Regulatory Mixing Zone Internal Management Directive

Part One: Allocating Regulatory Mixing Zones

May 2012

State of Oregon
Department of
Environmental
Quality

Last Updated: 5/31/12
By: Sonja Biorn-Hansen
DEQ 07-WQ-012 Rev. 2.0
SWM-RN-00478

Questions or comments on this IMD can be directed to:
Sonja Biorn-Hansen, DEQ Surface Water Management Section, or Steve Schnurbusch, Western Region, Salem Office.

Alternative formats (Braille, large type) of this document can be made available.
Contact DEQ's Office of Communications & Outreach, Portland, at (503) 229-5696, or toll-free in Oregon at
1-800-452-4011, ext. 5696.

Disclaimer

This internal management directive (IMD) represents the department's current process for allocating regulatory mixing zones and reviewing mixing zone studies. The recommendations in this IMD should not be construed as a requirement of rule or statute. The IMD outlines general guidelines; it is not meant to limit how the department conducts regulatory mixing zone analyses, which are performed on a case-by-case basis. The department anticipates revising this document as needed to address additional issues or clarify direction to staff.

Document Development

Prepared By: Sonja Biorn-Hansen May 2012

Reviewed By Steve Schnurbusch and Ranei Nomura Spring 2012

Approved By: _____ Date: _____

Table of Contents

1. Introduction

Overview

Purpose

The purpose of this internal management directive (IMD) is to assist department staff in allocating regulatory mixing zones (RMZs) in National Pollutant Discharge Elimination System (NPDES) individual permits for intermittent and continuous wastewater discharges. The effective implementation date for this IMD is June 1, 2012. All completed applications received after this date must be processed pursuant to the guidelines contained in the IMD.

The IMD is in two parts to address the following issues:

Part 1: Allocating Regulatory Mixing Zones

- Details the necessary steps for sizing and allocating an RMZ in accordance with state and federal regulations.
- Clarifies what documentation is needed in both the permit and permit evaluation report (fact sheet) to support allocation of an RMZ.

Part 2: Reviewing Mixing Zone Studies

- Provides for staff consistency when requesting and reviewing mixing zone study information.
- Clarifies for staff and permit applicants what information should be provided in a mixing zone study prior to permit development.

Organization

Part 1 of this IMD is organized into the following sections:

1. Introduction
2. Allocating New RMZ's and Re-Evaluating Existing RMZs
3. RMZ Rule Requirements and Sizing Guidelines
4. Additional Considerations
5. Field Assessments of RMZ Allocations
6. Evaluation Report and Permit Language
7. References

1.1 Background on regulatory mixing zones

What is a regulatory mixing zone?

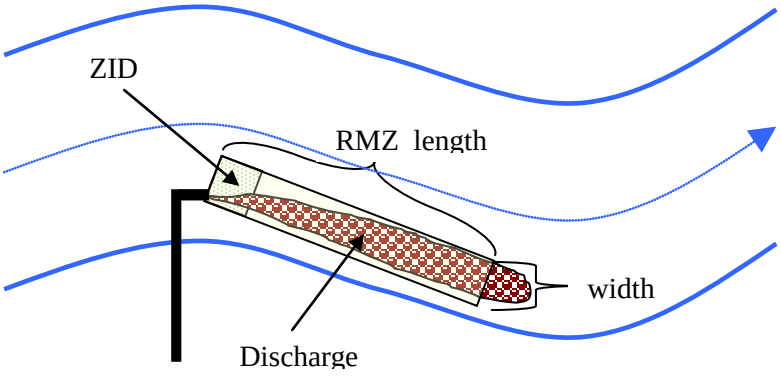
A regulatory mixing zone (RMZ) is an area defined in an NPDES permit where:

1. A discharge undergoes initial dilution and mixing in the receiving stream;
2. Water quality standards can be suspended for a short distance downstream of a discharge provided several conditions are met (see Section 3: RMZ Rule Requirements and Sizing Guidelines) ; and

3. Mixing zones are designed to be protective of human health, aquatic habitat and the water body as a whole.

See Figure 1-1 below for an example of an RMZ for a river. Note: The general term "mixing zone" may also be used to define the region in which mixing of a discharge occurs. Zone of Immediate Dilution (ZID) is discussed further in "Components of an RMZ" later in this section.

Figure 1-1. Example of Regulatory Mixing Zone (RMZ) for a River



What are the environmental effects of an RMZ?

The department is not allowed to allocate RMZs that endanger public health or negatively affect the integrity of a water body as a whole; however, minor effects may occur. As described in the federal Environmental Protection Agency's (EPA's) *Water Quality Standards Handbook, August 1994* (*Handbook*) sensitive species are less likely to reside within an RMZ for the long-term, and for those species that do continuously reside within an RMZ, conditions may not be adequate to ensure survival, growth, and reproduction.

To minimize potential effects, site-specific physical mixing processes during critical receiving water conditions (e.g., low instream flow conditions) are evaluated, and state and federal requirements and guidelines are used to properly size an RMZ. For example, RMZs that come in contact with the stream bottom where benthic organisms live are avoided. In addition, EPA's *Handbook* concludes that when the total area affected by all RMZs within a water body is kept small when compared with the total area of the water body (such as a river segment) the integrity of the water body as a whole will be protected.

Components of an RMZ

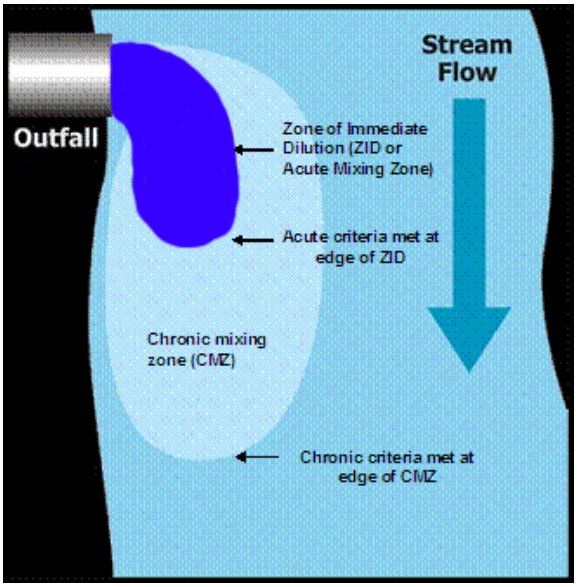
As allowed by Oregon Administrative Rule (OAR) 340-041-0053 (see Appendix A), an RMZ typically consists of both a "chronic" and an "acute" mixing zone (see Figure 1-2):

The chronic mixing zone is the area encompassed by the entire RMZ as described in an NPDES permit. Water quality criteria for both aquatic life and human health in OAR 340-041 Tables 20, 33A to 33C and 40 must be met outside the RMZ, though in some cases the RMZ may be sized differently for different parameters. Chronic criteria for aquatic life and human health criteria may be exceeded in the RMZ provided a number of protections are maintained and the RMZ is sized to protect the integrity of the water body as a whole.

The acute mixing zone or "Zone of Immediate Dilution" (ZID), is the area immediately surrounding the outfall and within the RMZ. In this area, the acute and chronic aquatic life criteria may be exceeded

however it must be sized so that the drift time for aquatic organisms passing through the ZID is below levels that cause lethality. This is discussed further in Section 3.2, Zone of Immediate Dilution.

Figure 1-2. RMZ Components: Chronic Mixing Zone and Zone of Immediate Dilution



How are RMZs regulated?

EPA allows states to adopt their own mixing zone regulations as part of the state's water quality standards (40 CFR §131.13). These state regulations are subject to review and approval by EPA. Oregon's mixing zone rule, OAR 340-041-0053 (reproduced in Appendix A), has been approved by EPA, and is discussed further in Section 3.1. Both Parts 1 and 2 of this IMD provide staff with further guidance on implementation of this rule in NPDES individual permits.

EPA also provides guidance on mixing zones in *Water Quality Standards Handbook, August 1994*, and *Technical Support Document for Water Quality-based Toxics Control, March 1991* (*TSD*). Applicable EPA guidance documents are referred to throughout this IMD. They provide the detailed technical information needed to allocate an RMZ in compliance with water quality standards.

2. Allocating New RMZs and Re-Evaluating Existing RMZs

Overview

Discharge monitoring, water quality assessments, and modeling capabilities have become more sophisticated and accessible over time. With these tools, permit writers are directed to follow the steps discussed in this section to:

1. Properly evaluate a proposed or existing RMZ in compliance with OAR 340-041-0053 (reproduced in Appendix A), and
2. Reduce inconsistencies in the department's allocation process.

2.1 Initial steps: Antidegradation policy and highest and best practicable treatment

Critical questions pertaining to the department's antidegradation policy and highest and best practicable treatment requirements must be addressed prior to allocating a new mixing zone or re-evaluating an existing mixing zone. A brief summary of the department's Antidegradation Policy Implementation IMD (March 2001) is presented below. (The RMZ IMD does not address these issues in detail because they are applicable to NPDES permits regardless of whether an RMZ is allocated.) Once the antidegradation policy requirements have been met, the permit writer may consider the allocation of an RMZ.

Antidegradation policy

The antidegradation policy in OAR 340-041-0004 generally requires a review of discharges to surface waters to ensure that existing water quality is not degraded unless necessary for economic and social benefit. For new permits that lower existing water quality, an in-depth review is required to determine if the economic and social benefits of the discharge warrant the degradation. For renewal permits, an in-depth review is required if the permitted mass loadings of pollutants are increased or the mixing zone is increased to support the discharge of a new pollutant.

State requirement for highest and best practicable treatment

OAR 340-041-0007(1) requires highest and best practicable treatment and/or control of wastes, activities, and flows to maintain the overall water quality at the highest possible levels and deleterious factors (e.g., temperature, toxics) at the lowest possible levels. While this is evaluated on a case-by-case basis, and additional state or federal regulations may apply, the department generally uses EPA technology-based effluent limitations to make this evaluation. These limitations require a minimum level of treatment for domestic and industrial point sources based on treatment technologies and apply as follows:

- For domestic wastewater treatment plants or publicly-owned treatment works (sewage treatment plants), highest and best practicable treatment is any process with results equivalent to "secondary treatment," a required performance level established by EPA.

- For industrial facilities, highest and best practicable treatment includes any process with results equivalent to EPA technology-based effluent limitation guidelines (ELGs). These ELGs are based on the demonstrated performance of a reasonable level of treatment that is within the economic means of specific categories of industrial facilities nationwide. For industry classifications without established ELGs, the department uses best professional judgment to establish appropriate technology-based effluent limitations. Typically, the department considers ELGs for similar industries when making this determination.

Note that EPA's technology based limits do not address water quality considerations. They are intended to require a *minimum* level of treatment necessary at domestic and industrial facilities. Water quality-based effluent limitations may still be necessary to protect the water body and higher levels of treatment may be necessary to meet these limitations.

2.2 Allocation Process

Basic process

Conduct a Tier 1 Reasonable Potential Analysis (RPA) on the effluent discharge to determine if the applicant's effluent is likely to exceed water quality criteria at the end-of-pipe. The process for conducting this analysis is explained in DEQ's RPA IMD at
http://www.deq.state.or.us/wq/pubs/imds/rpaIMD.pdf

If the applicant's effluent exceeds water quality criteria at the end-of-pipe, allocation of an RMZ may be considered provided the antidegradation policy and highest and best practicable treatment requirements have been met. This is done as part of an initial review process and, if applicable, the resulting RMZ/ZID is used to develop the effluent limits necessary to ensure that water quality criteria are met (as described in the department's *Reasonable Potential Analysis Internal Management Directive (RPA IMD)*). The basic allocation process is as follows:

1. **Review information provided by mixing zone study.**
   Typically, the applicant would provide information on the receiving water and discharge in a mixing zone study (see the most recent version of the department's *RMZ IMD Part 2: Reviewing Mixing Zone Studies*).

