United States
Environmental Protection
Agency

Office of Wastewater
Management 4203

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Local Limits Development Guidance Appendices

APPENDICES

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APPENDIX A -
LIST OF SUPPLEMENTAL DOCUMENTS

GENERAL GUIDANCE ON PRETREATMENT				
TITLE	**DATE**	**EPA Number**	**NTIS Number**	**ERIC Number**
CERCLA Site Discharges to POTWs Guidance Manual	August 1990	540-G-90-005	PB90-274531	W150
Control Authority Pretreatment Audit Checklist and Instructions	May 1992	--	--	--
Control of Slug Loadings To POTWs: Guidance Manual	February 1991	21W-4001	--	--
Environmental Regulations and Technology: The National Pretreatment Program	July 1986	625-10-86-005	PB90-246521	W350
Guidance for Conducting a Pretreatment Compliance Inspection	September 1991	300-R-92-009	PB94-120631	W273
Guidance For Developing Control Authority Enforcement Response Plans	September 1989	--	PB90-185083/AS	--
Guidance for Reporting and Evaluating POTW Noncompliance with Pretreatment Implementation Requirements	September 1987	--	PB95-157764	W304
Guidance Manual for POTW Pretreatment Program Development	October 1983	--	PB93-186112	W639
Guidance Manual for POTWs to Calculate the Economic Benefit of Noncompliance	September 1990	833-B-93-007	--	--
Guidance Manual for Preparation and Review of Removal Credit Applications	July 1985	833-B-85-200	--	--
Guidance Manual for Preventing Interference at POTWs	September 1987	833-B-87-201	PB92-117969	W106
Guidance Manual for the Control of Wastes Hauled to Publicly Owned Treatment Works	September 1999	833-B-98-003	--	--
Guidance Manual for the Identification of Hazardous Wastes Delivered to Publicly Owned Treatment Works by Truck, Rail, or Dedicated Pipe	June 1987	--	PB92-149251	W202
Guidance Manual for the Use of Production-Based Pretreatment Standards and the Combined Wastestream Formula	September 1985	833-B-85-201	PB92-232024	U095
Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program	December 1987	833-B-87-202	PB92-129188	W107
Guidance on Evaluation, Resolution, and Documentation of Analytical Problems Associated with Compliance Monitoring	June 1993	821-B-93-001	--	--
Guidance on the Privatization of Federally Funded Wastewater Treatment Works	August 2000	832-B-00-002	--	--
Guidance to Protect POTW Workers From Toxic And Reactive Gases And Vapors	June 1992	812-B-92-001	PB92-173236	W115

GENERAL GUIDANCE ON PRETREATMENT				
TITLE	**DATE**	**EPA Number**	**NTIS Number**	**ERIC Number**
Guides to Pollution Prevention: Municipal Pretreatment Programs	October 1993	625-R-93-006	--	--
Industrial User Inspection and Sampling Manual For POTWs	April 1994	831-B-94-001	PB94-170271	W305
Industrial User Permitting Guidance Manual	September 1989	833-B-89-001	PB92-123017	W109
Metals Translator: Guidance for Calculating a Total Recoverable Permit Limit from a Dissolved Criterion	June 1996	823-B-96-007	--	--
Model Pretreatment Ordinance	June 1992	833-B-92-003	PB93-122414	W108
Multijurisdictional Pretreatment Programs: Guidance Manual	June 1994	833-B-94-005	PB94-203544	W607
National Pretreatment Program: Report to Congress	July 1991	21-W-4004	PB91-228726	W694
NPDES Compliance Inspection Manual	September 1994	300-B-94-014	--	--
Pollution Prevention (P2) Guidance Manual for the Pesticide Formulating, Packaging, and Repackaging Industry: Implementing the P2 Alternative	June 1998	821-B-98-017	--	--
POTW Sludge Sampling and Analysis Guidance Document	August 1989	833-B-89-100	--	--
Prelim User's Guide, Documentation for the EPA Computer Program/Model for Developing Local Limits for Industrial Pretreatment Programs at Publicly Owned Treatment Works, Version 5.0	January 1997	--	--	--
Pretreatment Compliance Inspection and Audit Manual For Approval Authorities	July 1986	833-B-86-100	PB90-183625	W277
Pretreatment Compliance Monitoring and Enforcement Guidance and Software (Version 3.0)	(Manual) September 1986 (Software) September 1992	(Software) 831-F-92-001	(Software) PB94-118577	(Software) W269
Procedures Manual for Reviewing a POTW Pretreatment Program Submission	October 1983	833-B-83-200	PB93-209880	W137
Procuring Analytical Services: Guidance for Industrial Pretreatment Programs	October 1998	833-B-98-004	--	--
Region III Guidance for Setting Local Limits for a Pollutant Where the Domestic Loading Exceeds the Maximum Allowable Headworks Loading	June 1994	--	--	--
Protecting the Nation's Waters Through Effective NPDES Permits: A Strategic Plan FY 2001 and Beyond	June 2001	833-R-01-001	--	--
RCRA Information on Hazardous Wastes for Publicly Owned Treatment Works	September 1985	833-B-85-202	PB92-114396	W351
Report to Congress on the Discharge of Hazardous Wastes to Publicly Owned Treatment Works	February 1986	530-SW-86-004	PB86-184017 & PB95-157228	W922 & W692

GENERAL GUIDANCE ON PRETREATMENT				
TITLE	**DATE**	**EPA Number**	**NTIS Number**	**ERIC Number**
Supplemental Manual On the Development And Implementation of Local Discharge Limitations Under The Pretreatment Program	May 1991	21W-4002	PB93-209872	W113

Source: Updated, originally part of U.S. EPA's *Introduction to the National Pretreatment Program*, EPA-833-B-98-002, February 1999, pp. 51-52

GUIDANCE ON INDUSTRY PRETREATMENT STANDARDS				
TITLE	**DATE**	**EPA Number**	**NTIS Number**	**ERIC Number**
Aluminum, Copper, And Nonferrous Metals Forming And Metal Powders Pretreatment Standards: A Guidance Manual	December 1989	800-B-89-001	PB91-145441	W119
Guidance Manual For Battery Manufacturing Pretreatment Standards	August 1987	440-1-87-014	PB92-117951	W195
Guidance Manual for Electroplating and Metal Finishing Pretreatment Standard	February 1984	440-1-84-091-G	PB87-192597	W118
Guidance Manual For Implementing Total Toxic Organics (TTO) Pretreatment Standards	September 1985	440-1-85-009-T	PB93-167005	W339
Guidance Manual For Iron And Steel Manufacturing Pretreatment Standards	September 1985	821-B-85-001	PB92-114388	W103
Guidance Manual for Leather Tanning and Finishing Pretreatment Standards	September 1986	800-R-86-001	PB92-232024	W117
Guidance Manual for Pulp, Paper, and Paperboard and Builders' Paper and Board Mills Pretreatment Standards	July 1984	--	PB92-231638	W196
Guidance Manual for the Use of Production-Based Pretreatment Standards and the Combined Wastestream Formula	September 1985	833-B-85-201	PB92-232024	U095
Permit Guidance Document: Pulp, Paper, and Paperboard Manufacturing Point Source Category (40 CFR Section 430)	May 2000	821-B-00-003	PB2002-106590	--
Permit Guidance Document: Transportation Equipment Cleaning Point Source Category (40 CFR 422)	March 2001	821-R-01-021	--	--
Small Entity Compliance Guide: Centralized Waste Treatment Guidelines and Pretreatment Standards (40 CFR 437)	June 2001	821-B-01-003	--	--

Source: Updated, originally part of U.S. EPA's *Introduction to the National Pretreatment Program*, EPA-833-B-98-002, February 1999, pp. 51-52

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APPENDIX B - INDUSTRIAL CATEGORIES WITH PRETREATMENT STANDARDS

Source: U.S. EPA's *Introduction to the National Pretreatment Program*, EPA-833-B-98-002, February 1999, Figure 13, p. 14. (Updated)

Category (SIC Codes)* [NAICS Codes]**	40 CFR Part (Sub-parts)	Type of Standard***	Overview of Pretreatment Standards
Aluminum Forming (3353, 3354, 3355, 3357, 3363) [331315, 331316, 331319, 331521]	467(A-F)	PSES PSNS	Limits are production-based, daily maximums and monthly averages. Subpart C prohibits discharges from certain operations.
Battery Manufacturing (3691, 3692) [335911, 335912]	461(A-G)	PSES PSNS	Limits are production-based, daily maximums and monthly averages. No discharge is allowed from any process not specifically identified in the regulations.
Carbon Black Manufacturing (2895) [325182]	458 (A-D)	PSNS	Limits are for Oil & Grease only (no limit duration specified).
Centralized Waste Treatment (4953) [562211, 562219]	437 (A-D)	PSES PSNS	Limits are concentration-based, daily maximums and monthly averages.
Coil Coating (3411, 3479, 3492) [332431, 332812]	465 (A-D)	PSES PSNS	Limits are production-based, daily maximums and monthly averages.
Commercial Hazardous Waste Combustors (4953, 2819, 2869, 3241, 1422, 1429, 1459) [562213, 212312, 325188, 325199, 327310]	444 (A)	PSES PSNS	Limits are concentration-based daily maximums or maximum monthly averages.
Concentrated Animal Feeding Operations (0211, 0213, 0214, 0241, 0251, 0252, 0253, 0254, 0259, 0272) [112112, 11221, 11241, 11242, 112111, 11212, 11232, 11231, 11233, 11234, 11239, 11292]	412 (B)	PSNS	Discharge of process wastewater is prohibited, except when there is an overflow resulting from a chronic or catastrophic rainfall event.
Copper Forming (3351, 3357, 3463) [331421, 331422, 332112]	468 (A)	PSES PSNS	Limits are production-based, daily maximums and monthly averages.
Electrical and Electronic Components (3671, 3674, 3679) [334411, 334413, 334419]	469 (A-D)	PSES PSNS	Limits are concentration-based, daily maximums and 30-day averages or monthly averages (varies per subpart and pollutant parameter). Certification is allowed in lieu of monitoring for certain pollutants when a management plan is approved and implemented.

Category (SIC Codes)* [NAICS Codes]**	40 CFR Part (Sub-parts)	Type of Standard***	Overview of Pretreatment Standards
Electroplating (3471, 3672) [332813, 334412]	413 (A-B, D-H)	PSES	Limits are concentration-based (or alternative mass-based equivalents), daily maximums and four consecutive monitoring days averages. Two sets of limits exist, depending on if facility discharges more or less than 10,000 gallons per day of process wastewater. Certification is allowed in lieu of monitoring for certain pollutants when a management plan is approved and implemented.
Fertilizer Manufacturing (2873, 2874, 2875) [325311, 325312, 325314]	418 (A-G)	PSNS	Limits may specify zero discharge of wastewater pollutants (Subpart A), production-based daily maximums and 30-day averages (Subparts B-E) or concentration-based (Subparts F-G) with no limit duration specified.
Glass Manufacturing (3211, 3221, 3296) [327211, 327212, 327993]	426 (H, K-M)	PSNS	Limits are either concentration- or production-based, daily maximums and monthly averages.
Grain Mills (2041, 2043, 2044, 2045, 2046, 2047) [311111, 311211, 311212, 311213, 311221, 311230]	406 (A)	PSNS	Discharge of process wastewater is prohibited at a flow rate or mass loading rate which is excessive over any time period during the peak load at a POTW.
Ink Formulating (2893) [325910]	447 (A)	PSNS	Regulations specify no discharge of process wastewater pollutants to the POTW.
Inorganic Chemicals Manufacturing (2812, 2813, 2816, 2819) [325120, 325131, 325181, 325188]	415 (A-BO)	PSES PSNS	Limits vary for each subpart with a majority of the limits concentration-based, daily maximums and 30-day averages, or may specify no discharge of wastewater pollutants. Numerous subparts have no pretreatment standards.
Iron and Steel Manufacturing (3312, 3315, 3316, 3317, 3479) [331111, 331210, 331221, 331222, 332812]	420 (A-F, H-J, L, M)	PSES PSNS	Limits are production-based, daily maximums and 30 day averages, or may specify no discharge of wastewater pollutants.
Leather Tanning and Finishing (3111) [316110]	425 (A-I)	PSES PSNS	Limits are concentration-based, daily maximums and monthly averages. In certain instances, production volume dictates applicable pretreatment standards.
Metal Finishing (Industry groups: 34, 35, 36, 37, 38) [Industry Subsectors: 332, 333, 334, 336]	433 (A)	PSES PSNS	Limits are concentration-based, daily maximums and monthly averages. Certification is allowed for certain pollutants where a management plan is approved and implemented.
Metal Molding and Casting (3321, 3322, 3324, 3325, 3365, 3366, 3369) [331511, 331512, 331513, 331524, 331525, 331528]	464 (A-D)	PSES PSNS	Limits are primarily production-based, daily maximums and monthly averages. Discharges from certain processes are prohibited (Subparts A-C).
Nonferrous Metals Forming and Metal Powders (3356, 3357, 3363, 3497, 3499) [331491, 331422, 331521, 332117, 332999]	471 (A-J)	PSES PSNS	Limits are production-based, daily maximums and monthly averages. In some instances, the regulations prohibit the discharge of wastewater pollutants.

Category (SIC Codes)* [NAICS Codes]**	40 CFR Part (Sub-parts)	Type of Standard***	Overview of Pretreatment Standards
Nonferrous Metals Manufacturing (2819, 3331, 3334, 3339, 3341) [331311, 331312, 331314, 331411, 331419, 331423, 331492]	421 (B-AE)	PSES PSNS	Limits are production-based, daily maximums and monthly averages. The majority of the Subparts have both existing and new source limits, with others having solely new source requirements. In some instances, the regulations prohibit the discharge of wastewater pollutants.
Oil and Gas Extraction (1311) [211111]	435 (D)	PSES PSNS	Regulations specify no discharge of process wastewater (drilling fluieds, deck drainage, etc.) pollutants to the POTW.
Organic Chemicals, Plastics, and Synthetic Fibers (2821, 2823, 2824, 2865, 2869) [325211, 325221, 325222, 32511, 325132, 325192, 325188]]	414 (B-H, K)	PSES PSNS	Limits are mass-based (concentration-based standards multiplied by process flow), daily maximums and monthly averages. Standards for metals and cyanide apply only to metal- or cyanide-bearing wastestreams.
Paint Formulating (2851) [325510]	446 (A)	PSNS	Regulations specify no discharge of process wastewater pollutants to the POTW.
Paving and Roofing Materials (Tars and Asphalt) (2951, 2952, 3996) [324121, 324122, 326192]	443 (A-D)	PSNS	Limits are for Oil & Grease only (no limit duration specified).
Pesticide Chemicals (2879) [325320]	455 (A, C, E)	PSES PSNS	Limits are mass-based (concentration-based standards multiplied by process flow), daily maximums and monthly averages. Subpart C specifies no discharge of process wastewater pollutants but provides for pollution prevention alternatives. Subpart E specifies no discharge of process wastewater pollutants.
Petroleum Refining (2911) [324110]	419 (A-E)	PSES PSNS	Limits are concentration-based (or mass-based equivalent), daily maximums.
Pharmaceutical Manufacturing (2833, 2834) [325411, 325412]	439 (A-D)	PSES PSNS	Limits are concentration-based, daily maximums and monthly averages. Subpart A and C facilities may certify they do not use or generate cyanide in lieu of performing monitoring to demonstrate compliance.
Porcelain Enameling (3431, 3469, 3479, 3631, 3632, 3633, 3639) [332116, 332812, 332998, 335221, 335222, 335224, 335228]	466 (A-D)	PSES PSNS	Limits are concentration-based (or alternative production-based), daily maximums and monthly averages. Subpart B prohibits discharges certain operations.
Pulp, Paper, and Paperboard (2611, 2621, 2631) [322110, 322121, 322122, 322130]	430 (A-G, I-L)	PSES PSNS	Limits are production-based or concentration-based (or alternative production-based) daily maximums and monthly averages. These facilities may certify they do not use certain compounds in lieu of performing monitoring to demonstrate compliance. Facilities subject to Subparts B and E must also implement Best Management Practices as identified.
Rubber Manufacturing (2822) [325212]	428 (E-K)	PSNS	Limits are concentration- or production-based, daily maximums and monthly averages.

Category (SIC Codes)* [NAICS Codes]**	40 CFR Part (Sub-parts)	Type of Standard***	Overview of Pretreatment Standards
Soap and Detergent Manufacturing (2841) [325611]	417 (O-R)	PSNS	Regulations specify no discharge of process wastewater pollutants to the POTW.
Steam Electric Power Generating (4911) [221112]	423	PSES PSNS	Limits are either concentration-based, daily maximums, or "maximums for any time," or compliance can be demonstrated through engineering calculations. In some instances, the regulations prohibit the discharge of wastewater pollutants.
Timber Products Processing (2421, 2435, 2436, 2491, 2493, 2499) [321114, 321219, 321211, 321212]	429 (F-H)	PSES PSNS	All PSNS (and PSES for Subpart F) prohibit the discharge of wastewater pollutants. PSES for Subparts G and H are concentration-based, daily maximums (with production-based alternatives).
Transportation Equipment Cleaning (4491, 4499, 4741, 7699) [484230, 488320, 488390, 488210]	442 (A-C)	PSES PSNS	Limits are concentration-based daily maximums. Subpart A and B allow for a pollutant as an alternative to achieving PSES or PSNS.

* SIC = Standard Industrial Classification, 1987 SIC Manual
** NAICS = North American Industry Classification System, 1997 NAICS Manual.
*** PSNS = Pretreatment Standard New Source; PSES = Pretreatment Standard Existing Source

APPENDIX C - POLLUTANTS REGULATED BY CATEGORICAL PRETREATMENT STANDARDS

	Aluminum Forming	Battery Manufacturing	Carbon Black Manufacturing	Centralized Waste Treatment	Coil Coating	Copper Forming	Electrical and Electronic Components	Electroplating	Feedlots	Fertilizer Manufacturing	Glass Manufacturing	Grain Mills	Ink Formulating	Inorganic Chemicals Manufacturing	Iron and Steel Manufacturing	Leather Tanning and Finishing	Metal Finishing	Metal Molding and Casting	Nonferrous Metals Form./Metal Powders	Nonferrous Metals Manufacturing	Oil and Gas	Organic Chems., Plastics, and Syn. Fibers	Paint Formulating	Paving and Roofing Materials	Pesticide Chemicals	Petroleum Refining	Pharmaceutical Manufacturing	Porcelain Enameling	Pulp, Paper, and Paperboard	Rubber Manufacturing	Soap and Detergent Manufacturing	Steam Electric Power Generating	Timber Products Processing	Transportation Equip. Cleaning	Waste Combustors
Flow Restrictions Only									X				X								X		X								X				
Ammonia (as N)										X					X				X	X						X	X								
BOD												X																							
COD														X																X					
Fluoride					X		X				X			X					X	X															
Nitrate (as N)										X																									
Oil and Grease	X		X		X	X												X						X		X				X			X	
Oil (mineral)											X																								
Organic Nitrogen (as N)										X																									
pH										X				X		X																			
Phenols															X			X		X															
Phosphorus					X					X																									
Sulfide																X																			
TSS												X																							X
1,1-Dichloroethane					X			X									X					X									X			
1,1-Dichloroethylene					X		X	X									X					X			X						X			
1,1,1-Trichloroethane					X	X	X	X									X	X				X			X						X			
1,1,2-Trichloroethane							X	X									X					X									X			
1,1,2,2-Tetra-chloroethane					X			X									X														X			
1,2-Dichlorobenzene							X	X									X					X			X		X				X			
1,2-Dichloroethane							X	X									X					X			X		X				X			
1,2-Dichloropropane								X									X					X			X						X			
1,2-Diphenyl-hydrazine	X						X	X									X														X			
1,2-trans-Dichloroethylene								X									X					X			X						X			

	Aluminum Forming	Battery Manufacturing	Carbon Black Manufacturing	Centralized Waste Treatment	Coil Coating	Copper Forming	Electrical and Electronic Components	Electroplating	Feedlots	Fertilizer Manufacturing	Glass Manufacturing	Grain Mills	Ink Formulating	Inorganic Chemicals Manufacturing	Iron and Steel Manufacturing	Leather Tanning and Finishing	Metal Finishing	Metal Molding and Casting	Nonferrous Metals Form./Metal Powders	Nonferrous Metals Manufacturing	Oil and Gas	Organic Chems., Plastics, and Syn. Fibers	Paint Formulating	Paving and Roofing Materials	Pesticide Chemicals	Petroleum Refining	Pharmaceutical Manufacturing	Porcelain Enameling	Pulp, Paper, and Paperboard	Rubber Manufacturing	Soap and Detergent Manufacturing	Steam Electric Power Generating	Timber Products Processing	Transportation Equip. Cleaning	Waste Combustors
1,2,4-Trichloro-benzene							X	X									X					X										X			
1,3-Dichloro-benzene							X	X									X					X										X			
1,3-Dichloro-propene								X									X					X			X							X			
1,4-Dichloro-benzene							X	X									X					X			X							X			
2-Chloroethyl vinyl ether (mixed)								X									X															X			
2-Chloro-naphthalene								X									X															X			
2-Chlorophenol	X						X	X									X	X														X			
2-Nitrophenol							X	X									X					X										X			
2,3-Dichloro-aniline				X																															
2,3,4,6-Tetra-chlorophenol																													X						
2,4-Dichlorophenol							X	X									X	X														X			
2,4-Dimethyl-phenol								X									X	X														X			
2,4-Dinitrophenol								X									X															X			
2,4-Dinitro-toluene	X							X									X															X			
2,4,5-Trichloro-phenol																													X						
2,4,6-Trichloro-phenol				X			X	X									X	X											X			X			
2,6-Dinitro-toluene						X		X									X															X			
3,3-Dichloro-benzidine								X									X															X			
3,4,5-Trichloro-catechol																													X						
3,4,5-Trichloro-guaiacol																													X						
3,4,6-Trichloro-catechol																													X						
3,4,6-Trichloro-guaiacol																													X						
4-Bromophenyl phenyl ether								X									X															X			

	Aluminum Forming	Battery Manufacturing	Carbon Black Manufacturing	Centralized Waste Treatment	Coil Coating	Copper Forming	Electrical and Electronic Components	Electroplating	Feedlots	Fertilizer Manufacturing	Glass Manufacturing	Grain Mills	Ink Formulating	Inorganic Chemicals Manufacturing	Iron and Steel Manufacturing	Leather Tanning and Finishing	Metal Finishing	Metal Molding and Casting	Nonferrous Metals Form./Metal Powders	Nonferrous Metals Manufacturing	Oil and Gas	Organic Chems., Plastics, and Syn. Fibers	Paint Formulating	Paving and Roofing Materials	Pesticide Chemicals	Petroleum Refining	Pharmaceutical Manufacturing	Porcelain Enameling	Pulp, Paper, and Paperboard	Rubber Manufacturing	Soap and Detergent Manufacturing	Steam Electric Power Generating	Timber Products Processing	Transportation Equip. Cleaning	Waste Combustors
4-Chlorophenyl phenyl ether								X									X															X			
4-Nitrophenol							X	X									X	X				X										X			
4,4-DDD								X									X															X			
4,4-DDE								X									X															X			
4,4-DDT								X									X															X			
4,5,6-Trichloro-quaiacol																													X						
4,6-Dinitro-o-cresol								X									X					X										X			
Acenaphthene	X							X									X	X				X										X			
Acenaphthylene	X							X									X	X														X			
Acetone																											X								
Acrolein								X									X															X			
Acrylonitrile								X									X															X			
Aldrin								X									X															X			
Alpha-BHC								X									X															X			
Alpha-endosulfan								X									X															X			
Anthracene	X					X	X	X									X	X				X										X			
Benzene						X		X									X	X				X			X		X					X			
Benzidine								X									X															X			
Benzo (b) fluoranthene	X							X									X	X														X			
Benzo (a) anthracene								X									X	X														X			
Benzo (ghi) perylene	X							X									X															X			
Benzo (a) pyrene	X							X									X	X		X												X			
Benzo (k) fluoranthene								X									X	X														X			
Beta-BHC								X									X															X			
Beta-endosulfan								X									X															X			
Bis (2-chloro-ethoxy) methane								X									X															X			
Bis (2-chloro-isopropyl) ether								X									X															X			
Bis (2-chloro-ethyl) ether					X			X									X															X			
Bis (2-ethyl-hexyl) phthalate	X			X	X		X	X									X	X				X										X			
Bromoform								X									X								X							X			

	Aluminum Forming	Battery Manufacturing	Carbon Black Manufacturing	Centralized Waste Treatment	Coil Coating	Copper Forming	Electrical and Electronic Components	Electroplating	Feedlots	Fertilizer Manufacturing	Glass Manufacturing	Grain Mills	Ink Formulating	Inorganic Chemicals Manufacturing	Iron and Steel Manufacturing	Leather Tanning and Finishing	Metal Finishing	Metal Molding and Casting	Nonferrous Metals Form./Metal Powders	Nonferrous Metals Manufacturing	Oil and Gas	Organic Chems., Plastics, and Syn. Fibers	Paint Formulating	Paving and Roofing Materials	Pesticide Chemicals	Petroleum Refining	Pharmaceutical Manufacturing	Porcelain Enameling	Pulp, Paper, and Paperboard	Rubber Manufacturing	Soap and Detergent Manufacturing	Steam Electric Power Generating	Timber Products Processing	Transportation Equip. Cleaning	Waste Combustors
Butyl benzyl phthalate					X		X	X									X	X													X			
Carbon tetrachloride							X	X									X					X			X						X			
Carbazole				X																														
Chlordane (tech. mix. & metabolites)								X									X														X			
Chlorobenzene								X									X	X				X			X		X				X			
Chlorodibromo-methane								X									X								X						X			
Chloroethane								X									X					X									X			
Chloroform					X	X	X	X									X	X				X			X		X		X		X			
Chrysene	X							X									X	X													X			
Cresol				X																														
Delta-BHC								X									X														X			
Di-n-butyl phthalate	X				X		X	X									X	X													X			
Di-n-octyl phthalate								X									X														X			
Dibenzo (a,h) anthracene	X							X									X														X			
Dichlorobromo-methane							X	X									X								X						X			
Dieldrin								X									X														X			
Diethyl phthalate	X							X									X	X				X									X			
Diethylamine																											X							
Dimethyl phthalate								X									X	X				X									X			
Endosulfan sulfate	X							X									X														X			
Endrin	X							X									X														X			
Endrin aldehyde	X							X									X														X			
Ethyl acetate																											X							
Ethylbenzene	X					X	X	X									X					X			X						X			
Fluoranthene	X			X				X									X	X				X									X		X	
Fluorene	X							X									X	X				X									X			
Gamma-BHC								X									X														X			
Heptachlor epoxide								X									X														X			
Heptachlor								X									X														X			

	Aluminum Forming	Battery Manufacturing	Carbon Black Manufacturing	Centralized Waste Treatment	Coil Coating	Copper Forming	Electrical and Electronic Components	Electroplating	Feedlots	Fertilizer Manufacturing	Glass Manufacturing	Grain Mills	Ink Formulating	Inorganic Chemicals Manufacturing	Iron and Steel Manufacturing	Leather Tanning and Finishing	Metal Finishing	Metal Molding and Casting	Nonferrous Metals Form./Metal Powders	Nonferrous Metals Manufacturing	Oil and Gas	Organic Chems., Plastics, and Syn. Fibers	Paint Formulating	Paving and Roofing Materials	Pesticide Chemicals	Petroleum Refining	Pharmaceutical Manufacturing	Porcelain Enameling	Pulp, Paper, and Paperboard	Rubber Manufacturing	Soap and Detergent Manufacturing	Steam Electric Power Generating	Timber Products Processing	Transportation Equip. Cleaning	Waste Combustors
Hexachloro-benzene								X									X			X		X										X			
Hexachlorobuta-diene								X									X															X			
Hexachlorocyclo pentadiene								X									X					X										X			
Hexachloro-ethane								X									X					X										X			
Indeno (1,2,3-cd)pyrene	X							X									X															X			
Isobutylaldehyde																											X								
Isophorone	X						X	X									X															X			
Isopropyl acetate																											X								
Isopropyl ether																											X								
Methyl formate																											X								
Methyl bromide								X									X								X							X			
Methyl cellosolve																											X								
Methyl Isobutyl Ketone																											X								
Methyl chloride								X									X					X			X							X			
Methylene chloride					X	X	X	X									X	X				X			X		X					X			
n-Amyl acetate																											X								
n-Butyl acetate																											X								
n-Decane				X																															
n-Heptane																											X								
n-Hexane																											X								
N-nitrosodi-n-propylamine								X									X		X										X			X			
N-nitrosodi-methylamine								X									X		X													X			
N-nitrosodi-phenylamine	X					X		X									X		X													X			
n-Octadecane				X																															
Naphthalene	X					X	X	X							X		X	X				X			X							X			
Nitrobenzene								X									X					X										X			
Non-polar material (SGT-HEM)																																		X	
Parachloro-metacresol	X							X									X	X														X			
PCB–1016	X							X									X					X										X			

	Aluminum Forming	Battery Manufacturing	Carbon Black Manufacturing	Centralized Waste Treatment	Coil Coating	Copper Forming	Electrical and Electronic Components	Electroplating	Feedlots	Fertilizer Manufacturing	Glass Manufacturing	Grain Mills	Ink Formulating	Inorganic Chemicals Manufacturing	Iron and Steel Manufacturing	Leather Tanning and Finishing	Metal Finishing	Metal Molding and Casting	Nonferrous Metals Form./Metal Powders	Nonferrous Metals Manufacturing	Oil and Gas	Organic Chems., Plastics, and Syn. Fibers	Paint Formulating	Paving and Roofing Materials	Pesticide Chemicals	Petroleum Refining	Pharmaceutical Manufacturing	Porcelain Enameling	Pulp, Paper, and Paperboard	Rubber Manufacturing	Soap and Detergent Manufacturing	Steam Electric Power Generating	Timber Products Processing	Transportation Equip. Cleaning	Waste Combustors
PCB–1221	X							X									X														X			
PCB–1232	X							X									X														X			
PCB–1242	X							X									X														X			
PCB–1248	X							X									X														X			
PCB–1254	X							X									X														X			
PCB–1260	X							X									X														X			
Pentachloro-phenol					X		X	X									X	X													X			
Phenanthrene	X				X	X		X									X	X				X									X		X	
Phenol	X						X	X									X	X													X			
Pyrene	X							X									X	X				X									X			
TCDF																													X					
Tetrachloro-catechol																													X					
Tetrachloro-ethylene	X				X		X	X							X		X	X				X			X						X			
Tetrachloro-guaiacol																													X					
Tetrahydrofuran																											X							
Toluene	X				X	X	X	X									X	X				X			X		X				X			
Toxaphene								X									X														X			
Trichloro-ethylene	X					X	X	X									X	X				X									X			
Trichlorosyringol																													X					
Triethylamine																											X							
Vinyl chloride								X									X					X									X			
Xylenes																											X							
2,3,7,8-tetrachloro-dibenzo-p-dioxin								X									X												X			X		
Organic Pesticide Active Ingredients																									X									
Antimony				X			X							X					X	X											X			
Arsenic				X			X							X						X											X	X		X
Asbestos																															X			
Barium				X																														
Beryllium																				X											X			
Cadmium		X		X			X	X						X			X		X	X											X		X	X
Chromium, Total	X	X		X	X	X	X	X						X	X	X	X		X	X						X		X		X		X	X	X	X

	Aluminum Forming	Battery Manufacturing	Carbon Black Manufacturing	Centralized Waste Treatment	Coil Coating	Copper Forming	Electrical and Electronic Components	Electroplating	Feedlots	Fertilizer Manufacturing	Glass Manufacturing	Grain Mills	Ink Formulating	Inorganic Chemicals Manufacturing	Iron and Steel Manufacturing	Leather Tanning and Finishing	Metal Finishing	Metal Molding and Casting	Nonferrous Metals Form./Metal Powders	Nonferrous Metals Manufacturing	Oil and Gas	Organic Chems., Plastics, and Syn. Fibers	Paint Formulating	Paving and Roofing Materials	Pesticide Chemicals	Petroleum Refining	Pharmaceutical Manufacturing	Porcelain Enameling	Pulp, Paper, and Paperboard	Rubber Manufacturing	Soap and Detergent Manufacturing	Steam Electric Power Generating	Timber Products Processing	Transportation Equip. Cleaning	Waste Combustors
Chromium, Hexavalent														X	X																				
Cobalt		X		X										X						X															
Copper		X		X	X	X		X						X			X	X	X	X												X	X	X	X
Cyanide, Total	X	X		X	X			X						X	X		X		X	X		X			X		X					X			
Cyanide, Amenable														X			X																			
Gold																				X															
Indium																				X															
Iron														X						X															
Lead		X		X		X	X	X						X	X		X	X	X	X		X			X			X		X		X		X	X
Manganese		X			X																														
Mercury		X		X										X						X												X		X	X
Molybdenum				X															X	X															
Nickel		X		X		X		X						X	X		X		X	X								X				X		X	
Palladium																				X															
Platinum																				X															
Selenium				X										X						X												X			
Silver		X		X				X						X			X		X	X												X			X
Tantalum																				X															
Thallium																																X			
Tin				X																X															
Titanium				X																X															X
Tungsten																				X															
Vanadium				X																															
Zinc	X	X		X	X	X	X	X						X	X		X	X	X	X		X						X	X	X		X		X	X

Source: Updated from the 1991 *National Pretreatment Program Report to Congress*, pp. 5-6.

