

CSO Post Construction Compliance Monitoring Guidance

April 2011

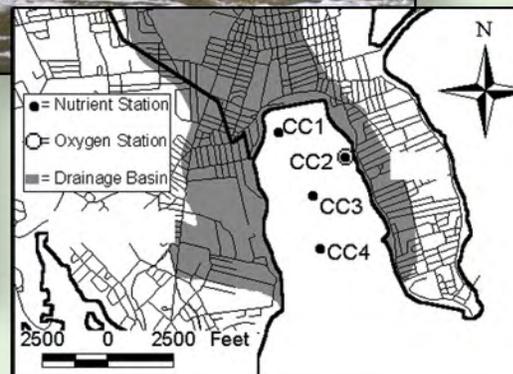
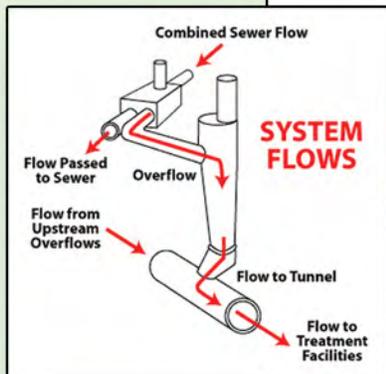


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EPA- 833-K-11-001

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MEMORANDUM

SUBJECT: Combined Sewer Overflows: Draft Post Construction Compliance Monitoring Guidance

FROM: James A. Hanlon, Director
Office of Wastewater Management (OWM)

TO: Interested Parties

The 1994 Combined Sewer Overflow (CSO) Control Policy provides a national framework for control of CSOs. The CSO Policy provides that the permittees with CSOs are responsible for developing and implementing long-term CSO control plans that will ultimately result in compliance with the requirements of the Clean Water Act (CWA). The CSO Policy provides that each long-term control plan should include a post-construction compliance monitoring program to verify compliance with water quality standards and protection of designated uses as well as to ascertain the effectiveness of CSO controls. Many communities that are served by combined sewer systems have developed and are implementing long term control plans are already implementing or about to take the next step of implementing a post-construction compliance monitoring program.

EPA is developing guidance on post-construction compliance monitoring programs to assist communities with this effort. A draft guidance is available at <http://www.epa.gov/npdes/cso>. The draft guidance summarize the requirements to develop a post-construction monitoring program and approaches for monitoring to verify the effectiveness of CSO controls and to assess compliance with water quality standards. The draft guidance also contains supplemental information that is intended for communities to use as they develop and implement their plans.

I invite you to review this draft guidance and provide us with your comments by September 30, 2011. We are especially interested in your views about how the recommended approaches can be tailored to small communities. Comments should be directed to Mohammed Billah. His email is billah.mohammed@epa.gov. Please contact me if you would like to discuss this guidance or call Mohammed at 202-564-2228.

Acknowledgements

The U.S. Environmental Protection Agency (EPA) wants to express appreciation to those individuals and organizations that took the time and energy to review and submit comments as part of the review process during the development of this document. EPA believes that these comments greatly improved the technical and scientific aspects of the manual and we hope that readers will find the information in the manual informative and useful as they develop and implement CSO post construction monitoring plans.

EPA also thanks the Northeast Ohio Regional Sewer District, and the New York City Department of Environmental Protection for allowing EPA to use their experiences in post construction compliance monitoring as case studies for this manual. EPA believes that the inclusion of case studies greatly enhances the value of the document.

Support in developing this manual was provided to EPA under contract number EP-C-05-046.

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Acronyms and Abbreviations

BEACH Act	Beaches Environmental Assessment and Coastal Health Act
BOD	Biochemical Oxygen Demand
CCC	Criteria Continuous Concentration
CFR	<i>Code of Federal Regulations</i>
C.L.	Confidence Limit
CPR	Cardiopulmonary Resuscitation
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
CWA	Clean Water Act
DMR	Discharge Monitoring Report
EPA	U.S. Environmental Protection Agency
GLI	Great Lakes Initiative
HPLC	High Performance Liquid Chromatography
IC25	Concentration at which the response of test organisms is 25 percent below that observed in the control
ID	Identification
L	Liter
lbs	Pounds
LCS	Laboratory Control Sample
LC50	Concentration that is lethal to 50 percent of the test organisms
LTCP	Long-Term Control Plan
MDL	Method Detection Limit
mg	Milligram
MG	Million Gallons
mL	Milliliter
MS	Matrix Spike
MSD	Matrix Spiked Duplicate
NELAC	National Environmental Laboratory Accreditation Conference
NELAP	National Environmental Laboratory Accreditation Program
NHD	National Hydrography Dataset

NMCs	Nine Minimum Controls
NOEC	No Observed Effect Concentration
NP	Nonpotable
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
NSQD	National Stormwater Quality Database
NTU	Nephelometric Turbidity Unit
NURP	Nationwide Urban Runoff Program
OECA	Office of Enforcement and Compliance Assurance
OFR	Office of the Federal Register
OPR	Ongoing Precision and Recovery
ORSANCO	Ohio River Valley Water Sanitation Commission
POTW	Publicly Owned Treatment Works
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RBPs	Rapid Bioassessment Protocols
SOP	Standard Operating Procedure
SRM	Certified Standard Reference Materials
SSM	Single Sample Maximum
SSO	Sanitary Sewer Overflow
TMDL	Total Maximum Daily Load
TSD	EPA's 1991 Technical Support Document for Water Quality-Based Toxics Control
TSS	Total Suspended Solids
TUa	Acute Toxic Units
TUc	Chronic Toxic Units
USGS	U.S. Geological Survey
WET	Whole Effluent Toxicity
WQS	Water Quality Standards

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Section 1. Introduction

This document presents guidance on how to conduct effective post construction compliance monitoring, as provided in the 1994 Combined Sewer Overflow (CSO) Control Policy (59 Fed. Reg. 18688; <http://www.epa.gov/npdes/pubs/owm0111.pdf>), which established a national approach under the National Pollutant Discharge Elimination System (NPDES) permit program for controlling discharges into the nation's waters from combined sewer systems (CSSs). This document provides technical assistance to NPDES authorities (permit writers, water quality specialists and CSO permittees) so that the post construction compliance monitoring plans collect sufficient data for (1) evaluating the effectiveness of CSO controls in meeting performance goals; and (2) assessing compliance with water quality standards.

The CSO Control Policy defines expectations for regulated communities, state water quality standards (WQS) authorities, and NPDES authorities. One of these expectations is that regulated communities should develop comprehensive CSO control measures. The term *CSO control measures*, as it is used in this document, includes controls based on an LTCP, but also controls that were agreed upon prior to the CSO Control Policy (and therefore not part of an LTCP). The ninth element of an LTCP listed in the CSO Control Policy, and the subject of this document, is the development of a post construction compliance monitoring program adequate to verify compliance with water quality-based requirements and ascertain the effectiveness of CSO controls. EPA expects, however, that all CSO communities, regardless of whether they have an LTCP, will conduct post construction compliance monitoring. In case of sewer separation, permittees need to coordinate with the NPDES and WQS authorities for the requirements and duration of conducting post construction compliance monitoring.

It is important that monitoring requirements in NPDES permits result in the generation of appropriate information to ascertain the effectiveness of CSO controls and to verify CSO-specific performance criteria and NPDES permit requirements. Because this information will ultimately be used to verify compliance with water quality-based requirements, reducing data uncertainty should be a high priority. Thus, data quality considerations are included in this document to assist permit writers and the regulated community in ensuring that the data collected are of the type and quality needed to meet the expectations established by the CSO Control Policy.

Permit writers and permittees should remain mindful that phased implementation of control measures and design features suggests an iterative monitoring program that will continue to support the implementation schedule. Evaluation of CSO control measures, CSO volume, loadings of conventional and toxic pollutants, and receiving water quality environmental indicators can be used to measure compliance, and post construction compliance monitoring requirements may evolve as different construction phases are implemented. The performance of the controls should be assessed during each phase. This document presents information about the continuum of monitoring needed to assess a CSO program so that if at any point in a monitoring program's evolution the results reveal evidence of controls that do not fulfill their design requirements, appropriate corrective actions can be identified.

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Section 2. Background

2.1 CSO Control Policy

The 1994 CSO Control Policy established a consistent national approach for controlling discharges from Combined Sewer Systems (CSSs) to the nation's waters. On December 15, 2000, Congress enacted Pub. L. No. 106-554, *which amended section 402* of the Federal Water Pollution Control Act (33 U.S.C. 1342) (the Clean Water Act) to add new paragraph (q) to that section. Section 402 (q) (1) provides:

(q) COMBINED SEWER OVERFLOWS. — (1) REQUIREMENT FOR PERMITS, ORDERS, AND DECREES.—Each permit, order, or decree issued pursuant to this Act after the date of enactment of this subsection for a discharge from a municipal combined storm and sanitary sewer shall conform to the Combined Sewer Overflow Control Policy signed by the Administrator on April 11, 1994 (in this subsection referred to as the 'CSO control policy').

As a result, NPDES permits issued to operators of publicly owned treatment works (POTWs) with combined sewer systems are required to “conform” to the CSO Control Policy. Under the Policy and Section 402 (q), “Phase I” permits were required to include provisions for permittees to immediately implement the Nine Minimum Controls (NMCs), which are technology-based controls that address CSO problems without extensive engineering studies or significant construction costs. Permittees are also required to develop LTCPs as the primary planning tools to document the specific approach or approaches that each permittee will use to control its CSOs to meet the requirements of the Clean Water Act, including attainment of WQS. Phase II permits must include requirements for permittees to implement LTCPs, as well as requirements to implement the NMCs, and other provisions.

