, skin, and respiratory tract irritation. Ingestion causes a burning sensation in the mouth, nausea, vomiting and abdominal pain. Delayed effects from short-term trichloroethylene poisoning include liver and kidney lesions, reversible nerve degeneration, and psychic disturbances. Long-term exposure can produce headache, dizziness, weight loss, nerve damage, heart damage, nausea, fatigue, insomnia, visual impairment, mood perturbation, sexual problems, dermatitis, and rarely jaundice. Degradation products of trichloroethylene (particularly phosgene) may cause rapid death due to respiratory collapse.

Carcinogenicity. Trichloroethylene is a probable human carcinogen via both oral and inhalation exposure, based on limited human evidence and sufficient animal evidence.

Environmental Fate. Trichloroethylene breaks down slowly in water in the presence of sunlight and bioconcentrates moderately in aquatic organisms. The main removal of trichloroethylene from water is via rapid evaporation.

Trichloroethylene does not photodegrade in the atmosphere, though it breaks down quickly under smog conditions, forming other pollutants such as phosgene, dichloroacetyl chloride, and formyl chloride. In addition, trichloroethylene vapors may be decomposed to toxic levels of phosgene in the presence of an intense heat source such as an open arc welder.

When spilled on the land, trichloroethylene rapidly volatilizes from surface soils. The remaining chemical leaches through the soil to groundwater.

Xylene (Mixed Isomers)

Toxicity. Xylenes are rapidly absorbed into the body after inhalation, ingestion, or skin contact. Short-term exposure of humans to high levels of xylenes can cause irritation of the skin, eyes, nose, and throat, difficulty in breathing, impaired lung function, impaired memory, and possible changes in the liver and kidneys. Both short- and long-term exposure to high concentrations can cause effects such as headaches, dizziness, confusion, and lack of muscle coordination. Reactions of xylenes (see environmental fate) in the atmosphere contribute to the formation of ozone in the lower atmosphere. Ozone can affect the respiratory system, especially in sensitive individuals such as asthma or allergy sufferers.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. The majority of releases to land and water will quickly evaporate, although some degradation by microorganisms will occur.

Xylenes are moderately mobile in soils and may leach into groundwater, where they may persist for several years.

Xylenes are volatile organic chemicals. As such, xylenes in the lower atmosphere will react with other atmospheric components, contributing to the formation of ground-level ozone and other air pollutants.

IV.C. Other Data Sources

The Aerometric Information Retrieval System (AIRS) contains a wide range of information related to stationary sources of air pollution, including the emissions of a number of air pollutants which may be of concern within a particular industry. With the exception of volatile organic compounds (VOCs), there is little overlap with the TRI chemicals reported above. Exhibit 31 summarizes annual releases of carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter of 10 microns or less (PM10), total particulates (PT), sulfur dioxide (SO_2), and volatile organic compounds (VOCs).

Exhibit 31
Pollutant Releases (Short Tons/Years)

Industry	CO	NO_2	PM_{10}	PT	SO_2	VOC
U.S. Total	97,208,000	23,402,000	45,489,000	7,836,000	21,888,000	23,312,000
Metal Mining	5,391	28,583	39,359	140,052	84,222	1,283
Nonmetal Mining	4,525	28,804	59,305	167,948	24,129	1,736
Lumber and Wood Products	123,756	42,658	14,135	63,761	9,149	41,423
Wood Furniture and Fixtures	2,069	2,981	2,165	3,178	1,606	59,426
Pulp and Paper	624,291	394,448	35,579	113,571	341,002	96,875
Printing	8,463	4,915	399	1,031	1,728	101,537
Inorganic Chemicals	166,147	108,575	4,107	39,082	182,189	52,091
Organic Chemicals	146,947	236,826	26,493	44,860	132,459	201,888
Petroleum Refining	419,311	380,641	18,787	36,877	648,153	309,058
Rubber and Misc. Plastic Products	2,090	11,914	2,407	5,355	29,364	140,741
Stone, Clay, Glass, and Concrete	58,043	338,482	74,623	171,853	339,216	30,262
Iron and Steel	1,518,642	138,985	42,368	83,017	238,268	82,292
Nonferrous Metals	448,758	55,658	20,074	22,490	373,007	27,375
Fabricated Metals	3,851	16,424	1,185	3,136	4,019	102,186
Electronics/ Computer	**367**	**1,129**	**207**	**293**	**453**	**4,854**
Motor Vehicles, Bodies, Parts, and Accessories	35,303	23,725	2,406	12,853	25,462	101,275
Dry Cleaning	101	179	3	28	152	7,310

Source: U.S. EPA Office of Air and Radiation, AIRS Database, May 1995.

IV.D. Comparison of Toxic Release Inventory Between Selected Industries

The following information is presented as a comparison of pollutant release and transfer data across industrial categories. It is provided to give a general sense as to the relative scale of releases and transfers within each sector profiled under this project. Please note that the following table does not contain releases and transfers for industrial categories that are not included in this project, and thus cannot be used to draw conclusions regarding the total release and transfer amounts that are reported to TRI. Similar information is available within the annual TRI Public Data Release book.

Exhibit 32 is a graphical representation of a summary of the 1993 TRI data for the electronics/computer industry and the other sectors profiled in separate notebooks. The bar graph presents the total TRI releases and total transfers on the left axis and the triangle points show the average releases per facility on the right axis. Industry sectors are presented in the order of increasing total TRI releases. The graph is based on the data shown in Exhibit 33 and is meant to facilitate comparisons between the relative amounts of releases, transfers, and releases per facility both within and between these sectors. The reader should note, however, that differences in the proportion of facilities captured by TRI exist between industry sectors. This can be a factor of poor SIC matching and relative differences in the number of facilities reporting to TRI from the various sectors. In the case of electronics/computer industry, the 1993 TRI data presented here covers 406 facilities. These facilities listed SIC 36 Electronics/Computer Industry as a primary SIC code.

Exhibit 32-bar graph
Summary of 1993 TRI Data: Releases and Transfers by Industry

Exhibit 33-Comparative TRI Table
Toxic Release Inventory Data for Selected Industries

Industry Sector	SIC Range	# TRI Facilities	Releases		Transfers		Total Releases + Transfers (10^6 pounds)	Average Release+ Transfers per Facility (pounds)
			Total Releases (10^6 pounds)	Average Releases per Facility (pounds)	1993 Total (10^6 pounds)	Average Transfers per Facility (pounds)		
Stone, Clay, and Concrete	32	634	26.6	41,895	2.2	3,500	28.2	46,000
Lumber and Wood Products	24	491	8.4	17,036	3.5	7,228	11.9	24,000
Furniture and Fixtures	25	313	42.2	134,883	4.2	13,455	46.4	148,000
Printing	2711-2789	318	36.5	115,000	10.2	732,000	46.7	147,000
Electronics/Computers	36	406	6.7	16,520	47.1	115,917	53.7	133,000
Rubber and Misc. Plastics	30	1,579	118.4	74,986	45.0	28,537	163.4	104,000
Motor Vehicle, Bodies, Parts and Accessories	371	609	79.3	130,158	145.5	238,938	224.8	369,000
Pulp and paper	2611-2631	309	169.7	549,000	48.4	157,080	218.1	706,000
Inorganic Chem. Mfg.	2812-2819	555	179.6	324,000	70.0	126,000	249.7	450,000
Petroleum Refining	2911	156	64.3	412,000	417.5	2,676,000	481.9	3,088,000
Fabricated Metals	34	2,363	72.0	30,476	195.7	82,802	267.7	123,000
Iron and Steel	3312-3313 3321-3325	381	85.8	225,000	609.5	1,600,000	695.3	1,825,000
Nonferrous Metals	**333, 334**	**208**	**182.5**	**877,269**	**98.2**	**472,335**	**280.7**	**1,349,000**
Organic Chemical Mfg.	2861-2869	417	151.6	364,000	286.7	688,000	438.4	1,052,000
Metal Mining	10	Industry sector not subject to TRI reporting						
Nonmetal Mining	14	Industry sector not subject to TRI reporting						
Dry Cleaning	7215, 7216, 7218	Industry sector not subject to TRI reporting						

Source: U.S. EPA, Toxics Release Inventory Database, 1993.

V. POLLUTION PREVENTION OPPORTUNITIES

The best way to reduce pollution is to prevent it in the first place. Some companies have creatively implemented pollution prevention techniques that improve efficiency and increase profits while at the same time minimizing environmental impacts. This can be done in many ways such as reducing material inputs, re-engineering processes to reuse by-products, improving management practices, and employing substitution of toxic chemicals. Some smaller facilities are able to actually get below regulatory thresholds just by reducing pollutant releases through aggressive pollution prevention policies.

In order to encourage these approaches, this section provides both general and company-specific descriptions of some pollution prevention advances that have been implemented within the electronics/computer industry. While the list is not exhaustive, it does provide core information that can be used as the starting point for facilities interested in beginning their own pollution prevention projects. When possible, this section provides information from real activities that can, or are being implemented by this sector -- including a discussion of associated costs, time frames, and expected rates of return. This section provides summary information from activities that may be, or are being implemented by this sector. When possible, information is provided that gives the context in which the techniques can be effectively used. Please note that the activities described in this section do not necessarily apply to all facilities that fall within this sector. Facility-specific conditions must be carefully considered when pollution prevention options are evaluated, and the full impacts of the change must examine how each option affects, air, land, and water pollutant releases.

