STATE TOXICS CONTROL PROGRAM:

DERIVATION OF WATER QUALITY-BASED DISCHARGE

TOXICITY LIMITS

FOR BIOMONITORING AND SPECIFIC POLLUTANTS

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HONOLULU, HAWAII

April, 1989

CONTENTS

I. PURPOSE:

This document provides guidance for the development of water quality-based toxicity limits in NPDES permits. The purpose of applying toxicity limits to surface water discharges is to prevent direct toxic impacts to human and aquatic life, and the bioaccumulation of toxic pollutants in aquatic organisms in concentrations which could impact human health. The prevention of these impacts is a basic requirement, applicable to all State surface waters, under section 11-54-04(a)(4) of the State Water Quality Standards. This standard requires that:

> "All state waters shall be free of substances attributable to domestic, industrial, or other controllable sources of pollutants including: high temperatures; biocides; pathogenic organisms; toxic corrosive, or other deleterious substances at levels or in combination sufficient to be toxic or harmful to human, animal, plant, or aquatic life, or in amounts sufficient to interfere with any beneficial use of the water."

In the past, there has been minimal enforcement of this regulation because of a lack of water quality standards for toxic pollutants, standardized methods for biomonitoring, and guidance for translating basic requirements into NPDES permit conditions. Revised water quality standards are being prepared which will contain specific standards for individual toxic pollutants, and clarify the biomonitoring toxicity requirements.

This document provides the procedures for translating the new standards into enforceable NPDES permit limits, however it may also be used on a case-by-case basis prior to the adoption of revised standards. Section 301(b)(1)(C) of the Clean Water Act requires that NPDES permits contain any conditions necessary to achieve compliance with State Water Quality Standards. Therefore permit writers have the authority to establish any conditions, including permit limits for individual pollutants and effluent toxicity, that are necessary to enforce section 11-54-04(a)(4), above, before new standards are adopted.

There are two types of toxicity limits discussed in this document; limits on specific toxic pollutants which are measured using traditional chemical analyses, and limits on whole effluent toxicity which is measured using biomonitoring. The purposes of these two types of limitations and the need for an integrated approach using both is discussed below.

Specific Pollutant Limitations: The purpose of effluent limitations for specific pollutants is to protect both aquatic life and human health. The proposed water quality standards contain numeric limitations for over 100 pollutants. The standards are divided into two main categories: aquatic toxicity standards and human health-related standards. The aquatic standards are divided into four subcategories which contain acute and chronic toxicity values to protect freshwater and saltwater organisms. The human health standards provide protection from consumption of contaminated aquatic organisms.

Whole Effluent Toxicity: The primary purpose of whole effluent toxicity limitations is to protect aquatic life. Whole effluent toxicity is measured by exposing organisms to a waste stream or water sample and observing the effects after a specified period of time. Biomonitoring tests can be designed to measure acute toxicity, which means adverse effects which occur quickly, or chronic toxicity which occurs over longer periods. Both acute and chronic impacts to aquatic life must be prevented.

The term "whole effluent toxicity" signifies that the test organisms react to the combination of all pollutants present in the sample. This is one advantage over chemical analyses for individual pollutants which provide no information on the potential toxic effects of pollutants in combinations. Biomonitoring is therefore the only method available for enforcing the "deleterious substances in combination" provision of the basic water quality standard. Other advantages of biomonitoring are that the organisms may be affected by pollutants which are not included in typical chemical scans, or by concentrations of pollutants which are below chemical detection levels, or by pollutants whose toxicity to aquatic organisms has never been determined. Simple biomonitoring tests may also be much cheaper than chemical scans.

The main disadvantage of biomonitoring is that it provides little protection to human health from certain pollutants particularly carcinogens - which may be directly ingested or bioaccumulate in aquatic organisms. The concentrations which produce carcinogenic risks through direct ingestion or bioaccumulation are often orders of magnitude below the concentrations which have been reported to cause aquatic toxicity. Another disadvantage of biomonitoring is that the organism used in a test may not be sensitive to a particular pollutant whose toxicity to sensitive aquatic organisms has already been established. For these reasons, an integrated approach, using both biomonitoring and limits on selected specific pollutants is necessary.

II. PROCEDURES FOR DEVELOPING NPDES PERMITS:

The basic procedures outlined below should be sufficient to prevent toxicity in most discharge situations. They provide a systematic approach for determining maximum allowable limits for individual dischargers for both specific pollutants and whole effluent toxicity. In certain circumstances, such as multiple discharger situations, or when necessary to enforce a wasteload allocation, more stringent limitations may be necessary to protect water quality.

There are four main steps in developing water quality-based permits which protect against toxicity:

- Determine whether the discharger has the potential to cause toxicity and is a candidate for toxicity limits.
- Determine dilution factors, if any.
- Calculate limits to prevent acute and chronic aquatic toxicity and protect human health.
- Establish other conditions including monitoring requirements, schedules of compliance, and toxicity reduction evaluation requirements.

A. <u>Candidates for Toxicity-based Limitations:</u>

Water quality-based toxicity limits should be considered for any discharge which contains any pollutant which is harmful to human or aquatic life, and for any discharge which has a high enough flowrate to significantly alter water quality. The primary candidates for toxicity limits are major NPDES discharges, minor industrial discharges which contain process water, discharges which contain algicides, biocides, or disinfectants, and discharges to flowing streams. The information necessary to determine which toxic pollutants should be considered for effluent limitations must be obtained during the application process.

Major NPDES discharges are both likely to contain toxic pollutants, and have large flowrates. Even non-industrial majors, such as agricultural discharges and Publicly Owned Treatment Works (POTWs) with little or no industrial component, may contain pesticides and other toxics. Federal regulations specify toxic pollutants which must be analyzed in applications for most major industrials. Additional information on pollutants likely to be present can be obtained from EPA effluent guideline Development Documents. Major POTWs with industrial flow should be required to perform priority pollutant scans as part of their applications. Other major sewage treatment plants should also be required to perform priority pollutant scans, or at minimum scans for pesticides and metals. Major agricultural NPDES dischargers should be required to analyze their effluents for pesticides and other toxics used. Any discharger may also be required to perform biomonitoring as part of its application requirements.

