Chapter NR 105

SURFACE WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

NR 105.01 Purpose. The purpose of this chapter is to establish water quality criteria and methods for developing criteria for toxic substances to protect public health and welfare, the present and prospective use of all surface waters for public and private water supplies, and the propagation of fish and aquatic life and wild and domestic animal life. This chapter also establishes how bioaccumulation factors used in deriving water quality criteria for toxic and organoleptic substances shall be determined. Water quality criteria are a component of surface water quality standards. This chapter and chs. NR 102 to 104 constitute quality standards for the surface waters of Wisconsin.

History: Cr. Register, February, 1989, No. 398, eff. 3-1-89.

NR 105.02 Applicability. (1) EXISTING AND SITE-SPECIFIC CRITERIA. The provisions of this chapter are applicable to surface waters of Wisconsin as specified in chs. NR 102 to 104 and in this chapter. A criterion contained within this chapter may be modified for a particular surface water segment or body. A criterion may be modified if specific information is provided which shows that the data used to derive the criterion does not apply and if additional information is provided to derive a site-specific criterion. Site-specific criteria are intended to be applicable to a specific surface water segment. Criteria may be modified for site-specific considerations according to the "Water Quality Standards Handbook" (USEPA, Office of Water Regulations and Standards, Dec. 1983). Any criterion modified for site-specific conditions shall be promulgated in ch. NR 104 before it can be applied on a site-specific basis.

(2) MODIFICATION OF CRITERIA. (a) The department may promulgate a less stringent criterion or remove a criterion from this chapter when the department determines that the previously promulgated criterion is more stringent than necessary, or unnecessary for the protection of humans, fish and other aquatic life or wild and domestic animal life. Such modification shall assure that the designated uses are protected and water quality standards continue to be attained.

(b) The department may promulgate a more stringent criterion in this chapter when the department determines that the previously promulgated criterion is inadequate for the protection of humans, fish and other aquatic life or wild and domestic animal life.

History: Cr. Register, February, 1989, No. 398, eff. 3-1-89.

NR 105.03 Definitions. (1) "Acute toxicity" means the ability of a substance to cause mortality or an adverse effect in an organism which results from a single or short-term exposure to the substance.

(2) "Acute toxicity criterion" or "ATC" means the maximum daily concentration of a substance which ensures adequate protection of sensitive species of aquatic life from the acute toxicity of that substance and will adequately protect the designated fish and aquatic life use of the surface water if not exceeded more than once every 3 years. If the available data indicate that one or more life stages of a particular species are more sensitive to a substance than other life stages of the same species, the ATC shall represent the acute toxicity of the most sensitive life stage.

(3) "Adequate protection" means a level of protection which ensures survival of a sufficient number of healthy individuals in a population of aquatic species to provide for the continuation of an unreduced population of these species.

(4) "Adverse effect" means any effect resulting in a functional impairment or a pathological lesion, or both, which may affect the performance of the whole organism, or which contributes to a reduced ability to respond to an additional challenge. Adverse effects include toxicant-induced mutagenic, teratogenic, or carcinogenic effects or impaired, developmental, immunological or reproductive effects.

(5) "Bioaccumulation factor" means the ratio of the concentration of a substance in an aquatic organism to the concentration of the substance in water to which the organism is exposed regardless of whether the concentration in an organism results solely from body contact with the water or from body contact plus ingestion of food contaminated with the substance.

(6) "Bioconcentration factor" means the ratio of the concentration of a substance in an aquatic organism to the concentration of the substance in water to which the organism is exposed when the concentration in the organism results solely from body contact with the water.

(7) "Carcinogen" means any substance listed in Table 9 or a substance for which the induction of benign or malignant neoplasms has been demonstrated in:

(a) Humans; or

(b) Two mammalian species; or

(c) One mammalian species, independently reproduced; or

(d) One mammalian species, to an unusual degree with respect to increased incidence, shortened latency period, variety of site, tumor type, or decreased age at onset; or

(e) One mammalian species, supported by reproducible positive results in at least 3 different types of short-term tests which are indicative of potential oncogenic activity.

(8) "Chronic toxicity" means the ability of a substance to cause an adverse effect in an organism which results from exposure to the substance for a time period representing that substantial portion of the natural life expectancy of that organism.

(9) "Chronic toxicity criterion" or "CTC" means the maximum 4-day concentration of a substance which ensures adequate protection of sensitive species of aquatic life from the chronic toxicity of that substance and will adequately protect the designated fish and aquatic use of the surface water if not exceeded more than once every 3 years.

(10) "EC_{50}" means a concentration of a toxic substance which causes an adverse effect including mortality in 50% of the exposed organisms in a given time period.

(11) "LC_{50}" means a concentration of a toxic substance which is lethal to 50% of the exposed organisms in a given time period.

(12) "LD_{50}" means a dose of a toxic substance which is lethal to 50% of the exposed organisms in a given time period.

(13) "Lipid-soluble substance" means a substance which is soluble in nonpolar organic solvents and which tends to accumulate in the fatty tissues of an organism exposed to the substance.

(14) "Lowest observable adverse effect level" or "LOAEL" means the lowest tested concentration that caused an adverse effect in comparison with a control when all higher test concentrations caused the same effect.

(15) "No observable adverse effect level" or "NOAEL" means the highest tested concentration that did not cause an adverse effect in comparison with a control when no lower test concentration caused an adverse effect.

(16) "Octanol/water partition coefficient" means the ratio of the concentration of a substance in the octanol phase to its concentration in the aqueous phase of a 2-phase octanol/water system after equilibrium of the substance between the 2 phases has been achieved.

(17) "Steady state" means that an equilibrium condition in the body burden of a substance in an organism has been achieved and is assumed when the rate of depuration of a substance matches its rate of uptake.

(18) "Toxic substance" means a substance or mixture of substances which through sufficient exposure, or ingestion, inhalation or assimilation by an organism, either directly from the environment or indirectly by ingestion through the food chain, will cause death, disease, behavioral or immunological abnormalities, cancer, genetic mutations, or developmental or physiological malfunctions, including malfunctions in reproduction or physical deformations, in such organisms or their offspring.

(19) "Water quality parameter" means one of the indicators available for describing the distinctive quality of water including, but not limited to, hardness, pH, or temperature.

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NR 105.04 Determination of adverse effects. (1) Substances may not be present in surface waters at concentrations which adversely affect public health or welfare, present or prospective uses of surface waters for public or private water supplies, or the protection or propagation of fish or other aquatic life or wild or domestic animal life.

(2) A substance shall be deemed to have adverse effects on fish or other aquatic life if it exceeds any of the following more than once every 3 years:

(a) The acute toxicity criterion as specified in s. NR 105.05, or

(b) The chronic toxicity criterion as specified in s. NR 105.06.

(c) The acute and chronic toxicity criteria for ammonia nitrogen shall be determined on a case-by-case basis by the department for the appropriate aquatic life use category.

(3) A substance shall be deemed to have adverse effects on wild or domestic animal life if it exceeds the wild and domestic animal criterion as specified in s. NR 105.07.

(4) A substance shall be deemed to have adverse effects on public health and welfare if it exceeds any of the following:

(a) The human threshold criterion as specified in s. NR 105.08; or

(b) The human cancer criterion as specified in s. NR 105.09; or

(c) The taste and odor criterion as specified in s. NR 102.14.

(5) The determination of the criteria for substances as calculated under ss. NR 105.05 to 105.09 shall be based upon the available scientific data base. References to be used in obtaining scientific data may include, but are not limited to:

(a) "Water Quality Criteria 1972", EPA-R3-73-033, National Academy of Sciences, National Academy of Engineering, United States Government Printing Office, Washington, D.C., 1974.

(b) "Quality Criteria for Water", EPA-440/9-76-003, United States Environmental Protection Agency, Washington, D.C., 1976.

(c) October 1980 and January 1985 U.S. Environmental Protection Agency (EPA) ambient water quality criteria documents.

(d) "Public Health Related Groundwater Standards: Summary of Scientific Support Documentation for NR 140.10", Wisconsin Department of Health and Social Services, Division of Health, September 1985.

(e) "Public Health Related Groundwater Standards - 1986: Summary of Scientific Support Documentation for NR 140.10", Wisconsin Department of Health and Social Services, Division of Health, June 1986.

(f) Health advisories published on March 31, 1987 by EPA, Office of Drinking Water.

(g) Any other reports, documents or information published by EPA or any other federal agency.

(h) Any other reports, documents or informaiton that the department, deems to be reliable.

(6) When reviewing any of the references in sub. (5) to determine the effect of a substance, the department:

(a) Shall use scientific studies on the toxicity of a substance to fish and other aquatic life and wild and domestic animals, indigenous to the state;

(b) May use scientific studies on the toxicity of a substance to fish or other aquatic life, plant, mammalian, avian, and reptilian species not indigenous to the state; and

(c) May consider biomonitoring information to determine the aquatic life toxicity of complex mixtures of toxic substances in addition to the chemical specific criteria specified in this chapter.