Pollution prevention (sometimes referred to as source reduction) is the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. Pollution prevention includes practices that reduce the use of hazardous materials, energy, water or other resources, and practices that protect natural resources through conservation or more efficient use.

EPA is promoting pollution prevention because it is often the most cost-effective option to reduce pollution and the environmental and health risks associated with pollution. Pollution prevention is often cost effective because it may reduce raw material losses; reduce reliance on expensive "end-of-pipe" treatment technologies and disposal practices; conserve energy, water, chemicals, and other inputs; and reduce the potential liability associated with waste generation. Pollution prevention is environmentally desirable for these very same reasons: pollution itself is reduced at the source while resources are conserved.

V.A. Identification of Pollution Prevention Activities in Use

The electronics and computer industries have participated in many pollution prevention projects and have been the focus of many case studies. Pollution prevention techniques and processes used by these industries can be grouped into four general categories:

¥ Process or equipment modification
¥ Raw material substitution or elimination
¥ Waste segregation/separation/preparation
¥ Recycling.

Each of these categories is briefly discussed below. Refer to Section V.B. for a list of specific pollution prevention techniques and associated costs, savings, and other information.

Process or equipment modification is used to reduce the amount of waste generated. For example, manufacturers can change equipment or processes to: enhance water conservation by installation of countercurrent rinsing systems; reduce alkaline and acid concentration in tanks by installing a pH controller; and reduce drag-out by decreasing the withdrawal rate of parts from plating tanks.

Raw material substitution or elimination is the replacement of existing raw materials with other materials that produce less waste, or a non-toxic waste. Examples include substituting non-cyanide solution for a sodium cyanide solution in copper plating baths and replacing hexavalent chromium with trivalent chrome plating system.

Waste segregation/separation/preparation involves avoiding the mixture of different types of wastes and avoiding the mixture of hazardous wastes with non-hazardous wastes. This makes the recovery of hazardous wastes easier by minimizing the number of different hazardous constituents in a given waste stream. Also, it prevents the contamination of non-hazardous wastes. A specific example is segregation of wastewater sludge by metal contaminants.

Recycling is the use or reuse of a waste as an ingredient or feedstock in the production process on-site. Examples of recycling include: recovering copper during the etching processes, recovering lead and tin from printed wiring boards, and installing a closed-loop recycling system to reuse freon (which is being phased-out) and reduce/reuse water consumption.

V.B. Pollution Prevention Techniques for the Electronics/Computer Industry

This section provides examples of pollution prevention techniques used in the electronics/computer industry. Much of the information provided in this section is from the following EPA offices/programs: the Common Sense Initiative (CSI), EPAÕs DfE Program, the Pollution Prevention Information Center, the Office of Environmental Engineering and Technology Demonstration, the Office of Pollution

Prevention, and Office of Research and Development. Other sources include the Oregon Department of Environmental Quality and the California Department of Toxic Substances and Control. Where available, cost information is provided. However, source documents did not always provide cost information.

V.B.1. Examples of Source Reduction and Recycling Options for Electroplating Operations

Technique - Process or Equipment Modification

Option 1 - Modify rinsing methods to control drag-out by:
- Increasing bath temperature
- Decreasing withdrawal rate of parts from plating bath
- Increasing drip time over solution tanks; racking parts to avoid cupping solution within part cavities
- Shaking, vibrating, or passing the parts through an air knife, angling drain boards between tanks
- Using wetting agents to decrease surface tension in tank.

Contact: Braun Intertec Environmental, Inc., and MN Office of Waste Management (612)Ê649-5750.

Option 2 - Utilize water conservation methods including:
- Flow restrictors on flowing rinses
- Counter current rinsing systems
- Fog or spray rinsing
- Reactive rinsing
- Purified or softened water
- Dead rinses
- Conductivity controllers
- Agitation to assure adequate rinsing and homogeneity in rinse tank
- Flow control valves.

Contact: Braun Intertec Environmental, Inc., and MN Office of Waste Management (612)Ê649-5750.

Option 3 - Implement counter flow rinsing and cascade rinsing systems to conserve consumption of water. **Costs and Savings:** Costs: $75,000 to upgrade existing equipment and purchasing new and used equipment. Waste Savings/Reduction: reduce water use and wastewater treatment costs. **Contact:** Eastside Plating and OR Department of Environmental Quality (800) 452-4011**.**

Option 4 - Use drip bars to reduce drag-out. **Costs and Savings:** Capital Investment: $100/tank. Savings: $600/year. **Contact:** NC Department of Natural Resources & Community Development, Gary Hunt (919) 733-7015.

Option 5 - Use drain boards between tanks to reduce generations of drag-out. **Costs and Savings:** Capital Investment: $25/tank. Savings: $450/year . **Contact:** NC Department of Natural Resources & Community Development, Gary Hunt (919) 733-7015.

Option 6 - Install racking to reduce generations of drag-out. **Costs and Savings:** Capital Investment: zero dollars. Operating Costs: minimal. Savings: $600/year. **Contact:** NC Department of Natural Resources & Community Development, Gary Hunt (919) 733-7015.

Option 7 - Employ drag out recovery tanks to reduce generations of drag-out. **Costs and Savings:** Capital Investment: $500/tank. Savings: $4,700/year. **Contact:** NC Department of Natural Resources & Community Development, Gary Hunt (919) 733-7015.

Option 8 - Install counter-current rinsing operation to reduce water consumption. **Costs and Savings:** Capital Investment: $1,800-2,300. No direct costs. Savings: $1,350/year. Waste Savings/Reductions: reduce water use by 90-99%. **Contact:** NC Department of Natural Resources & Community Development, Gary Hunt (919) 733-7015.

Option 9 - Redesign rinse tank to reduce water conservation. **Costs and Savings:** Capital Investment: $100. No direct costs. Savings: $750/year. **Contact:** NC Department of Natural Resources & Community Development, Gary Hunt (919) 733-7015.

Option 10 - Increase parts drainage time to reduce drag-out. **Contact:** City of Los Angeles Hazardous and Toxic Material Project; Board of Public Works (213) 237-1209.

Option 11 - Regenerate plating bath by activated carbon filtration to remove built up organic contaminants. **Costs and Savings:** Capital Investment: $9,192. Costs: $7,973/year. Savings: $122,420/year. Waste Savings/Reduction: 10,800 gallons/year. Reduce volume of plating baths disposed and requirements for virgin chemicals. **Contact:** EPA Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, Harry Freeman.

Option 12 - Install pH controller to reduce the alkaline and acid concentrations in tanks. **Contact:** Securus, Inc., DBA Hubbard Enterprises.

Option 13 - Install atmospheric evaporator to reduce metal concentrations. **Contact:** Securus, Inc., DBA Hubbard Enterprises.

Option 14 - Install process (e.g., CALFRAN) to reduce pressure to vaporize water at cooler temperatures and recycle water by condensing the vapors in another container, thus concentrating and precipitating solutes out. **Costs and Savings:** Waste Savings/Reduction: reduce volume and quantity of aqueous waste solutions by recovering pure water. **Contact**: CALFRAN International, Inc., (413) 525-4957.

Option 15- Use reactive rinsing and multiple drag-out baths. **Costs and Savings:** Savings: Reduce cost of treating spent process baths and rinsewaters. Waste Savings/Reduction: increase lifetime of process baths and reduce the quantity or rinsewater requiring treatment. **Contact:** SAIC, Edward R. Saltzberg.

Option 16 - Improve control of water level in rinse tanks, improve sludge separation, and enhance recycling of supernatant to the process by aerating the sludge. **Costs and Savings:** Savings: $2,000/year. Waste Savings/Reduction: reduce sludge generation by 32%. **Contact:** NJ Hazardous Waste Facilities Siting Commission, Hazardous Waste Source Reduction and Recycling Task Force.

Option 17 - Install system (e.g., Low Solids Fluxer) that applies flux to printed wiring boards, leaving little residue and eliminates the need for cleaning CFCs. **Costs and Savings:** Waste Savings/Reduction: reduce CFC emissions over 50%. **Contact:** AT&T Bell Laboratories, Princeton, NJ.

Option 18 - Install ion exchange system to reduce generation of drag-out. **Costs and Savings:** Savings: $1,900/year. Capital Investment: $78,000. Operating Costs: $3,200/year. **Contact:** NC Department of Natural Resources & Community Development; Pollution Prevention Pays Program Gary Hunt (919) 733-7015.

Option 19 - Employ reverse osmosis system to reduce generation of drag-out. **Costs and Savings:** Savings: $40,000/year. Capital Investment: $62,000. **Contact:** NC Department of Natural Resources & Community Development; Pollution Prevention Pays Program Gary Hunt (919)Ê733-7015.