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APPENDIX D - CLEAN WATER ACT PRIORITY POLLUTANTS AND THE FEDERAL WATER QUALITY CRITERIA

The appendix below lists, in three tables, the National Recommended Water Quality Criteria for:

- Specific chemical compounds that are identified by unique Chemical Abstract Service (CAS) registry numbers;
- Priority pollutants in the form of the Criteria Maximum Concentration (CMC) and Criterion Continuous Concentration (CCC);
- Non-priority pollutants in the form of the Criteria Maximum Concentration (CMC) and Criterion Continuous Concentration (CCC) for non-priority pollutants;
- Organoleptic effects in the form of Organoleptic Effect Criteria.

Please see page D-16 for further discussion and definitions of these criteria.

NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR PRIORITY POLLUTANTS

	Priority Pollutant	CAS Number	Freshwater CMC (µg/L)	Freshwater CCC (µg/L)	Saltwater CMC (µg/L)	Saltwater CCC (µg/L)	Human Health For Consumption of: Water + Organism (µg/L)	Human Health For Consumption of: Organism Only (µg/L)	FR Cite/Source
1	Antimony	7440360					14 B,Z	4300 B	57FR60848
2	Arsenic	7440382	340 A,D,K	150 A,D,K	69 A,D,bb	36 A,D,bb	0.018 C,M,S	0.14 C,M,S	62FR42160 57FR60848
3	Beryllium	7440417					J,Z	J	62FR42160
4	Cadmium	7440439	4.3 D,E,K	2.2 D,E,K	42 D,bb	9.3 D,bb	J,Z	J	62FR42160
5a	Chromium III	16065831	570 D,E,K	74 D,E,K			J,Z Total	J	EPA820/B-96 -001 62FR42160
5b	Chromium VI	18540299	16 D,K	11 D,K	1,100 D,bb	50 D,bb	J,Z Total	J	62FR42160
6	Copper	7440508	13 D,E,K,cc	9.0 D,E,K,cc	4.8 D,cc,ff	3.1 D,cc,ff	1,300 U		62FR42160
7	Lead	7439921	65 D,E,bb,gg	2.5 D,E,bb,gg	210 D,bb	8.1 D,bb	J	J	62FR42160
8	Mercury	7439976	1.4 D,K,hh	0.77 D,K,hh	1.8 D,ee,hh	0.94 D,ee,hh	0.050 B	0.051 B	62FR42160
9	Nickel	7440020	470 D,E,K	52 D,E,K	74 D,bb	8.2 D,bb	610 B	4,600 B	62FR42160
10	Selenium	7782492	L,R,T	5.0 T	290 D,bb,dd	71 D,bb,dd	170Z	11,000	62FR42160 IRIS 09/01/91
11	Silver	7440224	3.4 D,E,G		1.9 D,G				62FR42160
12	Thallium	7440280					1.7 B	6.3 B	57FR60848
13	Zinc	7440666	120 D,E,K	120 D,E,K	90 D,bb	81 D,bb	9,100 U	69,000 U	62FR42160 IRIS 10/01/92

NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR PRIORITY POLLUTANTS

	Priority Pollutant	CAS Number	Freshwater CMC (µg/L)	Freshwater CCC (µg/L)	Saltwater CMC (µg/L)	Saltwater CCC (µg/L)	Human Health For Consumption of: Water + Organism (µg/L)	Human Health For Consumption of: Organism Only (µg/L)	FR Cite/Source
14	Cyanide	57125	22 K,Q	5.2 K,Q	1 Q,bb	1 Q,bb	700 B,Z	220,000 B,H	EPA820/B-96-001 57FR60848
15	Asbestos	1332214					7 million fibers/L I		57FR60848
16	2,3,7,8-TCDD (Dioxin)	1746016					1.3E-8 C	1.4E-8 C	62FR42160
17	Acrolein	107028					320	780	57FR60848
18	Acrylonitrile	107131					0.059 B,C	0.66 B,C	57FR60848
19	Benzene	71432					1.2 B,C	71 B,C	62FR42160
20	Bromoform	75252					4.3 B,C	360 B,C	62FR42160
21	Carbon Tetrachloride	56235					0.25 B,C	4.4 B,C	57FR60848
22	Chlorobenzene	108907					680 B,Z	21,000 B,H	57FR60848
23	Chlorodibromomethane	124481					0.41 B,C	34 B,C	62FR42160
24	Chloroethane	75003							
25	2-Chloroethylvinyl Ether	110758							
26	Chloroform	67663					5.7 B,C	470 B,C	62FR42160
27	Dichlorobromomethane	75274					0.56 B,C	46 B,C	62FR42160
28	1,1-Dichloroethane	75343							
29	1,2-Dichloroethane	107062					0.38 B,C	99 B,C	57FR60848
30	1,1-Dichloroethylene	75354					0.057 B,C	3.2 B,C	57FR60848

NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR PRIORITY POLLUTANTS

	Priority Pollutant	CAS Number	Freshwater CMC (µg/L)	Freshwater CCC (µg/L)	Saltwater CMC (µg/L)	Saltwater CCC (µg/L)	Human Health For Consumption of: Water + Organism (µg/L)	Human Health For Consumption of: Organism Only (µg/L)	FR Cite/Source
31	1,2-Dichloropropane	78875					0.52 B,C	39 B,C	62FR42160
32	1,3-Dichloropropene	542756					10 B	1,700 B	57FR60848
33	Ethylbenzene	100414					3,100 B,Z	29,000 B	62FR42160
34	Methyl Bromide	74839					48 B	4000 B	62FR42160
35	Methyl Chloride	74873					J	J	62FR42160
36	Methylene Chloride	75092					4.7 B,C	1600 B,C	62FR42160
37	1,1,2,2-Tetrachloroethane	79345					0.17 B,C	11 B,C	57FR60848
38	Tetrachloroethylene	127184					0.8 C	8.85 C	57FR60848
39	Toluene	108883					6,800 B,Z	200,000 B	62FR42160
40	1,2-Trans-Dichloroethylene	156605					700 B,Z	140,000 B	62FR42160
41	1,1,1-Trichloroethane	71556					J,Z	J	62FR42160
42	1,1,2-Trichloroethane	79005					0.60 B,C	42 B,C	57FR60848
43	Trichloroethylene	79016					2.7 C	81 C	57FR60848
44	Vinyl Chloride	75014					2.0 C	525 C	57FR60848
45	2-Chlorophenol	95578					120 B,U	400 B,U	62FR42160
46	2,4-Dichlorophenol	120832					93 B,U	790 B,U	57FR60848
47	2,4-Dimethylphenol	105679					540 B,U	2,300 B,U	62FR42160
48	2-Methyl-4,6-Dinitrophenol	534521					13.4	765	57FR60848
49	2,4-Dinitrophenol	51285					70 B	14,000 B	57FR60848
50	2-Nitrophenol	88755							
51	4-Nitrophenol	100027							
52	3-Methyl-4-Chlorophenol	59507					U	U	

NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR PRIORITY POLLUTANTS

	Priority Pollutant	CAS Number	Freshwater CMC (µg/L)	Freshwater CCC (µg/L)	Saltwater CMC (µg/L)	Saltwater CCC (µg/L)	Human Health For Consumption of: Water + Organism (µg/L)	Human Health For Consumption of: Organism Only (µg/L)	FR Cite/Source
53	Pentachlorophenol	87865	19F,K	15F,K	13bb	7.9bb	0.28 B,C	8.2 B,C,H	62FR42160
54	Phenol	108952					21,000 B,U	4,600,000 B,H,U	62FR42160 57FR60848
55	2,4,6-Trichlorophenol	88062					2.1 B,C,U	6.5 B,C	62FR42160
56	Acenaphthene	83329					1,200 B,U	2,700 B,U	62FR42160
57	Acenaphthylene	208968							
58	Anthracene	120127					9,600 B	110,000 B	62FR42160
59	Benzidine	92875					0.00012 B,C	0.00054 B,C	57FR60848
60	Benzo (a) Anthracene	56553					0.0044 B,C	0.049 B,C	62FR42160
61	Benzo (a) Pyrene	50328					0.0044 B,C	0.049 B,C	62FR42160
62	Benzo (b) Fluoranthene	205992					0.0044 B,C	0.049 B,C	62FR42160
63	Benzo (ghi) Perylene	191242							
64	Benzo (k) Fluoranthene	207089					0.0044 B,C	0.049 B,C	62FR42160
65	Bis 2-Chloroethoxy Methane	111911							
66	Bis 2-Chloroethyl Ether	111444					0.031 B,C	1.4 B,C	57FR60848
67	Bis 2-Chloroisopropyl Ether	39638329					1,400 B	170,000 B	62FR42160 57FR60848
68	Bis 2-Ethylhexyl Phthalate [X]	117817					1.8 B,C	5.9 B,C	57FR60848
69	4-Bromophenyl Phenyl Ether	101553							
70	Butylbenzyl Phthalate [W]	85687					3,000 B	5,200 B	62FR42160
71	2-Chloronaphthalene	91587					1,700 B	4,300 B	62FR42160

NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR PRIORITY POLLUTANTS

	Priority Pollutant	CAS Number	Freshwater CMC (µg/L)	Freshwater CCC (µg/L)	Saltwater CMC (µg/L)	Saltwater CCC (µg/L)	Human Health For Consumption of: Water + Organism (µg/L)	Human Health For Consumption of: Organism Only (µg/L)	FR Cite/Source
72	4-Chlorophenyl Phenyl Ether	7005723							
73	Chrysene	218019					0.0044 B,C	0.049 B,C	62FR42160
74	Dibenzo (a,h) Anthracene	53703					0.0044 B,C	0.049 B,C	62FR42160
75	1,2-Dichlorobenzene	95501					2,700 B,Z	17,000 B	62FR42160
76	1,3-Dichlorobenzene	541731					400	2,600	62FR42160
77	1,4-Dichlorobenzene	106467					400 Z	2600	62FR42160
78	3,3'-Dichlorobenzidine	91941					0.04 B,C	0.077 B,C	57FR60848
79	Diethyl Phthalate [W]	84662					23,000 B	120,000 B	57FR60848
80	Dimethyl Phthalate [W]	131113					313,000	2,900,000	57FR60848
81	Di-n-Butyl Phthalate [W]	84742					2,700 B	12,000 B	57FR60848
82	2,4-Dinitrotoluene	121142					0.11 C	9.1 C	57FR60848
83	2,6-Dinitrotoluene	606202							
84	Di-n-Octyl Phthalate	117840							
85	1,2-Diphenylhydrazine	122667					0.040 B,C	0.54 B,C	57FR60848
86	Fluoranthene	206440					300 B	370 B	62FR42160
87	Fluorene	86737					1,300 B	14,000 B	62FR42160
88	Hexachlorobenzene	118741					0.00075 B,C	0.00077 B,C	62FR42160
89	Hexachlorobutadiene	87683					0.44 B,C	50 B,C	57FR60848
90	Hexachlorocyclopentadiene	77474					240 B,U,Z	17,000 B,H,U	57FR60848
91	Hexachloroethane	67721					1.9 B,C	8.9 B,C	57FR60848

NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR PRIORITY POLLUTANTS

			Freshwater		Saltwater		Human Health For Consumption of:		
	Priority Pollutant	CAS Number	CMC (µg/L)	CCC (µg/L)	CMC (µg/L)	CCC (µg/L)	Water + Organism (µg/L)	Organism Only (µg/L)	FR Cite/Source
92	Indeno (1,2,3-cd) Pyrene	193395					0.0044 B,C	0.049 B,C	62FR42160
93	Isophorone	78591					36 B,C	2,600 B,C	IRIS 11/01/97
94	Naphthalene	91203							
95	Nitrobenzene	98953					17 B	1,900 B,H,U	57FR60848
96	N-Nitrosodimethylamine	62759					0.00069 B,C	8.1 B,C	57FR60848
97	N-Nitrosodi-n-Propylamine	621647					0.005 B,C	1.4 B,C	62FR42160
98	N-Nitrosodiphenylamine	86306					5.0 B,C	16 B,C	57FR60848
99	Phenanthrene	85018							
100	Pyrene	129000					960 B	11,000 B	62FR42160
101	1,2,4-Trichlorobenzene	120821					260 Z	940	IRIS 11/01/96
102	Aldrin	309002	3.0 G		1.3 G		0.00013 B,C	0.00014 B,C	62FR42160
103	alpha-BHC	319846					0.0039 B,C	0.013 B,C	62FR42160
104	beta-BHC	319857					0.014 B,C	0.046 B,C	62FR42160
105	gamma-BHC (Lindane)	58899	0.95 K		0.16 G		0.019 C	0.063 C	62FR42160
106	delta-BHC	319868							
107	Chlordane	57749	2.4G	0.0043G,aa	0.09G	0.004G,aa	0.0021 B,C	0.0022 B,C	62FR42160 IRIS 02/07/98
108	4,4-DDT	50293	1.1G	0.001G,aa	0.13G	0.001G,aa	0.00059 B,C	0.00059 B,C	62FR42160
109	4,4-DDE	72559					0.00059 B,C	0.00059 B,C	62FR42160
110	4,4-DDD	72548					0.00083 B,C	0.00084 B,C	62FR42160

NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR PRIORITY POLLUTANTS

	Priority Pollutant	CAS Number	Freshwater CMC (µg/L)	Freshwater CCC (µg/L)	Saltwater CMC (µg/L)	Saltwater CCC (µg/L)	Human Health For Consumption of: Water + Organism (µg/L)	Human Health For Consumption of: Organism Only (µg/L)	FR Cite/Source
111	Dieldrin	60571	0.24K	0.056K,O	0.71G	0.0019G,aa	0.00014 B,C	0.00014 B,C	62FR42160
112	alpha-Endosulfan	959988	0.22G,Y	0.056G,Y	0.034G,Y	0.0087G,Y	110 B	240 B	62FR42160
113	beta-Endosulfan	33213659	0.22G,Y	0.056G,Y	0.034G,Y	0.0087G,Y	110 B	240 B	62FR42160
114	Endosulfan Sulfate	1031078					110 B	240 B	62FR42160
115	Endrin	72208	0.086K	0.036K,O	0.037G	0.0023G,aa	0.76 B	0.81 B,H	62FR42160
116	Endrin Aldehyde	7421934					0.76 B	0.81 B,H	62FR42160
117	Heptachlor	76448	0.52G	0.0038G,aa	0.053G	0.0036G,aa	0.00021 B,C	0.00021 B,C	62FR42160
118	Heptachlor Epoxide	1024573	0.52G,V	0.0038G,V, aa	0.053G,V	0.0036G,V, aa	0.00010 B,C	0.00011 B,C	62FR42160
119	Polychlorinated Biphenyls PCBs:			0.014 N,aa		0.03 N,aa	0.00017 B,C,P	0.00017 B,C,P	62FR42160 63FR16182
120	Toxaphene	8001352	0.73	0.0002aa	0.21	0.0002aa	0.00073B,C	0.00075B,C	62FR42160

Footnotes:

A This recommended water quality criterion was derived from data for arsenic (III), but is applied here to total arsenic, which might imply that arsenic (III) and arsenic (V) are equally toxic to aquatic life and that their toxicities are additive. In the arsenic criteria document (EPA 440/5-84-033, January 1985), Species Mean Acute Values are given for both arsenic (III) and arsenic (V) for five species and the ratios of the SMAVs for each species range from 0.6 to 1.7. Chronic values are available for both arsenic (III) and arsenic (V) for one species; for the fathead minnow, the chronic value for arsenic (V) is 0.29 times the chronic value for arsenic (III). No data are known to be available concerning whether the toxicities of the forms of arsenic to aquatic organisms are additive.

B This criterion has been revised to reflect The Environmental Protection Agency's q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of April 8, 1998. The fish tissue bioconcentration factor (BCF) from the 1980 Ambient Water Quality Criteria document was retained in each case.

C This criterion is based on carcinogenicity of 10^{-6} risk. Alternate risk levels may be obtained by moving the decimal point (e.g., for a risk level of 10^{-5} , move the decimal point in the recommended criterion one place to the right).

D Freshwater and saltwater criteria for metals are expressed in terms of the dissolved metal in the water column. The recommended water quality criteria value was calculated by using the previous 304(a) aquatic life criteria expressed in terms of total recoverable metal, and multiplying it by a conversion factor (CF). The term "Conversion Factor" (CF) represents the recommended conversion factor for converting a metal criterion expressed as the total recoverable fraction in the water column to a criterion expressed as the dissolved fraction in the water column. (Conversion Factors for saltwater CCCs are not currently available. Conversion factors derived for saltwater CMCs have been used for both saltwater CMCs and CCCs). See "Office of Water Policy

and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria," October 1, 1993, by Martha G. Prothro, Acting Assistant Administrator for Water, available from the Water Resource Center, USEPA, 401 M St., SW, mail code RC4100, Washington, DC 20460; and 40CFR§131.36(b)(1). Conversion Factors applied in the table can be found in Appendix A to the Preamble- Conversion Factors for Dissolved Metals.

E The freshwater criterion for this metal is expressed as a function of hardness (mg/L) in the water column. The value given here corresponds to a hardness of 100 mg/L. Criteria values for other hardness may be calculated from the following: CMC (dissolved) = $\exp\{mA\ [\ln(\text{hardness})] + b_A\}$ (CF), or CCC (dissolved) = $\exp\{m_C\ [\ln(\text{hardness})] + b_C\}$ (CF) and the parameters specified in Appendix B to the Preamble- Parameters for Calculating Freshwater Dissolved Metals Criteria That Are Hardness-Dependent.

F Freshwater aquatic life values for pentachlorophenol are expressed as a function of pH, and are calculated as follows: CMC = exp(1.005(pH)-4.869); CCC = exp(1.005(pH)-5.134). Values displayed in table correspond to a pH of 7.8.

G This Criterion is based on 304(a) aquatic life criterion issued in 1980, and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5-80-019), Chlordane (EPA 440/5-80-027), DDT (EPA 440/5-80-038), Endosulfan (EPA 440/5-80-046), Endrin (EPA 440/5-80-047), Heptachlor (440/5-80-052), Hexachlorocyclohexane (EPA 440/5-80-054), Silver (EPA 440/5-80-071). The Minimum Data Requirements and derivation procedures were different in the 1980 Guidelines than in the 1985 Guidelines. For example, a "CMC" derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.

H No criterion for protection of human health from consumption of aquatic organisms excluding water was presented in the 1980 criteria document or in the *1986 Quality Criteria for Water*. Nevertheless, sufficient information was presented in the 1980 document to allow the calculation of a criterion, even though the results of such a calculation were not shown in the document.

I This criterion for asbestos is the Maximum Contaminant Level (MCL) developed under the Safe Drinking Water Act (SDWA).

J EPA has not calculated human health criterion for this contaminant. However, permit authorities should address this contaminant in NPDES permit actions using the State's existing narrative criteria for toxics.

K This recommended criterion is based on a 304(a) aquatic life criterion that was issued in the *1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water,* (EPA-820-B-96-001, September 1996). This value was derived using the GLI Guidelines (60FR15393-15399, March 23, 1995; 40CFR132 Appendix A); the difference between the 1985 Guidelines and the GLI Guidelines are explained on page iv of the 1995 Updates. None of the decisions concerning the derivation of this criterion were affected by any considerations that are specific to the Great Lakes.

L The CMC = 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 µg/L and 12.83 µg/L, respectively.

M EPA is currently reassessing the criteria for arsenic. Upon completion of the reassessment the Agency will publish revised criteria as appropriate.

N PCBs are a class of chemicals which include aroclors, 1242, 1254, 1221, 1232, 1248, 1260, and 1016, CAS numbers 53469219, 11097691, 11104282, 11141165, 12672296, 11096825 and 12674112 respectively. The aquatic life criteria apply to this set of PCBs.

O The derivation of the CCC for this pollutant did not consider exposure through the diet, which is probably important for aquatic life occupying upper trophic levels.

P This criterion applies to total pcbs, i.e., the sum of all congener or all isomer analyses.

Q This recommended water quality criterion is expressed as µg free cyanide (as CN)/L.

R This value was announced (61FR58444-58449, November 14, 1996) as a proposed GLI 303(c) aquatic life criterion. EPA is currently working on this criterion and so this value might change substantially in the near future.

S This recommended water quality criterion refers to the inorganic form only.

T This recommended water quality criterion is expressed in terms of total recoverable metal in the water column. It is scientifically acceptable to use the conversion factor of 0.922 that was used in the GLI to convert this to a value that is expressed in terms of dissolved metal.

V This value was derived from data for heptachlor and the criteria document provides insufficient data to estimate the relative toxicities of heptachlor and heptachlor epoxide.

W Although EPA has not published a final criteria document for this compound it is EPA's understanding that sufficient data exist to allow calculation of aquatic criteria. It is anticipated that industry intends to publish in the peer reviewed literature draft aquatic life criteria generated in accordance with EPA Guidelines. EPA will review such criteria for possible issuance as national WQC.

X There is a full set of aquatic life toxicity data that show that DEHP is not toxic to aquatic organisms at or below its solubility limit.

Y This value was derived from data for endosulfan and is most appropriately applied to the sum of alpha-endosulfan and beta-endosulfan.

Z A more stringent MCL has been issued by EPA. Refer to drinking water regulations (40 CFR 141) or Safe Drinking Water Hotline (1-800-426-4791) for values.

aa This CCC is based on the Final Residue Value procedure in the 1985 Guidelines. Since the publication of the *Great Lakes Aquatic Life Criteria Guidelines* in 1995 (60FR15393-15399, March 23, 1995), the Agency no longer uses the Final Residue Value procedure for deriving CCCs for new or revised 304(a) aquatic life criteria.

bb This water quality criterion is based on a 304(a) aquatic life criterion that was derived using the 1985 Guidelines (*Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*, PB85-227049, January 1985) and was issued in one of the following criteria documents: Arsenic (EPA 440/5-84-033), Cadmium (EPA 440/5-84-032), Chromium (EPA 440/5-84-029), Copper (EPA 440/5-84-031), Cyanide (EPA 440/5-84-028), Lead (EPA 440/5-84-027), Nickel (EPA 440/5-86-004), Pentachlorophenol (EPA 440/5-86-009), Toxaphene, (EPA 440/5-86-006), Zinc (EPA 440/5-87- 003).

cc When the concentration of dissolved organic carbon is elevated, copper is substantially less toxic and use of Water-Effect Ratios might be appropriate.

dd The selenium criteria document (EPA 440/5-87-006, September 1987) provides that if selenium is as toxic to saltwater fishes in the field as it is to freshwater fishes in the field, the status of the fish community should be monitored whenever the concentration of selenium exceeds 5.0 µg/L in salt water because the saltwater CCC does not take into account uptake via the food chain.

ee This recommended water quality criterion was derived on page 43 of the mercury criteria document (EPA 440/5-84-026, January 1985). The saltwater CCC of 0.025 µg/L given on page 23 of the criteria document is based on the Final Residue Value procedure in the 1985 Guidelines. Since the publication of the *Great Lakes Aquatic Life Criteria Guidelines* in 1995 (60FR15393-15399, March 23, 1995), the Agency no longer uses the Final Residue Value procedure for deriving CCCs for new or revised 304(a) aquatic life criteria.

ff This recommended water quality criterion was derived in *Ambient Water Quality Criteria Saltwater Copper Addendum* (Draft, April 14, 1995) and was promulgated in the Interim final National Toxics Rule (60FR22228-222237, May 4, 1995).

gg EPA is actively working on this criterion and so this recommended water quality criterion may change substantially in the near future.

hh This recommended water quality criterion was derived from data for inorganic mercury (II), but is applied here to total mercury. If a substantial portion of the mercury in the water column is methylmercury, this criterion will probably be under protective. In addition, even though inorganic mercury is converted to methylmercury and methylmercury bioaccumulates to a great extent, this criterion does not account for uptake via the food chain because sufficient data were not available when the criterion was derived.

NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR NON-PRIORITY POLLUTANTS

	Priority Pollutant	CAS Number	Freshwater		Saltwater		Human Health For Consumption of:		FR Cite/Source
			CMC (µg/L)	CCC (µg/L)	CMC (µg/L)	CCC (µg/L)	Water + Organism (µg/L)	Organism Only (µg/L)	
1	Alkalinity	--	*	20000 F	*	*	*	*	Gold Book
2	Aluminum pH 6.5 - 9.0	7429905	750 G,I	87 G,I,L	*	*	*	*	53FR33178
3	Ammonia	7664417	FRESHWATER CRITERIA ARE pH DEPENDENT -- SEE DOCUMENT D SALTWATER CRITERIA ARE pH AND TEMPERATURE DEPENDENT						EPA822-R-98-008 EPA440/5-88-004
4	Aesthetic Qualities	--	NARRATIVE STATEMENT -- SEE DOCUMENT						Gold Book
5	Bacteria	--	FOR PRIMARY RECREATION AND SHELLFISH USES -- SEE DOCUMENT						Gold Book
6	Barium	7440393					1,000 A		Gold Book
7	Boron	--	NARRATIVE STATEMENT -- SEE DOCUMENT						Gold Book
8	Chloride	16887006	860000 G	230000 G					53FR19028
9	Chlorine	7782505	19	11	13	7.5	C		Gold Book
10	Chlorophenoxy Herbicide 2,4,5,-TP	93721					10 A		Gold Book
11	Chlorophenoxy Herbicide 2,4-D	94757					100 A,C		Gold Book
12	Chlorpyrifos	2921882	0.083 G	0.041 G	0.011 G	0.0056 G			Gold Book
13	Color	--	NARRATIVE STATEMENT -- SEE DOCUMENT F						Gold Book
14	Demeton	8065483		0.1 F		0.1 F			Gold Book
15	Ether, Bis Chloromethyl	542881					0.00013 E	0.00078 E	IRIS 01/01/91
16	Gases, Total Dissolved	--	NARRATIVE STATEMENT -- SEE DOCUMENT F						Gold Book
17	Guthion	86500		0.01 F		0.01 F			Gold Book
18	Hardness	--	NARRATIVE STATEMENT -- SEE DOCUMENT						Gold Book

NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR NON-PRIORITY POLLUTANTS

	Priority Pollutant	CAS Number	Freshwater		Saltwater		Human Health For Consumption of:		FR Cite/Source
			CMC (µg/L)	CCC (µg/L)	CMC (µg/L)	CCC (µg/L)	Water + Organism (µg/L)	Organism Only (µg/L)	
19	Hexachlorocyclo-hexane-Technical	319868					0.0123	0.0414	Gold Book
20	Iron	7439896		1000 F			300 A		Gold Book
21	Malathion	121755		0.1 F		0.1 F			Gold Book
22	Manganese	7439965					50 A	100 A	Gold Book
23	Methoxychlor	72435		0.03 F		0.03 F	100 A,C		Gold Book
24	Mirex	2385855		0.001 F		0.001 F			Gold Book
25	Nitrates	14797558					10,000 A		Gold Book
26	Nitrosamines	--					0.0008	1.24	
27	Dinitrophenols	25550587					70	14,000	Gold Book
28	Nitrosodibutylamine,N	924163					0.0064 A	0.587 A	Gold Book
29	Nitrosodiethylamine,N	55185					0.0008 A	1.24 A	Gold Book
30	Nitrosopyrrolidine,N	930552					0.016	91.9	Gold Book
31	Oil and Grease	--	NARRATIVE STATEMENT -- SEE DOCUMENT F						Gold Book
32	Oxygen, Dissolved	7782447	WARMWATER AND COLDWATER MATRIX -- SEE DOCUMENT O						Gold Book
33	Parathion	56382	0.065 J	0.013 J					Gold Book
34	Pentachlorobenzene	608935					3.5 E	4.1 E	IRIS 03/01/88
35	pH	--		6.5 - 9 F		6.5 - 8.5 F,K	5 - 9		Gold Book
36	Phosphorus Elemental	7723140				0.1 F,K			Gold Book
37	Phosphate Phosphorus	--	NARRATIVE STATEMENT -- SEE DOCUMENT						Gold Book

NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR NON-PRIORITY POLLUTANTS

	Priority Pollutant	CAS Number	Freshwater CMC (µg/L)	Freshwater CCC (µg/L)	Saltwater CMC (µg/L)	Saltwater CCC (µg/L)	Human Health For Consumption of: Water + Organism (µg/L)	Human Health For Consumption of: Organism Only (µg/L)	FR Cite/Source
38	Solids Dissolved and Salinity	--					250,000 A		Gold Book
39	Solids Suspended and Turbidity	--	NARRATIVE STATEMENT -- SEE DOCUMENT F						Gold Book
40	Sulfide-Hydrogen Sulfide	7783064		2.0 F		2.0 F			Gold Book
41	Tainting Substances	--	NARRATIVE STATEMENT -- SEE DOCUMENT						Gold Book
42	Temperature	--	SPECIES DEPENDENT CRITERIA -- SEE DOCUMENT M						Gold Book
43	Tetrachlorobenzene,1,2,4,5-	95943					2.3 E	2.9 E	IRIS03/01/91
44	Tributyltin TBT	--	0.46 N	0.063 N	0.37 N	0.010 N			62FR42554
45	Trichlorophenol,2,4,5-	95954					2,600 B,E	9800 B,E	IRIS 03/01/88

Footnotes:

A This human health criterion is the same as originally published in the Red Book which predates the 1980 methodology and did not utilize the fish ingestion BCF approach. This same criterion value is now published in the Gold Book.

B The organoleptic effect criterion is more stringent than the value presented in the non priority pollutants table.

C A more stringent Maximum Contaminant Level (MCL) has been issued by EPA under the Safe Drinking Water Act. Refer to drinking water regulations 40CFR141 or Safe Drinking Water Hotline (1-800-426-4791) for values.

D According to the procedures described in the *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*, except possibly where a very sensitive species is important at a site, freshwater aquatic life should be protected if both conditions specified in Appendix C to the Preamble--Calculation of Freshwater Ammonia Criterion are satisfied.

E This criterion has been revised to reflect The Environmental Protection Agency's q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of April 8, 1998. The fish tissue bioconcentration factor (BCF) used to derive the original criterion was retained in each case.

F The derivation of this value is presented in the Red Book (EPA 440/9-76-023, July, 1976).