History: Cr. Register, February, 1989, No. 398, eff. 3-1-89.

NR 105.05 Acute toxicity criteria for aquatic life (1) MINIMUM DATABASE FOR ACUTE CRITERION DEVELOPMENT. (a) To derive an acute toxicity criterion for aquatic life, the minimum information required shall be the results of acceptable acute toxicity tests with one or more species of freshwater animal in at least 8 different families provided that of the 8 species:

1. At least one is a salmonid fish,

2. At least one is a non-salmonid fish,

3. At least one is a planktonic crustacean (e.g., cladoceran, copepod)

4. At least one is a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish), and

5. At least one is an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge).

6. For a substance, if all of the above families are not represented, an acute toxicity criterion may not be developed for that substance.

(b) The acceptability of acute toxicity test results shall be judged according to the guidelines set forth in section IV of the United States environmental protection agency's 1985 "Guidelines for Deriving National Numerical Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses".

(2) ACUTE TOXICITY CRITERIA FOR SUBSTANCES WITH TOXICITY UNRELATED TO WATER QUALITY PARAMETERS. If the acute toxicity of a substance has not been adequately shown to be related to a water quality parameter (i.e., hardness, pH, temperature, etc.), the acute toxicity criterion (ATC) is calculated using the procedures specified in this subsection.

(a) For each species for which at least one acute value is available, the species mean acute value (SMAV) is calculated as the geometric mean of all available acute values.

(b) The SMAVs are ordered from high to low.

(c) Ranks (R) are assigned to the SMAVs from 1 for the lowest to N for the highest. If 2 or more SMAVs are identical, successive ranks are arbitrarily assigned.

(d) The cumulative probability (P) is calculated for each SMAV as $P=R/(N+1)$. If N is 19 or more, $J=0.05$. If N is less than 19 and greater than 9, $J=1/(N+1)$. If N is 9 or less, $J=0.1$.

(e) The (T) SMAVs (T = 3 for N = 6 or 7; T = 4 for N = 8 or greater) are selected which have P closest to J. If there are less than 59 SMAVs, these will always be the lowest SMAVs.

(f) Using the selected SMAVs and Ps, the ATC is calculated using the following:

1. Let EV = sum of the (T) ln SMAVs,
EW = sum of the (T) squares of the ln SMAVs,
EP = sum of the (T) P values,
EPR = sum of the (T) square roots of P, and
JR = square root of J.

2. $S = ((EW - (EV)^2/T)/(EP-(EPR)^2/T))^{0.5}$.

3. $L = (EV - S(EPR))/T$.

4. $A = (JR)(S) + L$.

5. Final Acute Value (FAV) = e^A.

6. ATC = FAV/2.

(g) If, for a commercially, recreationally or ecologically important species, the geometric mean of the acute values from flow-through tests in which the concentration of test material was measured is lower than the calculated ATC, then that geometric mean is used as the ATC instead of the calculated one.

(h) Table 1 contains the acute toxicity criteria for fish and aquatic life subcategories listed in s. NR 102.04 (3) that are calculated using the procedures described in this subsection for substances meeting the database requirements indicated in sub. (1) (a).

(3) ACUTE TOXICITY CRITERIA FOR SUBSTANCES WITH TOXICITY RELATED TO WATER QUALITY PARAMETERS. If data are available on a substance to show that acute toxicity to 2 or more species is similarly related to a water quality parameter (i.e., hardness, pH, temperature, etc.), the acute toxicity criterion (ATC) is calculated using the procedures specified in this subsection.

(a) For each species for which comparable acute toxicity values are available at 2 or more different values of the water quality parameter, a least squares regression of the acute toxicity values on the corresponding values of the water quality parameter is performed to obtain the slope of the curve that best describes the relationship. Because the most commonly documented relationship is that between hardness and acute toxicity of metals and a log-log relationship fits these data, geometric means and natural logarithms of both toxicity and water quality are used in the rest of this subsection to illustrate this method. For relationships based on other water quality parameters, no transformation or a different transformation might fit the data better, and appropriate changes shall be made as necessary throughout this subsection.

(b) For each species, the geometric mean of the available acute values (W) is calculated and then each of those acute values is divided by the mean for that species. This normalizes the acute values so that the geometric mean of the normalized values for each species individually and for any combination of species is 1.0.

(c) For each species, the geometric mean of the available corresponding water quality parameter values (X) is calculated and then each of those water quality parameter values is divided by the mean for that species. This normalizes the water quality parameter values so that the geometric mean of the normalized values for each species individually and for any combination of species is 1.0.

(d) A least squares regression of all the normalized acute values on the corresponding normalized values of the water quality parameter is performed to obtain the pooled acute slope (V). If the coefficient of determination, or r^2 value, calculated from that regression is found not to be significant based on a standard F-test at a 0.05 level, then the pooled acute slope shall be set equal to zero.

(e) For each species the logarithmic intercept (Y) is calculated using the equation: $Y = \ln W - V(\ln X)$.

(f) For each species the species mean acute intercept (SMAI) is calculated as e^Y.

(g) The SMAIs are ordered from high to low.

(h) Ranks (R) are assigned to the SMAIs from 1 for the lowest to N for the highest. If 2 or more SMAIs are identical, successive ranks are arbitrarily assigned.

(i) The cumulative probability (P) is calculated for each SMAI as $P = R/(N+1)$. If N is 19 or more, $J = 0.05$. If N is less than 19 and greater than 9, $J = 1/(N+1)$. If N is 9 or less, $J = 0.1$.

(j) The (T) SMAIs ($T = 3$ for $N = 6$ or 7; $T = 4$ for $N = 8$ or greater) are selected which have P closest to J. If there are less than 59 SMAIs, these will always be the lowest SMAIs.

(k) Using the selected SMAIs and Ps, the ATC is calculated using the following:

1. Let EV = sum of the (T) ln SMAIS,
   EW = sum of the (T) squares of the ln SMAIs,
   EP = sum of the (T) P values,
   EPR = sum of the (T) square roots of P, and
   JR = square root of J.
2. $S = ((EW - (EV)^2/T)/(EP-(EPR)^2/T))^{0.5}$.
3. $L = (EV - S(EPR))/T$.
4. $A = (JR)(S) + L$.
5. Final Acute Intercept (FAI) = e^A.
6. Acute Criterion Intercept (ACI) = FAI/2.

(l) The acute toxicity equation (ATE) is written as:
$ATC = e(V \ln(\text{water quality parameter}) + \ln ACI)$.

The ATE shall be applicable only over the range of water quality parameters equivalent to the mean plus or minus 2 standard deviations using the entire fresh water acute toxicity data base and the water quality parameter transformation employed in par. (a). Additional information may be used to modify those ranges.

(m) If, for a commercially, recreationally or ecologically important species, the SMAI is lower than the calculated FAI, then that SMAI is used as the FAI instead of the calculated one.

(n) Table 2 contains the acute toxicity criteria for the fish and aquatic life subcategories listed in s. NR 102.04 (3) that are calculated using the procedures described in this subsection for substances meeting the database requirements indicated in sub. (1) (a). Table 2A contains the water quality parameter ranges calculated in par. (l).

History: Cr. Register, February, 1989, No. 398, eff. 3-1-89.

NR 105.06 Chronic toxicity criteria for fish and aquatic life. (1) MINIMUM DATABASE FOR CHRONIC CRITERION DEVELOPMENT. (a) To derive a chronic toxicity criterion for aquatic life, the minimum information required shall be results of acceptable chronic toxicity tests with one or more species of freshwater animal in at least 8 different families provided that of the 8 species:

1. At least one is a salmonid fish,

2. At least one is a non-salmonid fish,

3. At least one is a planktonic crustacean (e.g., cladoceran, copepod),

4. At least one is a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish), and

5. At least one is an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge).

6. For a substance, if all of the above families are not represented, acute-chronic ratios as calculated in sub. (5) may be used to generate the chronic toxicity values necessary to calculate a criterion.

(b) The acceptability of chronic toxicity test results shall be judged according to the guidelines set forth in section VI of the United States environmental protection agency's 1985 "Guidelines for Deriving National Numerical Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses".

(2) CALCULATION OF A CHRONIC CONCENTRATION. A chronic concentration is obtained by calculating the geometric mean of the chronic lowest observable adverse effect level and the chronic no observable adverse effect level.

(3) CHRONIC TOXICITY CRITERIA FOR SUBSTANCES WITH TOXICITY UNRELATED TO WATER QUALITY PARAMETERS. If the chronic toxicity of a substance has not been adequately shown to be related to a water quality parameter (i.e., hardness, pH, temperature, etc.), the chronic toxicity criterion (CTC) is calculated using the procedures specified in this subsection.

(a) For each species for which at least one chronic value is available, the species mean chronic value (SMCV) is calculated as the geometric mean of all available chronic values.

(b) The SMCVs are ordered from high to low.