The data gathering conducted in the earliest stages of the Phase I permits informs the selection of appropriate CSO controls, and follow-up data monitoring is used to ensure that the chosen controls are achieving the control objectives. The selected CSO controls should include a post construction water quality monitoring program adequate to verify compliance with water quality standards and protection of designated uses as well as to ascertain the effectiveness of CSO controls. This water quality compliance monitoring program should include a plan to be approved by the NPDES authority that details the monitoring protocols to be followed, including the necessary effluent and ambient monitoring and, where appropriate, other monitoring protocols such as biological assessments, whole effluent toxicity testing, and sediment sampling.

Because the post construction compliance monitoring program evaluates what has been done to control CSOs, it is necessarily based on what has been done in previous phases of the permittee's CSO control program. It should build on previous data-collection efforts conducted under both the NMCs and the LTCP process and provide follow-up data to allow a determination of whether the controls that have been put in place have met their objectives and whether the permittee is complying with water quality-based effluent limits in its NPDES permit.

Data Collection Strategy Defined by the CSO Control Policy

The data collection that underpins the long-term control planning, and the subsequent evaluation of that control planning in the post construction compliance monitoring plan, begins during the implementation of the NMCs and continues with the development of the LTCP. Both Section II.B of the policy, which discusses implementation of the NMCs, and Section II.C, which discusses the CSO LTCP, include recommendations to collect data to *characterize* various aspects of the CSS and its impacts. These initial data-collection efforts should have established a baseline against which CSO controls are evaluated using data collected during post construction compliance monitoring.

The initial monitoring of the CSO should be done under the Phase I permit requirement to implement the NMCs. Section II.B of the policy describes the ninth NMC as “monitoring to effectively characterize CSO impacts and the efficacy of CSO controls.” Characterizing CSO impacts implicitly requires the permittee to identify the WQS of the receiving water and to evaluate how the CSO discharges are affecting the receiving waters with respect to these standards. This crucial step in the process was the first assessment of how to achieve receiving WQS. Characterizing the efficacy of CSO controls is also important because it leads to an initial assessment of the potential to control these CSOs, which can be used in later planning efforts to design controls for the CSS.

Subsequent monitoring is described under the LTCP requirements implemented through the Phase II permits. Section II.C of the policy defines the elements of the LTCP, with the first step being characterization, monitoring, and modeling of the CSS. Section II.C.1 states that “to design a CSO control plan adequate to meet the requirements of the CWA, a permittee should have a thorough understanding of its sewer system, the response of the system to various precipitation events, the characteristics of overflows, and the water quality impacts from CSOs.”

The policy states that the monitoring data “will be used to evaluate the expected effectiveness...of...the long-term CSO controls to meet water quality standards.” Section II.C.1.c goes on to state that “the permittee should develop a comprehensive, representative monitoring program that measures the frequency, duration, flow rate, volume and pollutant concentration of CSO discharges and assesses the impacts of CSOs in the receiving water. The monitoring program should include necessary CSO effluent and in-stream ambient monitoring and, where appropriate, other monitoring protocols such as biological assessment, toxicity testing and sediment sampling.”

These characterization monitoring requirements define the baseline effluent and ambient water quality against which the effectiveness of the CSO controls are measured in the post construction compliance monitoring plan. These requirements also establish the procedures and methods which should be followed when designing and implementing the post construction compliance monitoring plan to ensure that the data collected under this plan are comparable to previously collected data, and therefore that it allows a valid comparison “to verify compliance with water quality standards and protection of designated uses as well as to ascertain the effectiveness of CSO controls” as is required of the post construction compliance monitoring plan (discussed in the next section).

What is the role of post construction compliance monitoring in developing effective CSO long-term control plans?

The CSO Control Policy contains provisions for developing appropriate, site-specific NPDES permits for all combined sewer systems that overflow as a result of wet weather events. Permittees with CSOs are required to develop an adequate long term control plan (LTCP) designed to meet Clean Water Act (CWA) requirements. In addition to control overflows in sensitive areas, the plan should consider alternatives and adopt either the presumption or demonstration approach in its LTCP. The alternatives presented in the LTCP should be selected based on a “knee-of-the- curve” statistical analysis that considers water quality requirements to determine the appropriate level of control and a financial analysis to determine the appropriate time frame for implementation. Communities should give consideration to including the protection of sensitive areas in their LTCPs. If the planned implementation of feasible control measures would not result in attainment of water quality standards (WQSs), the community may consider revisions to the standards and if necessary revise the LTCP and or the standards accordingly. The WQSs may be permanently or temporarily revised by Use Attainability Analysis (UAA) or variance respectively. A UAA is a structured scientific assessment of the factors effecting the use, including the physical, chemical, biological, and economic factors described in 40 CFR 131.10 (g). Variances are short-term modifications in water quality standards, and subject to EPA approval. States with their own statutory authority may grant variance to a specific discharger for a specific pollutant. Justifications for variances are the same as those identified in 40 CFR 131.10 (g).

As communities implement their LTCPs, they should conduct **post construction compliance monitoring** to determine whether the controls specified by the LTCP are meeting their objectives and to assess whether the water quality standards (WQSs) are being met. The post construction compliance monitoring is a continuous process to determine whether the CSO LTCP is meeting the regulatory requirements as planned.

After reviewing their post construction compliance monitoring data, the permittee, in conjunction with the NPDES authority, should evaluate the need for additional controls that would meet WQS and then revise their LTCP and implement the appropriate additional controls. If, however, the data analysis indicates that a community could not meet WQS due to financial and/or technological infeasibility, they should develop a schedule for incremental improvements and then revisit additional controls as financial conditions change or as new control technologies emerge. The community can also request that the NPDES authority consider enforcement discretion, or they could seek a revised TMDL or try to obtain approval of UAA or variance and revise their WQS.

Post Construction Compliance Monitoring Defined by the CSO Control Policy

Section II.C.9 of the policy defines the post construction compliance monitoring element of the LTCP. This water quality compliance monitoring should include a plan to be approved by the NPDES authority that details the monitoring protocols to be followed, including the necessary effluent and ambient monitoring, and, where appropriate, other monitoring protocols such as biological assessments, whole effluent toxicity [WET] testing, and sediment sampling.”

The policy also discusses requirements for NPDES permits. Section B.2.d of the policy states that the Phase II permits should include “a requirement to implement, with an established schedule, the

approved post construction water quality assessment program including requirements to monitor and collect sufficient information to demonstrate compliance with WQS and protection of designated uses as well as to determine the effectiveness of CSO controls.”

2.2 NPDES Permit Program Requirements

The CSO Control Policy established the LTCP as the planning process for controlling CSOs that was to be implemented through the NPDES permitting program. The development and implementation of the LTCP, including the development and the implementation of the post construction compliance monitoring plan, are part of the requirements implemented by the permittee’s NPDES permit, order or decree. However, there may be CSO-related requirements in a permittee’s NPDES permit, order or decree—such as requirements to conduct end-of-pipe and effluent monitoring to collect data to support the development of water quality-based effluent limits—that are in addition to the LTCP requirements. It is important to keep both sets of requirements in mind when developing a post construction compliance monitoring plan, because NPDES requirements outside the LTCP process might influence the data collection done in the LTCP, and consequently influence the development of the post construction compliance monitoring plan. For example, the post construction compliance monitoring plan should include monitoring to provide data for evaluating compliance with water quality-based effluent limits in the NPDES permit.

EPA bypass regulations at 40 CFR 122.41 (m) allow for a facility to bypass some or all the flow from its treatment process under specified limited circumstances. Bypass means the intentional diversion of waste streams from any portion of a treatment facility. For approval of a CSO related bypass, the LTCP, at a minimum, should provide justification for the cut-off point at which the flow will be diverted from secondary treatment portion of the treatment plant. Where approval of anticipated bypass is provided in the NPDES permit, the permit must define under what specific wet weather conditions a CSO related bypass is approved and also specify what treatment or what monitoring, and effluent limitations and requirements apply to the bypass flow. The permit should also make it clear that all wet weather flow passing the headworks of the POTW treatment plant will receive at least primary clarification and solids and floatable removal and disposal, and disinfection, where necessary, and any other treatment that can reasonably be provided.

The monitoring requirements for CSO related bypass are the same as for other discharge and are very much site-specific.

2.3 Previous EPA Guidance on Post Construction Compliance Monitoring

Subsequent to the issuance of the CSO Control Policy, EPA developed technical guidance to facilitate implementation of the policy. EPA has previously issued *Guidance for Long-Term Control Plan* (1995b; <http://www.epa.gov/npdes/pubs/owm0272.pdf>), and *Combined Sewer Overflows Guidance for Permit Writers* (1995c; <http://cfpub.epa.gov/npdes/cso/guidedocs.cfm>), both of which provide specific guidance on the development and implementation of post construction compliance monitoring

programs. EPA has also issued *Guidance for Nine Minimum Controls* (1995d; <http://www.epa.gov/npdes/pubs/owm0030.pdf>) and *Combined Sewer Overflows Guidance on Monitoring and Modeling* (1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>), which provide information on the monitoring programs on which the post construction compliance monitoring programs may be based. The various sets of monitoring data should be coordinated with each other to provide consistent data that allows the evaluation of long-term trends to determine the effectiveness of the LTCP and the CSO controls. Permittees should evaluate the guidance on characterization of the CSS and receiving waters, and development of monitoring and modeling plans, to ensure that these plans and the data generated from the monitoring provides acceptable baseline data, and that later post construction monitoring data can be compared to these earlier data in a straightforward manner that allows the assessment of progress in controlling CSOs. Post construction compliance monitoring requirements based on previous guidance are summarized below.