G This value is based on a 304(a) aquatic life criterion that was derived using the 1985 Guidelines (*Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*, PB85-227049, January 1985) and was issued in one of the following criteria documents: Aluminum (EPA 440/5-86-008); Chloride (EPA 440/5-88-001); Chlorpyrifos (EPA 440/5-86-005).

I This value is expressed in terms of total recoverable metal in the water column.

J This value is based on a 304(a) aquatic life criterion that was issued in the *1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water* (EPA-820-B-96-001). This value was derived using the GLI Guidelines (60FR15393-15399, March 23, 1995; 40CFR132 Appendix A); the differences between the 1985 Guidelines and the GLI Guidelines are explained on page iv of the 1995 Updates. No decision concerning this criterion was affected by any considerations that are specific to the Great Lakes.

K According to page 181 of the Red Book:

> For open ocean waters where the depth is substantially greater than the euphotic zone, the pH should not be changed more than 0.2 units from the naturally occurring variation or any case outside the range of 6.5 to 8.5. For shallow, highly productive coastal and estuarine areas where naturally occurring pH variations approach the lethal limits of some species, changes in pH should be avoided but in any case should not exceed the limits established for fresh water, i.e., 6.5-9.0.

L There are three major reasons why the use of Water-Effect Ratios might be appropriate. (1) The value of 87 µg/L is based on a toxicity test with the striped bass in water with pH= 6.5-6.6 and hardness <10 mg/L. Data in "Aluminum Water-Effect Ratio for the 3M Plant Effluent Discharge, Middleway, West Virginia" (May 1994) indicate that aluminum is substantially less toxic at higher pH and hardness, but the effects of pH and hardness are not well quantified at this time. (2) In tests with the brook trout at low pH and hardness, effects increased with increasing concentrations of total aluminum even though the concentration of dissolved aluminum was constant, indicating that total recoverable is a more appropriate measurement than dissolved, at least when particulate aluminum is primarily aluminum hydroxide particles. In surface waters, however, the total recoverable procedure might measure aluminum associated with clay particles, which might be less toxic than aluminum associated with aluminum hydroxide. (3) EPA is aware of field data indicating that many high quality waters in the U.S. contain more than 87 µg aluminum/L, when either total recoverable or dissolved is measured.

M U.S. EPA. 1973. *Water Quality Criteria 1972.* EPA-R3-73-033. National Technical Information Service, Springfield, VA.; U.S. EPA. 1977. *Temperature Criteria for Freshwater Fish: Protocol and Procedures*. EPA-600/3-77-061. National Technical Information Service, Springfield, VA.

N This value was announced (62FR42554, August 7, 1997) as a proposed 304(a) aquatic life criterion. Although EPA has not responded to public comment, EPA is publishing this as a 304(a) criterion in today's notice as guidance for States and Tribes to consider when adopting water quality criteria.

O U.S. EPA. 1986. *Ambient Water Quality Criteria for Dissolved Oxygen*. EPA 440/5-86-003. National Technical Information Service, Springfield, VA.

NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR ORGANOLEPTIC EFFECTS

	Pollutant	CAS Number	Organoleptic Effect Criteria (µg/L)	FR Cite/Source
1	Acenaphthene	83329	20	Gold Book
2	Monochlorobenzene	108907	20	Gold Book
3	3-Chlorophenol	--	0.1	Gold Book
4	4-Chlorophenol	106489	0.1	Gold Book
5	2,3-Dichlorophenol	--	0.04	Gold Book
6	2,5-Dichlorophenol	--	0.5	Gold Book
7	2,6-Dichlorophenol	--	0.2	Gold Book
8	3,4-Dichlorophenol	--	0.3	Gold Book
9	2,4,5-Trichlorophenol	95954	1	Gold Book
10	2,4,6-Trichloropehnol	88062	2	Gold Book
11	2,3,4,6-Tetrachlorophenol	--	1	Gold Book
12	2-Methyl-4-Chlorophenol	--	1800	Gold Book
13	3-Methyl-4-Chlorophenol	59507	3000	Gold Book
14	3-Methyl-6-Chlorophenol	--	20	Gold Book
15	2-Chlorophenol	95578	0.1	Gold Book
16	Copper	7440508	1000	Gold Book
17	2,4-Dichlorophenol	120832	0.3	Gold Book
18	2,4-Dimethylphenol	105679	400	Gold Book
19	Hexachlorocyclopentadiene	77474	1	Gold Book
20	Nitrobenzene	98953	30	Gold Book

NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR ORGANOLEPTIC EFFECTS

	Pollutant	CAS Number	Organoleptic Effect Criteria (µg/L)	FR Cite/Source
21	Pentachlorophenol	87865	30	Gold Book
22	Phenol	108952	300	Gold Book
23	Zinc	7440666	5000	45FR79341

General Notes:

1. These criteria are based on organoleptic (taste and odor) effects. Because of variations in chemical nomenclature systems, this listing of pollutants does not duplicate the listing in Appendix A of 40 CFR Part 423. Also listed are the Chemical Abstracts Service (CAS) registry numbers, which provide a unique identification for each chemical.

NATIONAL RECOMMENDED WATER QUALITY CRITERIA

Additional Notes:

1. Criteria Maximum Concentration and Criterion Continuous Concentration

The Criteria Maximum Concentration (CMC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The Criterion Continuous Concentration (CCC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. The CMC and CCC are just two of the six parts of a aquatic life criterion; the other four parts are the acute averaging period, chronic averaging period, acute frequency of allowed exceedence, and chronic frequency of allowed exceedence. Because 304(a) aquatic life criteria are national guidance, they are intended to be protective of the vast majority of the aquatic communities in the United States.

2. Criteria Recommendations for Priority Pollutants, Non Priority Pollutants and Organoleptic Effects

This compilation lists all priority toxic pollutants and some non priority toxic pollutants, and both human health effect and organoleptic effect criteria issued pursuant to CWA §304(a). Blank spaces indicate that EPA has no CWA §304(a) criteria recommendations. For a number of non-priority toxic pollutants not listed, CWA §304(a) "water + organism" human health criteria are not available, but, EPA has published MCLs under the SDWA that may be used in establishing water quality standards to protect water supply designated uses. Because of variations in chemical nomenclature systems, this listing of toxic pollutants does not duplicate the listing in Appendix A of 40 CFR Part 423. Also listed are the Chemical Abstracts Service CAS registry numbers, which provide a unique identification for each chemical.

3. Human Health Risk

The human health criteria for the priority and non priority pollutants are based on carcinogenicity of 10 -6 risk. Alternate risk levels may be obtained by moving the decimal point (e.g., for a risk level of 10 -5 , move the decimal point in the recommended criterion one place to the right).

4. Water Quality Criteria published pursuant to Section 304(a) or Section 303(c) of the CWA

Many of the values in the compilation were published in the proposed California Toxics Rule (CTR, 62FR42160). Although such values were published pursuant to Section 303(c) of the CWA, they represent the Agency's most recent calculation of water quality criteria and thus are published today as the Agency's 304(a) criteria. Water quality criteria published in the proposed CTR may be revised when EPA takes final action on the CTR.

5. Calculation of Dissolved Metals Criteria

The 304(a) criteria for metals, shown as dissolved metals, are calculated in one of two ways. For freshwater metals criteria that are hardness-dependent, the dissolved metal criteria were calculated using a hardness of 100 mg/L as CaCO3 for illustrative purposes only. Saltwater and freshwater metals' criteria that are not hardness-dependent are calculated by multiplying the total recoverable criteria before rounding by the appropriate conversion factors. The final dissolved metals' criteria in the table are rounded to two significant figures. Information regarding the calculation of hardness dependent conversion factors are included in the footnotes.

6. Correction of Chemical Abstract Services Number

The Chemical Abstract Services number (CAS) for Bis(2-Chloroisopropyl) Ether, has been corrected in the table. The correct CAS number for this chemical is 39638-32-9. Previous publications listed 108-60-1 as the CAS number for this chemical.

7. Maximum Contaminant Levels

The compilation includes footnotes for pollutants with Maximum Contaminant Levels (MCLs) more stringent than the recommended water quality criteria in the compilation. MCLs for these pollutants are not included in the compilation, but can be found in the appropriate drinking water regulations (40 CFR 141.11-16 and 141.60-63), or can be accessed through the Safe Drinking Water Hotline (800-426-4791) or the Internet (http://www.epa.gov/ost/tools/dwstds-s.html).

8. Organoleptic Effects

The compilation contains 304(a) criteria for pollutants with toxicity-based criteria as well as non-toxicity based criteria. The basis for the non-toxicity based criteria are organoleptic effects (e.g., taste and odor) which would make water and edible aquatic life unpalatable but not toxic to humans. The table includes criteria for organoleptic effects for 23 pollutants. Pollutants with organoleptic effect criteria more stringent than the criteria based on toxicity (e.g., included in both the priority and non-priority pollutant tables) are footnoted as such.

9. Category Criteria

In the 1980 criteria documents, certain recommended water quality criteria were published for categories of pollutants rather than for individual pollutants within that category. Subsequently, in a series of separate actions, the Agency derived criteria for specific pollutants within a category. Therefore, in this compilation EPA is replacing criteria representing categories with individual pollutant criteria (e.g., 1,3-dichlorobenzene, 1,4-dichlorobenzene and 1,2-dichlorobenzene).

10. Specific Chemical Calculations

A. Selenium

(1) Human Health

In the 1980 Selenium document, a criterion for the protection of human health from consumption of water and organisms was calculated based on a BCF of 6.0 L/kg and a maximum water-related contribution of 35 mg Se/day. Subsequently, the EPA Office of Health and Environmental Assessment issued an errata notice (February 23, 1982), revising the BCF for selenium to 4.8 L/kg. In 1988, EPA issued an addendum (ECAO-CIN-668) revising the human health criteria for selenium. Later in the final National Toxic Rule (NTR, 57 FR 60848), EPA withdrew previously published selenium human health criteria, pending Agency review of new epidemiological data.

This compilation includes human health criteria for selenium, calculated using a BCF of 4.8 L/kg along with the current IRIS RfD of 0.005 mg/kg/day. EPA included these recommended water quality criteria in the compilation because the data necessary for calculating a criteria in accordance with EPA's 1980 human health methodology are available.

(2) Aquatic Life

This compilation contains aquatic life criteria for selenium that are the same as those published in the proposed CTR. In the CTR, EPA proposed an acute criterion for selenium based on the criterion proposed for selenium in the Water Quality Guidance for the Great Lakes System (61 FR 58444). The GLI and CTR proposals take into account data showing that selenium's two most prevalent oxidation states, selenite and selenate, present differing potentials for aquatic toxicity, as well as new data indicating that various forms of selenium are additive. The new approach produces a different selenium acute criterion concentration, or CMC, depending upon the relative proportions of selenite, selenate, and other forms of selenium that are present.

EPA notes it is currently undertaking a reassessment of selenium, and expects the 304(a) criteria for selenium will be revised based on the final reassessment (63FR26186). However, until such time as revised water quality criteria for selenium are published by the Agency, the recommended water quality criteria in this compilation are EPA's current 304(a) criteria.

B. 1,2,4-Trichlorobenzene and Zinc

Human health criteria for 1,2,4-trichlorobenzene and zinc have not been previously published. Sufficient information is now available for calculating water quality criteria for the protection of human health from the consumption of aquatic organisms and the consumption of aquatic organisms and water for both these compounds. Therefore, EPA is publishing criteria for these pollutants in this compilation.

C. Chromium (III)

The recommended aquatic life water quality criteria for chromium (III) included in the compilation are based on the values presented in the document titled: *1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water*, however, this document contains criteria based on the total recoverable fraction. The chromium (III) criteria in this compilation were calculated by applying the conversion factors used in the Final Water Quality Guidance for the Great Lakes System (60 FR 15366) to the 1995 Update document values.

D. Ether, Bis (Chloromethyl), Pentachlorobenzene, Tetrachlorobenzene 1,2,4,5-, Trichlorphenol

Human health criteria for these pollutants were last published in EPA's Quality Criteria for Water 1986 or "Gold Book". Some of these criteria were calculated using Acceptable Daily Intake (ADIs) rather than RfDs. Updated q1*s and RfDs are now available in IRIS for ether, bis (chloromethyl), pentachlorobenzene, tetrachlorobenzene 1,2,4,5-, and trichlorophenol, and were used to revise the water quality criteria for these compounds. The recommended water quality criteria for ether, bis (chloromethyl) were revised using an updated q1*, while criteria for pentachlorobenzene, and tetrachlorobenzene 1,2,4,5-, and trichlorophenol were derived using an updated RfD value.

E. PCBs

In this compilation EPA is publishing aquatic life and human health criteria based on total PCBs rather than individual arochlors. These criteria replace the previous criteria for the seven individual arochlors. Thus, there are criteria for a total of 102 of the 126 priority pollutants.

Conversion Factors for Dissolved Metals

Metal	Conversion Factor freshwater CMC	Conversion Factor freshwater CCC	Conversion Factor saltwater CMC	Conversion Factor saltwater CCC[1]
Arsenic	1.000	1.000	1.000	1.000
Cadmium	1.136672-[(ln hardness)(0.041838)]	1.101672-[(ln hardness)(0.041838)]	0.994	0.994
Chromium III	0.316	0.860	--	--
Chromium VI	0.982	0.962	0.993	0.993
Copper	0.960	0.960	0.83	0.83
Lead	1.46203-[(ln hardness)(0.145712)]	1.46203-[(ln hardness)(0.145712)]	0.951	0.951
Mercury	0.85	0.85	0.85	0.85
Nickel	0.998	0.997	0.990	0.990
Selenium	--	--	0.998	0.998
Silver	0.85	--	0.85	--
Zinc	0.978	0.986	0.946	0.946

Parameters* for Calculating Freshwater Dissolved Metals Criteria That Are Hardness-Dependent

Chemical	m_A	b_A	m_C	b_C	Freshwater Conversion Factors (CF)	
					Acute	Chronic
Cadmium	1.128	-3.6867	0.7852	-2.715	1.136672-[ln (hardness)(0.041838)]	1.101672-[ln (hardness)(0.041838)]
Chromium III	0.8190	3.7256	0.8190	0.6848	0.316	0.860
Copper	0.9422	-1.700	0.8545	-1.702	0.960	0.960
Lead	1.273	-1.460	1.273	-4.705	1.46203-[ln (hardness)(0.145712)]	1.46203-[ln (hardness)(0.145712)]
Nickel	0.8460	2.255	0.8460	0.0584	0.998	0.997
Silver	1.72	-6.52	--	--	0.85	--
Zinc	0.8473	0.884	0.8473	0.884	0.978	0.986

* Where m_A and b_A are conversion factors to calculate CMC and m_C and b_C are conversion factors necessary to calculate CCC

Appendix C - Calculation of Freshwater Ammonia Criterion

1. The one-hour average concentration of total ammonia nitrogen (in mg N/L) does not exceed, more than once every three years on the average, the CMC calculated using the following equation:

$$CMC = \frac{0.275}{1 + 10^{7.204 - pH}} + \frac{39.0}{1 + 10^{pH - 7.204}}$$

In situations where salmonids do not occur, the CMC may be calculated using the following equation:

$$CMC = \frac{0.411}{1 + 10^{7.204 - pH}} + \frac{58.4}{1 + 10^{pH - 7.204}}$$

2. The thirty-day average concentration of total ammonia nitrogen (in mg N/L) does not exceed, more than once every three years on the average, the CCC calculated using the following equation:

$$CCC = \frac{0.0858}{1 + 10^{7.688 - pH}} + \frac{3.70}{1 + 10^{pH - 7.688}}$$

and the highest four-day average within the 30-day period does not exceed twice the CCC.

Source: U.S. EPA's *National Recommended Water Quality Criteria-Correction*, EPA-822-Z-99-001, April 1999, pp. 7-25; http://www.epa.gov/OST/standards/wqcriteria.html

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Biosolids Land Application Limitations

Pollutant	Ceiling Concentration* (Table 1, 40 CFR 503.13)		Monthly Average Pollutant Concentration* (Table 3, 40 CFR 503.13)		Cumulative Pollutant Loading Rates* (Table 2, 40 CFR 503.13)		Annual Pollutant Loading Rate* (Table 4, 40 CFR 503.13)	
	mg/kg	lbs/1000 lbs	mg/kg	lbs/1000 lbs	kg/hectare	lbs/acre**	kg/hectare/ 365-day period	lbs/acre/ 365-day period**
Arsenic	75	75	41	41	41	37	2	1.8
Cadmium	85	85	39	39	39	35	1.9	1.7
Copper	4,300	4,300	1,500	1,500	1,500	1,338	75	67
Lead	840	840	300	300	300	268	15	13
Mercury	57	57	17	17	17	15	0.85	0.76
Molybdenum	75	75	-	-	-	-	-	-
Nickel	420	420	420	420	420	375	21	19
Selenium	100	100	100	100	100	89	5	4.5
Zinc	7,500	7,500	2,800	2,800	2,800	2,498	140	125

* Dry weight.

** Calculated using metric standards specified in 40 CFR 503.13 multiplied by the conversion factor of 0.8922.

Source: 40 CFR §503.13, Tables 1-4, October 25, 1995

Surface Disposal

Distance from the Boundary of Active Biosolids Unit to Surface Disposal Site Property Line (meters)	Pollutant Concentration*		
	Arsenic (mg/kg)	Chromium (mg/kg)	Nickel (mg/kg)
0 to less than 25	30	200	210
25 to less than 50	34	220	240
50 to less than 75	39	260	270
75 to less than 100	46	300	320
100 to less than 125	53	360	390
125 to less than 150	62	450	420
Equal to or greater than 150	73	600	420

* Dry-weight.

Source: 40 CFR Part 503.23 Table 1 and 2.

Conversion Factors

pounds per acre (lbs/ac) x 1.121 = kilograms per hectare (kg/ha)

kilograms per hectare (kg/ha) x 0.8922 = pounds per acre (lbs/ac)

pound (lb) = 0.4536 kilogram (kg)

kilogram (kg) = 2.205 pounds (lbs)

English ton = 0.9072 metric tonne

metric tonne = 1.102 English ton

APPENDIX F - TOXICITY CHARACTERISTIC LEACHATE PROCEDURE LIMITATIONS

EPA Hazardous Waste No.	Contaminant	CAS No.[1]	Regulatory Level (mg/L)
D004	Arsenic	7440–38–2	5.0
D005	Barium	7440–39–3	100.0
D018	Benzene	71–43–2	0.5
D006	Cadmium	7440–43–9	1.0
D019	Carbon tetrachloride	56–23–5	0.5
D020	Chlordane	57–74–9	0.03
D021	Chlorobenzene	108–90–7	100.0
D022	Chloroform	67–66–3	6.0
D007	Chromium	7440–47–3	5.0
D024	o-Cresol	95-48-7	200.0 [2]
D024	m-Cresol	108–39–4	200.0 [2]
D025	p-Cresol	106–44–5	200.0 [2]
D026	Cresols		200.0 [2]
D016	2,4-D	94–75–7	10.0
D027	1,4-Dichlorobenzene	106–46–7	7.5
D028	1,2-Dichloroethane	107–06–2	0.5
D029	1,1-Dichloroethylene	75–35–4	0.7
D030	2,4-Dinitrotoluene	121–14–2	0.13 [3]
D012	Endrin	72–20–8	0.02
D031	Heptachlor (and its epoxide)	76–44–8	0.008
D032	Hexachlorobenzene	118–74–1	0.13 [3]
D033	Hexachlorobutadiene	87–68–3	0.5
D034	Hexachloroethane	67–72–1	3.0
D008	Lead	7439–92–1	5.0
D013	Lindane	58–89–9	0.4
D009	Mercury	7439–97–6	0.2
D014	Methoxychlor	72–43–5	10.0
D035	Methyl ethyl ketone	78–93–3	200.0
D036	Nitrobenzene	98–95–3	2.0
D037	Pentachlorophenol	87–86–5	100.0
D038	Pyridine	110–86–1	5.0 [3]
D010	Selenium	7782–49–2	1.0
D011	Silver	7440–22–4	5.0
D039	Tetrachloroethylene	127–18–4	0.7
D015	Toxaphene	8001–35–2	0.5
D040	Trichloroethylene	79–01–6	0.5

EPA Hazardous Waste No.	Contaminant	CAS No.[1]	Regulatory Level (mg/L)
D041	2,4,5-Trichlorophenol	95–95–4	400.0
D042	2,4,6-Trichlorophenol	88–06–2	2.0
D017	2,4,5-TP (Silvex)	93–72–1	1.0
D043	Vinyl chloride	75–01–4	0.2

1 Chemical Abstracts Service number.

2 If o-, m-, and p-Cresol concentrations cannot be differentiated, the total cresol (D026) concentration is used. The regulatory level of total cresol is 200 mg/L.

3 Quantitation limit is greater than the calculated regulatory level. The quantitation limit therefore becomes the regulatory level.

Source: 40 CFR 261.24

APPENDIX G -
LITERATURE INHIBITION VALUES

Pollutant	Reported Range of Activated Sludge Inhibition Threshold Levels, mg/L	References*
METALS/NONMETAL INORGANICS		
Ammonia	480	(4)
Arsenic	0.1	(1), (2), (3)
Cadmium	1 - 10	(2), (3)
Chromium (VI)	1	(2), (3)
Chromium (III)	10 - 50	(2), (3)
Chromium (Total)	1 - 100	(1)
Copper	1	(2), (1), (3)
Cyanide	0.1 - 5 5	(1), (2), (3) (1)
Iodine	10	(4)
Lead	1.0 - 5.0 10 - 100	(3) (1)
Mercury	0.1 - 1 2.5 as Hg (II)	(2), (3) (1)
Nickel	1.0 - 2.5 5	(2), (3) (1)
Sulfide	25 -30	(4)
Zinc	0.3 - 5 5 - 10	(3) (1)
ORGANICS		
Anthracene	500	(1)
Benzene	100 - 500 125 - 500	(3) (1)
2-Chlorophenol	5 20 - 200	(2) (3)
1,2 Dichlorobenzene	5	(2)
1,3 Dichlorobenzene	5	(2)
1,4 Dichlorobenzene	5	(2)
2,4-Dichlorophenol	64	(3)
2,4 Dimethylphenol	40 - 200	(3)
2,4 Dinitrotoluene	5	(2)
1,2-Diphenylhydrazine	5	(2)
Ethylbenzene	200	(3)
Hexachlorobenzene	5	(2)
Naphthalene	500 500 500	(1) (2) (3)
Nitrobenzene	30 - 500 500 500	(3) (1) (2)

Pollutant	Reported Range of Activated Sludge Inhibition Threshold Levels, mg/L	References*
Pentachlorophenol	0.95 50 75 - 150	(2) (3) (1)
Phenanthrene	500 500	(1) (2)
Phenol	50 - 200 200 200	(3) (2) (1)
Toluene	200	(3)
2,4,6 Trichlorophenol	50 - 100	(1)
Surfactants	100 - 500	(4)

Pollutant	Reported Range of Trickling Filter Inhibition Threshold Levels, mg/L	References*
Chromium (III)	3.5 - 67.6	(1)
Cyanide	30	(1)

Pollutant	Reported Range of Nitrification Inhibition Threshold Levels, mg/L	References*
METALS/NONMETAL INORGANICS		
Arsenic	1.5	(2)
Cadmium	5.2	(1), (2)
Chloride	180	(4)
Chromium (VI)	1 - 10 [as $(CrO_4)^{2-}$]	(1)
Chromium (T)	0.25 - 1.9 1 - 100 (trickling filter)	(1), (2), (3) (1)
Copper	0.05 - 0.48	(2), (3)
Cyanide	0.34 - 0.5	(2), (3)
Lead	0.5	(2), (3)
Nickel	0.25 - 0.5 5	(2), (3) (1)
Zinc	0.08 - 0.5	(2), (3)
ORGANICS		
Chloroform	10	(2)
2,4-Dichlorophenol	64	(3)
2,4-Dinitrophenol	150	(2)
Phenol	4 4 - 10	(2) (3)

Pollutant	Reported Range of Anaerobic Digestion Inhibition Threshold Levels, mg/L	References*
METALS/NONMETAL INORGANICS		
Ammonia	1500 - 8000	(4)
Arsenic	1.6	(1)
Cadmium	20	(3)
Chromium (III)	130	(3)
Chromium (VI)	110	(3)
Copper	40	(3)
Cyanide	4 - 100 1 - 4	(1) (2), (3)
Lead	340	(3)
Nickel	10 136	(2), (3) (1)
Silver	13 - 65**	(3)
Sulfate	500 - 1000	(4)
Sulfide	50 - 100	(4)
Zinc	400	(3)
ORGANICS		
Acrylonitrile	5 5	(3) (2)
Carbon Tetrachloride	2.9 - 159.4 10 - 20 2.0	(1) (3) (2)
Chlorobenzene	0.96 - 3 0.96	(1) (2)
Chloroform	1 5 - 16 10 - 16	(2) (1) (3)
1,2-Dichlorobenzene	0.23 - 3.8 0.23	(1) (2)
1,4-Dichlorobenzene	1.4 - 5.3 1.4	(1) (2)
Methyl chloride	3.3 - 536.4 100	(1) (2)
Pentachlorophenol	0.2 0.2 - 1.8	(2) (1)
Tetrachloroethylene	20	(2)
Trichloroethylene	1 - 20 20 20	(1) (2) (3)
Trichlorofluoromethane	-	(2)

* Total pollutant inhibition levels, unless otherwise indicated.

** Dissolved metal inhibition levels.

(1) Jenkins, D.I., and Associates. 1984. *Impact of Toxics on Treatment Literature Review*.

(2) Russell, L. L., C. B. Cain, and D.I. Jenkins. 1984. *Impacts of Priority Pollutants on Publicly Owned Treated Works Processes: A Literature Review*. 1984 Purdue Industrial Waste Conference.

(3) Anthony, R. M., and L. H. Briemburst. 1981. *Determining Maximum Influent Concentrations of Priority Pollutants for Treatment Plants*. Journal Water Pollution Control Federation 53(10):1457-1468.

(4) U.S. EPA. 1986, *Working Document; Interferences at Publicly Owned Treatment Works*. September 1986.

Source: *EPA's Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program*, December 1987, pp. 3-44 to 3-49.

APPENDIX H -
CLOSED-CUP FLASHPOINTS FOR SELECT ORGANIC COMPOUNDS

Pollutant	Closed Cup Flashpoint (°F)
Acrolein	-15
Acrylonitrile	30
Benzene	12
Chlorobenzene	82
Chloroethane (Ethyl chloride)	-58
1,1-Dichloroethane	2
1,2-Dichloroethane (Ethylene dichloride)	56
1,1-Dichloroethylene (Vinylidene chloride)	-2
Trans-1,2-Dichloroethylene, (1,2-Dichloroethylene)	36-39
1,2-Dichloropropane (Propylene dichloride)	60
Ethylbenzene	55
Toluene	40

Source: Online *NIOSH Pocket Guide to Chemical Hazards* at http://www.cdc.gov/niosh/npg/npg.html.

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APPENDIX I -
DISCHARGE SCREENING LEVELS AND HENRY'S LAW CONSTANTS FOR ORGANIC COMPOUNDS

Discharge Screening Levels Based on Explosivity

Pollutant	LELs(1) % volume / volume	LELs (mol/m^3)	Henry's Law Constant $(mol/m^3)/(mg/L)$	MW (g/mol)	Discharge Screening Level (mg/L)
Acrolein	2.8	1.15	8.7E-05	56.1	13163
Acrylonitrile	3.0	1.23	8.4E-05	53.1	14586
Benzene	1.2	0.49	2.9E-03	78.1	169
Chlorobenzene	1.3	0.53	1.3E-03	112.6	395
Chloroethane	3.8	1.55	7.0E-03	65.5	222
1,1-Dichloroethane	5.4	2.21	2.4E-03	99	909
1,2-Dichloroethane	6.2	2.54	4.9E-04	99	5221
1,1-Dichloroethylene	6.5	2.66	1.2E-02	97	215
Trans-1,2-Dichloroethylene	5.6	2.29	4.0E-03	97	571
1,2-Dichloropropane	3.4	1.39	1.0E-03	113	1326
Ethyl benzene	0.8	0.33	3.1E-03	106.2	106
Hydrogen Cyanide	5.6	2.30	1.7E-4	27	13529
Hydrogen Sulfide	4.0	1.64	1.7E-2	34	96
Methyl bromide	10.0	4.09	2.7E-03	95	1521
Methyl chloride	8.1	3.31	7.4E-03	50.5	450
Methylene Chloride	13.0	5.32	1.2E-03	84.9	4307
Toluene	1.1	0.45	3.0E-03	92.1	152
1,1,2-Trichloroethane	6.0	2.45	2.6E-04	133.4	9611
1,1,1-Trichloroethane	7.5	3.07	5.2E-03	133.4	591
Trichloroethylene	8.0 (F)	3.20	3.1E-03	131.4	1029
Vinyl Chloride	3.6	1.47	1.7E-02	62.5	88

Lower Explosive Limits (LELs) assumed for 25°C unless noted otherwise.
MW = molecular weight

Source: Updated in 2002 via the online *NIOSH Pocket Guide to Chemical Hazards* at http://www.cdc.gov/niosh/npg/npg.html

Discharge Screening Levels Based upon Fume Toxicity

Pollutant	Exposure Limit* (mg/m^3)	Henry's Law Constant (mg/m^3/ mg/L)	Discharge Screening Level (mg/L)	Source
Acrolein	0.23	4.9	0.047	TLV-STEL
Acrylonitrile	21.70	4.5	4.822	PEL-Ceiling, REL- Ceiling
Benzene	3.19	228.0	0.014	REL-STEL
Bromoform	5.17	22.8	0.227	PEL-TWA, TLV-TWA, REL-TWA
Carbon Tetrachloride	12.58	1185.0	0.011	REL-STEL
Chlorobenzene	345.75	151.0	2.290	PEL-TWA
Chloroethane	2,640.00	449.0	5.880	PEL-TWA
Chloroform	9.76	163.5	0.060	REL-STEL
Dichloroethane, 1,1-	405.00	240.4	1.685	PEL-TWA, TLV-TWA, REL-TWA
Dichloroethane,1,2-	8.10	48.1	0.168	REL-STEL
Dichloroethylene, 1,1-	19.80	1202.1	0.016	TLV-TWA
Trans-Dichloroethylene,1,2-	794.00	389.3	2.040	PEL-TWA, TLV-TWA, REL-TWA
Dichloropropane,1,2	508.20	118.5	4.289	TLV-STEL
Ethyl benzene	542.50	327.0	1.659	TLV-STEL, REL-STEL
Hydrogen Cyanide	5.17	4.5	1.149	TLV-Ceiling, REL-STEL
Hydrogen Sulfide	14.00	414.4	0.034	REL-Ceiling
Methyl bromide	77.80	255.5	0.305	PEL-Ceiling
Methyl chloride	207.00	371.6	0.557	TLV-STEL
Methylene Chloride	433.75	104.8	4.139	PEL-STEL
Tetrachlorethane, 1,1,2,2-	34.35	18.6	1.847	PEL-TWA
Tetrachloroethylene	678.00	717.1	0.945	TLV-STEL
Toluene	565.50	272.5	2.075	REL-STEL
Trichloroethane, 1,1,2-	54.60	34.1	1.601	PEL-TWA, TLV-TWA, REL-TWA
Trichloroethane, 1,1,1	1,911.00	692.7	2.759	REL-Ceiling
Trichloroethylene	10.74	408.7	0.026	REL-Ceiling
Vinyl Chloride	12.80	1048.0	0.012	PEL Ceiling

*Exposure limits are lowest of acute toxicity data (NIOSH REL-STEL, ACGIH TLV-STEL, OSHA PEL-STEL, NIOSH REL-Ceiling, ACGIH TLV-Ceiling, OSHA PEL-Ceiling) converted from ppm to mg/m^3 through conversion factor. If acute toxicity data were not available, the highest chronic exposure limit (NIOSH REL-TWA, ACGIH TLV-TWA, OSHA PEL-TWA) was used. See Appendix J of this manual for full list of acute and chronic exposure data.