Option 20 - Use electrolytic metal recovery to reduce generation of drag-out. **Costs and Savings:**

Capital Investment: $1,000. **Contact:** NC Department of Natural Resources & Community Development; Pollution Prevention Pays Program Gary Hunt (919) 733-7015.

Option 21- Utilize electrodialysis to reduce generation of drag-out. **Costs and Savings:** Capital Investment: $50,000. **Contact:** NC Department of Natural Resources & Community Development; Pollution Prevention Pays Program Gary Hunt (919) 733-7015.

Option 22 - Implement evaporative recovery to reduce generation of drag-out. **Costs and Savings:** Capital Investment: $2,500. **Contact:** NC Department of Natural Resources & Community Development; Pollution Prevention Pays Program Gary Hunt (919) 733-7015.

Option 23- Implement the electrodialysis reversal process for metal salts in wastewater. **Costs and Savings**: Savings: $40,100/year in operating costs. **Contact:** Ionics, Inc., Separations Technology Division.

Technique - Raw Material Substitution

Option 1 - Substitute cyanide plating solutions with alkaline zinc, acid zinc, acid sulfate copper, pyrophosphate copper, alkaline copper, copper fluoborate, electroless nickel, ammonium silver, halide silver, methanesulfonate-potassium iodide silver, amino or thio complex silver, no free cyanide silver, cadmium chloride, cadmium sulfate, cadmium fluoborate, cadmium perchlorate, gold sulfite, and cobalt harden gold. **Contact:** Braun Intertec Environmental, Inc. and MN Office of Waste Management (612) 649-5750.

Option 2 - Substitute sodium bisulfite and sulfuric acid for ferrous sulfate in order to oxidize chromic acid wastes, and substitute gaseous chlorine for liquid chlorine in order to reduce cyanide reduction. **Costs and Savings:** Savings: $300,000/year. Waste Savings/Reduction: reduces feedstock by 50%. **Contact:** Eastside Plating and OR Department of Environmental Quality (800) 452-4011.

Option 3 - Replace hexavalent chromium with trivalent chromium plating systems. **Contact:** City of Los Angeles Hazardous and Toxic Material Project; Board of Public Works (213)Ê237-1209.

Option 4 - Replace cyanide with non-cyanide baths. **Contact:** City of Los Angeles Hazardous and Toxic Material Project; Board of Public Works (213) 237-1209.

Option 5 - Replace conventional chelating agents such as tartarates, phosphates, EDTA, and ammonia with sodium sulfides and iron sulfates in removing metal from rinse water which reduces the amount of waste generated from precipitation of metals from aqueous wastestreams. **Costs and Savings:** Costs: $178,830/year. Savings: $382,995/year. Waste Savings/Reduction: 496 tons of sludge/year. **Contact:** Tyndall Air Force Base, FL, Charles Carpenter (904) 283-2942; EG & G, Dan Sucia, Penny Wilcoff, & John Beller (208) 526-1149.

Option 6 - Replace methylene chloride, 1,1,1-trichloroethane, and perchloroethylene (solvent-based photochemical coatings) with aqueous base coating of 1% sodium carbonate. **Costs and Savings:** Waste Savings/Reduction: reduce solvent use by 60 tons/year. **Contact:** American Etching and Manufacturing, Pacoima, CA.

Option 7 - Replace methanol with nonflammable alkaline cleaners. **Costs and Savings:** Waste Savings/Reduction: eliminate 32 tons/year of flammable methyl alcohol. **Contact:** American Etching and Manufacturing, Pacoima, CA.

Option 8 - Substitute a non-cyanide for a sodium cyanide solution used in copper plating baths. **Costs and Savings:** Waste Savings/Reduction: reduce 7,630 pounds/year. **Contact:** Highland Plating Company, Los

Angeles, CA.

Technique - Recycling

Option 1 - Send drag-out waste to another company for waste exchange. **Contact:** NC Department of Natural Resources & Community Development; Pollution Prevention Pays Program Gary Hunt (919) 733-7015.

Option 2 - Reuse rinse water. **Costs and Savings:** Savings: $1,500/year. Capital Investment: $340/tank. No direct costs. **Contact:** NC Department of Natural Resources & Community Development; Pollution Prevention Pays Program Gary Hunt (919) 733-7015.

Option 3- Reuse drag-out waste back into process tank. **Contact:** NC Department of Natural Resources & Community Development; Pollution Prevention Pays Program Gary Hunt (919)Ê733-7015.

Option 4- Recover process chemicals with fog rinsing parts over plating bath. **Contact:** City of Los Angeles Hazardous and Toxic Material Project; Board of Public Works (213) 237-1209.

Option 5 - Evaporate and concentrate rinse baths for recycling. **Contact:** City of Los Angeles Hazardous and Toxic Material Project; Board of Public Works (213) 237-1209.

Option 6 - Use ion exchange and electrowinning, reverse osmosis, and thermal bonding when possible. **Contact:** City of Los Angeles Hazardous and Toxic Material Project; Board of Public Works (213) 237-1209.

Option 7 - Use sludge slagging techniques to extract and recycle metals. **Costs and Savings:** Capital Investment: $80,000 for 80 tons/year and $400,000 for 1,000 tons/year. Operating Costs: $18,000 per year for an 80 ton facility. Waste Savings/Reduction: reduces volume of waste by 94%. **Contact:** City of Los Angeles Hazardous and Toxic Material Project; Board of Public Works (213) 237-1209.

Option 8 - Use hydrometallurgical processes to extract metals from sludge. **Contact:** City of Los Angeles Hazardous and Toxic Material Project; Board of Public Works (213) 237-1209.

Option 9- Convert sludge to smelter feed. **Contact:** City of Los Angeles Hazardous and Toxic Material Project; Board of Public Works (213) 237-1209.

Option 10 - Remove and recover lead and tin from boards by electrolysis or chemical precipitation. **Contact:** Control Data Corporation and MN Office of Waste Management (612) 649-5750.

Option 11 - Install a closed loop batch treatment system for rinsewater to reduce water use and waste volume. **Costs and Savings:** Savings: $58,460/year. Capital Investment: $210,000. Waste Savings/Reduction: 40,000 gallons/year (40%). **Contact:** Pioneer Metal Finishing, Inc., Harry Desoi (609) 694-0400.

Option 12 - Install an electrolytic cell which recovers 92 percent of dissolved copper in drag-out rinses and atmospheric evaporator to recover 95 percent of chromatic acid drag-out, and recycle it into chromic acid etch line. **Contact:** Digital Equipment Corporation and Lancy International Consulting Firm, William McLay (412) 452-9360.

Option 13- Oxidize cyanide and remove metallic copper to reduce metal concentrations. **Contact:** Securus, Inc., DBA Hubbard Enterprises.

V.B.2. Examples of Source Reduction and Recycling Options for Etching Operations

Technique - Raw Material Substitution

Option 1 - Substitute sodium persulfate etchant (acid etch solution) with hydrogen peroxide/ sulfuric acid. **Contact**: ADC Products and MnTAP (612)Ê625-4949.

Technique - Recycling

Option 1 - Recover copper by electrolytic processes. **Contact**: ADC Products and MnTAP (612)Ê625-4949.

V.B.3. Examples of Source Reduction and Recycling Options for Semiconductor Manufacturing

Technique - Process or Equipment Modification

Option 1 - Install a system (e.g., the CALFRAN process) to reduce pressure to vaporize water at cooler temperatures, recycle water by condensing the vapors in another container, and concentrate and precipitate solutes. **Costs and Savings**: Waste Savings/Reduction: reduce volume and quantity of aqueous waste solutions by recovering pure water. **Contact**: CALFRAN International, Inc. Springfield, MA 01101, Val Partyka (413) 525-4957.

Option 2 - Reduce chrome waste generation by :

¥ Installing a rain cover over on outdoor tanks to reduce chrome waste
¥ Treating on-site with caustics and sodium bisulfite to reduce chrome VI liquid to chrome III sludge
¥ Repairing water leaks in process rinse tank to reduce chrome waste.

Costs and Savings: Capital Investment: $30,000 for the rain cover, pipe repairs, and on-site treatment system. Waste Savings/Reduction: Savings: $15,000/year in disposal costs, and reduce 95% of chrome wastes from 6,000 gallons to two or three drums generated per quarter. **Contact**: Wacker Siltronic Corporation and University of MN (612) 625-4949.

Technique - Raw Material Substitution

Option 1 - Replace chlorinated solvent baths with a non-hazardous product to reduce, and later, eliminate use of chlorinated solvents. **Costs and Savings**: Waste Savings/Reduction: reduce chlorinated solvent use by 93%, and then completely eliminate the use of the chemical. **Contact**: Wacker Siltronic Corporation and University of MN (612) 625-4949.

Technique - Recycling

Option 1 - Convert an open-top still into a closed loop system to recycle Freon 113. **Costs and Savings**: Costs: $20,000. Waste Savings/Reduction: $57,000/year in disposal and feedstock costs, and reduce waste volume by 85%. **Contact**: Wacker Siltronic Corporation and University of MN (612) 625-4949.

