

Table 1. Surrogates used for proportional allocation of area and mobile source emissions from county level to census tract level

Surrogate for emissions at census tract level	Emissions source categories
Population	Residential heating; architectural coatings; consumer products; non-industrial pesticide application; gasoline service stations; structure fires
1/Population density	Recreational vehicles; construction and construction equipment; aircraft; landfills; wastewater treatment
Roadway miles	Asphalt application
Combination of: Population and roadway miles	On-road mobile source emissions
Railway miles	Railroads
Residential land	Lawn and garden equipment
Commercial land	Commercial and institutional fuel combustion; commercial equipment; dry cleaners; commercial and institutional incinerators and landfills
Industrial land	Industrial fuel combustion; industrial equipment; chemical manufacturing; metal production and products; wood, rubber and plastics products; industrial coatings; degreasing and solvent utilization; chemical and fuel bulk stations/terminals and pipelines; incineration
Residential and commercial land	Non-industrial asphalt roofing
Commercial and industrial land	Petroleum and petroleum products storage and transport
Combination of: population and commercial land	Non-industrial solvent uses
Utility land	Electric utility fuel combustion
Farmland	Farm equipment; agricultural field burning
Orchard land	Orchard heaters
Agricultural land	Agriculture production
Rangeland	Oil and gas production
Forest land	Logging equipment; forest wildfires
Rangeland and forest land	Prescribed burning
Mining and quarry land	Mining and quarrying
Water	Marine vessels

Table 2. Estimated background concentrations of 28 hazardous air pollutants.

Pollutant	Background Concentration ($\mu\text{g}/\text{m}^3$)
Benzene	0.48
Bis(2-ethylhexyl) phthalate	1.60
Bromoform	0.021
Carbon disulfide	0.047
Carbon tetrachloride	0.88
Carbonyl sulfide	1.2
Chlordane	9.9E-06
Chloroform	0.083
Dibutylphthalate	0.0010
Dioxins/furans (toxicity equivalents)	1.5E-08
Ethylene dibromide	0.0077
Ethylene dichloride	0.061
Formaldehyde	0.25
Hexachlorobenzene	9.3E-05
Hexachlorobutadiene	0.0018
Hexachloroethane	0.0048
Lindane	0.00025
Mercury compounds	0.0015
Methyl bromide	0.039
Methyl chloride	1.2
Methyl chloroform	1.1
Methyl iodide	0.012
Methylene chloride	0.15
Phosgene	0.061
Polychlorinated biphenyls	0.00038
Tetrachloroethylene	0.14
Trichloroethylene	0.081
Xylene	0.17

Table 3. Characteristics of hazardous air pollutant monitoring programs used for ASPEN model evaluation. (Time period of data used for comparison.)

Monitoring Program	Number of Monitoring Sites	Number of Hazardous Air Pollutants¹
California Air Resources Board Ambient Toxics Network (1990)	20	14
San Francisco Bay Area Air Quality Management District (1990)	15	8
South Coast Air Quality Management District (CA) (1990)	4	11
Houston Regional Monitoring Corporation and South East Texas Regional Planning Commission (1990)	12	6
New York State Ambient Toxic Air Monitoring Network (1990)	10	10
Staten Island/New Jersey Urban Air Toxic Assessment Project (1988 – 1989)	3	7
Maryland Department of Environment, Baltimore City (1991 and 1992)	5	13
Urban Air Toxics Monitoring Program (UATMP) (1990 and 1991)	12	10

¹ Excludes HAPs in these programs for which measurements were dominated by values below the minimum detection level, and which therefore were not used for comparisons. Other pollutants not included in this study are also sampled in some of these programs.

Table 4. Population and area statistics for census tracts in the continental U.S.