Discharge Screening Level = Exposure Limit / Henry's Law Constant.

Henry's Law Constants Expressed in Alternate Units

Pollutant	Henry's Law Constant(2) M/atm @ 298 K (25°C)	Henry's Law Constant (atm m^3 / mol)	Henry's Law Constant (mol/m^3 / mg/L)	Henry's Law Constant (mg/m^3 / mg/L)
Acrolein	8.2	0.00012	0.000087	4.9
Acrylonitrile	9.15	0.00011	0.000084	4.5
Benzene	0.18	0.0056	0.0029	228
Bromoform	1.8	0.00056	0.000091	23
Carbon Tetrachloride	0.034	0.029	0.0077	1185
Chlorobenzene	0.27	0.0037	0.0013	151
Chloroethane	0.089	0.011	0.007	449
Chloroform	0.25	0.004	0.00137	164
1,1-Dichloroethane	0.17	0.0059	0.0024	240
1,2-Dichloroethane	0.85	0.0012	0.00049	48
1,1-Dichloroethylene	0.034	0.029	0.012	1202
Trans-1,2-Dichloroethylene	0.105	0.0095	0.004	389
1,2-Dichloropropane	0.345	0.0029	0.001	119
Ethyl benzene	0.125	0.008	0.0031	327
Hydrogen Cyanide	9.3	0.00011	0.00017	4.5
Hydrogen Sulfide	0.1	0.01	0.017	414.4
Methyl bromide	0.16	0.0063	0.0027	256
Methyl chloride	0.11	0.0091	0.0074	372
Methylene Chloride	0.39	0.0026	0.0012	105
1,1,2,2,-Tetrachlorethane	2.2	0.00045	0.00011	19
Tetrachloroethylene	0.057	0.018	0.00432	717
Toluene	0.15	0.0067	0.003	273
1,1,2-Trichloroethane	1.2	0.00083	0.00026	34
1,1,1-Trichloroethane	0.059	0.017	0.0052	693
Trichloroethylene	0.1	0.01	0.0031	409
Vinyl Chloride	0.039	0.026	0.017	1048

Source: *Compilation of Henry's Law Constants for Inorganic and Organic Species of Potential Importance in Environmental Chemistry*, R. Sanders 1999 (version 3).

H (atm m^3/mol) = [986.9 * H (M/atm)]-1

H (mg/m^3 / mg/L) = 40,893 * H(atm m^3 / mol)

H (mol/m^3 mg/L) = H (mg/m^3 / mg/L) / (1000 * MW)

MW = molecular weight in grams per mole

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APPENDIX J -
OSHA, ACGIH AND NIOSH EXPOSURE LEVELS

EXPOSURE LIMITS FROM VARIOUS AGENCIES FOR VOLATILE ORGANIC PRIORITY POLLUTANTS							
		OSHA Permissible Exposure Limits		ACGIH Threshold Limit Values		NIOSH Recommended Exposure Limits	
Volatile Organic Compounds	**mg/m^3 per ppm**	**TWA ppm**	**STEL ppm**	**TVA ppm**	**STEL ppm**	**TWA ppm**	**STEL ppm**
Acrolein	*2.29*	0.1			C 0.1	0.1	0.3
Acrylonitrile	*2.17*	2	C 10	2		1	C 10
Benzene	*3.19*	1	5	.5	2.5	0.1	1
Bromoform	*10.34*	0.5		0.5		0.5	
Carbon Tetrachloride	*6.29*	10	C 25	5	10		2
Chlorobenzene	*4.61*	75		10			
Chloroethane (Ethyl chloride)	*2.64*	1000		100			
Chloroform	*4.88*		C 50	10			2
Dichloroethane, 1,1-	*4.05*	100		100		100	
Dichloroethane,1,2- (Ethylene dichloride)	*4.05*	50	C 100	10		1	2
Dichloroethylene, 1,1- (Vinylidene chloride)	*3.96*			5			
trans-Dichloroethylene,1,2- (1,2-Dichloroethylene)	*3.97*	200		200		200	
Dichloropropane,1,2- (Propylene dichloride)	*4.62*	75		75	110		
Ethyl benzene	*4.34*	100		100	125	100	125
Hydrogen Cyanide	*1.10*	10			C 4.7		4.7
Hydrogen Sulfide	*1.40*		C 20	10	15		C 10
Methyl bromide	*3.89*		C 20	1			
Methyl chloride	*2.07*	100	C 200	50	100		
Methylene Chloride (Dichloromethane)	*3.47*	25	125	50			
Tetrachlorethane, 1,1,2,2-	*6.87*	5				1	
Tetrachloroethylene (Perchloroethylene)	*6.78*	100	C 200	25	100		
Toluene	*3.77*	200	C 300	50		100	150
Trichloroethane, 1,1,2-	*5.46*	10		10		10	
Trichloroethane, 1,1,1 (Methyl Chloroform)	*5.46*	350		350	450		C 350
Trichloroethylene	*5.37*	100	C 200	50	100	25	C 2
Vinyl Chloride	*2.56*	1	C 5	5			

Occupational Safety and Health Administration Permissible Exposure Limits (PELs) (29 CFR 1910.1000)
PEL time-weighted average (TWA) concentrations must not be exceeded during any 8-hour workshift of a 40-hour workweek. PEL short-term exposure limit (STEL) must not be exceeded over a 15-minute period unless noted otherwise. PEL ceiling concentrations (designated by "C" preceding the value in the STEL column) must not be exceeded during any part of the workday; if instantaneous monitoring is not feasible, the ceiling must be assessed as a 15-minute TWA exposure. OSHA values were updated in 2002 via the online *NIOSH Pocket Guide to Chemical Hazards*. http://www.cdc.gov/niosh/npg/npg.html.

American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs)
TLV Time-weighted average (TVA) concentrations are for a conventional 8-hour workday and a 40-hour workweek for which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect. TLV short-term exposure limit (STEL) concentrations are the 15-minute TWA exposure which should not be exceeded at any time during a workday even if the 8-hour TWA is within the TLV-TWA. TLV ceiling concentrations (designated by a "C" preceding the value in the STEL column) should not be exceeded during any part of the working exposure. ACGIH values found in the *ACGIH 2002 TLVs and BEIs.*

National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limits (RELs)
REL time-weighted average (TWA) concentrations must not be exceeded over a 10-hour workday during a 40-hour workweek. REL short-term exposure limits (STELs) are a 15-minute TWA exposure that should not be exceeded at any time during a workday. A ceiling REL, designated by "C" preceding the value in the STEL column, should not be exceeded at any time. NIIOSH values updated in 2003 via the online *NIOSH Pocket Guide to Chemical Hazards* at http://www.cdc.gov/niosh/npg/npg.html.

APPENDIX K -
LANDFILL LEACHATE LOADINGS

Landfill Leachate Monitoring Data*

Pollutant	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)	Average Concentration (mg/L)
INORGANICS			
Antimony	0.008	0.3	0.142
Arsenic	0.002	0.13	0.042
Barium	<0.1	0.55	0.201
Cadmium	< 0.001	1.25	0.03
Chromium (T)	0.007	12.1	0.633
Copper	0.007	10.87	0.395
Cyanide	0.04	0.05	0.029
Iron	1.5	4500	33.8
Lead	0.005	9.8	0.156
Manganese	0.63	73.2	13.224
Mercury	< 0002	0.002	0.002
Nickel	0.003	12.09	0.55
Selenium	< 002	0.02	0.01
Silver	< 0.01	0.05	0.019
Zinc	< 01	58	12.006
ORGANICS			
Acetone	2.8	2.8	2.8
Benzene	< 0.002	0.031	0.025
Benzoic Acid	0.02	< 0.4	0.19
Chlorobenzene	0.011	0.011	0.011
Chloroethane	< 0.001	< 0.1	0.021
p-chloro-m-Cresol	0.018	0.018	0.018
1,4-Dichlorobenzene	< 0.005	< 0.4	0.101
1,1-Dichloroethane	< 0.001	0.052	0.002
1,2-Dichloroethane	< 0.005	6.8	1.136
Ethylbenzene	0.017	0.54	0.171
Methyl Butyl Ketone	0.028	0.16	0.094
Methyl Ethyl Ketone	5.3	29	13.633
4-Methylphenol	0.065	0.065	0.065
Naphthalene	< 0.01	<0.4	0.113
N-Nitrosodiphenylamine	0.011	0.011	0.011
Pentachlorophenol	0.016	0.016	0.016
Phenol	0.008	2.9	1.06

Pollutant	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)	Average Concentration (mg/L)
Toluene	0.0082	1.6	0.735
Trichloroethene	< 0.001	< 0.1	0.025
1,1,1-Trichloroethane	0.011	0.022	0.019
2,4-Dimethyl Phenol	0.005	< 0.4	0.107
Diethyl Phthalate	0.11	0.11	0.11
Dimethyl Phthalate	0.0049	0.0049	0.0049
Di-N-Butyl Phthalate	0.0044	0.0044	0.0044
Vinyl Acetate	0.25	0.25	0.25
Vinyl Chloride	< 0.002	0.21	0.067

* Number of detections/number of observations could not be determined from data provided.

Source: U.S. EPA's *Supplemental Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Programs*, May 1991, pp. 1-30 and 1-31. "Pollutant levels reported below specified detection limit were considered in the data analysis and, for the purpose of statistical analysis, were considered to be equal to the detection limit."

Most Common Landfill Leachates*

Pollutant	Concentration Range (parts per million)
INORGANICS**	
Arsenic	0.0002 - 0.982
Barium	0.11 - 5
Cadmium	0.007 - 0.15
Chloride	31 - 5,475
Chromium (Total)	0.0005 - 1.9
Copper	0.03 - 2.8
Iron	0.22 - 2,280
Lead	0.005 - 1.6
Manganese	0.03 - 79
Nickel	0.02 - 2.2
Nitrate	0.01 - 51
Sodium	12 - 2,574
Sulfate	8 - 1,400
ORGANICS***	
1,1-Dichloroethane	0.004 - 44
Trans-1,2-Dichloroethylene	0.002 - 4.8
Ethylbenzene	0.006 - 4.9
Methylene Chloride	0.002 - 220
Phenol	0.007 - 28.8
Toluene	0.006 - 18

* Leachate data is compiled from a database of 70 MSWLFs [U.S. EPA 1988. *Summary of Data on Municipal Solid Waste Landfill Leachate Characteristics-Criteria for Municipal Solid Waste Landfills (40 CFR Part 258) - Subtitle D of Resource Conservation and Recovery Act* (Background Document)]. Washington, DC: Office of Solid Waste.

** Leachate data from 62 landfills.

*** Leachate data from 53 landfills.

Source: U.S. EPA's *National Pretreatment Program Report to Congress*, July 1991, p. 3-81.

Contaminant Concentration Ranges in Municipal Leachate

Pollutant Parameter	George (1972)	Chain /DeWalle (1977)	Metry/ Cross (1977)	Cameron (1978)	Wisconsin Report (20 Sites)	Sobotka Report (44 Sites)
CONVENTIONAL						
BOD	9 - 54,610	81 - 33,360	2,200 - 720,000	9 - 55,000	ND - 195,000	7 - 21,600
pH	3.7 - 8.5	3.7 - 8.5	3.7 - 8.5	3.7 - 8.5	5 - 8.9	5.4 - 8.0
TSS	6 - 2,685	10 - 700	13 - 26,500		2 - 140,900	28 - 2,835
NON-CONVENTIONAL						
Alkalinity	0 - 20,850	0 - 20,850	310 - 9,500	0 - 20,900	ND - 15,050	0 - 7,375
Bicarbonate			3,260 - 5,730			
Chlorides	34 - 2,800	4.7 - 2,467	47 - 2,350	34 - 2,800	2 - 11,375	120 - 5,475
COD	0 - 89,520	40 - 89,520	800 - 750,000	0 - 9,000	6.6 - 97,900	440 - 50,450
Fluorides				0 - 2.13	0 - 0.74	0.12 - 0.790
Hardness	0 - 22,800	0 - 22,800	35 - 8,700	0 - 22,800	52 - 225,000	0.8 - 9,380
NH_3-Nitrogen	0 - 1,106	0 - 1,106	0.2 - 845	0 - 1,106		11.3 - 1,200
NO -Nitrogen	0 - 1,300	0.2 - 1,0.29	4.5 - 18			0 - 5,0.95
Organic Nitrogen			2.4 - 550			4.5 - 78.2
Ortho-Phosphorus		6.5 - 85	0.3 - 136	0 - 154		
Sulfates	1 - 1,826	1 - 1,558	20 - 1,370	0 - 1,826	ND - 1,850	8 - 500
Sulfide				0 - 0.13		
TOC		256 - 28,000			ND - 30,500	5 - 6,884
TDS	0 - 42,276	584 - 44,900	100 - 51,000	0 - 42,300	584 - 50,430	1,400 - 16,120
Total-K-Nitrogen	0 - 1,416				2 - 3,320	47.3 - 938
Total Phosphorus	1 - 154	0 - 130			ND - 234	
Total Solids		0 - 59,200				1,900 - 25,873
METALS						
Aluminum				0 - 122	ND - 85	0.010 - 5.07
Arsenic				0 - 11.6	ND - 70.2	0 - 0.08
Barium				0 - 5.4	ND - 12.5	0.01 - 10
Beryllium				0 - 0.3	ND - 0.36	0.001 - 0.01

Pollutant Parameter	George (1972)	Chain /DeWalle (1977)	Metry/ Cross (1977)	Cameron (1978)	Wisconsin Report (20 Sites)	Sobotka Report (44 Sites)
Boron				0.3 - 73	0.867 - 13	
Cadmium		0.03 - 17		0 - 0.19	ND - 0.04	0 - 0.1
Calcium	5 - 4,080	60 - 7,200	240 - 2,570	5 - 4,000	200 - 2,500	95.5 - 2,100
Total Chromium				0 - 33.4	ND - 5.6	0.001 - 1.0
Copper	0 - 9.9	0 - 9.9		0 - 10	ND - 4.06	0.003 - 0.32
Cyanide				0 - 0.11	ND - 6	0 - 4.0
Iron	0.2 - 5,500	0 - 2,820	0.12 - 1,700	0.2 - 5,500	ND - 1,500	0.22 - 1,400
Lead	0 - 0.5	<0.10 - 2.0		0 - 5.0	0 - 14.2	0.001 - 1.11
Magnesium	16.5 - 15,600	17 - 15,600	64 - 547	16.5 - 15,600	ND - 780	76 - 927
Manganese	0.06 - 1,400	0.09 - 125	13	0.06 - 1,400	ND - 31.1	0.03 - 43
Mercury				0 - 0.064	ND - 0.01	0 - 0.02
Molybdenum				0 - 0.52	0.01 - 1.43	
Nickel				0.01 - 0.8	ND - 7.5	0.01 - 1.25
Potassium	2.8 - 3,770	28 - 3,770	28 - 3,800	2.8 - 3,770	ND - 2,800	30 - 1,375
Sodium	0 - 7,700	0 - 7,700	85 - 3,800	0 - 7,700	12 - 6,010	
Titanium				0 - 5.0	<0.01	
Vanadium				0 - 1.4	0.01	
Zinc	0 - 1,000	0 - 370	0.03 - 135	0 - 1,000	ND - 731	0.01 - 67

All concentrations in mg/L, except pH (standard units).
ND = Non-detect

Source: U.*S. EPA's Technical Development Document for Proposed Effluent Limitations Guidelines and Standards for the Landfills Point Source Category*, EPA 821-R-97-022, January 1998, Table 6-3.

* Literature sources were:

George, J. A., *Sanitary Landfill-Gas and Leachate Control, the National Perspective*, Office of Solid Waste Management Programs, U.S. EPA, 1972.

Chian, E. S., and F. B. DeWalle, *Evaluation of Leachate Treatment, Volume I, Characterization of Leachate*, EPA-600/2-77-186a.

Metry, A. A., and F. L. Cross, *Leachate Control and Treatment*, Volume 7, Environmental Monograph Series, Technomic Publishing Co., Westport, CT, 1977.

Cameron, R. D., *The Effect of Solid Waste Landfill Leachates on Receiving Waters*, Journal AWWA, March 1978.

McGinley, Paul M., and Peter Met. *Formation, Characteristics, Treatment and Disposal of Leachate from Municipal Solid Waste Landfills*, Wisconsin Department of Natural Resources Special Report, August 1, 1984.

Sobotka & Co., Inc., Case History Data Compiled and Reported to the U.S. Environmental Protection Agency Economic Analysis Branch, Office of Solid Waste, 1986.

APPENDIX L -
HAULED WASTE LOADINGS

Septage Hauler Monitoring Data

Pollutant	Number of Detections	Number of Samples	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)	Average Concentration (mg/L)
INORGANICS					
Arsenic	144	145	0	3.5	0.141
Barium	128	128	0.002	202	5.758
Cadmium	825	1097	0.005	8.1	0.097
Chromium (T)	931	1019	0.01	34	0.49
Cobalt	16	32	< 0.003	3.45	0.406
Copper	963	971	0.01	260.9	4.835
Cyanide	575	577	0.001	1.53	0.469
Iron	464	464	0.2	2740	39.287
Lead	962	1067	< 0.025	118	1.21
Manganese	5	5	0.55	17.05	6.088
Mercury	582	703	0.0001	0.742	0.005
Nickel	813	1030	0.01	37	0.526
Silver	237	272	< 0.003	5	0.099
Tin	11	25	< 015	1	0.076
Zinc	959	967	< 0.001	444	9.971
NONCONVENTIONALS					
COD	183	183	510	117500	21247.951
ORGANICS					
Acetone	118	118	0	210	10.588
Benzene	112	112	0.005	3.1	0.062
Ethylbenzene	115	115	0.005	1.7	0.067
Isopropyl Alcohol	117	117	1	391	14.055
Methyl Alcohol	117	117	1	396	15.84
Methyl Ethyl Ketone	115	115	1	240	3.65
Methylene Chloride	115	115	0.005	2.2	0.101
Toluene	113	113	0.005	1.95	0.17
Xylene	87	87	0.005	0.72	0.051

Source: U.S. EPA's *Supplemental Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Programs*, 21W-4002, May 1991, pp. 1-27 and 1-28. "Pollutant levels reported below specified detection limit were considered in the data analysis and, for the purpose of statistical analysis, were considered equal to the detection limit."

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APPENDIX M -
HAZARDOUS WASTE CONSTITUENTS - RCRA APPENDIX VIII

Constituent	CAS No.	Hazardous Waste No.
A2213	30558-43-1	U394
Acetonitrile	75-05-8	U003
Acetophenone	98-86-2	U004
2-Acetylaminefluarone	53-96-3	U005
Acetyl chloride	75-36-5	U006
1-Acetyl-2-thiourea	591-08-2	P002
Acrolein	107-02-8	P003
Acrylamide	79-06-1	U007
Acrylonitrile	107-13-1	U009
Aflatoxins	1402-68-2	-
Aldicarb	116-06-3	P070
Aldicarb sulfone	1646-88-4	P203
Aldrin	309-00-2	P004
Allyl alcohol	107-18-6	P005
Allyl chloride	107-18-6	-
Aluminum phosphide	20859-73-8	P006
4-Aminobiphenyl	92-67-1	-
5-(Aminomethyl)-3-isoxazolol	2763-96-4	P007
4-Aminopyridine	504-24-5	P008
Amitrole	61-82-5	U011
Ammonium vanadate	7803-55-6	P119
Aniline	62-53-3	U012
Antimony	7440-36-0	-
Antimony compounds, N.O.S.	-	-
Aramite	140-57-8	-
Arsenic	7440-38-2	-
Arsenic compounds, N.O.S.	-	-
Arsenic acid	7778-39-4	P010
Arsenic pentoxide	1303-28-2	P011
Arsenic trioxide	1327-53-3	P012
Auramine	492-80-8	U014
Azaserine	115-02-6	U015
Barban	101-27-9	U280
Barium	7440-39-3	-
Barium compounds, N.O.S.	-	-
Barium cyanide	542-62-1	P013
Bendiocarb	22781-23-3	U278
Bendiocarb phenol	22961-82-6	U364
Benomyl	17804-35-2	U271
Benz[c]acridine	225-51-4	U016
Benz[a]anthracene	56-55-3	U018
Benzal chloride	98-87-3	U017
Benzene	71-43-2	U019
Benzenearsonic acid	98-05-5	-
Benzidine	92-87-5	U021
Benzo[b]fluoranthene	205-99-2	-
Benzo[j]fluoranthene	205-82-3	-
Benzo(k)fluoranthene	207-08-9	-
Benzo[a]pyrene	50-32-8	U022
p-Benzoquinone	106-51-4	U197
Benzotrichloride	98-07-7	U023
Benzyl chloride	100-44-7	P028
Beryllium powder	7440-41-7	P015
Beryllium compounds, not otherwise specified (NOS)	-	-

Constituent	CAS No.	Hazardous Waste No.
Bis(pentamethylene)-thiuram tetrasulfide	120-54-7	-
Bromoacetone	598-31-2	P017
Bromoform	75-25-2	U225
4-Bromophenyl phenyl ether	101-55-3	U030
Brucine	357-57-3	P018
Butyl benzyl phthalate	85-68-7	-
Butylate	2008-41-5	-
Cacodylic acid	75-60-5	U136
Cadmium	7440-43-9	-
Cadmium compounds, NOS	-	-
Calcium chromate	13765-19-0	U032
Calcium cyanide	592-01-8	P021
Carbaryl	63-25-2	U279
Carbendazim	10605-21-7	U372
Carbofuran	1563-66-2	P127
Carbofuran phenol	1563-38-8	U367
Carbon disulfide	75-15-0	P022
Carbon oxyfluoride	353-50-4	U033
Carbon tetrachloride	56-23-5	U211
Carbosulfan	55285-14-8	P189
Chloral	75-87-6	U034
Chlorambucil	305-03-3	U035
Chlordane	57-74-9	U036
Chlordane (alpha and gamma isomers)	-	U036
Chlorinated benzenes, NOS	-	-
Chlorinated ethane, NOS	-	-
Chlorinated fluorocarbons, NOS	-	-
Chlorinated naphthalene, NOS	-	-
Chlorinated phenol, NOS	-	-
Chlornaphazin	494-03-1	U026
Chloroacetaldehyde	107-20-0	P023
Chloroalkyl ethers, NOS	-	-
p-Chloroaniline	106-47-8	P024
Chlorobenzene	108-90-7	U037
Chlorobenzilate	510-15-6	U038
p-Chloro-m-cresol	59-50-7	U039
2-Chloroethyl vinyl ether	110-75-8	U042
Chloroform	67-66-3	U044
Chloromethyl methyl ether	107-30-2	U046
beta-Chloronaphthalene	91-58-7	U047
o-Chlorophenol	95-57-8	U048
1-(o-Chlorophenyl)thiourea	5344-82-1	P026
Chloroprene	126-99-8	-
3-Chloropropionitrile	542-76-7	P027
Chromium	7440-47-3	-
Chromium compounds, NOS	-	-
Chrysene	218-01-9	U050
Citrus red No. 2	6358-53-8	-
Coal tar creosote	8007-45-2	-
Copper cyanide	544-92-3	P029
Copper dimethyldithiocarbamate	137-29-1	-
Creosote	-	U051
Cresol (Cresylic acid)	1319-77-3	U052
Crotonaldehyde	4170-30-3	U053
m-Cumenyl methylcarbamate	64-00-6	P202
Cyanides (soluble salts and complexes), NOS	-	P030
Cyanogen	460-19-5	P031
Cyanogen bromide	506-68-3	U246
Cyanogen chloride	506-77-4	P033

Constituent	CAS No.	Hazardous Waste No.
Cycasin	14901-08-7	-
Cycloate	1134-23-2	-
2-Cyclohexyl-4,6-dinitrophenol	131-89-5	P034
Cyclophosphamide	50-18-0	U058
2,4-D	94-75-7	U240
2,4-D, salts, esters	-	U240
Daunomycin	20830-81-3	U059
Dazomet	533-74-4	-
DDD	72-54-8	U060
DDE	72-55-9	-
DDT	50-29-3	U061
Diallate	2303-16-4	U062
Dibenz[a,h]acridine	226-36-8	-
Dibenz[a,j]acridine	224-42-0	-
Dibenz[a,h]anthracene	53-70-3	U063
7H-Dibenzo[c,g]carbazole	194-59-2	-
Dibenzo[a,e]pyrene	192-65-4	-
Dibenzo[a,h]pyrene	189-64-0	-
Dibenzo[a,i]pyrene	189-55-9	U064
1,2-Dibromo-3-chloropropane	96-12-8	U066
Dibutyl phthalate	84-74-2	U069
o-Dichlorobenzene	95-50-1	U070
m-Dichlorobenzene	541-73-1	U071
p-Dichlorobenzene	106-46-7	U072
Dichlorobenzene, NOS	25321-22-6	-
3,3'-Dichlorobenzidine	91-94-1	U073
1,4-Dichloro-2-butene	764-41-0	U074
Dichlorodifluoromethane	75-71-8	U075
Dichloroethylene, NOS	25323-30-2	-
1,1-Dichloroethylene	75-35-4	U078
1,2-Dichloroethylene	156-60-5	U079
Dichloroethyl ether	111-44-4	U025
Dichloroisopropyl ether	108-60-1	U027
Dichloromethoxy ethane	111-91-1	U024
Dichloromethyl ether	542-88-1	P016
2,4-Dichlorophenol	120-83-2	U081
2,6-Dichlorophenol	87-65-0	U082
Dichlorophenylarsine	696-28-6	P036
Dichloropropane, NOS	26638-19-7	-
Dichloropropanol, NOS	26545-73-3	-
Dichloropropene, NOS	26952-23-8	-
1,3-Dichloropropene	542-75-6	U084
Dieldrin	60-57-1	P037
1,2:3,4-Diepoxybutane	1464-53-5	U085
Diethylarsine	692-42-2	P038
Diethylene glycol, dicarbamate	5952-26-1	U395
1,4-Diethyleneoxide	123-91-1	U108
Diethylhexyl phthalate	117-81-7	U028
N,N'-Diethylhydrazine	1615-80-1	U086
O,O-Diethyl S-methyl dithiophosphate	3288-58-2	U087
Diethyl-p-nitrophenyl phosphate	311-45-5	P041
Diethyl phthalate	84-66-2	U088
O,O-Diethyl O-pyrazinyl phosphoro- thioate	297-97-2	P040
Diethylstilbesterol	56-53-1	U089
Dihydrosafrole	94-58-6	U090
Diisopropylfluorophosphate (DFP)	55-91-4	P043
Dimethoate	60-51-5	P044
3,3'-Dimethoxybenzidine	119-90-4	U091
p-Dimethylaminoazobenzene	60-11-7	U093

Constituent	CAS No.	Hazardous Waste No.
7,12-Dimethylbenz[a]anthracene	57-97-6	U094
3,3'-Dimethylbenzidine	119-93-7	U095
Dimethylcarbamoyl chloride	79-44-7	U097
1,1-Dimethylhydrazine	57-14-7	U098
1,2-Dimethylhydrazine	540-73-8	U099
alpha,alpha-Dimethylphenethylamine	122-09-8	P046
2,4-Dimethylphenol	105-67-9	U101
Dimethyl phthalate	131-11-3	U102
Dimethyl sulfate	77-78-1	U103
Dimetilan	644-64-4	P191
Dinitrobenzene, NOS	25154-54-5	-
4,6-Dinitro-o-cresol	534-52-1	P047
4,6-Dinitro-o-cresol salts	-	P047
2,4-Dinitrophenol	51-28-5	P048
2,4-Dinitrotoluene	121-14-2	U105
2,6-Dinitrotoluene	606-20-2	U106
Dinoseb	88-85-7	P020
Di-n-octyl phthalate	117-84-0	U017
Diphenylamine	122-39-4	-
1,2-Diphenylhydrazine	122-66-7	U109
Di-n-propylnitrosamine	621-64-7	U111
Disulfiram	97-77-8	-
Disulfoton	298-04-4	P039
Dithiobiuret	541-53-7	P049
Endosulfan	115-29-7	P050
Endothall	145-73-3	P088
Endrin	72-20-8	P051
Endrin metabolites	-	P051
Epichlorohydrin	106-89-8	U041
Epinephrine	51-43-4	P042
EPTC	759-94-4	-
Ethyl carbamate (urethane)	51-79-6	U238
Ethyl cyanide	107-12-0	P101
Ethyl Ziram	14324-55-1	-
Ethylenebisdithiocarbamic acid	111-54-6	U114
Ethylenebisdithiocarbamic acid, salts and esters	-	U114
Ethylene dibromide	106-93-4	U067
Ethylene dichloride	107-06-2	U077
Ethylene glycol monoethyl ether	110-80-5	U359
Ethyleneimine	151-56-4	P054
Ethylene oxide	75-21-8	U115
Ethylenethiourea	96-45-7	U116
Ethylidene dichloride	75-34-3	U076
Ethyl methacrylate	97-63-2	U118
Ethyl methanesulfonate	62-50-0	U119
Famphur	52-85-7	P097
Ferbam	14484-64-1	-
Fluoranthene	206-44-0	U120
Fluorine	7782-41-4	P056
Fluoroacetamide	640-19-7	P057
Fluoroacetic acid, sodium salt	62-74-8	P058
Formaldehyde	50-00-0	U122
Formetanate hydrochloride	23422-53-9	P198
Formic acid	64-18-6	U123
Formparanate	17702-57-7	P197
Glycidylaldehyde	765-34-4	U126

Constituent	CAS No.	Hazardous Waste No.
Halomethanes, NOS	-	-
Heptachlor	76-44-8	P059
Heptachlor epoxide	1024-57-3	-
Heptachlor epoxide (alpha, beta, and gamma isomers)	-	-
Heptachlorodibenzofurans	-	-
Heptachlorodibenzo-p-dioxins	-	-
Hexachlorobenzene	118-74-1	U127
Hexachlorobutadiene	87-68-3	U128
Hexachlorocyclopentadiene	77-47-4	U130
Hexachlorodibenzo-p-dioxins	-	-
Hexachlorodibenzofurans	-	-
Hexachloroethane	67-72-1	U131
Hexachlorophene	70-30-4	U132
Hexachloropropene	1888-71-7	U243
Hexaethyl tetraphosphate	757-58-4	P062
Hydrazine	302-01-2	U133
Hydrogen cyanide	74-90-8	P063
Hydrogen fluoride	7664-39-3	U134
Hydrogen sulfide	7783-06-4	U135
Indeno[1,2,3-cd]pyrene	193-39-5	U137
3-Iodo-2-propynyl n-butylcarbamate	55406-53-6	-
Isobutyl alcohol	78-83-1	U140
Isodrin	465-73-6	P060
Isolan	119-38-0	P192
Isosafrole	120-58-1	U141
Kepone	143-50-0	U142
Lasiocarpine	303-34-1	U143
Lead	7439-92-1	-
Lead compounds, NOS	-	-
Lead acetate	301-04-2	U144
Lead phosphate	7446-27-7	U145
Lead subacetate	1335-32-6	U146
Lindane	58-89-9	U129
Maleic anhydride	108-31-6	U147
Maleic hydrazide	123-33-1	U148
Malononitrile	109-77-3	U149
Manganese dimethyldithiocarbamate	15339-36-3	P196
Melphalan	148-82-3	U150
Mercury	7439-97-6	U151
Mercury compounds, NOS	-	-
Mercury fulminate	628-86-4	P065
Metam Sodium	137-42-8	-
Methacrylonitrile	126-98-7	U152
Methapyrilene	91-80-5	U155
Methiocarb	2032-65-7	P199
Methomyl	16752-77-5	P066
Methoxychlor	72-43-5	U247
Methyl bromide	74-83-9	U029
Methyl chloride	74-87-3	U045
Methyl chlorocarbonate	79-22-1	U156
Methyl chloroform	71-55-6	U226
3-Methylcholanthrene	56-49-5	U157
4,4'-Methylenebis(2-chloroaniline)	101-14-4	U158
Methylene bromide	74-95-3	U068
Methylene chloride	75-09-2	U080
Methyl ethyl ketone (MEK)	78-93-3	U159
Methyl ethyl ketone peroxide	1338-23-4	U160
Methyl hydrazine	60-34-4	P068
Methyl iodide	74-88-4	U138