Minor industrial discharges containing process water should also be evaluated for toxicity. Process water is any water which has come into contact with any raw material, intermediate product, finished product, byproduct, spill or leak, waste product, or wastewater. Examples of process waters are spent plating solutions, and water drawn from petroleum product storage tanks. Minor industrials are required to submit chemical analyses in their NPDES applications for any toxic pollutants which are known or suspected to be present in their wastewater. Any toxic pollutant which the waste stream has come into contact with should be suspected to be present. Water which has come into contact with petroleum products, for example, should be suspected to contain benzene, toluene, ethylbenzene, naphthalene, phenanthrene, fluorene, phenol, and lead. Applicants may also be required to perform biomonitoring toxicity tests as part of their application requirements.

Non-process discharges, particularly non-contact cooling waters, are typically given low priority for toxicity evaluations. However, these discharges are often treated with algicides, biocides, chromates or disinfectants to prevent fouling. Applicants should be asked to submit OSHA Material Safety Data sheets for any chemicals added to non-process discharges and to report rate of use. Any non-process discharge which is treated should be evaluated for toxicity.

Discharges to flowing streams and wetlands represent a special case where toxicity should be considered because of limited dilution even when there is no reason to suspect discharge toxicity. Flowing streams have a very limited capacity to assimilate toxic discharges because of low volume, and because maximum dilution does not increase with distance from the discharge. Discharges to streams are therefore likely to have the most stringent toxicity-based effluent limitations. All discharges to flowing streams and wetlands should be screened for toxicity using biomonitoring.

At the end of the permit application process, there should be a list of specific pollutants which, in addition to biomonitoring toxicity, should be considered for water quality-based limitations.

B. Determination of Dilution Factors:

"Dilution" means the reduction in the concentration of a pollutant or discharge which results from mixing with the receiving water. The magnitude of the dilution depends on many factors including time and distance, the physical characteristics of the receiving water, the velocity and nature of the discharge, the design and placement of the outfall structure, and whether average or low dilution receiving water conditions are used. In addition, for discharges to streams, different dilution values are determined for acute and chronic toxic effects. The larger the available dilution, the greater the capacity of the receiving water to assimilate pollutants without toxic impacts.

It is necessary to determine whether any dilution factors are appropriate for each discharger in order to calculate water quality-based toxics limits and to determine whether the minimum allowable limits for protecting aquatic life will be based upon acute or chronic toxicity. A pollutant discharge can cause acutely toxic effects, such as fish kills near the discharge pipe, or less evident chronic effects, such as reduced reproduction, over a wide area. Both types of adverse toxic effects must be prevented. The two main categories of direct dischargers in Hawaii are marine dischargers with submerged outfalls and marine dischargers without submerged outfalls. A submerged outfall provides discharge-induced dilution while most surface discharges do not. Limits for continuous discharges from submerged outfalls are calculated based upon chronic toxicity and human health values, while minimum limits for marine discharges without outfalls are primarily calculated based upon acute toxicity values. Three minor discharger categories are stream dischargers, surface dischargers with high-rate outfalls which also provide discharge-induced dilution, and dischargers to dry streams, ditches, and storm drains.

It should be emphasized that since the "freedom from toxicity" standard quoted above is a basic standard, applicable to all waters, it is not subject to the Zone of Mixing provisions of section 11-54-09 of the Water Quality Standards. Therefore NPDES permits must be written to ensure that all state waters are free from toxicity, including those within approved Zones of Mixing. The dilution factors which are discussed in this section are limited to "discharge-induced" dilution, which is provided only by submerged and "high-rate" outfall designs, and to flow-weighted stream dilution. Use of these limited dilution factors will ensure that all waters are free from toxicity caused by point-source discharges.

1. Marine Discharges through Submerged Outfalls

A submerged marine outfall induces rapid dilution because of two characteristics of the discharge - momentum and buoyancy. As long as the discharge plume is moving in relation to the receiving water, it will entrain dilution water, decreasing the effluent concentration. After a short time, both plume momentum and buoyancy are lost, or the discharge surfaces, and discharge-induced dilution ends. Further dilution is then governed by much slower ambient processes.

The discharge-induced dilution from a submerged outfall is calculated using the models in Initial Mixing Characteristics of Municipal Ocean Discharges (EPA/600/3-85/073, November, 1985). The models are also applicable to industrial discharges as long as the effluent is not more dense than the receiving water. The models can be used in simple situations, such as a single buoyant plume in a stagnant receiving water, to very complex ones, such as a multiple port diffuser with merging plumes in a receiving water where current and density change with depth.

The discharge-induced dilution factors calculated with these models may be based upon either minimum dilution receiving water conditions or average conditions. Minimum dilution conditions are associated with maximum density stratification which usually occurs during the summer. Under these conditions the discharge plume is trapped at some level below the surface, and is not diluted as much as it would be if it could rise to higher depths. In addition, minimum dilution is calculated using the maximum projected discharge flowrate, while average dilution is calculated using the design flowrate. For deep outfalls, the difference between minimum and average dilution values may be a factor of 5 to 10. A discharge from a near-shore outfall however, might surface under all conditions and have much closer minimum and average dilution factors.