(c) Ranks (R) are assigned to the SMCVs from 1 for the lowest to N for the highest. If 2 or more SMCVs are identical, successive ranks are arbitrarily assigned.

(d) The cumulative probability (P) is calculated for each SMCV as $P=R/(N+1)$. If N is 19 or more, $J=0.05$. If N is less than 19 and greater than 9, $J=1/(N+1)$. If N is 9 or less, $J=0.1$.

(e) The (T) SMCVs ($T=3$ for $N=6$ or 7; $T=4$ for $N=8$ or greater) are selected which have P closest to J. If there are less than 59 SMCVs, these will always be the lowest SMCVs.

(f) Using the selected SMCVs and Ps, the CTC is calculated using the following:

1. Let EV = sum of the (T) ln SMCVs,
EW = sum of the (T) squares of the ln SMCVs,
EP = sum of the (T) P values,
EPR = sum of the (T) square roots of P, and
JR = square root of J.

2. $S = ((EW - (EV)^2/T)/(EP-(EPR)^2/T))^{0.5}$

3. $L = (EV - S(EPR))/T$.

4. $A = (JR)(S) + L$.

5. $CTC = e^A$.

(g) If, for a commercially, recreationally or ecologically important species, the geometric mean of the chronic values is lower than the calculated CTC then that geometric mean is used as the CTC instead of the calculated one.

(h) Table 3 contains the chronic toxicity criteria for the fish and aquatic life subcategories listed in s. NR 102.04 (3) that are calculated using the procedures described in this subsection for substances meeting the database requirements indicated in sub. (1).

(4) CHRONIC TOXICITY CRITERIA FOR SUBSTANCES WITH TOXICITY RELATED TO WATER QUALITY PARAMETERS. (a) If data are available on a substance to show that chronic toxicity to 2 or more species is similarly related to a water quality parameter (i.e., hardness, pH, temperature, etc.), the chronic toxicity criterion (CTC) is calculated using the procedures specified in this paragraph.

1. For each species for which comparable chronic toxicity values are available at 2 or more different values of the water quality parameter, a least squares regression of the chronic toxicity values on the corresponding values of the water quality parameter is performed to obtain the slope of the curve that best describes the relationship. Because the most commonly documented relationship is that between hardness and the chronic toxicity of metals and a log-log relationship fits these data, geometric means and natural logarithms of both toxicity and water quality are used in the rest of this subsection to illustrate this method. For relationships based on other water quality parameters, no transformation or a different transformation might fit the data better, and appropriate changes shall be made as necessary throughout this subsection.

2. For each species, the geometric mean of the available chronic values (W) is calculated and then each of the chronic values is divided by the mean for that species. This normalizes the chronic values so that the geometric mean of the normalized values for each species individually and for any combination of species is 1.0.

3. For each species, the geometric mean of the available corresponding water quality parameter values (X) is calculated and then each of the water quality parameter values is divided by the mean for that species. This normalizes the water quality parameter values so that the geometric mean of the normalized values for each species individually and for any combination of species is 1.0.

4. A least squares regression of all the normalized chronic values on the corresponding normalized values of the water quality parameter is performed to obtain the pooled chronic slope (V). If the coefficient of determination, or r^2 value, calculated from that regression is found not to be significant based on a standard F-test at a 0.05 level, then the pooled chronic slope shall be set equal to zero.

5. For each species the logarithmic intercept (Y) is calculated using the equation: $Y = \ln W - V(\ln X)$.

6. For each species the species mean chronic intercept (SMCI) is calculated as e^Y.

7. The SMCIs are ordered from high to low.

8. Ranks (R) are assigned to the SMCIs from 1 for the lowest to N for the highest. If 2 or more SMCIs are identical, successive ranks are arbitrarily assigned.

9. The cumulative probability (P) is calculated for each SMCI as $P = R/(N + 1)$. If N is 19 or more, $J = 0.05$. If N is less than 19 and greater than 9, $J = 1/(N+1)$. If N is 9 or less, $J = 0.1$.

10. The (T) SMCIs ($T = 3$ for $N = 6$ or 7; $T = 4$ for $N = 8$ or greater) are selected which have P closest to J. If there are less than 59 SMCIs, these will always be the lowest SMCIs.

11. Using the selected SMCIs and Ps, the CTC is calculated using the following:

a. Let EV = sum of the (T) ln SMCIs,
EW = sum of the (T) squares of the ln SMCIs,
EP = sum of the (T) P values,
EPR = sum of the (T) square roots of P, and
JR = square root of J.

b. $S = ((EW - (EV)^2/T)/(EP-(EPR)^2/T))^{0.5}$

c. $L = (EV - S(EPR))/T$.

d. $A = (JR)(S) + L$.

e. Chronic Criterion Intercept (CCI) = e^A.

12. The chronic toxicity equation (CTE) is written as:
$CTC = e^{(V \ln(\text{water quality parameter}) + \ln CCI)}$.

The CTE shall be applicable only over the range of water quality parameters equivalent to the mean plus or minus two standard deviations using the entire freshwater chronic toxicity data base and the water quality parameter transformation employed in subd. 1. Additional information may be used to modify those ranges.

13. If, for a commercially, recreationally or ecologically important species, the SMCI is lower than the calculated CCI, then that SMCI is used as the CCI instead of the calculated one.

(b) Table 4 contains the chronic toxicity criteria for the fish and aquatic life subcategories listed in s. NR 102.04 (3) that are calculated using the procedures described in this subsection for substances meeting the database requirements indicated in sub. (1). Table 4A contains the water quality parameter ranges calculated in par. (a) 1.

(5) ACUTE-CHRONIC RATIOS. (a) The acute-chronic ratio is used to estimate the chronic toxicity of a substance to fish or other aquatic species when the database of sub. (1) (a) is not satisfied.

(b) The acute-chronic ratio for a species equals the acute concentration from data considered under s. NR 105.05 (1) divided by the chronic concentration from data calculated under sub. (1), subject to the following conditions:

1. If the acute toxicity of a substance is related to any water quality parameter, the acute-chronic ratio shall be based on acute and chronic toxicity data obtained from organisms exposed to test water with similar, if not identical, values of those water quality parameters. Preference under this paragraph shall be given to data from acute and chronic tests done by the same author or reference in order to increase the likelihood of comparable test conditions.

2. If the acute and chronic toxicity data indicate that the acute-chronic ratio varies with changes in the values of the water quality parameters, the acute-chronic ratio used at specified values of the water quality parameters shall be based on the ratios at values closest to that specified.

(c) A chronic toxicity criterion shall be calculated for a substance under this subsection only if at least one acute-chronic ratio is available for a freshwater vertebrate and a freshwater invertebrate, and if at least one is a relatively sensitive freshwater species on an acute toxicity basis.

(d) If the acute toxicity of a substance is unrelated to water quality parameters, the acute-chronic ratio may be derived from any acute and chronic test on a species regardless of the similarity in values of those parameters. Preference under this paragraph shall be given to data from acute and chronic tests done by the same author or reference in order to increase the likelihood of comparable test conditions.

(e) The geometric mean acute-chronic ratio is calculated for each species using the available acute-chronic ratios for that species. That mean ratio shall be called the species mean acute-chronic ratio (SMACR).

(f) For a given substance, if the SMACR appears to increase or decrease as the species mean acute values (SMAV) calculated for that substance using the procedure described in s. NR 105.05 increase, the final

acute-chronic ratio (FACR) shall be equal to the geometric mean of the SMACRs for species with SMAVs closest to the final acute value.

(g) For a given substance, if no trend is apparent regarding changes in SMACRs and SMAVs, the FACR shall be equal to the geometric mean of all freshwater SMACRs available for that substance.

(h) For a given substance, the chronic toxicity criterion (CTC) shall be equal to the final acute value (FAV) divided by the final acute-chronic ratio (FACR).

(i) Chronic toxicity criteria for the fish and aquatic life subcategories listed in s. NR 102.04 (3) that are calculated using acute-chronic ratios are listed in Table 5 for substances with acute toxicity unrelated to water quality parameters and in Table 6 for substances with acute toxicity related to water quality parameters. Equations listed in Table 6 are applicable over the same range of water quality parameters as contained in Table 2A.

Table 1
Acute Toxicity Criteria for Substances
With Toxicity Unrelated to Water Quality
(in ug/L except where indicated)

Substance	Great Lakes	Cold Water	Warm Water Sportfish	All Other Fish and Aquatic Life Subcategories
Arsenic (+3)*	363.8	363.8	363.8	363.8
Chromium (+6)*	14.2	14.2	14.2	14.2
Mercury (+2)*	1.53	1.53	1.53	1.53
Selenium (+4)*	58	58	58	58
Cyanide, free	22.4	22.4	46.2	46.2
Chlorine*	18.4	18.4	18.4	18.4
Aldrin	1.94	1.94	2.16	2.16
Gamma - BHC	1.32	1.32	3.80	3.80
Chlordane	1.06	1.06	1.06	1.06
Dieldrin	1.33	1.33	2.10	2.10
4,4′ - DDT	0.43	0.43	0.43	0.43
Endosulfan	0.169	0.169	0.471	0.471
Endrin	0.101	0.101	0.158	0.158
Heptachlor	0.396	0.396	0.396	0.396
Toxaphene	0.61	0.81	0.61	0.81
Parathion	0.08	0.08	0.08	0.08

Note: * - Criterion listed is applicable to the "total recoverable" form except for chlorine which is applicable to the "total residual" form.