2. **Determine if an RMZ may be allocated.**
   Guidelines in this IMD should be used to review the physical, chemical and environmental characteristics of a receiving water to determine if there is the necessary assimilative capacity and if an RMZ can be allocated in compliance with OAR 340-041-0053.

   If there is assimilative capacity, the result of this exercise will provide the physical constraints of the RMZ and an available dilution factor. This dilution factor will be used in the reasonable potential analysis (see the *RPA IMD*) to develop permit effluent limitations.

   If there is insufficient assimilative capacity for the discharge to allow a mixing zone, other alternatives may have to be considered. These include: compliance schedule, intake credits, development of site-specific criteria, variances, or a change in beneficial uses of the receiving

stream. As of this writing, the following Internal Management Directives are available to help establish whether or not a particular alternative is appropriate:

- Use Attainability Analysis and Site-specific Criteria IMD, (April 2, 2007)
- Variances for NPDES Permit Holders (February 2012)
- Compliance Schedules in NPDES Permits (June 2010)

Additional IMDs are under development.

3. **Describe physical constraints of RMZ (e.g., length, width) in the proposed permit and support allocation in evaluation report (fact sheet).**
   This is discussed further in Section 6 of this document.

Allocation of RMZ for multiple pollutants

Generally, a separate RMZ for each pollutant is neither feasible nor warranted to protect the water body because physical and ecological constraints of the water body typically drive the RMZ sizing and allocation process regardless of the different pollutants in the discharge. The assessment of the receiving water body and its existing and designated beneficial uses determines if it is acceptable to allow a portion of the water-body to exceed water quality criteria for a single pollutant or multiple pollutants. Typically, the RMZ will be sized to be as small as possible prioritizing the pollutant of most concern in the design.

When to consider multiple RMZs

All pollutant parameters should be considered in an overall RMZ analysis with the available dilution being applicable to the entire discharge. However, there may be instances when a separate RMZ for temperature or human health criteria may be appropriate. This is discussed further in Section 3.6 for temperature and Section 3.4 for human health criteria.

2.3 New Permits

Decision flow chart

The decision steps for allocating a RMZ in a new permit are as follows (see Figure 2-1 for the decision flow chart):

1. **Does the discharge have the reasonable potential to exceed water quality criteria at end-of-pipe?**
   See the RPA IMD for more information on this process.

2. **Is assimilative capacity/dilution in the receiving stream available?**
   If there is no available dilution due to lack of flow or because the stream is water quality-limited for the parameter in question, water quality criteria should be applied at the end-of-pipe or other alternatives considered (e.g., development of site-specific criteria, use of a variance, change in beneficial uses of the receiving stream). As of this writing, the following Internal Management Directives are available to help establish whether or not a particular alternative is appropriate:

   - Use Attainability Analysis and Site-specific Criteria IMD, (April 2, 2007)
   - Variances for NPDES Permit Holders (February 2012)

- Compliance Schedules in NPDES Permits (June 2010)

Additional IMDs are under development.

3. **Has the appropriate level of mixing zone study been performed?**
   See Part 2 of the RMZ IMD for detailed information on what is needed for a complete mixing zone study . Generally, study components include:

   - Environmental mapping
   - Outfall and mixing zone characteristics
   - Ambient receiving water conditions
   - Discharge characteristics
   - Mixing zone modeling analysis.

   Use the checklist contained in Appendix A of Part 2 of the RMZ IMD to evaluate the completeness of a mixing zone study. If a complete study was not performed, request the necessary information prior to proceeding. Information above the levels described in Part 2 may also be requested at this stage or included as a permit condition (e.g., a field assessment that is not typically required for a Level 1 "simple" discharge). Note that it may be acceptable to proceed with conservative assumptions if specific information is not available or it will take too long to collect (See Part 2 of the RMZ IMD). For example, conservative estimates of instream critical flow conditions may be used if actual flow data is incomplete and instream monitoring is not feasible because the critical flow condition for the year has recently passed. In some cases, the permit applicant may also accept more conservative assumptions to prevent delays in permit issuance.

4. **Review mixing zone study. (See Part 2 of the RMZ IMD)**

5. **Are department sizing requirements and guidelines for RMZs used to develop inputs into mixing zone model?**
   See Section 3: RMZ Rule Requirements and Sizing Guidelines, and RMZ IMD Part 2, Section 4.5: Mixing Zone Modeling Analysis.

6. **Conduct reasonable potential analysis using resulting dilution factors from mixing zone study modeling.**
   See the RPA IMD.

7. **Will the discharge meet water quality criteria outside the RMZ (no reasonable potential to violate)?**
   See the RPA IMD. If the discharge cannot meet water quality criteria outside of the RMZ, the outfall may need to be reconfigured and/or effluent quality improved.

8. **Is the proposed RMZ protective of the instream water quality, public health, and other designated beneficial uses of the water body?**
   If the proposed RMZ is developed according to applicable OAR 340-041-0053 requirements, it is expected to be protective of the existing and designated beneficial uses of the water body.

   Use the **RMZ Evaluation Report Checklist** in Appendix B to document the necessary findings. In certain sensitive situations, additional field assessments may be desirable. See Section 5: Field Assessments of RMZ Allocations.

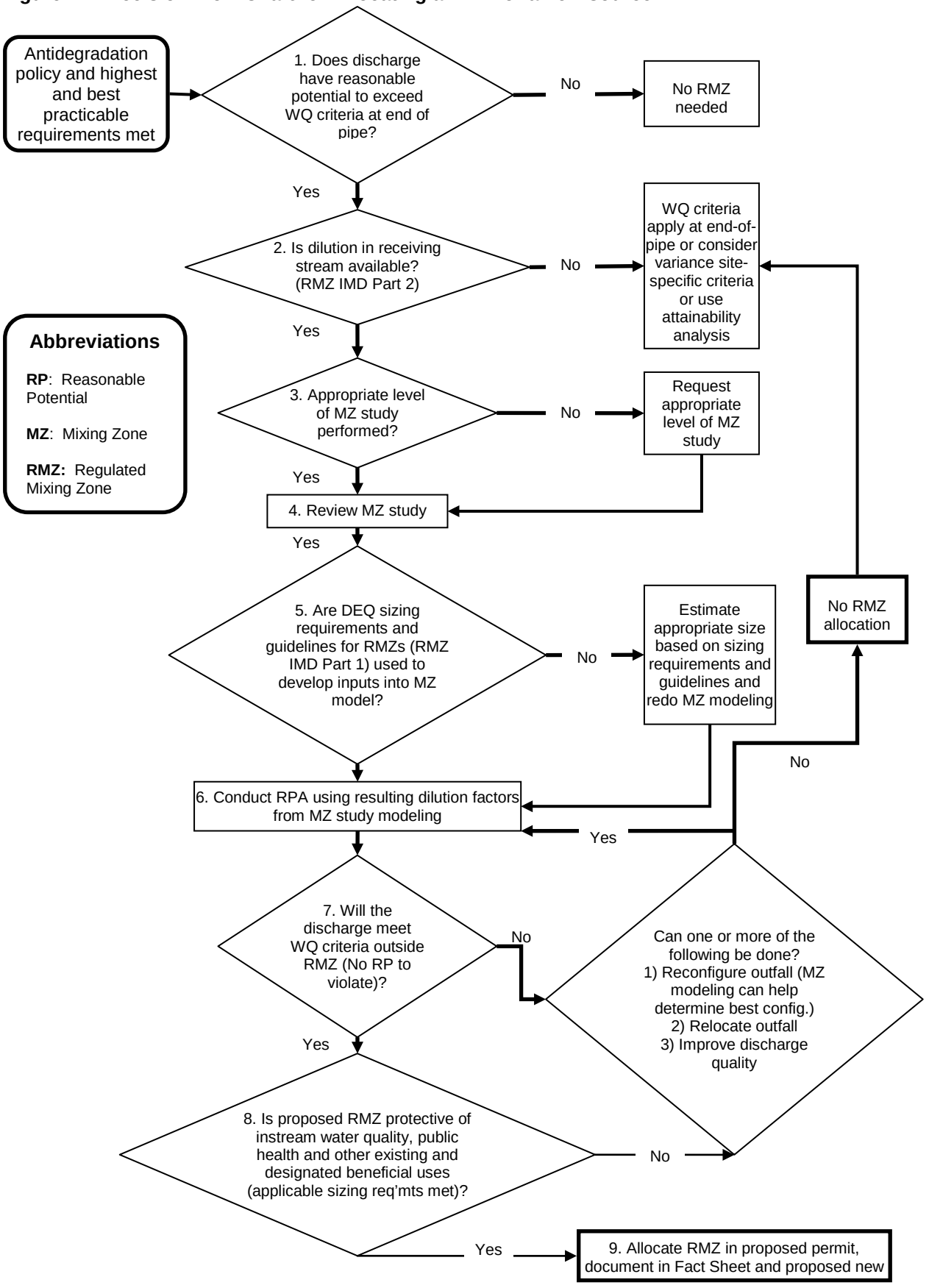
If the RMZ is not consistent with applicable OAR 340-041-0053 requirements, then allocation of the RMZ must be denied. It is appropriate, however, to reevaluate the proposed RMZ if one or more of the following changes are made:

- RMZ proposed size is revised
- Discharge quality is improved
- Outfall is reconfigured
- Outfall is relocated

Other alternatives may be considered when an RMZ cannot be allocated. For example, site-specific criteria may be developed, a variance may be obtained, or beneficial uses of the receiving water body changed. Note, however, that these options are likely to be rare and the request may be denied. See DEQ's *Use Attainability Analysis and Site-specific Criteria IMD, (April 2, 2007)* and the *Variances for NPDES Permit Holders (February 2012)* for more information.

9. Allocate RMZ in proposed permit, document allocation in evaluation report, and propose new permit.
See Section 6: Evaluation Report and Permit Language.

Figure 2-1. Decision Flow Chart for Allocating a RMZ for a new source



2.4 Permit Renewals

Decision Flow Chart

For an existing permittee, the current RMZ will need to be re-evaluated because it may have been originally allocated with inadequate or outdated information on the receiving water body or mixing process. The steps are as follows (see Figure 2-2, for the decision flow chart):

1. **Was the appropriate level of mixing zone study with current flow conditions used to allocate the RMZ?**
   See Part 2 of the RMZ IMD. The appropriate level of information for each component of a mixing zone study described in Part 2 should be provided for the study to be considered complete. These components include environmental mapping, outfall and mixing zone characteristics, ambient receiving water conditions, discharge characteristics, mixing zone modeling analysis, and, if needed, additional water quality data.

   If the appropriate level of study was not performed, request the necessary information prior to proceeding. Information above the levels discussed in Part 2 may also be requested at this stage or included as a permit condition (e.g., a field assessment that is not typically required for a Level 1 "simple" discharge). Note that it may be acceptable to proceed with conservative assumptions if specific information is not available. For example, lower estimates of instream critical flow conditions may be used if actual flow data is incomplete and instream monitoring is not feasible because the critical flow condition for the year has recently passed. In some cases, the permit applicant may also accept more conservative assumptions to prevent delays in permit issuance.

2. **Review mixing zone study, previous evaluation report, and department sizing requirements and guidelines.**
   When conducting this review, use the RMZ Evaluation Report Checklist in Appendix B to document the necessary findings. It may be necessary to review information from several past permit renewals to determine how the existing RMZ was determined.

3. **Is the RMZ sized to be protective of instream water quality, public health, and other existing and designated beneficial uses of the water body and no reasonable potential to violate water quality criteria outside of the RMZ?**
   If the RMZ meets the applicable OAR 340-041-0053 requirements, it is expected to be protective of the existing and designated beneficial uses of the water body. Use the RMZ Evaluation Report Checklist in Appendix B to determine if applicable rule requirements are met and document the necessary findings.