Minimum dilution is used for establishing limits based upon chronic aquatic toxicity and human health standards for non-carcinogens. Average conditions are used when establishing human-health related limits based upon fish consumption for carcinogens. The minimum dilution factor is used for preventing chronic toxicity because minimum dilution conditions may exist for long periods (e.g., months) in relation to the length of the critical life stages of aquatic organisms and 24-hour exposure basis of the proposed chronic standards for specific pollutants. Minimum dilution is also used for non-carcinogens because their toxic effects may occur following short-term exposures. Average dilution factors are used for calculating human health-related limitations for carcinogens, because the criteria are based upon bioaccumulation in organisms consumed by man over much longer periods (e.g., 70 years). Analyses of effluent limits calculated to prevent acute and chronic toxicity from submerged outfalls indicate that the chronic toxicity-based limitations are more stringent. If the discharge is limited so that chronic toxicity criteria are achieved by discharge-induced dilution, then there will not be acutely toxic conditions near the outfall. Even if an organism is entrained in the plume, the effluent concentration will drop to below chronic levels within a few minutes.

Use of the dilution models requires detailed information about the outfall and receiving water. If this information is not already available, preparations to collect it should be made well in advance of the permit application. The permit writer can either calculate the dilution factors, or require the discharger to provide the dilution factors along with the data and calculations. If a discharger fails to provide necessary information in a timely manner, dilution factors can be calculated using conservative assumptions such as zero current and high density stratification. Dilution factors should already be available for current and former 301(h) applicants.

2. Discharges Without Submerged Outfalls

Discharges without submerged outfalls primarily include discharges to the ocean, bays, and harbors, but also include discharges to wetlands and reservoirs. These discharges (with the exception of high-rate discharges which will be discussed under section B.4., below) do not induce rapid dilution and are therefore qualitatively distinct from discharges through submerged outfalls. Assimilation in the receiving waters of discharges without outfalls is controlled by ambient processes which may provide little or no dilution over time frames significant to aquatic toxicity—particularly acute toxicity. As discussed above, the criteria for preventing acute toxicity from specific pollutants are based upon an exposure time of one hour. Under stagnant receiving water conditions, such as those that occur at high and low tide, an acutely toxic discharge could cause acutely toxic receiving water conditions. Even with an ambient current, a discharge can hug the shoreline or maintain a well defined acutely toxic plume. Therefore in order to prevent acute toxicity in the receiving waters, the discharge itself must not be acutely toxic or contain pollutants in concentrations which exceed the saltwater or freshwater acute criteria.

The "no acute toxicity" discharge standard for discharges without submerged outfalls should be sufficient to prevent chronic receiving water toxicity under most discharge situations. Intermittent discharges, in particular, should have little potential to cause chronic toxicity if they meet the no acute toxicity standard. On the other hand, a large or continuous discharge might cause chronic toxicity even if it met the no acute toxicity standard. A discharge to a bay or wetland with little circulation might also cause chronic toxicity.

Permit writers should use their Best Professional Judgement in deciding which discharges may need more stringent chronic or human health-based toxicity limitations. Although modeling of discharge plume movements in shallow areas is probably too difficult and inexact, the permit writer can require receiving water monitoring to demonstrate that the discharge does not cause chronic receiving water toxicity or violations of the human-health criteria. Several monitoring stations within a radius of 100 meters of the discharge would be appropriate. The permit writer can also require the discharger to perform a dye study to determine plume movement, especially if a particularly sensitive area, such as a reef, is nearby. The study could be required either as an application requirement, or through a Clean Water Act Section 308 information request.

3. Discharges to Streams

If a discharge enters a stream, the effluent limits necessary to prevent acute toxicity are the same as for discharges without outfalls. The discharge itself must not be acutely toxic or contain pollutants in concentrations which exceed the criteria for freshwater aquatic life (with the exception of high-rate discharges discussed under section B.4., below). In addition, the dilution available to prevent chronic toxicity and to protect human health must be calculated in order to determine whether limits based on these considerations will be more stringent than the acute toxicity limits.

The chronic toxicity and human-health dilution factors can be determined with a simple mass balance giving the ultimate stream concentration after complete mixing with the discharge. The dilution is equal to the sum of the stream flowrate and discharge design flowrate, divided by the discharge design flowrate. As with submerged outfalls, minimum dilution is used for chronic toxicity and human health-based limits for non-carcinogens, while average dilution is used for carcinogens. Minimum flow is defined as the lowest average flow which is expected to occur over seven consecutive days once every ten years. This is called the "7Q10," and is determined from historical USGS stream flow data. The discharge design flowrate is used instead of the maximum flowrate because it is unlikely that both minimum stream flow and maximum discharge flow will coincide. For human health considerations, an average dilution factor should be calculated using the mean dryweather flowrate and the discharge design flowrate (or the actual flowrate if it is higher).

To summarize, for discharges to flowing streams, there are three dilution factors: 1) No dilution for acute toxicity; 2) Dilution based upon minimum flow for chronic toxicity and human health-based limits for non-carcinogens; and 3) Dilution based on mean dryweather flow for human health based limitations for carcinogens.

4. High-rate Discharges

As discussed in sections 2 and 3 above, acute toxicity from a discharger without a submerged outfall is typically prevented by requiring that the discharge itself is not acutely toxic. The discharger can also limit the impact of an acutely toxic discharge by designing a "high-rate" discharge outfall to produce a rapidly moving plume which entrains receiving water so that organisms suspended in the water column or swimming through the discharge are exposed to undiluted concentrations for only a very brief time. In this case, the discharger is given some credit for discharge-induced dilution, which is reflected in less stringent acute toxicity based effluent limits. It is not known whether any dischargers in Hawaii qualify as "high-rate" dischargers.