Percentile	Population			Land Area (sq km)		
	Urban Census Tracts ¹	Rural Census Tracts	All Census Tracts	Urban Census Tracts	Rural Census Tracts	All Census Tracts
1	526	0	0	0.1	0.003	0.01
5	1354	143	739	0.2	1.3	0.2
10	1849	1073	1492	0.3	4.6	0.6
25	2747	2381	2560	0.9	12	1.7
50	3897	3637	3762	1.8	49	6
75	5378	5090	5230	3.1	212	60
90	7105	6763	6931	5	513	295
95	8338	7979	8143	6	942	543
99	11653	11407	11523	10	3084	2155
Mean	4283	3888	4072	2.3	243	131
Total	121 MM	126 MM	247 MM	0.07 MM	7.85MM	7.92 MM
Number of Census Tracts	28,314	32,354	60,668	28,314	32,354	60,668

MM = million

¹Urban census tracts are defined as those with population density of 750 or more people per square kilometer. Table excludes 135 census tracts with no population and no area.

Table 5. Summary statistics of ratios of ASPEN 1990 concentration predictions to monitored annual average concentrations, for HAPs with available monitoring data.

Pollutant	Number of sites	Geometric mean of ratios	Geometric standard deviation of ratios
Acetaldehyde	32	0.37	2.04
Benzene	81	0.69	1.92
1,3-butadiene	20	0.27	1.72
Carbon tetrachloride	63	1.03	1.42
Chloroform	44	0.62	1.78
Ethylbenzene	24	0.50	2.04
Formaldehyde	34	0.74	2.28
Hexane	2	1.30	1.51
Methanol	4	0.14	2.03
Methyl chloride	5	1.03	1.15
Methyl chloroform	70	0.77	2.18
Methylene chloride	29	0.20	2.12
p-dichlorobenzene	25	0.22	2.50
Styrene	25	0.10	3.00
Tetrachloroethylene	67	0.42	2.81
Toluene	81	0.47	2.06
Trichloroethylene	60	0.96	3.82
2,2,4-trimethylpentane	9	0.80	1.82
Xylene	61	0.48	2.02
OVERALL	736	0.53	2.63

Table 6. Classification of HAP health effects information for comparison with estimated outdoor concentrations¹.

Health Effect	Tier ²	Number of HAPs with value	Health Effect Value
Cancer ³	I	40	EPA inhalation unit risk for carcinogenicity
	II	37	EPA oral unit risk for carcinogenicity, expressed in inhalation units; California EPA inhalation unit risk estimate
Noncancer—Chronic ⁴	I	33	EPA inhalation reference concentration
	II	57	EPA provisional reference concentration; California EPA reference exposure level; Agency for Toxic Substances and Disease Registry minimum risk level
Noncancer—Acute ⁵	I	1	EPA inhalation reference concentration (developmental)
	II	15	EPA LOC/1000

¹ See Attachment 1 for benchmark concentrations for each HAP. Development of benchmark concentrations is described by Caldwell et al. (1998).

²The tiers indicate the level of priority for use of toxicological data. Tier I represents those values with the most consistency in derivation and highest level of peer review

³The pollutant groups arsenic, beryllium, cadmium, chromium, lead, and nickel compounds have each been assigned a single cancer benchmark concentration applicable to the entire group. Other HAPs with cancer benchmarks are individual pollutants.

⁴The pollutant groups manganese, cadmium, cobalt and selenium compounds have each been assigned a single chronic benchmark concentration applicable to the entire group. Other HAPs with chronic benchmarks are individual pollutants.

⁵The pollutant group chromium compounds has been assigned a single acute benchmark concentration applicable to the entire group. Other HAPs with acute benchmarks are individual pollutants.

Table 7. Exceedances of benchmark concentrations in urban and rural census tracts, for HAPs with exceedances in more than 50 urban census tracts.