Option 2 - Use Athens system to reprocess sulfuric acid generated during wafer fabrication operations. The acid is heated to boil off water and other impurities, purified through distillation, and pumped back into wet stations to continue wafer processing. Costs and savings: Annual savings/Reductions: $2.9 million from not purchasing sulfuric acid and 28% reduction in sulfuric acid generated in 1993. Contact: Intel or Alameda Instruments, Inc. and Athens Corporation (manufacturers of this type of equipment).

V.B.4. Examples of Source Reduction and Recycling Options for Printed Wiring Board Manufacturing

V.B.4.a. General Operations

Technique - Process or Equipment Modification

Option 1 - Modify sludge pretreatment processes by:
¥ Adding flow control valves
¥ Installing metal recovery equipment
¥ Adding of deionization system
Costs and Savings: Costs: lower chemical treatment costs. Waste Savings/Reduction: $90,000 in disposal costs. **Contact**: Unisys Corporation and MnTAP (612) 625-4949.

Option 2 - Redesign board during board assembly. **Contact**: Capsule Environmental Engineering Inc. and MN Office of Waste Management (612) 649-5750.

Option 3 - Install a system (e.g., CALFRAN process) to reduce pressure to vaporize water at cooler temperatures, recycle water by condensing the vapors in another container, concentrate and precipitate solutes. **Costs and Savings**: Waste Savings/Reduction: reduce volume and quantity of aqueous waste solutions by recovering pure water. **Contact**: CALFRAN International, Inc. Springfield, MA 01101, Val Partyka (413) 525-4957.

Option 4 - Alternatives to wet chemical processes include:
¥ Mechanical cleaning as an alternative to chemical methods;
¥ Process efficiency improvements for applying photopolymers, printing, and developing;
¥ Alternative processes for connecting the PWB layers together; and
¥ Alternatives to lead-based soldering involving the use of lasers, reactive gases, or ultrasonics.
Contact: EPA CSI.

Technique - Raw Material Substitution

Option 1 - Substitute semiaqueous or aqueous photoresist for TCA and methylene chloride during board manufacturing. **Contact**: Capsule Environmental Engineering Inc. and MN Office of Waste Management (612) 649-5750.

Option 2 - Substitute no-clean fluxes for CFC 113 and TCA during board assembly. **Contact**: Capsule Environmental Engineering Inc. and MN Office of Waste Management (612) 649-5750.

Option 3 - Substitute aqueous clean fluxes for CFC 113 and TCA during board assembly. **Contact**: Capsule Environmental Engineering Inc. and MN Office of Waste Management (612) 649-5750.

Option 4 - Substitute semi-aqueous cleaning materials for CFC 113 and TCA during board assembly. **Contact**: Capsule Environmental Engineering Inc. and MN Office of Waste Management (612) 649-5750.

Option 5 - Substitute other solvents for CFC 113 and TCA during board assembly. **Contact**: Capsule Environmental Engineering Inc. and MN Office of Waste Management (612) 649-5750.

Technique - Waste Segregation/Separation/Preparation

Option 1 - Segregate wastewater sludge to prepare for metal recovery. **Contact**: Unisys Corporation and MnTAP (612)Ê625-4949.

Technique - Recycling

Option 1 - Remove and recover lead and tin from boards by electrolysis-chemical precipitation. **Contact**: Control Data Corporation and MN Office of Waste Management (612) 649-5750.

V.B.4.b. Cleaning Operations

Technique - Process or Equipment Modification

Option 1 - Install a system (e.g., Low Solids Fluxer {LSF}) which applies flux to printed wiring boards, leaves little residue, and eliminates the need for cleaning with CFCs. **Costs and Savings**: Waste Savings/Reduction: reduce CFC emissions over 50%. **Contact**: AT&T Bell Laboratories, Princeton, NJ.

Technique - Raw Material Substitution

Option 1 - Substitute for CFC 113 used in defluxing with:
- Fully aqueous system using water soluble fluxes
- Aqueous system using saponifiers to remove rosin based fluxes
- Semi-aqueous system using terpenes as a solvent
- Hydrogenated CFCs with chlorinated solvents

Contact: Medtronic Inc. and MN Technical Assistance Program (MnTAP) (612) 627-4848 Maria Scheller.

Option 2 - Substitute CFC 113 used in hand cleaning boards with:
- Blend of HCFC and methanol dispensed from a trigger-grip device that limits the amount of solvent lost to the atmosphere

Contact: Medtronic Inc. and MN Technical Assistance Program (MnTAP) (612) 627-4848 Maria Scheller.

V.B.4.c. Electroplating Operations

Technique - Raw Material Substitution

Option 1 - During tin-lead electroplating process, substitute fluoboric acid with:
- Organic sulfonic acid (OSA) plating
- Acid tin sulfate plating which eliminates lead use
- Hot air leveling
- Conductive, solderable polymer solutions

Contact: Capsule Environmental Engineering Inc. and MN Office of Waste Management (612) 649-5750.

V.B.5. Examples of Source Reduction and Recycling Options for Cathode Ray Tube Manufacturing

Technique - Process or Equipment Modification

Option 1- Reduce building of contamination in bath solutions by increasing process efficiency (e.g., implement ion exchange technology). **Contact:** EPA CSI.

Technique - Raw Material Substitution

Option 1 - Replace lacquer in panel preparation with a wax-like material similar to floor wax. It provides the necessary coating without a high VOC content. One potential drawback, however, is the use of ammonia. **Contact:** EPA CSI.

Option 2 - Replace Freon as a cleaning agent for removing particulate contaminants from panel mask frames with air blow cleaning and an aqueous wash (nearly all CRT manufacturers have implemented this change). **Contact:** EPA CSI.

Option 3 - Identify less hazardous cleaning chemicals, such as isopropyl alcohol, as alternatives to acetone or chlorinated solvents in maintenance and cleanup processes. **Contact:** EPA CSI.

Option 4 - Find substitutes for chromium-based photoresists. **Contact:** EPA CSI.

Option 5 - Identify alternatives to the lead-based frit used in sealing the funnel with the panel mask. **Contact:** EPA CSI.

Technique - Recycling

Option 1 - Regenerate acids for glass cleaning and frit removal in waste glass recovery operations using existing technologies and equipment. **Contact:** EPA CSI.

Option 2 - Reclaim and reuse photoresists from one of the panel preparation processes. **Contact:** EPA CSI.

Option 3 - Recover soluble lead generated during the waste glass recovery operation by ion exchange resins. Reuse in lead smelting operations. **Contact:** EPA CSI.

Option 4 - Improve phosphor solution recovery and recycling efficiencies to further reduce discharge of metals to the environment. **Contact:** EPA CSI.

Option 5- Reduce or recover the following:
¥ Chrome wastes
¥ Cleaning materials (hydrofluoric acids)
¥ EP effluent
¥ Furnaces slag
¥ Cullet dust
¥ Fugitive dust
¥ Refractory brick wastes
¥ Alcohols
Contact: EPA CSI.

V.C. Pollution Prevention Case Studies

The electronics/computer industry is actively involved in pollution prevention activities, especially for products such as semiconductors and printed wiring boards. Pollution prevention techniques are available and have been implemented successfully for processes such as cleaning, etching, electroplating, and wastewater treatment. California's *Assessment of the Semiconductor Industry Source Reduction Planning Efforts* provides additional information and case studies on pollution prevention techniques. Eastside Plating, Unisys Corporation, and Wacker Siltronic Corporation are examples of companies with successful pollution prevention programs. The pollution prevention activities employed in these three case studies provided each company with significant savings.

Eastside Plating, Portland, Oregon's oldest and largest electroplating facility, demonstrated that complying with environmental laws and implementing pollution prevention activities is cost effective. Eastside used three major pollution prevention techniques: water conservation, material substitution, and machinery automation and upgrade.

The first activity addressed the challenge of diminishing the use of water. Ninety percent of water required for electroplating is used during the rinsing process (to clean the wafer, end chemical reactions, and prevent contaminants from being released into the next bath). Eastside modified the rinsing process by installing two systems that conserve water: counter flow and cascade rinsing systems. Counter flow rinsing recycles and reuses water throughout a multiple tank system, reducing significantly the volume of water required. Fresh water is only introduced in the last tank of the system. Cascade rinsing also reduces the volume of water required. This system uses one tank with a center divider which allows the water to spill into the other side. During cascade rinsing, the tank is filled and drained slowly and continuously in order to reduce water consumption. Overflow from one tank can be used as the water supply for another compatible rinsing system.

Eastside also reduced chromium and cyanide wastes through material substitution. The reducing agent for chromic acid wastes was changed from ferrous sulfate to bisulfite and sulfuric acid, which reduced the volume of sludge produced. Cyanide wastes are reduced more efficiently with gaseous instead of liquid chlorine.

Finally, three major waste treatment components were upgraded or automated: the cyanide oxidation tank, chromium reduction tank, and the acid/alkali neutralization tank. The goal of automating and upgrading this equipment was to increase efficiency, separate tank flow, and eliminate contamination of acid/alkali neutralization tank. Automated metering equipment was installed and reduced the expensive caustic chemicals required to treat acid wastes by 50 percent. The cyanide and chromic acid oxidation tanks were redesigned as gravity flow systems to equalize flow rate and to eliminate the risks associated with plumbing failure. To prevent cross contamination of the tanks, the plumbing was segregated.