The design criteria which must be met to be considered a "high-rate" discharger eligible for acute toxicity dilution credit are given on page 34 in EPA's Technical Support Document for Water Quality-based Toxics Control (EPA 440/4-85-032, September, 1985, the "Technical Support Document"). The primary criteria is that the discharge outlet velocity must be greater than 3 meters per second (10 feet per second). The discharge must also enter the receiving water horizontally or nearly so. A discharge entering vertically will rise and re-entrain itself, building up the effluent concentration. Given these initial requirements, the maximum allowable distance for assimilating acute toxicity through discharge-induced dilution must be determined in order to calculate the acute toxicity dilution factor. The maximum allowable distance is obtained from the most stringent of the following three criteria:

a) The distance may be no more than 10 percent of the mixing zone dimension. Note that "mixing zones" discussed in the EPA document refer to areas of discharge-induced dilution and are not the same as State "Zones of Mixing," issued under section 11-54-09 for conventional pollutants, but not for toxicity. Use of this criteria requires a designation of the maximum distance allowable for assimilating chronic toxicity through discharge induced dilution. 100 meters is a generous allowance and is cited under EPA's Ocean

Discharge Criteria (40 CFR 125.121(c)). The maximum distance for assimilating acute toxicity through discharge-induced dilution is then 10 meters.

b) The distance may be no more than 50 times the squareroot of the cross sectional area of any discharge outlet. If the discharge pipe diameter is less than 8 inches, this will result in a maximum distance of less than 10 meters.

c) The distance may be no more than five times the local water depth at the discharge point. (Thus, a discharge at the shoreline, with the depth equal to zero, gets no dilution credit.)

Using the smallest of the allowable distances above, the dilution with respect to acute toxicity is calculated using the equation given on page 35 of the EPA Technical Support Document: The dilution equals 0.31 times the maximum allowable distance, divided by the diameter of the outfall. Both the distance and diameter must be expressed in the same units since dilution is a dimensionless quantity.

Example: A high-rate discharge enters water with a depth of 1.5 meters through a 6-inch pipe. The distance for assimilating acute toxicity is the lowest of: a) 10 meters; b) 50 times the square root of the cross-sectional area of the pipe (6.75 meters); or c) 5 times the depth (7.5 meters). The maximum distance is therefore 6.75 meters. The dilution with respect to acute toxicity equals 0.31 times 6.75 meters divided by 6 inches (0.152 meters), or 13.7.

5. Discharges to Dry Stream Beds, Ditches, and Storm Drains

Discharges to intermittent or dry streams, and discharges to drainage ditches and storm drains, should be handled on a caseby-case basis. The goal should be the protection of the ultimate receiving water of the discharge, whether it be a stream, wetland, marine water, or groundwater. The minimum discharge standard should be no acute toxicity, as it is for any discharge without a submerged outfall.

In addition, Best Professional Judgement should be used to decide whether more stringent chronic toxicity or human-health based limits are necessary. For example, if the storm drain receiving the discharge leads to a stream, then the discharge limits should be calculated as if the discharge entered the stream directly.

C. Calculating Permit Limits

The calculation of highest allowable permit limits is a simple matter once the discharge has been categorized among the four types given in the dilution section above, and appropriate dilution factors, if any, have been determined. In this section, the derivation of limits for specific pollutants and for biomonitoring will be discussed separately, followed by discussions of other considerations such as safety factors, effluent variability, chemical detection levels, and the necessity of particular limitations.

1. Limits for Specific Pollutants

Specific pollutant limits may be calculated for both aquatic life protection and human health protection. Aquatic toxicity limits must be calculated for all dischargers while the need for human health-based limits is more dependant upon the discharge situation. When both types of limit are calculated for a particular pollutant, the more stringent limitation applies.

(a) Aquatic Toxicity Limits

The four categories of proposed aquatic toxicity water quality standards are: Saltwater Acute Standards, Saltwater Chronic Standards, Freshwater Acute Standards, and Freshwater Chronic Standards. The choice of whether saltwater or freshwater standards are used depends on the salinity of the receiving water. Freshwater standards are used when the dissolved inorganic ion concentration is less than 0.5 parts per thousand. The saltwater standards are used above 0.5 parts per thousand. The choice of whether acute or chronic standards are be used depends upon the category of the discharger in the dilution section above. The methods for determining limits for the four categories are given below:

(i) Effluent limits for **marine dischargers through submerged outfalls** are based upon the chronic standards. The 24-hour average limit for a particular pollutant is equal to the product of the proposed standard and the minimum dilution factor. This limit may be expressed as a "Daily Maximum" using a composite sample in permits.

(ii) Maximum effluent limits for **dischargers without submerged outfalls are** based upon acute toxicity standards. The maximum limit for a particular pollutant is equal to the proposed acute toxicity standard, unless there is a high-rate outfall. This limit may be expressed as a "Daily Maximum" using a grab sample in permits. More stringent limits based on the chronic standards may be developed using Best Professional Judgement or receiving water monitoring.

(iii) Effluent limits for **discharges to streams** must be determined using both acute and chronic standards in order to determine which are more stringent. The maximum acute limits are equal to the proposed freshwater acute standards, unless there is a high-rate outfall. The 24-hour average limits (with or without a high-rate outfall) are equal to the products of the proposed chronic standards and the minimum dilution factor (based on the stream 7Q10).

(iv) Maximum effluent limits for **discharges from high-rate outfalls** are based upon the acute toxicity standards. The maximum limit for a particular pollutant is equal to the product of the proposed acute standard and the acute dilution factor determined according to section B.4., above. More stringent limits based on the chronic standards may be developed using Best Professional Judgement or receiving water monitoring.

The pollutant limitations derived above are basic requirments which, for most discharges, should protect beneficial uses of the receiving waters. Under certain circumstances discussed in section C.3.(b), below, more stringent maximum and average limits may be statistically derived from the limits obtained above.

For certain pollutants, there may be an acute standard, but no chronic standard, or visa versa. In these cases, the effluent limit should be based upon the available standard and an assumed acute to chronic ratio of 10. For example, the proposed chronic standard for the pesticide malathion is 0.1 ug/1 for both fresh and saltwaters. There is no proposed acute standard so for dischargers whose limits are based upon acute toxicity standards, the acute standard for malathion should be assumed to be 1 ug/1. If a measured acute to chronic ratio for a particular pollutant in either fresh or saltwaters is known, it can be used instead of 10.

