TABLE 6
RECOMMENDED AND ADOPTED CHEMICAL ACCUMULATION/CONCENTRATION METHODS *

Chemical	EPA Recommended Method	ADEM Adopted Method
1,1,1-Trichloroethane 71556	BAF	
1,1,2,2-Tetrachloroethane 79345	BAF	BCF
1,1,2-Trichloroethane 79005	BAF	BCF
1,1-Dichloroethylene 75354	BAF	BCF
1,2,4-Trichlorobenzene 120821	BAF	BCF
1,2-Dichlorobenzene 95501	BAF	BCF
1,2-Dichloroethane 107062	BAF	BCF
1,2-Dichloropropane 78875	BAF	BCF
1,2-Diphenylhydrazine 122667	BAF	BCF
1,3-Dichlorobenzene 541731	BAF	BCF
1,3-Dichloropropene 542756	BAF	BCF
1,4-Dichlorobenzene 106467	BAF	BCF
2,3,7,8-TCDD (Dioxin) 1746016	BCF	BCF
2,4,6-Trichlorophenol 88062	BAF	BCF

Chemical	EPA Recommended Method	ADEM Adopted Method
2,4-Dichlorophenol 120832	BAF	BCF
2,4-Dimethylphenol 105679	BAF	BCF
2,4-Dinitrophenol 51285	BAF	BCF
2,4-Dinitrotoluene 121142	BAF	BCF
2-Chloronaphthalene 91587	BAF	BCF
2-Chlorophenol 95578	BAF	BCF
2-Methyl-4,6-Dinitrophenol 534521	BAF	BCF
3,3'-Dichlorobenzidine 91941	BAF	BCF
3-Methyl-4-Chlorophenol 59507	BAF	
Acenaphthene 83329	BAF	BCF
Acrolein 107028	BAF	BCF
Acrylonitrile 107131	BAF	BCF
Aldrin 309002	BAF	BCF
alpha-Hexachlorocyclohexane (HCH) 319846	BAF	BCF
alpha-Endosulfan 959988	BAF	BCF

Chemical	EPA Recommended Method	ADEM Adopted Method
Anthracene 120127	BAF	BCF
Antimony 7440360	BCF	BCF
Arsenic 7440382	BCF	BCF
Asbestos 1332214		
Benzene 71432	BAF	BCF
Benzidine 92875	BAF	BCF
Benzo(a)anthracene 56553	BAF	BCF
Benzo(a)pyrene 50328	BAF	BCF
Benzo(b)fluoranthene 205992	BAF	BCF
Benzo(k)fluoranthene 207089	BAF	BCF
beta-Hexachlorocyclohexane (HCH) 319857	BAF	BCF
beta-Endosulfan 33213659	BAF	BCF
Bis(2-Chloro-1-methylethyl) Ether 108601	BAF	BCF
Bis(2-Chloroethyl) Ether 111444	BAF	BCF
Bis(2-Ethylhexyl) Phthalate 117817	BAF	BCF

Chemical	EPA Recommended Method	ADEM Adopted Method
Bromoform 75252	BAF	BCF
Butylbenzyl Phthalate 85687	BAF	BCF
Carbon Tetrachloride 56235	BAF	BCF
Chlordane 57749	BAF	BCF
Chlorobenzene 108907	BAF	BCF
Chlorodibromomethane 124481	BAF	BCF
Chloroform 67663	BAF	BCF
Chrysene 218019	BAF	BCF
Copper 7440508		
Cyanide 57125	BCF	BCF
Dibenzo(a,h)anthracene 53703	BAF	BCF
Dichlorobromomethane 75274	BAF	BCF
Dieldrin 60571	BAF	BCF
Diethyl Phthalate 84742	BAF	BCF
Dimethyl Phthalate 131113	BAF	BCF

Chemical	EPA Recommended Method	ADEM Adopted Method
Di-n-Butyl Phthalate 84742	BAF	BCF
Endosulfan Sulfate 1031078	BAF	BCF
Endrin 72208	BAF	BCF
Endrin Aldehyde 7421934	BAF	BCF
Ethylbenzene 100414	BAF	BCF
Fluoranthene 206440	BAF	BCF
Fluorene 86737	BAF	BCF
gamma-Hexachlorocyclohexane (HCH) [Lindane] 58899	BAF	BCF
Heptachlor 76448	BAF	BCF
Heptahlor Epoxide 1024573	BAF	BCF
Hexachloroenzene 118741	BAF	BCF
Hexachlorobutadiene 87683	BAF	BCF
Hexachlorocyclopentadiene 77474	BAF	BCF
Hexachloroethane 67721	BAF	BCF
Indeno(1,2,3-cd)pyrene 193395	BAF	BCF