- The post construction compliance monitoring plan should be implemented during the implementation of the LTCP, and it should continue after the LTCP has been implemented.
- The plan should be designed to measure effectiveness of the overall LTCP and provide accountability. It should include a discussion of appropriate measures of success.
- The plan should account for variability of rainfall and CSOs and should focus on ensuring that the data specifically allow the evaluation of the effect of a particular control on the receiving water(s).
- The plan should include a map of the monitoring stations, monitoring schedules (including the frequency and duration of sampling at each station) a parameter list, a discussion of monitoring protocols, and a quality assurance project plan (QAPP).
- The ambient monitoring locations should be appropriate to determine the full range of CSO impacts on the waterbody(ies).
- To the extent possible, the plan should incorporate existing monitoring stations (both those used in previous studies and those used for collecting data during system characterization). This will allow the comparison of post construction data to pre-construction data to evaluate long-term trends.
- The plan should include two types of data collection:
 - Data collection to measure the overall effects of the program on water quality
 - Data collection to determine the effectiveness of CSO controls
- The types of pollutants and parameters to be analyzed should be based on pollutants key to the attainment of designated use(s) of the receiving water, and pollutants affected by the CSO controls, and might include chemical, physical, or biological parameters.
- The monitoring should be coordinated with any ongoing or planned state monitoring programs, programs of other permittees within the same watershed, or both.

2.4 Compliance Monitoring Strategy from the Office of Compliance and Enforcement

On September 16, 2003, EPA's Office of Enforcement and Compliance Assurance (OECA) and the U.S. Department of Justice released a policy on the Negotiation of CSO Consent Decrees. The policy acknowledges that during the course of consent decree negotiations with representatives of publicly owned treatment works (POTWs) regarding long-term remedial measures to address CSOs, issues have arisen regarding the incorporation of LTCPs into CSO consent decrees. The policy addressed the need to specify an end date for completion of all construction and to define the compliance that the POTW should achieve before the decree can be terminated. LTCP's may be modified to account for certain circumstances including, for example, where the LTCP was based on an anticipated change in water quality standards that did not occur, or where subsequent monitoring or other information indicates that the LTCP will not meet water quality standards. The policy also envisions that all construction and all post construction compliance monitoring envisioned in the LTCP or consent decree (or both) would have been satisfactorily completed in accordance with the consent decree.

OECA's policy on Clean Water Act NPDES Compliance Monitoring Strategy for the Core Program and Wet Weather Sources dated October 17, 2007, describes that verifying implementation of a [post construction compliance] monitoring program is recommended when inspecting CSSs.

2.5 Roles and Responsibilities

Different parties are responsible for different aspects of the post construction compliance monitoring program. This section discusses the parties and their roles in this process.

Permittees

Permittees are responsible for developing and implementing the post construction compliance monitoring plan. Permittees should develop the post construction compliance monitoring plan as an integrated part of their LTCP, and they should ensure that the plan is informed by the data collected during system and receiving water characterization efforts that are done in the early phases of planning. They should also ensure that the post construction compliance monitoring plan results in collecting data that allows an evaluation of the effectiveness of CSO controls and their impacts on water quality. This includes ensuring that the plan includes sampling sufficient to allow evaluation of ambient WQS. The permittee should work with the NPDES authority to coordinate the post construction compliance monitoring plan with other monitoring that is occurring in the receiving waters. The permittee is responsible for implementing the plan and doing the data collection and then reporting the resulting data to the NPDES authority.

Permittees are also responsible for complying with their NPDES permit requirements and any specific monitoring done outside the LTCP requirements that could affect post construction compliance. For example, permittees are responsible for conducting any effluent or ambient monitoring required by the permit and for complying with any water quality-based effluent limits. Permittees are required to report these data on their Discharge Monitoring Reports (DMRs).

NPDES Authorities

NPDES authorities are responsible for reviewing and approving the post construction compliance monitoring plan as part of their evaluation of the LTCP. NPDES authorities should review the plan to determine if it will provide sufficient data to evaluate the effectiveness of CSO controls and their impacts on water quality. NPDES authorities should evaluate the proposed sampling to ensure that it provides data to evaluate representative CSO impacts on receiving waters. NPDES authorities should also help coordinate a permittee's post construction compliance monitoring plan with any other monitoring in the receiving water to maximize the data collection efforts in providing a comprehensive picture of water quality and water quality trends in the receiving water, while minimizing cost to the permittees and potential overlap in efforts.

NPDES authorities are also responsible for evaluating the data provided by the permittee to determine if the permittee is achieving the goals of the LTCP. Evaluation of the data should first include an assessment of system performance to determine if the LTCP resulted in the system meeting the Presumption or Demonstration Approach upon which the LTCP was based. Next, the evaluation should determine if water quality standards are being met following the construction of controls per the LTCP. In situations where water quality standards cannot be met due to other sources in the receiving water, the permittee should demonstrate that any remaining CSO discharges do not cause the impairment of water quality standards. Evaluation of water quality improvements should be based on assessing the trends in the pollutants that the LTCP identified as contributing to impacts on WQS and designated uses of the receiving water. EPA recognizes that it is often difficult to identify the specific impacts that individual CSO controls have on receiving waters; therefore, EPA encourages NPDES authorities to evaluate long-term trends to determine improvements in water quality. This process retains the NPDES authority's flexibility to apply site-specific methodology when evaluating the impacts of CSO controls on water quality.

CSO Policy: Small System Considerations

The scope of the long-term CSO control plan including the characterization, monitoring and modeling, and evaluation of alternatives portions of this Policy may be difficult for some small CSS. At the discretion of the NPDES authority, jurisdictions with populations under 75,000 may not need to complete each of the formal steps outlined in Section II. C. of this Policy, but should be required through their permits or other enforceable mechanisms to comply with the nine minimum controls (II. B.), public participation (II. C.2), and sensitive areas (II.C.3) portions of the CSO Control Policy.

In addition, permittees may propose to implement any of the criteria contained in this Policy for evaluation of alternatives described in II.C.4. Following approval of the proposed plan, such jurisdictions should construct the control projects and propose a monitoring program sufficient to determine whether WQS are attained and designated uses are protected. In developing long-term CSO control plan based on the small system considerations discussed in the preceding paragraph, permittees are encouraged to discuss the scope of their long-term CSO control plan with the WQS authority and the NPDES authority. These discussions will ensure that the plan includes sufficient information to enable the permitting authority to identify the appropriate CSO controls.

NPDES authorities are also responsible for coordinating any NPDES permit requirements outside the LTCP that could affect the post construction compliance monitoring, including any permit requirements to conduct monitoring or to comply with water quality-based effluent limits. The NPDES authority should consider integrating the post construction compliance monitoring requirements with any effluent or ambient monitoring that is required by the permit to reduce redundancy in these efforts.

Water Quality Standards Staff

WQS staff should work with the NPDES authorities to ensure that there is a consistent understanding of the WQS in the receiving water(s) and to support the NPDES authorities in their review of the post construction compliance monitoring plan to ensure that it will provide adequate data to evaluate against the WQS in the receiving water(s). Total Maximum Daily Load (TMDL) studies might be occurring in CSO communities with impaired waters, in which case, there might be a role for TMDL authorities during the development and implementation of post construction compliance monitoring plans.

Compliance and Enforcement Authorities

Compliance and enforcement authorities are responsible for working with the NPDES authorities to ensure that the permittees are complying with their NPDES permit requirements. Specifically, with respect to the post construction compliance monitoring plan, compliance and enforcement authorities can work with NPDES authorities to evaluate the data from the post construction compliance monitoring plan to ensure that it meets LTCP goals. While state NPDES authorities play the primary role in reviewing post construction compliance monitoring plans and post construction compliance monitoring data in states with delegated NPDES authority, EPA sometimes retains a strong role in reviewing Post Construction Monitoring Plans, particularly in instances involving federal enforcement. EPA's role in reviewing post construction compliance monitoring plans is particularly important in situations where the plans are used to evaluate LTCP CSO control performance to determine if a federal consent decree has been satisfied and can be terminated.

Others

Other entities may have responsibilities for, or may contribute to, the development and implementation of individual post construction compliance monitoring plans. For example, local health department officials might be able to contribute data on various pollutants (such as bacteria) in the receiving water. This could help in providing either a baseline for comparison of post construction controls, or it might be useful in characterizing other locations in the watershed that might or might not be affected by CSOs. Upstream and downstream dischargers could provide similar data on other pollutants, and it might be useful to include these dischargers in larger watershed planning efforts. Local stakeholders, such as watershed groups or local governments, can play a role in shaping the post construction compliance monitoring plan by providing their input concerning their local needs and interests.

Section 3. Development of a Post Construction Compliance Monitoring Plan

Project planning is critical to the development of a successful CSO post construction compliance monitoring plan. Permittees should develop and implement project planning to ensure their understanding of flows, frequency, and duration of wet-weather events and overflow events is reflected in their plan to verify the adequacy and effectiveness of the design requirements and schedules that were used to develop the CSS capacity and treatment controls. Further, the monitoring program should provide data necessary to verify compliance with WQS and protection of designated uses in the receiving waters. Examples of planning documents that permittees should consider preparing for post construction compliance monitoring include quality assurance project plans (QAPPs), plans for assessing CSO controls, field sampling plans and standard operating procedures (SOPs). The project planning documents should be distributed to the NPDES authority for review and to all staff who will be performing the work.