Table 2
Acute Toxicity Criteria for Substances
With Toxicity Related to Water Quality
(all in ug/L)

Water Quality Parameter: Hardness (in ppm as $CaCO_3$)

$ATC = e^{(V \ln(\text{hardness}) + \ln ACI)}$			ATC at Various Hardness (ppm) Levels		
Substance	V	ln ACI	50	100	200
Total Recoverable Cadmium:					
Great Lakes	1.147	-3.8831	1.83	4.05	8.97
Cold Water	1.147	-3.7684	2.05	4.54	10.06
Warm Water Sportfish	1.147	-2.3912	8.13	18.01	39.88
All Others	1.147	-1.9805	12.26	27.16	60.14
Total Recoverable Chromium (+3):					
Great Lakes	0.819	3.7627	1061	1871	3301
Cold Water	0.819	3.7627	1061	1871	3301
Warm Water Sportfish	0.819	3.7627	1061	1871	3301
All Others	0.819	3.7627	1061	1871	3301

Substance	V	ln ACI	50	100	200
Total Recoverable Copper:					
Great Lakes	0.9422	-1.531	8.63	16.58	31.85
Cold Water	0.9422	-1.531	8.63	16.58	31.85
Warm Water Sportfish	0.9422	-1.531	8.63	16.58	31.85
All Others	0.9422	-1.531	8.63	16.58	31.85
Total Recoverable Lead:					
Great Lakes	1.273	-0.7321	69.96	169.1	408.6
Cold Water	1.273	-0.7321	69.96	169.1	408.6
Warm Water Sportfish	1.273	-0.7321	69.96	169.1	408.6
All Others	1.273	-0.7321	69.96	169.1	408.6
Total Recoverable Nickel:					
Great Lakes	0.846	3.0865	599.5	1078	1937
Cold Water	0.846	3.0865	599.5	1078	1937
Warm Water Sportfish	0.846	3.0865	599.5	1078	1937
All Others	0.846	3.0865	599.5	1078	1937
Total Recoverable Silver:					
Great Lakes	1.169	-4.6949	0.885	1.99	4.48
Cold Water	1.169	-4.6949	0.885	1.99	4.48
Warm Water Sportfish	1.169	-4.6949	0.885	1.99	4.48
All Others	1.169	-4.6949	0.885	1.99	4.48
Total Recoverable Zinc:					
Great Lakes	0.8473	0.7352	57.39	103.3	185.8
Cold Water	0.8473	0.8236	62.69	112.8	202.9
Warm Water Sportfish	0.8473	0.7352	57.39	103.3	185.8
All Others	0.8473	0.8236	62.69	112.8	202.9

Water Quality Parameter: pH

$ATC = e^{(V(pH) + \ln ACI)}$

	V	lnACI	ATC at Various pH (s.u.) Levels 6.5	7.8	8.8
Pentachlorophenol:					
Great Lakes	1.005	-4.7033	6.23	23.00	62.8
Cold Water	1.005	-4.7033	6.23	23.00	62.8
Warm Water Sportfish	1.005	-4.7033	6.23	23.00	62.8
All Others	1.005	-4.7033	6.23	23.00	62.8

Table 2A
Water Quality Parameter Ranges for Substances
With Acute Toxicity Related to Water Quality

Substance	Parameter	Applicable Range
Cadmium	Hardness (ppm)	6 - 449
Chromium (+3)	Hardness (ppm)	12 - 319
Copper	Hardness (ppm)	14 - 448
Lead	Hardness (ppm)	8 - 487
Nickel	Hardness (ppm)	12 - 274
Silver	Hardness (ppm)	15 - 260
Zinc	Hardness (ppm)	10 - 364
Pentachlorophenol	pH (s.u.)	6.5 - 8.8

Table 3
Chronic Toxicity Criteria for Substances
With Toxicity Unrelated to Water Quality
(all in ug/L)

Substance	Great Lakes	Cold Water	Warm Water Sportfish	All Other Fish and Aquatic Life Subcategories
		(Reserved)		

Table 4
Chronic Toxicity Criteria for Substances
With Toxicity Unrelated to Water Quality
(all in ug/L)

Water Quality Parameter: Hardness (in ppm as $CaCO_3$)

$CTC = e^{(V \ln(\text{hardness}) + \ln CCI)}$			CTC at Various Hardness (ppm) Levels		
Substance	V	CCI	50	100	175
Total Recoverable Cadmium:					
Great Lakes	0.7852	-3.015	1.06	1.82	2.83
Cold Water	0.7852	-3.015	1.06	1.82	2.83
Warm Water Sportfish	0.7852	-2.9109	1.17	2.02	3.14
All Others	0.7852	-2.9109	1.17	2.02	3.14

Table 4A
Water Quality Parameter Ranges for Substances
With Chronic Toxicity Related to Water Quality

Substance	Parameter	Applicable Range
Cadmium	Hardness (ppm)	19-173

Table 5
Chronic Toxicity Criteria
Using Acute-Chronic Ratios for Substances
With Toxicity Unrelated to Water Quality
(all in ug/L)

Substance	Great Lakes	Cold Water	Warm Water Sportfish	All Other Fish and Aquatic Life Subcategories
Arsenic (+3)*	153	153	153	153
Chromium (+6)*	9.74	9.74	9.74	9.74
Selenium (+4)*	7.07	7.07	7.07	7.07
Cyanide, free	4.96	4.96	4.96	4.96
Chlorine*	7.06	7.06	7.06	7.06
Gamma - BHC	0.335	0.335	0.877	0.877
Chlordane	0.188	0.188	0.188	0.188
Endosulfan	0.115	0.115	0.321	0.321
Toxaphene	0.01	0.01	0.01	0.01
Parathion	0.0141	0.0141	0.0141	0.0141

Note: * - Criterion listed is applicable to the "total recoverable" form except for chlorine which is applicable to the "total residual" form.

Table 6
Chronic Toxicity Criteria
Using Acute-Chronic Ratios for Substances
With Toxicity Related to Water Quality
(all in ug/L)

Water Quality Parameter: Hardness (in ppm) as $CaCO_3$)

$CTC = e^{(V \ln(\text{hardness}) + \ln CCI)}$			CTC at Various Hardness (ppm) Levels		
Substance	V	ln CCI	50	100	200
Total Recoverable Chromium (+3):					
Great Lakes	0.819	0.2184	30.60	54.60	95.37
Cold Water	0.819	0.2184	30.60	54.60	95.37
Warm Water Sportfish	0.819	0.2184	30.60	54.60	95.37
All Others	0.819	0.2184	30.60	54.60	95.37

Substance	V	ln CCI	50	100	200
Total Recoverable Copper:					
Great Lakes	0.9422	-1.8956	5.99	11.51	22.12
Cold Water	0.9422	-1.8956	5.99	11.51	22.12
Warm Water Sportfish	0.9422	-1.8956	5.99	11.51	22.12
All Others	0.9422	-1.8956	5.99	11.51	22.12
Total Recoverable Lead:					
Great Lakes	1.273	-3.5511	4.17	10.09	24.38
Cold Water	1.273	-3.5511	4.17	10.09	24.38
Warm Water Sportfish	1.273	-3.5511	4.17	10.09	24.38
All Others	1.273	-3.5511	4.17	10.09	24.38
Total Recoverable Nickel:					
Great Lakes	0.846	0.2956	36.79	66.13	118.9
Cold Water	0.846	0.2956	36.79	66.13	118.9
Warm Water Sportfish	0.846	0.2956	36.79	66.13	118.9
All Others	0.846	0.2956	36.79	66.13	118.9
Total Recoverable Silver:					
Great Lakes	1.169	-4.6949	0.885	1.99	4.48
Cold Water	1.169	-4.6949	0.885	1.99	4.48
Warm Water Sportfish	1.169	-4.6949	0.885	1.99	4.48
All Others	1.169	-4.6949	0.885	1.99	4.48
Total Recoverable Zinc:					
Great Lakes	0.8473	0.0019	27.57	49.59	89.23
Cold Water	0.8473	0.0019	27.57	49.59	89.23
Warm Water Sportfish	0.8473	0.0019	27.57	49.59	89.23
All Others	0.8473	0.0019	27.57	49.59	89.23

Water Quality Parameter: pH

$CTC = e^{(V\,(pH) + \ln CCI)}$

Substance	V	ln CCI	CTC at Various pH (s.u.) Levels 6.5	7.8	8.8
Pentachlorophenol:					
Great Lakes	1.005	-4.9779	4.73	17.48	47.8
Cold Water	1.005	-4.9779	4.73	17.48	47.8
Warm Water Sportfish	1.005	-4.9779	4.73	17.48	47.8
All Others	1.005	-4.9779	4.73	17.48	47.8

History: Cr. Register, February, 1989, No. 398, eff. 3-1-89; am. (5) (f) and Tables 2, 2a, 4, 4a and 6, Register, July, 1995, No. 475, eff. 8-1-95.

