
Analytical Detection and Quantification Limits: Survey of State and Federal Approaches

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Analytical Detection and Quantification Limits: Survey of State and Federal Approaches

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Abstract

As analytical methods and technologies continue to improve, and trace concentrations of pollutants in ambient waters are better quantified, regulatory agencies are increasingly setting effluent permit limits for some pollutants near analytical detection limits, and establishing policies for determining compliance with these stringent limits. The American Petroleum Institute (API) conducted a review of state policies related to analytical detection and quantification limits, with particular focus on water quality and wastewater issues in permitting and compliance. Of the ten states considered in this review, every state was found to incorporate detection or quantification terms in its regulations to some extent. Some of the states prefer to have the most detailed policies in their water quality implementation procedures; other states prefer to put the detail directly in the regulations. Most of the states specify, either in their regulations or implementation procedures, how compliance is demonstrated. Permittees can ensure that they obtain permit limits that do not cause compliance monitoring problems by paying particular attention to effluent data during the permit application process, by identifying early in the permitting process the need for site-specific detection and quantification limits, and by understanding the state's permit requirements and policies specifying how compliance is to be demonstrated.

Table of Contents

Executive Summary	1
Introduction	2
Overview of Report.....	2
Overview of Approaches.....	2
State Policies	8
Recommendations for Compliance Monitoring	29
Appendix	
List of State Regulations Citing Detection/Quantification Terms	31

Tables

1	Detection and Quantification Terms	3
2	Other Detection and Quantification Terms Used in Federal Water and Wastewater Programs.....	4
3	Comparison of Detection and Quantification Terms	9
4	Detection and Quantification Terms Used in Other Federal Programs.....	12
5	Summary of Analytical Detection and Quantification Terms Used by States	15

Analytical Detection and Quantification Limits: Survey of State and Federal Approaches

Executive Summary

The American Petroleum Institute (API) conducted a review of state policies related to analytical detection and quantification limits, with particular focus on water quality and wastewater issues in permitting and compliance. Ten states were reviewed: Alabama, California, Illinois, Louisiana, New Jersey, Ohio, Oklahoma, Pennsylvania, Texas, and Washington.

Summary findings of this review are:

- Every state incorporates detection or quantification terms in its regulations. Terms referenced in regulations are usually defined in the regulations, but not always. The most frequently used terms are detection limit/level, method detection limit (MDL), and practical quantitation level (PQL). Minimum level (ML) is used by Alabama, California, Illinois, and Ohio.
- The states vary in the extent to which detection and quantification terms are incorporated into their regulatory language. Some states prefer to have the most detailed policies in their water quality implementation procedures; other states prefer to put the detail directly in the regulations.
- The states will set wastewater permit limits at or below detection or quantification levels, where considered protective of water quality. Most states specify, either in their regulations or implementation procedures, how compliance is demonstrated in such cases. Compliance with a maximum concentration limit is demonstrated by a “less-than” analytical result (a detection or quantification limit, as applicable). Where a mass load or average concentration is calculated, most states specify that zero be used in lieu of less-than values. In some situations, one-half the detection limit must be used.
- Although the states have procedures for allowing wastewater permittees to develop site-specific detection or quantification limits based on state- or EPA-defined methods, none of the states had specific procedures for developing or approving alternative methods. State staff indicated that approval of alternative methods would be on a case-by-case basis, and likely coordinated with the USEPA.
- Permittees can ensure that they obtain permit limits that do not cause compliance monitoring problems related to detection and quantification issues. During the permitting process, permittees should pay particular attention to effluent data in the application, the need for site-specific detection and quantification limits or procedures, and permit requirements specifying how compliance is to be demonstrated.

Introduction

The purpose of this review was to determine the analytical detection and quantification limit policies of various state agencies. Of particular interest were policies for setting wastewater discharge permit limits at or below detection or quantification limits, for determining compliance with such limits, and for using alternative approaches to determining detection or quantification limits. Although the main focus of this review was on state policies involving water quality issues, included in the review were the policies of programs in other environmental areas as well as in federal regulations and statutes.

Ten states were selected for review: Alabama, California, Illinois, Louisiana, New Jersey, Ohio, Oklahoma, Pennsylvania, Texas, and Washington. State environmental regulations and water quality implementation procedures were reviewed, and state environmental staff were contacted and interviewed, to obtain information on detection and quantification limit policies.

Overview of Report

Presented first is an overview of approaches for analytical detection and quantification limits in environmental programs. The overview describes various detection and quantification terms, including method detection limit (MDL), minimum level (ML), practical quantitation (or quantification) level (PQL), alternative minimum level (AML), interlaboratory quantification estimate (IQE), and others. Next, the policies of the ten selected states are presented. Lastly, recommendations are provided for setting effluent limits and compliance monitoring requirements in wastewater discharge permits.

Overview of Approaches

This section provides an overview of selected approaches for determining analytical detection and quantification levels used in environmental programs. Table 1 lists the terms most often used in these programs, as well as two alternatives (AML, IQE) that have been suggested by others. In the following sections, these terms, as they are used in wastewater programs, are discussed in detail, and their similarities and differences are compared. Terms used in other environmental programs, both state and federal, are identified.

Water and Wastewater Programs

The most common detection and quantification limits in water and wastewater programs are the MDL, ML, and PQL. The MDL can be used to calculate both the ML and the PQL. Variations of these and other related terms can be found in water and wastewater programs. Definitions of these terms as given in the regulations are provided

Table 1
Detection and Quantification Terms

Detection Terms	
DL	Detection limit
LOD	Limit of detection
MDL	Method detection limit
Quantification Terms	
AML	Alternative minimum level
IQE	Interlaboratory quantification estimate
LOQ	Limit of quantitation
ML	Minimum level
PQL	Practical quantitation level
	Practical quantification level

in Table 2; no references to analytical detection terms were found in federal environmental statutes. These basic definitions are discussed in the following sections.

Detection Levels

The USEPA has a specific definition of the MDL in its regulations. Among the various state and federal programs, there may be modifications to this definition or references to other detection terms (some defined and some not).

Method Detection Limit (MDL)

The MDL is a detection term defined by the USEPA as:

“...the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.”
[40 *CFR* 136, Appendix B]

The typical MDL procedure is to analyze seven aliquots of a sample at a low concentration, 1 to 5 times the estimated MDL. The MDL can be measured in reagent water (water with no impurities) or in any wastewater matrix (matrix-specific MDL). If the sample does not already contain the analyte in this concentration range, it is spiked with the analyte. The standard deviation of the seven analytical values is calculated. The

Table 2
Other Detection and Quantification Terms
Used in Federal Water and Wastewater Programs

Term	Definition	Reference
Drinking Water		
Detection level	The lowest concentration of a target contaminant that a given method or piece of equipment can reliably ascertain and report as greater than zero (e.g., instrument detection limit, method detection limit, or estimated detection limit).	40 <i>CFR</i> 141.35
Practical quantitation level	No definition given in regulations	40 <i>CFR</i> 141.81 40 <i>CFR</i> 141.89
Effluent Guidelines		
Instrument detection limit	No definition given in regulations	40 <i>CFR</i> 430, Appendix A
Method detection limit	The minimum concentration of a substance that can be identified, measured and reported with 99 percent confidence that the analyte concentration is greater than zero and determined from analysis of a sample in a given matrix containing analyte [sic].	40 <i>CFR</i> 425, Appendix C
Method detection limit	No definition given in regulations	40 <i>CFR</i> 434.64
Pretreatment Standards		
Analytical detection limit	No definition given in regulations	40 <i>CFR</i> 403.6
Water Quality Standards		
Quantification level	A measurement of the concentration of a contaminant obtained by using a specified laboratory procedure calibrated at a specified concentration above the method detection level. It is considered the lowest concentration at which a particular contaminant can be quantitatively measured using a specified laboratory procedure for monitoring the contaminant.	40 <i>CFR</i> 132.2
Minimum level Quantification level	The minimum level (ML) specified in or approved under 40 <i>CFR</i> 136 for the method for that pollutant. If no such ML exists, or if the method is not specified or approved under 40 <i>CFR</i> 136, the quantification level shall be the lowest quantifiable level practicable.	40 <i>CFR</i> 132, Appendix F

MDL is calculated as the standard deviation multiplied by the “Student’s” t value for the 99th percentile (3.143 for seven analyses).