The post construction monitoring plan should include the baseline data collected during initial monitoring, modeling and characterization of the system. The baseline data complements and builds on the initial flow and wet-weather event characteristics. These data are used to develop the CSO long-term control plan, and later to monitor the design performance as control measures are implemented under the LTCP schedule. EPA's guidance document, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (2006; <http://www.epa.gov/QUALITY/qs-docs/g4-final.pdf>), provides a practical framework for project planning to incorporate the data user's information requirements, performance objectives, and available resources.

The initial monitoring of the CSOs has more than likely focused heavily on the flows, frequency, and duration of wet-weather and overflow events, possibly followed by basic water quality assessments for ambient, stormwater, and overflow events. Because the early monitoring can be iterative, and can result in more complex flow monitoring requirements to design effective controls and implement sufficient measures, early efforts of some permittees might have met limited success. Where the early monitoring efforts might have revealed insufficient understanding of the various inputs to the CSS and any design limitations in historical and modified control measures, continued efforts in this regard should be encouraged and integrated into the CSS monitoring program to optimize the effectiveness of control measures and to reassess the current and future control measures selected, scheduled, and implemented under the LTCP. It is critical to develop and implement an effective post construction compliance monitoring plan, it is also critical to maintain awareness of the resources available to the CSS to monitor, design, and implement the control plan over time.

An effective monitoring plan should have first adequately represented the existing CSS inputs and capacities in sufficient resolution to ensure selection and implementation of the appropriate design features and control measures. Once the conceptual plan and schedule have been developed, however, continued monitoring should support the assessment of controls implemented throughout their

implementation in addition to assessment of receiving waters and the impacts of CSO overflow events. Thus, while the early monitoring program targeted the CSS and range of weather events in the region, the monitoring program evolves with best management practice implementation schedules to confirm reduction in flows, verify performance of control measures, and to more regularly assess the receiving water impacts due to CSO events.

This section should be used as general guide to developing planning documents for CSO post construction compliance monitoring. EPA recognizes that in some situations (e.g., small communities), permittees might streamline the post construction compliance monitoring plan development process as appropriate.



Diversion of flow from a combined sewer overflow to a new treatment plant in the background.

3.1 The Post Construction Compliance Monitoring Plan and its Relationship to the Implementation of the NMCs and Development of LTCPs

The success of the permittee in achieving the expectation of the CWA and CSO Control Policy through the implementation of the NMCs and the CSO controls proposed in their LTCP can be evaluated by evaluating whether the permittee has achieved the goals of the Presumption or the Demonstration approach, because those goals are selected to develop the CSO long-term control plans with an expectation of meeting the water quality standards and protecting the designated uses of the waterbody. Ideally, the permittee has documented whether they are using the Presumption Approach or the Demonstration Approach in developing their LTCP, and evaluating CSO control can be a straightforward evaluation of whether the permittee has met the requirements of the approach they have chosen. For example, if the permittee has chosen the Presumption Approach of no more than four overflows on average per year, the post construction compliance monitoring plan should be set up to collect data that allows evaluation of whether the system has achieved, on average, no more than four overflows per year. Similarly, if the permittee has chosen the Presumption Approach of capture of the mass of pollutants identified as causing water quality impairment, the post construction compliance monitoring plan should set up a data collection effort that collects data on the specific pollutants identified as causing water quality impairments and that allows a mass-balance analysis of the system to determine whether the controls have achieved capture by mass of those pollutants. The ultimate responsibility of the permittee is to meet WQs and protect designated uses of the waterbody regardless of whatever approach is considered in designing the CSO long-term control plan.

Likewise, the success of the permittee in achieving water quality goals based on the implementation of the CSO controls proposed in the LTCP can be evaluated by comparing water quality data collected before implementing the controls to water quality data collected after implementing controls. The expectation is that the data collected after implementing CSO controls will meet the WQSs. EPA recognizes that it is often difficult to document the direct relationship between individual CSO controls and specific improvements in water quality, but the comparison of long-term water quality trends before and after implementing the LTCP, if the data are available, can provide a correlation between CSO controls and improvements in water quality if other things stay the same.

Having established that the goal of post construction compliance monitoring is to evaluate whether the level of CSO control proposed in the LTCP (including the proposed water quality goals) has been achieved, it is clear that the evaluations and planning decisions made during the earliest phases of long-term control planning have major implications for the development and implementation of the post construction compliance monitoring plan. For example, the methods used for initial characterization of the CSS, including the evaluation of the number and location of overflows, the evaluation of pollutant loading, and other factors, should be repeated during measurements of these parameters in the post construction compliance monitoring step so that the data are comparable. Likewise, the permittee should also be consistent in collecting receiving water data. For example, the permittee should ensure that receiving water data collected during post construction compliance monitoring is analyzed for the same parameters that were identified as causing water quality impacts during the receiving water characterization phase of the

CSO Policy: Reopener Clause

A reopener clause authorizing the NPDES authority to reopen and modify the permit upon determination that the CSO controls fail to meet WQS or protect designated uses. Upon such determination, the NPDES authority should promptly notify the permittee and proceed to modify or reissue the permit.

The permittee should be required to develop, submit and implement, as soon as practicable, a revised CSO control plan which contains additional controls to meet WQS and designated uses.

If the initial CSO control plan was approved under the demonstration provision of Section II.C.4.b., the revised plan, at a minimum, should provide for controls that satisfy one of the criteria in Section II.C.4.a (Presumption Approach), unless the permittee demonstrates that the revised plan is clearly adequate to meet WQS at a lower cost and it is shown that the additional controls resulting from the criteria in Section II.C.4.a. will not result in a greater overall improvement in water quality.

Unless the permittee can comply with all of the requirements of the Phase II permit, the NPDES authority should include, in an enforceable mechanism, compliance dates on the fastest practicable schedule for those activities directly related to meeting the requirements of the CWA.

For major permittees, the compliance schedule should be placed in a judicial order.

Proper compliance with the schedule for implementing the controls recommended in the long-term CSO control plan constitutes compliance with the elements of this Policy concerning planning and implementation of a long term CSO remedy.

LTCP. The data collection procedures used to collect data for pre-construction evaluations should be retained in the post construction compliance monitoring field sampling plan so that the post construction data is consistent and comparable with pre-construction data. These procedures should include monitoring locations, parameters monitored, the frequency at which the monitoring is done, the frequency of wet- vs. dry-weather monitoring, etc.

The post construction compliance monitoring plan will also depend on the schedule for implementing the LTCP. For example, the permittee might need to design its post construction compliance monitoring plan in phases to follow the phased implementation of controls within the system. In a phased approach, the monitoring plan is envisioned to follow the implementation of system controls, shifting from collecting data to assess the effectiveness of controls (wet-weather event frequencies, duration, flows, CSS capacities), to one that focuses on water quality in the receiving streams and provides data necessary to demonstrate effectiveness of the LTCP CSO controls.

Post construction compliance monitoring program helps to make necessary adjustment in CSO controls based on the data collected during the various implementation phases of the CSO long-term control plan.

3.2 Data Quality Considerations

This section provides an overview of how to ensure that a permittee's post construction compliance monitoring program incorporates appropriate data quality considerations. EPA provides guidance for developing QAPPs in the following two documents:

- *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* - March 2001 (Reissued May 2006), EPA/240/B-01/003. <http://www.epa.gov/QUALITY/qs-docs/r5-final.pdf>
- *Guidance for Quality Assurance Project Plans (G-5)* - December 2002, EPA/240/R-02/009. <http://www.epa.gov/quality/qs-docs/g5-final.pdf>

For information regarding sampling, refer to:

- *Guidance on Choosing a Sampling Design for Environmental Data Collection (G-5S)* - December 2002, EPA/240/R-02/005. <http://www.epa.gov/quality1/qs-docs/g5s-final.pdf>

In addition, if the permittee is planning to use models to evaluate the effectiveness of CSO controls, the permittee should refer to:

- *Guidance for Quality Assurance Project Plans for Modeling (G-5M)* - December 2002, EPA/240/R-02/007. <http://www.epa.gov/QUALITY/qs-docs/g5m-final.pdf>

The permittee should use EPA's Quality Assurance Project Plan (QAPP) guidance and all applicable state or local QAPP guidance to develop a QAPP for post construction monitoring.

QAPPs are prepared to ensure that environmental and related data collected, compiled, or generated for a project are complete, accurate, and of the type, quantity, and quality required for their intended use. QAPPs include standardized, recognizable elements that cover the entire project. The four groups of elements included in a QAPP are (A) Project management; (B) Data generation and acquisition; (C)

Assessment and oversight; and (D) Data validation and usability. The intent of these four groups is summarized in EPA's *Requirements for Quality Assurance Project Plans* (EPA/240/B-01/003 March, 2001; <http://www.epa.gov/QUALITY/qs-docs/r5-final.pdf>). A detailed discussion of the content of the four groups of elements, as it pertains to the development of a CSO post construction monitoring QAPP, is presented in Appendix A.

3.2.1. Defining the Causes of Water Quality Impairment and Determining Study Questions

Permittees should determine the causes of water quality impairment by evaluating pertinent background information about CSO in the receiving waterbody to identify water quality-based factors and then describe the work that will be done to collect the post construction compliance monitoring data under the QAPP. An important step in this process is determining data quality objectives and criteria that describe quality specifications regarding the level of the decision or study question and the level of the measurements to support the decision or study question. Example study questions that could be used for a post construction compliance monitoring QAPP include

- Do the number of overflows per year or volume of overflow captured during an average precipitation year meet the goals of the basic approach selected by the permittee in the LTCP to verify the effectiveness of CSO control?
- What pollutants and pollutant concentrations are detected at end-of-pipe locations or in proximity to sensitive areas?
- Does receiving water quality measured immediately downstream of the CSO (or mixing zone, if applicable) during wet weather meet applicable WQS or criteria?
- Does receiving water quality measured upstream of the CSO during wet or dry weather meet WQS or criteria for pollutants for which the receiving water is listed as impaired?
- Are concentrations of pollutants detected in the receiving water downstream of the CSO greater than those detected upstream?

