WATER QUALITY DIVISION
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
AGENCY OF NATURAL RESOURCES
STATE OF VERMONT

WASTE MANAGEMENT ZONE DESIGNATION PROCEDURE

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ADOPTED:

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Department of Environmental Conservation

INTRODUCTION

Surface waters of the State of Vermont are classified according to the suitability of their uses per authority of V.S.A. Title 10, Chapter 47. Section 1252 defines the various uses of these waters, and describes the process by which the Secretary may establish a waste management zone (WMZ) as part of the issuance of a discharge permit. Direct discharge of any wastes which, prior to treatment contained organisms pathogenic to human beings is prohibited except within a waste management zone.

While contact recreation outside of waste management zones is not represented to be completely devoid of risk, it is generally accepted that such an activity within a WMZ does involve an increased level of risk to public health. The proper use of this procedure is therefore not as a utility for establishing specific contact recreation areas, but rather as a planning tool for use in minimizing these risks through proper siting of new and expanded waste management zones.

The purpose of this waste management zone designation procedure is to present a technically based, equitable process for determining the recommended distance from a treated sanitary wastewater discharge where contact recreation would become a suitable use.

The process for creation or expansion of a waste management zone necessarily has two distinct parts, the technical evaluation of its requisite length, and then the public participation process for evaluation of its acceptability relative to the public interest. The results of this analysis can be used both for the proper siting of new effluent outfalls, as well as for resizing existing waste management zones.

The WMZ length analysis would typically be performed by the Vermont Department of Environmental Conservation (VTDEC) with any necessary supporting information supplied by the applicant. The technical basis for determining the recommended length and the necessary simplifying assumptions used in the analysis are presented as Appendix A of this document.

The following stepwise procedure for the evaluation and creation of a waste management zone is derived from legislative guidance provided in *10 V.S.A 47 § 1252,* the Vermont Water Quality Standards, and the VTDEC NPDES Application Procedure (available from VTDEC- Water Quality Division).

VTDEC WMZ DESIGNATION PROCEDURE

1. The applicant seeking a new or increased Waste Management Zone shall first complete Steps 1 and 2 of the VTDEC NPDES Permit Application Procedure (Appendix B) regarding initial project screening and evaluation of direct discharge alternatives.

2. The applicant shall formally apply for an NPDES permit with the Wastewater Management Division of the VTDEC. This will involve completing all required paperwork, and any additional studies required for WMZ length determination modeling.

3. The VTDEC will use the WMZ length determination model (Appendix A) as a tool to calculate a base length for the proposed waste management zone. In most cases the resulting length will be recommended for adoption in the NPDES permit. However, in certain situations where existing downstream uses preclude the adoption of a sufficiently long waste management zone, other appropriate risk management alternatives may be recommended in addition to adoption of the maximum practical WMZ length. These may include additional treatment processes, increased treatment reliability (e.g. redundant processes), alternative discharge locations, or other options deemed appropriate by the Secretary. Any such additional measures that are required will be included as part of the final NPDES permit requirements.

4. The VTDEC will publish a notice in both a local newspaper generally circulating in the area where the affected waters are located, and in a separate newspaper(s) generally circulating throughout the state announcing a public informational meeting to be held in a location convenient to the area where the Waste Management Zone is proposed. The purpose of this meeting will be to disseminate information about the WMZ and the proposed discharge, and to accept public comment regarding any public uses of the waters which will be affected.

5. The VTDEC will prepare findings concerning the proposed waste management zone and its consistency with the Vermont Water Quality Standards and the state Anti-Degradation Policy. These findings will be provided to all interested parties, and will be used as a basis for preparation of final recommendations regarding the suitability of the WMZ.

6. Provided the proposed discharge satisfies the applicable regulatory requirements for issuance of a discharge permit, the VTDEC will prepare a draft permit which includes a description of the proposed waste management zone.

7. The VTDEC will provide public notice and opportunity for comment on the WMZ designation simultaneously with such notice and opportunity for public comment on

the proposed discharge permit. The hearing notice shall describe the draft permit and proposed waste management zone and provide for the opportunity to file written comment for not less than seven days following the hearing.

8. The VTDEC will forward copies of the notice, the draft permit and the description of the proposed waste management zone to any municipality and regional planning commission within the area where the affected waters are located not less than 21 days prior to the hearing. The notice, the draft permit and the description of the waste management zone shall also be provided to any person upon request.

9. The VTDEC will hold a public hearing convenient to the waters affected. The purpose of this hearing will be to accept oral and written public comment on the proposed waste management zone and the draft NPDES permit.

10. The VTDEC will determine through evaluation of public comment received and through other available information whether the creation or expansion of such a waste management zone is in the public interest after giving due consideration to the following factors (as specified in 10 V.S.A. § 1253(e)).

