MASSACHUSETTS WATER QUALITY STANDARDS

IMPLEMENTATION POLICY FOR THE CONTROL OF

TOXIC POLLUTANTS IN SURFACE WATERS

February 23, 1990

Summary:

1. This policy applies to all toxic pollutants. It includes a separate section on chlorinated discharges.

2. Effluent limits for toxic pollutants shall be derived in three ways: 1) the water quality criteria; 2) recommended limits; and 3) site-specific limits. The latter two are established through the permit process.

3. The Division has identified a number of sources for recommended limits and methods to establish site-specific limits. Final effluent limitations shall be based on the most sensitive water use for the receiving water Class as determined by the Division.

4. Whole effluent toxicity testing will be used to complement specific chemical testing. At high dilutions, limits will be based on mixing zone considerations; acute testing is used. At low dilutions receiving waters become water-quality limited; chronic testing is used in these cases.

I. Introduction

Toxic pollutants are broadly defined as any substance or combination of substances that are capable of producing an adverse effect to an organism or its off-spring. The effect may be the result of direct or indirect exposure and may injure structure, or function, or cause death to the organism. These pollutants include, but are not limited to, those identified in 314 CMR 3.16. This list corresponds to Section 307(a) of the Federal Clean Water Act which lists 65 compounds and families of compounds (which potentially include thousands of specific compounds) as toxic pollutants. EPA has interpreted that list to include 126 priority pollutants for regulatory purposes. EPA's "Gold Book" - Quality Criteria for Water 1986, EPA 440/5-86-001 - contains information and recommendations for these compounds.

The purpose of this policy is to set the Division's goals with regard to toxic pollutants, interpret the water quality standards, and explain the use of biotoxicity tests in the permit process.

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II. Goals

The objectives for the control of toxic pollutants are to:

1. protect public health;
2. protect aquatic life and wildlife; and
3. prevent the accumulation of toxic substances in toxic amounts.

The protection of public health encompasses such water uses as public drinking water supply, primary contact recreation and secondary contact recreation. Protection of aquatic life and wildlife refers to both short-term (acute) and long-term (chronic) protection. Prevention of the accumulation of toxic pollutants refers to the concentration of pollutants in sediment and/or biota that may eventually become toxic and cause an adverse effect to human health or aquatic life. The edibility of fish and shellfish for both commercial and recreational use are included in this goal.

III. Water Quality Standards

The Surface Water Quality Standards use both narrative and numerical criteria to control toxic pollutants. This is necessary because relatively few numerical criteria have been established for the vast number of potentially toxic substances. Narrative criteria also add necessary flexibility to the regulation. The blanket application of numerical criteria to all waters under all circumstances is not always prudent or reasonable. Severe economic impacts may occur if the Division does not exercise some authority to establish site-specific criteria.

Water quality criteria are found in Section 4.05 of the Surface Water Quality Standards. Each water use Class carries eight parameters with criteria specific to that Class. These include (1) Dissolved Oxygen, (2) Temperature, (3) pH, (4) Fecal Coliform Bacteria, (5) Solids, (6) Color and Turbidity, (7) Oil and Grease and (8) Taste and Odor. These are generally considered "conventional pollutants" as defined by the Federal Clean Water Act. Four additional criteria applicable to all waters (not Class-specific) are presented in Subsection (5). Of these, Section 4.05(5)(e) contains the main narrative criteria for "toxic pollutants". The narrative divided into four parts (1) Recommended Limits, (2) Site-Specific Limits, (3) Accumulation of Pollutants and (4) Public Notice.

The narrative states that where the Division determines that a toxic pollutant is of concern, and no criterion is specified in the regulation, then the Division will use a recommended limit. A recommended limit is a proposed criterion from an authoritative source. The main source of recommended limits is EPA's "Gold Book". However, where appropriate, the Division may use other sources such as the Massachusetts Drinking Water Regulations (310 CMR 22.00) or the Federal Food and Drug Administration's Action Levels for fish and shellfish. In this respect recommended limits function exactly like criteria except that they are listed and documented by these other authoritative sources. Incorporating these limits by reference is appropriate for they are firmly established and widely used publications and it is not necessary to reproduce them within the regulations.

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Where recommended limits are not available for a pollutant of concern the Division shall establish a site-specific limit. Site-specific limits are also appropriate when local conditions are so different than those used to develop a recommended limit or criterion, that the recommended limit is deemed invalid. Site-specific limits may be established to account for some unique aspect of the local situation such as background water chemistry or the presence/absence of particular water uses. The major source of site-specific limits are (1) DEP's Office of Research and Standards and (2) safe exposure levels determined by toxicity testing using methods approved by the Director. Toxicity testing requirements are detailed in Part V of this policy.