   If the RMZ is not consistent with applicable OAR 340-041-0053 requirements, then allocation of the RMZ must be denied. It is appropriate, however, to reevaluate the RMZ if one or more of the following changes are made:

   - RMZ size is revised
   - Discharge quality is improved
   - Outfall is reconfigured
   - Outfall is relocated

   Other alternatives may also be considered when an RMZ cannot be allocated. For example, site-specific criteria may be developed, a variance may be obtained, or beneficial uses of the receiving water body changed. Note, however, that these options are likely to be rare and the request may be denied. See the department's *Use Attainability Analysis and Site Specific Criteria IMD, April 2,*

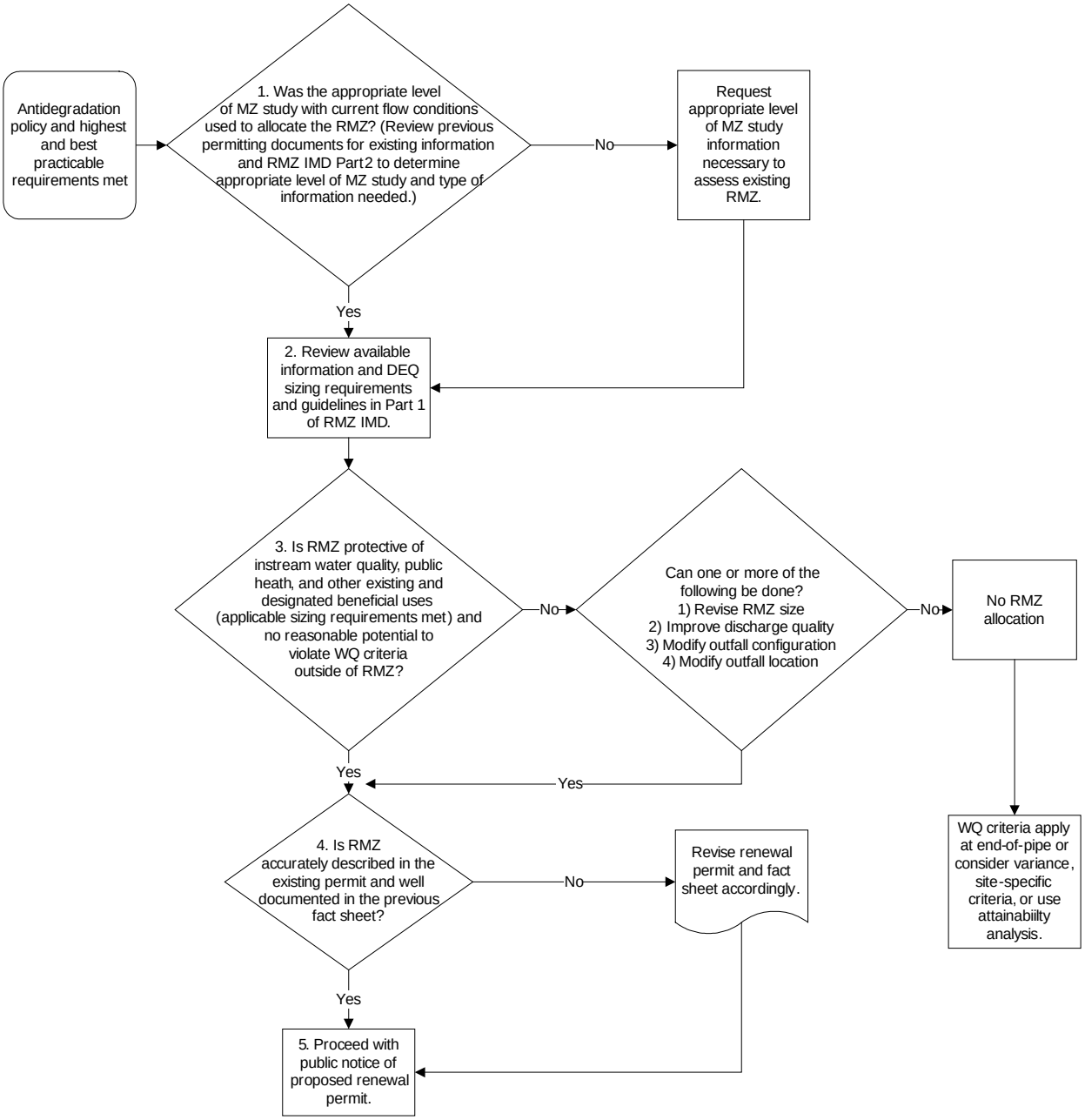
2007, Variances for NPDES Permit Holders (February 2012) and *Implementing Site Specific Background Pollutant Criteria (anticipated issuance:June 2012)* for more information.

Use the checklist in Appendix B to document the necessary findings. In certain sensitive situations, additional field assessments may be desirable. See Section **Error! Reference source not found.**: Field Assessments of RMZ Allocations.

4. **Is the RMZ accurately described in the existing permit and documented in the previous evaluation report?**
   See Section 6, Evaluation Report and Permit Language.

5. **Proceed with public notice of proposed renewal permit.**

Figure 2-2. Decision Flow Chart for RMZ Review in Renewal Permit



2.5 Renewal Process Questions

Caution

The following are general renewal process questions with basic responses; however, many renewal situations are quite complex and it will be necessary to consider a variety of issues before proceeding with a proposed renewal if these types of questions arise.

General questions

1. **There is no information in the previous evaluation report(s) on how the RMZ was developed. Can the existing RMZ still be allowed?**
   No. Allocation of the existing RMZ must be reviewed and documented in the permit and evaluation report as directed in this *IMD* before it can be allowed. See Part 2 of this IMD for more on the information that is needed to properly assess an existing RMZ.

2. **Will better documenting the existing RMZ or making other similar changes during the renewal process require an in-depth antidegradation review?**

   It depends on several factors. RMZ allocations have not always been well documented. In these cases, some basic assumptions will need to be made and documented to move forward. For example, if the permittee's discharge characteristics have not changed over the years, then simply improving the description of the RMZ based on more accurate modeling information would not warrant an in-depth antidegradation review. Assuming there is no mass load increase above permitted levels or an increased dilution provided by the RMZ to allow a new pollutant to be discharged (such as increased dilution resulting from a multi-port diffuser upgrade), antidegradation review should not be an issue. See Section 2.1: Initial Steps: Antidegradation policy andhighest and best practicable treatment, and OAR 340-041-0004(3)(a).

Resizing or reorienting RMZs

3. **Can an RMZ be re-oriented (described differently in the renewal permit as larger or smaller or in a different location due to new or better information)? Can an outfall be re-located?**
   DEQ expects that implementation of the methodologies outlined in this IMD will result in smaller mixing zones. However, it is possible for a mixing zone to be re-defined as larger or in a different location due to the availability of new information. DEQ rules do not prohibit these actions provided the RMZ meets OAR 340-041-0053 (see Appendix A). If these actions result in an increase in the mass load or an increase in RMZ dilution to accommodate a new pollutant, then a review to determine if economic and social benefits outweigh the environmental degradation would be required. See Section 2.1 and OAR 340-041-0004(9).

4. **Would increasing the size of a RMZ or ZID without increasing effluent limitations be considered backsliding and, therefore, prohibited by anti-backsliding regulations?**
   Generally, no. The anti-backsliding provisions in federal regulation, Clean Water Act §303(d)(4), CWA §402(c), 40 CFR §122.44, require that numeric effluent limitations in reissued NPDES permits be as stringent as the previous permits with some exceptions. These provisions are not directly applicable to sizing RMZs or ZIDs.

Zone of immediate dilution

5. **Does a ZID need to be defined in the renewal permit?**
   Sometimes. If a dilution factor related to the size of the ZID was used to calculate the previous permit's effluent limitations and the same limits are being proposed at renewal, a ZID must be described in the permit.

If the limitations in the previous and renewal permit have not changed and were not based on the allocation of a ZID (either water quality criteria applicable at end-of-pipe for acute criteria or limits based on dilution factor from RMZ), then inclusion of a ZID in the permit is not needed.

6. **Is the addition of a ZID in a renewal permit where one was not previously defined considered a lowering of water quality and, therefore, subject to an in-depth antidegradation review?**
   Generally, no. An in-depth antidegradation review would only be required if the addition of the ZID increased the permitted mass load or added new pollutants.

7. **Is the addition of a ZID in a renewal permit where one was not previously defined considered anti-backsliding?**
   Generally, no. Anti-backsliding provisions would only apply if the addition of a ZID was a result of an increase in permit effluent limitations.

3. RMZ Rule Requirements and Sizing Guidelines

Overview

The purpose of this section is to:

1. Describe the OAR RMZ requirements and guidelines that have been designed to ensure that RMZs are protective of the integrity (existing and designated beneficial uses) of the water body as a whole.
2. Explain how to allocate an RMZ in compliance with these requirements into permitting decisions. Due to the narrative nature of the requirements, in some cases this must be done using best professional judgment.

Permit Writer's Checklist

Compliance with RMZ requirements must be documented by the permit writer. The *RMZ Evaluation Report Checklist* developed for this purpose may be found in Appendix B.

Need for Supporting Information

Supporting information on the nature of the discharge and receiving stream is necessary to allocate an RMZ consistent with the requirements and guidelines discussed in this section. The type of information (e.g., estimates, field observation, computer modeling) is dependent on the complexity of the discharge scenario. This information is typically submitted to the department in a "mixing zone study" by the applicant; however, the department may provide assistance as resources allow. This is discussed further in Part 2 of the RMZ IMD.

3.1 Regulatory Mixing Zone

Requirements

To allow an RMZ, OAR 340-041-0053 requires that the department ensure that the RMZ be:

[Note: The numbering of these requirements does not correspond to the OAR numbering system, but they are listed in the order laid out in rule.]

1. Free of materials in concentrations that will cause acute toxicity to aquatic life. (Acute toxicity in 100% effluent as measured by a bioassay test may be allowed if it can be demonstrated that immediate dilution of the effluent within the RMZ reduces toxicity below lethal concentrations.)
2. Free of materials that will settle to form objectionable deposits.
3. Free of floating debris, oil, scum, or other materials that cause nuisance conditions.
4. Free of substances in concentrations that produce deleterious amounts of fungal or bacterial growths.
5. As small as feasible.
6. Sized to avoid overlap with other mixing zones to the extent possible.
7. Less than the total stream width as necessary to allow passage of fish and other aquatic organisms.

8. Sized to minimize adverse effects on the indigenous biological community especially when species are present that warrant special protection for their economic importance, tribal significance, ecological uniqueness, or other similar reasons.
9. Sized so it does not threaten public health.

Requirements for conditions outside of the RMZ are discussed in Section 3.3: Outside the RMZ, and requirements for thermal plumes are discussed in Section 3.6.

Meeting Requirements

To meet OAR requirements, the following apply:

#1 No acute toxicity

OAR 340-041-0053(2)(A)
Acute criteria (Tables 20 and 33A to 33C in OAR 340-041) must be met at end of pipe unless it can be demonstrated that immediate dilution of the effluent (also known as the ZID or zone of immediate dilution) within the RMZ reduces toxicity below lethal concentrations and will not cause lethality to passing organisms nor impact overall integrity of the water body due to impacts on benthic communities. The RMZ Evaluation Report Checklist in Appendix B provides additional information that is consistent with EPA guidance on how to make this determination.

#2 – 4 Free of deposits, nuisance materials, etc.

OAR 340-041-0053(2)(a)(B-D)
To ensure that the requirements pertaining to no objectionable deposits, floating nuisance materials, and substances that produce fungal or bacterial growths are met, visual observations within an existing RMZ should be made. If a new discharge, the proposed effluent should be evaluated to determine the expected characteristics and compliance with the criteria described above.

#5 – 9 Small as feasible, avoid overlap, allow fish passage, minimize effect to indigenous biological community, protect public health

OAR 340-041-0053(2)(c)(A-D)
The sections below provide further guidance on how this is to be accomplished. See Section 3.4: Human Health Considerations, for more information on protecting public health.