Pollutant	Percentage of Urban Census Tracts Exceeding Benchmark ¹	Percentage of Rural Census Tracts Exceeding Benchmark ¹	Type of Benchmark			
			Cancer		Chronic	
			Tier I	Tier II	Tier I	Tier II
Benzene	100	100	X			
Bis(2-ethylhexyl)phthalate	100	100		X		
Carbon tetrachloride	100	100	X			
Chloroform	100	100	X			
Ethylene dibromide	100	100	X			
Ethylene dichloride	100	100	X			
Formaldehyde ²	100	100	X			
Methyl chloride	100	100	X			
Butadiene (1,3)	>99	95	X			
Acrolein ³	>99	84			X	
Chromium compounds ⁴	>99	80	X			
Dichloropropene (1,3)	96	27	X			
Acetaldehyde	86	28	X			
Arsenic compounds	77	23	X			
Nickel compounds	57	19	X			
Vinyl chloride	53	16	X			
p-dichlorobenzene	37	5		X		
Acrylonitrile	30	10	X			
Trichloroethylene	28	6	X			
Cadmium compounds	23	7	X			
Dioxins/Furans	22	4	X			
Lead compounds	20	3		X		
Tetrachloroethylene	6	1	X			
Ethylene oxide	3	0.8		X		
Methylene chloride	2	1	X			
Ethyl acrylate	2	0.8		X		
Hydrazine	1	0.5	X			
Quinoline	1	0.5		X		
Hexachlorobenzene	1	0.4	X			
Methylene diphenyl diisocyanate	0.8	0.2			X	
Manganese compounds	0.7	0.4			X	
Propylene dichloride	0.7	0.2		X		
Acrylamide	0.5	0.2	X			
Heptachlor	0.4	0.3	X			
Trichloroethane (1,1,2)	0.4	0.1	X			
Benzotrichloride	0.3	0.4		X		
PCBs	0.2	0.1	X			
Hexachlorocyclopentadiene	0.2	<0.1				X

¹ There are 28,314 urban census tracts and 32,489 rural census tracts.

² Formaldehyde also exceeds a chronic toxicity Tier II benchmark in 11% of urban census tracts and 2% of rural census tracts.

³Acrolein also exceeds an acute toxicity Tier II benchmark in 1% of urban census tracts and 1% of rural census tracts.

⁴Chromium also exceeds a chronic toxicity Tier II benchmark in 28% of urban census tracts and 6% of rural census tracts, and exceeds an acute toxicity Tier II benchmark in 0.1% of urban census tracts and 0.1% of rural census tracts.

Table 8. Exceedances of benchmark concentrations in urban and rural census tracts for eight HAPs with high background concentrations.

Pollutant	Background Concentration (ug/m ³)	Cancer Benchmark Concentration (ug/m ³)	Percentage of Census Tracts with Exceedances, Disregarding Background ¹	
			Urban	Rural
Benzene	0.48	0.12	>99	87
Bis(2-ethylhexyl) phthalate	1.6	0.25	<0.1	<0.1
Carbon tetrachloride	0.88	0.067	3	2
Chloroform	0.083	0.043	8	8
Ethylene dibromide	0.0077	0.0045	2	1
Ethylene dichloride	0.061	0.038	32	11
Formaldehyde	0.25	0.077	>99	90
Methyl chloride	1.2	0.56	0.2	0.2

¹ There are 28,314 urban census tracts and 32,489 rural census tracts.

Table 9. Exceedances of benchmark concentrations from area source concentrations in urban census tracts.

Pollutant	Percentage of Urban Census Tracts With Benchmark Exceedance ¹	Type of Benchmark			
		Cancer		Chronic	
		Tier I	Tier II	Tier I	Tier II
Butadiene(1,3)	99	X			
Acrolein	99			X	
Benzene	98	X			
Formaldehyde	98	X			
Dichloropropene (1,3)	96	X			
Chromium compounds	90	X			
Vinyl chloride	50		X		
p-dichlorobenzene	36	X			
Nickel compounds	34		X		
Ethylene dichloride	27	X			
Acrylonitrile	25	X			
Arsenic compounds	23	X			
Acetaldehyde	19	X			
Trichloroethylene	15	X			
Cadmium compounds	9	X			
Lead compounds	4		X		
Tetrachloroethylene	3	X			
Chloroform	2	X			
Carbon tetrachloride	2	X			
Ethyl acrylate	1		X		
Methylene chloride	0.5	X			
Dioxins/Furans	0.2	X			
Manganese compounds	0.2				X
Ethylene oxide	0.1		X		
Chloroprene	0.1				X
Propylene dichloride	0.1		X		
Hydrochloric acid	< 0.1			X	
Methyl tert-butyl ether	< 0.1		X		
Maleic anhydride	< 0.1				
Beryllium compounds	< 0.1	X			

¹Number of urban census tracts = 28314

Table 10. Exceedances of benchmark concentrations from point source concentrations for selected HAPs in urban census tracts¹.