Constituent	CAS No.	Hazardous Waste No.
Methyl isocyanate	624-83-9	P064
2-Methyllactonitrile	75-86-5	P069
Methyl methacrylate	80-62-6	U162
Methyl methanesulfonate	66-27-3	-
Methyl parathion	298-00-0	P071
Methylthiouracil	56-04-2	U164
Metolcarb	1129-41-5	P190
Mexacarbate	315-18-4	P128
Mitomycin C	50-07-7	U010
MNNG	70-25-7	U163
Molinate	2212-67-1	-
Mustard gas	505-60-2	-
Naphthalene	91-20-3	U165
1,4-Naphthoquinone	130-15-4	U166
alpha-Naphthylamine	134-32-7	U167
beta-Naphthylamine	91-59-8	U168
alpha-Naphthylthiourea	86-88-4	P072
Nickel	7440-02-0	-
Nickel compounds, NOS	-	-
Nickel carbonyl	13463-39-3	P073
Nickel cyanide	557-19-7	P074
Nicotine	54-11-5	P075
Nicotine salts	-	P075
Nitric oxide	10102-43-9	P076
p-Nitroaniline	100-01-6	P077
Nitrobenzene	98-95-3	U169
Nitrogen dioxide	10102-44-0	P078
Nitrogen mustard	51-75-2	-
Nitrogen mustard, hydrochloride salt	-	-
Nitrogen mustard N-oxide	126-85-2	-
Nitrogen mustard, N-oxide, hydro- chloride salt	-	-
Nitroglycerin	55-63-0	P081
p-Nitrophenol	100-02-7	U170
2-Nitropropane	79-46-9	U171
Nitrosamines, NOS	35576-91-1D	-
N-Nitrosodi-n-butylamine	924-16-3	U172
N-Nitrosodiethanolamine	1116-54-7	U173
N-Nitrosodiethylamine	55-18-5	U174
N-Nitrosodimethylamine	62-75-9	P082
N-Nitroso-N-ethylurea	759-73-9	U176
N-Nitrosomethylethylamine	10595-95-6	-
N-Nitroso-N-methylurea	684-93-5	U177
N-Nitroso-N-methylurethane	615-53-2	U178
N-Nitrosomethylvinylamine	4549-40-0	P084
N-Nitrosomorpholine	59-89-2	-
N-Nitrosonornicotine	16543-55-8	-
N-Nitrosopiperidine	100-75-4	U179
N-Nitrosopyrrolidine	930-55-2	U180
N-Nitrososarcosine	13256-22-9	-
5-Nitro-o-toluidine	99-55-8	U181
Octamethylpyrophosphoramide	152-16-9	P085
Osmium tetroxide	20816-12-0	P087
Oxamyl	23135-22-0	P194
Paraldehyde	123-63-7	U182
Parathion	56-38-2	P089
Pebulate	1114-71-2	-
Pentachlorobenzene	608-93-5	U183
Pentachlorodibenzo-p-dioxins	-	-
Pentachlorodibenzofurans	-	-

Constituent	CAS No.	Hazardous Waste No.
Pentachloroethane	76-01-7	U184
Pentachloronitrobenzene (PCNB)	82-68-8	U185
Pentachlorophenol	87-86-5	F027
Phenacetin	62-44-2	U187
Phenol	108-95-2	U188
Phenylenediamine	25265-76-3	-
Phenylmercury acetate	62-38-4	P092
Phenylthiourea	103-85-5	P093
Phosgene	75-44-5	P095
Phosphine	7803-51-2	P096
Phorate	298-02-2	P094
Phthalic acid esters, NOS	-	-
Phthalic anhydride	85-44-9	U190
Physostigmine	57-47-6	P204
Physostigmine salicylate	57-64-7	P188
2-Picoline	109-06-8	U191
Polychlorinated biphenyls, NOS		-
Potassium cyanide	151-50-8	P098
Potassium dimethyldithiocarbamate	128-03-0	-
Potassium n-hydroxymethyl-n-methyl-dithiocarbamate	51026-28-9	-
Potassium n-methyldithiocarbamate	137-41-7	-
Potassium pentachlorophenate	7778736	-
Potassium silver cyanide	506-61-6	P099
Promecarb	2631-37-0	P201
Pronamide	23950-58-5	U192
1,3-Propane sultone	1120-71-4	U193
n-Propylamine	107-10-8	U194
Propargyl alcohol	107-19-7	P102
Propham	122-42-9	U373
Propoxur	114-26-1	U411
Propylene dichloride	78-87-5	U083
1,2-Propylenimine	75-55-8	P067
Propylthiouracil	51-52-5	-
Prosulfocarb	52888-80-9	U387
Pyridine	110-86-1	U196
Reserpine	50-55-5	U200
Resorcinol	108-46-3	U201
Saccharin	81-07-2	U202
Saccharin salts	-	U202
Safrole	94-59-7	U203
Selenium	7782-49-2	-
Selenium compounds, NOS	-	-
Selenium dioxide	7783-00-8	U204
Selenium sulfide	7488-56-4	U205
Selenium, tetrakis(dimethyl-dithiocarbamate)	144-34-3	-
Selenourea	630-10-4	P103
Silver	7440-22-4	-
Silver compounds, NOS	-	-
Silver cyanide	506-64-9	P104
Silvex (2,4,5-TP)	93-72-1	F027
Sodium cyanide	143-33-9	P106
Sodium dibutyldithiocarbamate	136-30-1	-
Sodium diethyldithiocarbamate	148-18-5	-
Sodium dimethyldithiocarbamate	128-04-1	-
Sodium pentachlorophenate	131522	None
Streptozotocin	18883-66-4	U206
Strychnine	57-24-9	P108
Strychnine salts	-	P108
Sulfallate	95-06-7	-

Constituent	CAS No.	Hazardous Waste No.
TCDD	1746-01-6	-
Tetrabutylthiuram disulfide	1634-02-2	-
1,2,4,5-Tetrachlorobenzene	95-94-3	U207
Tetrachlorodibenzo-p-dioxins	-	-
Tetrachlorodibenzofurans	-	-
Tetrachloroethane, NOS	25322-20-7	-
1,1,1,2-Tetrachloroethane	630-20-6	U208
1,1,2,2-Tetrachloroethane	79-34-5	U209
Tetrachloroethylene	127-18-4	U210
2,3,4,6-Tetrachlorophenol	58-90-2	F027
2,3,4,6-tetrachlorophenol, potassium salt	53535276	-
2,3,4,6-tetrachlorophenol, sodium salt	25567559	-
Tetraethyldithiopyrophosphate	3689-24-5	P109
Tetraethyl lead	78-00-2	P110
Tetraethyl pyrophosphate	107-49-3	P111
Tetramethylthiuram monosulfide	97-74-5	-
Tetranitromethane	509-14-8	P112
Thallium	7440-28-0	-
Thallium compounds, NOS	-	-
Thallic oxide	1314-32-5	P113
Thallium(I) acetate	563-68-8	U214
Thallium(I) carbonate	6533-73-9	U215
Thallium(I) chloride	7791-12-0	U216
Thallium(I) nitrate	10102-45-1	U217
Thallium selenite	12039-52-0	P114
Thallium(I) sulfate	7446-18-6	P115
Thioacetamide	62-55-5	U218
Thiodicarb	59669-26-0	U410
Thiofanox	39196-18-4	P045
Thiomethanol	74-93-1	U153
Thiophanate-methyl	23564-05-8	U409
Thiophenol	108-98-5	P014
Thiosemicarbazide	79-19-6	P116
Thiourea	62-56-6	U219
Thiram	137-26-8	U244
Tirpate	26419-73-8	P185
Toluene	108-88-3	U220
Toluenediamine	25376-45-8	U221
Toluene-2,4-diamine	95-80-7	-
Toluene-2,6-diamine	823-40-5	-
Toluene-3,4-diamine	496-72-0	-
Toluene diisocyanate	26471-62-5	U223
o-Toluidine	95-53-4	U328
o-Toluidine hydrochloride	636-21-5	U222
p-Toluidine	106-49-0	U353
Toxaphene	8001-35-2	P123
Triallate	2303-17-5	U389
2,4,6-Tribromophenol	118-79-6	U408
1,2,4-Trichlorobenzene	120-82-1	-
1,1,2-Trichloroethane	79-00-5	U227
Trichloroethylene	79-01-6	U228
Trichloromethanethiol	75-70-7	P118
Trichloromonofluoromethane	75-69-4	U121
2,4,5-Trichlorophenol	95-95-4	F027
2,4,6-Trichlorophenol	88-06-2	F027
2,4,5-T	93-76-5	F027

Constituent	CAS No.	Hazardous Waste No.
Trichloropropane, NOS	25735-29-9	-
1,2,3-Trichloropropane	96-18-4	-
Triethylamine	121-44-8	U404
O,O,O-Triethyl phosphorothioate	126-68-1	-
1,3,5-Trinitrobenzene	99-35-4	U234
Tris(1-aziridinyl)phosphine sulfide	52-24-4	-
Tris(2,3-dibromopropyl) phosphate	126-72-7	U235
Trypan blue	72-57-1	U236
Uracil mustard	66-75-1	U237
Vanadium pentoxide	1314-62-1	P120
Vernolate	1929-77-7	-
Vinyl chloride	75-01-4	U043
Warfarin, concentrations less than 0.3%	81-81-2	U248
Warfarin, concentrations greater than 0.3%	81-81-2	P001
Warfarin salts, when present at concentrations less than 0.3%.	-	U248
Warfarin salts, when present at concentrations greater than 0.3%.	-	P001
Zinc cyanide	557-21-1	P121
Zinc phosphide, when present at concentrations greater than 10%.	1314-84-7	P122
Zinc phosphide, when present at concentrations of 10% or less.	1314-84-7	U249
Ziram	137-30-4	P205

Source: 40 CFR Part 261, Subpart D and Appendix VIII - Hazardous Constituents.

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APPENDIX N - STATISTICAL APPROACH TO DETERMINING SAMPLING FREQUENCY

The use of statistical analyses can help establish an acceptable minimum number of samples needed to adequately represent a population of pollutants influent and effluent at an acceptable confidence level.

The procedure for establishing an acceptable minimum number of samples is calculated using the technique described in: *Statistical Methods for Environmental Pollution Monitoring* (Gilbert, 1987). This text is frequently cited in environmentally related statistical work. The method utilizes Equation 1 to calculate the sample size required to estimate the true mean of a population, based on the coefficient of variation, a confidence level, and a relative error. The method assumes a normal distribution of samples.

$$n = (Z_{1-\alpha/2}\eta/d_r)^2 \qquad \text{Eq. 1}$$

Where:

n	=	Sample size required for estimating the true mean, μ
$Z_{1-\alpha/2}$	=	Normal deviate of desired confidence level
η	=	Coefficient of variation
d_r	=	Relative error

The coefficient of variation is determined by Equation 2.

$$\eta = s / \bar{X} \qquad \text{Eq. 2}$$

Where:

s	=	Standard deviation
$\bar{X}$	=	Mean

The sample standard deviation is determined by Equation 3.

$$s = \left[\frac{1}{n-1} \cdot \sum_{i=1}^{n} (X_i - \bar{X})^2 \right]^{1/2}$$

Eq. 3

The mean and standard deviation used above should be taken from an acceptable past available sample. Both an acceptable confidence level and an acceptable relative error must be selected, each of which will vary depending on the type of pollutant being measured. Selection of both levels should be determined by the POTW based on the situation. The confidence level expresses the certainty of the estimated mean while the relative error indicates the accuracy of the estimated mean compared to the true mean.

Table 1-1 is an example matrix which applies Equation 1 to calculate sample size.

Table 1-1. Sample Sizes Required for Estimating the True Mean

Confidence Level	Relative Error	Coefficient of Variation (η)					
(1-α)	(d_r)	0.10	0.30	0.50	1.00	1.50	2.00
0.80 ($Z_{0.90}$ = 1.28)	0.10	2	15	41	164	369	656
	0.25	-	3	7	27	59	105
	0.50	-	1	2	7	15	27
	1	-	-	-	2	4	7
0.90 ($Z_{0.975}$ = 1.645)	0.10	3	25	68	271	609	1083
	0.25	-	4	11	44	98	174
	0.50	-	1	3	11	25	44
	1	-	-	1	3	7	11

As shown in Table 1-1, establishing the number of samples needed to estimate the true mean is critically dependent on a data set's coefficient of variation (CV).

For example, a past, reliable sample produced a data set with standard deviation of 2 mg/L and a mean of 2 mg/L, resulting in CV equal to one. If a confidence level of 0.80 (with a corresponding $Z_{1-\alpha/2} = 1.28$) and a relative error of 0.25 are determined to be adequate, then Equation 1 is used as follows:

$$n = (1.28 * 1 / .25)^2 = 26.21$$

The sample size must then be rounded to the next whole number, in this case, 27. The 27 samples may be taken throughout the year if desired, or as determined by the POTW. In the case of taking the samples throughout the year, the POTW might take two samples per month and an additional three samples at random times during the year. One sample may be evaluated for multiple contaminants; however, each location would need to be sampled independently.

Under these conditions, there would be 80% confidence that the estimated mean from 27 samples (as illustrated in Table 1-1) would be within $\pm$ 25% of the true mean. Therefore, if the estimated mean is 4 mg/L, there would be 80% confidence that the true mean is within the interval of 3 to 5 (*i.e.*, 4 ± 1). If a confidence level of 0.90 and relative error of 0.10 were desired, the number of samples would increase substantially. Under these conditions, there would be 90% confidence that the estimated mean from 271 samples (as illustrated in Table 1-1) would be within $\pm$ 10% of the true mean. Therefore, if the estimated mean was 2 mg/L, there would be 90% confidence that the true mean was within the interval of 1.8 to 2.2 (*i.e.*, 2 ± 0.2).

Source: SAIC. 1998. POTW Metals Analysis Project, Task 3 Deliverable to U.S. EPA Region VIII, EPA, Contract No. 68-C4-0068; Work Assignment Number PS-3-1, SAIC Project Number 01-0833-08-2696-800, August 25, 1998.

APPENDIX O - MINIMIZING CONTAMINATION IN SAMPLES

Some of the data reported as below the detection level (BDL) may be the result of the POTW sampling techniques and chosen analytical methods. With the need to accurately detect trace levels of pollutants, POTWs should thoroughly examine potential sources of gross and trace contamination and select analytical methods that can detect very low levels of pollutants. EPA has established new performance based[1] sampling and analysis methods (1600 series) for measuring 13 toxic metals in the low ppt to ppb range. While these methods were developed for ambient water quality monitoring, POTWs may apply some of the concepts in Method 1669, *Sampling Ambient Water for Determination of Metals at EPA Water Quality Criteria Levels*, to improve the reliability of data collected, potentially even utilizing analytical methods 1631, 1632, 1636-40.

Excerpts from Section 4.2.2 of Method 1669 are provided below.

Minimizing Contamination: Sampling Location, Sampling Equipment and Materials, and Chemicals:

- *Where possible, limit exposure of the sample and equipment in areas of higher contamination, e.g., downwind from the sludge beds.*

- *Minimize contact with airborne dust, dirt, particulate matter, or vapors from automobile exhaust; cigarette smoke; nearby corroded or rusted bridges, pipes, poles, or wires; nearby roads; and even human breath. Areas where nearby soil is bare and subject to wind erosion should be avoided.*

- *Clean the sampling equipment and minimize the time between cleaning of equipment and use.*

- *Use metal-free equipment, i.e., equipment should be nonmetallic and free of material that may contain metals of interest. When it is not possible to obtain equipment that is completely free of the metal(s) of interest, the sample should not come into direct contact with the equipment.*

- *Do not use sampling equipment where there are indications that it may not be clean, e.g., sampler tubing or collection bottle is stained, has not been changed out in some time, was used to collected a sample of a slug load that hit the WWTP, etc.*

- *Avoid contamination by carryover. Contamination may occur when a sample containing low concentrations of metals is processed immediately after a sample containing relatively high concentrations of these metals.*

- *Where possible, do not collect, process, or ship samples containing high concentrations of metals (e.g., untreated effluents, in-process waters, landfill leachates) at the same time as samples being collected for trace metals determinations.*

- *Wear clean, non-talc dusted gloves during all operations involving handling of equipment, samples, and blanks. Change gloves once they have become contaminated.*

[1] An alternate procedure or technique may be used so long as neither samples nor blanks are contaminated when following alternate procedures.

- *Fluoropolymer (FEP, PTFE), conventional or linear polyethylene, polycarbonate, polysulfone, polypropylene, or ultrapure quartz are the preferred materials for coming in contact with samples. Fluoropolymer or glass containers are preferred for samples that will be analyzed for mercury because mercury vapors can diffuse in or out of other materials, resulting either in contamination or low-biased results.*

Lot Analyses of Metals in Different Grades of Nitric Acid (SOURCE-FISHER-INTERNET)

	Highest Grade	Higher Grade	High Grade
Antimony	<0.01 ppb	<0.1 ppb	
Arsenic	<0.1 ppb	<0.3 ppb	≤4 ppb
Cadmium	<0.005 ppb	<0.1 ppb	
Chromium	<0.03 ppb	≤9 ppb	≤100 ppb
Copper	≤0.05 ppb	<1 ppb	≤50 ppb
Lead	≤0.01 ppb	<0.3 ppb	≤100 ppb
Mercury	<0.1 ppb	<0.5 ppb	
Nickel	≤0.1 ppb	<1 ppb	≤50 ppb
Selenium		<0.5 ppb	
Silver	<0.005 ppb	<0.1 ppb	

- *The following materials have been found to contain trace metals: Pyrex, Kimax, methacrylate, polyvinyl chloride, nylon, Vycor, highly colored plastics, paper cap liners, pigments used to mark increments on plastics, and rubber. It is recommended that these materials not be used to hold liquids that come in contact with the sample or must not contact the sample.*

- *Use an appropriate grade of chemicals when prepping equipment/materials and chemically preserving samples.*

Quality Control:

- *Serial numbers should be indelibly marked or etched on each piece of Apparatus so that contamination can be traced, and logbooks should be maintained to track the sample from the container through the sampling process to shipment to the laboratory. Chain-of-custody procedures should be used so that contamination can be traced to particular handling procedures or lab personnel.*

- *Equipment blanks should be periodically generated and analyzed to identify contamination that may result from improper preparation or handling of sampling equipment and bottles in the laboratory. Equipment blanks include processing reagent water (i.e., water known not to contain pollutants at detectable levels) through sampling equipment and sample bottle(s) prior to taking the equipment or bottle(s) to the field.*

- *A trip blank should be periodically generated and analyzed to identify incidental contamination that may occur to sampling equipment/bottles while in transit to and from the sampling location. Essential, reagent water is place in a sample bottle prior to going to the field.*

- *Field blanks should be periodically generated and analyzed to identify contamination that may occur to sampling equipment/bottles while in the field. Like equipment blanks, it involves process reagent water through the sampling equipment/bottle.*

APPENDIX P -
METHODS FOR CALCULATING REMOVAL EFFICIENCY

There are three methods of calculating removal efficiencies: average daily removal efficiency (ADRE) method, mean removal efficiency (MRE) method, and the decile approach. As defined in Equation 5.1, the ADRE across a plant is defined as:

$$R_{potw} = \frac{\Sigma(I_n - E_{potw,n})/I_n}{N}$$

Where:

R_{potw}	=	Plant removal efficiency from headworks to plant effluent (as decimal)
I_n	=	POTW influent pollutant concentration at headworks , mg/L
$E_{potw,\ n}$	=	POTW effluent pollutant concentration
n	=	Paired observations, numbered 1 to N

As defined in Equation 5.2, the MRE across a plant is defined as:

$$R_{potw} = \frac{\overline{I_r} - \overline{E_{potw,t}}}{\overline{I_r}}$$

Where:

R_{potw}	=	Plant removal efficiency from headworks to plant effluent (as decimal)
I_r	=	POTW influent pollutant concentration at headworks, mg/L
$E_{potw,\ t}$	=	POTW effluent pollutant concentration, mg/L
t	=	Plant effluent samples, numbered 1 to T
r	=	Plant influent samples, numbered 1 to R

It is important to realize that the portion of the pollutant removed through a treatment process is transferred to another wastestream, typically the sludge. For conservative pollutants, such as metals, all the pollutant from the influent ends up in either the effluent or the sludge. For example, a 93% overall plant removal means that 93% of the cadmium in the influent is transferred to the sludge, while 7% remains in the effluent wastewater.

1. REVIEW OF THE DATA SET AND EXCLUSION OF CERTAIN DATA

A good first step in determining removal efficiencies is to review the data set. This review can identify any data values that are extremely high or low. If there are isolated extreme values, there are formal statistical procedures that can be applied to evaluate whether a value can be classified as an "outlier" relative to the rest of the data set. Two methods most widely used to make this determination are described in the following two paragraphs.

If the data is known to closely follow a normal distribution, then any data point that lies more than two standard deviations from the mean is considered an outlier. Consider, for example, the DRE data values

located in Table 1 of this appendix, and assume that this data is from a normal distribution. The 15 observations have a mean of 52.69 and a standard deviation of 34.65. Using this method, any data point that lies outside of the range -16.61 to 121.99, or 52.69 ± 2*34.65, can be considered an outlier. In this case, one value, -20.25, falls outside of the range and can be determined to be an outlier.

However, the DRE data values do not approximate a "bell-shaped" normal distribution. In this case, outliers can be determined based on the interquartile range (IQR) of the data set. First, order the data from smallest to largest and locate the data points that fall at the 25th percentile (also referred to as the first quartile or Q1), and the 75th percentile (also referred to as the third quartile or Q3). The IQR is equal to the value of the observation at Q3 minus the value of the observation at Q1. Any data point that lies more than 1.5 times this IQR below Q1, or above Q3, is considered an outlier. Again, consider the data in Table 1, but now make no assumptions about the distribution of the population from which the sample was taken. The Q1 and Q3 of this data set are located at 38.04 and 78.5 respectively. Based on these values, the IQR is equal to 40.46 (78.5 - 38.04). Any value that falls below -22.65 (38.04 - 1.5*40.46), or above 139.19 (78.5 + 1.5*40.46), can be considered an outlier. In this case, there are no values that fall outside of the range and, consequently, no values should be determined to be outliers.

Both of these methods are meant to determine any values that may be candidates for exclusion from the data set. Data exclusion should be performed only if technical justification exists to support such action (e.g., poor removals due to temporary maintenance or operational problems or known sampling problems). For example, if an examination of the data set shows that an unusually high influent value is from the same sampling day/event as an unusually high effluent value, this occurrence of corresponding extreme values should be investigated to determine if the data values can be explained by technical or operational problems not related to treatment system performance (e.g., maintenance, repair, or sampling problems). If this is the case, dropping the data pair from the data set may be appropriate.

Review of the data may also show patterns such as increasing effluent values over time. If a similar pattern is not observed for the influent values, this will generate a pattern of decreasing DREs over time. A graph or plot of DRE against sampling day/event (in order from first to most recent sample) can help identify such trends. This may alert the POTW to operational problems that should be investigated. A plot can also highlight unusually low DREs that call for further review, such as checking laboratory quality control samples to determine if blank or duplicate samples indicate anything out of the ordinary. If abnormalities are found in laboratory QA/QC (quality assurance/quality control) data, the POTW may consider excluding the affected values from the data set.

Table 1 contains an example data set of 15 influent and effluent sample pairs for zinc. The influent and effluent concentrations have been converted to loadings using the POTW flows for the sample days. The influent and effluent concentrations may be used instead of converting to loadings. Whether loadings or concentrations are used will likely have little impact on the results of the ADRE and decile approaches.

Influent and effluent flows are probably similar (if not the same) for a data pair and therefore will have little effect on the relative size of the influent and effluent values, so DREs will change little. However, converting to loadings may have a noticeable impact on the MRE method if a POTW has high variability in its flows. Because influent and effluent loadings for high flow days will increase more relative to influent and effluent loadings for low flow days, the net effect is to give greater weight to the removal rates on those days with high flows. If the POTW has high variability in its flows, it should evaluate whether its removal rates tend to go up and down in relation to flow. If so, the POTW should consider calculating an MRE using both concentrations and loadings and evaluating which is more appropriate.

Table 1. Removal Efficiency Example

Sample Day	Date	Influent Load (lbs/day)	Effluent Load (lbs/day)	DRE (%)
1	3/4/99	518.22	111.41	78.50
2	3/5/99	163.98	173.99	-6.10
3	3/6/99	110.15	97.64	11.36
4	3/7/99	1739.93	474.41	72.73
5	3/8/99	266.48	320.45	-20.25
6	4/15/99	170.48	105.15	38.32
7	5/11/99	473.16	132.67	71.96
8	5/12/99	314.19	148.96	52.59
9	5/13/99	306.68	132.69	56.73
10	5/14/99	232.57	92.63	60.17
11	5/15/99	226.52	72.60	67.95
12	6/15/99	533.25	98.87	81.46
13	7/1/99	141.43	87.63	38.04
14	7/15/99	1166.77	103.90	91.10
15	8/1/99	2301.00	97.88	95.75
Average		577.65	150.06	52.69

Review of the data shows that:

- The data set does not require removal of outliers.
- The three particularly high influent values (sample days 4, 14, and 15) all have DREs of more than 70%, so the high influent values do not appear to make the data candidates for elimination.
- There are two effluent values (sample days 4 and 5) that are significantly higher than the others. For one, the corresponding influent value is also high and the DRE is 73%. For the other day, the DRE is negative (-20%) because the influent value is relatively low. These results are from samples taken on two consecutive days (March 7 and March 8), which may indicate that the POTW treatment system was experiencing some operational difficulties or interference at the time. The POTW should investigate the matter to determine if there are valid reasons for dropping these data from the removal calculations data set.
- There are two negative DREs (one for March 8) calculated from the influent and effluent data pairs. They occurred three days apart and may indicate temporary operational problems, so the POTW should investigate the matter (as noted above).

A plot of the data may help the POTW identify any data concerns that should be investigated. Based on the review of data for this example, it was determined that no justification exists for excluding any of the data from the data set.

2. CALCULATION OF REMOVAL EFFICIENCIES

Once the data set has been reviewed, the POTW can proceed to calculating removal efficiencies. The following sections describe each of the methods for calculating removal efficiencies and perform the calculations using the example data set in Table 1.

2.1 Average Daily Removal Efficiency (ADRE)

The ADRE is calculated by first calculating a DRE for each pair of influent and effluent values (i.e., an influent value and an effluent value from the same sampling day/event are used to calculate a DRE). This set of DREs is then averaged to determine the ADRE for a pollutant. Use of the ADRE method requires that a POTW only use data for the sampling days/events for which it has both an influent and an effluent value, and the influent value is greater than zero.

Example

For the example data set in Table 1, the ADRE is calculated as:

ADRE = [78.5+(-6.1)+11.36+72.73+(-20.25)+38.32+71.96+52.59+56.73+60.17+67.95+81.46+38.04 +91.10+95.75)]/15 = 52.69%

2.2 Mean Removal Efficiency (MRE)

The MRE is calculated by using the same formula as for the DRE (shown at the beginning of the Appendix), but instead of using individual influent and effluent values from sampling days/events, the set of influent values is first averaged to determine the average influent value and the same is done for the set of effluent values (either concentrations or loadings). These average values are then used in the DRE equation to result in the MRE for a pollutant. Unlike the ADRE method, the MRE method does not require paired influent and effluent values from the same sampling days/events. The MRE can be based on influent and effluent sample values that are not always paired (e.g., one effluent sample is lost or destroyed, so the influent average is based on one more value than the effluent average). However, the POTW should use caution in building the data sets for calculating influent and effluent averages because if too many unpaired values are used the removal efficiencies may be meaningless because the influent data and effluent data may represent different time periods, and treatment plant conditions do vary over time.

Example

For the example data set in Table 1, the MRE is calculated as:

Average of the *influent* values = 577.65 lbs/day
Average of the *effluent* values = 150.06 lbs/day
MRE = 100*(577.65-150.06)/577.65 = 74.02%

2.3 Comparison of Results from ADRE and MRE Methods

Note that the MRE (74.02%) is higher than the ADRE (52.69%). The three days with the highest influent loadings have relatively high DREs and the two negative DREs (Day 2 and Day 5) occur on days with values that are not significantly greater than the other days. In the ADRE calculation, each day/DRE is given the same weight as the others, while the MRE method gives greater weight to the days with greater loadings. This means that the high removals on the days with high influent loadings affect the MRE more than the other days do, leading to a higher MRE, while the negative values do not have as great an impact because they occur on days with less elevated influent and effluent values If each DRE were to be weighted by its proportion of the total loading, the result would be the same as with the MRE method.

Usually, the MRE and ADRE are slightly different from each other, and can be quite different (as in the example presented here). The POTW can calculate both and decide if one of the estimates is the most appropriate for use in AHL calculations. The POTW can also use the decile approach to determine representative removal efficiencies.

2.4 Decile Approach

The decile approach, unlike the above methods, considers how often the actual DRE will be above or below a specified removal rate, thereby taking into account the variability of POTW removal efficiencies over time. The decile approach involves putting the set of DREs (calculated using the formula presented at the beginning of this appendix) in order from least to greatest and then determining nine decile values. Each decile is the value below which a certain percentage of the DREs fall. For example, the first decile is the value below which 10% of the DREs fall. Similarly, the second decile is the value below which 20% of the DREs fall, on up to the ninth decile, which is the value below which 90% of the DREs fall. The fifth decile is the median and half of the DREs fall below this number. To apply the decile approach, a minimum of nine DREs are required. If exactly nine DREs are available, the nine estimated deciles are simply the nine DREs. If more then nine DREs are used, the POTW needs to calculate the nine decile estimates.

Tables 2 and 3 below illustrate use of the decile approach for the example zinc data set. The steps are:

- ***Step 1:*** Take the set of DREs and put the values in order from smallest to largest (see Table 2).

- ***Step 2:*** The entries for Column 1 are obtained by performing the two calculations. First, define the location for the first decile and then calculate the next eight multiples of that location value to determine the location for the second through ninth deciles. The first location is determined by the equation: (N+1)/10, where N = the number of data pairs/DREs used. For the example data set, N=15, so the location for the first decile is (15+1)/10 = 1.6. The location for the second decile is 2 x 1.6 = 3.2, the location for the third decile is 3 x 1.6 = 4.8, and so on up to the ninth decile of 9 x 1.6 = 14.4. (Column 1 in Table 3)

- ***Step 3:*** For each decile, take the whole number part of the value in Column 1 and place it in Column 2 (e.g., the first decile is 1.6, so the whole number part is 1; the fourth decile is 6.4, so the whole number part is 6).

- ***Step 4:*** The entries in Column 3 of Table 3 are taken from the ordered list of DREs in Table 2. The whole number values in Column 2 correspond to the entry in the ordered list in Table 2 [e.g., the whole number part for the first decile is 1, so entry 1 (-20.25%) from Table 2 is the correct value and is placed in Column 3 of Table 3; similarly, the fourth decile whole number part is 6, so value 6 (52.59%) is placed in Column 3 of Table 3 for the fourth decile].

- ***Step 5:*** Following a similar procedure as in Step 4, values for Column 4 are taken from Table 2 and place in Table 3, except that this time the values taken from Table 2 are the ones that immediately follow the Column 3 entries [e.g., for the first decile, the value placed in Column 4 is -6.10, which is value 2 (the value immediately after value 1) from Table 2; for the fourth decile, the value placed in Column 4 is 56.73, which is value 7 from Table 2].