Limit of Detection (LOD)

The LOD is defined by the American Chemical Society (ACS) as:

“...the lowest concentration level that can be determined to be statistically different from a blank.”

[ACS 1983, pg. 2216]

The LOD is calculated as three times the standard deviation, σ , at either zero (blank) or the lowest level of measurement. It differs from the USEPA's MDL in the multiplying factor [3 versus 3.143 (or other Student's t value)] and in not having a recommended number of replicate analyses. Use of σ , the population standard deviation, implies an infinite number of analyses, or at least a very large number. In practice, the sample standard deviation, s , would be used as a substitute for σ .

Other Detection Terms

Other detection terms used in state programs are discussed in the section on **State Policies**. Those found in federal regulations are listed in Table 2.

Quantification Levels

The USEPA's approaches to the ML and PQL are described in the following sections. Although the term LOQ is not used per se in these programs, a description of the term is also provided because of its relation to the ML. The AML and IQE, which have been promoted to the USEPA as improved quantification levels, are also described. Following these descriptions is a summary of other quantification terms used in water and wastewater programs.

Minimum Level

The ML is a quantification term defined by the USEPA as:

“The concentration at which the entire analytical system must give a recognizable signal and acceptable calibration point. The ML is the concentration in a sample that is equivalent to the concentration of the lowest calibration standard analyzed by a specific analytical procedure, assuming that all of the method-specified sample weights, volumes, and processing steps have been followed.”¹

The ML concept and how it is calculated have evolved over time. Currently, MLs are usually either calculated as 3.18 times the MDL, or set equal to the lowest calibration standard. The factor of 3.18 is derived from another quantification term, the LOQ (see description later in this section).

¹“National Guidance for the Permitting, Monitoring, and Enforcement of Water Quality-Based Effluent Limitations Set Below Analytical Detection/Quantitation Levels,” Draft, U.S. Environmental Protection Agency, Washington, DC, March 22, 1994.

Interim Minimum Level

Interim minimum level (IML) is a term created by the USEPA to describe MLs that are based on 3.18 times the MDL, to distinguish them from MLs that have been promulgated.

Practical Quantitation Level

The PQL is a quantitation term originally developed by the USEPA for its drinking water program. The USEPA defined the PQL as:

“The lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions...”

[50 FR 46906]

The PQL is intended to account for interlaboratory variability and matrix effects on quantitation. PQLs may be based on USEPA laboratory performance evaluation (PE) studies, choosing a level at which a majority of the laboratories can obtain results within a given range—for example, 80% of the laboratories fall within $\pm 40\%$ of the true value. In practice, a PQL usually is set at 5 to 10 times an MDL based on reagent water. Thus, if the MDL is used to calculate both the PQL and ML, the PQL will be higher.

Limit of Quantitation

The LOQ is defined by the ACS as:

“...the level above which quantitative results may be obtained with a specified degree of confidence.”

[ACS 1983, pg. 2216]

It is calculated as 10 times the standard deviation, σ , at either zero (blank) or the lowest level of measurement. Thus, it is 3.33 times the LOD ($10\sigma \div 3\sigma$). The USEPA equates its ML to the LOQ (10σ) and its MDL sample standard deviation, s , to σ . Because the USEPA's MDL is $3.143s$, its ML is 3.18 times the MDL ($10s \div 3.143s = 3.18$).

The factor of 10 in the LOQ approach is based on a target performance level, measured by a relative standard deviation (RSD) of 10%, or conversely, a signal-to-noise ratio of 10:1. The choice of 10% is arbitrary, but is considered reasonable.

Interlaboratory Quantification Estimate

The IQE is published by the American Society for Testing and Materials (ASTM) as the standard procedure D6512-00, “Standard Practice for Interlaboratory Quantitation

Estimate.” The IQE is associated with Z% relative standard deviation (IQEZ%). The IQEZ% is calculated as the lowest concentration for which a single measurement from a laboratory in a group of qualified laboratories in an interlaboratory study will have an estimated Z% relative standard deviation, based on the interlaboratory standard deviation. Z is typically an integer multiple of 10 (10, 20, 30, etc.).

Alternative Minimum Level

The AML is defined by Gibbons et al. (1997) on the same basis as USEPA’s ML, but with notable differences. Like the ML, the AML is defined as the concentration at which the instrument response is 10 times the standard deviation, s . With the AML, the standard deviation is calculated as a function of concentration, whereas the ML uses a fixed standard deviation from a set of replicate analyses. The AML can account for interlaboratory variability and sample matrix effects. Where only single laboratory (intralaboratory) data are available, an adjustment is made to estimate an interlaboratory value.

Other Terms

Other quantification terms used in state programs are discussed in **State Policies**. Those found in federal regulations are listed in Table 2. Definitions are included in Table 2 if they were given in the regulations. No references to analytical quantification terms were found in federal environmental statutes.

Comparison of Approaches

A comparison of the USEPA’s approaches (MDL, ML, PQL) to the alternate AML and IQE is provided in Table 3. The LOD and LOQ approaches are included in the comparison because of their relationship to the others. Table 3 lists for each term its calculation basis, its advantages, and its disadvantages or issues of concern.

The MDL is simple to calculate and widely used in regulatory programs, but has been criticized for various reasons. Because it assumes that the standard deviation does not vary with concentration, its calculation is sensitive to the choice of concentration for the replicate analyses instead of the actual capability of the analytical method. The standard deviation used in the calculation is based on a relatively small data set, usually seven replicates from one laboratory. Because of the extra care a laboratory will take with this procedure, an MDL is not likely to represent routine laboratory performance. The ML is also simple to calculate and widely used in regulatory programs, but because of its relation to the MDL, it has been criticized in a similar manner.

The LOD and LOQ are not used as often in regulatory programs. The LOD is similar to the MDL and the LOQ to the ML in calculation and in assuming that the standard deviation does not vary with concentration. The LOD and LOQ are based on the

population standard deviation, which is usually not known or would require a large number of samples to estimate.

The PQL is simple to calculate and widely used in regulatory programs. It is sensitive to concentration, whether it is based on the MDL or PE studies. Laboratories involved in PE studies usually are experienced and know they are being tested, so that a PQL based on these data are not likely to represent capabilities of ordinary laboratories working under routine conditions. PQLs based on PE studies may be too high if the study concentrations are much higher than quantitation levels. Many of the already published PQLs are often fixed values derived by consensus rather than specific laboratory studies.

The AML and IQE have been proposed as improvements to the USEPA's ML and PQL approaches. The AML is not sensitive to concentration because it defines the standard deviation as a function of concentration. It requires more calculation steps, but these calculations can be easily set up in a spreadsheet. The AML can incorporate variability from multiple analysts, instruments, and laboratories. It incorporates uncertainty in the calibration function relating instrument response to true concentration and uncertainty in the standard deviation.

The IQE method is intended to allow most laboratories, using a standard measurement system, to attain at reasonable cost the IQE quantification performance in routine analyses. The IQE should realistically include sources of bias and variation that are common to the measurement process (for example, instrument noise, differences in laboratories, analysts, sample preparation, and instruments). The IQE should realistically exclude avoidable sources of bias and variation (for example, modifications to the sample, analytical procedure, analytical equipment, and transcription errors). The IQE applies to methods for which calibration error is minor relative to other sources.

Terms Used in Other Programs

Besides water and wastewater, analytical detection and quantification terms are used in other regulatory programs. Those used in state programs are discussed in the next section, **State Policies**. Table 4 here lists terms found in federal regulations for air, solid waste and hazardous waste, and hazardous substances. No references to analytical detection or quantification terms were found in federal environmental statutes.

State Policies

Ten states were selected for review of their policies for analytical detection and quantification in their environmental programs: Alabama, California, Illinois, Louisiana, New Jersey, Ohio, Oklahoma, Pennsylvania, Texas, and Washington. An overview of the policies in these states as a group is provided first, followed by a more detailed discussion of each individual state's policies.