Other important steps taken by Eastside Plating to enhance pollution prevention included collaborating with suppliers on modifications to reaction and neutralization tanks, working with regulators to solve problems, and providing employee education.

The new rinsing systems, materials substitution, and upgrade/ automation of equipment cost Eastside $75,000. Overall, Eastside implemented changes to the operation which has saved the company more than $300,000 annually. In addition, pollution prevention and waste minimization has resulted in a cleaner facility, increased productivity, and a better product.

Unisys is a manufacturer of both large and small computers. In 1986, Unisys implemented pollution prevention/waste minimization techniques associated with the automated copper plating process in its printed circuit board manufacturing plant in Roseville, Minnesota. Unisys worked with Minnesota Technical Assistance Program (MnTAP) to reduce the two to three drums of wastewater treatment sludge produced each day.

MnTAP recommended several changes in the pretreatment process such as: segregation of the wastestreams; addition of flow control valves; installation of metal recovery equipment; and addition of a deionization system. Wastestream segregation involved changing the plumbing to separate the wastestreams containing metal contaminants. Another modification reduced overall water usage through the installation of flow control valves. Metal recovery techniques, such as ion exchange and electrolytic metal recovery, reclaim copper from metal-bearing wastestreams. The deionization systems allow the pretreatment process to operate more efficiently. Ion exchange and electrolytic recovery is enhanced by deionization by removing hard water ions in the process and rinse tanks. The modifications ensure environmental compliance, lower treatment chemical costs, and reduce sludge disposal costs by an estimated $90,000 per year. In addition, the pollution prevention and waste minimization changes have allowed Unisys to expand its plating line.

Wacker Siltronic Corporation, a semiconductor manufacturer, successfully implemented pollution prevention and waste minimization techniques similar to those employed by Unisys and Eastside. In order to maintain cleanliness in silicon wafer production, Wacker made extensive use of chloride solvent baths. Once the disposal of chlorinated solvent wastes at a Oregon hazardous waste facility was prohibited by Federal regulations, Wacker sought to recycle the solvents. However, the potential liability associated with transporting thousands of gallons of solvents to a recycling facility led Wacker to seek other alternatives. A six month pilot project was first implemented to decrease chlorinated solvent use which resulted in the elimination of 93 percent of Wacker's chlorinated solvent waste. Ultimately, Wacker eliminated completely the use of chlorinated solvents through replacement with non-hazardous cleaning products.

Wacker used to generate 2000 gallons of chrome VI waste each month, which needed to be sent off-site for disposal. Reduction of chrome waste to two to three drums each quarter involved three techniques: installation of a rain cover over the outdoor tanks; on-site treatment of chrome VI waste using caustics and sodium bisulfite; and repairing water leaks in the process rinse tank. The rain cover cost $7,000, but reduced the volume of waste shipments by 25 percent. The new treatment of the chrome VI liquid reduced it to a less hazardous chrome III sludge which can be dried and sent off-site for disposal. Repair of small leaks in the rinse tanks resulted in a 50 percent reduction of wastes. The cover, pipe repairs, and on-site treatment system cost $30,000 and led to a 95 percent reduction of chrome waste as well as annual savings of $15,000. The initial costs were recovered within three years.

A final pollution prevention waste minimization technique involved recycling Freon 113. An open-top still was converted into a closed-loop system at a cost of $20,000. The conversion reduced the volume of Freon waste by 85 percent and saves the company $57,000 each year. Overall, Wacker states that pollution prevention and waste minimization has resulted in annual savings of $300,000.

VI. SUMMARY OF FEDERAL STATUTES AND REGULATIONS

This section discusses the Federal statutes and regulations that may apply to this sector. The purpose of this section is to highlight, and briefly describe the applicable Federal requirements, and to provide citations for more detailed information. The three following sections are included.

¥ Section IV.A contains a general overview of major statutes
¥ Section IV.B contains a list of regulations specific to this industry
¥ Section IV.C contains a list of pending and proposed regulations

The descriptions within Section IV are intended solely for general information. Depending upon the nature or scope of the activities at a particular facility, these summaries may or may not necessarily describe all applicable environmental requirements. Moreover, they do not constitute formal interpretations or clarifications of the statutes and regulations. For further information, readers should consult the Code of Federal Regulations (CFR) and other State or local regulatory agencies. EPA Hotline contacts are also provided for each major statute.

VI.A. General Description of Major Statutes

Resource Conservation And Recovery Act

The Resource Conservation And Recovery Act (RCRA) of 1976 which amended the Solid Waste Disposal Act, addresses solid (Subtitle D) and hazardous (Subtitle C) waste management activities. The Hazardous and Solid Waste Amendments (HSWA) of 1984 strengthened RCRAÕs waste management provisions and added Subtitle I, which governs underground storage tanks (USTs).

Regulations promulgated pursuant to Subtitle C of RCRA (40 CFR Parts 260-299) establish a Òcradle-to-graveÓ system governing hazardous waste from the point of generation to disposal. RCRA hazardous wastes include the specific materials listed in the regulations (commercial chemical products, designated with the code "P" or "U"; hazardous wastes from specific industries/sources, designated with the code "K"; or hazardous wastes from non-specific sources, designated with the code "F") or materials which exhibit a hazardous waste characteristic (ignitibility, corrosivity, reactivity, or toxicity and designated with the code "D").

Regulated entities that generate hazardous waste are subject to waste accumulation, manifesting, and recordkeeping standards. Facilities that treat, store, or dispose of hazardous waste must obtain a permit, either from EPA or from a State agency which EPA has authorized to implement the permitting program. Subtitle C permits contain general facility standards such as contingency plans, emergency procedures, recordkeeping and reporting requirements, financial assurance mechanisms, and unit-specific standards. RCRA also contains provisions (40 CFR Part 264 Subpart S and ¤264.10) for conducting corrective actions which govern the cleanup of releases of hazardous waste or constituents from solid waste management units at RCRA-regulated facilities.

Although RCRA is a Federal statute, many States implement the RCRA program. Currently, EPA has delegated its authority to implement various provisions of RCRA to 46 of the 50 States.

Most RCRA requirements are not industry specific but apply to any company that transports, treats, stores, or disposes of hazardous waste. Here are some important RCRA regulatory requirements:

¥ **Identification of Solid and Hazardous Wastes** (40 CFR Part 261) lays out the procedure every generator should follow to determine whether the material created is considered a hazardous waste, solid waste, or is exempted from regulation.

¥ **Standards for Generators of Hazardous Waste** (40 CFR Part 262) establishes the responsibilities of hazardous waste generators including obtaining an ID number, preparing a manifest, ensuring proper packaging and labeling, meeting standards for waste accumulation units, and recordkeeping and reporting requirements. Generators can accumulate hazardous waste for up to 90 days (or 180 days depending on the amount of waste generated) without obtaining a permit.

¥ **Land Disposal Restrictions** (LDRs) are regulations prohibiting the disposal of hazardous waste on land without prior treatment. Under the LDRs (40 CFR 268), materials must meet land disposal restriction (LDR) treatment standards prior to placement in a RCRA land disposal unit (landfill, land treatment unit, waste pile, or surface impoundment). Wastes subject to the LDRs include solvents, electroplating wastes, heavy metals, and acids. Generators of waste subject to the LDRs must provide notification of such to the designated TSD facility to ensure proper treatment prior to disposal.

¥ **Used Oil Management Standards** (40 CFR 279) impose management requirements affecting the storage, transportation, burning, processing, and re-refining of the used oil. For parties that merely generate used oil, regulations establish storage standards. For a party considered a used oil marketer (one who generates and sells off-specification used oil directly to a used oil burner), additional tracking and paperwork requirements must be satisfied.

¥ **Tanks and Containers** used to store hazardous waste with a high volatile organic concentration must meet emission standards under RCRA. Regulations (40 CFR Part 264-265, Subpart CC) require generators to test the waste to determine the concentration of the waste, to satisfy tank and container emissions standards, and to inspect and monitor regulated units. These regulations apply to all facilities who store such waste, including generators operating under the 90-day accumulation rule.

- **Underground Storage Tanks** (USTs) containing petroleum and hazardous substance are regulated under Subtitle I of RCRA. Subtitle I regulations (40 CFR Part 280) contain tank design and release detection requirements, as well as financial responsibility and corrective action standards for USTs. The UST program also establishes increasingly stringent standards, including upgrade requirements for existing tanks, that must be met by 1998.
- **Boilers and Industrial Furnaces** (BIFs) that use or burn fuel containing hazardous waste must comply with strict design and operating standards. BIF regulations (40 CFR Part 266, Subpart H) address unit design, provide performance standards, require emissions monitoring, and restrict the type of waste that may be burned.

EPA's RCRA/Superfund/UST Hotline, at (800) 424-9346, responds to questions and distributes guidance regarding all RCRA regulations. The RCRA Hotline operates weekdays from 8:30 a.m. to 7:30 p.m., EST, excluding Federal holidays.