Pollutant	Percentage of Urban Census Tracts With Benchmark Exceedance ²	Type of Benchmark			
		Cancer		Chronic	
		Tier I	Tier II	Tier I	Tier II
Chromium compounds	79	X			
Nickel compounds	26	X			
Benzene	25	X			
Arsenic compounds	23	X			
Formaldehyde	15	X			
Dioxins/Furans	12	X			
Butadiene(1,3)	10	X			
Vinyl chloride	7	X			
Ethylene dichloride	7	X			
Acrolein	6			X	
Acrylonitrile	5	X			
Chloroform	5	X			
Cadmium compounds	4	X			
Lead compounds	4		X		
Acetaldehyde	3	X			
Ethylene oxide	2		X		
Ethylene dibromide	2	X			
Trichloroethylene	2	X			
Hydrazine	1	X			
Quinoline	1		X		
Hexachlorobenzene	1	X			
Methylene diphenyl diisocyanate	0.8		X		
Propylene dichloride	0.6			X	
Methylene chloride	0.6	X			
Carbon tetrachloride	0.5	X			
Acrylamide	0.5	X			
Heptachlor	0.4	X			
Tetrachloroethylene	0.4	X			
Manganese compounds	0.4			X	
Trichloroethane(1,1,2)	0.4	X			
p-dichlorobenzene	0.3	X			
Benzotrichloride	0.3		X		
Hexachlorocyclopentadiene	0.2				X
Methyl chloride	0.1	X			

¹This table shows the percentage of urban census tracts with benchmark concentration exceedances resulting from estimated point source concentrations, for 34 HAPs with point source exceedances in more than 50 urban census tracts. An additional 29 HAPs, not shown in this table, have exceedances from point source concentrations in fewer than 50

urban census tracts. Eighteen out of these 29 have exceedances in fewer than 10 urban census tracts.

²Number of urban census tracts = 28314

Table 11. Exceedances of benchmark concentrations from mobile source concentrations in urban census tracts

Pollutant	Percentage of Urban Census Tracts With Benchmark Exceedance ¹	Type of Benchmark			
		Cancer		Chronic	
		Tier I	Tier II	Tier I	Tier II
Butadiene(1,3)	> 99	X			
Formaldehyde	> 99	X			
Benzene	> 99	X			
Acrolein	> 99				X
Chromium compounds	95	X			
Acetaldehyde	66	X			
Arsenic compounds	23	X			
Nickel compounds	5	X			
Lead compounds	< 0.1			X	
Cadmium compounds	< 0.1	X			

¹Number of urban census tracts = 28314

Table 12. Exceedances of benchmark concentrations in urban census tracts, by source category group, for HAPs with estimated exceedances in more than 50 urban census tracts.

POLLUTANT	Percentage of Urban Census Tracts Exceeding Benchmark Concentrations			
	Area Sources	Point Sources	Mobile Sources	Total ¹
Butadiene(1,3)	99	10	>99	>99
Acrolein	99	6	>99	>99
Benzene ²	98	25	>99	100
Formaldehyde ²	98	15	>99	100
Dichloropropene (1,3)	96	<0.1	0	96
Chromium compounds	90	79	95	>99
Vinyl chloride	50	7	0	53
p-dichlorobenzene	36	0.3	0	37
Nickel compounds	34	26	5	57
Ethylene dichloride ²	27	7	0	100
Acrylonitrile	25	5	0	30
Arsenic compounds	23	23	23	77
Acetaldehyde	19	3	66	86
Trichloroethylene ³	15	2	0	28
Cadmium compounds	9	4	<0.1	23
Lead compounds	4	4	<0.1	20
Tetrachloroethylene	3	0.4	0	6
Chloroform ²	2	5	0	100
Carbon tetrachloride ²	2	0.5	0	100
Ethyl acrylate	1	0.1	0	2
Methylene chloride ³	0.5	0.6	0	2
Dioxins/Furans ³	0.2	12	0	22
Manganese compounds	0.2	0.4	0	0.7
Ethylene oxide	0.1	2	0	3
Propylene dichloride	0.1	0.6	0	0.7
Ethylene dibromide ²	0	2	0	100
Methyl chloride ²	0	0.2	0	100
Bis(2-ethylhexyl)phthalate ²	0	<0.1	0	100
PCBs ²	0	0.1	0	0.2
Hydrazine	0	1	0	1
Quinoline	0	1	0	1
Hexachlorobenzene ³	0	1	0	1
MDI	0	0.8	0	0.8
Acrylamide	0	0.5	0	0.5
Heptachlor	0	0.4	0	0.4
Trichloroethane (1,1,2)	0	0.4	0	0.4
Benzotrichloride	0	0.3	0	0.3
Hexachlorocyclopentadiene	0	0.2	0	0.2