If, for a particular pollutant, there is neither an acute or chronic aquatic toxicity standard for saltwaters, limits should not be developed using the freshwater standards. Additional saltwater and freshwater toxicity information is available for many pollutants from the EPA-Duluth AQUIRE data base. Permit writers may develop limits for specific pollutants on a case-by-case basis using AQUIRE or other sources of toxicity information.

(b) Human Health-Based Limits

Effluent limits based upon the Fish Consumption standards should be calculated for any discharge which has the potential to cause a long-term impact on water quality. The fish consumption standards are based upon the bioaccumulation of toxics in aquatic organisms followed by consumption by humans. There are applied as 30-day averages for non-carcinogens, and annual averages for carcinogens. If an annual average human health-based limit is appropriate, the minimum monitoring frequency should be once per quarter, so that a reasonable average can be determined. Compliance would be determined each quarter based on the last four samples. If fewer than four samples per year are taken, then compliance must still be based on the average of the samples, or, if only one sample is taken, on the single value.

The primary candidates for human health-based limits are the continuous major discharges. These discharges have the potential to cause long-term impacts on water quality. Effluent limits should be calculated by multiplying the fish consumption standards by the discharge's minimum dilution factor for non-carcinogens and average dilution factor for carcinogens.

Other possible candidates for limits based on the fish consumption standards include minor continuous discharges, particularly to streams or areas of limited dilution, such as wetlands. Limits for streams should be calculated in the same manner as limits to prevent chronic toxicity except that mean annual stream flow should be used instead of the 7Q10. Limits for low-dilution areas like wetlands would be difficult to calculate, although various dilution models are discussed in chapter 5 of the EPA Technical Support Document. If a situation occurred where human health-based limits were necessary for a discharge to a wetland, it might be simpler and more accurate to base permit conditions and compliance on the results of receiving water monitoring.

Intermittent discharges should have little potential to cause human health impacts unless a particular pollutant concentration is very high in relation to the fish consumption standard. Very rough estimates of water quality impact may be made to determine whether there is cause to develop an effluent limitation or receiving water monitoring permit condition. For example, for a discharge to a small embayment, the annual discharge mass can be divided into the total embayment volume, with or without some allowance for other factors such as hydraulic residence time, volatilization, or decay, to give some idea of annual concentration. The permit writer might decide to develop a permit condition if the result is within two orders of magnitude of the Fish Consumption standard. This could be possible for very toxic pollutants which have very low fish consumption standards. In the very unlikely instance that an applicant requested authorization to discharge a wastestream containing dioxin for example, it would be difficult under any condition to ensure that the Fish Consumption standard of 1.4×10^{-8} ug/1 would not be violated.

c) Examples of Effluent Limit Derivations

The following are examples of how effluent limits for preventing aquatic toxicity and human health impacts would be developed for the discharge situations discussed in sections (a)(i-iv), above. The examples are based upon the following EPA water quality criteria given in ug/1. When State Water Quality Standards for toxics have been adopted, they must be used instead of the EPA criteria.

Pollutant	Saltwater Acute	Saltwater Chronic	Fresh Acute	Fresh Chronic	Fish Cons.
Benzene*	5,100	700	5,300	-	40
Endosulfan	0.034	0.0087	0.22	0.056	159
Chromium (VI)	1,100	50	16	11	-
Trichloroethylene*	2,000	-	45,000	21,900	80.7

*Carcinogens

Example 1: A POTW has a submerged ocean outfall with a minimum dilution factor of 100 and an average dilution factor of 1000. As discussed in section (a)(i), limits must be developed for chronic toxicity and fish consumption for non-carcinogens using the minimum dilution factor, and for fish consumption for carcinogens using the average dilution factor. As there is no saltwater chronic standard for trichloroethylene, an assumed chronic standard of 200 ug/1 is used based upon the saltwater acute standard and an assumed acute to chronic ratio of 10. Since there is no Fish Consumption standard for hexavalent chromium, there will be no human health-based limit developed for chromium. The resulting permit limits expressed in ug/1 are:

	Saltwater Chronic (24-hour)	Fish Consumption (annual avg.)
Benzene	70,000	40,000
Endosulfan	0.87	15,900
Chromium (VI)	5,000	-
Trichloroethylene	20,000	80,700

The average limits for endosulfan and trichloroethylene can be eliminated since they are less stringent than the maximums. Further, as will be discussed in section C.3.(e), below, the chronic limits for benzene and trichloroethylene are so high that they are probably unnecessary.

Example 2: A petroleum product storage facility discharges 50,000 gallon batches of tank draw water to a marine embayment six to ten times per year. The discharge drops vertically off a pier into the bay. As there is no submerged outfall, the basic discharge limits are based upon the acute toxicity standards. Since the discharge does not enter the receiving water horizontally, it cannot qualify as a "high-rate" discharge regardless of velocity or receiving water depth. The saltwater acute standards are therefore applied directly as the maximum effluent standards, as discussed in section (a)(ii). The maximum limits for the two parameters suspected of being present, benzene and hexavalent chromium, are 5,100 and 1,100 ug/1, respectively.

Example 3: The discharger in example 2 above, installs a high-rate outfall as described in the example given in section B.4. The acute dilution factor of this outfall is 13.7. The maximum limits for benzene and chromium are therefore increased by this dilution factor to 69,900 and 15,100 ug/1, respectively.