Part three of the narrative explains that, where necessary, the Division will employ an additional margin of safety when establishing effluent limits to prevent pollutants from accumulating to toxic levels in the environment. This means that the Division's "fishable" goal includes edibility. Effluent limits shall be established to assure that fish, shellfish and other aquatic life are suitable for consumption. It also means that toxic pollutants that accumulate to levels that are toxic to aquatic life shall be controlled. Where a specific chemical is known to bioaccumulate, more stringent limits than those required by the toxicity testing requirements may be required.

Two important points are made in the narrative:

1. There is no blanket application of recommended limits. Recommended limits and site-specific limits are established case-by-case based on the Division's perception of the pollutants of concern and the potential impacts;

2. Recommended limits and site-specific limits are not established as permanent criteria within the regulation. They are used to establish permit limits or regulate abatement actions where criteria are unavailable or invalid. Therefore, they last only for the life of the permit or abatement action. They are subject to revision when the permit is renewed. This may occur, for example, as the Gold Brook is revised, or other new information becomes available to the Division.

Part four of the narrative provides for public input. In all cases recommended limits and site-specific limits undergo intergovernmental and public review as part of the permit process. This means that the limit is reviewed in its proper context, as part of the particular permit or abatement action in question.

IV. Interpretation of the Narrative Criterion

Table I is provided to summarize the information necessary to interpret the narrative. Each water use Class is listed in a column. Based on the specific designated uses for each Class, those categories that have a potential for toxic problems are indicated by X's. Toxic problems are divided by the Division's three goals - human health, aquatic life and bioaccumulation. Human health is further subdivided into four major exposure routes: 1) drinking water ingestion, 2) dermal contact and 3) inhalation; and 4) fish ingestion. Aquatic life is subdivided into acute and chronic effects.

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TABLE I

SOURCES OF RECOMMENDED AND SITE-SPECIFIC LIMITS

	HUMAN HEALTH				AQUATIC LIFE		BIOACCUMULATION
CLASS	DRINKING WATER	DERMAL CONTACT	INHALATION	FISH INGESTION	ACUTE	CHRONIC	
A	X	X	X	X	X	X	X
B	(X)	X	X	X	X	X	X
C	-	(X)	X	X	X	X	X
SA	-	X	X	X	X	X	X
SB	-	X	X	X	X	X	X
SC	-	(X)	X	X	X	X	X
CRITERIA							
1. Gold Book	X	-	-	X	X	X	-
2. ORS	-	X*	X*	X*	-	-	-
3. FDA Acton Levels	-	-	-	X	-	-	-
4. MA DWR (SDWA)	X	-	-	-	-	-	-
5. MA SWQ	-	-	-	-	X*	X*	X*

X = Area of Concern
(X) = Minor Application
X* = Site-Specific Limit

1. Gold Book = Quality Criteria for Water 1986
2. ORS = Office of Research and Standards
3. FDA = Federal Food and Drug Administration
4. MA DWR = MA Drinking Water Regulations
5. MA SWQ = Surface Water Quality Standards

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From the chart it can be seen that some problems, such as chronic toxicity to aquatic life, are universal throughout the classes. Other problems, such as drinking water ingestion are limited to Class A waters (note that some Class B waters are designated supplies with appropriate treatment).

In the bottom half of the chart, the potential sources of recommended limits and site-specific limits are identified. There are five basic sources: 1) EPA's Gold Book; 2) the Massachusetts Department of Environmental Protection's Office of Research and Standards; 3) Federal Food and Drug Administration's Action Levels; 4) the Massachusetts Drinking Water Regulations (310 CRM 22.00); and 5) the Massachusetts Surface Water Quality Standards (314 CMR 4.00). When these sources are exhausted other sources may be used.

A. Protection of Human Health

When drinking water ingestion is a perceived problem, as it is in Class A waters (and to a minor extent in Class B waters), two sources of recommended limits are available: EPA's Gold Book and the Massachusetts Drinking Water Regulations. Both sources rely heavily on Maximum Contaminant Levels (MCL's) from the Federal Safe Drinking Water Act.

Other human health exposure routes are universally applicable to all Classes except for dermal contact. Dermal contact has only a minor application in Class C and Class SC waters because they are designated for secondary contact recreation only. Recommended limits for fish ingestion are provided in the Gold Book and the FDA Action Levels. These can be expressed either as safe levels in the surface water or a concentration in the fish or shellfish flesh. Of the latter, these are sometimes expressed for either the whole organism or the edible portions alone. Recommended limits for dermal contact and inhalation are unavailable. Therefore, the Division shall establish site-specific limits as necessary. The Division shall rely on methodologies and recommendations of the Office of Research and Standards for setting these limits.