Table 3
Comparison of Detection and Quantification Terms

Term	Method of Calculation	Advantages	Disadvantages/Issues
Detection Levels			
MDL	3.143s (1)	Simple to calculate Widely used in regulatory programs	Value is sensitive to concentration level used in replicate analyses. Assumes standard deviation does not vary with concentration. Extra care taken with MDL samples not likely to represent routine laboratory performance. Standard deviation based on relatively small data set (seven replicates from one laboratory).
LOD	3 σ	Simple to calculate	Assumes standard deviation does not vary with concentration. Based on standard deviation of population when usually only sample standard deviation is available. Not commonly used in regulatory programs.
Quantification Levels			
ML	10s 3.18 MDL Lowest calibration standard	Simple to calculate Widely used in regulatory programs	Value is sensitive to concentration level used in replicate analyses. Assumes standard deviation does not vary with concentration and is the same at the MDL as it is at the ML. Extra care taken with MDL samples not likely to represent routine laboratory performance. Not specifically designed to incorporate interlaboratory variability. Earlier promulgated MLs based on screening protocols or USEPA contract reporting levels, which may not represent current laboratory performance. Standard deviation based on relatively small data set (seven replicates from one laboratory). Because ML is a single point estimate, actual %RSD cannot be calculated and compared to data quality objectives.

Table 3 (continued)

Comparison of Detection and Quantification Terms

Term	Method of Calculation	Advantages	Disadvantages/Issues
LOQ	10σ	Simple to calculate Requires the %RSD to be relatively small (10%)	Assumes standard deviation does not vary with concentration. Based on standard deviation of population when usually only sample standard deviation is available. Not commonly used in regulatory programs.
PQL	5 to 10 times MDL Level which certain percentage of laboratories can achieve	Simple to calculate Widely used in regulatory programs	Value is sensitive to concentration level used in replicate analyses. Usually determined at single concentration. Laboratories involved in interlaboratory studies usually are experienced and know they are being tested; results are not likely to represent capabilities of ordinary laboratories working under routine conditions. PQLs based on USEPA performance evaluation (PE) studies may be too high if PE sample concentrations are much higher than quantitation levels. Published values are often fixed values derived by consensus rather than specific laboratory studies.
AML	Concentration at which the instrument response is 10s (2)	Not sensitive to concentration levels used in replicate analyses Can incorporate variability from multiple analysts, instruments, and laboratories Incorporates uncertainty in the calibration function relating instrument response to true concentration and uncertainty in the standard deviation at the AML Typically provides an %RSD around 10%	Requires more calculation steps, but can be set up for spreadsheet calculation. Standard deviation must be expressed as function of concentration.

Table 3 (continued)
Comparison of Detection and Quantification Terms

Term	Method of Calculation	Advantages	Disadvantages/Issues
IQE	The lowest concentration for which a single measurement from a laboratory in a group of qualified laboratories in an interlaboratory study will have an estimated Z% relative standard deviation, where Z is typically an integer multiple of 10, such as 10, 20, or 30.	Should allow most laboratories to attain the IQE quantitation performance in routine analyses, using a standard measurement system, at reasonable cost.	Not widely used.
s-Sample standard deviation σ-Population standard deviation %RSD-Percent relative standard deviation (100% x s/mean) (1) The value of 3.143 is Student's t for seven replicate analyses. (2) The standard deviation is a function of concentration. The actual calculation of the AML requires several additional steps, not shown here.			

Overview

Table 5 lists detection and quantification terms used by the ten states. The most frequently used terms are detection limit/level, MDL, and PQL. ML is used by Alabama, California, Illinois, and Ohio. States vary in how much they incorporate these terms in their regulatory language. The extensive table in the Appendix lists excerpts from state regulations (and some water quality implementation procedures) where detection or quantification terms were found. Terms are listed alphabetically by state. Each entry provides the term used, the actual regulatory language referencing the term, regulatory citation, the type of environmental program to which the regulation relates, and use of the regulation (definition, wastewater permit limit/compliance, alternative limits, and other).

Every state includes detection or quantification terms in their regulations. Definitions of terms referenced in regulations are usually given in the regulations, but not always.

The states commonly set wastewater permit limits at or below detection or quantification levels, where necessary to protect water quality or include federal industrial effluent limits. Most states specify, either in their regulations or implementation procedures, how compliance is demonstrated in such cases. Compliance with a maximum concentration limit is demonstrated by a “less-than” analytical result (detection or quantification limit, as applicable). Where an average or mass load is calculated, most states specify that zero be used for less-than values. In some situations, one-half the detection limit must be used.

Table 4
Detection and Quantification Terms Used in Other Federal Programs

Program	Term	Definition	Reference
Air	Analytical uncertainty (AU)	Not given in regulation	40 CFR 63, Appendix A
	Detection limit	Not given in regulation	40 CFR 60, Appendix A
	Detection limit	The detection limit is the lowest concentration of an analyte for which its overall fractional uncertainty (OFU) is required to be less than its analytical uncertainty limit (AU).	40 CFR 63, Appendix A
	Instrumental detection limit	Not given in regulation	40 CFR 63, Appendix A
	Lower concentration limit	Not given in regulation	40 CFR 50, Appendix L
	Lower detection limit	Not given in regulation	40 CFR 50, Appendix L 40 CFR 60, Appendix A 40 CFR 63.145 40 CFR 63, Appendix A
	Minimum analytical uncertainty (MAU)	The MAU is the minimum analyte concentration for which the analytical uncertainty limit (AU) can be maintained.	40 CFR 63, Appendix A
	Minimum detection limit (MDL)	The minimum detection limit (MDL) is the minimum concentration or amount of an analyte that can be determined with a specified degree of confidence to be different from zero.	40 CFR 60, Appendix A
	Minimum detection limit (MDL)	Not given in regulation	40 CFR 63, Appendix A
	Practical lower detection limit	Not given in regulation	40 CFR 63, Appendix A
	Practical lower detection range	Quantitation limit	40 CFR 63, Appendix A
	Practical quantitation limit (PQL)	Not given in regulation	40 CFR 60, Appendix A
	Quantitation limit	The PQL is the lower limit of detection for the FTIR system configuration in the sample spectra. Since the noise in subtracted sample spectra may be much greater than in a zero absorbance spectrum, the quantitation limit is generally much higher than the sensitivity.	40 CFR 63, Appendix A
	Quantification limit	Not given in regulation.	40 CFR 63, Appendix A
	Sensitivity	The noise-limited compound-dependent detection limit for the FTIR system configuration. This is estimated by the MAU. It depends on the RMSD in an analytical region of a zero absorbance line.	40 CFR 63, Appendix A

Table 4 (continued)
Detection and Quantification Terms Used in Other Federal Programs

Program	Term	Definition	Reference
Solid Waste and Hazardous Waste			
	Analytical detection limit	Not given in regulation	40 <i>CFR</i> 266, Appendix IX
	In-stack detection limit		
	In-stack method detection limit		
	Method detection limit		
	Minimum required detection limit	Not given in regulation	40 <i>CFR</i> 261.38, Table 1
	Practical quantitation limit (PQL)	The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions that are available to the facility.	40 <i>CFR</i> 257.23 40 <i>CFR</i> 258.53
	Practical quantitation limit (PQL)	Not given in regulation	40 <i>CFR</i> 261, Appendix IX 40 <i>CFR</i> 264.97
	Quantitation limit	Not given in regulation	40 <i>CFR</i> 261.24
Hazardous Substances			
	Contract-required detection limit (CRDL)	Equivalent to contract-required quantitation limit, but used primarily for inorganic substances.	40 <i>CFR</i> 300, Appendix A
	Contract-required quantitation limit (CRQL)	Substance-specific level that a laboratory in the contract laboratory program (CLP) must be able to routinely and reliably detect in specific sample matrices. It is not the lowest detectable level achievable, but rather the level that a CLP laboratory should reasonably quantify. The CRQL may or may not be equal to the quantitation limit of a given substance in a given sample. For hazard ranking system (HRS) purposes, the term CRQL refers to both the contract-required quantitation limit and the contract-required detection limit.	40 <i>CFR</i> 300, Appendix A
	Detection limit (DL)	Lowest amount that can be distinguished from the normal random "noise" of an analytical instrument or method. For HRS purposes, the detection limit used is the method detection limit (MDL) or, for real-time field instruments, the detection limit of the instrument as used in the field.	40 <i>CFR</i> 300, Appendix A

Table 4 (continued)
Detection and Quantification Terms Used in Other Federal Programs

Program	Term	Definition	Reference
	Method detection limit (MDL)	Lowest concentration of analyte that a method can detect reliably in either a sample or blank.	40 <i>CFR</i> 300, Appendix A
	Sample quantitation limit (SQL)	Quantity of a substance that can be reasonably quantified given the limits of detection for the methods of analysis and sample characteristics that may affect quantitation (for example, dilution, concentration).	40 <i>CFR</i> 300, Appendix A

Although states have procedures for allowing wastewater permittees to develop site-specific detection or quantification limits based on state or EPA defined methods (for example, the MDL procedure at 40 *CFR* 136), none of the states had specific procedures for developing or approving alternative methods (such as the AML or IQE). In fact, none of the state staff contacted for this review had personally encountered this situation. Staff indicated that approval of alternative methods would be on a case-by-case basis, and likely coordinated with the USEPA.