- ***Step 6:*** Fill in Column 5 by subtracting Column 3 from Column 4 and entering the result.

- ***Step 7:*** Similar to the process for filling Column 2 (explained in Step 3) of Table 3, place the decimal part of the Column 1 entries in Column 6 of Table 3 (e.g., for the first decile, use 0.6; for the fourth decile, use 0.4).

- ***Step 8:*** Fill in Column 7 by multiplying the values in Column 5 by the values in Column 6 and entering the result.

- ***Step 9:*** Add Column 3 and Column 7 and enter the result in Column 8 of Table 3. These values are the estimated deciles.

Table 2. Set of DREs Sorted in Ascending Order

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
-20.25	-6.1	11.36	38.04	38.32	52.59	56.73	60.17	67.95	71.96	72.73	78.50	81.46	91.10	95.75

Table 3. Decile Approach for Zinc Example

Deciles	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8
1st	1.6	1	-20.25	-6.10	14.15	0.6	8.490	-11.76
2nd	3.2	3	11.36	38.04	26.68	0.2	5.336	16.70
3rd	4.8	4	38.04	38.32	0.28	0.8	0.224	38.26
4th	6.4	6	52.59	56.73	4.14	0.4	1.656	54.25
5th	8.0	8	60.17	67.95	7.78	0	0.000	60.17
6th	9.6	9	67.95	71.96	4.01	0.6	2.406	70.36
7th	11.2	11	72.73	78.50	5.77	0.2	1.154	73.88
8th	12.8	12	78.50	81.46	2.96	0.8	2.368	80.87
9th	14.4	14	91.10	95.75	4.65	0.4	1.860	92.96

The main value of the decile approach is that it provides an estimate of how often a POTW is expected to exceed certain removal values, such as the ADRE and MRE. For the example, the ADRE is 53% and the MRE is calculated as 74%. If the POTW uses either one of these values, what amount of the time will its removal efficiency exceed those values? This can be estimated using the decile approach. The ADRE of 53% falls between the third and fourth deciles (38.26% and 54.25%, respectively), meaning that the actual removal efficiency is estimated to exceed the ADRE 60% to 70% of the time [(e.g., the third decile means that 30% of the time values will fall below that value (38.26% in this case)]. The MRE of 74% lies between the seventh and eight deciles (73.88% and 80.87%, respectively), so the POTW is estimated to exceed the MRE 20% to 30% of the time.

In developing local limits, appropriate removal efficiencies must be selected for calculation of AHLs for each pollutant. POTWs have often selected a pollutant's ADRE for local limits calculations. EPA recommends that POTWs consider using the decile approach or the MRE method because they better account for variabilities in removal efficiencies over time. For example, because a higher removal efficiency means more pollutant is removed to the sludge, if the POTW used the ADRE from the above example (which is likely exceeded 60% to 70% of the time) to calculate an AHL to protect sludge quality, the resulting AHL may not be adequately protective. More pollutant will likely be removed to the sludge 60% to 70% of the time, so loadings in the sludge will higher than was estimated in the AHL calculations and may lead to exceedances of sludge disposal standards.

A different approach that may address this concern is to use one decile for AHL calculations to protect sludge quality (for sludge disposal and for sludge digester inhibition for conservative pollutants) and a different decile for AHL calculations for protection against Pass Through concerns (e.g., NPDES permit limits). For example, a POTW can base its sludge quality-based AHLs on the seventh decile removal which means that greater removals to sludge and hence greater sludge loadings would be estimated to occur 30% of the time.

Similarly, the POTW can use the third decile for calculating its water quality-based AHLs because lower removals (and hence higher effluent loadings) would be estimated to occur about 30% of the time. Although use of these deciles estimates that AHLs would be exceeded 30% of the time, in reality this is not highly likely. If the entire AHL is allocated to IUs, all IUs would have to discharge at their maximum allowed level to reach the AHL. Then if the removal achieved is greater than the seventh decile, more loading would go to the sludge than is provided for with the AHL. If some IUs discharge at below their allocated loadings, which is very likely at any given time, the likelihood of exceeding the allowed loading to the sludge is much lower.

3. NON-CONSERVATIVE POLLUTANTS

The above discussion of removal efficiency calculations applies to conservative pollutants (e.g., metals). However removal efficiencies for non-conservative pollutants can be used to calculate AHLs based on Pass Through criteria (e.g., biological process inhibition data, NPDES permit limits) and the guidance above can be used for non-conservative pollutants only in these cases. Conservative pollutant removal efficiencies are determined by pollutant concentrations in the POTW influent and effluent streams. The presumption applied to conservative pollutants (that removed pollutants are exclusively transferred to the POTW's sludge streams) cannot be extended to non-conservative pollutants because losses through degradation and volatilization do not contribute to pollutant loadings in sludge. Therefore, non-conservative pollutant removal efficiencies cannot be used in deriving AHLs from criteria/standards applicable to the POTW's sludge streams (e.g., digester inhibition, sludge disposal).

Equation 5.13, for calculating AHLs for non-conservative pollutants, based on criteria for sludge digester inhibition, is:

$$AHL_{dgstr} = (L_{infl}) * \frac{C_{dgstinhib}}{C_{dgstr}}$$

Where:

AHL_{dgstr}	=	AHL based on sludge digestion inhibition, lb/day
L_{infl}	=	POTW influent loading, lb/day
$C_{dgstinhib}$	=	Sludge digester inhibition criterion, mg/L
C_{dgstr}	=	Existing pollutant level in sludge, mg/L

The equation can be rewritten as:

$$AHL_{dgstr} = \frac{C_{dgstinhib}}{\frac{C_{dgstr}}{L_{infl}}}$$

Where the factor C_{dgstr}/L_{infl} is a partitioning factor that relates the pollutant level in the POTW sludge, C_{dgstr}, to the headworks loading of the pollutant, L_{infl}. The partitioning factor enables calculation of an allowable loading based upon sludge digestion inhibition, AHL_{dgstr}, from a sludge digester inhibition criteria, $C_{dgstinhib}$, for a non-conservative pollutant. To determine the partitioning factor for a particular pollutant, the POTW's influent and sludge must be routinely sampled for that pollutant.

The factor C_{dgstr}/L_{infl} expresses non-conservative pollutant removals to sludge. Non-conservative pollutant removals to sludge are highly variable, and are dependent on such factors as wastewater temperature, ambient air temperature, biodegradation rates (which are temperature dependent), aeration rates, and POTW influent flow. Because non-conservative pollutant removals to sludge are highly variable, the variability in non-conservative pollutant sludge partitioning factors should be addressed in the local limits development process. The procedures and recommendations presented in this manual for addressing removal efficiency variability for conservative pollutants (e.g., the calculation of mean removals and the decile approach) can be extended to addressing variability in non-conservative pollutant sludge partitioning factors. In calculating sludge AHLs, the sludge partitioning factor should be used in place of the removal efficiency for non-conservative pollutants.

APPENDIX Q -
METHODS FOR HANDLING DATA BELOW DETECTION LEVEL

The occurrence of values below the detection limit (DL) in environmental data sets is a major statistical complication. Uncertainty about the actual wastewater treatment plant influent and effluent values below the DL can bias subsequent statistical analyses to determine the removal efficiencies.

The various approaches to handling below detection level (BDL) data can be broken into three main categories:

- Regression order statistic (ROS) and probability plotting (MR) methods
- Maximum likelihood estimation (MLE) methods
- Simple replacement of a single value (e.g., detection limit or one half detection limit).

Although this discussion focuses on handling data below the detection limit, the same techniques can be applied to those data below the minimum level of quantitation (ML) as well. These methods can be applied by those without a background in statistics. However, EPA strongly recommends a statistician perform these data manipulations.

REGRESSION ORDER STATISTIC (ROS) AND PROBABILITY PLOTTING (MR) METHODS

Both the original ROS and the MR methods are based on ordered statistics of observed data and the assumption that data come from a normal or log-normal distribution. If Y is from a normal distribution with mean μ and standard deviation σ ($Y \sim N(\mu,\sigma)$) and Z is from a normal distribution with mean 0 and standard deviation 1 ($Z \sim N(0, 1)$), statistical theories show that $Y = \mu + \sigma Z$ when Y and Z are at the same percentiles in their respective distributions. For a given observation (sampling result) Y that is above the detection limit, we can calculate the "order statistic", i.e., the proportion of observations that are less than Y. This order statistic of Y is an estimate of the percentile. The corresponding Z value is available by either using existing computer program or checking the normal distribution table. In other words, we have a list of observations that are above the detection limit (Y_1, Y_2, ..., Y_m) and a list of Z values (Z_1, Z_2, ..., Z_m) that are of the same percentiles as the respective Y values. By performing a regression analysis of Y against Z, the resulting intercept and slope are estimates of the mean and standard deviation of the distribution of Y.

When the data are from a log-normal[2] distribution, a log transformation is needed before the regression. The estimated mean and standard deviation is for the log-transformed variable. To convert the estimates to the original metric, the standard log-normal distribution results should be used. For example, if Y is from a log-normal distribution, and estimated mean and variance for log(Y) are μ and σ, the mean of Y is and the variance of Y is $e^{2\mu+\sigma^2}\left(e^{\sigma^2}-1\right)$.

Alternatively, one may use the regression equation to "fill in" the missing (BDL) values. This is possible because we can calculate the order statistics for all BDL values. For example, suppose we have 20 out of 100 observations are BDL. The order statistics for the 20 BDL values are 0.01, 0.02, ..., 0.20. Using these order statistics, we can get the corresponding Z values Z_1, Z_2, ..., Z_{20}. Substitute these Z values into the regression model, we have the 20 fill-in Y values.

[2] Log-normal distributions are probability distributions which are closely related to normal distributions: if X is a normally distributed random variable, then exp(X) has a log-normal distribution. In other words: the natural logarithm of a log-normally distributed variable is normally distributed.

To recap, we first define the variables used in this method:

n = Total number of observations
k = Number of BDL observations
Y_i= Value of the ith ranked observation

To utilize the ROS method, data are first ranked from smallest to largest so that Y_n is the largest data value and Y_1 through Y_k are the unknown BDL values. If an approximately normal distribution is expected, each Y_i is plotted on the y-axis against the expected normal order statistic Z_i for each rank i. The following linear regression is used to obtain μ and σ, using only the points above the DL (i.e., $i = k+1,...,n$).

$$Y_i = \mu + \sigma Z_i$$

One may use the estimated intercept and slope as the mean and standard deviation. Alternatively, one may use the above equation to obtain appropriate "fill-in" values for each of the k BDLs using the Z-statistic. The mean and standard deviation are then calculated using traditional formulas applied to both the observed and filled-in data. Thus, the estimated data are based on the assumption of normality, while the observed data are used directly with no assumption about their distribution. This method is relatively robust to departures from normality or lognormality (Gilliom and Helsel 1986).

If a distribution is expected to be skewed, then $\log(Y_i)$ is plotted against Z_i and the fitted data and the observed data are transformed back to original units from which the mean and standard deviation are calculated (Gilliom and Helsel 1986). Transformation of the data, rather than the summary statistics, avoids inherent transformation bias (Helsel 1990).

MR METHOD

The MR method, an extension of the ROS method, accounts for multiple detection limits. When there is only one detection limit, the k-BDL values are assigned order statistics of 1 through k. When there are multiple detection limits, it is not obvious how to assign the order statistic for some of the data, both below or above some detection limits. For example, suppose we have the following five observations: <100, 110, <200, 250, and 300. It is obvious that the two largest observations, 250 and 300 should receive order statistics of 4 and 5. But the rest is not clear, because the value labeled as <200 can be 199 or 9. Helsel and Cohn (1988) developed a plotting position method for assigning order statistics when there are multiple detection limits. The idea is that although we don't know exactly where the value, say <200, should fall, we can lay out all possible positions for this particular value and take the average rank of all possible ranks. For example, the value labeled as <200 can be the smallest (rank 1), the second smallest (rank 2), or the third smallest (rank 3), the average rank is (1+2+3)/3 = 2. The value 110 can be the second smallest or the third smallest, therefore a rank of (2+3)/2 = 2.5. Finally, the observation <100 receives a rank of (1+2)/2=1.5. Once the order statistics are assigned, one may use the same regression analysis method in the ROS method. When there is only one detection limit, the MR method is the same as the ROS method.

Helsel and Cohn (1988) found that if a single estimating method for several descriptive statistics is desired and the sampling distribution of a data set is unknown, the MR method should be utilized. The actual plotting procedure for the MR method is detailed in Appendix B of *Estimation of Descriptive Statistics for Multiple Censored Water Quality Data* (Helsel and Cohn, 1988).

MAXIMUM LIKELIHOOD ESTIMATION (MLE) METHOD

The MLE method is based on a specific probabilistic assumption about the observations. For example, suppose the data we observed (Y_1, Y_2, ..., Y_n) are from a normal distribution with unknown mean and standard deviation. The likelihood of observing a specific value, say Y_i, is calculated by the normal distribution density function:

$$L(Y_i) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(Y_i-\mu)^2}{2\sigma^2}}$$

The likelihood for a BDL value is:

$$L(Y_k) = \int_{-\infty}^{DL} \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(X-\mu)^2}{2\sigma^2}} dX$$

The likelihood of observing all the data (Y_1, Y_2, ..., Y_n), both below and above the detection limit is the product of all individual likelihoods. The likelihood of observing all data is a very complicated function of μ and σ. A different set of μ and σ values will lead to a different likelihood value. The maximum likelihood estimator is the pair of μ and σ values that maximize the likelihood function. Because the likelihood function is often very complicated, computation of the MLE method is difficult.

Gilliom and Helsel (1986) found that the ROS and the MR methods appear to be more robust to departures from distributional assumptions.

MLE methods have been shown to have the smallest mean-squared error (i.e., higher accuracy) of available techniques when the data distribution is exactly normal or lognormal (Harter and Moore 1966). However, simulation results indicate that ROS and MR methods are superior when distribution shape population is unknown (Gilliom and Helsel 1986).

In a simulation study by Newman et al. (1989) comparing mean and standard deviation estimates between MLE and ROS, the results were similar. However, the MLE method provided slightly more accurate results when BDL values comprised less than 30 percent of the data set, while ROS methods provided slightly more accurate results when BDL values represented 30 percent or more.

SIMPLE SUBSTITUTION METHODS

Simple substitution methods simply replace the below detection value with another value, such as zero, the detection limit, or one-half the detection limit. Both ROS and MLE methods offer substantial advantages over most simple replacement methods (Gilbert 1987, Gleit 1985, Helsel and Gilliom 1986, Newman et al.1989).

In general, replacement methods result in a greater bias when calculating the mean or standard deviation. Additionally, their relative performance worsens as the proportion of BDLs increases (Gilliom and Helsel 1986). Helsel (1989) reasons that because large differences may occur in the resulting estimates for any given population, and because the choice of the replacement value is essentially arbitrary without some knowledge of instrument readings below the reporting limit, estimates resulting from simple substitution are not defensible.

CONCLUSION

The MR method is most applicable for use in local limits development because of the data set's multiple detection limits and unknown parent distribution. Additionally, the MR method is recommended when the data set contains a relatively high percentage of BDL values.

Further information on statistical methods can be found in the literature listed below.

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ATTACHMENT - DESCRIPTION OF THE MR METHOD

Method:

(1) If an analytical result is reported as ND (to be referred to as a nondetect), set the result $c_i = 1$. Annotate the result with a "<" and consider this observation to be "< a detection limit."

(2) Divide the observations into two groups: Nondetects, those observations annotated with a "<" sign, and detects.

(3) Let m = number of distinct detection limits.

(4) Let A_j = number of detected observations at or above the jth detection limit (j = 1,...,m) and below the next highest detection limit.

(5) Let B_j = number of detected and nondetected observations below the jth detection limit (j = 1,...,m).

(6) Let $p_{e,j} = p_{e,j+1} + (A_j/[A_j + B_j])(1 - p_{e,j+1})$, and solve iteratively for j = m,m-1,...,2,1. By convention, $p_{e,m+1} = 0$.

(7) Determine plotting positions, p(i), for detected observations as:

$p(i) = (1 - p_{e,j}) + (p_{e,j} - p_{e,j+1})\cdot r/(A_j + 1)$, where r is the rank of the ith observation above the jth detection limit. If detected observations are "tied," arbitrarily order the "tied" observations before assigning ranks. Whether the "tied" observations are arbitrarily ordered or assigned the same mid-rank (average of the corresponding ranks) is expected to be of negligible importance. If detected observations are present below the lowest detection limit, assume the "0th detection limit" is 0, and consequently $p_{e,0} = 1$.

(8) Assign plotting positions, pc(i), for nondetected observations as:

$pc(i) = (1- p_{e,j})\cdot r/(C_j + 1)$, r = 1,...,$C_j$. C_j is the number of nondetected values known only to be less than the jth detection limit (j = 1,...m). The formula for C_j is: $C_j = B_j - (A_{j-1} + B_{j-1})$, where $A_0 = B_0 = 0$. Plotting positions are therefore assigned separately within the j groups of nondetects (j=1,...,m).

(9) Perform a simple linear regression using only the detected observations. The natural logarithm of the detected observations ($z_i = \ln(y_i)$) is the dependent variable, and the normal quantile associated with the corresponding plotting position ($\Phi^{-1}(p(i))$) is the independent variable, where $\Phi^{-1}(\cdot)$ is the normal quantile.

(10) Use the estimated regression line ($\hat{z}_i = \hat{b}_0 + \hat{b}_1\cdot\Phi^{-1}(pc(i))$) to "fill in" (using the terminology of Helsel and Cohn) estimated natural logarithm values for nondetected observations, based on the normal quantile associated with the calculated plotting position (pc(i)).

(11) Calculate a natural log mean ($\hat{\mu}$) and log standard deviation ($\hat{\sigma}$) of the detected and "filled in" observations using the formulas below. Assume $z_i = \ln(y_i)$, where z_i represents the natural logarithm of detected observations where available, and "filled in" estimated natural logarithm values where nondetects were observed.

$$\hat{\mu} = \frac{\sum_{i=1}^{n} z_i}{n} \quad \textbf{(1)}$$

$$\hat{\sigma} = \sqrt{\frac{\sum_{i=1}^{n} (z_i - \bar{z})^2}{n-1}} \quad \textbf{(2)}$$

(12) Use the values of $\hat{\mu}$ and $\hat{\sigma}$ to estimate a 90th percentile using a lognormal distribution: $P_{90} = \exp(\hat{\mu} + 1.282 \cdot \hat{\sigma})$.

An example of the MR method is given below.

Comments:

Although the algorithm for determining plotting positions when multiple detection limits are present appears rather cumbersome, as described in the 12-step process above, the process of fitting a regression line to order statistics is well-established as a method for determining parameters of a distribution. The ROS method utilizes plotting positions to "spread" nondetected observations along a continuum, rather than simply substituting an arbitrary value for each nondetected measurement. In practice, one would expect nondetected values to be "spread out" rather than all fixed at a single point, as would be the case with simple substitution methods.

The MR method described above directly mimics the methods of Helsel and Cohn. However, the article by Helsel and Cohn contains an inaccurate formula for C_j, which has been revised above. In addition, the article did not address ties in detected observations and detected observations below the lowest detection limit. These questions have been addressed in Steps 7 and 9 above.

At least two detected observations are necessary to estimate a regression line. Consequently, this procedure is not useful when 0 or only 1 detected observation is present.

Software which utilizes the MR method to compute summary statistics is available. The feasibility of utilizing the software available at this site for implementation among numerous POTWs must be explored further. For example, the software is restrictive in some ways, such as the format of data which can be processed.

Reference:

Helsel, D.R., and T.A. Cohn. 1988. *Estimation of Descriptive Statistics for Multiple Censored Water Quality Data.* Water Resources Research 24:1997-2004.

EXAMPLE OF THE MR METHOD

Suppose we have a set of data from multiple sources with varying detection limits. When combined, the data set is ordered as follow:

Data Summary

<50	<200	<400	100	300	500	
<50	<200	<400	100	300	500	
<50	<200	<400			700	
						1000
						1200

In order to provide estimates of the mean and standard deviation, it is necessary to fill-in the non-detected values. Once the non-detected values are filled-in, sample mean and standard deviation can be estimated. The following are the MR steps for filling in the nondetected values.

1. Summary statistics:

n = 18
m = 3 (1st detection limit = 50, 2nd detection limit = 200, 3rd detection limit = 400)

A_1 = 2 (2 detects ≥50 but <200)
A_2 = 2 (2 detects ≥200 but <400)
A_3 = 5 (5 detects ≥400)

B_1 = 3 (3 nondetects <50)
B_2 = 8 (3 nondetects <50, 3 nondetects <200, and 2 detects <200)
B_3 = 13 (3 nondetects <50, 3 nondetects <200, 3 nondetects <400, 2 detects <200, and 2 detects <400)

C_1 = 3 (3 nondetects <50)
C_2 = 3 (3 nondetects <200)
C_3 = 3 (3 nondetects <400)

$p_{e,3} = p_{e,4} + (A_3/[A_3 + B_3])(1 - p_{e,4}) = 0 + (5/[5+13])\cdot 1 = 0.278$
$p_{e,2} = p_{e,3} + (A_2/[A_2 + B_2])(1 - p_{e,3}) = 0.278 + (2/[2+8])\cdot(1-0.278) = 0.422$
$p_{e,1} = p_{e,2} + (A_1/[A_1 + B_1])(1 - p_{e,2}) = 0.422 + (2/[2+3])\cdot(1 - 0.422) = 0.653$

2. Determination of plotting positions:

Nondetected observations:

x_i	j	r	$p_{e,j}$	C_j	Plotting Position $pc(i) = (1- p_{e,j})\cdot r/(C_j + 1)$
<50	1	1	0.653	3	0.087
<50	1	2	0.653	3	0.173
<50	1	3	0.653	3	0.260
<200	2	1	0.422	3	0.144
<200	2	2	0.422	3	0.289
<200	2	3	0.422	3	0.433
<400	3	1	0.278	3	0.181
<400	3	2	0.278	3	0.361
<400	3	3	0.278	3	0.542

Detected observations:

x_i	j	r	$p_{e,j}$	$p_{e,j+1}$	A_j	Plotting Position $p(i) = (1 - p_{e,j}) + (p_{e,j} - p_{e,j+1})\cdot r/(A_j + 1)$
100	1	1	0.653	0.422	2	0.424
100	1	2	0.653	0.422	2	0.500
300	2	1	0.422	0.278	2	0.626
300	2	2	0.422	0.278	2	0.674
500	3	1	0.278	0	5	0.769
500	3	2	0.278	0	5	0.815
700	3	3	0.278	0	5	0.861
1000	3	4	0.278	0	5	0.907
1200	3	5	0.278	0	5	0.954

3. Linear regression

A simple linear regression is then performed using the following detected observations and their associated plotting points. The regression is based on z_i as the dependent variable and p(i) as the independent variable.

x_i	$z_i = \ln(x_i)$	p(i)	$\Phi^{-1}(p(i))$
100	4.605	0.424	-0.192
100	4.605	0.500	0.000
300	5.704	0.626	0.321
300	5.704	0.674	0.451
500	6.215	0.769	0.736
500	6.215	0.815	0.896
700	6.551	0.861	1.085
1000	6.908	0.907	1.323
1200	7.090	0.954	1.685

The regression equation based on these nine detected observations is:

$$\hat{z}_i = 4.9614 + 1.4186 \cdot \Phi^{-1}(p(i))$$

4. Fill-in

This equation is used to "fill in" estimated nondetect values for the nine nondetects above. The results of the calculation are shown below:

x_i	pc(i)	$\Phi^{-1}(pc(i))$	$\hat{z}_i$
<50	0.087	-1.360	3.032
<50	0.173	-0.942	3.625
<50	0.260	-0.643	4.049
<200	0.144	-1.063	3.453
<200	0.289	-0.556	4.173
<200	0.433	-0.169	4.722
<400	0.181	-0.912	3.668
<400	0.361	-0.356	4.456
<400	0.542	0.106	5.112

The z_i and the $\hat{z}_i$ from the two tables above are then combined to estimate a natural log mean and a log standard deviation. The data and calculated values for $\hat{\mu}$ and $\hat{\sigma}^2$ are shown below:

4.605	5.704	6.551	3.032	3.453	3.668
4.605	6.215	6.908	3.625	4.173	4.456
5.704	6.215	7.090	4.049	4.722	5.112

$\hat{\mu} = 4.9937$
$\hat{\sigma}^2 = 1.5632 \quad (\hat{\sigma} = 1.2503)$

The calculated values for $\hat{\mu}$ and $\hat{\sigma}$ can then be used for estimating the arithmetic mean of the sample: $m = \exp(\hat{\mu} + 0.5\,\hat{\sigma}^2) = 322.241$ and sample standard deviation $s = m\sqrt{e^{\hat{\sigma}^2} - 1} = 626.168$. In some instances, one may be interested in the 90th percentile of the data, which can be estimated as $P_{90} = \exp(\hat{\mu} + 1.282 \cdot \hat{\sigma}) = 732.585$. It is worthwhile to note that these calculations are based on the assumption that the data follow a log-normal distribution. For most water quality related variables, such as BOD concentration, the log-normal distribution is appropriate. However, when percent removal is the variable of concern, log-normal is no longer an appropriate probability distribution. Instead, one may apply the MR method to the concentration variables first and calculate the percent removal after the non-detected concentration values have been filled-in.

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APPENDIX R -
PRIORITY POLLUTANT REMOVAL EFFICIENCIES

Priority Pollutant Removal Efficiencies (%) Through Primary Treatment*

Priority Pollutant	Median	Number of POTWs with Removal Data**
METAL/NONMETAL INORGANICS		
Cadmium	15	6 of 40
Chromium	27	12 of 40
Copper	22	12 of 40
Cyanide	27	12 of 40
Lead	57	1 of 40
Mercury	10	8 of 40
Nickel	14	9 of 40
Silver	20	4 of 40
Zinc	27	12 of 40
ORGANICS		
Benzene	25	8 of 40
Chloroform	14	11 of 40
1,2-trans-Dichloroethylene	36	9 of 40
Ethylbenzene	13	12 of 40
Naphthalene	44	4 of 40
Phenol	8	11 of 40
Butyl benzyl phthalate	62	4 of 40
Di-n-butyl phthalate	36	3 of 40
Diethyl phthalate	56	1 of 40
Tetrachloroethylene	4	12 of 40
1,1,1-Trichloroethane	40	10 of 40
Trichloroethylene	20	12 of 40

* Pollutant removals between POTW influent and primary effluent. From *Fate of Priority Pollutants in Publicly Owned Treatment Works, Volume I* (EPA 440/1-82/303), U.S. Environmental Protection Agency, Washington, D.C., September 1982, p. 61.

** Median removal efficiencies from a data base of removal efficiencies for 40 POTWs. Only POTWs with average influent concentrations exceeding three times each pollutant's detection limit were considered.

Source: U.S. EPA's *Guidance Manual on the Development and Implementation of Local Discharger Limitations Under the Pretreatment Program*, December 1987, p. 3-55.

Priority Pollutant Percent Removal Efficiencies (%) Through Activated Sludge Treatment*

Priority Pollutant	Range	Second Decile	Median	Eight Decile	Number of POTWs with Removal Data
METALS/NONMETAL INORGANICS**					
Arsenic	11-78	31	45	53	5 of 26
Cadmium	25-99	33	67	91	19 of 26
Chromium	25-97	68	82	91	25 of 26
Copper	2-99	67	86	95	26 of 26
Cyanide	3-99	41	69	84	25 of 26
Lead	1-92	39	61	76	23 of 26
Mercury	1-95	50	60	79	20 of 26
Nickel	2-99	25	42	62	23 of 26
Selenium	25-89	33	50	67	4 of 26
Silver	17-95	50	75	88	24 of 26
Zinc	23-99	64	79	88	26 of 26
ORGANICS**					
Anthracene	29-99	44	67	91	5 of 26
Benzene	25-99	50	80	96	18 of 26
Chloroform	17-99	50	67	83	24 of 26
1,2-trans-Dichloroethylene	17-99	50	67	91	17 of 26
Ethylbenzene	25-99	67	86	97	25 of 26
Methylene chloride	2-99	36	62	77	26 of 26
Naphthalene	25-98	40	78	90	16 of 26
Phenanthrene	29-99	37	68	86	6 of 26
Phenol	3-99	75	90	98	19 of 26
Bis (2-ethylhexyl) phthalate	17-99	47	72	87	25 of 26
Butyl benzyl phthalate	25-99	50	67	92	16 of 26
Di-n-butyl phthalate	11-97	39	64	87	19 of 26
Diethyl phthalate	17-98	39	62	90	15 of 26
Pyrene	73-95	76	86	95	2 of 26
Tetrachloroethylene	15-99	50	80	93	26 of 26
Toluene	25-99	80	93	98	26 of 26
1,1,1-Trichloroethane	18-99	75	85	94	23 of 26
Trichloroethylene	20-99	75	89	98	25 of 26

* Pollutant removals between POTW influent and secondary effluent (including secondary clarification). Based on a computer analysis of POTW removal efficiency data (derived from actual POTW influent and effluent sampling data) provided in U.S. EPA's *Fate of Priority Pollutants in Publicly Owned Treatment Works, Volume II* (EPA 440/1-82/303), September 1982.

** For the purpose of deriving removal efficiencies, effluent levels reported as below detection were set equal to the reported detection limits. All secondary activated sludge treatment plants sampled as part of the study were considered.

Source: U.S. EPA's *Guidance Manual on the Development and Implementation of Local Discharger Limitations Under the Pretreatment Program*, December 1987, p. 3-56.

Priority Pollutant Removal Efficiencies (%) Through Trickling Filter Treatment*

Priority Pollutant	Range	Second Decile	Median	Eighth Decile	Number of POTWs with Removal Data
METALS/NONMETAL INORGANICS**					
Cadmium	33-96	33	68	93	6 of 11
Chromium	5-92	34	55	71	9 of 11
Copper	12-97	32	61	89	9 of 11
Cyanide	7-88	33	59	79	8 of 11
Lead	4-84	25	55	70	6 of 11
Mercury	14-80	33	50	62	9 of 11
Nickel	7-72	11	29	57	9 of 11
Silver	11-93	38	66	86	8 of 11
Zinc	14-90	34	67	81	9 of 11
ORGANICS**					
Benzene	5-98	50	75	93	7 of 11
Chloroform	21-94	50	73	84	9 of 11
1,2-trans-Dichloroethylene	14-99	50	50	96	7 of 11
Ethylbenzene	45-97	50	80	91	10 of 11
Methylene chloride	5-98	28	70	85	10 of 11
Naphthalene	33-93	40	71	87	6 of 11
Phenol	50-99	75	84	96	8 of 11
Bis (2-ethylhexyl) phthalate	4-98	21	58	81	10 of 11
Butyl benzyl phthalate	25-90	37	60	77	9 of 11
Di-n-butyl phthalate	29-97	41	60	82	10 of 11
Diethyl phthalate	17-75	40	57	67	8 of 11
Tetrachloroethylene	26-99	53	80	93	10 of 11
Toluene	17-99	80	93	97	10 of 11
1,1,1-Trichloroethane	23-99	75	89	97	10 of 11
Trichloroethylene	50-99	67	94	98	10 of 11

* Pollutant removals between POTW influent and secondary effluent (including secondary clarification). Based on a computer analysis of POTW removal efficiency data (derived from actual POTW influent and effluent sampling data) provided in U.S EPA's *Fate of Priority Pollutants in Publicly Owned Treatment Works, Volume II*, (EPA 440/182/303), September 1982.

** For the purpose of deriving removal efficiencies, effluent levels reported as below detection were set equal to the reported detection limits. All secondary trickling filter plants sampled as part of the study were considered.