NR 105.07 Wild and domestic animal criterion. (1) The wild and domestic animal criterion is the concentration of a substance which if not exceeded protects Wisconsin's wild and domestic animals from adverse effects resulting from ingestion of surface waters of the state and from ingestion of aquatic organisms taken from surface waters of the state.

(a) For any substance not shown in Table 7, the wild and domestic animal criterion (WDAC) is the lowest species wild and domestic animal value (WDAV) calculated pursuant to sub. (2).

(b) Table 7 contains the wild and domestic animal criteria calculated according to the procedures of this chapter.

Table 7
Wild and Domestic Animal Criteria

Substance	Criteria (all in ng/L)
DDT & Metabolites	0.015
Mercury	2.0
Polychlorinated Biphenyls	3.0

(2) (a) The species wild and domestic animal value shall be calculated as follows using information available from scientifically acceptable studies of animal species exposed repeatedly to the substance via oral routes including gavage:

$$WDAV = \frac{NOAEL \times Wt_A \times SSF}{W_A + [F_A \times BAF]}$$

Where: WDAV = Wild and domestic animal value in milligrams per liter (mg/L).

NOAEL = No observed adverse effect level in milligrams of substance per kilogram of body weight per day (mg/kg-d) as derived from mammalian or avian studies or as specified in subs. (3) to (5).

Wt_A = Average weight in kilograms (kg) of the test animals.

W_A = Average daily volume of water in liters consumed per day (L/d) by the test animals or as specified in sub. (6).

SSF = An uncertainty factor ranging between 0.01 and 1 to account for differences in species sensitivity.

F_A = Average daily amount of food consumed by the test animals in kilograms (kg/d) or as specified in sub. (6).

BAF = Aquatic life bioaccumulation factor with units of liter per kilogram (L/kg) as derived in s. NR 105.10.

(b) The selection of the species sensitivity factor (SSF) shall be based on the available toxicological data base and available physicochemical and toxicokinetic properties of the substance in question.

(c) A species WDAV is calculated as the geometric mean of the WDAVs if more than one WDAV is available for a species.

(3) In those cases in which a no observed adverse effect level (NOAEL) is available from studies of mammalian or avian species exposed repeatedly to the substance via oral routes including gavage, but is available in units other than mg/kg-d as specified in sub. (2), the following procedures shall be used to express the NOAEL prior to calculating the wild and domestic animal value:

(a) If the NOAEL is given in milligrams of toxicant per liter of water consumed (mg/L), the NOAEL shall be multiplied by the daily average

volume of water consumed by the test animals in liters per day (L/d) and divided by the average weight of the test animals in kilograms (kg).

(b) If the NOAEL is given in milligrams of toxicant per kilogram of food consumed (mg/kg), the NOAEL shall be multiplied by the average amount of food in kilograms consumed daily by the test animals (kg/d) and divided by the average weight of the test animals in kilograms (kg).

(4) In those cases in which a NOAEL is unavailable and a lowest observed adverse effect level (LOAEL) is available from studies of animal species exposed repeatedly to the substance via oral routes including gavage, the LOAEL may be substituted with proper adjustment to estimate the NOAEL. An uncertainty factor of between one and 10 may be applied to the LOAEL, depending on the sensitivity of the adverse effect, to reduce the LOAEL into the range of a NOAEL. If the LOAEL is available in units other than mg/kg-d, the LOAEL shall be expressed in the same manner as that specified for the NOAEL in sub. (3).

(5) For those substances for which a NOAEL or LOAEL is not available for any species but an LD_{50} has been derived from studies of animal species exposed to the substance via oral routes including gavage, a NOAEL may be estimated using and LD_{50} value and an appropriate ratio relating acute to chronic effects considering the physicochemical and toxicokinetic properties of the substance.

(6) If drinking or feeding rates are not given in the study or studies from which a WDAV is being calculated, drinking (W_A) and feeding rates (F_A) shall be calculated for laboratory rodents as specified in par. (a) and for other mammalian or avian species by using the allometric equations given in pars. (b) and (c).

(a) For studies done with laboratory rats or mice the following reference shall be consulted: National Institute for Occupational Safety and Health, 1980, Registry of Toxic Effects of Chemical Substances.

(b) For mammalian species the allometric equations are as follows:

1. $F_A = 0.0687 \times (Wt_A)^{0.82}$

   Where: F_A = Feeding rate of mammalian species in kilograms per day (kg/d).

   Wt_A = Average weight in kilograms (kg) of the test animals.

2. $W_A = 0.099 \times (Wt_A)^{0.90}$

   Where: W_A = Drinking rate of mammalian species in liters per day (L/d).

   Wt_A = Average weight in kilograms (kg) of the test animals.

(c) For avian species the allometric equations are as follows:

1. $F_A = 0.0582\,(Wt_A)^{0.65}$

   Where: F_A = Feeding rate of avian species in kilograms per day (kg/d).

Wt_A = Average weight in kilograms (kg) of the test animals.

2. $W_A = 0.059 \times (Wt_A)^{0.67}$

Where: W_A = Drinking rate of avian species in liters per day (L/d).

Wt_A = Average weight in kilograms (kg) of the test animals.

History: Cr. Register, February, 1989, No. 398, eff. 3-1-89; am. table 7, Register, July, 1991, No. 427, eff. 8-1-91.

NR 105.08 Human threshold criterion. (1) The human threshold criterion (HTC) is the maximum concentration of a substance established to protect humans from adverse effects resulting from contact with or ingestion of surface waters of the state and from ingestion of aquatic organisms taken from surface waters of the state. Human threshold criteria are derived for those toxic substances for which a threshold dosage or concentration can be estimated below which no adverse effect or response is likely to occur.

(2) Human threshold criteria are listed in Table 8.

(3) To derive human threshold criteria for substances not included in Table 8 the following methods shall be used:

(a) The human threshold criterion shall be calculated as follows:

$$HTC = \frac{ADI \times 70\ kg \times RSC}{W_H + (F_H \times BAF)}$$

Where: HTC = Human threshold criterion in milligrams per liter (mg/L).

ADI = Acceptable daily intake in milligrams toxicant per kilogram body weight per day (mg/kg-d) as specified in sub. (4).

70 kg = Average weight of an adult male in kilograms (kg).

RSC = Relative source contribution factor used to account for routes of exposure other than consumption of contaminated water and aquatic organisms. In the absence of sufficient data on alternate sources of exposure, including but not limited to non-fish diet and inhalation, the relative source contribution factor shall be set equal to 0.8.

W_H = Average per capita daily water consumption of 2 liters per day (L/d) for surface waters classified as public water supplies or, for all other surface waters, 0.01 liters per day (L/d) for exposure through body contact or ingestion of small volumes of water during swimming or other recreational activities.

F_H = Average per capita daily consumption of sport-caught fish by Wisconsin anglers equal to 0.02 kilograms per day (kg/d).

BAF = Aquatic organism bioaccumulation factor with units of liter per kilogram (L/kg) as derived in s. NR 105.10.

Table 8
Human Threshold Criteria
(mg/L unless specified otherwise[1])