Alabama

Excerpts from state regulations that reference detection or quantification limits are included in the Appendix. A summary of these regulations is provided below.

Use of Terms

In its NPDES regulations for direct dischargers, the Alabama Department of Environmental Management (ADEM) uses the terms IML, MDL, and ML. In its groundwater and solid/hazardous waste programs, the ADEM uses the terms, DL, LOD, and PQL. In its pretreatment program, it refers to values less than the DL, but does not define the term.

Use in NPDES Permits and Compliance

The ADEM specifies in its wastewater regulations and permit language that less-than values will be treated as zeros in calculating discharge averages. For the purpose of reporting and compliance, permittees must use the ML as established by EPA. All analytical values at or above the ML must be reported as the measured value, and values below the ML must be reported as zero. For parameters without an EPA-established ML, IML, or matrix-specific ML, a less-than value constitutes compliance if the detection

Table 5
Summary of Analytical Detection and Quantitation Terms Used by States

State Programs	DL	IDL	IML	LOD	LOQ	MDL	ML	QL	PQL	Other
Alabama										
Groundwater	X			X					X	
Solid/hazardous waste										
Water quality*	X		X			X	X			
California										
Drinking water	X						X			DLR
Groundwater	X	X		X		X			X	
Solid/hazardous waste										
Health/safety				X						
Water quality*					X	X	X		X	
Illinois										
Drinking water	X					X			X	MLQ ADL
Groundwater	X			X		X			X	EDL EQL MLQ
Solid/hazardous waste										
Laboratories						X				
Pesticides	X					X				MLQ
Water quality*	X			X	X	X	X	X		
Louisiana										
Air	X			X	X					
Groundwater	X			X				X	X	
Solid/hazardous waste										
Water quality*	X									LOM MLQ**
New Jersey										
Drinking water						X				
Groundwater	X	X			X	X		X	X	CRDL
Solid/hazardous waste										
Laboratories	X	X				X				
Water quality*	X					X			X	NJQL LOD*
Ohio										
Air					X					
Drinking water	X					X				
Groundwater	X			X					X	ADL
Solid/hazardous waste										

Table 5 (continued)
Summary of Analytical Detection and Quantitation Terms Used by States

State Programs	DL	IDL	IML	LOD	LOQ	MDL	ML	QL	PQL	Other
Laboratories						X				
Underground Storage Tanks						X		X		
Water quality*						X	X	X	X	ADL
Oklahoma										
Air	X									ADL MLD MQL*
Drinking water									X	MDL*
Groundwater	X			X					X	
Solid/hazardous waste										
Water quality*										MQL*
Pennsylvania										
Air										
Drinking water						X			X	
Groundwater						X		X	X	EQL
Solid/hazardous waste										
Water quality*	X			X		X			X	
Texas										
Air	X									
Drinking water	X					X			X	
Groundwater	X			X		X			X	MQL
Solid/hazardous waste										SQL
Water quality*						X				MAL
Washington										
Air									X	
Drinking water	X									
Groundwater	X			X	X	X			X	
Solid/hazardous waste										
Water quality*	X					X			X	
Notes: Water quality* - Includes water quality, NPDES, and pretreatment programs. Key to acronyms: ADL Analytical detection limit/level, acceptable detection limit CRQL Contract required quantitation limit DL Detection limit/level DLR Detection limit for purpose of reporting										

Table 5 (continued)
Summary of Analytical Detection and Quantitation Terms Used by States

EDL	Estimated detection limit
EQL	Estimated quantitation limit
IDL	Instrument detection limit
IML	Interim minimum level
NJQL	New Jersey quantitation level
LOD	Level/limit of detection
LOD*	Level of detectability
LOM	Limit of measurement
LOQ	Limit of quantitation/quantification
MAL	Minimum analytical level
MDL	Method detection limit/level
MDL*	Minimum detection limit
ML	Minimum limit
MLD	Minimum level of detectability
MQL	Method quantitation limit
MQL*	Minimum quantification level/limit
MQL**	Minimum analytical quantification level
PQL	Practical quantitation/quantification limit/level
QL	Quantification level
SQL	Sample quantitation limit

limit of all analytical methods is higher than the permit limit. If there are multiple analytical methods for a monitoring parameter, the permittee must use one having an ML lower than the permit limit. If all method MLs are higher than the permit limit, the permittee must use the one with the lowest ML, and a less-than value will constitute compliance and be reported as zero. Should EPA approve a method with a lower ML during the permit term, the permittee must use the new method. The ML must be reported on the permittee's discharge monitoring report (DMR).

For pretreatment permits for significant industrial dischargers (SIDs), analytical methods must have a detection limit less than the permit limit, or if there are none below the limit, the one with the lowest detection limit must be used.

Use of Alternative Limits and Procedures

The ADEM regulations specify that if there is no established ML (presumably meaning not promulgated), an interim ML equal to 3.18 times the MDL shall be used. Subject to approval by the ADEM, where an effluent matrix prevents attainment of the

established ML, NPDES permittees may develop an effluent matrix-specific ML. They may do so during permit issuance, reissuance, modification, or during a compliance schedule. With respect to alternative approaches to detection/quantification limits, ADEM staff stated that they had no specific approval procedures, and that they generally follow procedures at 40 *CFR* 136 (This was a general reference given by the staff; there are no approval procedures there).

California

Excerpts from state regulations that reference detection or quantification limits are included in the Appendix. A summary of these regulations is provided below.

Use of Terms

The California Environmental Protection Agency (CEPA) regulations refer to the following analytical detection/quantitation terms in the state's environmental programs: water quality—LOQ, MDL, and PQL; drinking water—DL, DLR (detection limit for purpose of reporting), and ML; groundwater, solid/hazardous water—DL, IDL, LOD, MDL, and PQL; and health and safety—LOD. The CEPA's implementation procedures for toxic pollutants (*Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California*) use the terms, MDL and ML.

Use in NPDES Permits and Compliance

Determining which priority pollutants require water quality-based effluent limits requires consideration of detection limits. If a pollutant is not detected in any of the effluent samples and any of the reported detection limits are below the water quality standard, the maximum effluent pollutant concentration (MEC) is set at the lowest detection limit (The MEC is not the permit limit, it is an estimate of the effluent concentration used in water quality limit calculations). If, after making adjustments in the permit calculations for factors such as pH, hardness, translators, and time-scales, the adjusted MEC is greater than the water quality standard, then a permit limit is required. If data are unavailable or insufficient to conduct such an analysis for a pollutant, or if all effluent detection limits are greater than the water quality standard, interim requirements for additional monitoring will be placed in the permit.

When effluent concentration allowances (ECA) are multiplied by variability factors to determine long-term average discharge conditions, the coefficient of variation (CV) incorporated in the factor will be set at 0.6 when at least 80% of the effluent data are reported as non-detects. Otherwise, the CV is calculated and any non-detects are given a value of one-half the detection limit.