When a pollutant of concern is a carcinogen, an excess lifetime cancer risk (ELCR) must be selected to determine a limit. EPA has estimated risk levels of 10^{-5}, 10^{-6}, and 10^{-7} in its Gold Book under one set of exposure assumptions. The Division shall use a risk management goal of 10^{-6} for individual chemicals and 10^{-5} for mixtures of chemicals. Application of these recommended limits for monitoring ambient water quality shall be tempered by consideration of the practical quantitation limit (PQL) for these parameters. In cases where the PQL is greater than the concentration of the chemical in water set on the basis of cancer risk, the PQL shall be used for evaluation of ambient water quality and enforcement purposes.

When the Division evaluates specific wastewater discharges, the health-based concentration shall be used as the goal for discharge limits. The Division reserves the right to consider costs and availability of waste treatment technologies when applying the health-based number to effluent limits. It is also understood that these management goals are based upon lifetime human exposure assumptions. Should the projected exposure scenario not concur with this assumption, then the risks may be managed differently.

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B. Protection of Aquatic Life

Protection of aquatic life is universally applicable to all Classes of surface water. Since the chronic limit is always equal to, or more stringent than, the acute limit, it becomes the controlling factor. Furthermore, as a general rule, aquatic life limits for non-carcinogens are more stringent than human health limits. Therefore, waterbodies can often be protected for both human health and aquatic life by using the chronic limit. (As noted, this general rule does not apply to pollutants that are carcinogens). The Gold Book has recommended chronic exposure limits for 34 of the 126 priority pollutants. When limits are not available or considered unapplicable because of site-specific conditions, a toxicity limit is applied to the discharge. When effluents do not exceed the specified limits for toxic units (based on aggregate toxicity measured by a biotoxicity test) they are considered in compliance with chronic toxicity requirements of the regulations.

C. Prevention of Bioaccumulation

Prevention of bioaccumulation is the third goal. Bioaccumulation results from pollutants persisting in the environment and accumulating in biota or food chains to become potential toxic problems. The bioaccumulant may affect either human health or aquatic life. The fish ingestion exposure route addresses only a part of this goal. Pollutants may accumulate in plants or animals to a degree that adversely affect the organism, its offspring or the food chain. Recommended limits for protection from bioaccumulation are largely unavailable because each problem has many complicating site-specific factors. Therefore, site-specific limits must be established. The narrative empowers the Division to use an appropriate additional margin of safety when developing effluent limitations to account for the adverse effects of bioaccumulation. The Division shall use bioconcentration factors established in the literature, Octanol-Water partition coefficients and other relevant sources of information to establish site-specific limits for pollutants that bioaccumulate.

V. Toxicity Tests in the Permit Process

A. Background

Toxicity tests are a means to determine the adverse affects of a chemical or a complex effluent using living organisms. The tests measure the degree of response of an exposed test organism to a specific chemical or effluent. It is the method of choice for analyzing effects to aquatic life because:

1. Effluents could contain chemicals that may be overlooked in specific chemical testing. Toxicity testing measures the response to a whole effluent without concern for its specific chemical makeup;

2. Combinations of chemicals may have additive, synergistic or antagonistic effects. These effects generally unpredictable from chemical specific testing but are measured directly with toxicity testing; and

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3. The bioavailability of toxic pollutants may vary with site-specific factors. For example, the toxicity of certain heavy metals may vary with the hardness of the water. These factors can be addressed by using site water for dilution.

Toxic effects to aquatic life can be either short-term or long-term. Short-term, or acute effects are evinced in a few days. Long-term, or chronic effects, are more subtle and may involve the impairment of an organism's competitive ability, survival behavior or reproductive potential.

The Division recommends specific tests and methodologies for the measurement of acute and chronic toxicity. At least two species (usually a vertebrate and invertebrate)are required. The results of the most sensitive test are used for enforcement purposes. The specific organisms, laboratory procedures and quality and control measures are referenced in Attachment I.

In terms of biotoxicity tests the Division interprets its narrative criterion for the protection of aquatic life to mean that the acceptable receiving water concentration whole effluent toxicity is the highest measured continuous concentration of an effluent that causes no observed acute or chronic effect on a representative standard test organism. This is referred to as the No Observed Effect Concentration (NOEC). Therefore at critical conditions, the NOEC measured in percent must be greater than or equal to the receiving water concentration (RWC) of effluent in percent by volume:

$$NOEC \geq RWC$$

Critical conditions for inland rivers and streams are defined by the standards as the lowest average flow for seven consecutive days to be expected once in ten years (7Q10). For lakes, ponds, and for marine waters, critical conditions are more difficult to define and must be established case-by-case.