Location and Size Guidelines

To ensure that the requirements in OAR 340-041-0053(2)(c)(A-D) are met (i.e., small as feasible, avoid overlaps with other RMZs to the extent possible, allows fish passage, minimize effect to indigenous biological community, protects public health), the department primarily follows EPA's *Handbook*. This guidance states that RMZs must:

- Prevent impairment of critical resource areas (e.g., recreational areas, breeding grounds, areas with sensitive biota). This is accomplished by:

  - ✓ Avoiding impingement on cold water refugia (see Section 3.6 for more on thermal plumes), critical structural habitat (e.g., large woody debris), and areas with poor mixing or specialized habitat (e.g., backwaters, sloughs, coves). Note: This guideline does not prevent the discharger from removing wood or other debris to maintain the performance of the outfall diffuser.
  - ✓ Preventing shore and bottom-hugging plumes to protect salmonid spawning areas, littoral (shore) zones, and shellfish growing and benthic habitat.
  - ✓ Avoiding encroachment on drinking water intakes where drinking water contaminants are a concern.
  - ✓ Avoiding known areas that are frequently used for fish harvesting
  - ✓ Avoiding known, public swimming areas that are frequently used

- ✓ Following requirements for thermal plumes to prevent adverse impacts to salmonids and their habitat when discharge temperature is a concern. For more information see Section 3.6.

- Provide a continuous zone of passage that meets water quality criteria for free-swimming and drifting organisms. This may be accomplished by:

  - ✓ Avoiding overlap with other RMZs to the extent possible. If overlap occurs, the impact to organisms passing through overlapped areas must be evaluated to determine that acute toxicity will not occur and passage for fish and other organisms will not be blocked. DEQ's internal webpage on outfall location data may be used to determine if there is overlap between RMZs. See http://deq05/wqoutfalls/EOPbasics.aspx
  - ✓ Following requirements for thermal plumes to prevent migration blockage when discharge temperature is a concern. For more information see Section 3.6.
  - ✓ Providing for an EPA-recommended zone of passage of 75% of the cross-sectional area or volume of flow of a stream or estuary. (Brungs, 1986). Due to the inherent variability in receiving streams and discharge characteristics, the department may vary from EPA guidelines on a case-by-case basis provided a determination is made that OAR requirements for RMZs will still be met, which include protection of existing and designated beneficial uses of water body and public health. It may be acceptable to allow an RMZ to extend across the entire width of the stream if OAR requirements are met. OAR requirements may be met when discharges provide needed flow to receiving streams and in some cases aquatic life is dependent on these flows. Bottom or bank attachments may also be acceptable if there is no critical habitat in the discharge location or there are other areas providing better habitat that are not impacted by the RMZ.

- Be limited to an area or volume as small as practicable so it will not interfere with existing and designated uses or cause lethality to passing organisms. This is accomplished by:

  - ✓ Keeping the total area affected by all RMZs small when compared with the total area of the water body.
  - ✓ See Size guidelines in Section 3.2 for information on how to prevent lethality to passing organisms.

Note: Adequate information is necessary to determine if the RMZ is within EPA guidelines and will comply with requirements #5 – 9 [OAR 340-041-0053(2)(c)(A-D)]. At a minimum, this will include the existing and designated beneficial uses of the receiving water and information on the indigenous biological community if species are present that warrant special protection for their economic importance, tribal significance, or ecological uniqueness. Pursuant to OAR 340-041-0053(2)(e), the department can require the applicant to submit this information to define an RMZ. See Part 2 of the RMZ IMD for more information on what should be provided in a mixing zone study prior to permit development.

Summary of RMZ Sizes

Table 3-1 is a summary of the State's average RMZ lengths compared to the width of the receiving water bodies, as of 2007. Although each RMZ will be sized according to hydrologic, environmental, and supply conditions, this table can be used as a guide to help assess the results compared to statewide averages. Note: The expectation is that the implementation of the methodologies outlined in this IMD will result in reducing the size of RMZs, not enlarging them.

Table 3-1. Average RMZ Sizes

Water Body Type		Length of RMZ (feet)	Width
Rivers and Streams (width in feet)	<31	60	< 25% of cross-sectional area of a river or stream to allow for fish passage Should not extend across the mouth of the river or stream
	31-100	100	
	101-200	110	
	>200	200	
Estuaries	<300 feet in any horizontal direction		
Oceans	< 500 feet plus the depth of water at mean lower low water		

Variations to EPA Guidelines

If RMZs vary from the guidelines discussed in the previous section, they must be supported by in-depth characterizations of the chemical and physical (mixing) nature of the discharge in the receiving stream. Field assessments to confirm the instream biological condition may also be needed. For example, an evaluation may be needed to confirm that fish passage is not affected by an RMZ that mixes with the entire flow of the receiving stream. A benthic invertebrate community survey may be needed to determine if bank and bottom attachments are negatively impacting the overall integrity of the water body or sufficient habitat exists elsewhere in the water body. See Section 5: Field Assessments of RMZ Allocations for more information. Additional data from whole effluent toxicity testing or other bioassay toxicity tests on the discharge may also be needed to assist in making these determinations (see Section 4.3: Whole effluent toxicity testing for more information).

Additionally, the rationale and supporting data for varying from the general guidelines must be documented in the permit evaluation report.

Is the RMZ as Small as Feasible?

OAR 340-041-0053(2)(c)(A) requires RMZs to be as small as feasible but does not specifically define feasibility. DEQ interprets this requirement to involve the exercise of professional judgment relating to economic costs, engineering alternatives, overall environmental impact, and other relevantfactors.

DEQ considers an RMZ to be as small as feasible if the permit applicant:

- Uses the best available treatment technology that is economically achievable as required by applicable federal effluent limitation guidelines;
- Uses the best technology that is economically achievable to design and locate the outfall to allow for adequate mixing while avoiding sensitive areas; and
- Meets the other RMZ rule requirements (e.g., RMZ is protective of public health, allows for aquatic life passage).

For a routine permit renewal, the permit writer is not required to review the technologies employed by the permittee unless a significant change in discharge characteristics is being proposed, receiving stream characteristics or federal effluent limitation guidelines have changed, or the facility is undergoing a major upgrade.

3.2 Zone of Immediate Dilution

When is a ZID Allowed?

OAR 340-041-0053(2)(a)(A) allows for a zone of immediate dilution (ZID) where a discharge may exceed acute criteria if can be demonstrated that it will not result in acute toxicity to aquatic organisms. The size guidelines in EPA's *Handbook* (described below) are used to make this determination.

EPA Guidance

EPA stresses that mixing zones should be established to ensure that there is no lethality to organisms passing through the RMZ. Rapid dilution is critical to this effort because it quickly reduces pollutant concentrations within the RMZ, which results in less exposure of organisms to high pollutant concentrations (see Section 4.1: Outfall considerations). In addition, to protect aquatic life and prevent lethality to organisms passing through the ZID where acute criteria may be exceeded, EPA's *Handbook* recommends that the acute criteria (see OAR 340-041 Tables 20 and 33A to 33C) be met within a short distance and timeframe from the outfall. The *Handbook* details design considerations presented below for both low and high velocity discharges.

Size Guidelines

EPA's *Handbook* states that if a full analysis of concentrations and hydraulic residence times within the mixing zone indicates that organisms drifting through the centerline of the plume along the path of maximum exposure would not be exposed to concentrations exceeding the acute criteria when averaged over the one-hour averaging period for acute criteria, then lethality to swimming or drifting organisms should ordinarily not be expected, even for rather fast-acting toxicants. *Generally, travel time through the acute mixing zone must be less than 15 minutes if a one-hour average exposure is not to exceed the acute criterion.* This will translate to a specific size requirement for the ZID. In addition, the *Handbook* provides the following guidance:

1. High velocity discharges

For a high velocity discharge with an initial velocity of 3 m/s or more, limiting the ZID to 50 times the discharge length scale (discharge length scale = square root of cross-sectional area of the pipe or port) in any direction should ensure the criterion maximum concentration (CMC) is met within a few minutes under practically all conditions.

2. Low velocity discharges

Higher velocity discharges typically provide for better mixing and, thus, are more desirable; however, low velocity discharges may still exist. The most restrictive of the following conditions should be met for low velocity discharges:

a. The acute criteria should be met within 10% of the distance from the edge of the outfall structure to the edge of the RMZ in any spatial direction. Note: This is usually the most conservative but the demonstration should be documented in the permit evaluation report.

b. The acute criteria should be met with a distance of 50 times the discharge length scale in any direction (the discharge length scale is defined as the square root of the cross sectional area of the outfall pipe or individual port).

c. The acute criteria should be met within a distance of five times the local water depthin any horizontal direction from any discharge outlet.

3. Other
The discharger could provide data or modeling analysis showing that a drifting organism would not be exposed to one-hour average concentrations exceeding the CMC. This data should be collected during environmental conditions that replicate critical flow conditions.

Computer modeling, dye studies, or monitoring studies should be conducted to provide information to satisfy No. 2 or 3 above.

Attraction Issues

The above recommendations assume the effluent is repulsive to free-swimming organisms thus causing them to avoid the RMZ. In cases where discharges containing toxic substances are attractive to free-swimming organisms, restriction or elimination of a RMZ may be appropriate. Based on a literature review, EPA's *Handbook* indicates that a majority of toxic pollutants elicit an avoidance or neutral response at low concentrations. However, EPA cautions that there was not sufficient data to develop predictive methods for every pollutant. Review of criteria development documents or current peer-reviewed and corroborated technical literature may be necessary to determine if attraction will be an issue.

3.3 Outside the RMZ

Requirements Outside RMZ

OAR 340-041-0053(2) further requires that conditions outside the RMZ:

1. Be free of materials in concentrations that will cause chronic toxicity. [OAR 340-041-0053(2)(b)(A)]
2. Meet all other water quality standards under normal annual low flow conditions. [OAR 340-041-0053(2)(b)(B)]
3. Minimize adverse effects on other designated beneficial uses outside the mixing zone. [OAR 340-041-0053(2)(c)(E)]

3.4 Human Health Considerations

Exposure Pathways

As discussed previously in Section 3.1, OAR 340-041-0053(2)(c)(D) requires that RMZs are sized so that they do not threaten public health. EPA's *Handbook* expands on this by stating that mixing zones must be sized and located such that they do not create significant health risks when using reasonable assumptions about exposure pathways. Likely pathways of exposure include direct human contact or intake that could occur when swimming in an RMZ, or indirect human intake of drinking water, fish, or shellfish affected by an RMZ.

Applicability of Bacteria Criteria

To prevent human health risks, RMZs for bacteria are generally not allowed. The bacteria criteria in OAR 340-041-0009 apply as follows:

- For freshwater and non-shellfish growing estuarine water, the *E. coli* criteria [OAR 340-041-0009(1)(a)] must be met at end-of-pipe whenever the existing or designated use is water contact recreation; no RMZs are allowed in this situation. This reduces the short-term human health risks of waterborne diseases originating from fecal sources.

In rare cases, where human exposure to fecal bacteria through direct contact is not of concern (e.g., deep ocean outfall with no known human fecal source of pollutants, where the deep discharge does not surface), an RMZ may be considered provided highest and best practicable treatment technology is being employed.

- For shellfish growing marine waters and estuarine water, fecal coliform bacteria criteria [OAR 340-041-0009(1)(b)] must be met at the shellfish harvesting area; no RMZs are allowed in this situation.

Sizing Guidelines

The previous sizing guidelines provided in Section 3.1 are applied to protect public health. The two key protections in this section are reiterated here:

- RMZs must avoid drinking water intakes and known public swimming areas. If an RMZ does not contain pollutants that would affect human health, placement of an RMZ in these areas may be considered (e.g., an RMZ for temperature is typically not a pollutant of concern for drinking water or a drinking water treatment system).

- RMZs must be sized such that they do not encroach on areas of fish and shellfish harvesting, particularly stationary species of shellfish.