If all receiving water samples are below detection limits, the maximum ambient background concentration is set to the lowest detection limit. If any sample has detected concentrations, the maximum ambient background concentration is set to the maximum

concentration. In calculating background averages, if all samples are below detection limits, the ambient background concentration is set to the lowest detection limit. If any sample has detected concentrations, the ambient background concentration is set to the mean, using detection limits for less-than values.

When there is more than one ML for a pollutant in a permit, the permit will list all analytical methods and their associated MLs that are below the permit limit. The permittee may select any one of the analytical methods for compliance determination. If no ML value is below the permit limit, the permit will require the analytical method with the lowest ML.

In DMRs, sample results less than the reported ML, but greater than or equal to the laboratory's MDL, are reported as "Detected, but Not Quantified" (DNQ). The estimated concentration must also be reported. The laboratory must write the estimated concentration next to DNQ as well as the words "Estimated Concentration." The laboratory may, if such information is available, include numerical estimates of the data quality for the reported result (may be percent accuracy, numerical ranges (low to high), or any other means considered appropriate by the laboratory). Sample results less than the laboratory's MDL must be reported as "Not Detected" (ND).

Dischargers are considered out of compliance with a permit limit if the concentration is greater than the permit limit and greater than or equal to the ML. When determining compliance with a monthly average limit and more than one sample result is available in a month, the discharger uses the mean unless the data set contains one or more DNQ or ND results. In the latter case, the discharger calculates the median. If the monitoring result (single value or average) is below the ML, but there is evidence that the pollutant is present in the effluent above a permit limit, the discharger is not considered out of compliance if the discharger conducts a PMP (pollutant minimization program).

Use of Alternative Limits and Procedures

There are no specific procedures for approving alternative procedures for determining detection or quantification limits; however, the "Specials Studies" section in CEPA's implementation procedures could be used as guidance for such. The special studies process includes a workplan, data review by an independent scientific review panel (if necessary), compliance schedule, assessment of environmental and economic impacts, and review of antidegradation and other legal requirements.

Illinois

Excerpts from state regulations that reference detection or quantification limits are included in the Appendix. A summary of these regulations is provided below.

Use of Terms

The Illinois Environmental Protection Agency (IEPA) refers to the following analytical detection/quantitation terms in the state's environmental programs: water quality—DL, LOD, LOQ, MDL, ML, and QL; drinking water—DL, MDL, MQL (method quantitation limit), and PQL; groundwater, solid/hazardous water—ADL (acceptable detection limit), DL, EDL (estimated detection limit), EQL (estimated quantitation limit), LOD, MDL, MQL, and PQL; laboratory accreditation—MDL; and pesticides—DL, MDL, and MQL.

The IEPA water quality regulations include definitions of MDL, ML, and QL. These same regulations use the terms, DL, LOD, and LOQ, but do not define them. The IEPA definitions of MDL and ML are the same as the USEPA definitions. The QL is equated to the ML, or lowest quantifiable level practicable. Although the IEPA defines MDL and ML, in the application of its water quality regulations, it primarily uses the term QL.

Use in NPDES Permits and Compliance

The IEPA NPDES regulations specify that LODs and LOQs will be considered in setting permit limits and background concentrations for total maximum daily loads (TMDLs) and wasteload allocations (WLAs). If all values in a background data set are below the detection limit, all values are assumed to be zero; otherwise, “commonly accepted” statistical techniques are to be used to calculate the geometric mean background concentration. Where permit limits are set below a detection limit, a less-than value constitutes compliance. For mass calculations, a zero is used for a less-than value. When calculating averages, one-half the detection limit is used for less-than values. In the pretreatment regulations, an alternative pretreatment limit for a categorical discharger cannot be used if it is below the analytical detection limit.

When a water quality based effluent limit (WQBEL) is less than the QL, a wastewater permit must include the WQBEL as calculated, must specify the most sensitive applicable analytical method, and the analytical method must be the method used for compliance assessment, including enforcement actions. The permit also must identify the QL that can be achieved. In determining the practicability of a method, the IEPA considers the ability of competent commercial laboratories to achieve the target detection level. The permit must include a requirement for a pollutant minimization program (PMP) for each pollutant with a WQBEL below the QL, unless the permittee demonstrates that an alternative technique is adequate to assess compliance with the WQBEL.

Use of Alternative Limits and Procedures

The IEPA will allow a higher QL because of effluent-specific matrix interference. Wastewater discharge permits can be modified to incorporate a new or alternative

analytical method or QL. The analytical procedure used for determining a QL must be a procedure published by the USEPA or nationally recognized organization; however, an alternative method may be allowed if scientifically defensible. IEPA staff stated that it had not encountered a request for an alternative procedure to derive detection/quantification limits. If such a case did occur, it would have the party submit a request to the department, including an explanation of why established procedures are not satisfactory. The request would probably be reviewed in cooperation with EPA.

Louisiana

Excerpts from state regulations that reference detection or quantification limits are included in the Appendix. A summary of these regulations is provided below.

Use of Terms

The Louisiana Department of Environmental Quality (LDEQ) includes only one quantitation level definition in its water quality regulations, a “limit of measurement” in its pretreatment program. This term is used only concerning removal credits where calculations with data sets containing values below the limit of measurement are specified. The term, DL, is referenced in the water quality regulations, but is not defined. In its implementation procedures, the LDEQ uses the term, minimum analytical quantification level (MQL). Detection and quantitation terms used in other programs include: groundwater, solid/hazardous water—DL, LOD, QL, and PQL; and air—DL, LOD, and LOQ.

Use in NPDES Permits and Compliance

In the LDEQ water quality regulations, if a constituent is prohibited in a discharge, it must be “absent” as determined by any analytical method. If a water quality criterion is below the detection limit, no detectable concentrations are allowed in the ambient water; however, for dilution calculations or water quality modeling used to develop TMDLs and WLAs, the assigned criteria, even if below the detection limit, will be used. In the pretreatment regulations, an alternative pretreatment limit for a categorical discharger cannot be used if it is below the analytical detection limit.

The LDEQ generally implements MQLs that are currently used by the USEPA Region VI for detection limits; however, these MQLs are subject to change. Using more sensitive analytical test methods, the LDEQ may impose an effluent-specific MQL lower than the listed MQL for discharges to receiving streams with known water quality problems or for discharges to receiving streams where numerical criteria may be exceeded. If the permit limit for any pollutant is less than the MQL, the LDEQ will use the MQL to determine compliance.

Use of Alternative Limits and Procedures

The permittee may develop an effluent specific MDL in accordance with Appendix B to 40 *CFR* Part 136. The permittee must send to the USEPA Region VI and the LDEQ a report containing quality assurance/quality control (QA/QC) documentation, analytical results, and calculations necessary to demonstrate that the effluent specific MDL was correctly calculated. An effluent specific MQL is calculated as 3.3 times the MDL. Upon written approval by the USEPA Region VI and the LDEQ, the permittee may use the effluent specific MQL for all DMR calculations and reporting requirements. The LDEQ has no specific procedures for approving alternative procedures for determining detection or quantification limits.

New Jersey

Excerpts from state regulations that reference detection or quantification limits are included in the Appendix. A summary of these regulations is provided below.

Use of Terms

The New Jersey Department of Environmental Protection (NJDEP) refers to the following analytical detection/quantitation terms in the state's environmental programs: water quality—DL, LOD (level of detectability), MDL, and PQL; drinking water—MDL; groundwater, solid/hazardous water—DL, IDL, LOQ, MDL, QL, PQL, and CRQL (contract required quantitation limit); and laboratory requirements—DL, IDL, and MDL. The NJDEP water quality regulations do not define DL, MDL, or PQL, although definitions of these terms are found in other regulations (for example, drinking water and laboratory requirements).

Use in NPDES Permits and Compliance

In calculating the “total pollutant load” for the purpose of setting fees, effluent parameters will be excluded if all analyses are non-detects (applies to volatile organic compounds, acid extractable compounds, base-neutral organic compounds, pesticides, and polychlorinated biphenyls (PCBs)). Otherwise, one-half the detection limit will be used in calculating the load. In the pretreatment regulations, an alternative pretreatment limit for a categorical discharger cannot be used if it is below the analytical detection limit.