The development of the study questions is the ideal time to determine the sampling design. The permittee, when developing the sampling design, should try to minimize Type I and Type II decision errors (false positives and false negatives). A false positive means a problem is found to exist when it in fact does not. A false negative means a problem is not found when in fact it does exist. Sources of error or uncertainty include collecting, handling, storing and analyzing samples (USEPA 2002a; <http://www.epa.gov/QUALITY/qs-docs/g5-final.pdf>). This section should also describe the types of environmental data that will be collected for the project and the name(s) of the organization(s) responsible for their collection.

For more information on documenting sampling design considerations in a CSO control assessment plan and field sampling plan, see Sections 3.3 and 3.4 below, respectively.

3.3 CSO Control Assessment Plan

The ideal time to develop the CSO control assessment plan is during development of the CSO control study questions. The CSO control assessment plan should include a discussion of the basic approach (i.e., Presumption Approach, Demonstration Approach) selected by the permittee in the LTCP to verify the effectiveness of CSO controls. In addition, the CSO control assessment plan should discuss how the permittee will verify compliance with the selected approach. The CSO control assessment plan should be submitted to the NPDES authority for review and approval before implementation. Note that there will be some overlapping topics in the CSO control assessment plan, field sampling plan, and QAPP. To reduce redundancy, the permittee should reference the applicable discussions in the other document(s) when possible.

Detailed information on performing monitoring to verify the effectiveness of CSO controls is provided in Section 4.1 of this guidance document as well as in Section 5 of EPA's (1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) *Combined Sewer Overflows Guidance for Monitoring and Modeling*.

3.3.1 Verifying Effectiveness of CSO Controls Using the Presumption Approach

If the Presumption Approach has been selected, the permittee should describe in the CSO control assessment plan how the specific criterion that the permittee has chosen under the Presumption Approach will be verified. Note that when the Presumption Approach is selected, the permittee should define *system-wide* and *annual average* conditions in the CSO control assessment plan. Permittees should discuss the appropriate time frames for evaluating the success of CSO control targets with the NPDES authority to ensure that adequate data are collected.

Implementing the Presumption Approach requires the permittee to define system-wide and annual average conditions. System-wide is defined as the baseline condition for the entire CSS. The annual average has both sewage and runoff components. The annual average sewage volume can be determined by modeling or metering records. The annual average rainfall component should include ranking annual rainfall, assessing month-to-month variations, assessing rainfall intensity, and assessing return frequency.

Evaluating the Effectiveness of CSO Controls Under Criterion i

If the permittee is using Criterion i of the Presumption Approach, the permittee should describe whether the frequency of CSO events per year will be evaluated through direct monitoring or modeling. If direct monitoring is chosen, the permittee should describe things like the method that will be used to determine whether a CSO has occurred; the CSOs that will be monitored, etc. For detailed information on field monitoring, the permittee might want to reference the field sampling plan (see Section 3.4 of this guidance document).

If a model is selected to predict the number of overflow events during a continuous simulation period, the permittee should describe the model that will be used for this purpose and the data that will be

needed to calibrate and validate the model. The permittee should include a discussion of how they will collect monitoring data to calibrate or verify the model, including references to the field sampling plan, as appropriate.

The permittee should discuss how monitored or modeled data will be evaluated on an average annual basis to verify whether the CSO controls are meeting the frequency goals of the selected approach.

Evaluating the Effectiveness of CSO Controls Under Criterion ii

If the permittee is using Criterion ii of the Presumption Approach, the permittee should describe in the CSO control assessment plan how flows to the CSS (e.g., flows from satellite communities that contribute to the CSS, I/I in separate sanitary areas that contribute flow to the CSS) will be identified. Permittees should have a good idea of the various flows in their system and what they represent from the system characterization phase of the LTCP. If additional flows to the CSS need to be identified, the permittee should describe what tools will be used to identify these flows, including additional monitoring to determine flow contributions from different parts of the system.

After accounting for all the flows to the CSS, the permittee should describe whether the flow and volume of CSO events per year will be evaluated through direct monitoring or modeling. If direct monitoring is chosen, the permittee should describe the location(s) at which flow will be measured, and the flow monitoring equipment. For detailed information on flow monitoring, the permittee might want to reference the field sampling plan (see Section 3.4 of this guidance document).

If a model is selected to predict the flow and volume of CSO events per year, the permittee should describe the model that will be used for this purpose and the data that will be needed to calibrate and validate the model. The permittee should include a discussion of how they will collect monitoring data to calibrate or verify the model, including references to the field sampling plan, as appropriate. The permittee should discuss how monitored or modeled data will be evaluated on an average annual basis to verify whether the CSO controls are meeting the volume goals of the selected approach. Because percent capture must be evaluated on an annual basis, the permittee should describe how many years of data (as determined in consultation with the NPDES authority) they will use for this analysis. EPA recommends the use of long term data, if possible, in order to establish a “typical rainfall year.” Many of these data collection and modeling decisions may have been made during previous phases of LTCP development (for example, during the system characterization, monitoring and modeling phase). The permittee should leverage as much of this information as is appropriate for this evaluation to ensure consistency with previous work and to minimize costs.

Evaluating the Effectiveness of CSO Controls Under Criterion iii

If the permittee is using Criterion iii of the Presumption Approach, the permittee should describe in the CSO control assessment plan how the mass of pollutants identified as causing water quality impairment for the volumes that would be eliminated or captured for treatment under Criterion ii will be eliminated or removed. For additional information on what pollutants should be selected for evaluation, see Section 4.2.2 of this guidance document. The permittee should describe in the CSO control assessment

plan how average pollutant loads will be calculated (using a mass balance approach) to evaluate the elimination or removal of pollutants.

Average pollutant loads might have been calculated during the characterization, modeling, and monitoring of the CSS performed during the development of the CSS. If average pollutant loads have not been previously determined, the permittee should describe what information will be used to assign them, such as historical NPDES monitoring data from the CSS, treatment plant optimization studies, and facility plans and designs. In addition, the permittee might need to perform limited sampling at locations within the CSS and at selected CSO outfalls to obtain recent and reliable characterization data. If sampling is to be performed, the permittee should describe the CSS locations that will be monitored. For detailed information on monitoring, the permittee might want to reference the field sampling plan (see Section 3.4 of this guidance document).

3.3.2 Verifying Effectiveness of CSO Controls Using the Demonstration Approach

If the Demonstration Approach is selected, the permittee should describe in the CSO control assessment plan how its key requirements will be demonstrated.

The majority of post construction compliance monitoring for the Demonstration Approach should focus on receiving water monitoring. Information on developing a field sampling plan for receiving water monitoring is provided in Section 3.4 of this guidance document. In addition, the permittee should describe whether a receiving water model will be used to help demonstrate the impact of the CSOs on the receiving water. If a model will be used, the permittee should describe the model and the data that will be needed to calibrate and validate the model. Permittees should also include a discussion of how they will collect monitoring data to calibrate or verify the model, including references to the field sampling plan, as appropriate.

Permittee needs to realize that ultimate expectation of the CWA and CSO Control Policy is meeting the WQs and protecting the designated uses of the waterbody. Presumption and Demonstration approaches are CSO control design criteria use to develop long-term CSO control plan.

3.3.3 Verifying Effectiveness of Pre-Policy CSO Control Plans

EPA recognizes that extensive work has been done by many Regions, States, and municipalities to abate CSOs. As such, portions of the CSO Control Policy may already have been addressed by permittees previous efforts to control CSOs. Therefore, portions of the Policy may not apply, as determined by the NPDES authority on a case-by-case basis, (see box on next page).

In the case of any ongoing or substantially completed CSO control effort, the NPDES permit or other enforceable mechanism, as appropriate, should be revised to include all appropriate permit requirements consistent with Section IV.B. of the CSO Control Policy.

Communities with pre-policy CSO control plans can also use this guidance for their post construction compliance monitoring requirements.

3.4 Field Sampling Plan

As described in the discussion at the beginning of the previous Section (3.3), the ideal time to develop the sampling design is during development of the study questions. The sampling design should be documented in a field sampling plan and submitted to the NPDES authority for review and approval before implementation. Note that there will be some overlapping topics in the field sampling plan, CSO

CSO Policy: Effect on Current CSO Control Efforts

EPA recognizes that extensive work has been done by many Regions, States, and municipalities to abate CSOs. As such, portions of this Policy may already have been addressed by permittee's previous efforts to control CSOs. Therefore, portions of this Policy may not apply, as determined by the permitting authority on a case-by-case basis, under the following circumstances:

1. Any permittee that, on the date of publication of this final Policy, has completed or substantially completed construction of CSO control facilities that are designed to meet WQS and protect designated uses, and where it has been determined that WQS are being or will be attained, is not covered by the initial planning and construction provisions in this Policy; however, the operational plan and post construction monitoring provisions continue to apply. If, after monitoring, it is determined that WQS are not being attained, the permittee should be required to submit a revised CSO control plan that, once implemented, will attain WQS.
2. Any permittee that, on the date of publication of this final Policy, has substantially developed or is implementing a CSO control program pursuant to an existing permit or enforcement order, and such program is considered by the NPDES authority to be adequate to meet WQS and protect designated uses and is reasonably equivalent to the treatment objectives of this Policy, should complete those facilities without further planning activities otherwise expected by this Policy. Such programs, however, should be reviewed and modified to be consistent with the sensitive area, financial capability, and post construction monitoring provisions of this Policy.
3. Any permittee that has previously constructed CSO control facilities in an effort to comply with WQS but has failed to meet such applicable standards or protect designated uses due to remaining CSOs may receive consideration for such efforts in future permits or enforceable orders for long-term CSO control planning, design and implementation.