Source: U.S. EPA's *Guidance Manual on the Development and Implementation of Local Discharger Limitations Under the Pretreatment Program*, December 1987, p. 3-57.

Priority Pollutant Removal Efficiencies (%) Through Tertiary Treatment*

Priority Pollutant	Range	Second Decile	Median	Eighth Decile	Number of POTWs with Removal Data
METALS/NONMETAL INORGANICS**					
Cadmium	33-81	50	50	73	3 of 4
Chromium	22-93	62	72	89	4 of 4
Copper	8-99	58	85	98	4 of 4
Cyanide	20-93	32	66	83	4 of 4
Lead	4-86	9	52	77	3 of 4
Mercury	33-79	43	67	75	4 of 4
Nickel	4-78	17	17	57	3 of 4
Silver	27-87	55	62	82	3 of 4
Zinc	1-90	50	78	88	4 of 4
ORGANICS**					
Benzene	5-67	40	50	54	2 of 4
Chloroform	16-75	32	53	64	3 of 4
1,2-trans-Dichloroethylene	50-96	50	83	93	2 of 4
Ethylbenzene	65-95	80	89	94	3 of 4
Methylene Chloride	11-96	31	57	78	4 of 4
Naphthalene	25-94	33	73	86	3 of 4
Phenol	33-98	80	88	96	4 of 4
Bis (2-ethylhexyl) phthalate	45-98	59	76	94	4 of 4
Butyl benzyl phthalate	25-94	50	63	85	4 of 4
Di-n-butyl phthalate	14-84	27	50	70	4 of 4
Diethyl phthalate	20-57	29	38	50	3 of 4
Tetrachloroethylene	67-98	80	91	97	4 of 4
Toluene	50-99	83	94	97	4 of 4
1,1,1-Trichloroethane	50-98	79	94	97	4 of 4
Trichloroethylene	50-99	62	93	98	4 of 4

* Pollutant removals between POTW influent and tertiary effluent (including final clarification). Based on a computer analysis of POTW removal efficiency data (derived from actual POTW influent and effluent sampling data) provided in U.S. EPA's *Fate of Priority Pollutants in Publicly Owned Treatment Works, Volume II* (EPA 440/1-82/303), September 1982. Tertiary treatment was taken to include POTWs with effluent microscreening, mixed media filtration, post aeration, and/or nitrification/denitrification.

** For the purpose of deriving removal efficiencies, effluent levels reported as below detection were set equal to the reported detection limits. All tertiary treatment plants sampled as part of the study were considered.

Source: U.S. EPA's *Guidance Manual on the Development and Implementation of Local Discharger Limitations Under the Pretreatment Program*, December 1987, p. 3-58.

APPENDIX S -
SPECIFIC GRAVITY OF SLUDGE

The allowable headworks loading (AHL) equations presented in Chapter 5 for sewage sludge disposal contain a factor for the specific gravity of sludge (sludge density). This factor accounts for differences in the density of sludge based on the percent solids of sludge to disposal. The unit conversion factor (8.34) in the same equations converts the overall units into pounds per day (lbs/day), using a specific gravity or density of sludge equal to 1 kg/L, which assumes that sludge has the same density as water. If the dewatered sludge density is different from the density of water, the unit conversion factor is not fully accurate. As the percent solids of a sludge increases, the density of the sludge increases and therefore the error introduced by the inaccurate unit conversion factor increases. To correct this inaccuracy, the numerator of the AHL equation should be multiplied by the specific gravity of the dewatered sludge (as noted in Chapter 6). If a sludge is not dewatered before disposal, the inaccuracy produced by using the unit conversion factor (8.34) without a specific gravity factor would probably not be significant.

The POTW can determine the specific gravity (density) of its sludge prior to disposal through a simple laboratory measurement. The POTW should take this measurement as part of its local limits monitoring program and average the resulting data set (e.g., 7-10 data points) to determine a representative sludge specific gravity (density) factor for use in local limits calculations. The POTW can also estimate the specific gravity of its sludge using the equations below and information on the percent solids.

For a typical wet sludge at 10% solids, the approximate density is 1.03 kg/L. For a typical dewatered sludge at 30% solids, the approximate density is 1.11 kg/L. A sludge at 50% solids may reach a density of 1.2 to 1.3 kg/L, which would result in a 20% to 30% conservative error in the calculation of an AHL if a specific gravity factor is not used. All of these values depend on the amount of volatile solids in the sludge in comparison with the amount of fixed mineral solids, which vary with percent solids, and the densities of each of these types of solids.

$$\frac{M_{WS}}{S_{WS}} = \frac{M_S}{S_S} + \frac{M_W}{S_W}$$

Equation to determine specific gravity of wet sludge

Where:

M_{WS}	=	Mass of wet sludge (kg)
S_{WS}	=	Specific gravity of wet sludge (kg/L)
M_S	=	Mass of dry sludge solids (kg)
S_S	=	Specific gravity of sludge solids (kg/L)
M_W	=	Mass of water (kg)
S_W	=	Specific gravity of water (kg/L)

$$\frac{M_S}{S_S} = \frac{M_F}{S_F} + \frac{M_V}{S_V}$$

Equation to determine specific gravity of dry sludge solids

Where:

M_F	=	Mass of fixed solids (kg)
S_F	=	Specific gravity of fixed solids (kg/L)
M_V	=	Mass of volatile solids (kg)
S_V	=	Specific gravity of volatile solids (kg/L)

The result from the second equation is used in the first equation.

Example

Sludge is 10% solids:

Assume solids consist of 33% fixed mineral solids with a specific gravity of 2.5 kg/L and 67% volatile solids with a specific gravity of 1.2 kg/L.

To determine the specific gravity of the dry sludge solids, use the second equation:

$$\frac{M_S}{S_S} = [(0.33)x\frac{M_S}{2.5}] + [(0.67)x\frac{M_S}{1.2}]$$

which results in S_s = 1.45 kg/L. Using this value in the first equation:

$$\frac{M_{WS}}{S_{WS}} = [(0.10)x\frac{M_{WS}}{1.45}] + [(0.90)x\frac{M_{WS}}{1}]$$

yields S_{WS} = 1.03 kg/L.

APPENDIX T -
SLUDGE AHL EQUATIONS USING FLOW (IN METRIC UNITS)

Some POTWs may have sludge flow data available in dry metric tons per day, rather than MGD. The AHL equations for sludge disposal in Chapter 6 can be converted to use sludge flow data in these units. Some of the equations in Chapter 6 are presented below using flows in dry metric tons per day. Use of these "dry flows" eliminates the need for the specific gravity factor in the equations.

GENERAL SLUDGE EQUATION FOR CONSERVATIVE POLLUTANTS

$$L_{INFL} = \frac{(C_{CRIT})(Q_{SLDG})(0.0022)}{R_{POTW}}$$

Where:

L_{INFL}	=	Allowable influent loading, lbs/day
C_{CRIT}	=	Sludge criteria, mg/kg dry sludge
Q_{SLDG}	=	Total sludge flow to disposal, dry metric tons per day
R_{POTW}	=	Removal efficiency across POTW (as decimal)
0.0022	=	Unit conversion factor

LAND APPLICATION

As explained in Chapter 6, determining the land application sludge criteria for use in the general sludge equation requires that the POTW first convert 40 CFR §503 Table 2 and Table 4 sludge criteria into values in mg/kg of dry sludge units. Because Table 2 and Table 4 criteria are in metric units (kg/ha), they must be converted into English units (lbs/acre) so that they can be used with the equations in Chapter 6 which use other English units (e.g., flow in MGD, area in acres). Table 2 and Table 4 criteria are provided in both metric and English units in Appendix E.

Another option is for POTWs to use the land application criteria equations in metric units (e.g., area in hectares, flow in dry metric tons per day), thus eliminating the need to convert Table 2 and Table 4 values to English units. These equations are provided below. These equations avoid the need for a specific gravity factor because they use also use a "dry flow" for sludge.

$$C_{CRIT} = \frac{(C_{CUM})(SA)}{(SL)(Q_{LA})(0.365)}$$

Where:

C_{CRIT}	=	Sludge criteria, mg/kg dry sludge
C_{CUM}	=	Federal (Table 2 of 40 CFR 503.13) or State land application cumulative pollutant loading rate, kg/ha
SA	=	Site area, hectares
SL	=	Site life, years
Q_{LA}	=	Sludge flow to bulk land application at an agricultural, forest, public contact, or reclamation site, dry metric tons per day
0.365	=	Unit conversion factor

$$C_{CRIT} = \frac{C_{ANN}}{(AWSAR)(0.001)}$$

Where:

C_{CRIT}	=	Sludge criteria, mg/kg dry sludge
C_{ANN}	=	Federal (Table 4 of 40 CFR 503.13) or State land application annual pollutant loading rate, kg/ha
AWSAR	=	Annual whole sludge application rate, metric tons per hectare per year dry weight basis
0.001	=	Unit conversion factor

INCINERATION

Sludge standards for maximum pollutant concentrations in sludge feed to the incinerator need to be in mg/kg dry sludge to be used in the equations at the beginning of Section 6.2.3 to calculate AHLs. A POTW disposing of sludge through incineration may already have sludge standards in mg/kg dry sludge, such as through a waste disposal agreement with the operator of a sludge incincerator. As noted in Chapter 6, if no sludge standards have been calculated for the sludge feed to the incinerator, POTWs should use the Part 503 equations (provided below) to determine the maximum pollutant concentrations for the incinerator feed. These maximum concentrations are then used in the equations at the beginning of Section 6.2.3 to calculate AHLs.

$$C_{CRIT} = \frac{(RSC)(86{,}400)}{(DF)(1 - CE)(Q_{INC})}$$ Arsenic, Cadmium, Chromium, Nickel

$$C_{CRIT} = \frac{(0.1)(NAAQS)(86{,}400)}{(DF)(1 - CE)(Q_{INC})}$$ Lead

$$C_{CRIT} = \frac{NESHAP}{(1 - CE)(Q_{INC})}$$ Beryllium, Mercury, pollutants with State limits

Where:

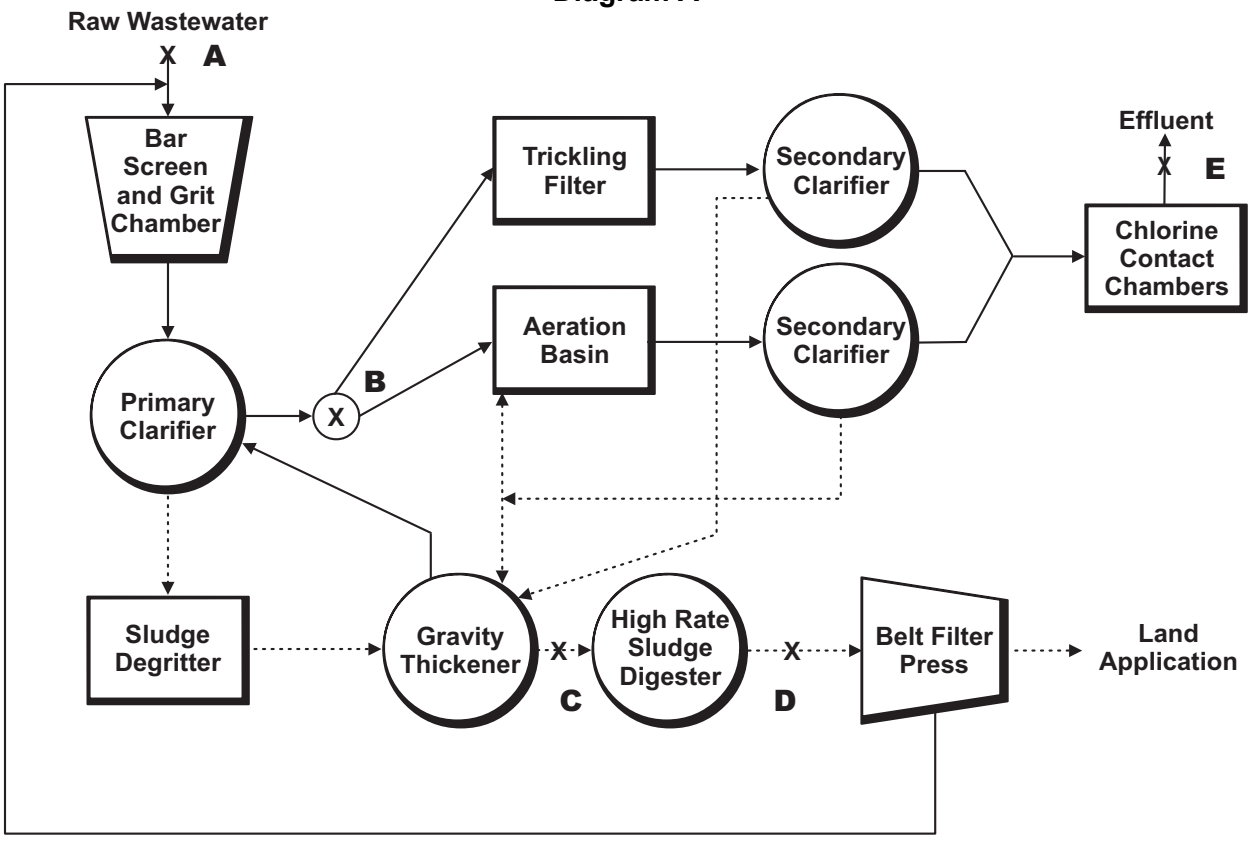
C_{CRIT}	=	Sludge criteria, mg/kg dry sludge
NESHAP	=	National emission standard for beryllium or mercury from 40 CFR Part 61, g/day
NAAQS	=	National Ambient Air Quality Standard for lead, ug/m^3
RSC	=	Federal risk specific concentration limit for arsenic, cadmium, chromium, or nickel from 40 CFR 503.43, ug/m^3
CE	=	Control efficiency (removal efficiency) for sewage sludge incinerator for the given pollutant (as a decimal)
Q_{INC}	=	Sludge flow to incinerator (i.e., sewage sludge feed rate), dry metric tons per day
DF	=	Dispersion factor, ug/m^3/g/sec
0.1 and 86,400	=	Unit conversion factors

For pollutants with State incinerator emissions standards, limits should be entered in g/day in place of the NESHAPs limits in the first equation above.

APPENDIX U - POTW CONFIGURATIONS

The diagrams and discussions below demonstrate sampling locations to develop allowable headworks loadings (AHLs). For illustrative purposes, in this appendix all three plants must determine the AHLs based upon effluent limitations, secondary treatment inhibition, sludge digester inhibition, and sludge land application. Three different plants, with very different secondary treatment trains, are diagramed below along with sampling points for the AHL calculations.

Diagram A



AHL FOR SECONDARY TREATMENT INHIBITION

At this POTW a trickling filter and an activated sludge system (aeration basin) operated in parallel provide secondary treatment of the raw wastewater. The concentration of a pollutant that could cause inhibition at the trickling filter may be different than the pollutant concentration that causes inhibition (known as the inhibition threshold level) at the aeration basin. The plant must determine a headworks loading protective of these two secondary treatment units. Using Equation 5.10, an AHL based on secondary treatment inhibition can be calculated.

$$AHL_{inhtf} = \frac{(C_{inhtf})(Q_{potw})(8.34)}{(1 - R_{prim})}$$ Trickling Filter

$$AHL_{inhab} = \frac{(C_{inhab})(Q_{potw})(8.34)}{(1 - R_{prim})}$$ Aeration Basin

Where:

AHL_{inhab}	=	AHL based on aeration basin inhibition, lbs/day
AHL_{inhtf}	=	AHL based on trickling filter inhibition, lbs/day
C_{inhab}	=	Inhibition criteria for aeration basin, mg/L
C_{inhtf}	=	Inhibition criteria for trickling filter, mg/L
Q_{potw}	=	Total POTW flow, MGD
R_{prim}	=	Removal efficiency from headworks to primary treatment effluent as a decimal (See Section 5.1.1 for calculating removal efficiencies)
8.34	=	Unit conversion factor

The equations to calculate the AHL based on trickling filter and aeration basin inhibition includes an inhibition criteria for the trickling filter, C_{inhtf}, and aeration basin, C_{inhab}, respectively. Both equations use the same removal rate, R_{prim}, from the headworks to the primary treatment effluent. R_{prim} can be determined by sampling loading at point "A," the headworks, and point "B," primary clarifier effluent (See Section 5.1 for these calculations). Q_{potw} can be determined through flow sampling at point "A" as well. AHL_{ab} and the AHL_{tf} would be calculated, compared and the more stringent selected.

AHL FOR SLUDGE DIGESTER INHIBITION

This plant must determine a headworks loading protecting the high-rate sludge digester from inhibition. Using Equation 5.12, an AHL based on sludge digester inhibition can be calculated.

$$AHL_{inhhrsd} = \frac{8.34(C_{inbhrsd})(Q_{hrsd})}{R_{potw}}$$

Where:

$AHL_{inhhrsd}$	=	AHL based on high-rate sludge digester inhibition, lbs/day
$C_{inbhrsd}$	=	High-rate sludge digester inhibition criteria, mg/L
Q_{hrsd}	=	Sludge flow to high-rate sludge digester, MGD
R_{potw}	=	Plant removal efficiency from headworks to plant effluent (as decimal)
8.34	=	Unit conversion factor

The equation to calculate the AHL based on high-rate sludge digester inhibition includes an inhibition criteria for the digester, $C_{inbhrsd}$, sludge flow to the digester, Q_{hrsd} , and an overall plant removal rate from headworks to plant effluent, R_{potw}. Q_{hrsd} can be determined by sampling flow at point "C," the sludge wastestream from gravity thickener to digester. R_{potw} can be determined by sampling at point "A," the headworks before the bar screen and grit chamber, and at point "E," the effluent after the chlorine contact chambers.

AHL FOR EFFLUENT LIMITS

The plant must determine headworks loading that would lead to effluent from its chlorine contact chambers (CCC) comply with NPDES Permit limits. Using Equation 5.5, the AHL based on NPDES Permit limit can be calculated.

$$AHL_{effccc} = \frac{(8.34)(C_{npdes})(Q_{potw})}{(1 - R_{potw})}$$

Where:

AHL_{effccc}	=	AHL based on CCC effluent compliance with NPDES, lbs/day
C_{npdes}	=	NPDES permit limit, mg/L
Q_{potw}	=	POTW flow, average, MGD
R_{potw}	=	Plant removal efficiency from headworks to plant effluent (as decimal)
8.34	=	Conversion factor

The equation to calculate the AHL based on CCC effluent compliance with NPDES includes the NPDES permit limit, C_{npdes}, total POTW flow, Q_{potw}, and an overall plant removal rate from headworks to plant effluent, R_{potw}. R_{potw} can be determined by sampling loading at point "A," the headworks before the bar screen and grit chamber, and at point "E," the effluent after the chlorine contact chambers. Q_{potw} can be determined through sampling flow at point "A" as well.

AHL FOR SLUDGE APPLICATION

The plant must determine a headworks that would lead to sludge from the belt filter press suitable for land application. Using equation 5.9 an AHL based on sludge land application can be calculated.

$$AHL_{sabfp} = \frac{(8.34)(C_{slgstd})(PS/100)(Q_{bpf})(G_{sldg})}{R_{potw}}$$

Where:

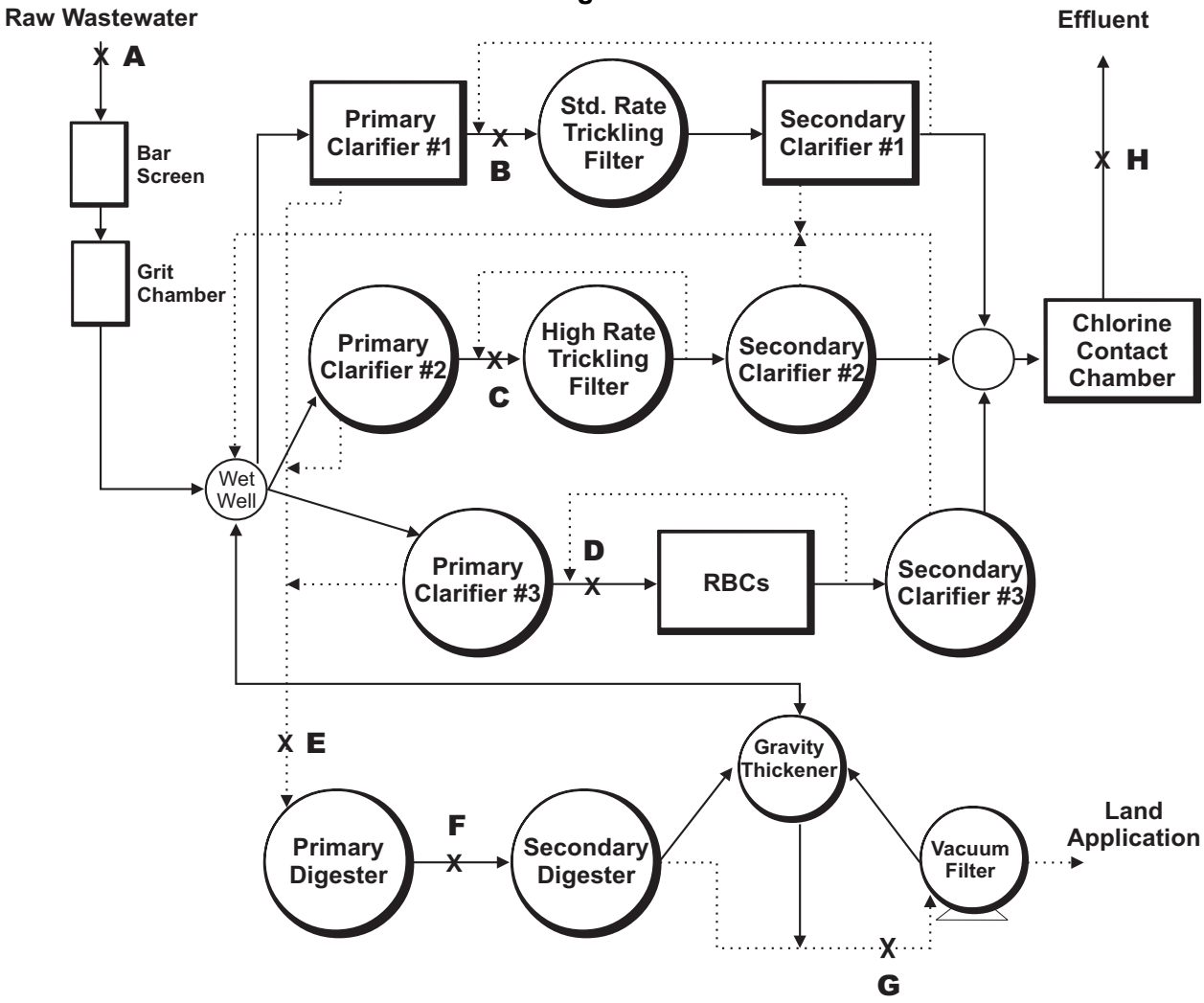
AHL_{sabfp}	=	AHL based on compliance with sludge application standards, lbs/day
C_{slgstd}	=	Sludge standard, mg/kg dry sludge
PS	=	Percent solids of sludge leading to belt filter press
Q_{bfp}	=	Total sludge flow to belt filter press, MGD
R_{potw}	=	Plant removal efficiency from headworks to plant effluent (as decimal)
G_{sldg}	=	Specific gravity of sludge leading to filter press, kg/L
8.34	=	Unit conversion factor

The equation to calculate the AHL based on belt filter press sludge compliance with sludge standards includes the sludge limit, C_{slgstd}; the flow, percent solids and specific gravity of sludge leading to the belt filter press, Q_{bfp}, PS, and G_{sldg}, respectively; and the overall plant removal rate from headworks to plant effluent, R_{potw}. R_{potw} can be determined by sampling loading at point "A," the headworks before the bar screen and grit chamber, and at point "E," the effluent after the chlorine contact chambers. Q_{bfp}, PS, and G_{sldg}, can be determined through sampling point "D" the sludge waste stream to the belt filter press.

AHL FOR SECONDARY TREATMENT INHIBITION

At this POTW a standard rate trickling filter, a high rate trickling filter, and rotating biological contactors (RBCs) operated in parallel provide secondary treatment of the raw wastewater. Each of these biological units is preceded by a different primary clarifier. An AHL (to prevent inhibition) should be determined for each of these biological unit processes because:

Diagram B



- The concentration of a pollutant that could cause inhibition at the standard rate trickling filter, high rate trickling filter, and RBCs are different.

- The design and operational loadings to each of the secondary treatment units are different and therefore loading is different.

- The primary clarifiers may have different removal efficiencies and therefore the pollutant concentrations to each of the secondary treatment unit may be different.

The three equations listed below can be used to calculate secondary treatment inhibition.

$$AHL_{inhstf} = \frac{(C_{inhstf})(Q_{potw})(8.34)}{(1 - R_{prim1})}$$ Standard Trickling Filter

$$AHL_{inhhrtf} = \frac{(C_{inhhrtf})(Q_{potw})(8.34)}{(1 - R_{prim2})}$$ High-Rate Trickling Filter

$$AHL_{inhrbc} = \frac{(C_{inhrbc})(Q_{potw})(8.34)}{(1 - R_{prim3})}$$ RBCs

Where:

AHL_{inhstf}	=	AHL based on standard trickling filter inhibition, lbs/day
$AHL_{inhhrtf}$	=	AHL based on high-rate trickling filter inhibition, lbs/day
AHL_{inhrbc}	=	AHL based on RBC inhibition, lbs/day
C_{inhstf}	=	Inhibition criteria for standard trickling filter, mg/L
$C_{inhhrtf}$	=	Inhibition criteria for high-rate trickling filter, mg/L
C_{inhrbc}	=	Inhibition criteria for RBC, mg/L
Q_{potw}	=	Total POTW flow, MGD
R_{prim1}	=	Removal efficiency from headworks to primary clarifier #1 effluent as a decimal (See Section 5.1.1 for calculating removal efficiencies)
R_{prim2}	=	Removal efficiency from headworks to primary clarifier #2 effluent as a decimal
R_{prim3}	=	Removal efficiency from headworks to primary clarifier #3 effluent as a decimal
8.34	=	Unit conversion factor

Each of the AHL equations has an inhibition criteria for each secondary treatment unit, C_{inhstf} , $C_{inhhrtf,}$, and C_{inhrbc} and removal rates from the headworks to corresponding primary clarifier unit effluent, R_{prim1}, R_{prim2}, and R_{prim3}. Data from sampling locations "A" and "B" is used to calculate the removal efficiency from headworks to the primary clarifier #1 effluent, R_{prim1}. Data from sampling locations "A"and "C" is used to calculate the removal efficiency from headworks to primary clarifier #2 effluent, R_{prim2}. Data from sampling locations "A" and "D" is used to calculate the removal efficiency from headworks to primary clarifier #3 effluent, R_{prim3}. Q_{potw} can be determined at sampling point "A." The AHL_{inhstf}, $AHL_{inhhrtf}$, and AHL_{inhrbc} should be calculated, compared, and the most stringent (smallest) selected.

AHL FOR SLUDGE DIGESTER INHIBITION

This plant must determine a headworks loading protecting both the primary and secondary sludge digesters from inhibition. Using Equation 5.12, an AHL based on sludge digester inhibition can be calculated.

$$AHL_{inbpd} = \frac{8.34(C_{inbpd})(Q_{pd})}{R_{potw}}$$ Primary Digester

$$AHL_{inbsd} = \frac{8.34(C_{inbsd})(Q_{sd})}{R_{potw}}$$ Secondary Digester

Where:

AHL_{inbpd}	=	AHL based on primary digester inhibition, lbs/day
AHL_{inbsd}	=	AHL based on secondary digester inhibition, lbs/day
C_{inbpd}	=	Primary digester inhibition criteria, mg/L
C_{inbsd}	=	Primary digester inhibition criteria, mg/L
Q_{pd}	=	Sludge flow to primary digester, MGD
Q_{sd}	=	Sludge flow to secondary digester, MGD
R_{potw}	=	Plant removal efficiency from headworks to plant effluent (as decimal)
8.34	=	Unit conversion factor

The equations to calculate the AHL based on sludge digester inhibition include primary and secondary inhibition criteria, C_{inbpd} and C_{inbsd}, sludge flow to the primary and secondary digesters, Q_{pd} and Q_{sd}, and an overall plant removal rate from headworks to plant effluent, R_{potw}. Q_{pd} can be determined by sampling flow at point "E," the sludge wastestream to the primary digester. Q_{sd} can be determined by sampling flow at point "F," the sludge wastestream from the primary digester to the secondary digester. R_{potw} can be determined by sampling loading at point "A," the headworks before the bar screen and grit chamber, and at point "H," the effluent after the chlorine contact chambers. AHL_{inbpd} and AHL_{inbsd} should be calculated, compared and the more stringent selected.

AHL FOR EFFLUENT LIMITS

The plant must determine headworks loading that would lead to effluent from its chlorine contact chambers (CCC) comply with NPDES Permit limits. Using Equation 5.5, the AHL based on NPDES Permit limit can be calculated.

$$AHL_{effccc} = \frac{(8.34)(C_{npdes})(Q_{potw})}{(1 - R_{potw})}$$

Where:

AHL_{effccc}	=	AHL based on CCC effluent compliance with NPDES, lbs/day
C_{npdes}	=	NPDES permit limit, mg/L
Q_{potw}	=	POTW flow, average, MGD
R_{potw}	=	Plant removal efficiency from headworks to plant effluent (as decimal)
8.34	=	Conversion factor

The equation to calculate the AHL based on CCC effluent compliance with NPDES includes the NPDES permit limit, C_{npdes}, total POTW flow, Q_{potw}, and an overall plant removal rate from headworks to plant effluent, R_{potw}. R_{potw} can be determined by sampling at point "A," the headworks before the bar screen and grit chamber, and at point "H," the effluent after the chlorine contact chambers. Q_{potw} can be determined through sampling flow at point "A" as well.

AHL FOR SLUDGE APPLICATION

The plant must determine a headworks that would lead to sludge from the vacuum filter suitable for land application. Using equation 5.9 an AHL based on sludge land application can be calculated.