In wastewater permitting, if an effluent limit is below the level of detectability, the NJDEP will set a limit of nondetectability in the permit. The reportable quantitation limit (RQL) is set at 5 times the MDL. The permittee is considered in compliance if

analyses are less than the RQL. When calculating averages or mass loads, one-half the detection limit is used for less-than values.

The NJDEP is in the process of reviewing its water quality regulations. Changes being considered include a definition of a “New Jersey Quantitation Level” (NJQL) and compliance with permit limits set below the quantitation level. The proposed NJQL is similar to the USEPA’s definition of a PQL. Compliance with a permit limit set below the NJQL would be demonstrated if the analytical result were below the NJQL.

Use of Alternative Limits and Procedures

The NJDEP has no specific procedures for approving alternative procedures for determining detection or quantification limits. To obtain approval, NJDEP staff stated that the discharger would be required to demonstrate the need for an alternative procedure, and a review of its laboratory data would be required as part of that demonstration.

Ohio

Excerpts from state regulations that reference detection or quantification limits are included in the Appendix. A summary of these regulations is provided below.

Use of Terms

The Ohio Environmental Protection Agency (OEPA) has definitions in its water quality regulations for ADL (analytical detection limit), MDL, ML, PQL, and QL. The definitions of MDL and ML are consistent with the USEPA’s. The PQL is defined as 5 times the MDL, but the OEPA may set an alternate PQL. The QL is set equal to the PQL, except for discharges to the Lake Erie basin, where it set equal to the ML (for those analytical methods that have MLs). Terms used in other programs include: air—LOQ; drinking water—DL and MDL; groundwater and solid/hazardous waste—ADL, DL, LOD, and PQL; laboratory requirements—MDL; and underground storage tanks—MDL and QL.

Use in NPDES Permits and Compliance

In determining WQBELs, OEPA specifies in its water quality regulations how it will handle data less than the analytical detection limit or PQL. For any discharge into the Lake Erie Basin where a WQBEL is below the QL, the permittee must have a pollutant minimization program. For compliance, if a permit limit is less than the QL, any value reported below the QL is considered compliant. For averages, zero is to be used for any data point less than the QL. Permittees may apply for discharge-specific QLs. If the QL

for an analytical procedure decreases, the permittee may be given a compliance schedule to demonstrate compliance using the new QL.

In determining background water quality where at least some data are above detection levels, when calculating the mean or median, values less than the detection level are replaced with one-half the detection level. If the detection level is not reported or available, the detection level for the most sensitive analytical method currently approved at 40 *CFR* 136, or other method detection level deemed acceptable by the director, is used. If all data are below detection levels, one-half of the detection level for the pollutant or one-half of the lowest water quality criterion, whichever is lower, is used as the background water quality if the pollutant is reasonably suspected of causing or contributing to the impairment or threatening of the designated use in the receiving water. Zero is used for the background concentration if default mixing assumptions are used and the pollutant is not suspected of causing impairment of the water body.

If all effluent analyses are below detection level, then the OEPA does not calculate a maximum and average PEQ (projected effluent quality), and a determination of WLAs will generally not be required. If there is at least one detected value, then the OEPA will normally determine the maximum and average PEQ. Monitoring is not recommended for any pollutant that did not require a WLA because all effluent analyses were below the analytical detection level.

If either total recoverable or dissolved metal concentrations on which a dissolved metal translator (DMT) measurement is based are less than the PQL, then the DMT measurement will not be used in determining the discharge-specific DMT unless the inaccuracies associated with concentrations less than PQL can be demonstrated to be insignificant or are accounted for through application of scientifically defensible conservative measures.

Use of Alternative Limits and Procedures

The OEPA may establish PQLs for a pollutant with a method listed at 40 *CFR* 136 or, if there is no 40 *CFR* 136 method, the OEPA may establish a PQL using an appropriate consensus standard or other generally accepted standard for the analytical method. If no such standard exists, the director may establish a PQL in the permit based on MDLs determined using the procedures in 40 *CFR* 136, Appendix B. The OEPA may establish a PQL on a basis different than 5 times the MDL if it is consistent with and no more stringent than the appropriate national consensus standard or other generally accepted standard. The OEPA has no specific procedures for obtaining approval of alternative procedures for determining detection or quantification procedures.

Oklahoma

Excerpts from state regulations that reference detection or quantification limits are included in the Appendix. A summary of these regulations is provided below.

Use of Terms

In the water quality regulations of the Oklahoma Department of Environmental Quality (ODEQ), only the quantitation term MQL (minimum quantification level) is referenced (but not defined). Terms used in other programs include: air—ADL (analytical detection limit), DL, MLD (minimum level of detectability), and MQL (minimum quantification limit); drinking water—MDL (minimum detection limit) and PQL; and groundwater and solid/hazardous waste—DL, LOD, and PQL.

Use in NPDES Permits and Compliance

In determining compliance with a water quality criterion, if sample values are below the MQL and the water quality criterion is above the MQL, nonparametric statistical measures are required. If sample values are below the MQL and the criterion is also below the MQL, 50% of the criterion value may be used.

Where the data used to characterize the effluent or upstream concentration and/or loading levels are reported as less than the MQL, zero will be used. Where data include measurable and less-than values, one-half the level of sensitivity will be used for the less-than values. If a pollutant is reported as nondetectable with a level of sensitivity above the MQL, the permit writer will assume that the pollutant is present at the level of sensitivity. An opportunity to perform additional analyses may be provided to confirm and quantify actual pollutant levels. In addition, data may be discarded if determined to be inappropriate, non-representative, or of inadequate quality.

Where calculated water quality-based limits are below the MQL, compliance will be based on the MQL. The calculated limit will be placed in the permit, and if any analytical test result for that pollutant is less than the MQL, zero may be used for DMR calculations and reporting. If a pollutant is of particular concern (for example, if the pollutant has a high bioconcentration factor) the permittee may also be required to develop an effluent-specific MDL. Additional requirements such as fish tissue collection and analyses, limits and/or monitoring requirements on internal waste streams, and limits and/or monitoring for surrogate parameters may also be required in the permit. Reductions in monitoring frequencies are not recommended in cases where a water quality-based limit is below the QL. Permittees will normally be considered in compliance when monitored levels are below the QL.

Use of Alternative Limits and Procedures

The ODEQ has no specific procedures for approving alternative procedures for determining detection or quantification limits.

Pennsylvania

Excerpts from state regulations that reference detection or quantification limits are included in the Appendix. A summary of these regulations is provided below.

Use of Terms

In its water quality regulations, the Pennsylvania Department of Environmental Protection (PDEP) uses the terms, DL, LOD, MDL, and PQL. The MDL definition is similar to EPA's; however, the PDEP adds that the MDL indicates "something is really there." In its other programs, the PDEP uses the following terms: drinking water—MDL and PQL; and groundwater and solid/hazardous waste—EQL (estimated quantitation limit), MDL, QL, and PQL.

Use in NPDES Permits and Compliance

The PDEP considers USEPA analytical test procedures when reviewing NPDES permit applications, and for establishing detection limits and methods of analysis in permits. For any pollutant with an effluent limit of "not detectable" the permittee generally is expected to achieve the detection limit of the most sensitive method. The words "Not Detectable" or ND will be given as the permit limit. In addition, the MDL for the required test method will be given together with a requirement that if the sensitivity of the sample measurement reported is less sensitive than the MDL, an explanation must be provided. If between two methods, the detection limit differs by less than 1 microgram per liter ($\mu\text{g/L}$) or a factor of 2, either method may be used.

Permittees generally are required to meet the detection limits set by the PDEP. An alternate analytical method may be used if the permittee is able to meet the level of detection of the selected method or the water quality-based limit. If a detection limit is not provided, the permittee is required to develop one using an MDL study. Monitoring results that are less-than values are reported as "less than" the stated value.

In the pretreatment regulations, an alternative pretreatment limit for a categorical discharger cannot be used if it is below the analytical detection limit.