Substance	Public Water Supply			Non-public Water Supply		
	Warm Water Sport Fish Communities	Cold Water Communities	Great Lakes Communities	Warm Water Sport Fish Communities	Cold Water Communities	Warm Water Forage and Limited Forage Fish Communities and Limited Aquatic Life
Acrolein	0.23	0.11	0.11	0.47	0.14	87
Antimony	0.12	0.12	0.12	7.8	7.8	24
Bis(2-chloroisopropyl) ether	0.027	0.026	0.026	1.1	0.36	5.6
Cadmium[2]	0.01	0.01	0.01	0.082	0.082	2.8
Chlorobenzene	1.1	0.94	0.95	14	4.4	240
Chromium (+3)[2]	140	140	140	9500	9500	29000
Chromium (+6)[2]	0.05	0.05	0.05	9	9	27
Cyanide, total	0.6	0.6	0.6	40	40	120
1,2-Dichlorobenzene	2	1.4	1.4	10	3	500
1,3-Dichlorobenzene	2.1	1.5	1.6	13	4	500
cis-1,2-Dichloroethene	0.28	0.27	0.27	15	5.4	56
trans-1,2-Dichloroethene	0.28	0.27	0.27	15	5.4	56
2,4-Dichlorophenol	2.2	1.4	1.4	10	2.9	560
Dichloropropenes[3]	0.069	0.066	0.066	3.2	1.1	14
Di-2-ethylhexyl phthalate	11	5.8	5.9	30	8.9	3400
Diethyl phthalate	270	170	170	1100	330	70000
Dimethyl phthalate	240	180	190	1700	530	56000
Di-n-butyl phthalate	23	13	13	65	19	7000
4,6-Dinitro-o-cresol	0.01	0.0095	0.01	0.22	0.07	2.2
Dinitrophenols[3]	0.055	0.054	0.054	3	1.1	11
Endosulfan	0.051	0.022	0.023	0.094	0.028	22
Endrin (ug/L)	0.065	0.02	0.021	0.069	0.02	250
Ethylbenzene	2.1	1.4	1.4	10	3	540
Fluoranthene (ug/L)	28	9.1	9.3	32	9.5	41000
Hexachlorocyclopentadiene	0.16	0.16	0.16	7.1	2.5	33
Isophorone	4.1	3.9	3.9	170	59	840
Lead[4]	0.05	0.05	0.05	0.05	0.05	0.05
Mercury (ug/L)	0.079	0.079	0.079	0.08	0.08	880
Nickel	0.17	0.17	0.17	0.46	0.46	56
Nitrobenzene	15	15	15	540	180	3200
Pentachlorobenzene	0.046	0.015	0.015	0.051	0.015	93
Pentachlorophenol	0.84	0.76	0.76	17	5.4	180
Phenol	2.8	2.7	2.7	160	58	560
Selenium[2]	0.01	0.01	0.01	0.17	0.17	5.6
Silver (ug/L)	6.4	6.4	6.4	430	430	1300
1,2,4,5-Tetrachlorobenzene (ug/L)	24	7.9	8.1	28	8.4	28000
Thallium (ug/L)	6.5	6.5	6.5	11	11	3000
Toluene	8.9	7.6	7.6	110	34	1900
1,1,1-Trichloroethane[2]	0.2	0.2	0.2	33	11	200
2,4,5-Trichlorophenol	1.6	0.79	0.81	3.7	1.1	560

1 A human threshold criterion expressed in micrograms per liter (ug/L) can be converted to milligrams per liter (mg/L) by dividing the criterion by 1000.

2 For this substance the human threshold criteria for public water supply receiving water classifications equal the maximum contaminant level pursuant to s. NR 105.08(3)(b).

3 The human threshold criteria for this chemical class are applicable to each isomer.

4 The human threshold criteria for lead equal the maximum contaminant level.

(b) For surface waters classified as public water supplies, if the human threshold criterion for a toxic substance as calculated in par. (a) exceeds the maximum contaminant level (MCL) for that substance as specified in ch. NR 109 or the July 8, 1987 Federal Register (52 FR 25690), the MCL shall be used as the human threshold criterion.

(4) The acceptable daily intake (ADI) referenced in sub. (3) represents the maximum amount of a substance which if ingested daily for a lifetime results in no adverse effects to humans. Paragraphs (a) to (c) list methods for determining the acceptable daily intake.

(a) The department shall review available references for acceptable daily intake or equivalent values, such as a reference dose (RfD) as used by the U.S. environmental protection agency, and for human or animal toxicological data from which an acceptable daily intake can be derived. Suitable references for review include, but are not limited to, those presented in s. NR 105.04 (5).

(b) When human or animal toxicological data is available, the department may derive an acceptable daily intake by using as guidance procedures presented by the U.S. environmental protection agency in "Water Quality Criteria Documents; Availability" (45 FR 79318, November 28, 1986). Additional guidance for deriving acceptable daily intakes from toxicological data are given in subds. 1 to 4. Alternate procedures may be used if supported by credible scientific evidence.

1. No observable adverse effect levels (NOAELs) and lowest observable adverse effect levels (LOAELs) from studies of humans or mammalian test species shall be divided by an uncertainty factor to derive an acceptable daily intake. Uncertainty factors reflect uncertainties in predicting acceptable exposure levels for the general human population based upon experimental animal data or limited human data. Factors to be considered when selecting an uncertainty factor include, but are not limited to, interspecies and individual variations in response and susceptibility to a toxicant, and the quality and quantity of the available data. The following guidelines shall be considered when selecting an uncertainty factor:

a. Use an uncertainty factor of 10 when extrapolating from valid experimental results from studies on prolonged ingestion by humans. This 10-fold factor protects sensitive members of the human population.

b. Use an uncertainty factor of 100 when extrapolating from valid results of long-term feeding studies on experimental animals with results of studies of human ingestion not available or insufficient (e.g., acute exposure only). This represents an additional 10-fold uncertainty factor in extrapolating data from the average animal to the average human.

c. Use an uncertainty factor of 1000 when extrapolating from less than chronic results on experimental animals with no useful long-term or acute human data. This represents an additional 10-fold uncertainty factor in extrapolating from less than chronic to chronic exposures.

d. Use an additional uncertainty factor of between 1 and 10 depending on the severity of the adverse effect when deriving an acceptable daily intake from a lowest observable adverse effect level (LOAEL). This uncertainty factor reduces the LOAEL into the range of a no observable adverse effect level (NOAEL).

e. Use an additional uncertainty factor of 10 when deriving an acceptable daily intake for a substance which the U.S environmental protection agency classifies as a "group C" carcinogen, but which is not defined as a carcinogen in s. NR 105.03 (7).

2. Results from studies of humans or mammalian test species used to derive acceptable daily intakes shall have units of milligrams of toxicant per kilogram of body weight per day (mg/kg-d). When converting study results to the required units, a water consumption of 2 liters per day (L/d) and a body weight of 70 kilograms (kg) is assumed for humans. The following examples and procedures illustrate the conversion of units:

a. Results from human studies which are expressed in milligrams of toxicant per liter of water consumed (mg/L) are converted to mg/kg-d by multiplying the results by 2 L/d and dividing by 70 kg.

b. Results from animal studies which are expressed in milligrams of toxicant per liter of water consumed (mg/L) are converted to mg/kg-d by multiplying the results by the daily average volume of water consumed by the test animals in liters per day (L/d) and dividing by the average weight of the test animals in kilograms (kg).

c. Results from animal studies which are expressed in milligrams of toxicant per kilogram of food consumed (mg/kg) are converted to mg/kg-d by multiplying the results by the average amount of food consumed daily by the test animals in kilograms per day (kg/d) and dividing by the average weight of the test animals in kilograms (kg).

d. If a study does not specify water or food consumption rates, or body weight of the test animals, standard values taken from appropriate references, such as the National Institute of Occupational Safety and Health, 1980, Registry of Toxic Effects of Chemical Substances, may be used to convert units.

e. Results from animal studies in which test animals were not exposed to the toxicant each day of the test period shall be multiplied by the ratio of days that the test animals were dosed to the total days of the test period. For the purposes of this adjustment, the test period is defined as the interval beginning with the administration of the first dose and ending with the administration of the last dose, inclusive.

3. When assessing the acceptability and quality of human or animal toxicological data from which an acceptable daily intake can be derived, the department may use the following documents as guidance:

a. "Guidelines for Mutagenicity Risk Assessment", (51 FR 34006, September 24, 1986).

b. "Guidelines for the Health Risk Assessment of Chemical Mixtures", (51 FR 34014, September 24, 1986).

c. "Guidelines for the Health Assessment of Suspect Development Toxicants", (51 FR 34028, September 24, 1986).

d. "Guidelines for Exposure Assessment", (51 FR 34042, September 24, 1986).

e. Any other documents that the department deems reliable.

4. When the available human or animal toxicological data contains conflicting information, the department may consult with experts outside of the department for guidance in the selection of the appropriate data.

(c) Using sound scientific judgment, the department shall select an acceptable daily intake as derived in pars. (a) and (b) for calculation of the human threshold criterion. When selecting an acceptable daily intake, the department shall adhere to the following guidelines unless a more appropriate procedure is supported by credible scientific evidence:

1. Acceptable daily intakes based on human studies are given preference to those based on animal studies.

2. When deriving an acceptable daily intake from animal studies preference is given to chronic studies involving oral routes of exposure, including gavage, over a significant portion of the animals' life span. If acceptable studies using oral exposure routes are not available, acceptable daily intakes derived from studies using alternate exposure routes, such as inhalation, may be used.

3. When 2 or more acceptable daily intake values are available and have been derived from studies having equal preference as defined in subd. 1 and 2., the lowest acceptable daily intake is generally selected. If the acceptable daily intake values differ significantly, the department may consult with experts outside of the department for guidance in the selection of the more appropriate acceptable daily intake.

History: Cr. Register, February, 1989, No. 398, eff. 3-1-89.

NR 105.09 Human cancer criterion. (1) The human cancer criterion (HCC) is the maximum concentration of a substance or mixture of substances established to protect humans from an unreasonable incremental risk of cancer resulting from contact with or ingestion of surface waters of the state and from ingestion of aquatic organisms taken from surface waters of the state. Human cancer criteria are derived for those toxic substances which are carcinogens as defined in s. NR 105.03 (7).