As a general rule the Division prefers to use acute toxicity tests in the permit process. The normal end point measured by the acute test is the LC_{50} or the concentration that is lethal to 50% of the test organisms. An LC_{50} value, measured in percent, represents the degree of toxicity on a inverse logarithmic scale. A more convenient unit of expression is the toxic unit (T.U.). A toxic unit is defined as 100 divided by the LC_{50}:

$$T.U. = \frac{100}{LC_{50}}$$

Therefore an LC_{50} of 100% equals 1 T.U.

B. Effluent Limits

In order to determine the allowable effluent concentration of toxicity it is necessary to know the dilution available to particular effluent. The dilution factor is the ratio of the receiving water flow (Qr) plus the effluent flow (Qe) to the effluent flow:

$$\frac{Qr + Qe}{Qe} = \text{dilution factor}$$

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The Division assigns effluent limits according to dilution factors based on perceived risk.

Calculation of receiving water concentrations using dilution factors assumes completely mixed conditions. Usually there is a transition distance where the effluent concentration is diluted to the receiving water concentration. This area or volume of the receiving water is referred to as a mixing zone. Additional limits are often needed to protect mixing zones from toxic effects.

The standards allow mixing zones to exceed criteria so long as there is safe and adequate passage for swimming and drifting organisms with no deleterious effects on their populations. It is assumed that chronic toxicity is not a concern in mixing zones because swimming and drifting organisms will not be in the zone long enough for chronic exposure. Acute toxicity is a concern but is also dependent on time-exposure relationships. In the absence of detailed site-specific time-exposure histories for all important species, it is necessary to set a conservative (non-time dependent) acute limit.

The recommended criterion to prevent acutely toxic effects is 0.3 T.U. This is based on an adjustment factor of one-third used to extrapolate the LC_{50} to an LC. (concentration at which 1% of the test organisms die). In order to assure that this limit is met within a short distance of the effluent pipe the Division has established an end-of-pipe limit of 1.0 T.U. for dilution factors less than or equal to 100 and 2.0 T.U. for dilution factors greater than 100.

Table II takes mixing zone considerations and other effluent limitations into account. It shows the allowable whole effluent toxicity limitations and testing requirements based on available dilution at critical conditions.

At dilution factors less than 10, effluent toxicity poses a high risk to receiving waters. These waters are considered water quality limited in that the effluent limit of 1.0 Toxic Unit may not be stringent enough to protect receiving waters. The Division requires both acute and chronic end points to be reported. Two limits apply to the effluent: (1) the chronic test should result in a No Observed Effect Concentration greater than or equal to the Receiving Water Concentration (NOEC $\geq$ RWC) and (2) the acute level should be less than or equal to 1.0 Toxic Unit (an $LC_{50} \geq 100\%$).

Dilutions from 10 - 100 have an effluent limit of 1.0 Toxic Unit. In the lower portion of this range (from 10 - 20) waters may be water-quality limited if the specific toxicants involved have high acute to chronic ratios. Therefore, the Division requires chronic monitoring to assure that the effluent limitation is adequate. In the range of dilution from 20 - 100 chronic monitoring is not required. Waters with dilutions above 100 have an effluent limit of 2.0 Toxic Units.

Recommended methods for toxicity testing are referenced in the Amendment to this policy. Basically, the Division requires four (4) samples per year at dilutions less than or equal to 100. Each sample is tested with two (2) test species. At dilutions greater than 100, two samples per year are required.

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TABLE II

WHOLE EFFLUENT TOXICITY

REQUIREMENTS FOR NPDES PERMITS

DILUTION FACTOR[1]	EFFLUENT LIMITS[2]	TESTING REQUIREMENTS
< 10	NOEC ≥ RWC 1.0 Toxic Unit	4 samples/year; 2 species; Acute and chronic endpoints
10 - 20	1.0 Toxic Unit	4 samples/year; 2 species; Acute and chronic endpoints
>20 - 100	1.0 Toxic Unit	4 samples/year; 2 species; Acute endpoint
>100	2.0 Toxic Unit	2 samples/year; 2 species; Acute endpoint

Notes: 1 Ratio of receiving water plus effluent flow to effluent flow at critical conditions:

$$\frac{Qr + Qe}{Qe} = \text{dilution factor}$$

2 Effluent limits apply to the total toxicity concentration prior to mixing with receiving water. Limits are in Toxic Units where:

$$\frac{100}{LC_{50}} = \text{Toxic Units}$$

and LC_{50} = Concentration lethal to 50% of the test organisms

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VI. Chlorinated Discharges

Chlorination is a commonly used method of disinfection for wastewater effluents because of its effectiveness and relative low cost. However, chlorine is toxic to higher forms of life and its discharge to surface waters may be damaging to aquatic life.