In the case of any ongoing or substantially completed CSO control effort, the NPDES permit or other enforceable mechanism, as appropriate, should be revised to include all appropriate permit requirements consistent with Section IV.B. of this Policy.

control assessment plan and QAPP. Field sampling plans or Sampling and Analysis Plans should generally be included as appendices to QAPPs, as the QAPP is incomplete without sampling details. To reduce redundancy, the permittee should reference the applicable discussions in the other document when possible.

For sampling design considerations and examples, see EPA's *Combined Sewer Overflows Guidance for Monitoring and Modeling* (EPA 832 –B-99-002 January 1, 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>). In addition, EPA's *Guidance on Choosing a Sampling Design for Environmental Data Collection* (EPA/240/R-02/005 December 2002; <http://www.epa.gov/quality1/qs-docs/g5s-final.pdf>) will be useful for determining the number of samples needed and how to allocate these samples across space (within the spatial boundaries of the study) and across time (within the temporal boundaries of the study), to lower uncertainty related to heterogeneity to the greatest extent possible.

The field sampling plan should address assessment of the CSO controls and both effluent and ambient monitoring. Ambient monitoring should be conducted at representative CSO locations appropriate to determine the full range of CSO impacts on the waterbody. The monitoring should be done at CSO outfalls and outside the area of CSO impact, including areas upstream of CSOs.

The field sampling plan should provide detailed monitoring protocols and associated schedules (including the duration of different monitoring activities). The monitoring protocols should include the necessary effluent and ambient monitoring, and, where appropriate, biological assessments, WET testing, and sediment sampling. These types of monitoring may be appropriate depending on the WQS in the receiving water. For example, ambient toxicity testing, using samples collected up and downstream of the CSO outfall during wet weather events might be useful in smaller streams and rivers to determine compliance with narrative toxicity standards. Alternatively, direct WET testing of CSO outfall samples during wet weather events can be used to evaluate compliance with the narrative toxicity standard.

One of the main considerations in determining the frequency, duration and scheduling of monitoring is identifying the number of storm events needed to provide data for evaluating receiving water impacts. The National Research Council's (NRC; 2008; http://www.epa.gov/npdes/pubs/nrc_stormwaterreport.pdf) *Urban Stormwater Management in the United States*, provides a detailed discussion of the number of data points needed to characterize a set of conditions. NRC recommends collecting approximately 50 sample pairs (i.e., upstream-downstream samples during a particular storm condition), with typical sample variabilities, as a reasonable objective for most stormwater projects to statistically be able to detect a difference of at least 25 percent. Depending on budgetary constraints, the permitting community could decide to space sampling events over several years to obtain this number of paired samples. Alternatively, the permitting community could decide to choose a more judgmental sampling approach for sampling, where fewer samples are collected and conclusions are based on professional judgment (USEPA 2002c; <http://www.epa.gov/quality1/qs-docs/g5s-final.pdf>).

EPA's (2002c; <http://www.epa.gov/quality1/qs-docs/g5s-final.pdf>) *Guidance on Choosing a Sampling Design for Environmental Data Collection for Use in Developing a Quality Assurance Project Plan* provides guidance on the judgmental sampling approach and more statistically robust sampling designs. This guidance document notes that when judgmental sampling is used as the sampling design, quantitative statements about the level of confidence in an estimate (such as confidence intervals) cannot be made and that conclusions about the target population are limited and depend entirely on the validity and accuracy of professional judgment. This guidance document also explains how expert judgment may be used in conjunction with other sampling designs so that more statistically defensible data can be obtained from sampling.

The post construction monitoring plan should identify the types of pollutants and parameters to be analyzed for effluent and ambient monitoring. Monitoring may include chemical, physical, or biological parameters. The permittee should base the decision on what parameters to monitor on site-specific factors, including the water quality criteria for the specific designated use(s) of the receiving water, pollutants key to the attainment of designated use(s), and pollutants affected by the CSO controls.

The plan should include appropriate measures of success. In addition, the monitoring should be coordinated with any ongoing or planned state monitoring programs or programs of other permittees within the same watershed.

3.4.1 Data Monitoring Needs

As described in EPA's *Combined Sewer Overflows Guidance for Monitoring and Modeling* (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>), the monitoring effort necessary to address the study questions will depend on factors such as the layout of the collection system; land uses in the drainage basin; the quantity, quality and variability of existing historical data; and the available budget. In some cases, sufficient historical monitoring data might be available so that only limited additional monitoring might be necessary. The monitoring design should be updated as needed to reflect changes in data needs.

The field sampling plan should address the following major elements (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>):

- Duration of monitoring program
- Monitoring locations
- Frequency of sampling and number of wet-weather events to be sampled
- Criteria for when samples will be collected (e.g., criteria for both wet weather events and ambient conditions, i.e., x days/hours from the previous precipitation event)
- greater than x days between events, rainfall events greater than 0.4 inch to be sampled)

- Strategy for determining when to initiate wet-weather monitoring
- Sampling protocols (e.g., sample types, sample containers, preservation methods [see also Title 40 of the *Code of Federal Regulations* (CFR) Part 136 (Appendix E to this document)])
- Flow measurement protocols
- Pollutants or parameters to be analyzed or measured
- Sampling and safety equipment and personnel
- QA/QC procedures for sampling and analysis
- Procedures for validating, tracking and reporting sampling results

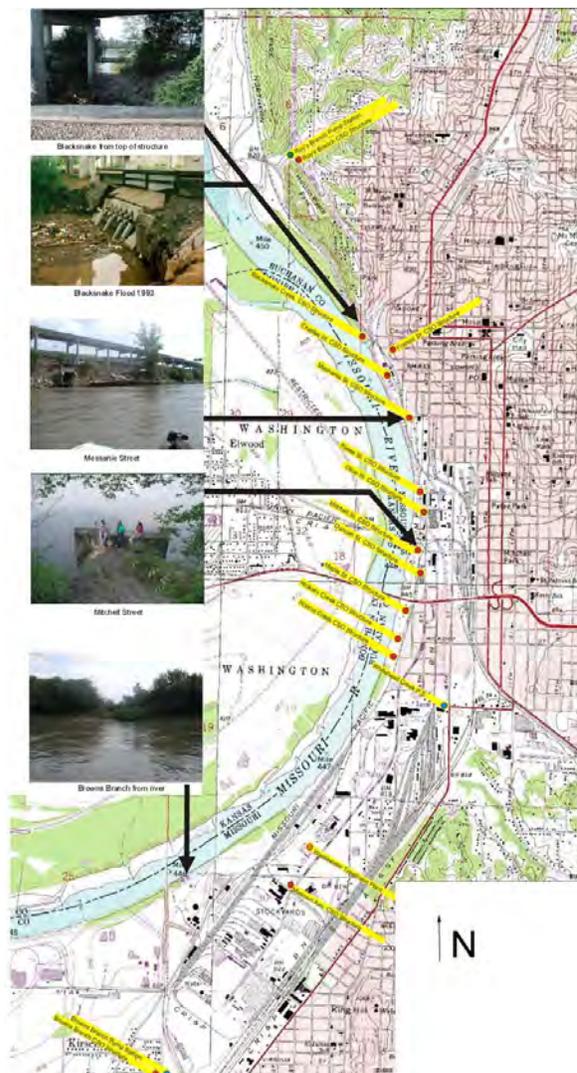
Guidance on determining these elements is provided in this document as well as in Section 4 of EPA's *Combined Sewer Overflows Guidance for Monitoring and Modeling* (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>).

3.4.2 Combined Sewer System and Receiving Water Quality Monitoring

Section 4 of this document and Chapters 5 and 6 of EPA's *Combined Sewer Overflows Guidance for Monitoring and Modeling* (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) provide detailed guidance on how to perform CSS and receiving water quality monitoring. The permittee should document its monitoring procedures in the field sampling plan. In many cases, this information is provided in SOPs attached to the monitoring plan. For guidance on developing SOPs, see Section 3.5.

3.5 Standard Operating Procedures

An SOP should be prepared for field, laboratory, and database management activities that need to be performed the same way every time. The permittee should prepare SOPs for activities such as calibration, use, and maintenance of a flow meter; collecting grab samples from surface waters;



CSO Monitoring Plan for St. Joseph's Missouri.

collecting field blanks; and measuring turbidity. The permittee should include all applicable SOPs as attachments to the project QAPP or to the post construction monitoring plan.

For detailed information on developing SOPs, the permittee should see EPA's *Guidance for Preparing Standard Operating Procedures* (USEPA 2007a; <http://www.epa.gov/quality/qs-docs/g6-final.pdf>). As described in that document, the following general elements should be included in a technical SOP:

1. Title page
2. Table of contents (if needed because of length of document)
3. Procedures
 - a. Scope and applicability
 - b. Summary of method
 - c. Definitions
 - d. Health and safety warnings
 - e. Cautions
 - f. Interferences
 - g. Personnel qualifications/responsibilities
 - h. Equipment and supplies
 - i. Procedure
 - j. Data and records management
4. Quality assurance and quality control
5. References

The SOP should describe in detail the method for a given procedure. The method should be presented in sequential steps and should include specific facilities, equipment, materials and methods, QA and QC procedures, and other factors required to perform the procedure. SOPs should be revised when new equipment is used, when comments by personnel indicate that the directions are not clear, or when a problem occurs.