Generally, the more conservative of the aquatic life or human health mixing zone size must be used. In rare cases a separate RMZ for human health criteria may be warranted because the human health criteria are based on long-term exposure.

Use Appropriate Flow Conditions in Mixing Zone Model

When evaluating the RMZ relative to human health criteria, DEQ uses the 30Q5 flow condition for pollutants that are non-carcinogens and harmonic mean flow for pollutants that are carcinogens. These flows are recommended by EPA, and reflect the nature of the risks to human health that the criteria are designed to protect against. These risks are discussed in more detail later in this section.

For a more detailed discussion of flow conditions, see Section 4.2: Critical Receiving Stream Design periods. As explained further in the *RPA IMD*, the most restrictive effluent limitation from the RPA exercise will be used in the permit.

Conditions for Separate Human Health RMZ

Oregon has water quality criteria designed for the protection of human health for 113 different pollutants. The criteria for a particular pollutant are designed to protect against cancer and other health effects that may result from the long-term consumption of drinking water and from the long-term consumption of fish containing the pollutant in question. The assumed consumption rates are 2 liters (0.53 gallons) per day of water and 175 grams/day (about 22 meals per month) of fish over a 70-year period. The acceptable level of risk upon which the criteria are based is one case of cancer (or, in the case of non-carcinogens, 1 exceedance of the reference dose) per 1 million individuals. Because of the conservative basis on which the human health criteria are developed, DEQ has determined that it is acceptable to have an RMZ based on human health criteria that is larger than the aquatic life RMZ when the human health risk is minimal due to factors such as:

a. Inaccessibility of receiving stream to humans or general lack of human use (e.g., no drinking water intakes, public beaches, docks, boat ramps. or shellfish harvesting areas).

b. No overlap with RMZs from other discharges.

- The pollutant under consideration does not bioaccumulate and tends to break down in the aquatic environment
- Other considerations identified by DEQ.

3.5 General Discussion of Persistent Bioaccumulative Toxics (PBTs)

What is a PBT?

"Persistent bioaccumulative toxic" or "PBT" is the term commonly used to describe a pollutant of concern that bioaccumulates. Bioaccumulation is the process by which a chemical concentrates in an organism as a result of chemical uptake through all possible routes of exposure.

Why is Bioaccumulation a Concern?

Chemicals that bioaccumulate can present higher health risks to humans and wildlife than chemicals that breakdown soon after being released to a waterbody, because they can become concentrated in the tissues of organisms that may then be consumed by humans and wildlife.

Bioaccumulative pollutant sources may include point source discharges, non-point sources (such as urban and rural run-off), and legacy sources (such as run-off from abandoned mines). Bioaccumulation of toxic pollutants in fish tends to affect entire water bodies rather than a narrow-scale problem confined to RMZs.

How are PBTs addressed in RMZs?

Because they take into account the consumption of fish as well as the consumption of water, the human health criteria in OAR Table 40 take into account bioaccumulative properties of different pollutants. They are based on an assumed fish consumption rate of 175 grams/day. As a result, an RMZ developed to protect human health as discussed in Section 3.4: Human Health Considerations, is not expected to cause negative effects from bioaccumulation.

3.6 Additional Requirements for Thermal Plumes

Requirements

OAR 340-041-0053(2)(d) requirements for thermal plumes are fairly detailed. The rule requires the following:

1. Prevent or minimize impairment of an active salmonid spawning area where spawning redds are located or likely to be located.
   - Limit potential fish exposure to temperatures of 13°C (55.4°F) or more for salmon and steelhead and 9°C (48°F) or more for bull trout in areas where are they likely to be spawning.

2. Prevent or minimize acute impairment or instantaneous lethality.
   - Limit potential fish exposure to temperatures of 32.0°C (89.6°F) or more to less than two seconds.

3. Prevent or minimize thermal shock caused by a sudden increase in water temperature.

- Limit potential fish exposure to temperatures of 25.0° C (77.0° F) or more to less than 5% of the cross section of 100% of the 7Q10 low flow of the water body;
- The department may develop additional exposure timing restrictions to prevent thermal shock.

4. Prevent or minimize migration blockage.
    - Unless the ambient temperature is 21.0°C (69.8°F) or greater, limit potential fish exposure to temperatures of 21.0°C (69.8°F) or more to less than 25% of the cross section of 100% of the 7Q10 low flow of the water body.

The above requirements are reflected in the RMZ Evaluation Report Checklist contained in Appendix B.

4. Additional Considerations

Overview

This section provides a brief summary of additional issues that must be considered when allocating an RMZ, including EPA guidance, and applicability of other rules and internal management directives.

4.1 Outfall Considerations

Location

To minimize the biological and human health risks that may be associated with a RMZ, the outfall should be placed to avoid critical or sensitive areas. These areas are discussed further in Section 3.1 in the discussion of location and size guidelines.

Design

The best practicable engineering design should be used. An outfall should be designed to produce rapid initial dilution, which is critical to limiting the concentrations in the areas surrounding the outfall, thereby limiting the impact to the aquatic community (EPA's *Handbook*).

4.2 Critical Receiving Stream Design Periods

What Are They?

RMZs should be modeled under reasonable "critical" design periods in the water body to ensure that impacts to receiving waters are minimal and beneficial uses are protected. Critical design periods are based on hydraulic conditions in the receiving stream that result in worst-case mixing. In river systems this typically occurs during low flow conditions. However, there may be critical conditions not typically associated with low flow conditions that may be important when evaluating a discharge. For example, peak discharge flow or wet weather conditions could be critical conditions. Late fall conditions where instream temperatures have cooled but stream flow is still low, or winter conditions when discharge temperature is high but receiving stream temperature is low may also need to be considered.

These critical flow conditions for streams and rivers, also referred to as flow statistics, are briefly discussed in the next section. For more detail on critical flow conditions for other systems, such as tidally-influenced water bodies, see Section 4.3, Ambient Receiving Water Conditions and Appendix C in Part 2 of the RMZ IMD.

Flow Condition Descriptions for Riverline Systems

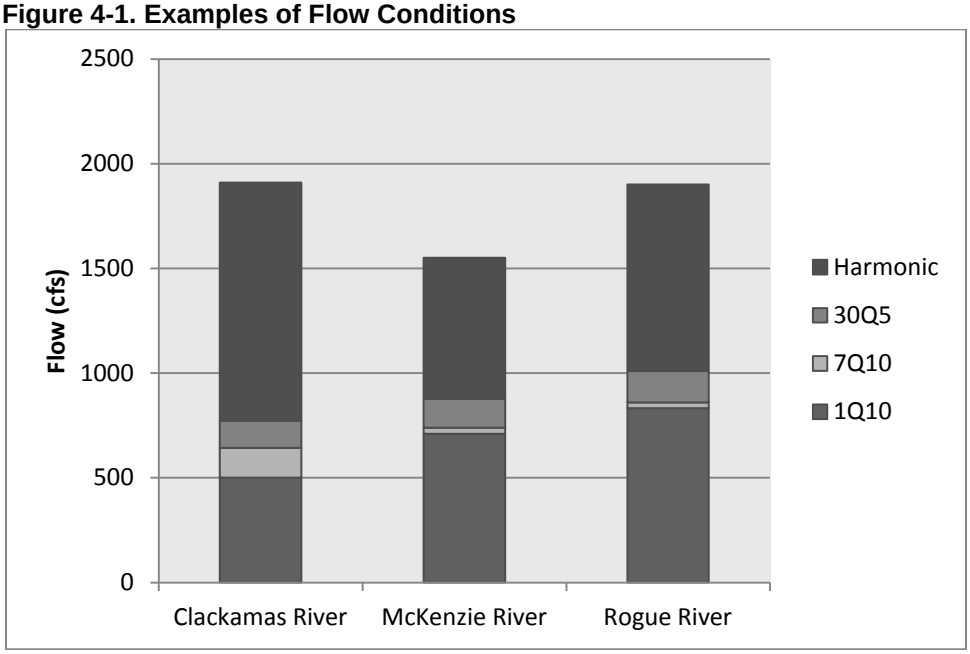
For riverine systems:

- 1Q10 = the lowest one average day flow with a recurrence frequency of once in 10 years. Used in conjunction with aquatic health criteria for protection against acute toxicity.
- 7Q10 = lowest average 7 consecutive day low flow with a recurrence frequency of once in 10 years. Used in conjunction with aquatic chronic health criteria for protection against acute toxicity.

- 30Q5 = lowest average 30 consecutive day low flow with a recurrence frequency of one in 5 years. Used in conjunction with human health criteria for protection against non-carcinogens.
- Harmonic mean flow = long term mean flow value calculated by dividing the number of daily flows by the sum of the reciprocals of those daily flows. Used in conjunction with human health criteria for protection against carcinogens.

The following chart illustrates the critical flow rates for three Oregon streams. The flow corresponding to the top of each box corresponds to the flow for that flow statistic. For example, the 7Q10 flow for the Rogue River is a little over 1000 cfs.

Figure 4-1. Examples of Flow Conditions



4.3 Whole Effluent Toxicity Testing

What Is It?

"Whole Effluent Toxicity" (WET) testing measures whether an effluent in its entirety (with its mixture of various chemicals) causes toxicity in aquatic organisms. WET testing is usually conducted in controlled laboratory experiments in which aquatic organisms are exposed to samples of effluent at different dilutions.

How Does It Relate to RMZs?

A discharger may not cause or significantly contribute constituents or physical properties in concentrations that will cause acute toxicity outside of its ZID (see Section 3.2 for more information on the ZID) or chronic toxicity outside of its RMZ [OAR 340-041-0053(2)(b)(A)]. To assess acute or chronic toxicity levels of an effluent, the department typically uses EPA-approved WET testing methods.

How To Use Wet Test Results

WET tests characterize the effluent concentrations at which chronic and acute toxicity may occur. If WET test results indicate acute or chronic toxicity at concentrations likely to occur at the edge of the ZID or the RMZ respectively, the permit holder may need to re-test the effluent or conduct an evaluation to determine the cause of toxicity.

What are the WET Testing Requirements?

For an overview of WET testing requirements, see the *RPA IMD* which may be found at: http://www.deq.state.or.us/wq/pubs/imds/rpaIMD.pdf

Interpreting Test Results

Interpreting standard WET or rapid screening test results may require the assistance of department laboratory biomonitoring staff.

5. Field Assessments of RMZ Allocations

Overview

This chapter provides information to permit writers to help them determine when additional field assessments may be needed beyond the minimum levels discussed in *Part 2* of the *RMZ IMD* and the types of assessments currently available.

Note: *Part 2* of the *RMZ IMD* specifies the minimum level of information needed in mixing zone studies for permit writers to properly evaluate RMZs. These studies are classified as Level 1- Simple, Level 2- Moderate, or Level 3 - Complex depending on the nature of the discharge and sensitivity of the receiving water. Level 2 – Moderate and Level 3 – Complex studies typically have a field assessment component to ensure the mixing zone is behaving as predicted; however, there may be other situations when further assessment may be necessary beyond what is discussed in *Part 2* of the *RMZ IMD*.

5.1 Why and When?

Why is Further Assessment Necessary?

A field assessment of an existing RMZ may be necessary to ensure that adverse effects to existing and designated beneficial uses outside the RMZ are minimized (see Section 3.3: Outside the RMZ), confirm that mixing zone modeling analyses are accurate, or determine that the permittee is in compliance with RMZ permit conditions. DEQ may request such information from the permittee pursuant to OAR 340-041-0053(2)(f). If field assessments indicate a problem with the RMZ, allocation of the RMZ needs to be re-evaluated. This could result in reducing or relocating the RMZ, eliminating the RMZ, or improving effluent quality.