Comprehensive Environmental Response, Compensation, And Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a 1980 law commonly known as Superfund, authorizes EPA to respond to releases, or threatened releases, of hazardous substances that may endanger public health, welfare, or the environment. CERCLA also enables EPA to force parties responsible for environmental contamination to clean it up or to reimburse the Superfund for response costs incurred by EPA. The Superfund Amendments and Reauthorization Act (SARA) of 1986 revised various sections of CERCLA, extended the taxing authority for the Superfund, and created a free-standing law, SARA Title III, also known as the Emergency Planning and Community Right-to-Know Act (EPCRA).

The CERCLA **hazardous substance release reporting regulations** (40 CFR Part 302) direct the person in charge of a facility to report to the National Response Center (NRC) any environmental release of a hazardous substance which exceeds a reportable quantity. Reportable quantities are defined and listed in 40 CFR 302.4. A release report may trigger a response by EPA, or by one or more Federal or State emergency response authorities.

EPA implements **hazardous substance responses** according to procedures outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR Part 300). The NCP includes provisions for permanent cleanups, known as remedial actions, and other cleanups referred to as "removals." EPA generally takes remedial actions only at sites on the National Priorities List (NPL), which currently includes approximately 1300 sites. Both EPA and States can act at other sites; however, EPA provides responsible parties the opportunity to conduct removal and remedial actions and encourages community involvement throughout the Superfund response process.

EPA's RCRA/Superfund/UST Hotline, at (800) 424-9346, answers questions and references guidance pertaining to the Superfund program. The CERCLA Hotline operates weekdays from 8:30 a.m. to 7:30 p.m., EST, excluding Federal holidays.

Emergency Planning And Community Right-To-Know Act

The Superfund Amendments and Reauthorization Act (SARA) of 1986 created the Emergency Planning and Community Right-to-Know Act (EPCRA, also known as SARA Title III), a statute designed to improve community access to information about chemical hazards and to facilitate the development of chemical emergency response plans by State and local governments. EPCRA required the establishment of State emergency response commissions (SERCs), responsible for coordinating certain emergency response activities and for appointing local emergency planning committees (LEPCs).

EPCRA and the EPCRA regulations (40 CFR Parts 350-372) establish four types of reporting obligations for facilities which store or manage specified chemicals:

¥ **EPCRA ¤302** requires facilities to notify the SERC and LEPC of the presence of any "extremely hazardous substance" (the list of such substances is in 40 CFR Part 355, Appendices A and B) if it has such substance in excess of the substance's threshold planning quantity, and directs the facility to appoint an emergency response coordinator.

¥ **EPCRA ¤304** requires the facility to notify the SERC and the LEPC in the event of a release exceeding the reportable quantity of a CERCLA hazardous substance or an EPCRA extremely hazardous substance.

¥ **EPCRA ¤¤311 and 312** require a facility at which a hazardous chemical, as defined by the Occupational Safety and Health Act, is present in an amount exceeding a specified threshold to submit to the SERC, LEPC, and local fire department material safety data sheets (MSDSs) or lists of MSDSs and hazardous chemical inventory forms (also known as Tier I and II forms). This information helps the local government respond in the event of a spill or release of the chemical.

¥ **EPCRA ¤313** requires manufacturing facilities included in SIC codes 20 through 39, which have ten or more employees, and which manufacture, process, or use specified chemicals in amounts greater than threshold quantities, to submit an annual toxic chemical release report. This report, commonly known as the Form R, covers releases and transfers of toxic chemicals to various facilities and environmental media, and allows EPA to compile the national Toxic Release Inventory (TRI) database.

All information submitted pursuant to EPCRA regulations is publicly accessible, unless protected by a trade secret claim.

EPA's EPCRA Hotline, at (800) 535-0202, answers questions and distributes guidance regarding the emergency planning and community right-to-know regulations. The EPCRA Hotline operates weekdays from 8:30 a.m. to 7:30 p.m., EST, excluding Federal holidays.

Clean Water Act

The primary objective of the Federal Water Pollution Control Act, commonly referred to as the Clean Water Act (CWA), is to restore and maintain the chemical, physical, and biological integrity of the nation's surface waters. Pollutants regulated under the CWA include "priority" pollutants, including various toxic pollutants; "conventional" pollutants, such as biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform, oil and grease, and pH; and "non-conventional" pollutants, including any pollutant not identified as either conventional or priority.

The CWA regulates both direct and indirect discharges. The **National Pollutant**

Discharge Elimination System (NPDES) program (CWA ¤402) controls direct discharges into navigable waters. Direct discharges or "point source" discharges are from sources such as pipes and sewers. NPDES permits, issued by either EPA or an authorized State (EPA has presently authorized forty States to administer the NPDES program), contain industry-specific, technology-based and/or water quality-based limits, and establish pollutant monitoring and reporting requirements. A facility that intends to discharge into the nation's waters must obtain a permit prior to initiating its discharge. A permit applicant must provide quantitative analytical data identifying the types of pollutants present in the facility's effluent. The permit will then set forth the conditions and effluent limitations under which a facility may make a discharge.

A NPDES permit may also include discharge limits based on Federal or State water quality criteria or standards, that were designed to protect designated uses of surface waters, such as supporting aquatic life or recreation. These standards, unlike the technological standards, generally do not take into account technological feasibility or costs. Water quality criteria and standards vary from State to State, and site to site, depending on the use classification of the receiving body of water. Most States follow EPA guidelines which propose aquatic life and human health criteria for many of the 126 priority pollutants.

Storm Water Discharges

In 1987 the CWA was amended to require EPA to establish a program to address **storm water discharges**. In response, EPA promulgated the NPDES storm water permit application regulations. Storm water discharge associated with industrial activity means the discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant (40 CFR 122.26(b)(14)). These regulations require that facilities with the following storm water discharges apply for a NPDES permit: (1) a discharge associated with industrial activity; (2) a discharge from a large or medium municipal storm sewer system; or (3) a discharge which EPA or the State determines to contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.

The term "storm water discharge associated with industrial activity" means a storm water discharge from one of 11 categories of industrial activity defined at 40 CFR 122.26. Six of the categories are defined by SIC codes while the other five are identified through narrative descriptions of the regulated industrial activity. If the primary SIC code of the facility is one of those identified in the regulations, the facility is subject to the storm water permit application requirements. If any activity at a facility is covered by one of the five narrative categories, storm water discharges from those areas where the activities occur are subject to storm water discharge permit application requirements.

Those facilities/activities that are subject to storm water discharge permit application requirements are identified below. To determine whether a particular facility falls within one of these categories, the regulation should be consulted.

Category i: Facilities subject to storm water effluent guidelines, new source performance standards, or toxic pollutant effluent standards.

Category ii: Facilities classified as SIC 24-lumber and wood products (except wood kitchen cabinets); SIC 26-paper and allied products (except paperboard containers and products); SIC 28-chemicals and allied products (except drugs and paints); SIC 29-petroleum refining; and SIC 311-leather tanning and finishing.

Category iii: Facilities classified as SIC 10-metal mining; SIC 12-coal mining; SIC 13-oil and gas extraction; and SIC 14-nonmetallic mineral mining.

Category iv: Hazardous waste treatment, storage, or disposal facilities.

Category v: Landfills, land application sites, and open dumps that receive or have received industrial wastes.

Category vi: Facilities classified as SIC 5015-used motor vehicle parts; and SIC

5093-automotive scrap and waste material recycling facilities.

Category vii: Steam electric power generating facilities.

Category viii: Facilities classified as SIC 40-railroad transportation; SIC 41-local passenger transportation; SIC 42-trucking and warehousing (except public warehousing and storage); SIC 43-U.S. Postal Service; SIC 44-water transportation; SIC 45-transportation by air; and SIC 5171-petroleum bulk storage stations and terminals.

Category ix: Sewage treatment works.

Category x: Construction activities except operations that result in the disturbance of less than five acres of total land area.

Category xi: Facilities classified as SIC 20-food and kindred products; SIC 21-tobacco products; SIC 22-textile mill products; SIC 23-apparel related products; SIC 2434-wood kitchen cabinets manufacturing; SIC 25-furniture and fixtures; SIC 265-paperboard containers and boxes; SIC 267-converted paper and paperboard products; SIC 27-printing, publishing, and allied industries; SIC 283-drugs; SIC 285-paints, varnishes, lacquer, enamels, and allied products; SIC 30-rubber and plastics; SIC 31-leather and leather products (except leather and tanning and finishing); SIC 323-glass products; SIC 34-fabricated metal products (except fabricated structural metal); SIC 35-industrial and commercial machinery and computer equipment; SIC 36-electronic and other electrical equipment and components; SIC 37-transportation equipment (except ship and boat building and repairing); SIC 38-measuring, analyzing, and controlling instruments; SIC 39-miscellaneous manufacturing industries; and SIC 4221-4225-public warehousing and storage.