3.6 Example Planning Documents

Some examples of QAPPs, Field Sampling Plans and SOPs that have been prepared for CSO projects include the following:

- Rouge River National Wet Weather Demonstration Project (2004), including the Rouge River Watershed Sediment Reconnaissance Survey QAPP <http://www.rougeriver.com/>
<http://www.rougeriver.com/proddata/catalog.cfm?category=sampling>
- Several Rouge River Field Sampling Plans and SOPs <http://www.rougeriver.com/>
- Merrimack River Watershed Assessment Study QAPP (USACE 2003)

<http://www.nae.usace.army.mil/projects/ma/merrimack/LMRBqapp.pdf>

- Merrimack River Watershed Assessment Field Sampling Plan

<http://www.nae.usace.army.mil/projects/ma/merrimack/LMRBfieldsamplingplan.pdf>

Section 4. Post Construction Compliance Monitoring

This section is intended to show how the questions that were identified in the planning process described in section 3 can be answered. The questions are some variant of: Are the CSO controls achieving the level of CSO control they were designed to meet, and are the CSO controls achieving compliance with WQS, NPDES permit requirements or enforcement actions (orders or decrees)?

This section presents the two components of post construction compliance monitoring in detail: (1) to collect data for evaluating the effectiveness of CSO controls in meeting their intended purpose, and (2) to collect ambient data for assessing compliance with WQS. This section also provides general information on monitoring, discusses the premise that monitoring should be meaningful and enable verification, and that site-specific conditions will often dictate the extent and adequacy of monitoring.

This section also provides general information on CSS and receiving water monitoring, as well as detailed information on setting up and conducting post construction compliance monitoring that meets the goals of the CSO Control Policy.

Goals of Post Construction Compliance Monitoring

As outlined in the CSO Control Policy, post construction compliance monitoring is intended to provide data that can be used to

- Verify the effectiveness of CSO controls
- Demonstrate compliance with WQS, protection of designated uses and sensitive areas

Individual permittees may set performance standards in their LTCP that can help to define potential ways to “verify the effectiveness of CSO controls.” The CSO Control Policy emphasizes that long-term CSO control plan to give the highest priority to controlling overflows to sensitive areas, as determined by the NPDES authority in coordination with State and Federal agencies. The goal of a CSO community’s post construction compliance monitoring program should also give the highest priority to monitor the overflows to sensitive areas. NPDES authorities should work with individual permittees to ensure that these performance standards are meaningful and that they contribute to an understanding of the effectiveness of the CSO control program. The post construction compliance monitoring may also be linked to specific NPDES permit requirements, such as demonstrating compliance with water quality-based effluent limits. Because water quality-based effluent limits are required to be based on the applicable WQS in the receiving water, monitoring data that can be used to evaluate compliance with water quality-based effluent limits should also meet the requirements for data that can be used to demonstrate compliance with WQS and protection of designated uses.

Organization of this Section

This section presents detailed discussions of potential methods that permittees can use to verify the effectiveness of CSO controls and demonstrate compliance with WQS and protection of designated uses. The section is organized into two major subsections according to the types of monitoring being conducted. Subsection 4.1 discusses monitoring to “verify the effectiveness of CSO controls.” Subsection

4.2 discusses ambient monitoring to gather data to be used in assessing compliance with WQS. Each subsection will focus on the type of monitoring to be done to help define *what*, *where*, and *when* to monitor.

4.1 Monitoring to Verify the Effectiveness of CSO Controls

Monitoring to verify the effectiveness of CSO controls can take several different forms, which may include documenting and evaluating implementation milestones, performance measures, or operations and maintenance requirements. For example, previous EPA guidance describes measures of success for CSO control in four broad categories, including the following:

- Administrative measures that track programmatic activities;
- End-of-pipe measures that show trends in the discharge of CSS flows to the receiving waterbody, such as reduction of pollutant loads, the frequency of CSOs, and the duration of CSOs;
- Receiving waterbody measures that show trends of the conditions in the waterbody to which the CSO occurs, such as trends in dissolved oxygen levels and sediment oxygen demand; and
- Ecological, human health, and use measures that show trends in conditions relating to the use of the waterbody, its effect on the health of the population that uses the waterbody, and the health of the organisms that reside in the waterbody. These might include beach closures, attainment of designated uses, habitat improvements, and fish consumption advisories. Such measures would be coordinated on a watershed basis as appropriate.

The third and fourth bullets are primarily measures of the CSO's impact on the receiving water and on local ecology and human health. These measures will be discussed in detail in Subsection 4.2. This subsection focuses on the measures in the first and second bullets, with an emphasis on discussing methods to collect data allowing an evaluation of CSO control effectiveness as defined by end-of-pipe measures.

The CSO Control Policy defines two basic approaches for achieving CSO control through the LTCP: the Presumption Approach and the Demonstration Approach.

Verifying CSO Control through Verifying Compliance with the Presumption or Demonstration Approach

A straightforward approach to verifying *CSO control* as described in the CSO Control Policy is to verify compliance with the approach used in the permittee's LTCP—either the Presumption or the Demonstration Approach. EPA has laid out very specific requirements for each approach, and verifying whether the permittee has met the appropriate approach can consist of verifying whether the permittee has met these requirements. The expectation of the CWA and CSO Control Policy is, the permittee will ultimately meet WQSs and protect designated uses of the waterbody. Meeting the requirements of any CSO control approach does not guarantee that the permittee is fulfilling their regulatory requirements. Post construction compliance monitoring programs determine whether the permittee's regulatory requirements are met.

CSO Policy: “Presumption” Approach

A program that meets any of the criteria listed below would be presumed to provide an adequate level of control to meet the water quality-based requirements of the CWA, provided the permitting authority determines that such presumption is reasonable in light of the data and analysis conducted in the characterization, monitoring, and modeling of the system and the consideration of sensitive areas described in this Policy. These criteria are provided because data and modeling of wet weather events often do not give a clear picture of the level of CSO controls necessary to protect WQS.

- i. No more than an average of four overflow events per year, provided that the permitting authority may allow up to two additional overflow events per year. For the purpose of this criterion, an overflow event is one or more overflows from a CSS as the result of a precipitation event that does not receive the minimum treatment specified below; or
- ii. The elimination or the capture for treatment of no less than 85% by volume of the combined sewage collected in the CSS during precipitation events on a system-wide annual average basis; or
- iii. The elimination or removal of no less than the mass of pollutants identified as causing water quality impairment through the sewer system characterization, monitoring, and modeling efforts for the volumes that would be eliminated or captured for treatment under paragraph ii above.

Combined sewer flows remaining after implementation of the nine minimum controls and within the criteria specified at II.C.4.a.i or ii should receive a minimum of:

- Primary clarification (Removal of floatables and settleable solids may be achieved by any combination of treatment technologies or methods that are shown to be equivalent to primary clarification);
- Solids and floatables disposal; and
- Disinfecting effluent, if necessary, to meet WQS, protect designated uses and protect human health, including removal of harmful disinfection chemical residuals, where necessary.

EPA’s *Combined Sewer Overflows Guidance for Monitoring and Modeling* (1999;

<http://www.epa.gov/npdes/pubs/sewer.pdf>) can be very helpful in establishing programs to verify CSO controls. Permittees and NPDES authorities should review that guidance as post construction compliance monitoring plans are developed.

4.1.1 CSO Frequency Control Targets

This document breaks the compliance requirements into two parts; this part deals with the effectiveness of CSO controls, and this subsection specifically with whether or not CSO frequency targets are being met. Criterion i of the Presumption Approach states that the permittee will achieve no more than an average of four overflow events per year (note that the definition states that the NPDES authority may allow up to two additional overflow events per year, so some permittees may be allowed up to six overflows per year, on average). This type of CSO control can be evaluated by collecting and studying CSO frequency data.

CSO Policy: “Demonstration” Approach

A permittee may demonstrate that a selected control program, though not meeting the criteria specified in II.C.4.a. above (Presumption Approach) is adequate to meet the water quality-based requirements of the CWA. To be a successful demonstration, the permittee should demonstrate each of the following:

- i. The planned control program is adequate to meet water quality standards and protect designated uses, unless water quality standards or uses cannot be met as a result of natural background conditions or pollution sources other than CSOs;
- ii. The CSO discharges remaining after implementing the planned control program will not preclude attainment of water quality standards or the receiving waters' designated uses or contribute to their impairment. Where water quality standards and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs, a total maximum daily load, including a wasteload allocation and a load allocation, or other means should be used to apportion pollutant loads;
- iii. The planned control program will provide the maximum pollution reduction benefits reasonably attainable; and
- iv. The planned control program is designed to allow cost-effective expansion or cost-effective retrofitting if additional controls are subsequently determined to be necessary to meet WQS or designated uses.

The policy defines an overflow event for the purposes of criterion i as one or more untreated overflow events from anywhere within a particular CSS caused by a precipitation event. The CSS discharge is considered an untreated overflow if it does not receive the minimum treatment described in Section 4.1 above.

Overflow data should be presented so that they can be evaluated on an average annual basis. Figure 1 below shows the number of untreated overflow events per year after CSO control implementation for a six-year period (years 2 through 7) compared to an average of pre-control conditions (year 1). It is worth noting that, although the permittee exceeded four overflows in year 3 (the second year of post control), the annual average for the six post-control years is less than four overflows per year. This indicates that the permittee is in compliance with this requirement. Note that the six years of post CSO control data presented in the figure are for example purposes only; each individual permittee should discuss the appropriate time frames for evaluating the success of CSO frequency targets with their NPDES authority to ensure agreement that adequate data are collected.