Example 4: A continuous discharge with a design flowrate of 10,000 gpd enters a stream with an average dry weather flowrate of 10 MGD and a 7Q10 of 20,000 gpd. Since the receiving water is a stream, limits for the four pollutants must be calculated for acute toxicity, chronic toxicity and human health. The outfall is not "high-rate," therefore the acute toxicity limits are equal to the freshwater proposed standards. The freshwater chronic toxicity limits and fish consumption limit for endosulfan are based upon the minimum dilution factor which is 3 [(10,000 + 20,000)/10,000]. The freshwater chronic standard for benzene is estimated to be 530 ug/1 based upon an assumed acute to chronic ratio of 10. The human health limits for the carcinogens are based upon the average dilution factor which is 1,001 [(10,000 + 10,000,000)/10,000]. The resulting limits expressed in ug/1 are:

	Fresh Acute (maximum)	Fresh Chronic (24-hour)	Fish Consumption (average)
Benzene	5,300	1,590	40,040
Endosulfan	0.22	0.17	477
Chromium (VI)	16	33	-
Trichloroethylene	45,000	65,700	807,800

All the average limits may be eliminated because they are higher than the maximums. Both the acute and chronic limits may be enforced as maximums using a single composite sample. The resulting limits are the chronic values for benzene and endosulfan, and the acute values for hexavalent chromium and trichloroethylene. As will be discussed in section 3.C.(e), below, the trichloroethylene limit is so high that it is probably unnecessary.

2. Whole Effluent Toxicity Limits

Whole effluent toxicity limits are typically expressed either as percent survival in an acute test, or as the percentage of effluent producing a toxic effect in a chronic test. Acute tests, usually last 96 hours, and chronic tests typically last 7 days. The basic acute toxicity limit is 80 percent survival in undiluted effluent. Less than 80 percent survival demonstrates a significant difference between the test organisms and the controls (90 percent survival is required for control organisms).

Chronic toxicity limits are expressed as the No Observed Effect Concentration (NOEC), which means the highest effluent concentration that causes no observable adverse effect in a chronic toxicity test. The adverse effects measured in chronic tests are typically non-lethal, such as a reduction in growth or fertilization success. An NOEC of 1 percent means that at effluent concentrations higher than 1 percent, there is an observable difference between the test organisms and control organisms. The highest possible limit is 100 percent, which means that undiluted effluent can have No Observable Adverse Effect on the organisms in a chronic toxicity test, with respect to control organisms.

The decision of whether to derive an acute toxicity limit or a chronic toxicity limit depends upon the discharge dilution categories given in Section B., in exactly the same manner that the choice of whether to base specific pollutant limitations on acute or chronic standards was determined. The methods for determining whole effluent toxicity limits for the two common discharge situations are:

i) Toxicity limits for **discharges from submerged outfalls** are based upon chronic toxicity. The NOEC, expressed as percent effluent, is equal to 100 divided by the minimum dilution factor.

ii) Toxicity limits for **discharges without submerged outfalls** are based upon acute toxicity. The basic limit is 80 percent survival in 100 percent effluent, unless the discharge is "high-rate."

Once the chronic toxicity-based limit has been determined for a discharge from a submerged outfall, it is possible to convert it to an acute limit and enforce it using an acute test. Again, the acute to chronic ratio for "toxicity" is assumed to be 10. A chronic NOEC limit of 4 percent can be enforced by demonstrating no acute toxicity (i.e., percent survival) in 40 percent effluent. If the chronic NOEC is above 10 percent, however, it cannot be enforced with an acute test because the maximum effluent concentration which can be used in an acute test is 100 percent.

Initially, the derivation of whole effluent toxicity limitations may be confusing. A few examples, however, will show that they are easier to derive than limits for specific pollutants. The following examples use the same discharge situations for which specific pollutant limits were developed in section C.1.(c), above:

Example 1: For a POTW with a submerged outfall the whole effluent toxicity limit is based upon chronic toxicity. The NOEC is equal to 100 divided by the critical dilution factor, which in this case is 100. The limit is therefore an NOEC of 1 percent. The equivalent acute limit would be 10 times the NOEC, or 10 percent survival in 10 percent effluent.

Example 2: For a discharger without a submerged outfall the limit is based upon acute toxicity, and is 80 percent survival in undiluted effluent.

The discussion of the two less common discharge situations–discharges to streams and discharges from high-rate outfalls - is slightly more complex. The methods for deriving the limits are:

iii) Toxicity limits for **discharges to streams** must be developed to prevent both acute and chronic toxicity. The acute limit is 80 percent survival in undiluted effluent unless the discharge is "high-rate." The chronic NOEC is equal to 100 divided by the minimum dilution factor. By multiplying the chronic NOEC by 10, it can be compared to the acute limit to determine which is more stringent.

iv) Toxicity limits for **high-rate discharges** are based upon acute toxicity. Eighty percent survival must be achieved at the high-rate dilution concentration.

Examples of permit limit derivation, again using the situations discussed in section C.1.(c), above are:

Example 3: For a discharge to a stream, the limit to prevent acute toxicity is 80 percent survival in undiluted effluent. The limit to prevent chronic toxicity is equal to 100 divided by the minimum dilution, which in this case is 3. Therefore, the required NOEC is 33 percent. In this case, the limit required to prevent chronic toxicity is more stringent (since the equivalent acute limit to enforce the chronic toxicity limit would be 330 percent), so the chronic limit would be chosen for the permit.

Example 4: For a high-rate discharge the limit is based upon acute toxicity and is equal to 100 divided by the dilution factor, which in this case is 13.7. The limit is therefore 80 percent survival in 7.3 percent effluent.

3. Other Considerations

The limits derived in sections C.1. and C.2. are basic limits which should be sufficient to prevent receiving water toxicity under most situations. However, the permit writer may also consider requiring more stringent limitations based upon receiving water quality, effluent variability and safety factors for biomonitoring. Other considerations which may affect the final limitations are method detection limits and the determination of the necessity of a particular limit.