(2) For any single carcinogen or any mixture of carcinogens the incremental cancer risk from exposure to surface waters and aquatic organisms taken from surface waters may not exceed one in 100,000. The combined cancer risk of individual carcinogens in a mixture is assumed to be additive unless an alternate model is supported by credible scientific evidence.

(3) Human cancer criteria are listed in Table 9.

Table 9
Human Cancer Criteria (ug/L unless specified otherwise[1])

Substance	Public Water Supply: Warm Water Sport Fish Communities	Public Water Supply: Cold Water Communities	Public Water Supply: Great Lakes Communities	Non-public Water Supply: Warm Water Sport Fish Communities	Non-public Water Supply: Cold Water Communities	Non-public Water Supply: Warm Water Forage and Limited Forage Fish Communities and Limited Aquatic Life
Acrylonitrile	0.56	0.44	0.44	4.7	1.4	130
Aldrin (ng/L)	0.54	0.17	0.17	0.57	0.17	6100
Arsenic[2]	50	50	50	50	50	50
alpha-BHC	0.07	0.033	0.034	0.15	0.045	26
beta-BHC	0.12	0.059	0.06	0.27	0.079	46
gamma-BHC (lindane)	0.14	0.067	0.068	0.3	0.09	53
BHC, technical grade	0.094	0.044	0.045	0.2	0.06	35
Benzene[3]	5	5	5	140	45	1300
Benzidine (ng/L)	1.1	0.64	0.65	3.8	1.1	300
Benzo(a)pyrene	0.023	0.023	0.023	0.1	0.1	6.1
Beryllium	0.033	0.033	0.033	0.2	0.2	7.9
Bis(2-chloroethyl) ether	0.3	0.28	0.28	8.8	2.9	61
Bis(chloromethyl) ether (ng/L)	0.037	0.037	0.037	3.4	1.5	7.5
Carbon tetrachloride	2.5	2.1	2.1	31	10	540
Chlordane (ng/L)	4.3	1.3	1.3	4.4	1.3	54000
Chloroethene (vinyl chloride)	0.15	0.15	0.15	10	3.7	30
Chloroform(trichloromethane)	1.9	1.8	1.8	87	31	380
4,4'-DDT (ng/L)	0.14	0.042	0.043	0.14	0.042	8300
1,4-Dichlorobenzene	15	11	11	100	30	3500
3,3'-Dichlorobenzidine	0.09	0.038	0.039	0.16	0.047	41
1,2-Dichloroethane	3.8	3.7	3.7	370	170	760
1,1-Dichloroethene	2.3	2.1	2.1	48	15	480
Dichloromethane (methylene chloride)	48	47	47	3600	1400	9600
Dieldrin (ng/L)	0.54	0.17	0.17	0.57	0.17	2300
2,4-Dinitrotoluene	9.2	8.6	8.6	260	85	1900
1,2-Diphenylhydrazine	0.39	0.28	0.28	2.4	0.74	91
Halomethanes[4]	1.9	1.8	1.8	87	31	380
Heptachlor (ng/L)	1.4	0.41	0.42	1.4	0.42	16000
Hexachlorobenzene (ng/L)	5.3	1.6	1.6	5.5	1.6	41000
Hexachlorobutadiene	4.4	4.2	4.2	160	53	900
Hexachloroethane	18	11	11	65	19	4900
N-Nitrosodiethylamine (ng/L)	8	8	8	1100	670	1600
N-Nitrosodimethylamine	0.013	0.013	0.013	1.8	1	2.7
N-Nitrosodi-n-butylamine	0.063	0.059	0.059	1.9	0.64	13
N-Nitrosodiphenylamine	45	24	24	120	36	14000
N-Nitrosopyrrolidine	0.16	0.16	0.16	29	23	33
Polychlorinated biphenyls (ng/L)	0.49	0.14	0.15	0.49	0.15	16000
Polynuclear Aromatic Hydrocarbons[5]	0.023	0.023	0.023	0.1	0.1	6.1
2,3,7,8-Tetrachloro-dibenzo-p-dioxin (pg/L)	0.097	0.03	0.03	0.1	0.03	450
1,1,2,2-Tetrachloroethane	1.7	1.6	1.6	64	22	350
Tetrachloroethene	5.8	4.6	4.6	49	15	1300
Toxaphene (ng/L)	5.6	1.7	1.7	5.7	1.7	62000
1,1,2-Trichloroethane	5.8	5.3	5.3	140	46	1200
Trichloroethene[3]	5	5	5	360	110	3600
2,4,6-Trichlorophenol	9	4.1	4.2	18	5.4	3600

[1] A human cancer criterion expressed in micrograms per liter (ug/L), nanograms per liter (ng/L) or picograms per liter (pg/L) can be converted to milligrams per liter (mg/L) by dividing the criterion by 1000, 1,000,000 or 1,000,000,000, respectively.

[2] Human cancer criteria for arsenic equal the maximum contaminant level.

[3] For this substance the human cancer criteria for public water supply receiving water classifications equal the maximum contaminant level pursuant to s. NR 105.09(4)(b).

[4] Human cancer criteria for halomethanes are applicable to any combination of the following chemicals: bromomethane (methyl bromide), chloromethane (methyl chloride), tribromomethane (bromoform), bromodichloromethane (dichloromethyl bromide), dichlorodifluoromethane (fluorocarbon 12) and trichlorofluoromethane (fluorocarbon 11).

[5] Human cancer criteria for polynuclear aromatic hydrocarbons are applicable to any combination of the following chemicals: benzo(a)anthracene (1,2-benzanthracene), benzo(b)fluoranthene (3,4-benzofluoranthene), benzo(g,h,i)perylene (1,12-benzoperylene), benzo(k)fluoranthene (11,12-benzofluoranthene), chrysene, dibenzo(a,h)anthracene (1,2,5,6-dibenzanthracene), indeno(1,2,3-cd)pyrene, phenanthrene and pyrene.

(4) To derive human cancer criteria for substances not included in Table 9 the following methods shall be used:

(a) The human cancer criterion shall be calculated as follows:

$$HCC = \frac{RAI \times 70\ kg}{W_H + (F_H \times BAF)}$$

Where:

HCC = Human cancer criterion in milligrams per liter (mg/L).

RAI = Risk associated intake in milligrams toxicant per kilogram body weight per day (mg/kg-d) that is associated with a lifetime incremental cancer risk equal to one in 100,000 as derived in sub. (5).

70 kg = Average weight of an adult male in kilograms (kg).

W_H = Average per capita daily water consumption of 2 liters per day (L/d) for surface waters classified as public water supplies or, for other surface waters, 0.01 liters per day (L/d) for exposure through contact or ingestion of small volumes of water during swimming or during other recreational activities.

F_H = Average per capita daily consumption of sport-caught fish by Wisconsin anglers equal to 0.02 kilograms per day (kg/d).

BAF = Aquatic life bioaccumulation factor with units of liter per kilogram (L/kg) as derived in s. NR 105.10.

(b) For surface waters classified as public water supplies, if the human cancer criterion for a toxic substance as calculated in par. (a) exceeds the maximum contaminant level (MCL) for that substance as specified in ch. NR 109 or the July 8, 1987 Federal Register (52 FR 25690), the MCL shall be used as the human cancer criterion.

(5) The risk associated intake (RAI) referenced in sub. (4) represents the maximum amount of a substance which if ingested daily for a lifetime of 70 years has an incremental cancer risk equal to one case of human cancer in a population of 100,000. Methods for deriving the risk associated intake are specified in pars. (a) to (d).

(a) The department shall review available references for acceptable human and animal studies from which the risk associated intake can be derived. The department shall use sound scientific judgment when determining the acceptability of a study and may use the U.S. environmental protection agency's "Guidelines for Carcinogen Risk Assessment" (FR

51 33992, September 24, 1986) as guidance for judging acceptability. Suitable references for review include, but are not limited to, those presented in s. NR 105.04 (5).

(b) If an acceptable human epidemiologic study is available, contains usable exposure data, and indicates a carcinogenic effect, the risk associated intake shall be set equal to the lifetime average exposure which would produce an incremental cancer risk of one in 100,000 based on the exposure information from the study and assuming the excess cancer risk is proportional to the lifetime average exposure. If more than one human epidemiologic study is judged to be acceptable, the most protective risk associated intake derived from the studies is generally used to calculate the human cancer criterion. If the risk associated intake values differ significantly, the department may consult with experts outside of the department for guidance in the selection of the more appropriate value.

(c) In the absence of an acceptable human epidemiologic study, the risk associated intake shall be derived from available studies which use mammalian test species and which are judged acceptable. Methods for deriving the risk associated intake are specified in subds. 1. to 4.

1. A linear, non-threshold dose-response relationship as applied by the U.S. environmental protection agency in "Water Quality Criteria Documents; Availability" (45 FR 79318, November 28, 1980) shall be assumed unless a more appropriate dose-response relationship or extrapolation model is supported by credible scientific evidence.