When to Consider Additional Field Assessments

Field assessments should be considered in the following situations:

- RMZ encroaches on spawning or unique habitat of threatened or endangered species.
- RMZ forms bank or bottom attachments.
- RMZ is located in a small receiving water with little available dilution and the discharger has problems meeting permit effluent limitations.
- RMZ is located in a small receiving water that is water quality limited for the pollutants being discharged and the discharger has problems meeting permit effluent limitations.
- RMZ overlaps with an RMZ for a different discharger under critical flow conditions.
- Whole effluent testing results indicate a potential toxicity problem with the discharge.

This is not an exhaustive list. Other situations may need field assessments. In addition, note that the requirement for a field assessment is not to be used as substitute for discharge monitoring required by permit to determine compliance with effluent limits.

Assistance to Choose Correct Assessment and Interpret Data

The permit writer is not expected to be an expert in field assessments because these assessments are specialized fields of study. Consultation with department modeling and laboratory staff will be necessary. The department *Quality Assurance Project Plan* for mixing zone studies (DEQ06-LAB-

0041-QAPP September, 2006) provides additional information on developing these studies. It will also be necessary to discuss potential field assessments and resulting data interpretations with the discharger and, if applicable, the discharger's consultant. Other experts such as model developers and researchers may also need to be consulted.

How to Require a Field Assessment

The assessments discussed in this section can be required in the permit provided the assessment is not identified as a minimum component of an appropriate mixing zone study needed prior to allocating or reviewing an RMZ (see RMZ IMD Part 2) or during the application process. See Section 6.3 for what to consider when requiring assessments.

5.2 Types of Assessments

Generally, there are three different types of field assessments that may be included in a mixing zone study: mixing/dilution assessments, biological assessments, and chemical assessments. These are briefly described in the following sections.

Mixing/Dilution Assessments

Mixing/dilution assessments are conducted to determine the mixing zone dilutions and to determine the behavior of the plume within the receiving stream (how and when the plume mixes with the receiving stream). Table 5-1 provides a brief overview of different assessments, when they should be useful, what information they provide, and additional references for more information. Part 2 of the RMZ IMD also discusses how assessment information should be used in modeling analyses.

Bioassessments

Bioassessments may be used to investigate concerns that a water body is experiencing ecological impacts due to the discharge and RMZ. Table 5-2 provides a brief overview of different bioassessment techniques that the department believes may be useful in assessing RMZ-specific effects in a water body. Table 5-3 lists additional techniques that are less likely to measure RMZ-specific effects, but that still have the potential to be used for assessing overall health of the water body. These may be more applicable to future RMZ studies.

Chemical Assessments

Chemical assessments require sampling for pollutants outside of the defined ZID or RMZ to determine if the permittee is in compliance with the permit limitations. This type of assessment may also provide information on how a pollutant may react in the environment and undergo a chemical change in form. Chemical assessments are often incorporated into the assessments described above.

Table 5-1. Mixing/Dilution Assessments

Field Assessment	Description	Waterbody Type	Purpose	References (see Appendix C)
Dye Study	Assess mixing and dilution in and around the RMZ	All water bodies	To develop dilution values for use in modeling	(1)
Conductivity	Measure water column conductivity in and around the RMZ	All water bodies	To develop dilution values for use in modeling	(2)
Stream or Effluent Flow	Measure stream or effluent flow	Medium to small streams	To develop flow estimates for use in dilution calculations and modeling	(2)

Table 5-2. RMZ-Related Bioassessment Techniques

Field Assessment	Description	Applications	What does it tell you? (Objectives)	Minimum Sampling	References (see Appendix C)
Macro-invertebrate community survey	Well developed, commonly used bioassessment tool for wadeable streams	▪ Wadeable streams; limited use in larger streams ▪ Point or non-point sources ▪ Long or short term effects	Benthic impairment, diagnose temperature or sediment stress (Aquatic life beneficial use support)	Replicated upstream, ZID, RMZ, downstream sample design	Sampling (3) Analysis (4)
Ambient water column bioassay	Lab test of ambient water. Similar to whole effluent toxicity testing at different dilutions; good potential to characterize effluent toxicity in receiving stream	▪ Large streams typically ▪ Point or non-point sources ▪ Long or short term effects	Direct measure of water body toxicity (Surrogate for beneficial use support)	Replicated upstream, ZID, RMZ, downstream sample design	Sampling and analysis (5)
Rapid screening toxicity tests	Lab test of effluent or ambient water. Similar to whole effluent toxicity testing, but quicker and less expensive	▪ All water bodies ▪ Point or non-point sources	Direct measure of water body or effluent toxicity (Surrogate for beneficial use support)	Replicated upstream, ZID, RMZ, downstream sample design	Sampling and analysis (6)
In-situ bioassay (caged fish studies)	Fish exposed short-term in stream to evaluate exposure effects	▪ All water bodies ▪ Generally point sources ▪ Short term effects	Connects exposure to fish effects (Aquatic life beneficial use support)	Replicated upstream, ZID, RMZ, downstream sample design	Sampling and analysis (7)
Virtual fish studies (lipid bag studies)	Surrogate of fish lipophilic organics contaminant load; becoming more common	▪ All water bodies ▪ Point or non-point sources ▪ Long or short term effects	Surrogate body burden representative of organics from a stream reach (Human/ecological health exposure data)	Replicated upstream, ZID, RMZ, downstream sample design	Sampling and analysis (8)

Table 5-3. Additional Biaoassessment Techniques

Field Assessment	Description	Applications	What does it tell you? (Objectives)	Minimum sampling	References (see **Error! Reference source not found.**)
Vertebrate (Fish) community survey	Well developed bioassessment tool for wadeable streams; relatively common	▪ Wadeable streams; limited use in larger streams ▪ Generally non-point sources ▪ Long term effects	Native fish community impairment (Aquatic life beneficial use support)	Replicated upstream and downstream sample design	Sampling (9) Analysis (10)
Periphyton community survey	Bioassessment tool for wadeable streams and lakes (in development)	▪ Wadeable streams; limited use in larger streams. ▪ Point or non-point sources ▪ Long or short term effects	Primary producer impairment, nutrients, physical/chemical stress (Aquatic life beneficial use support)	Replicated upstream and downstream sample design	Sampling (9) Analysis (11)
Phytoplankton community survey	Bioassessment tool for lakes/large streams (in development)	▪ Large streams and lakes ▪ Point or non-point sources ▪ Long or short term effects	Primary producer impairment (Aquatic life beneficial use support)	Replicated upstream and downstream sample design	Sampling and analysis (12)
Ambient sediment bioassay	Lab test of ambient sediment; common in contaminated sediment work	▪ Large streams typically ▪ Generally point sources ▪ Long or short term effects	Connects sediment exposure to benthic effects (Surrogate for beneficial use support)	Replicated upstream and downstream sample design	Sampling and analysis (13)
Ambient fish or invertebrate tissue survey	Measure of fish contaminant (metals/organics load); common method	▪ All water bodies ▪ Point or non-point sources ▪ Long or short term effects	Body burden representative of water body studied (Human/ecological health exposure data)	Replicated upstream and downstream sample design	Sampling and analysis (14)
Biomarker studies ▪ Enzyme ▪ Tissue ▪ Histo-pathology	Measure of physiological effects of contaminants; less common in Pacific Northwest	▪ All water bodies – focus on sites with known contamination ▪ Generally point sources ▪ Long or short term effects	Connects exposures to sub-chronic effects (Aquatic life beneficial use support)	Laboratory studies, exposed and non-exposed populations	Sampling (15) Analysis (16)

6. Evaluation Report and Permit Language

6.1 Evaluation Report (Fact Sheet) and Checklist

What to Include in Evaluation Report

OAR 340-045-0035(4) requires an evaluation report (fact sheet) be prepared for draft permits that are for "major" facilities or of widespread public interest. The evaluation report must briefly describe the principle facts and significant factual, legal, methodological and policy questions considered in preparing the draft permits. In practice, the department prepares an evaluation report for all NPDES draft permits. If an RMZ is to be allocated, the following information must be included in the evaluation report, preferably in a section titled "Regulatory Mixing Zone Analysis":

I. Mixing zone rule
Include a citation to OAR 340-041-0053 and brief summary of the rule.

II. Mixing zone study
A. Include the level of mixing zone study (e.g., Level I, II, or III; see RMZ IMD Part 2) and a brief description of study results.
B. Include a description of the outfall location and configuration.
C. Include a description on the discharge plume and how it mixes in the receiving water. For example, note any bottom or bank attachments, stratification boundaries, depth of the outfall, estimated distance for plume to reach the surface, etc.

III. Regulatory mixing zone (RMZ)
A. Provide a physical description of the RMZ and whether the RMZ applies to a specific pollutant or to the entire discharge.
B. Include the resulting dilution factor.
C. A statement that the RMZ complies with OAR 340-041-0053.

IV. Zone of immediate dilution (ZID) if allocated
A. Provide a physical description of the ZID.
B. Include the resulting dilution factor
C. A statement that the RMZ complies with OAR 340-041-0053.

V. Permit writer's checklist
Attach checklist in Appendix B.

Permit Writer's Checklist

To document that the RMZ meets the rule requirements, the checklist in Appendix B must be completed and attached to the permit evaluation report.

Examples

See Appendix D for examples of RMZ allocations in evaluation reports.

6.2 Permit Language

RMZ Template Language (Schedule A)

OAR 340-041-0053(2)(c) requires that the limits of the RMZ be described in the permit. The following or similar language must be used for this description:

> *No wastes may be discharged or activities conducted that cause or contribute to a violation of water quality standards in OAR 340-041 applicable to the [insert basin name] basin except as provided for in OAR 340-045-0080 and the following regulatory mixing zone:*

[insert description – see example descriptions below for what needs to be included in a description]

RMZ Not Allowed

If an RMZ is not allocated, use the following or similar language:

> *No wastes may be discharged or activities conducted that cause or contribute to a violation of water quality standards in OAR 340-041 applicable to the [insert basin name] basin except as provided for in OAR 340-045-0080.*

Information to Include in Descriptions

The description of the RMZ must include enough information to easily locate it. Note that this is not a specific description of the location of discharge plume because mixing is variable and controlled by different factors (e.g., velocity and flow rate of the discharge, characteristics of the receiving stream). If a ZID is allowed, it must also be described in the permit. The following must be included:

- **Shape**
  Describe the shape of the RMZ in general terms. For example, radius, band, rectangle, etc.

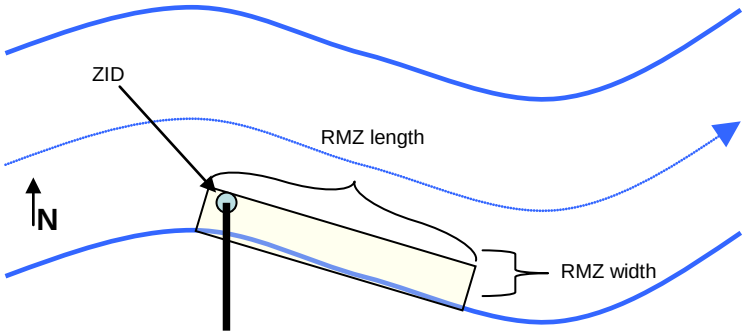
- **Length**
  Specify distance and indicate if upstream or downstream or both. Use reference points such as outfall, discharge point, south bank, etc., to orient the reader.

- **Width**
  Specify distance or easy to understand cross-section (e.g., ½ of stream width). Use reference points such as outfall, discharge point, south bank, etc., to orient the reader.

DO NOT use flow percentages as the *sole* descriptor for an RMZ. This is not an adequate description of an RMZ.