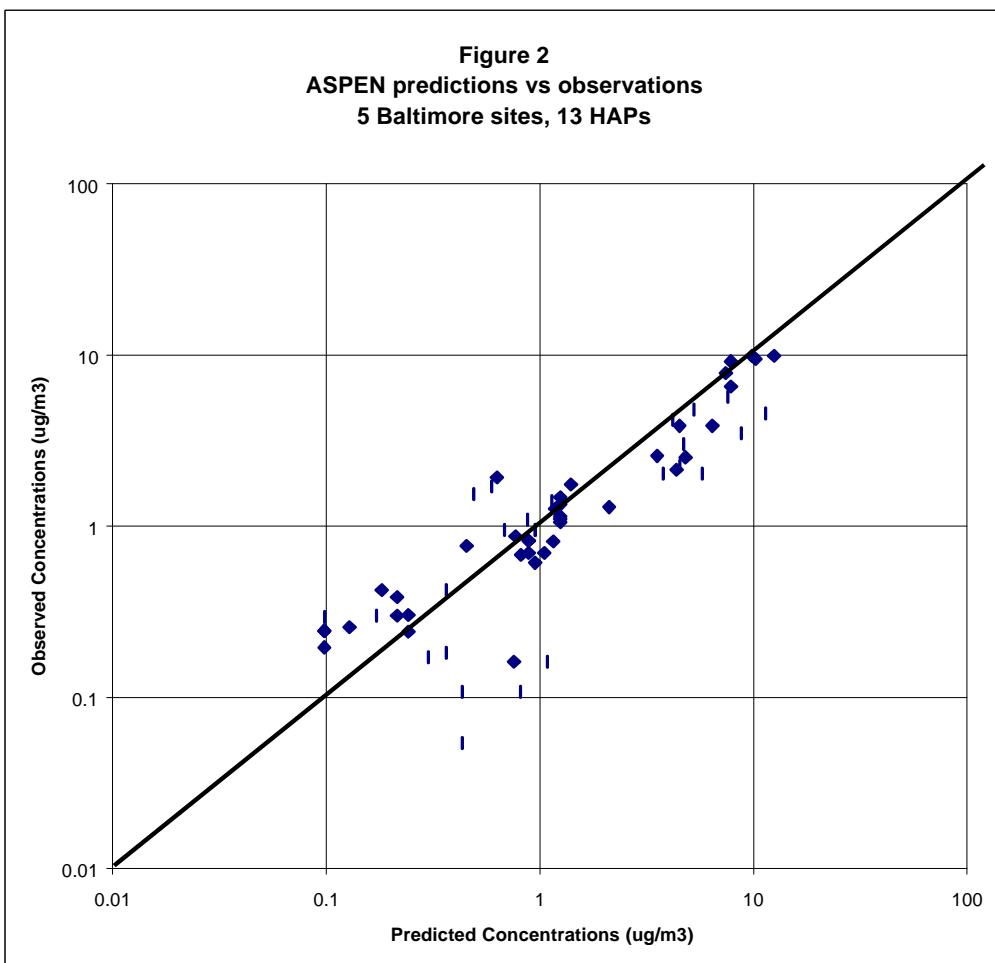
¹Percentage of urban census tracts with modeled concentrations exceeding benchmarks, considering combined contributions from all source categories and from background.

²Pollutants with estimated background concentrations greater than benchmark concentrations.

³Pollutants with estimated background concentrations greater than zero but less than benchmark concentrations.