Pretreatment Program

Another type of discharge that is regulated by the CWA is one that goes to a publicly-owned treatment works (POTWs). The national **pretreatment program** (CWA ¤307(b)) controls the indirect discharge of pollutants to POTWs by "industrial users." Facilities regulated under ¤307(b) must meet certain pretreatment standards. The goal of the pretreatment program is to protect municipal wastewater treatment plants from damage that may occur when hazardous, toxic, or other wastes are discharged into a sewer system and to protect the quality of sludge generated by these plants. Discharges to a POTW are regulated primarily by the POTW itself, rather than the State or EPA.

EPA has developed technology-based standards for industrial users of POTWs. Different standards apply to existing and new sources within each category. "Categorical" pretreatment standards applicable to an industry on a nationwide basis are developed by EPA. In addition, another kind of pretreatment standard, "local limits," are developed by the POTW in order to assist the POTW in achieving the effluent limitations in its NPDES permit.

Regardless of whether a State is authorized to implement either the NPDES or the pretreatment program, if it develops its own program, it may enforce requirements more stringent than Federal standards.

EPAÕs Office of Water, at (202) 260-5700, will direct callers with questions about the CWA to the appropriate EPA office. EPA also maintains a bibliographic database of Office of Water publications which can be accessed through the Ground Water and Drinking Water resource center, at (202) 260-7786.

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) mandates that EPA establish regulations to protect human health from contaminants in drinking water. The law authorizes EPA to develop national drinking water standards and to create a joint Federal-State system to ensure compliance with these standards. The SDWA also directs EPA to protect underground sources of drinking water through the control of underground injection of liquid wastes.

EPA has developed primary and secondary drinking water standards under its SDWA authority. EPA and authorized States enforce the primary drinking water standards, which are, contaminant-specific concentration limits that apply to certain public drinking water supplies. Primary drinking water standards consist of maximum contaminant level goals (MCLGs), which are non-enforceable health-based goals, and maximum contaminant levels (MCLs), which are enforceable limits set as close to MCLGs as possible, considering cost and feasibility of attainment.

The SDWA **Underground Injection Control (UIC)** program (40 CFR Parts 144-148) is a permit program which protects underground sources of drinking water by regulating five classes of injection wells. UIC permits include design, operating, inspection, and monitoring requirements. Wells used to inject hazardous wastes must also comply with RCRA corrective action standards in order to be granted a RCRA permit, and must meet applicable RCRA land disposal restrictions standards. The UIC permit program is primarily State-enforced, since EPA has authorized all but a few States to administer the program.

The SDWA also provides for a Federally-implemented Sole Source Aquifer program, which prohibits Federal funds from being expended on projects that may contaminate the sole or principal source of drinking water for a given area, and for a State-implemented Wellhead Protection program, designed to protect drinking water wells and drinking water recharge areas.

EPAÕs Safe Drinking Water Hotline, at (800) 426-4791, answers questions and distributes guidance pertaining to SDWA standards. The Hotline operates from 9:00 a.m. through 5:30 p.m., EST, excluding Federal holidays.

Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) granted EPA authority to create a regulatory framework to collect data on chemicals in order to evaluate, assess, mitigate, and control risks which may be posed by their manufacture, processing, and use. TSCA provides a variety of control methods to prevent chemicals from posing unreasonable risk.

TSCA standards may apply at any point during a chemicalÕs life cycle. Under TSCA ¤5, EPA has established an inventory of chemical substances. If a chemical is not already on the inventory, and has not been excluded by TSCA, a premanufacture notice (PMN) must be submitted to EPA prior to manufacture or import. The PMN must identify the chemical and provide available information on health and environmental effects. If available data are not sufficient to evaluate the chemical's effects, EPA can impose restrictions pending the development of information on its health and environmental effects. EPA can also restrict significant new uses of chemicals based upon factors such as the projected volume and use of the chemical.

Under TSCA ¤6, EPA can ban the manufacture or distribution in commerce, limit the use, require labeling, or place other restrictions on chemicals that pose unreasonable risks. Among the chemicals EPA regulates under ¤6 authority are asbestos, chlorofluorocarbons (CFCs), and polychlorinated biphenyls (PCBs).

EPAÕs TSCA Assistance Information Service, at (202) 554-1404, answers questions and distributes guidance pertaining to Toxic Substances Control Act standards. The Service operates from 8:30 a.m. through 4:30 p.m., EST, excluding Federal holidays.

Clean Air Act

The Clean Air Act (CAA) and its amendments, including the Clean Air Act Amendments (CAAA) of 1990, are designed to Òprotect and enhance the nation's air resources so as to promote the public health and welfare and the productive capacity of the population.Ó The CAA consists of six sections, known as Titles, which direct EPA to establish national standards for ambient air quality and for EPA and the States to implement, maintain, and enforce these standards through a variety of mechanisms. Under the CAAA, many facilities will be required to obtain permits for the first time. State and local governments oversee, manage, and enforce many of the requirements of the CAAA. CAA regulations appear at 40 CFR Parts 50-99.

Pursuant to Title I of the CAA, EPA has established national ambient air quality standards (NAAQS) to limit levels of "criteria pollutants," including carbon monoxide, lead, nitrogen dioxide, particulate matter, ozone, and sulfur dioxide. Geographic areas that meet NAAQS for a given pollutant are classified as attainment areas; those that do not meet NAAQS are classified as non-attainment areas. Under ¤110 of the CAA, each State must develop a State Implementation Plan (SIP) to identify sources of air pollution and to determine what reductions are required to meet Federal air quality standards.

Title I also authorizes EPA to establish New Source Performance Standards (NSPS), which are nationally uniform emission standards for new stationary sources falling within particular industrial categories. NSPS are based on the pollution control technology available to that category of industrial source but allow the affected industries the flexibility to devise a cost-effective means of reducing emissions.

Under Title I, EPA establishes and enforces National Emission Standards for Hazardous Air Pollutants (NESHAP), nationally uniform standards oriented towards controlling particular hazardous air pollutants (HAPs). Title III of the CAAA further directed EPA to develop a list of sources that emit any of 189 HAPs, and to develop regulations for these categories of sources. To date, EPA has listed 174 categories and developed a schedule for the establishment of emission standards. The emission standards will be developed for both new and existing sources based on "maximum achievable control technology" (MACT). The MACT is defined as the control technology achieving the maximum degree of reduction in the emission of the HAPs.

Title II of the CAA pertains to mobile sources, such as cars, trucks, buses, and planes. Reformulated gasoline, automobile pollution control devices, and vapor recovery nozzles on gas pumps are a few of the mechanisms EPA uses to regulate mobile air emission sources.

Title IV establishes a sulfur dioxide emissions program designed to reduce the formation of acid rain. Reduction of sulfur dioxide releases will be obtained by granting to certain sources limited emissions allowances, which, beginning in 1995, will be set below previous levels of sulfur dioxide releases.

Title V of the CAAA of 1990 created a permit program for all "major sources" (and certain other sources) regulated under the CAA. One purpose of the operating permit is to include in a single document all air emissions requirements that apply to a given facility. States are developing the permit programs in accordance with guidance and regulations from EPA. Once a State program is approved by EPA, permits will be issued and monitored by that State.

Title VI is intended to protect stratospheric ozone by phasing out the manufacture of ozone-depleting chemicals and restrict their use and distribution. Production of Class I substances, including 15 kinds of chlorofluorocarbons (CFCs), will be phased out entirely by the year 2000, while certain hydrochlorofluorocarbons (HCFCs) will be phased out by 2030.

EPA's Control Technology Center, at (919) 541-0800, provides general assistance and information on CAA standards. The Stratospheric Ozone Information Hotline, at (800) 296-1996, provides general information about regulations promulgated under Title VI of the CAA, and EPA's EPCRA Hotline, at (800) 535-0202, answers questions about accidental release prevention under CAA ¤112(r). In addition, the Technology Transfer Network Bulletin Board System (modem access (919) 541-5742)) includes recent CAA rules, EPA guidance documents, and updates of EPA activities.

VI.B. Industry Specific Requirements

Clean Air Act (CAA)

Under the CAA, the National Ambient Air Quality Standards (NAAQS) have been established for six pollutants. The only one that significantly impacts the electronics/computer industry is the standard for ozone. While the electronics/computer industry is not a major source of ozone, it is a major source of volatile organic compounds (VOC). A source defined as "major" in ozone nonattainment areas must install Reasonable Available Control Technology (RACT) as prescribed in the applicable State Implementation Plan (SIP). A major source is both defined by the size of the source's emissions and the category of the nonattainment area. A determination of the necessary RACT requirements is made on the basis of a case by case review of each facility. In an attempt to issue uniform guidelines, EPA has begun to issue Control Technology Guidance (CTG) for each industrial category. The following CTGs may apply to the semiconductor industry:

¥ Miscellaneous Metal Parts and Products
¥ Plastic Parts
¥ Alternative Control Technology (ATG) for Solvent Cleaning.

Clean Water Act (CWA)

The National Pollution Discharge Elimination System (NPDES) permit program regulates the discharge of pollutants to the waters of the United States. A permit is required if a source discharges directly to surface waters. Facilities must provide the results of biological toxicity tests and any information on its "effluent characteristics.Ó The electronics/computer industry must test for all 126 priority pollutants listed in 40 CFR 122, Appendix D. Facilities must provide quantifiable data only for discharges of priority pollutants which the applicant knows or has reason to believe will be greater than trace amounts. Priority pollutants likely to be discharged by facilities in the electronics/computer industry include copper, lead, lead compounds, silver, chromium, and trichloroethylene.