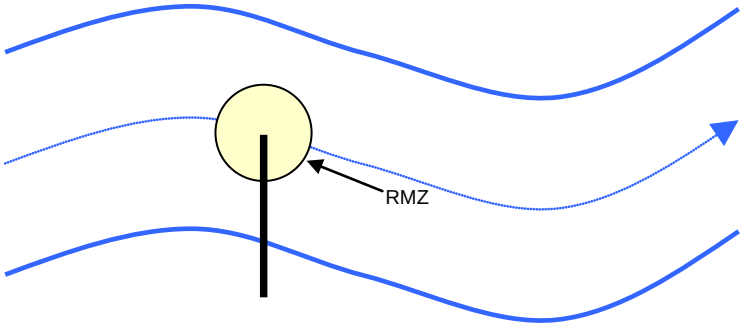
Example Descriptions

1. The portion of ABC River contained within a band extending out 25 feet from the south bank of the river and extending from a point 10 feet upstream of the outfall to a point 75 feet downstream from the outfall. The ZID is the portion of the regulatory mixing zone that is within a 5 foot radius of the point of the outfall.



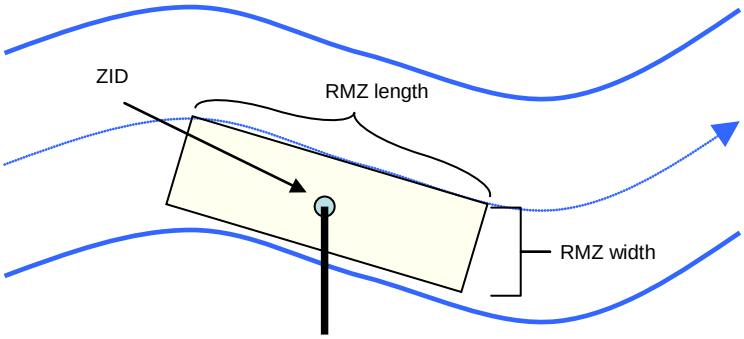
(graphic representation not to scale)

2. The portion of Rogue River within a radius of 100 feet from the outfall. (No ZID allocated in this example.)



(graphic representation not to scale)

3. The portion of ABC Slough contained within a band extending out from the shore side of the outfall to ½ the width of the channel, 200 feet downstream and 200 feet upstream. The ZID is the portion of the regulatory mixing zone that is within a 20 foot radius of the outfall.



(graphic representation not to scale)

6.3 Field Assessment Considerations

Mixing/Dilution Assessment Requirements

At a minimum the permit writer must specify the following when requiring a field assessment by permit or as a permit application requirement:

- Purpose of the assessment (e.g., characterization of the plume dynamics and dilutions at the edge of chronic mixing zone and ZID).
- Minimum elements of the study such as study period, type (e.g., dye or conductivity), plant productions, and discharge conditions (e.g., normal vs. peak).
- Due dates for submittal of necessary information to DEQ. Typically, a plan for conducting a mixing study is required to be submitted to the department for review and approval.

Mixing/Dilution Assessment Example

The following example provides a general idea of what needs to be required:

By no later than {**insert date**}, the permittee must submit a plan for a mixing zone dilution study to DEQ for approval. The purpose of the study is to determine the dilution at the edge of the discharge plume. The study must be conducted using a dye tracer {**or other appropriate tracer**} during the critical receiving stream design conditions {**insert time period**} under normal plant production and discharge conditions. Results of the study must be submitted to the DEQ by {**insert date**}.

Bioassessment Requirements

At a minimum the permit writer must specify the following when requiring a field assessment by permit or as a permit application requirement:

- Purpose of the bioassessment.
- Minimum elements of bioassessment (e.g., study period, number and location of sites).
- References for the sampling and analysis protocol that will be followed. For example references, see Table 5-1 and Table 5-2 and Appendix C.
- Due dates for submittal of necessary information to DEQ.

Bioassessment Example

The following example is unique to a macroinvertebrate bioassessment. Not all bioassessments will be of this nature; however, the example provides a general idea of how the requirement should be written.

1. The permittee must conduct a macroinvertebrate community survey and submit the results to the department within {*insert number of months or year(s)*} of permit issuance. The purpose of this survey is to determine if the aquatic life beneficial use of {*insert stream name*} is negatively impacted outside of regulatory mixing zone's boundaries.

    a. Within {*insert number of months*} of permit issuance and prior to conducting the survey, the permittee must develop and submit a sampling plan to the department for approval. The sampling plan design must be consistent with the guidelines in the Oregon Watershed

Enhancement Board's *Water Quality Monitoring Technical Guide Book (1999)*, Section 12: Stream Macroinvertebrate Protocol, for Level 3 assessments.

b. At a minimum, the permittee must sample {insert *number and type (e.g., riffle, pool)*} sites upstream and {*insert number and type*} downstream of the regulatory mixing zone and between July and September.

c. DEQ may revise the permit to address any issue raised by the survey.

References

Brungs, W.A. 1986. Allocated Impact Zones for Areas of Non-Compliance/ U.S. EPA, Region 1, Water Management Division, Boston, MA.

U.S. EPA. 1991. Technical Support Document for Water Quality–based Toxics Control. EPA/505/2-90-001

U.S. EPA. 1994. Water Quality Standards Handbook: Second Edition. EPA-823/B-94-005a.

Marshall, Randall. 2005. Washington State Department of Ecology Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria. Pub. #95-80. http://www.ecy.wa.gov/biblio/9580.html

Appendix A
Mixing Zone Rule OAR 340-041-0053

340-041-0053

Mixing Zones

(1) The department may allow a designated portion of a receiving water to serve as a zone of dilution for wastewaters and receiving waters to mix thoroughly and this zone will be defined as a mixing zone;
(2) The department may suspend all or part of the water quality standards, or set less restrictive standards in the defined mixing zone, provided that the following conditions are met:
  (a) A point source for which the mixing zone is established may not cause or significantly contribute to any of the following:
    (A) Materials in concentrations that will cause acute toxicity to aquatic life as measured by a Department approved bioassay method. Acute toxicity is lethal to aquatic life as measured by a significant difference in lethal concentration between the control and 100 percent effluent in an acute bioassay test. Lethality in 100 percent effluent may be allowed due to ammonia and chlorine only when it is demonstrated on a case-by-case basis that immediate dilution of the effluent within the mixing zone reduces toxicity below lethal concentrations. The department may on a case-by-case basis establish a zone of immediate dilution if appropriate for other parameters;
    (B) Materials that will settle to form objectionable deposits;
    (C) Floating debris, oil, scum, or other materials that cause nuisance conditions; and
    (D) Substances in concentrations that produce deleterious amounts of fungal or bacterial growths.
  (b) A point source for which the mixing zone is established may not cause or significantly contribute to any of the following conditions outside the boundary of the mixing zone:
    (A) Materials in concentrations that will cause chronic (sublethal) toxicity. Chronic toxicity is measured as the concentration that causes long-term sublethal effects, such as significantly impaired growth or reproduction in aquatic organisms, during a testing period based on test species life cycle. Procedures and end points will be specified by the department in wastewater discharge permits;
    (B) Exceedances of any other water quality standards under normal annual low flow conditions.
  (c) The limits of the mixing zone must be described in the wastewater discharge permit. In determining the location, surface area, and volume of a mixing zone area, the department may use appropriate mixing zone guidelines to assess the biological, physical, and chemical character of receiving waters, effluent, and the most appropriate placement of the outfall, to protect instream water quality, public health, and other beneficial uses. Based on receiving water and effluent characteristics, the department will define a mixing zone in the immediate area of a wastewater discharge to:
    (A) Be as small as feasible;
    (B) Avoid overlap with any other mixing zones to the extent possible and be less than the total stream width as necessary to allow passage of fish and other aquatic organisms;
    (C) Minimize adverse effects on the indigenous biological community, especially when species are present that warrant special protection for their economic importance, tribal significance, ecological uniqueness, or other similar reasons determined by the department and does not block the free passage of aquatic life;

(D) Not threaten public health;
(E) Minimize adverse effects on other designated beneficial uses outside the mixing zone.

(d) Temperature Thermal Plume Limitations. Temperature mixing zones and effluent limits authorized under 340-041-0028(12)(b) will be established to prevent or minimize the following adverse effects to salmonids inside the mixing zone:
  (A) Impairment of an active salmonid spawning area where spawning redds are located or likely to be located. This adverse effect is prevented or minimized by limiting potential fish exposure to temperatures of 13 degrees Celsius (55.4 Fahrenheit) or less for salmon and steelhead, and 9 degrees Celsius (48 degrees Fahrenheit) for bull trout;
  (B) Acute impairment or instantaneous lethality is prevented or minimized by limiting potential fish exposure to temperatures of 32.0 degrees Celsius (89.6 degrees Fahrenheit) or more to less than 2 seconds);
  (C) Thermal shock caused by a sudden increase in water temperature is prevented or minimized by limiting potential fish exposure to temperatures of 25.0 degrees Celsius (77.0 degrees Fahrenheit) or more to less than 5 percent of the cross section of 100 percent of the 7Q10 low flow of the water body; the department may develop additional exposure timing restrictions to prevent thermal shock; and
  (D) Unless the ambient temperature is 21.0 degrees of greater, migration blockage is prevented or minimized by limiting potential fish exposure to temperatures of 21.0 degrees Celsius (69.8 degrees Fahrenheit) or more to less than 25 percent of the cross section of 100 percent of the 7Q10 low flow of the water body.

(e) The department may request the applicant of a permitted discharge for which a mixing zone is required, to submit all information necessary to define a mixing zone, such as:
  (A) Type of operation to be conducted;
  (B) Characteristics of effluent flow rates and composition;
  (C) Characteristics of low flows of receiving waters;
  (D) Description of potential environmental effects;
  (E) Proposed design for outfall structures.

(f) The department may, as necessary, require mixing zone monitoring studies and/or bioassays to be conducted to evaluate water quality or biological status within and outside the mixing zone boundary;

(g) The department may change mixing zone limits or require the relocation of an outfall, if it determines that the water quality within the mixing zone adversely affects any existing beneficial uses in the receiving waters.

Appendix B
RMZ Evaluation Report Checklist

Oregon DEQ RMZ Evaluation Report Checklist - NPDES Individual Permits (v2-2012)			
Legal Name:			
Common Name:			
File #:	Permit #:		
Application Date:	Application #:		
Application Type: ☐ New	☐ Renewal	☐ Modification	
RMZ Description			
OAR 340-041-0053(2)(c)	**Length**	**Width**	**Shape**
Description of ZID in permit:			
Description of RMZ in permit:			

Conditions within the RMZ	
OAR 340-041-0053(2)	**Demonstration**
No materials in concentrations that will cause acute toxicity to aquatic life; ZID allowed if immediate dilution	Check one: ☐ No ZID necessary; RPA conducted and no reasonable potential to violate acute criteria at end of pipe. ☐ No ZID allowed; cannot meet IMD guidelines. ☐ ZID allowed; IMD guidelines met (check one): ☐ High velocity discharge – ZID limited to 50 times discharge length scale[1] ☐ Low velocity discharge, most restrictive met (check one): ☐ ZID limited to 10% of RMZ ☐ ZID limited to 50 times discharge length scale ☐ ZID limited to 5 times local water depth form discharge outlet. ☐ Other: [1]Discharge length scale = square root of the pipe cross sectional area.(RMZ IMD Part 1, Section 3.2)
No objectionable deposits, floating debris, oil, scum, or other nuisance materials; no substances in concentrations that produce deleterious fungal or bacterial growths	Check one: ☐ For new permit, chemical and physical characteristics of discharge reviewed and should not be a problem. ☐ For permit renewal, chemical and physical characteristics of discharge reviewed and should not be a problem (if feasible, visited outfall location to observe discharge). (RMZ IMD Part 1, Section 3.1)