Figure 1. Distribution of modeled concentrations in urban census tracts for 38 selected HAPs.

Figure 2
ASPEN predictions vs observations
5 Baltimore sites, 13 HAPs



Attachment 1
Benchmark Concentrations (ug/m³) for Hazardous Air Pollutants

HAP	Chronic Toxicity Tier 1	Chronic Toxicity Tier 2	Acute Toxicity	Cancer Tier 1	Cancer Tier 2
Acetaldehyde	9	.	.	0.45	.
Acetamide	0.05
Acetonitrile	.	50	.	.	.
Acetophenone
Acrolein	0.02	.	1.2	.	.
Acrylamide	.	0.7	.	0.00077	.
Acrylic acid	1	.	.	.	.
Acrylonitrile	2	.	.	0.015	.
Allyl chloride	1	.	.	.	0.17
Aniline	1	.	.	.	0.63
Anisidine	0.025
Antimony compounds
Arsenic compounds	.	0.5	.	0.00023	.
Benzene	.	71	.	0.12	.
Benzotrichloride	.	.	0.7	.	0.00028
Benzyl chloride	.	12	5.2	.	0.02
Beryllium compounds	.	0.0048	.	0.00042	.
Biphenyl
Bis(2-ethylhexyl)phthalate	.	71	.	.	0.25
Bis(chloromethyl)ether	.	.	.	0.000016	.
Bromoform	.	.	.	0.91	.
Butadiene(1,3)	.	8.0	.	.0036	.
Cadmium compounds	.	3.5	.	0.00056	.
Calcium cyanamide
Captan	1
Carbaryl
Carbon disulfide	700	.	.	.	.
Carbon tetrachloride	.	2.4	.	0.067	.
Carbonyl sulfide
Catechol
Chloramben
Chlordane	.	0.018	.	0.0027	.
Chloroacetic acid	.	.	1.8	.	.
Chlorobenzene	.	70	.	.	.
Chloroform	.	35	.	0.043	.

HAP	Chronic Toxicity Tier 1	Chronic Toxicity Tier 2	Acute Toxicity	Cancer Tier 1	Cancer Tier 2
Chloromethyl methyl ether	.	.	1.8	.	0.0014
Chloroprene	.	1	.	.	.
Chromium compounds	.	0.002	0.05	0.000083	.
Cobalt compounds	.	0.0050	.	.	.
Cresol	.	180	.	.	.
Cumene
Cyanide compounds
D(2,4)
Dibutylphthalate
Dichlorobenzidene(3,3')	0.0078
Dichloroethyl ether	.	.	.	0.003	.
Dichloropropene(1,3)	20	.	.	0.027	.
Dichlorvos	0.50	.	.	.	0.012
Diethanolamine
Diethyle sulfate
Dimethoxybenzidine(3,3')	0.0067
Dimethyl formamide	30	.	.	.	.
Dimethyl hydrazine(1,1)	.	0.022	.	.	0.0004
Dimethyl phthalate
Dimethyl sulfate	.	.	5	.	.
dinitro-o-cresol(4,6)	.	.	0.5	.	.
Dinitrophenol(2,4)
Dinitrotoluene(2,4)	.	7.0	.	.	0.0091
dioxane(1,4)	.	400	.	.	0.32
Epichlorohydrin	1	.	.	0.83	.
Epoxybutane(1,2)	20	.	.	.	.
Ethyl acrylate	.	48	.	.	0.073
Ethyl carbamate	0.036
Ethyl chloride	10,000	.	.	.	.
Ethylbenzene	1000	.	.	.	.
Ethylene dibromide	.	0.20	.	0.0045	.
Ethylene dichloride	.	95	.	0.038	.
Ethylene glycol
Ethylene oxide	.	600	540	.	0.043
Ethylene thiourea	.	3.0	.	.	0.032
Ethyldenedichloride	0.63
Formaldehyde	.	3.6	.	0.077	.
Glycol ethers