Quantitative testing is required for non-conventional pollutants if they are expected to be present in discharges. Examples of hazardous substances and non-conventional pollutants likely to be discharged by the electronics/computer industry include butyl acetate, xylene, formaldehyde, tin-total, nitrate/nitrites, titanium-total, and chlorine-total residual.

The electronics/computer industry must satisfy the following technology-based effluent limitation guidelines:

- 40 CFR Part 469 applies to discharges from all processes associated with semiconductor manufacturing except sputtering, vapor deposition, and electroplating.
- 40 CFR Part 433 applies to semiconductor manufacturing plants that perform any of six metal finishing operations - electroplating, electroless plating, anodizing, coating, chemical etching, milling, and printed wired board manufacturing.
- 40 CFR Part 433 applies to discharges associated with the manufacture of printed wiring boards (PWB), except indirect discharging job shops and independent PWB manufacturers who discharge to POTWs, which are covered by Part 413.
- 40 CFR Part 469, Subpart C applies to discharges from display manufacturing.
- 40 CFR Part 469, Subpart D applies to discharges from the manufacturing of luminescent materials which are used in coatings in fluorescent lamps and cathode ray tubes. Luminescent materials include, but are not limited to, calcium halophosphate, zinc sulfide, and zinc-cadmium.
- 40 CFR Part 413 applies to electroplating of common metals, chemical etching and milling, and electroless plating. Subpart A refers to discharges of pollutants from processes that involve ferrous or nonferrous material electroplated with (or any combination of) copper, nickel, chromium, zinc, tin, lead, cadmium, iron, or aluminum. Subpart F applies to process wastewaters from chemical milling or etching of ferrous or nonferrous materials. Subpart G applies to process wastewaters from the electroless plating of a metallic layer on a metallic or nonmetallic substrate.

Facilities that discharge to POTWs must comply with categorical and general pretreatment requirements:

- 40 CFR Part 413, Subpart B applies to electroplating of precious metals or to discharges from a process in which a ferrous or nonferrous material is plated with, or a combination of, gold, silver, iridium, palladium, platinum, rhodium, or ruthenium.

Resource Conservation and Recovery Act (RCRA)

Many wastes generated by the electronics/computer industry are considered RCRA toxicity characteristic (TC) hazardous wastes due to constituents such as silver, trichloroethylene, and lead. The greatest quantities of RCRA listed waste and characteristic hazardous waste present in the electronics/computer industry are identified in Exhibit 30. For more information on RCRA hazardous waste, refer to 40 CFR Part 261.

Exhibit 34
Hazardous Wastes Relevant to the Electronics/Computer Industry

EPA Hazardous Waste No.	Hazardous Waste
D006 (cadmium) D007 (chromium) D008 (lead) D011 (silver)	Wastes which are hazardous due to the characteristic of toxicity for each of the constituents.
F001	Halogenated solvents used in degreasing: tetrachloroethylene, 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 10 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.
F002	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, one or more of the above halogenated solvents or those listed in F001, F004, F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.
F003	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 10% or more (by volume) of one of those solvents listed in F001, F002, F004, F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.
F004	Spent non-halogenated solvents: cresols and cresylic acid, and nitrobenzene; all spent solvent mixtures/blends containing, before use, a total of 10% 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.
F005	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 10% 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 solvents mixtures.
F006	Wastewater treatment sludges from electroplating operations except from the following processes: (1) sulfuric acid anodizing of aluminum; (2) tin plating on carbon steel; (3) zinc plating (segregated basis) on carbon steel; (4) aluminum or zinc-aluminum plating on carbon steel; (5) cleaning/stripping associated with tin, zinc, and aluminum plating on carbon steel; and (6) chemical etching and milling of aluminum.
F007	Spent cyanide plating bath solutions from electroplating operations.
F008	Plating bath residues from the bottom of plating baths from electroplating operations where cyanides are used in the process.
F009	Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process.

Source: Based on 1994 Sustainable Industry: Promoting Strategic Environmental Protection in the Industrial Sector, Phase 1 Report.

VI.B.1. Notable State Regulations

California's *Hazardous Waste Source Reduction and Management Review Act of 1988*, commonly referred to as SB14, requires generators that produce over 12,000 kilograms of hazardous waste or 12 kilograms of extremely hazardous waste to produce two documents every four years. The documents include a Source Reduction Plan and a Management Performance Report. The Act intends to promote hazardous waste reduction at the source and recycling. For more information on the compilation of these reports by the semiconductor industry, see the October 1994 *Assessment of the Semiconductor Industry Source Reduction Planning Efforts*, by the California Department of Toxic Substances Control.

According to Daryl Burn of the California Air Resources Board, the Board has promulgated Rule 830, Semiconductor Manufacturing Operations, which regulates VOC emissions from semiconductor manufacturing facilities. VOCs are released during wafer preparation, photolithography, and cleaning operations. Rule 830 was developed in 1988 for the Bay Area Air Quality Management District (San Francisco area) because a large concentration of semiconductor manufacturing facilities are located in South Bay and San Francisco. The Board does not provide assistance to facilities to help achieve compliance.

VI.C. Pending and Proposed Regulatory Requirements

SDWA/Underground Injection Control Wells (UIC)

New regulations are being developed for UIC which will amend 40 CFR 144 and 146. The regulations will establish minimum Federal requirements for the permitting, operating, monitoring, and closure of several types of shallow injection wells. Restrictions will be imposed on the operation of certain types of shallow disposal wells, especially those that inject industrial wastes. Computer manufacturing facilities located in areas without sewer systems that rely on shallow waste injection wells to dispose of industrial and non-sanitary wastes will be impacted by these regulations.

Resource Conservation and Recovery Act (RCRA)

RCRA prohibits the land disposal of most hazardous wastes until they meet a waste specific treatment standard. While most hazardous wastes have already been assigned treatment standards, EPA must still promulgate additional rule makings to address newly listed wastes and to make changes to the land disposal restrictions (LDR) program. Rules are required every time EPA lists a waste.

The Phase III LDR rulemaking proposes to establish treatment standards for some newly listed wastes and RCRA equivalent treatment standards for certain formerly characteristic hazardous wastes that are injected into UIC wells under the Safe Drinking Water Act (SDWA) or managed in Subtitle D surface impoundments prior to discharge pursuant to the Clean Water Act (CWA). By consent decree, EPA must promulgate the final rule for Phase III by January 1996.

Phase IV will similarly consider restrictions on other newly listed or identified wastes from land disposal and evaluate what, if any, treatment standards may be needed to mitigate the impact of sludges, leaks, and air emissions from surface impoundments that manage decharacterized wastes. In addition to considering restrictions on the land disposal of the previously exempt Bevill wastes and wastes from wood preserving, Phase IV will also consider adjustments to the treatment standards applicable to wastes that exhibit the toxicity characteristic for a metal constituent. Subject to the same consent decree, Phase IV has been assigned a judicial deadline of June 1996 for promulgation of a final rule.

Clean Air Act (CAA)

Lead NAAQS may impact the electronics/computer industry in the future. It is believed that emissions from the use of lead in soldering and other processes are not significant enough to subject facilities to air pollution control requirements. However, EPA has not yet studied the electronics/computer industry as a source of lead emissions.

Clean Air Act Amendments of 1990 (CAAA)

EPA promulgated a final NESHAP for chromium emissions from new and existing electroplating operations on January 25, 1995. The 1990 CAA Amendments (CAAA) list chromium compounds as a criteria air pollutant under ¤112. The purpose of the rule is to limit chromium emissions to the level of Maximum Achievable Control Technology (MACT) (60 FR 4948).

A NESHAP for halogenated solvent cleaning was issued December 2, 1994. The regulation applies to organic halogenated solvent cleaners (degreasers) using specified halogenated HAP solvents.

Several hazardous air pollutants (HAP) which are used in printed wired board manufacturing as well as semiconductor manufacturing and assembly are scheduled for MACT standards. According to IPC and EPA, these HAPs include: ethylene glycol; hydrochloric acid; hydrofluoric acid; lead compounds; and nickel compounds.

EPA is in the process of identifying industries that emit any substantial quantities of the 189 HAPs. Regulations that apply specifically to the semiconductor industry are expected in 1997.

Clean Water Act (CWA)

EPA is scheduled to propose effluent limitation guidelines and standards for metal products and machinery. These guidelines and standards will address facilities that generate wastewater while processing metal parts, products, and machinery. The proposal will also include facilities that generate wastewater during the following processes: manufacturing, assembly, repairing, rebuilding, and maintenance. Phase I of these guidelines and standards covers seven industries. The industries relevant to SIC code 36 and 35 are stationary industrial equipment (electrical equipment) and electronic equipment (including communication equipment). A notice of proposed rule making is expected to be published by November 1994, and final action on this proposed regulation is scheduled for May 1996.