Chemical	EPA Recommended Method	ADEM Adopted Method
Isophorone 78591	BAF	BCF
Methylmercury 22967926	BAF	
Methyl Bromide 74839	BAF	BCF
Methylene Chloride 75092	BAF	BCF
Nickel 744000	BCF	BCF
Nitrobenzene 98953	BAF	BCF
N-Nitrosodimethylamine 62759	BCF	BCF
N-Nitrosodi-n-Propylamine 621647	BCF	BCF
N-Nitrosodiphenylamine 86306	BCF	BCF
Pentachlorophenol 87865	BAF	BCF
Phenol 108952	BAF	BCF
p,p'-Dichlorodiphenyldichloroethane (DDD) 72548	BAF	BCF
p,p -Dichlorodiphenyldichloroethylene (DDE) 72559	BAF	BCF
p,p'-Dichlorodiphenyltrichloroethane (DDT) 50293	BAF	BCF

Chemical	EPA Recommended Method	ADEM Adopted Method
Polychlorinated Biphenyls (PCBs) 1336363	BCF	BCF
Pyrene 129000	BAF	BCF
Selenium 7782492	BCF	BCF
Tetrachloroethylene 127184	BAF	BCF
Thallium 7440280	BCF	BCF
Toluene 108883	BAF	BCF
Toxaphene 8001352	BAF	BCF
trans-1,2-Dichloroethylene 156605	BAF	BCF
Trichloroethylene 79016	BAF	BCF
Vinyl Chloride 75014	BAF	BCF
Zinc 7440666	BCF	BCF

*** Summary:**

Table 6 identifies the bioaccumulation or bioconcentration methodology used by EPA to calculate national recommended water quality criteria for 97 toxic pollutants to protect human health and by ADEM to calculate adopted water quality criteria for 92 toxic pollutants to protect human health. The former are based on individual water quality criteria documents for toxic pollutants hyperlinked in *National Recommended Water Quality Criteria - Human Health Criteria Table*, https://www.epa.gov/wqc/national-recommended-water-quality-criteria-

human-health-criteria-table (accessed Dec. 31, 2021). The latter are based on ADEM Admin. Code r. 335-6-10-.07, Appendix A.

EPA has used bioaccumulation factors (BAFs) to calculate water quality criteria for 86 of 97 toxic pollutants. EPA has used bioconcentration factors (BCFs) to calculate water quality criteria for 12 toxic pollutants. ADEM has used bioconcentration factors (BCFs) to calculate water quality criteria for 94 toxic pollutants. ADEM has not adopted water quality criteria to protect human health for 3 toxic pollutants: 1,1,1-Trichloroethane, 3-Methyl-4-Chlorophenol, and Methylmercury. ADEM's less stringent and omitted BAFs/BCFs (highlighted in yellow) underestimate the exposure of humans to toxic pollutants having systemic (non-cancer) health effects.

Comments:

Human exposure to toxic pollutants in water is primarily through consumption of contaminated water and contaminated aquatic organisms (fish and shellfish). Aquatic organisms become contaminated when they ingest toxic pollutants.

In *Water Quality Standards Handbook* (EPA 823-B-17-001 2017), Chap. 3, at § 3.3.2, EPA explained why BAFs are preferable to BCFs as follows:

> Bioaccumulation refers to the uptake and retention of a chemical by an aquatic organism from all surrounding media (e.g., water, food, sediment) whereas bioconcentration refers to the uptake and retention of a chemical by an aquatic organism from water only. For some chemicals, particularly those that are persistent and hydrophobic, the magnitude of bioaccumulation by aquatic organisms can be substantially greater than the magnitude of bioconcentration. Thus, an assessment of bioconcentration alone may underestimate the extent of accumulation in aquatic biota for these chemicals.
>
> The magnitude of bioaccumulation by aquatic organisms varies widely depending on the chemical, but can be extremely high for some persistent and hydrophobic chemicals. For such bioaccumulative chemicals, concentrations in aquatic organisms may pose unacceptable human health risks from fish and shellfish consumption even when concentrations in water are too low to cause unacceptable health risks from drinking water consumption alone. These

chemicals may also biomagnify in aquatic food webs, a process whereby chemical concentrations increase in aquatic organisms of each successive trophic level due to increasing dietary exposures (e.g., increasing concentrations from algae, to zooplankton, to forage fish, to predatory fish).

The EPA's 2000 Human Health Methodology recommends the use of bioaccumulation factors (BAFs), where available, to reflect the uptake of a contaminant from all sources (e.g., ingestion, sediment) by fish and shellfish, rather than only from the water column as reflected by the use of bioconcentration factors (BCFs) in the 1980 Human Health Methodology.3 Criteria developed using BAFs better represent exposures to pollutants that affect human health than do criteria developed using BCFs. The EPA's Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000); Technical Support Document Volume 2: Development of National Bioaccumulation Factors (2003) contains procedures for calculating BAFs. The EPA also recommends that states and authorized tribes calculate site-specific BAFs, where possible, for use in developing their state and authorized tribal human health water quality criteria. The EPA's Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000); Technical Support Document Volume 3: Development of Site Specific Bioaccumulation Factors (2009) contains procedures for calculating site-specific BAFs. The EPA applied the methodologies above in its 2015 human health criteria updates.

See Human Health Ambient Water Quality Criteria: 2015 Update (EPA 820-F-15-001 June 2015).

Use of BAFs in the calculation of water quality criteria for the protection of human health typically, if not always, results in more stringent criteria assuming all other factors in the calculation remain the same.