HAP	Chronic Toxicity Tier 1	Chronic Toxicity Tier 2	Acute Toxicity	Cancer Tier 1	Cancer Tier 2
Heptachlor	.	.	.	0.00077	.
Hexachlorobenzene	.	2.8	.	0.0022	.
Hexachlorobutadiene	.	90	.	0.045	.
Hexachlorocyclopentadiene	.	0.07	0.02	.	.
Hexachloroethane	.	80	.	0.25	.
Hexane	200	.	.	.	.
Hydrazine	.	0.24	.	0.0002	.
Hydrochloric acid	20	.	.	.	.
Hydrofluoric acid	.	5.9	1.6	.	.
Hydroquinone	.	.	.	.	.
Lead compounds	.	1.5	.	.	0.013
Lindane	.	1.0	.	0.0026	.
Maleic anhydride	.	2.4	.	.	.
Manganese compounds	0.05	.	.	.	.
Methyl ethyl ketone	1000	.	.	.	.
Mercury compounds	.	.	.	.	.
Methanol	.	620	.	.	.
Methoxychlor	.	.	.	.	.
Methyl bromide	5	.	.	.	.
Methyl chloride	.	.	.	0.56	.
Methyl chloroform	.	320	.	.	.
Methyl hydrazine	.	.	0.94	.	0.0032
Methyl iodide	10	.	.	.	.
Methyl isobutyl ketone	.	.	.	.	.
Methyl isocyanate	.	0.36	4.7	.	.
Methyl methacrylate	.	980	.	.	.
Methyl tert-butyl ether	3000	.	.	.	6
Methylene bis(2-chloroaniline)	.	.	.	.	0.011
Methylene chloride	.	3000	.	2.1	.
Methylene diphenyl diisocyanate	0.02	.	.	.	.
Methylenedianiline(4,4')	.	1.9	.	.	0.0022
N,N-diethyl/dimethylaniline	.	.	.	.	.
Naphthalene	.	14	.	.	.
Nickel compounds	.	0.24	.	0.0042	.
Nitrobenzene	.	1.7	.	.	.
nitrophenol(4)	.	.	.	.	.
nitropropane(2)	20	.	.	.	.
o-toluidine	.	.	.	.	0.18

HAP	Chronic Toxicity Tier 1	Chronic Toxicity Tier 2	Acute Toxicity	Cancer Tier 1	Cancer Tier 2
p-dichlorobenzene	800	.	.	.	0.15
p-phenylenediamine	.	.	.	.	.
Parathion	.	.	2	.	.
PCDD/PCDFs	.	3.5E-06	.	3.00E-08	.
Pentachloronitrobenzene	.	.	.	.	0.014
Pentachlorophenol	.	0.2	.	.	0.033
Phenol	.	45	.	.	.
Phosgene	.	0.30	0.8	.	.
Phthalic anhydride	120	.	.	.	.
Polychlorinated biphenyls	.	1.2	.	0.0020	.
Polycyclic organic matter	.	.	.	.	.
Propionaldehyde	.	.	.	.	.
Propoxur	.	.	.	.	0.91
Propylene dichloride	4	.	.	.	0.053
Propylene oxide	30	.	.	0.27	.
Propylenimine(1,2)	.	.	.	.	0.00015
Quinoline	.	.	.	.	0.00029
Quinone	.	.	.	.	.
Selenium compounds	.	0.5	.	.	.
Styrene	1000	.	.	.	.
Styrene oxide	.	6.0	.	.	0.022
Tetrachloroethane(1,1,2,2)	.	.	.	0.017	.
Tetrachloroethylene	.	35	.	1.7	.
Toluene	400	.	.	.	.
Toluene diamine(2,4)	.	.	.	.	0.0011
Toluene diisocyanate(2,4)	0.07	.	7	.	0.091
Trichlorobenzene(1,2,4)	200	.	.	.	.
Trichloroethane(1,1,2)	.	400	.	0.063	.
Trichloroethylene	.	640	.	0.59	.
Trichlorophenol(2,4,6)	.	.	.	0.32	.
Trifluralin	.	.	.	.	0.45
Trimethylpentane(2,2,4)	.	.	.	.	.
Vinyl acetate	200	.	.	.	.
Vinyl bromide	3	.	.	0.031	.
Vinyl chloride	.	26	.	0.012	.
Vinylidene chloride	.	32	.	0.02	.
Xylene	.	300	.	.	.