Three factors dictate a separate policy for the control of chlorine from other toxic pollutants:

1) the potential benefits to water uses (swimming, shellfish, etc.) from chlorination practices;

2) the nearly universal use of chlorine as a disinfectant at wastewater treatment facilities in Massachusetts; and

3) the complex chemistry of chlorine and its reactiveness, that may rapidly render it non-toxic by factors other than dilution.

The following policy is recommended in order to resolve the sometimes conflicting goals of disinfection and protection of aquatic life in a practical manner for the issuance of permits.

A. Disinfection Requirements

Disinfection shall provide adequate protection for public health. Disinfection of effluents containing pathogenic organisms shall be required:

1) year-round in segments designated for public water supply or shellfishing;

2) seasonally (April 1 through October 15) in segments designated for primary contact recreation;

3) as necessary in other waters where the Division determines there is a public health need.

B. Dechlorination or Alternative Disinfection

Aquatic life shall be protected from the harmful effects of disinfection by-products. High risk categories include areas with low dilution or areas with particularly sensitive species. Dechlorination or alternative means disinfection shall be required:

1) in segments with dilution factors less than 10;

2) in segments designated cold water fisheries.

These requirements will be implemented through the facilities planning process for municipal discharges or at the time of permit application for industrial discharges.

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C. Water Quality Criteria

EPA criteria shall be used to establish acceptable receiving water levels of residual chlorine. Total maximum daily loads shall be based on an allowable receiving water concentration of 0.01 mg/l Total Residual Chlorine (TRC). This level may be exceeded:

1) within authorized mixing zones; or

2) where site-specific alternative criteria have been established by the Division.

D. Effluent Limitations

Waters shall be protected from unnecessary discharges of excess chlorine. In segments with dilution factors greater than 100, the maximum effluent concentration of chlorine shall not exceed 1.0 mg/l TRC.

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AMENDMENT

RECOMMENDED METHODS FOR TOXICITY TESTING FOR NPDES PERMITS

Inland Waters

Acute Test

- 48-hour *Ceriodaphnia dubia* static test
- 48 hour *Pimephales promelas* static test

Chronic Tests

- 7-day *Ceriodaphnia dubia* static renewal test
- 7-day *Pimphales promelas* static renewal test

Coastal and Marine Waters

Acute Tests

- 48-hour or 96-hour *Mysidopsis bahia* static test
- 48-hour or 96-hour *Cyprinodon variegatus* static test

Chronic Tests

- 7-day *Cyprinodon variegatus* survival and growth test
- 7-day *Mennidia* sp. survival and growth test
- *Arbacia punctulata* fertilization test
- 7-9 day *Champia parvula* sexual reproduction test

Recommended Manuals

Weber, C.I. et al, 1989. Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms. Second Edition. Office of Research and Development, Cincinnati, OH, EPA-/4-89/001.

Peltier, W. and Weber C.I. 1985. Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms. Third Edition. Office of Research and Development, Cincinnati, OH, EPA-600/4-85-013.

Weber, C.I. et al, 1988. Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms, Office of Research and Development, Cincinnati, OH, EPA-600/4-87/28.

APHA 1985, Standard Methods for the Examination of Water and Wastewater, 16th Edition. American Public Health Association, 1015 Fifteenth St., N.W., Washington, D.C. 20005.

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REFERENCES

1. Biomonitoring to Achieve Control of Toxic Effluents, U.S. EPA, Technology Transfer, EPA/625/8-87/013.

2. Hutchinson, Michael S., Regulation of Suspected Carcinogens in Wastewater, Massachusetts Department of Environmental Protection, Office of Research and Standards, Memorandum to Russell Isaac, February 23, 1989.

3. Permit Writer's Guide to Water Quality - Based Permitting for Toxic Pollutants, U.S. EPA Office of Water, Washington, D.C., July 1987 EPA/440/4-87-005.

4. Technical Support Document for Water Quality - Based Toxics Control, U.S. EPA Office of Water, Washington, D.C., September 1985.

5. Water Quality Criteria 1972, National Academies of Science and Engineering, Washington, D.C. 1972.

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