Use of Alternative Limits and Procedures

The primary source for detection limits used by the PDEP is the USEPA MDL studies. Where the USEPA has not performed an MDL study or reported the detection limit, other sources, particularly *Standard Methods (Standard Methods for the Examination of Water and Wastewater, 20th Edition, American Public Health Association, American Water Works Association, Water Environment Federation, Washington, DC, 1998)* are consulted. When there is no literature or detection limit, the PDEP may ask its Bureau of Laboratories to determine the detection limit based on an

MDL study. Detection limits may be based on other criteria, such as instrument signal-to-noise ratios. The PDEP regulations state that detection limits for metals are generally instrument detection limits.

If an NPDES permittee cannot meet a listed detection limit, the PDEP may grant a case-specific MDL if a matrix effect is demonstrated. Permittees are required to follow the MDL procedure at 40 *CFR* Part 136, Appendix B.

The PDEP has no specific procedures for approving alternative procedures for determining detection or quantification limits.

Texas

Excerpts from state regulations that reference detection or quantification limits are included in the Appendix. A summary of these regulations is provided below.

Use of Terms

The Texas Natural Resource Conservation Commission (TNRCC) uses the terms, MDL and MAL (minimum analytical level), in its water quality regulations. The MAL is a state-defined term analogous to the USEPA's ML. Both the MDL and MAL are defined in the TNRCC's water quality regulations and discussed in its implementation procedures for water quality standards. The TNRCC regulations state that the MAL is not the published method detection limit for an EPA-approved analytical method (which is based on analysis in reagent (distilled) water), rather that the MAL is based on analyses in the matrix of concern (that is, wastewater effluents). When a matrix-specific MAL is not available, the TNRCC uses the generally applicable MAL it has established.

Terms used in other programs include: air—DL; drinking water—DL, MDL, and PQL; and groundwater and solid/hazardous waste—DL, LOD, MDL, MQL (method quantitation limit), PQL, and SQL (sample quantitation limit).

Use in NPDES Permits and Compliance

In setting permit limits, the TNRCC begins by considering quantitation levels in the permit application. Reporting levels for laboratory analyses submitted with wastewater applications must be at least as low as the MALs. When deciding whether to set a permit limit for a toxic pollutant, effluent average concentrations are compared to water quality standards. If all analyses are less than or equal to the MAL, zero is taken as the average. If any of the analyses are quantifiable, then one-half the MAL or reported level (whichever is less) is used in the calculation for any less-than values.

A permit limit may be set below the MAL; however, compliance is based upon the MAL. An exception is when the substance is of particular concern, for example, if it has

a high bioconcentration factor. In such a case, the TNRCC requires the permittee to develop a site-specific MDL and when there are effluent matrix problems, the permittee may develop an alternative site-specific MAL. An alternate MAL may also be developed anytime that existing analytical methods cannot resolve interference and matrix problems.

The TNRCC's NPDES permit language states that test methods to determine compliance with permit limits must be sensitive enough to achieve the MAL. When an analysis of the effluent sample is less than the MAL, the result must be reported as "<(MAL value)," and this is interpreted as a value of zero for compliance purposes. For discharge monitoring reports (DMRs), when calculating averages, any analytical value below the MAL is considered a zero.

Use of Alternative Limits and Procedures

The TRNCC has published MALs for general usage; however, NPDES permittees are allowed to develop matrix-specific MALs. If a permittee cannot attain a MAL and has tried all available techniques to solve interference and matrix problems, the permittee may request an opportunity to demonstrate an alternative site-specific MAL for the effluent. The permittee may apply for an alternate MAL through the alternate analytical test method procedure provided that all documentation of attempted solutions to the interference/matrix problems is included with the permit application. This documentation must include all QA/QC data.

The TNRCC has a process for approving site-specific MALs or MALs developed from alternative test methods. After reviewing the documentation provided by the TPDES permittee, the TNRCC issues a written decision. If the request is approved, the change will be implemented in the TPDES permit. The TNRCC intends to publish written procedures for this process.

Washington

Excerpts from state regulations that reference detection or quantification limits are included in the Appendix. A summary of these regulations is provided below.

Use of Terms

In its water quality regulations, the Washington State Department of Ecology (WSDE) uses the terms, DL, MDL, and PQL. In its other programs, the WSDE uses the following terms: air—PQL; drinking water—DL; and groundwater and solid/hazardous waste—DL, LOD, LOQ, MDL, and PQL.

Use in NPDES Permits and Compliance

For demonstrating compliance, WSDE regulations state that analytical results below the MDL are set to one-half the MDL. Results between the MDL and PQL are generally set equal to the MDL. When values must be summed for a group of chemicals or isomers, if analytical results are undetected values for every individual compound/isomer, then the single highest detection limit represents the sum of the respective compounds/isomers. Where analyses detect one or more individual compounds/isomers, only the detected concentrations are added to represent the group sum. In compliance with water quality standards, where a sediment sample indicates that a chemical is not detected, the detection limit must be reported and must not exceed the marine sediment quality criterion.

WSDE implementation procedures have different reporting procedures. In the case where a permit limit falls between the MDL and QL, compliance is evaluated by comparison with the QL. Measurements below the QL may be in compliance, and measurements in this range will not support enforcement of daily maximum limits. When calculating averages, all measures at or above the MDL should be used and all data below the MDL should be counted as zero. In the case where the effluent limit is less than both the MDL and QL, if the compliance measurement is below the QL, the sample may be in compliance, and enforcement actions are not taken. When calculating averages, all measures at or above the MDL should be used and all data below the MDL should be counted as zero.

Use of Alternative Limits and Procedures

A discharger may be allowed to develop a matrix-specific QL if the discharger can show that problems attaining the MDL are due to matrix effects and not to poor laboratory performance.

WSDE staff stated that it had not encountered a request for an alternative procedure to derive detection/quantification limits. If such a case did occur, it would have the party submit a request to the department. The request would probably be reviewed in cooperation with EPA.

Recommendations for Compliance Monitoring

Wastewater permittees can take several steps to ensure that permit limits involving detection or quantification issues do not cause compliance monitoring problems. Permittees should take an active role during the permitting process, beginning with the permit application.

Permittees should make sure that all required effluent analyses in the permit application meet the permitting agency's minimum analytical levels. The agency will use these levels when it assesses whether the discharge has the potential to violate water

quality standards for toxic pollutants. If a permittee reports a less-than value higher than the minimum analytical level and higher than the water quality standard, the agency may conclude that there is a potential to exceed the standard and place either a permit limit or monitoring-only requirement in the permit.

Permittees should know in advance of the permit application if their effluent has matrix effects that will require higher detection and quantification limits. The permittee should provide the necessary documentation to the permitting agency that demonstrates the need for a higher limit. This documentation should be provided during the permitting process. Options for dealing with matrix effects may include a different analytical method, a modification of analytical method procedures, site-specific detection and quantification limits, or an alternative procedure for developing detection and quantification limits.

The permittee should carefully review the draft permit and provide written comments when changes are necessary. For any pollutants that have proposed permit limits below detection or quantification limits, the permittee should ensure that the permit describes how compliance is determined. Any reporting and calculation procedures should describe how nondetect or less-than values are handled (for example, reported as less-than, equated to zero or one-half the detect/quantification limit), and these procedures should be consistent with the agency's implementation procedures and regulations.

After the permit is finalized, the permittee should ensure that its discharge data are being interpreted and recorded properly at the permitting agency. For example, if a daily maximum value is reported as "< X," the agency's records should reflect the less-than sign.