(a) Receiving Water Quality

The effluent limitation derivations above are equivalent to single discharger wasteload allocations where the receiving water is assumed to be unpolluted. However, if there is more than one discharger of a toxic pollutant or toxicity to a stream or small area, or if the receiving water is already contaminated by point or non-point sources, more stringent limits may be necessary to ensure compliance with the basic toxicity standard and the proposed numeric standards. For continuous discharges from submerged outfalls and to streams, the revised limits can be determined from simple mass and concentration balances. For other dischargers the determination of appropriate limits would be much more complex. The available options are similar to those discussed above for determining chronic toxicity and human health-based limits on a case-by-case basis.

(b) Effluent Variability

In the derivation of the acute and chronic toxicity limits in section C.1.(a) it was stated that the limits should be applied as daily maximums. This will ensure that the receiving water is protected as long as the limit is never violated. However, EPA's Technical Support Document points out that effluent concentrations are variable. If there was continuous effluent monitoring, variability would be no problem because any violation would be detected. With periodic monitoring, however, the probability of detecting a violation decreases as the monitoring frequency decreases. Infrequent monitoring, such as once per month, is likely to give only an average picture of effluent quality.

The permit writer can compensate for the decreased probability of detecting a violation by requiring the discharger to comply with an average limitation which is more stringent than the maximum limitation. Given a variable effluent, the average effluent concentration must be lower than the maximum limit if the maximum is never to be exceeded. A simple approach is to divide the daily maximum by a factor of 2 (or 1.5 for less variable effluents, such as those from ponds) to produce a 30-day average limitation. Compliance with this 30-day average limitation will increase the probability that the maximum is never violated, despite the fact that there is not continuous monitoring.

Chapter 6 of EPA's Technical Support Document provides a much more complex statistically derived approach for establishing permit limits. A slightly simplified version of this approach is also provided in EPA's Permit Writer's Guide to Water Quality-Based Permitting for Toxic Pollutants (EPA 440/4-87-005, July, 1987, the "Permit Writer's Guide"). Using the maximum limit calculated in section C.1.(a) as the wasteload allocation (WLA), the Technical Support Document approach requires the calculation of a long-term average (LTA) effluent concentration which must be achieved in order to meet the WLA. Daily maximum and 30-day average limits are then calculated based upon the monitoring frequency to ensure that the LTA is achieved with either 95 percent or 99 percent confidence. The main drawbacks to this approach are its complexity, and the fact that there is rarely enough detailed information about effluent quality to really make use of the statistics. In most cases the permit writer must fall back on assumed values for effluent variability which reduces the advantage of using the statistical approach over the simple approach given in the paragraph above.

(c) Safety Factors for Biomonitoring

A major concern about biomonitoring as a means to prevent toxicity is that the organisms used in the test may not be as sensitive as the most sensitive organism which either inhabits the receiving water, or would be present in the absence of pollution. The Technical Support Document contains an extensive discussion of the uncertainty associated with test species. Generally, testing with three diverse species (e.g., from different taxa) is likely to ensure protection of the most sensitive receiving water species. In certain critical cases, testing with additional species may be desirable.

The probability of protecting sensitive species can also be increased, in cases where fewer than three test species are used, by increasing the stringency of the toxicity limit by a factor of 10 for two species, and by 100 for one species.

(d) Chemical Detection Levels

The method detection levels for chemical analyses for specific pollutants are listed in 40 CFR Part 136, and in EPA's Methods for Chemical Analysis of Water and Wastes (EPA 600/4-79-020, latest revision). NPDES dischargers are required under 40 CFR 122.44(i)(1)(iii) to use the methods listed in 40 CFR Part 136, unless other methods are specified in the permit.

Chemical detection levels can increase the complexity of the permitting process in two ways. First, if the required effluent limit is below the detection level, routine effluent monitoring will not be sufficient to protect water quality. The "non-detectable" level may be orders of magnitude above the limit. Effluent limits near or below routine chemical detection levels should be avoided if at all possible. One solution would be to allow the discharger to contract or perform non-routine analyses, at lower detection levels. However, the preferable solution in such cases is to identify the source of the pollutant and either prohibit its discharge, or limit it in an internal wastestream. The NPDES regulations at 40 CFR 122.45(h) allow permit writers to impose limitations on internal wastestreams prior to mixing with other wastestreams or cooling water, when limitations at the point of discharge are impractical. Limits below the detection level clearly qualify as impractical. The limit for the internal wastestream would be equal to the product of the final effluent limit and the dilution of the internal wastestream in other wastestreams or cooling water. Other types of permit conditions, such as limitations on production processes or pollutant use, can also be calculated to ensure that the desired effluent concentration is achieved.

Effluent limits at or near the chemical detection level can also be problematic because the standard error of chemical analyses increases dramatically near the detection level and may be well over 100 percent. This increases the probability of false positive results. For example, if the detection level is 1 ug/1, but the standard deviation in the analysis at this level is 250 percent, then a result of 2 ug/1 is not significantly different from 1 ug/1. The EPA definition of significant non-compliance for NPDES permits, however, is 40 percent above the permit limit, so that the 2 ug/1 result would be a significant violation. Because of this, if a final effluent limit will be less than 10 times the routine method detection level, alternative permit conditions, such as limits on internal wastestreams discussed above, are preferable.

Limits at or near detection levels could cause particular problems for dischargers like POTWs who must screen for numerous pollutants which may be discharged to the collection system, but are <u>not known</u> to be present. In these situations, the permit writer may consider applying a "practical quantitation level" for screening purposes which is 5 times the method detection level. The discharger then reports "Not Quantifiable" or "NQ" for results below this level. This should help prevent false positive results. If the result is above the practical quantitation level, then there can be little doubt that the pollutant is actually present, and the source must be determined and limited. Practical quantitation levels should be used only for pollutants which are not known to be discharged, and only when it is not possible to establish a more stringent permit condition such as a limit on an internal wastestream. In particular, if an industry is known to use a pollutant in a process which produces wastewater, it would not be appropriate to apply a practical quantitation level as the industry's final effluent limit. POTW local pretreatment limits for indirect discharges must also be based upon achieving compliance with the proposed standards, and not upon meeting practical quantitation levels.