Note: The linear non-threshold dose-response model used by the U.S. environmental protection agency provides an upper-bound estimate (i.e., the one-sided 95 percent upper confidence limit) of incremental cancer risk. The true cancer risk is unknown. While the true cancer risk is not likely to be greater than the upper bound estimate, it may be lower.

2. When a linear, non-threshold dose-response relationship is assumed, the risk associated intake shall be calculated using the following equation:

$$RAI = \frac{1}{q_1^*} \times 0.00001$$

Where:

RAI = Risk associated intake in milligrams toxicant per kilogram body weight per day (mg/kg-d).

0.00001 = Incremental risk of human cancer equal to one in 100,000.

q_1^* = Upper 95% confidence limit (one-sided) of the carcinogenic potency factor in days per milligram toxicant per kilogram body weight (d-kg/mg) as derived from the procedures referenced in subd. 1 and the guidance presented in subd. 3.

3. The department shall adhere to the following guidance for deriving carcinogenic potency factors, or corresponding values if an alternate dose-response relationship or extrapolation model is used, unless more appropriate procedures are supported by credible scientific evidence:

a. If 2 or more mammalian studies are judged acceptable, but vary in either species, strain or sex of the test animals, or in tumor type or site, the study giving the greatest carcinogenic potency factor shall be used. Studies which produce a spuriously high carcinogenic potency factor due to the use of a small number of test animals may be excluded.

b. If 2 or more mammalian studies are judged acceptable, are comparable in size and are identical in regard to species, strain and sex of the test animals and to tumor sites, the geometric mean of the carcinogenic potency factors derived from each study shall be used.

c. If in an acceptable study, tumors were induced at more than one site, the number of animals with tumors at one or more of the sites shall be used as incidence data when deriving the cancer potency factor.

d. The combination of benign and malignant tumors shall be used as incidence data when deriving the cancer potency factor.

e. Calculation of an equivalent dose between animal species and humans using a surface area conversion, and conversion of units of exposure to milligrams of toxicant per day (mg/d) shall be performed as specified by the U.S. environmental protection agency in "Water Quality Criteria Documents; Availability" (45 FR 79318, November 28, 1980).

f. If the duration of the mammalian study (D) is less than the natural life span of the test animal (LS), the carcinogenicity potency factor is multiplied by the factor $(D/LS)^3$.

4. When available mammalian studies contain conflicting information, the department shall consult with the department of health and social services and may consult with experts outside of the department for guidance in the selection of the appropriate study.

(d) If both a human epidemiologic study and a study of mammalian test species are judged reliable but only the animal study indicates a carcinogenic effect, it is assumed that a risk of cancer to humans exists but that it is less than could have been detected in the epidemiologic study. An upper limit of cancer incidence may be calculated assuming that the true incidence is just below the level of detection in the cohort of the epidemiologic study. The department may consult with experts outside of the department for guidance in the selection of the appropriate study.

(6) For informational purposes, the department shall maintain a comprehensive list of known or suspected human carcinogens. This list shall be updated at least yearly.

History: Cr. Register, February, 1989, No. 398, eff. 3-1-89; am. table 9 and (6), Register, July, 1991, No. 427, eff. 8-1-91.

NR 105.10 Bioaccumulation factor. (1) The bioaccumulation factor used to derive wild and domestic animal, human threshold, human cancer and taste and odor criteria is determined as specified in pars. (a) to (d):

(a) Bioaccumulation factors shall be calculated from field data if the following conditions are met:

1. Data are available to show that the concentration of the substance in the water to which the aquatic organism was exposed remained reasonably constant over the range of territory inhabited by the organism long enough for the concentration of the substance in the aquatic organism to reach a steady state.

2. Competing mechanisms for removal of the substance from solution did not markedly affect the bioavailability of the substance.

3. The concentration of the substance to which the organism was exposed is less than the lowest concentration causing any adverse effects on the organism.

(b) Bioaccumulation factors shall be derived from laboratory tests by setting the bioaccumulation factor equal to the bioconcentration factor if the following conditions are met:

1. The bioconcentration factor was calculated from measured concentrations of the substance in the test solution and of the substance and its metabolites in the test organism.

2. The laboratory test was of sufficient duration for the concentration of the substance in the aquatic organism to have reached a steady state. In the absence of a laboratory test of sufficient duration, the bioconcentration factor may be calculated from a laboratory test with a duration equal to or greater than 28 days or from the laboratory test with the longest duration greater than 28 days if more than one test is available for the same species.

3. The concentration of the substance to which the test organism was exposed was less than the lowest concentration causing any adverse effects in the organism.

4. If more than one bioconcentration factor for the same aquatic species is available, the geometric mean of the bioconcentration factors is used.

5. The bioconcentration factor was calculated on the basis of wet tissue weights. If bioconcentration factors based on wet tissue weights are not available, a bioconcentration factor calculated using dry tissue weights may be converted to a wet tissue weight basis by multiplying the dry weight bioconcentration factor by 0.1 for plankton and by 0.2 for individual species of fishes and invertebrates.

(c) In absence of any bioaccumulation factors derived from field data as specified in par. (a) or laboratory tests as specified in par. (b), the bioaccumulation factor for lipid-soluble substances shall equal the bioconcentration factor calculated as follows:

$$\log_{10} BCF = (0.79 \log_{10} K_{ow}) - 0.4$$

Where: $\log_{10}$ = Logarithm base 10.

BCF = Bioconcentration factor at approximately 6% lipids.

K_{ow} = The octanol/water partition coefficient which if not available from laboratory testing may be calculated from structure-activity relationships or available regression equations.

Note: The above equation may be inappropriate for a chemical with a molecular weight greater than 600 or a log K_{ow} greater than 6.5, or which is readily metabolized by fish.

(d) For lipid-soluble substances, bioaccumulation factors are assumed to be directly proportional to the percent lipids from one tissue to another and from one aquatic species to another.

(2) The bioaccumulation factors derived in sub. (1) shall be used to calculate water quality criteria for a substance as specified in pars. (a) and (b):

(a) To derive a wild and domestic animal criterion as described in s. NR 105.07, the geometric mean of all available whole body bioaccumulation factors (BAF) derived according to sub. (1) (a) or (b) for aquatic species shall be used. In addition, the geometric mean for all available plant bioaccumulation factors derived according to sub. (1) (a) or (b) for aquatic plants shall be calculated and compared to the geometric mean BAF derived for vertebrates and multicellular invertebrates. If the BAF calculated for plants is greater than the BAF calculated for vertebrates and multicellular invertebrates, the plant BAF shall be used. In the absence of any bioaccumulation factor measured from field studies as described in sub. (1) (a) or lab studies as specified in sub. (1) (b), the bioaccumulation factor for lipid-soluble substances may be calculated as specified in sub. (1) (c). Additional considerations in deriving bioaccumulation factors include:

1. For lipid-soluble substances, an edible portion bioaccumulation factor may be converted to a whole body bioaccumulation factor for a fish or shellfish species by multiplying the edible-portion bioaccumulation factor by the ratio of the percent lipid in the whole body to the percent lipid in the edible portion of the same species.

2. For lipid-soluble substances, a bioaccumulation factor calculated as described in sub. (1) (c) is assumed to be proportional to 6% lipids and may be converted to a whole body bioaccumulation factor by multiplying the calculated bioconcentration factor by the ratio of the percent lipid in the whole body to 6.

3. For inorganic substances, the bioaccumulation factor is set equal to the geometric mean of all available aquatic species whole body bioaccumulation factors.

(b) To derive a human threshold criterion or a human cancer criterion as described in ss. NR 105.08 and 105.09, respectively, or a taste and odor criterion as described in s. NR 102.14, the bioaccumulation factor is calculated as follows:

1. Preference shall be given to bioaccumulation factors derived from field data as specified in sub. (1) (a) over those derived from laboratory tests as specified in sub. (1) (b). Bioaccumulation factors derived from octanol/water partition coefficients as specified in sub. (1) (c) shall be used only if bioaccumulation factors derived from field data or laboratory tests are not available.

2. For lipid-soluble substances the bioaccumulation factor is calculated by multiplying the geometric mean of all available aquatic species bioaccumulation factors adjusted for percent lipids by either 1.3 for warm water sport fish communities, 4.4 for cold water communities, or 4.3 for great lakes communities. Bioaccumulation factors are adjusted for percent lipids by dividing the whole body or edible portion bioaccumulation factor of an aquatic species by the percent lipids in the whole or edible portion of the same species. A bioaccumulation factor calcu-

lated as described in sub. (1) (c) is adjusted for percent lipids by dividing the bioconcentration factor by 6.

3. For inorganic substances, the bioaccumulation factor is set equal to the geometric mean of all available aquatic species edible portion bioaccumulation factors. If edible portion bioaccumulation factors are not available, whole body bioaccumulation factors may be used.

4. For warm water forage, limited forage and limited aquatic life communities the bioaccumulation factor is set equal to zero.

History: Cr. Register, February, 1989, No. 398, eff. 3-1-89.