Appendix

List of State Regulations Citing Detection/Quantification Terms

**Terms Used for Analytical Detection and Quantification Limits
in State Environmental Regulations
(Selected States)**

State	Term	Regulatory Language	Citation	Definition	NPDES Permit Limits	Use		
						Compliance	Alternative Limits	Other
Alabama								
	Detection limit	When an EPA approved method having a detection limit lower than the permit limitation or when the EPA approved method having the lowest detection limit for a substance is used by the permittee, a value of less than detectable shall be considered zero for purposes of calculating the average monthly discharge of the substance.	COA 335-6-5-.02(b) (NPDES)				X	
	Detection limit	When an EPA approved method having a detection limit lower than the permit limitation or when the EPA approved method having the lowest detection limit for a substance is used by the permittee, a value of less than detectable shall be considered zero for purposes of calculating the average weekly discharge of the substance.	COA 335-6-5-.02(c) (NPDES)				X	
	Detection limit	When more than one approved test method exists for a substance limited in the SID Permit, the SID Permit shall require the use of a method having a detection limit below the permit limit for the substance or, when no method has a detection limit as low as the permit limit, the SID Permit shall require the use of a method having the lowest detection limit.	COA 335-6-5-.16(9) (pretreatment)		X			
	Detection limit	Calculations for all limitations which require averaging of measurements shall utilize an arithmetic mean (zero discharge days shall not be used in these calculations) unless otherwise specified by the Director in the permit.	COA 335-6-6-.12(k)(1)(5)(iv) (NPDES)				X	
	Detection limit	Constituent specifications. For compounds listed in Table 1 of 335-14-2-.04(9) the specification levels and, where non-detect is the specification, minimum required detection limits are as listed in Table 1.	COA 335-14-2-.04(9)(a)(2) (hazardous waste)					X

**Terms Used for Analytical Detection and Quantification Limits
in State Environmental Regulations
(Selected States)**

State	Term	Regulatory Language	Citation	Use				
				Definition	NPDES Permit Limits	Compliance	Alternative Limits	Other
	Interim minimum level	Calculated when a method-specific minimum level does not exist. It is equal to 3.18 times the method-specified method detection limit.	COA 335-6-6-.02(w) (NPDES)	X				
	Interim minimum level	For pollutant parameters without an established ML, an interim ML shall be utilized. The interim ML shall be calculated as 3.18 times the Method Detection Level (MDL) calculated pursuant to 40 CFR Part 136 (1994), Appendix B.	COA 335-6-6-.15(12)(b) (NPDES)	X				
	Limit of detection	The statistical method shall account for data below the limit of detection with one or more statistical procedures that are protective of human health and the environment.	COA 335-13-4-.27(2)(m)(5) COA 335-14-5-.06(8)(i)(5) (groundwater)					X
	Method detection limit	The minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero as determined by a specific laboratory method (40 CFR Part 136) (1994).	COA 335-6-6-.02(z) (NPDES)	X				
	Method detection limit	The interim ML shall be calculated as 3.18 times the Method Detection Level (MDL) calculated pursuant to 40 CFR Part 136 (1994), Appendix B.	COA 335-6-6-.15(12)(b) (NPDES)	X				
	Minimum level	Average monthly discharge limitation. When an EPA approved method is used by the permittee, a value of less than the Minimum Level (ML) shall be considered zero for purposes of calculating the average monthly discharge of the substance.	COA 335-6-6-.02(c) (NPDES)		X			
	Minimum level	Average weekly discharge limitation. When an EPA approved method is used by the permittee, a value of less than the Minimum Level (ML) shall be considered zero for purposes of calculating the average weekly discharge of the substance.	COA 335-6-6-.02(d) (NPDES)		X			

**Terms Used for Analytical Detection and Quantification Limits
in State Environmental Regulations
(Selected States)**

State	Term	Regulatory Language	Citation	Use				
				Definition	NPDES Permit Limits	Compliance	Alternative Limits	Other
	Minimum level	The concentration at which the entire analytical system must give a recognizable signal and acceptable calibration point. The minimum level is the concentration of the lowest calibration standard analyzed by a specific analytical procedure, assuming that all the method-specified sample weights, volumes, and processing steps have been followed.	COA 335-6-6-.02(aa) (NPDES)	X				
	Minimum level	For the purpose of reporting and compliance, permittees shall use the Minimum Level (ML) as established by EPA. All analytical values at or above the ML shall be reported as the measured value. Values below the ML shall be reported as "0."	COA 335-6-6-.15(12)(a) (NPDES)		X			
	Minimum level	For pollutant parameters without an established ML, an interim ML shall be utilized.	COA 335-6-6-.15(12)(b) (NPDES)					X
	Minimum level	Permittees may develop an effluent matrix-specific ML, where an effluent matrix prevents attainment of the established ML. However, a matrix specific ML shall be based upon proper laboratory method and technique. Matrix-specific MLs must be approved by the Department, and may be developed by the permittee during permit issuance, reissuance, modification, or during a compliance schedule.	COA 335-6-6-.15(12)(d) (NPDES)				X	
	Practical quantification limit	Where practical quantification limits (pqls) are used in any of the following statistical procedures to comply with 335-14-5-.06(8)(i)5., the pql must be proposed by the owner or operator and approved by the Department.	COA 335-14-5-.06(8)(h) (groundwater)				X	
	Practical quantification limit	Any practical quantification limit (pql) approved by the Department under 335-14-5-.06(8)(h) that is used in the statistical method shall be the lowest concentration level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions that are available to the facility	COA 335-14-5-.06(8)(i)(5) (groundwater)	X				

**Terms Used for Analytical Detection and Quantification Limits
in State Environmental Regulations
(Selected States)**

State	Term	Regulatory Language	Citation	Definition	Use			
					NPDES Permit Limits	Compliance	Alternative Limits	Other
	Practical quantitation limit	Any practical quantitation limit (pql) that is used in the statistical method shall be the lowest concentration level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions that are available to the facility.	COA 335-13-4-.27(2)(m)(5) (groundwater)	X				
	Practical quantitation limit	PQLs are the lowest concentrations of analytes in groundwaters that can be reliably determined within specified limits of precision and accuracy by the indicated methods under routine laboratory operating conditions. The PQLs listed are generally stated to one significant figure. PQLs are based on 5 mL samples for volatile organics and 1 L samples for semivolatile organics. CAUTION: The PQL values in many cases are based only on a general estimate for the method and not on a determination for individual compounds; PQLs are not a part of the regulation.	COA 335-13-4-Appendix II (solid waste)	X				
	Practical quantitation limit	Practical quantitation limits (PQLs) are the lowest concentrations of analytes in groundwaters that can be reliably determined within specified limits of precision and accuracy by the indicated methods under routine laboratory operating conditions. The PQLs listed are generally stated to one significant figure. CAUTION: The PQL values in many cases are based only on a general estimate for the method and not on a determination for individual compounds; PQLs are not a part of the regulation.	COA 335-14-5-Appendix IX (hazardous waste)	X				
California								
	Detection limit	Detection limit for the purposes of reporting (DLR) means the designated minimum level at or above which any analytical findings of a contaminant in drinking water resulting from monitoring required under this chapter shall be reported to the Department.	CCR 22-64400.45, 64671.15 (drinking water)	X				

**Terms Used for Analytical Detection and Quantification Limits
in State Environmental Regulations
(Selected States)**

State	Term	Regulatory Language	Citation	Use				
				Definition	NPDES Permit Limits	Compliance	Alternative Limits	Other
	Detection limit	A water system is deemed to have optimized corrosion control if it submits results of tap water monitoring...that demonstrate for two consecutive six month monitoring periods that the difference between the 90th percentile tap water lead level...and the highest source water lead concentration, is less than the detection limit for purposes of reporting in Section 64672(b).	CCR 22-64673(b)(3) (drinking water)			X		
	Detection limit	Until new guidance or standards are developed, the owner or operator may demonstrate such good-faith efforts by achieving a detection limit for the constituent that does not exceed an order of magnitude above the level provided by section 66268.43 for F039 nonwastewaters...	CCR 22-66266.112(b)(2)(A) (hazardous waste)			X		
	Detection limit	For wastes with organic constituents having treatment standards expressed as concentration levels, if compliance with the treatment standards is based in whole or in part on the analytical detection limit alternative specified in section 66268.40(d), the certification, signed by an authorized representative, shall state the following...	CCR 22-66268.7(b)(4)(C) (hazardous waste)			X		
	Instrument detection limit	The instrument detection limit (IDL) was determined by the analysis of eleven replicates, blanks, and standards. The IDL was based on three times the standard deviation...	CCR 22-66261.126, Appendix XI, 11.2 (hazardous waste)	X				
	Limit of detection	Using a predefined level of confidence, this is the lowest measured value at which some of the measured material is likely to have come from the sample.	CCR 8-5207, Appendix F, 2.0 (health and safety)	X				
	Limit of detection Defined as "Sensitivity."		CCR 8-5207, Appendix F, 2.0 (health and safety)	X				