Oregon DEQ RMZ Evaluation Report Checklist - NPDES Individual Permits (v2-2012)	
Legal Name:	
Common Name:	
File #:	Permit #:
Application Date:	Application #:
Application Type: ☐ New	☐ Renewal ☐ Modification
Avoid overlap with other mixing zones to extent possible	Check one: ☐ Avoids overlap with all known individual permit RMZs. ☐ Overlaps with RMZ(s) from different permittee(s); overlap acceptable as discussed in evaluation report. ☐ Overlaps with RMZ(s) from different outfall(s); overlap acceptable as discussed in evaluation report. To be determined by permit writer. See http://deq05/wqoutfalls/EOPbasics.aspx (RMZ IMD Part 1, Section 3.1)
Less than the total stream width as necessary to allow passage of fish and other aquatic organisms	Check one: ☐ RMZ width less than stream width. ☐ RMZ extends across full width of stream, but acceptable as discussed in evaluation report. (RMZ IMD Part 1, Section 3.1)
Not threaten public health	Check one: ☐ *E. coli* criteria for water contact recreation met at end of pipe. ☐ RMZ for *E. coli* criteria allowed, but acceptable as discussed in evaluation report. Check one: ☐ Fecal coliform criteria met at shellfish harvesting area. ☐ Fecal coliform criteria for shellfish consumption not applicable. Check all that apply: ☐ RMZ does not overlap with drinking water intake(s). To be determined by permit writer. See http://deq05/wqoutfalls/EOPbasics.aspx ☐ Results of environmental mapping indicate that RMZ does not impinge on public beaches, boat ramps, docks, or shellfish harvesting areas. (RMZ IMD Part 1, section 3.1 and Part 2, Section 4.1) (RMZ IMD Part 1, Section 3.4)

Oregon DEQ RMZ Evaluation Report Checklist - NPDES Individual Permits (v2-2012)	
Legal Name:	
Common Name:	
File #:	Permit #:
Application Date:	Application #:
Application Type: ☐ New	☐ Renewal ☐ Modification
Minimize adverse effects on the indigenous biological community	☐ Results of environmental mapping indicate that RMZ does not impinge on spawning areas, critical structural habitat (e.g., large woody debris), shellfish growing areas or other biologically sensitive areas. (RMZ IMD Part 1, section 3.1 and Part 2, Section 4.1) ☐ Total area affected by all RMZs combined is small when compared with the total area of the water body. To be determined by permit writer. See http://deq05/wqoutfalls/EOPbasics.aspx (RMZ IMD Part 1, Ch. 3) ☐ If required, results of field assessment (e.g., dye study, bioassessment) indicate adverse effects nonexistent or minimized. (RMZ IMD, Part 1, Section 5)
Thermal plume requirements	Check one: ☐ Temperature is not a pollutant of concern. ☐ Temperature is a pollutant of concern, however, RMZ meets ALL of the following (check to indicate that each condition has been evaluated): ☐ Potential fish exposure to temperatures of 13°C (55.4°F) or more for salmon and steelhead, and 9°C (48°F) or more for bull trout prevented. ☐ Potential fish exposure to temperatures of 32.0°C (89.6°F) or more to less than 2 seconds prevented. ☐ Potential fish exposure to temperatures of 25.0° C (77.0° F) or more to less than 5 percent of the cross section of 100 percent of the 7Q10 low flow of the water body prevented; OR additional exposure timing restrictions to prevent thermal shock developed. ☐ Ambient temperature is 21.0°C (69.8°F) or greater ☐ Ambient temperature is less than 21.0°C (69.8°F) so potential fish exposure to temperatures of 21.0°C (69.8°F) or more to less than 25 percent of the cross section of 100 percent of the 7Q10 low flow of the water body prevented. (RMZ IMD, Part 1, Section 3.5)

Appendix C

References for Mixing/Dilution Assessments and Bioassessment

1. USGS Fluorometric procedures for dye tracing, revised, by J.F. Wilson, Jr., E.D. Cobb, and F.A. Kilpatrick: USGS-TWRI Book 3, Chapter A12. 1986.

2. **Oregon Department of Environmental Quality Laboratory Method of Operations Manual – Version 31. 2004.** ODEQ. Portland, Oregon.

3. **Oregon Watershed Enhancement Board. 2001.** Oregon Plan for Salmon and Watersheds - Water Quality Monitoring Guidebook.

   Peck, D. V., J. M. Lazorchak, and D. L. Klemm (editors). 2001. Unpublished Draft. Environmental Monitoring and Assessment Program – Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams. U.S. EPA, Washington, D. C.

4. **Wright, J.F., D. Moss, P.D. Armitage, and M.T. Furse. 1984.** A preliminary classification of running water sites in Great Britain based on macro-invertebrate species and the prediction of community type using environmental data. *Freshwater Biology* 14: 221-256.

   Wright, J.F., M.T. Furse, and P.D. Armitage. 1994. Use of macroinvertebrates communities to detect environmental stress in running waters. In *Water quality and stress indicators in marine and freshwater systems: linking levels of organisation*, D. W. Sutcliffe (ed.), pp. 15-34. Freshwater Biological Association, Ambleside.

   Wright, J.F. 1995. Development of a system for predicting the macroinvertebrate fauna of flowing waters. *Australian Journal of Ecology* 20:181-197.

   Wright, J.F. 2000. An introduction to RIVPACS. In *Assessing the Biological Quality of Fresh Waters*, J.F. Wright, D.W. Sutcliffe and M.T. Furse (eds.), pp. 1-24. Freshwater Biological Association, Ambleside, UK.

5. **Crane, M., P. Delaney, C. Mainstone, and S. Clarke. 1996.** Measurement by in situ bioassay (on site or on-the-field) of water quality in an agricultural catchment. *Water Res.* 29:2441–48.

6. **Washington Department of Ecology's *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria (revised June 2005)*.** Pub. No. WQ-R-95-80, http://www.ecy.wa.gov/biblio/9580.html

7. **Schulz, R, Liess, M. 1999.** Validity and Ecological Relevance of an active in situ bioassay *using Gammarus pulex* and *Limnephilus lunatus*. Environmental Toxicology and Chemistry, 18:10, pp: 2243-2250.

   Grange, F. 2002. Organophosphate Insecticides and Inhibition of Acetylcholinesterase Activity in Steelhead. Master's Thesis, Portland State University.

8. **USGS Semipermeable Membrane Devices (SPMD) bibliography:** http://wwwaux.cerc.cr.usgs.gov/SPMD/SPMD_references.htm.

9. **Peck, D. V., J. M. Lazorchak, and D. L. Klemm (editors). 2001.** Unpublished Draft. Environmental Monitoring and Assessment Program – Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams. U.S. EPA, Washington, D. C.

10. **Hughes, R.M., S. Howlin, and P.R. Kaufmann. 2004.** A Biointegrity index for Coldwater Streams of Western Oregon and Washington. *Transactions of the American Fisheries Society* 133:1497-1515.

    Mebane, C.A., T.R. Maret, and R.M. Hughes. 2003. An Index of Biological Integrity (IBI) for Pacific Northwest Rivers. *Transactions of American Fisheries Society* 132 (2):239-261.

    Hughes, R. M., and J.R. Gammon. 1987. Longitudinal Changes in Fish Assemblages and Water Quality in the Willamette River, Oregon. *Transactions of American Fisheries Society* 116:196-209.

11. **Pan, Y., A. T. Herlihy, P.R. Kaufmann, P.J. Wigington, J. Van Sickle, and T.J. Moser. 2004.** Linkages between land-use, water quality, physical habitat conditions and lotic diatom assemblages: a multi-scale assessment. *Hydrobiologia* 515:59-73.

    Pan, Y., R. J. Stevenson, B. H. Hill, A. T. Herlihy, and G. B. Collins. 1996. Using diatoms as indicators of ecological conditions in lotic systems: a regional assessment. *Journal of the North American Benthological Society* 15(4): 481-495.

12. **Moulton, S.R., II, J.G. Kennen, R.M. Goldstein, J.A. Hambrook. 2002.** Revised protocols for sampling algal, invertebrate, and fish communities in the National Water-Quality Assessment program, USGS Open-File Report 02-150. In Press.

    Porter, S.D., T.F. Cuffney, M.E. Gurtz, M.R. Meador. 1993. Methods for Collecting Algal Samples as Part of the National Water Quality Assessment Program. USGS Open-File Report 93-409, Raleigh, NC [39 pp]: http://water.usgs.gov/nawqa/protocols/OFR-93-409/alg1.html Note on USGS page that this has been superseded by 02-150: http://water.usgs.gov/nawqa/protocols/OFR02-150/index.html

13. **Castro, B.B. et al. 2003.** In situ bioassay chambers and procedures for assessment of sediment toxicity with *Chironomus riparuis*; *Environmental Pollution* 125(3): 325-335, 2003.

    Woodall, D.W., N.N. Rabalais, R.P. Gambrell, and R.D. DeLaune. 2003. Comparing methods and sediment contaminant indicators for determining produced water fate in a Louisiana estuary. *Marine Pollution Bulletin* 46(6): 731-740, 2003.

    USGS Sediment Toxicity Testing Methods and Data Interpretation Bibliography: http://www.cerc.cr.usgs.gov/pubs/sedtox/sedbib.htm.

    U.S. EPA. 1998. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates, Second Edition. Draft 4/1/98, Duluth, MN.

14. **U.S. EPA. 1995.** Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual – Estuaries, Volume 1: Biological and Physical Analyses. United States

Environmental Protection Agency, Office of Research and Development, Narragansett, RI. EPA/620/R-95/008

U.S. EPA. 2001. National Coastal Assessment: Field Operations Manual. U.S. EPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA 620/R-01/003.

U.S.EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Plan 2001-2004. U.S. EPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA 620/R-01/002.

15. **Liess, M., R. Shulz. 1999.** Linking insecticide contamination and population response in an agricultural stream. *Environmental Toxicology and Chemistry*, 18:9 pp: 1948-1955.

16. **USGS Biomonitoring of Environmental Status and Trends (BEST)** program biomarker studies in coastal estuaries: http://www.best.usgs.gov/.

17. **Sandahl, J., J.J. Jenkins. 2002.** Pacific steelhead exposed to chlorpyrifos: Benchmark concentration estimates for Acetylcholinesterase Inhibition. *Environmental Toxicology and Chemistry*, 21:11, pp: 2452-2458.

Appendix E

Revision History

Overview

Rev. 1 Initial Publishing of document, December 2007
Rev. 1.1 Minor editorial changes, November 2008
Rev. 2.0 Changes to content, wording and formatting, May 2012.

Revisions

Rev. 1.1

- P.19, Table 3-1, change title from "*Average Mixing Zone Size*" to "*Average RMZ Size*"
- Minor formatting changes throughout document
- Addition of **Appendix E: Revision History**

Rev. 2.0
Section 1

- The term CMZ has been deleted and replaced with the term RMZ for the purposes of consistency.

Section 2

- The description of the allocation process has been clarified by including mention of the RPA Tier 1 analysis.

- The IMD has been modified to clarify that the RMZ developed for the protection of human health does not have to be the same size as the RMZ developed for the protection of aquatic health. A justification is provided.

- A discussion of options that exist when there is insufficient assimilative capacity to accommodate a mixing zone has been added. This includes a listing of DEQ's applicable IMDs.

Section 3

- The terms swimming holes, swimming areas and fishing holes have been replaced with the terms public beaches, docks and boat ramps because they are more identifiable and therefore less likely to be overlooked.

- The requirement to review treatment technology in relation to the "as small as feasible" requirement for mixing zones has been clarified.

- The term "CMC" has been replaced with the term "ZID". For the purposes of this document, they refer to the same thing and it is unnecessarily confusing to use two terms where one will do.

- The justification for allowing an RMZ for the protection of human health that is larger than the RMZ for the protection of aquatic life has been expanded to include explanation of the basis on which human health criteria are developed.

- The discussion of PBTs has been modified for readability, and the discussion of SB737 has been deleted because it is outdated.

Section 4

- The discussion of flow statistics has been expanded to say when each is used.
- The graph demonstrating the difference between the various flow statistics has been replaced with one that is more illustrative.

- The discussion of WET (Whole Effluent Toxicity) testing has been updated to reflect DEQ's current practice.

Appendix B

- The RMZ Evaluation Report Checklist has been modified slightly. Changes include the addition of a definition of the discharge length scale as well as links to DEQ's internal webpage with information on outfall location data.