(e) Unnecessary Limits

The Clean Water Act requires that permits contain any limits necessary to achieve compliance with State water quality standards. However, this does not mean that limitations must be established for all pollutants which might be present. For example, in Example 1 in section C.1.(c) above, the final limit for trichloroethylene in the POTW discharge is 20,000 ug/1. It is practically inconceivable that any POTW could ever discharge at this level. Unless it was known that a very large source of this pollutant was discharged to the POTW, it would be unnecessary to include the effluent limit for trichloroethylene.

Permit writers should use their Best Professional Judgement in deciding when certain limitations are unnecessary. A rule of thumb might be that if the discharge concentration has or could exceed 1 percent of the limit, then the limit should be included in the permit. Decisions not to limit certain pollutants present in the discharge should be justified in permit fact sheets.

D. Other Permit Conditions

1) Effluent Monitoring Programs

Effluent monitoring programs should provide sufficient information to insure that dischargers are in compliance with their effluent limitations. Monitoring programs are established using Best Professional Judgement. Factors to be considered in determining appropriate monitoring frequencies and conditions include: the size and type of discharger, effluent variability, the proximity of the mean effluent concentration to the permit limit, and the compliance history of discharger.

The most important information is effluent data. If the effluent concentration is close to the limit, or if the effluent is highly variable, then more frequent monitoring is necessary to ensure compliance with the limit. However, for many permittees, the only data available for specific toxic pollutants will be the single analysis required in the permit application. Based on the lack of information, initial monitoring frequencies for toxic pollutants should be fairly high. A reasonable level would be once per month for continuous dischargers and once per discharge for intermittent dischargers. Higher frequencies might be appropriate for larger dischargers.

In addition, monitoring programs do not have to be limited to set frequencies such as once per month or once per quarter. Special conditions can be used to trigger more frequent monitoring whenever there is a violation of an effluent limit. This automatically raises the monitoring frequencies for pollutants of concern without requiring frequent monitoring for all pollutants. An example of a special permit condition is:

> "If the permittee violates the effluent limitation for any toxic pollutant, the monitoring frequency for that pollutant shall increase to once per week as soon as the permittee knows of the violation. The monitoring frequency shall remain at once per week until the permittee complies with the limitation six consecutive times. The permittee shall submit a special report, describing such increased monitoring, including results of all analyses, with his Discharge Monitoring Reports (DMRs)."

Special conditions also assist in ensuring permit compliance by increasing monitoring at appropriate times without the need for an enforcement action, and by providing an incentive for permittees to come back into compliance quickly.

Once sufficient effluent data (e.g., 20 samples covering all seasons) is available, the permit writer may consider reducing monitoring frequencies for specific pollutants for which there have been no violations. The statistical approaches in the EPA Technical Support Document can be used to analyze the effluent performance. The permit writer might decide to reduce the monitoring frequency to once per quarter if the mean effluent concentration was more than one standard deviation below the limit, and to once per year if it was more than two standard deviations below the limit. Again, a special condition can be used to encourage permittees to request reductions in monitoring frequencies. An example is:

> "If, after 20 effluent samples have been analyzed, the permittee has not has a violation of a particular toxic pollutant limit, he may request a permit modification to reduce the monitoring frequency for that pollutant."

2) Schedules of Compliance

When a permit contains a new effluent limitation, the permit writer may allow the permittee a reasonable amount of time to come into compliance with the limit. For specific toxic pollutants, one year should be sufficient to identify sources and limit their discharge, or to find an alternative to surface discharge. However, if a process change is necessary, two years may be appropriate. Similarly, for whole effluent toxicity testing, one to two years should be sufficient for permittees to achieve compliance.

When a compliance schedule lasts more than one year, it must contain interim compliance dates and requirements. For toxics, these may be reports of progress in identifying pollutant sources, and requirements to submit detailed plans for achieving compliance by the final date.

3) Toxicity Reduction Evaluations

Permits which contain whole effluent toxicity limits should also contain standard Toxicity Reduction Evaluation requirements. The strategy behind these conditions is to allow the permittee to determine the appropriate means for achieving compliance during the schedule of compliance with minimal oversight. Once the final compliance date has passed, however, a violation of the limit triggers increased monitoring similar to the special condition discussed in section D.1., above. The increased monitoring will demonstrate whether the effluent toxicity was an isolated occurrence or is persistent. If the toxicity is persistent, then the permittee must submit a comprehensive toxicity reduction plan to the compliance authority for approval. An example of a Toxicity Reduction Evaluation permit condition is:

> "During the first 2 years after the effective date of the permit, it is the permittee's responsibility to perform toxicity reduction evaluations as necessary to achieve compliance with the final toxicity limitations in Section 2.b., above. If after the final toxicity limitation becomes effective, the permittee violates the limitation, the permittee shall increase the biomonitoring frequency to once per week. The frequency shall remain at once per week until the permittee has complied with the toxicity limitation six consecutive times. If the permittee has two consecutive failures of the toxicity limitation, or if requested by the Director, the permittee shall submit, within 45 days, a plan and schedule for conducting a toxicity reduction evaluation. The toxicity reduction evaluation, when completed, shall determine the source of toxicity and how the permittee can achieve the effluent toxicity limitation, including an implementation schedule. After review of the plan by the Director, the permittee shall conduct the evaluation within the specified timeframes. Upon completion of the toxicity reduction evaluation, this permit may be modified, or alternatively revoked and reissued, in order to incorporate appropriate permit conditions and compliance schedules. The submission of a

toxicity reduction evaluation plan does not waive other remedies or penalties applicable under the Clean Water Act."

Guidance for conducting Toxicity Reduction Evaluations is available in EPA's Permit Writer's Guide and Technical Support Document.