    (a) existing and obtainable water qualities;

    (b) existing and potential use of waters for public water supply, recreational, agricultural, industrial and other legitimate purposes;

    (c) natural sources of pollution;

    (d) public and private pollution sources and the alternative means of abating the same;

    (e) consistency with the state water quality policy established in 10 V.S.A. § 1250;

    (f) suitability of waters as habitat for fish, aquatic life and wildlife;

    (g) need for and use of minimum streamflow requirements;

    (h) federal requirements for classification and management of waters;

    (i) consistency with applicable municipal, regional and state plans; and

    (j) any other factors relevant to determine the maximum beneficial use and enjoyment of waters.

11. The VTDEC will determine through evaluation of public comment received, and other available information whether the creation or expansion of such a zone will:

(a) Create a public health hazard; or

(b) Constitute a barrier to the passage or migration of fish or result in an undue adverse effect on fish, aquatic biota or wildlife; or

(c) Interfere with those uses which have actually occurred on or after Nov. 28, 1975, in or on a water body, whether or not the uses are included in the standard for classification of the particular water body; or

(d) Be inconsistent with the anti-degradation policy in the water quality standards.

12. The VTDEC will provide written response to public comments and written findings with respect to steps (10) and (11) of this procedure.

13. If the findings resulting from step (12) of this process indicate that creation of the WMZ is in the public interest, the VTDEC will formally adopt the waste management zone through the issuance of the final NPDES Permit.

Appendix A

MATHEMATICAL MODEL FOR WMZ LENGTH DETERMINATION

BACKGROUND

The model is based upon three precepts concerning the nature of domestic wastewater treatment facility discharges which must be considered when determining the length of a waste management zone segment.

The first addresses the use of coliform bacteria as an indicator of pathogenic organisms. The proper use of this test is as a positive indicator of possible pathogenic contamination. When high counts (i.e. > 77 colonies of Escherichia coli/100 ml) are found in conjunction with a sanitary discharge, there is a high probability that pathogens are also present. The widely recognized problem with the use of coliform as an indicator organism is that they are more easily removed by disinfection processes than are many pathogens.

Moderate numbers of viruses, cyst forming organisms and pathogenic bacteria can survive a disinfection process that is meeting coliform bacteria standards. Therefore, the absence of high coliform counts in the immediate vicinity of a sanitary discharge does not necessarily indicate the absence of pathogenic organisms. The latter require extremely difficult and expensive testing for detection, and therefore are not typically measured.

Pathogenic organisms that do survive the disinfection process eventually succumb to the relatively harsh aquatic environment and die. The rate at which they expire can be expressed as a function of time. Since there are many different species of pathogens which may be present, and since they are affected differently by environmental variables such as pH, temperature, and light, it is very difficult to generalize a single decay term to describe the rate of their dieoff.

Secondly, although all treatment plants are required to discharge bacteria concentrations equal to or less than the Class B standard, various types of disinfection failures do occur. A ten year data base of compliance monitoring records was selected for wastewater treatment facilities (WWTFs) throughout the State. Those facilities with known operational or design problems were excluded from this analysis. During the period when this data was collected, total coliform was used as an indicator of WWTF performance, however the relative numbers are directly proportional to the Escherichia coli counts used today. The discharged concentrations measured at these facilities were used to construct a probability versus concentration graph. This relationship can then be used to select an initial coliform concentration by which an instream waste management zone (WMZ) zone length can be calculated based upon the desired degree of public risk, as defined by the probability of failure.

The third consideration involves the concept of risk management. If waste management zones were sized to completely protect against total disinfection failure, they would be unreasonably long. However, a reasonably sized waste management segment does provide a "buffer zone" downstream of the wastewater discharge in which contact recreation is not recommended. If a disinfection failure should occur at the WWTF, the time of travel through this zone will provide time during which some pathogen dieoff will occur, and may also allow time for public notification.

GENERAL PRINCIPLES

The sizing of waste management zones is based upon several simplifying assumptions which provides a comparable method of analysis and ensures comparable levels of public health protection and risk management throughout the State.

1) Pathogen concentrations decay through dieoff as a function of time, and are transported downstream as a function of instream velocity. The relative magnitudes of these two rates is a principal factor in determining the length required for a waste management zone. The rates of dieoff are further governed by stream temperature, light and water chemistry, however little empirical information is available concerning the behavior of pathogens in the aquatic environment.

Since so little information is available on pathogens, and a relationship can be established between the behavior of pathogens and coliform in the environment, coliform decay was chosen as a means of establishing waste management zone lengths. A decay rate of 1.5 day $^{-1}$ based upon typical values in the literature for coliform dieoff, and an initial coliform concentration of 10,000 which corresponded with an non-exceedance probability of 85 %, were chosen for the model.

2) The length required to reduce the bacterial concentration to below the accepted standard is very dependent upon the ratio of treatment plant size to receiving water flow. The initial effluent concentration is reduced upon mixing with the receiving water. In cases where a relatively small facility discharges to a large stream, once this dilution is achieved, concentrations will be reduced sufficiently to meet standards.