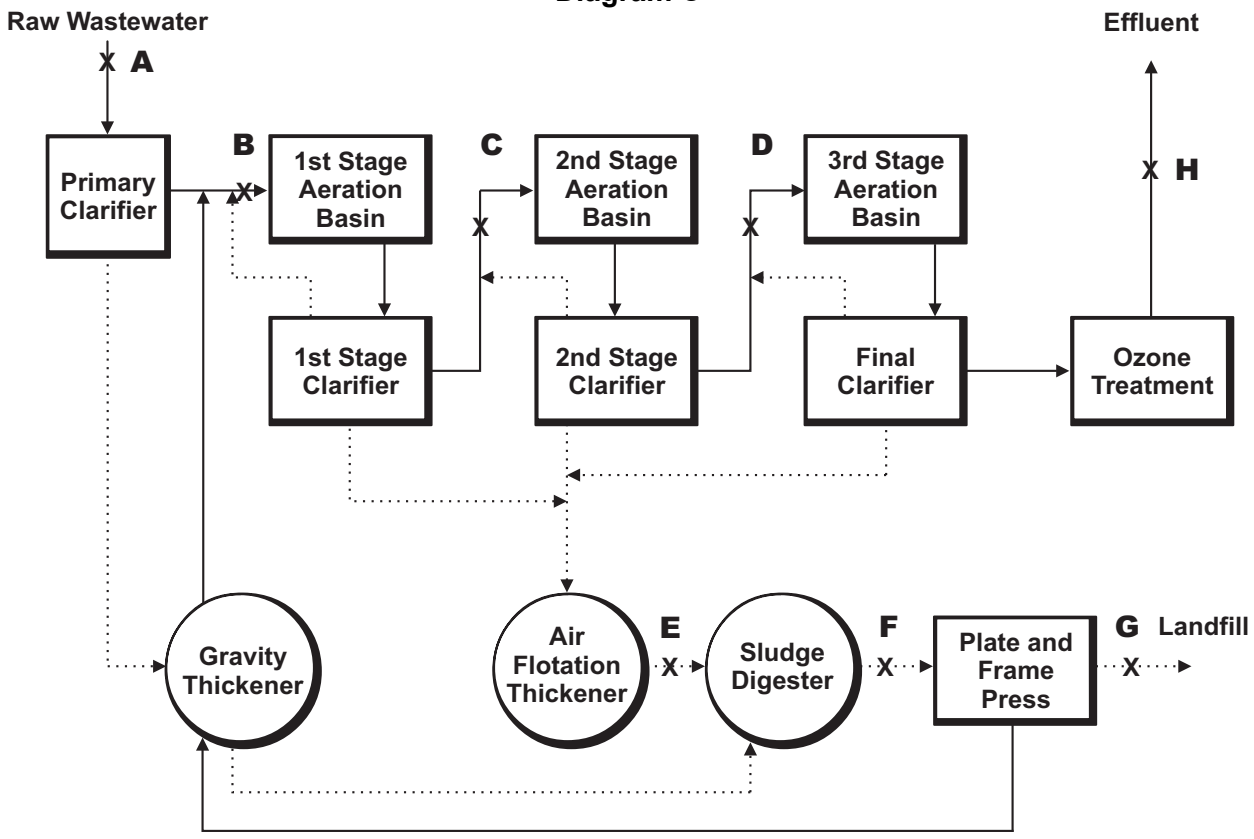
$$AHL_{savf} = \frac{(8.34)(C_{slgstd})(PS/100)(Q_{vf})(G_{sldg})}{R_{potw}}$$

Where:

AHL_{savf}	=	AHL based on compliance with sludge application standards, lbs/day
C_{slgstd}	=	Sludge standard, mg/kg dry sludge
PS	=	Percent solids of sludge leading to vacuum filter
Q_{vf}	=	Total sludge flow to vacuum filter, MGD
R_{potw}	=	Plant removal efficiency from headworks to plant effluent (as decimal)
G_{sldg}	=	Specific gravity of sludge leading to vacuum filter, kg/L
8.34	=	Unit conversion factor

The equation to calculate the AHL based on vacuum filter sludge compliance with sludge standards includes the sludge limit, C_{slgstd}; the flow, percent solids and specific gravity of sludge leading to the belt filter press, Q_{vf}, *PS,* and G_{sldg}, respectively; and the overall plant removal rate from headworks to plant effluent, R_{potw}. R_{potw} can be determined by sampling at point "A," the headworks before the bar screen and grit chamber, and at point "H," the effluent after the chlorine contact chambers. Q_{vf}, *PS,* and G_{sldg}, can be determined through sampling at point "G" the sludge waste stream to the vacuum filter.

Diagram C



AHL FOR SECONDARY TREATMENT INHIBITION

At this POTW three activated sludge units (aeration basins) operated in series provide secondary treatment of the raw wastewater. The concentration of a pollutant entering the First Stage Aeration Basin would be different from the concentration of that pollutant entering the Second Stage Aeration Basin and the Third Stage Aeration Basin because of the removal occurring in each unit. An AHL (to prevent inhibition) should be determined for each of these secondary treatment units.

$$AHL_{inhab1} = \frac{(C_{inhab1})(Q_{potw})(8.34)}{(1 - R_{prim})}$$ 1st Stage Aeration Basin

$$AHL_{inhab2} = \frac{(C_{inhab2})(Q_{potw})(8.34)}{(1 - R_{ab1})}$$ 2nd Stage Aeration Basin

$$AHL_{inhab3} = \frac{(C_{inhab3})(Q_{potw})(8.34)}{(1 - R_{ab2})}$$ 3rd Stage Aeration Basin

Where:

AHL_{inhab1}	=	AHL based on 1st Stage Aeration Basin inhibition, lbs/day
AHL_{inhab2}	=	AHL based on 2nd Stage Aeration Basin inhibition, lbs/day
AHL_{inhab3}	=	AHL based on 3rd Stage Aeration Basin inhibition, lbs/day
C_{inhab1}	=	Inhibition criteria for 1st Stage Aeration Basin, mg/L
C_{inhab2}	=	Inhibition criteria for 2nd Stage Aeration Basin, mg/L
C_{inhab3}	=	Inhibition criteria for 3rd Stage Aeration Basin, mg/L
Q_{potw}	=	Total POTW flow, MGD
R_{prim}	=	Removal efficiency from headworks to primary treatment effluent as a decimal (See Section 5.1.1 for calculating removal efficiencies)
R_{ab1}	=	Removal efficiency from headworks to 1st Stage Aeration Basin effluent as a decimal
R_{ab2}	=	Removal efficiency from headworks to 2nd Stage Aeration Basin effluent as a decimal
8.34	=	Unit conversion factor

Each of the equations to calculate AHLs for secondary treatment has it own inhibition criteria for each basin, C_{inhab1}, C_{inhab2}, and C_{inhab3} and corresponding removal rate, R_{prim}, R_{ab1}, and R_{ab2}, respectively, for the 1st, 2nd, and 3rd stage aeration basins. Data from sampling locations "A" and "B" is used to determine the removal efficiency from headworks to primary clarifier effluent, R_{prim}. Data from sampling locations "A" and "C" is used to determine the removal efficiency from headworks to 1st stage clarifier effluent, $R_{ab1.}$ Data from sampling locations "A" and "D" is used to determine the removal efficiency from headworks to 2nd stage clarifier effluent, R_{ab2}. Q_{potw} can be determined by sampling at location "A." The AHL_{inhab1}, AHL_{inhab2}, and AHL_{inhab3} should be calculated, compared, and the most stringent (smallest) selected.

AHL FOR SLUDGE DIGESTER INHIBITION

This plant must determine a headworks loading protecting the sludge digester from inhibition. Using Equation 5.12, an AHL based on sludge digester inhibition can be calculated.

$$AHL_{inhsd} = \frac{8.34(C_{inhsd})(Q_{sd})}{R_{potw}}$$

Where:

AHL_{inhsd}	=	AHL based on sludge digester inhibition, lbs/day
C_{inhsd}	=	Sludge digester inhibition criteria, mg/L
Q_{sd}	=	Sludge flow to sludge digester, MGD
R_{potw}	=	Plant removal efficiency from headworks to plant effluent (as decimal)
8.34	=	Unit conversion factor

The equation to calculate the AHL based on high-rate sludge digester inhibition includes an inhibition criteria for the digester, C_{inhsd}, sludge flow to the digester, Q_{sd} , and an overall plant removal rate from headworks to plant effluent, R_{potw}. Q_{sd} can be determined by sampling flow at point "E," the sludge wastestream from air flotation thickener to the digester. R_{potw} can be determined by sampling loading at point "A," the headworks before the bar screen and grit chamber, and at point "H," the effluent after the ozone treatment unit.

AHL FOR EFFLUENT LIMITS

The plant must determine headworks loading that would lead to effluent from its ozone treatment unit (OTU) comply with NPDES Permit limits. Using Equation 5.5, the AHL based on NPDES Permit limit can be calculated.

$$AHL_{effotu} = \frac{(8.34)(C_{npdes})(Q_{potw})}{(1 - R_{potw})}$$

Where:

AHL_{effotu}	=	AHL based on OTU effluent compliance with NPDES, lbs/day
C_{npdes}	=	NPDES permit limit, mg/L
Q_{potw}	=	POTW flow, average, MGD
R_{potw}	=	Plant removal efficiency from headworks to plant effluent (as decimal)
8.34	=	Conversion factor

The equation to calculate the AHL based on OTU effluent compliance with NPDES includes the NPDES permit limit, C_{npdes}, total POTW flow, Q_{potw}, and an overall plant removal rate from headworks to plant effluent, R_{potw}. R_{potw} can be determined by sampling loading at point "A," the headworks before the bar screen and grit chamber, and at point "H," the effluent after the OTU. Q_{potw} can be determined through sampling flow at point "A" as well.

AHL FOR SLUDGE APPLICATION

The plant must determine a headworks that would lead to sludge from the plate and frame press (PFP) suitable for land application. Using equation 5.9 an AHL based on sludge land application can be calculated.

$$AHL_{sapfp} = \frac{(8.34)(C_{slgstd})(PS/100)(Q_{sldg})(G_{sldg})}{R_{potw}}$$

Where:

AHL_{sapfp}	=	AHL based on compliance with sludge application standards, lbs/day
C_{slgstd}	=	Sludge standard, mg/kg dry sludge
PS	=	Percent solids of sludge leading to PFP
Q_{pfp}	=	Total sludge flow to PFP, MGD
R_{potw}	=	Plant removal efficiency from headworks to plant effluent (as decimal)
G_{sldg}	=	Specific gravity of sludge leading to PFP, kg/L
8.34	=	Unit conversion factor

The equation to calculate the AHL based on PFP sludge compliance with sludge standards includes the sludge limit, C_{slgstd}; the flow, percent solids and specific gravity of sludge leading to the PFP, Q_{pfp}, PS, and G_{sldg}, respectively; and the overall plant removal rate from headworks to plant effluent, R_{potw}. R_{potw} can be determined by sampling loading at point "A," the headworks before the bar screen and grit chamber, and at point "H," the effluent after the OTU. Q_{pfp}, PS, and G_{sldg}, can be determined through sampling flow at point "E" the sludge waste stream to the PFP.

APPENDIX V -
DOMESTIC POLLUTANT LOADINGS

Residential/Commercial Trunkline Monitoring Data

Pollutant	Number of Detections	Number of Samples	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)	Average Concentration (mg/L)
INORGANICS					
Arsenic	140	205	0.0004	0.088	0.007
Barium	3	3	0.04	0.216	0.115
Boron	4	4	0.1	0.42	0.3
Cadmium	361	538	0.00076	0.11	0.008
Chromium (III)	1	2	< 0.005	0.007	0.006
Chromium (T)	311	522	< 0.001	1.2	0.034
Copper	603	607	0.005	0.74	0.14
Cyanide	7	7	0.01	0.37	0.082
Fluoride	2	2	0.24	0.27	0.255
Iron	18	18	0.0002	3.4	0.989
Lead	433	540	0.001	2.04	0.058
Lithium	2	2	0.03	0.031	0.031
Manganese	3	3	0.04	0.161	0.087
Mercury	218	235	< 0.0001	0.054	0.002
Nickel	313	540	< 0.001	1.6	0.047
Phosphate	2	2	27.4	30.2	28.8
Total Phosphorous	1	1	0.7	0.7	0.7
Silver	181	224	0.0007	1.052	0.019
Zinc	636	638	0.01	1.28	0.231
ORGANICS					
Chloroform	21	30	<0.002	0.069	0.009
1,1-Dichloroethene	2	29	0.005	0.008	0.007
1,1-Dichloroethane	1	28	0.026	0.026	0.026
Trans-1,2-Dichloroethene	1	28	0.013	0.013	0.013
Fluoranthene	2	5	0.00001	<0.001	0.001
Methylene Chloride	7	30	0.00008	0.055	0.027
Phenols	2	2	0.00002	0.00003	0.000025
Bis (2-ethylhexyl) Phthalate	5	5	0.00002	0.022	0.006
Pyrene	2	3	0.00001	<0.005	0.0002
Tetrachloroethene	5	29	0.00001	0.037	0.014
1,2,4-Trichlorobenzene	1	3	<0.002	0.035	0.013
PESTICIDES					
Total BHC	3	3	0.001	0.001	0.001
4,4-DDD	3	3	0.00026	0.0004	0.0003
Total Endosulfan	3	3	0.002	0.002	0.002

Source: U.S. EPA's *Supplemental Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Programs*, May 1991. "Pollutant levels reported below specified detection limit were considered in the data analysis and, for the purpose of statistical analysis, were considered equal to the detection limit."

APPENDIX W -
BEST MANAGEMENT PRACTICES MINI-CASE STUDIES

POTWs can implement best management practice (BMP) programs to gain control over wastewater discharges from commercial sources. By developing a less formal source control program with emphasis on source control, education, BMPs, as-needed inspections, and individual or "general" permits, POTWs can gain additional control over uncontrolled wastewater discharges from commercial sources. Source control programs should place emphasis on certain specific pollutants of concern. For example, silver and mercury are often of great concern to POTWs because of NPDES permit requirements.

The commercial sources of wastewater that are addressed by BMP-based source control tend to have lower pollutant concentrations and loadings than other more traditional industrial facilities regulated by the traditional pretreatment program. Taken as a group, however, numerous uncontrolled commercial establishments may represent a significant source control opportunity that can lead to measurable improvement in environmental quality. Several pretreatment programs have documented pollutant reductions after the implementation of BMP and source reduction programs.

Several BMP/source control programs implemented at several POTWs are summarized in the following paragraphs to illustrate a variety of approaches that have been taken to utilize BMPs for the control of commercial sources of wastewater. Programs reviewed include: East Bay Municipal Utility District (EBMUD) in Oakland, California; Metropolitan Wastewater in San Diego, California; Seattle Metropolitan/King County in Washington State; Western Lake Superior Sanitary District, Duluth, Minnesota; and the Connecticut Department of Environmental Protection (CT DEP), Hartford, Connecticut.

EAST BAY MUNICIPAL DISTRICT (EBMUD), OAKLAND, CA

EBMUD has been issuing pollution prevention permits (PPPs) since 1988. EBMUD began their PPP program in response to tighter air emission standards and more stringent NPDES permit requirements. As a result, EBMUD had to augment headworks sampling and analysis programs for the development and local limits. Based on attentive tracking of regulatory requirements over the past 10 years, EBMUD has sequentially identified POCs, identified commercial users contributing those pollutants, and developed PPPs with best management practice requirements.

When EBMUD recognizes a pollutant of concern, they follow step-wise procedures. First, information on businesses and commercial activities that may be contributing the targeted POC is collected and refined. Next, EBMUD engages in an outreach program and works with the businesses to define BMPs. Finally, EBMUD issues the PPP and evaluates compliance. Generally, there is one sector of business activity that is responsible for the specific pollutant. For example, silver is linked to the photo finishers. EBMUD works with representatives of the commercial sector to research and develop BMPs that will effectively minimize the pollutant in effluent wastewater.

EBMUD believes that the most important aspect of a successful PPP program is education, outreach, and user awareness combined with an enforceable permit. When conducting outreach, EBMUD gets in touch with each user to confirm the nature of their business and the processes they use at the business that can contribute wastewater and pollutants of concern. The establishment is asked to participate in educational workshops to review EBMUD's concerns, review and refine preliminary methods to prevent pollutant releases and lay the groundwork for successful communications and understanding of the problem and the solution. Users are introduced to the permitting and enforcement process in a non-threatening forum. EBMUD's inventory of users is based on water supply account information. Whenever a user opens a water account, it is

automatically characterized for wastewater and source control purposes. A revenue collection system ($3.25 per commercial account per month) assures adequate funding for the PPP program.

EBMUD staff researches ideas for generalized BMPs through discussions with the business sector and State trade group associations. Each of the EBMUD staff tracks one or more business sectors and are responsible for knowing current pollution control measures and trends. During the research phase of BMP development, each user that is a potential contributor of a POC is sent a letter to notify them that EBMUD is working on a PPP and reviewing the anticipated time frame for permit issuance.

The PPP includes similar BMPs for each permittee. Some examples include silver recovery canisters connected in series to optimize removal of silver with a required logging procedure that assures canisters are changed at the appropriate frequency to eliminate break through. EBMUD PPPs vary in length from two to 8 pages and are issued in industry group batches for a duration of 5 years. In the administration of their PPP program, EBMUD conducts visits/inspections of the permittees, provides follow up education, distributes fact sheets, procedures and posters illustrating acceptable waste and wastewater disposal procedures. During the life of a 5-year permit, EBMUD tries to inspect the permittee at least once or twice. Based on the findings of the initial visit, and the degree to which the permittee is implementing the prescribed BMPs, the follow up frequency is set. When EBMUD fails to get cooperation from businesses, they initiate enforcement actions. As an example, EBMUD sought and obtained a $27,000 penalty from a dry cleaner.

A partial list of the businesses for which EBMUD has developed BMPs and PPP permits includes:

- Photofinishers
- Boat Yards
- Dry Cleaners
- Auto Repairs
- Print Shop
- Radiator Repair Shops
- Furniture Stripping

METROPOLITAN WASTEWATER, SAN DIEGO, CA

Metropolitan Wastewater issues sector-specific BMP discharge authorizations to commercial customers. These authorizations require:

- Specific pollution prevention measures.
- An initial certification of compliance.
- On-going semi-annual "reminder" certifications for businesses to demonstrate familiarity with their pollution prevention measures.

Metropolitan Wastewater covers a variety of sectors with this program. General permits are issued to film processing and dry cleaners. The photo processing BMPs are based on the Code of Management Practice for Silver Dischargers (AMSA 1996) developed by the Silver Council in concert with the Association of Metropolitan Sewerage Agencies and EPA. Metropolitan Wastewater conducted workshops to review silver control BMPs with their users. Boat repair yards or dry docks are required to submit their own customized BMPs which are incorporated into a permit. Food establishment discharge permits are also issued and require grease removal equipment, operation and maintenance, and compliance with general and specific discharge prohibitions. Auto repair shops that have steam-cleaning operations are required to have a sump for all O&G

wastewater from steam cleaning operations. San Diego has initiated a more aggressive program to enforce grease trap cleaning particularly at food establishments. They have discovered that excessive amounts of grease buildup contribute to dry weather flows into San Diego and Mission Bay. Analytical/Research Labs are required to implement a solvent certification program that is very similar to the total toxic organic (TTO) certification program for metal finishers and electroplaters.

San Diego has a 301(h) waiver for their wastewater treatment facility, allowing conditional discharge of wastewater without full secondary treatment. One condition of the waiver requires the City to reexamine their local limits every year and reassess loadings from all sources (domestic, SIU, and non-SIU contributions). The IU is considered a "contributor" of a pollutant of concern (presently one of six heavy metals) if the user has one of the six metals in its effluent at a concentration that is two standard deviations above the average domestic concentration. Once the IU is deemed to be a "contributor" of a pollutant of concern, wastewater flow is evaluated to determine whether the load is significant enough to be assigned to the "allocated" versus "non-allocated" load for their local limits accounting procedures. When the load is significant, the user is included in the allocated portion of headworks load calculations and the user is required to comply with local limits. Users with minor concentrations or loadings of pollutants of concern are not required to comply with local limits. However, they may still be required to comply with BMPs and general permit requirements.

SEATTLE METROPOLITAN/KING COUNTY, WASHINGTON

Seattle Metropolitan /King County (Seattle Metro) has a very large and active pollution prevention program that has acquired a great deal of information on dental mercury source control. Dental facilities in the Seattle Metro collection system are subject to the mercury local limits. After strong lobbying by the Dental Association against mandatory BMPs, dental facilities currently have latitude in controlling mercury through BMPs. Seattle Metro has developed a variety of tools to control mercury, including:

- A certified list of the vendors and technologies that are able to achieve a 90% reduction in metals.
- Videotape on mercury and silver source control from dental offices entitled "Amalgam Waste Conference."
- A dental facility waste management poster and a booklet entitled, "Waste Management Guidelines for Dental Facilities."
- Records on the amount of amalgam that is being reclaimed by recyclers as a means of tracking the success of their education efforts.
- Voucher program that gives $500 to dental offices to obtain one of the approved metal removal units identified in the list above.
- Educational materials (posters, videos, booklets).

WESTERN LAKE SUPERIOR SANITARY DISTRICT (WLSSD), DULUTH, MINNESOTA

With support from the Great Lakes Protection Fund, the WLSSD conducted a two-year Mercury Zero Discharge Project to examine the sources of mercury to its wastewater treatment plant and to determine how to reduce or eliminate those sources. This project included cooperative initiatives with industries known to be discharging mercury, programs aimed at specific uses of mercury, a monitoring program to identify additional sources and a public awareness campaign. In addition to these external programs, WLSSD also examined its own facilities and practices.

WLSSD has authored the *Blueprint for Mercury Elimination, Mercury Reduction Project Guidance for Wastewater Treatment Plants*, March, 1997. Selected for an AMSA National Environmental Achievement Award for excellence in Public Information & Education, the document examines sources of mercury in the environment, reviews contributions to the wastewater collection system, and gives examples of success stories on mercury source reduction. Appendices to the document provide useful "how to" references for implementing a source reduction program, such as a sample news release for a mercury reduction project, sample letters to mercury contributors, telephone survey forms to interview possible contributors, survey forms for hospitals and dental offices.

CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION (CT DEP), HARTFORD, CONNECTICUT

In 1992, CT DEP began a Statewide general permit program. The program established requirements for industries that were not SIUs, regulated by CT DEP's State-run pretreatment permitting program, but were a potential source of concern for POTWs. The general permitting program is "self implementing" and expects commercial establishments to be made aware of general permit program requirements by the local Town officials, the State, or through consultants. Thus, the general permitting program avoids the resource intensive individual permitting of traditional programs.

The program works in the following manner. An IU assesses their eligibility for a general permit (versus a traditional pretreatment permit). CT DEP encourages industries to determine eligibility for a general permit, as the permitting process is quicker and less costly for the IU and CT DEP. Each general permit identifies BMPs that must be followed by each permit holder. CT DEP conducts selective auditing and enforcement of general permit holders, and facilities that may have failed to register for a general permit. By publicizing the enforcement actions and penalties, industries are made aware of their duties to have a permit and comply with the BMPs, record keeping, monitoring, and where applicable, effluent limits. General permits developed by CT DEP include the following sectors:

1. Constructions and Operation of Certain Recycling Facilities
2. Car Wash Wastewater
3. Domestic Sewage of 50,000 gallons per day or 5% of the POTW Design Flow
4. Groundwater Contamination Recovery Systems
5. Hydrostatic Pressure Testing
6. Minor Boiler Blowdown
7. Minor Non-Contact Cooling Water
8. Minor Photographic Processing
9. Minor Tumbling and Cleaning of Parts Wastewater
10. Storm Water Associated with Industrial Activities
11. Storm Water and Dewatering Wastewaters - Construction Activities
12. Vehicle Service Floor Drain and Car Wash Wastewater
13. Storm Water Associated with Commercial Activities
14. Minor Printing and Publishing Wastewater
15. Water Treatment Wastewater - Commercial
16. Food Processing Wastewater
17. Public Swimming Pool Backwash
18. Water Softening/Treatment Unit Wastewater-Individual Homes (under development)

APPENDIX X -
REGION 1, REASSESSMENT OF TECHNICALLY BASED INDUSTRIAL DISCHARGE LIMITS CHECKLIST

Attachment A.

EPA - New England

Reassessment of Technically Based Industrial Discharge Limits

Under 40 CFR 122.21(j)(4), all Publicly Owned Treatment Works (POTWs) with approved Industrial Pretreatment Programs (IPPs) shall provide the following information to the Director: a written evaluation of the need to revise local industrial discharge limits under 40 CFR 403.5(c)(1).

Below is a form designed by the U.S. Environmental Protection Agency (EPA - New England) to assist POTWs with approved IPPs in evaluating whether their existing Technically Based Local Limits (TBLLs) need to be recalculated. The form allows the permittee and EPA to evaluate and compare pertinent information used in previous TBLLs calculations against present conditions at the POTW.

Please read direction below before filling out form.

ITEM I.

* In Column (1), list what your POTW's influent flow rate was when your existing TBLLs were calculated. In Column (2), list your POTW's present influent flow rate. Your current flow rate should be calculated using the POTW's average daily flow rate from the previous 12 months.

* In Column (1) list what your POTW's SIU flow rate was when your existing TBLLs were calculated. In Column (2), list your POTW's present SIU flow rate.

* In Column (1), list what dilution ratio and/or 7Q10 value was used in your old/expired NPDES permit. In Column (2), list what dilution ratio and/or 7Q10 value is presently being used in your new/reissued NPDES permit.

  The 7Q10 value is the lowest seven day average flow rate, in the river, over a ten-year period. The 7Q10 value and/or dilution ratio used by EPA in your new NPDES permit can be found in your NPDES permit "Fact Sheet."

* In Column (1), list the safety factor, if any, that was used when your existing TBLLs were calculated.

* In Column (1), note how your biosolids were managed when your existing TBLLs were calculated. In Column (2), note how your POTW is presently disposing of its biosolids and how your POTW will be disposing of its biosolids in the future.

ITEM II.

* List what your existing TBLLs are - as they appear in your current Sewer Use Ordinance (SUO).

ITEM III.

* Identify how your existing TBLLs are allocated out to your industrial community. Some pollutants may be allocated differently than others, if so please explain.

ITEM IV.

* Since your existing TBLLs were calculated, identify the following in detail:

  (1) if your POTW has experienced any upsets, inhibition, interference or pass-through as a result of an industrial discharge.

  (2) if your POTW is presently violating any of its current NPDES permit limitations - include toxicity.

ITEM V.

* Using current sampling data, list in Column (1) the average and maximum amount of pollutants (in pounds per day) received in the POTW's influent. Current sampling data is defined as data obtained over the last 24 month period.

  All influent data collected and analyzed must be in accordance with 40 CFR 136. Sampling data collected should be analyzed using the lowest possible detection method(s), e.g., graphite furnace.

* Based on your existing TBLLs, as presented in Item II., list in Column (2), for each pollutant the Maximum Allowable Industrial Headwork Loading (MAIHL) values derived from an applicable environmental criteria or standard, e.g., water quality, sludge, NPDES, inhibition, etc. For each pollutant, the MAIHL equals the calculated Maximum Allowable Headwork Loading (MAHL) minus the POTW's domestic loading source(s). For more information, please see p. 3-28 in EPA's *Guidance Manual on the Development and Implementation of Local Limits Under the Pretreatment Program, 12/87*.

ITEM VI.

* Using current sampling data, list in Column (1) the average and maximum amount of pollutants (in micrograms per liter) present in your POTW's effluent. Current sampling data is defined as data obtained during the last 24-month period.

  All effluent data collected and analyzed must be in accordance with 40 CFR 136. Sampling data collected should be analyzed using the lowest possible detection method(s), e.g., graphite furnace.

* List in Column (2A) what the Water Quality Standards (WQS) were (in micrograms per liter) when your TBLLs were calculated, please note what hardness value was used at that time. Hardness should be expressed in milligram per liter of calcium carbonate.

  List in Column (2B) the current WQSs or "Chronic Gold Book" values for each pollutant multiplied by the dilution ratio used in your new/reissued NPDES permit. For example, with a dilution ratio of 25:1 at a hardness of 25 mg/L - calcium carbonate (copper's chronic WQS equals 6.54 ug/L) the chronic NPDES permit limit for copper would equal 156.25 ug/L.

ITEM VII.

* In Column (1), list all pollutants (in micrograms per liter) limited in your new/reissued NPDES permit. In Column (2), list all pollutants limited in your old/expired NPDES permit.

ITEM VIII.

* Using current sampling data, list in Column (1) the average and maximum amount of pollutants in your POTW's biosolids. Current data is defined as data obtained during the last 24 month period. Results are to be expressed as total dry weight.

  All biosolids data collected and analyzed must be in accordance with 40 CFR 136.

  In Column (2A), list current State and/or Federal sludge standards that your facility's biosolids must comply with. Also note how your POTW currently manages the disposal of its biosolids. If your POTW is planing on managing its biosolids differently, list in Column (2B) what your new biosolids criteria will be and method of disposal.

In general, please be sure the units reported are correct and all pertinent information is included in your evaluation. If you have any questions, please contact your pretreatment representative at EPA - New England.

REASSESSMENT OF TECHNICALLY BASED LOCAL LIMITS (TBLLs)

POTW Name & Address :
_____

NPDES PERMIT # :
_____

Date EPA approved current TBLLs :
_____

Date EPA approved current Sewer Use Ordinance :
_____

ITEM I.

In Column (1), list the conditions that existed when your current TBLLs were calculated. In Column (2), list current conditions or expected conditions at your POTW.

	Column (1) EXISTING TBLLs	Column (2) PRESENT CONDITIONS
POTW Flow (MGD)		
SIU Flow (MGD)		
Dilution Ratio or 7Q10 (from NPDES Permit)		
Safety Factor		N/A
Biosolids Disposal Method(s)		

ITEM II.

EXISTING TBLLs

POLLUTANT	NUMERICAL LIMIT (mg/L) or (lb/day)	POLLUTANT	NUMERICAL LIMIT (mg/L) or (lb/day)
---	---	---	---
---	---	---	---
---	---	---	---
---	---	---	---
---	---	---	---
---	---	---	---
---	---	---	---

ITEM III.

Note how your existing TBLLs, listed in Item II., are allocated to your Significant Industrial Users (SIUs), i.e., uniform concentration, contributory flow, mass proportioning, other. Please specify by circling.

ITEM IV.

Has your POTW experienced any upsets, inhibition, interference or pass-through from industrial sources since your existing TBLLs were calculated?

If yes, explain.

_____

_____

Has your POTW violated any of its NPDES permit limits and/or toxicity test requirements?

If yes, explain.

_____

_____

ITEM V.

Using current POTW influent sampling data fill in Column (1). In Column (2), list your Maximum Allowable Headwork Loading (MAHL) values used to derive your TBLLs listed in Item II. In addition, please note the Environmental Criteria for which each MAHL value was established, i.e., water quality, sludge, NPDES, etc.

Pollutant	Column (1) Influent Data Analyses Maximum (lb/day)	Average (lb/day)	Column (2) MAHL Values (lb/day)	Criteria
Arsenic	----------		----------	
Cadmium	----------		----------	
Chromium	----------		----------	
Copper	----------		----------	
Cyanide	----------		----------	
Lead	----------		----------	
Mercury	----------		----------	
Nickel	----------		----------	
Silver	----------		----------	
Zinc	----------		----------	
Other (List)				
-------	----------		----------	
-------	----------		----------	
-------	----------		----------	

ITEM VI.

Using current POTW effluent sampling data, fill in Column (1). In Column (2A) list what the Water Quality Standards (Gold Book Criteria) were at the time your existing TBLLs were developed. List in Column (2B) current Gold Book values multiplied by the dilution ratio used in your new/reissued NPDES permit.

Pollutant	Column (1) Effluent Data Analyses		Columns (2A) (2B) Water Quality Criteria (Gold Book) From TBLLsToday	
	Maximum (ug/L)	Average (ug/L)	(ug/L)	(ug/L)
Arsenic				
*Cadmium				
*Chromium				
*Copper				
Cyanide				
*Lead				
Mercury				
*Nickel				
Silver				
*Zinc				
Other (List)				

*Hardness Dependent (mg/L - CaCO3)

ITEM VII.

In Column (1), identify all pollutants limited in your new/reissued NPDES permit. In Column (2), identify all pollutants that were limited in your old/expired NPDES permit.

Column (1) NEW PERMIT Pollutants	Limitations (ug/L)	Column (2) OLD PERMIT Pollutants	Limitations (ug/L)

ITEM VIII.

Using current POTW biosolids data, fill in Column (1). In Column (2A), list the biosolids criteria that was used at the time your existing TBLLs were calculated. If your POTW is planing on managing its biosolids differently, list in Column (2B) what your new biosolids criteria would be and method of disposal.

Pollutant	Column (1) Biosolids Data Analyses Average (mg/kg)	Columns (2A) Biosolids Criteria From TBLLs (mg/kg)	(2B) New (mg/kg)
Arsenic	---------	---------	---------
Cadmium	---------	---------	---------
Chromium	---------	---------	---------
Copper	---------	---------	---------
Cyanide	---------	---------	---------
Lead	---------	---------	---------
Mercury	---------	---------	---------
Nickel	---------	---------	---------
Silver	---------	---------	---------
Zinc	---------	---------	---------
Molybdenum	---------	---------	---------
Selenium	---------	---------	---------
Other (List)	---------	---------	---------
	---------	---------	---------