In these cases, a mixing zone plume analysis would be needed to determine the necessary waste management zone length. Analyses of this type are complicated and very dependent upon site specific factors, and therefore will not routinely be performed. In lieu of this analysis, a minimum waste management zone length of one river mile will be recommended. This length represents the maximum practicable distance required for complete mixing in any river found in Vermont, and also provides an adequate buffer zone.

3) In many cases, concentrations are not sufficiently reduced upon complete mixing with the receiving water. A time based waste management zone analysis is then required. This analysis calculates the distance bacteria will travel downstream under critical flow

conditions before their concentration is reduced to below standards through natural dieoff. Critical flow conditions are a result of site specific factors such as channel geometry and slope. These factors govern the relationship between higher flows which provide greater dilution, yet also produce correspondingly further and faster transport of bacteria before dieoff.

Differing hydromorphologic features and their unpredictable effects on flow/velocity relationships make generalizations about critical flow regimes difficult. The length of the waste management zone would obviously depend on the distance a discrete parcel of water will travel during the period required for dilution and decay to reduce pathogen concentrations to acceptable levels. The longest zones sometimes result at flows greater than design low flow conditions (7Q10) since the correspondingly higher velocities may have a proportionally greater effect than the increasing dilution.

MODEL CONSTRUCTS

Because of site specific factors, flow versus velocity relationships should be established for the reach in question by performing travel time measurements under two different flow regimes. Once this relationship has been established, an iterative search procedure is used with the model to find the critical flow which would maximize the waste management zone length. The actual model structure and data requirements are presented below.

The model is a rearrangement of the general first order decay formula:

(1) $$C_f = C_i * e^{-(\frac{KX}{u})}$$

Where:
- Cf = final coliform concentration (#/100 ml)
- Ci = initial mixed coliform concentration (#/100 ml)
- K = coliform decay rate (1.5/day)
- X = distance (miles)
- u = stream velocity (miles/day)

A coliform decay rate of 1.5 per day was chosen as representing a typical rate of dieoff derived from literature values. An initial wastewater treatment facility effluent concentration of 10,000 coliform per 100 ml was chosen. This corresponded to an exceedance probability of 15 percent.

Equation (1) can then be solved for required instream distance, yielding:

(2) $$X = \frac{-u * \ln(\frac{C_f}{C_i})}{K}$$

Where: Cf = final coliform concentration (#/100 ml)
Ci = initial mixed coliform concentration (#/100 ml)
K = coliform decay rate (1.5/day)
X = distance (miles)
u = stream velocity (miles/day)

The final concentration (Cf) is set at a receiving water coliform density resulting from environmental dieoff that is generally used to indicate "safe" pathogenic levels (500 #/ 100 ml).

Since both velocity (u) and initial mixed concentration (Ci) are functions of flow (Q), a mathematical generation of velocities and mixed concentrations for incremental increases in flows can be performed using equations # 3, 4 and 5:

(3) $$C_i = \frac{Q_s * C_s + Q_w * C_w}{Q_s + Q_w}$$

Where: Qs = incremental streamflow (cfs)
Cs = stream background concentration (#/100 ml)
Qw = WWTF design flow (cfs)
Cw = WWTF failure probability concentration (#/100 ml)

The data derived from the travel time measurements are used to mathematically represent instream velocity through equations # 4 & 5:

$$u = V_2(\frac{Q_s^m}{Q_2})$$

(4)

Where: u = stream velocity (ft/sec)
Qs = incremental streamflow (cfs)
V_2 = measured velocity at flow Q_2 (ft/sec)
Q_2 = measured streamflow #2 (cfs)
m = slope derived from equation # 5

(5)

$$m = \frac{\ln(\frac{V_1}{V_2})}{\ln(\frac{Q_1}{Q_2})}$$

Where:

m = slope of log normal line

V_1 = measured velocity at flow Q_1 (ft/sec)

Q_1 = measured streamflow #1 (cfs)

V_2 = measured velocity at flow Q_2 (ft/sec)

Q_2 = measured streamflow #2 (cfs)

MODEL APPLICATION

The model is applied in an iterative manner using hydraulic design flows from the treatment facility, and a range of stream flows likely to be encountered during the summer recreational period.

First, an initial dilution calculation is applied to determine the relationship of stream flow at 7Q10, to treatment facility design flow. In cases where this results in a ratio of 20:1 or greater, the waste management zone length will be the default minimum, one river mile.

In cases when the initial mix is insufficient to provide the required reduction, the above referenced equations are applied to determine the necessary waste management length. Two instream travel time measurements must be conducted to provide a mathematical relationship between velocity and flow. Background coliform concentrations are assumed to be zero unless an upstream waste management is present. In this case, the model would be used to solve for remaining coliform concentration at the point of the new discharge, and this would become the background concentration.

The model output produces a matrix of waste management zone lengths for the various flow regimes within the selected range. The maximum resulting length is then chosen, thereby providing protection throughout the given range of flows.