Permittees should provide data on the number of overflows from the CSS that meet the overflow definition provided above. These data can either be measured or modeled. In smaller, less complex systems, it might be most appropriate to monitor the number of overflow events directly. However, in more complex systems with a large number of outfalls or when CSO outfalls are submerged, it could be difficult to monitor all the outfalls directly to record overflows. In such cases, it might be more appropriate to use a model to predict the number of overflows in the reporting period. The number of overflows could be based on running a properly calibrated and validated model with precipitation data

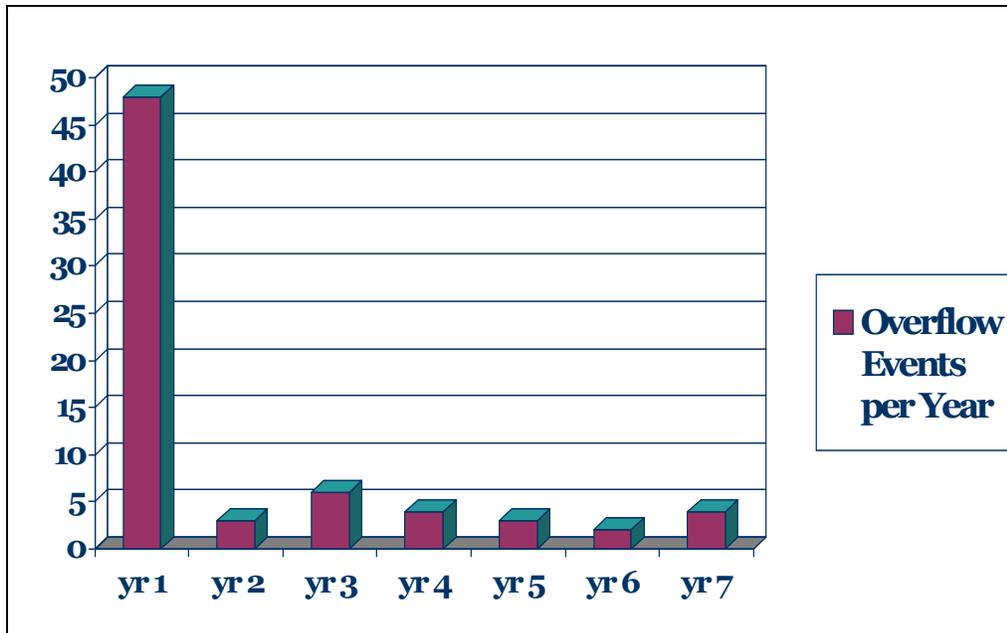


Figure 1. Annual Overflow Events Used to Evaluate Criterion i of the Presumption Approach

collected during the reporting period, or it could be based on modeling a series of design storms used in developing the LTCP. The following section discusses how to monitor CSO frequency, including discussions of where and how to monitor, how to use hydrologic and hydraulic models to estimate CSO frequency, and then provides some examples of monitoring programs designed to collect data on CSO frequency.

4.1.1.1 Direct Monitoring of CSO Frequency

Direct monitoring of CSO frequency consists of recording physical data indicating that CSOs have occurred. The types of data that can be used to indicate that CSOs have occurred can be direct monitoring methods, such as meters or monitors that measure CSO discharges as they occur, or simple “yes/no” methods, such as placing a wood block or other float on a CSO weir and checking after each storm event to see if it has been dislodged from the weir. Permittees using direct methods for monitoring CSO frequency should develop a plan that summarizes what method or combination of methods they will use to determine if CSO discharges have occurred in the CSS (e.g., block method, direct measurement); which CSOs they will monitor within the system (e.g., every outfall; outfalls discharging the most frequently on the basis of previous observations; outfalls in sensitive areas); when and how often they will monitor them (e.g., after every precipitation event delivering a measurable amount of precipitation; after every precipitation event reaching a certain threshold level of precipitation); what type of data they will collect from an event (e.g., block present or absent, meter reading); how that data should be used to determine if a CSO event has occurred (e.g., CSO event has occurred if the block is absent from the weir or CSO event has occurred if the meter has registered flow); and, perhaps most importantly, explain how their data are suitably *representative* of all the CSOs in the system. It would be expected that permittees with populations more than 75,000 would utilize metering or an event monitoring/modeling system.

4.1.1.1.1 Methods for Measuring CSO Frequency

There are a number of methods for evaluating whether a CSO has occurred, ranging from the simple to the sophisticated. This section discusses several of these methods, but individual permittees may devise other methods for determining whether CSOs have occurred. NPDES authorities should review the methods proposed by the permittees to ensure that they will measure CSO discharges effectively, and that the method proposed is appropriate to provide the data needed for the LTCP.

- Visual observation—This is the most direct way to determine if a CSO is occurring is to have field personnel conduct visual observations at the CSO. There are drawbacks to this method, including timing, the health and safety of field personnel and the fact that it can be expensive to mobilize field crews to monitor wet-weather events, and some discharges may also occur below the water line.
- Block method—In this method, a wood or foam block or some other type of lightweight marker is placed on top of the weir or hydraulic control at the approximate water level that initiates an overflow. The block is then checked after each rainfall to determine if it has been dislodged. If the block has moved or is missing, a CSO discharge is presumed to have occurred. If the block is still on the weir, no CSO event has occurred.

The block method is simple and low cost. However, it is appropriate only for outfalls that have a weir system or some suitable type of structure on which the block can be placed. This method also requires field crews to access the location after each rainfall.

- Chalk board method¹—In this method, a chalk board is used as a simple depth-measuring device, and the occurrence of a CSO is interpreted from the depth of the water at the location of the chalkboard. The chalkboard is placed at a strategic location in the CSS—typically in a manhole. A horizontal chalk line is drawn on the board at a height representing the depth of water needed to cause a CSO discharge. The chalkboard is checked after each rainfall. If the chalk line is washed away, the water level reached the chalk line, and a CSO discharge is presumed to have occurred.

The chalk method can be effective if there is a suitable location and space to fasten the chalkboard. However, this method requires the permittee to know accurately beforehand at what depth of water in each manhole CSOs will occur.

- Metering—Metering is an excellent way to capture an abundance of data about CSOs, including whether they have occurred, overflow duration and the volume discharged. However, metering is expensive because of the capital costs of the meters themselves, costs for meter installation, operations and maintenance, and potential replacement costs for damaged meters.
- Hydraulic Monitoring Using Remote Sensors—Recent advances in wireless radio network technology makes it possible for communities to establish a data acquisition system that uploads flow information collected from various points throughout the CSS to a secure website.

¹ A variation of the chalk board method is to use pressurized air to blow a coating of chalk dust onto the walls and bottom of normally dry CSO outfall pipes and observe the coating after each rainfall. When the coating is missing, a CSO discharge can be inferred.

This approach avoids the costs associated with creating a centralized database or linking to an existing SCADA system. Microcomputers embedded within the CSS are connected to flow sensors that are mounted on the undersides of manhole covers. Remote sensors can also be used to detect pressure and actuate valves that divert flows to basins for storage or treatment.

4.1.1.1.2 Determining the Outfalls to Evaluate

When identifying the outfalls to evaluate for determining CSO frequency, the permittee can focus on the worst-case scenario and restrict monitoring to the outfall or outfalls that are known to be most susceptible to overflows. These outfalls might be known from historical observations, or they can be determined by hydraulic analysis to identify flow bottlenecks in the sewer system. If historical data or analysis of the system suggests that different rain events cause different CSOs to overflow, this should be taken into account when deciding on which outfalls to monitor for results that are adequately representative of the whole system.

4.1.1.1.3 Determining When and How Often to Monitor

As with determining which outfalls to evaluate, historical observations or analysis of rainfall response patterns may provide insight into when and how often to monitor the outfalls. These historical data could show the volume and intensity of precipitation that typically causes overflows, and permittees can track rain events and then determine which outfalls need to be monitored. Alternatively, if the permittee does not have a good idea of the rainfall/response relationship, monitoring could consist of the following:

- Choosing a certain number of precipitation events to monitor (e.g., monitor until five storms of a certain size are evaluated)
- Targeting a certain sized precipitation event (e.g., 3-month, 24-hour storm)
- Monitoring all precipitation events over a representative time period

If the permittee does not choose to monitor all precipitation events, the permittee will have to extrapolate the number of CSO events from the data collected. Therefore, it is important to choose a monitoring method that will allow extrapolation of the number of overflows with a reasonable expectation of accuracy. For example, if the permittee has a good model of the system, it might be possible to predict overflows at several outfalls by monitoring for overflows at several key outfalls.

4.1.1.1.4 Data Collection

The data collected should allow an evaluation of whether a CSO has occurred. For the simple methods, such as direct observation of the outfall or evaluation of blocks or chalk lines, a simple *yes* or *no* on whether a CSO has occurred should be sufficient. For other methods of evaluating CSO occurrences, such as metering, permittees might want to collect other data, such as the volume and duration of overflow. These data can be used for a calibration of a hydraulic model of the CSS or in other analyses. Permittees should also collect coincidental precipitation data to define or validate previously-developed rainfall response relationships.

4.1.1.1.5 Data Evaluation

For most methods of evaluating whether a CSO has occurred—such as block testing and evaluating chalk lines—the evaluations should be straightforward. However, for metering data, the permittee might have to evaluate the data to determine whether a CSO has occurred. If the permittee had previously used metering data as part of the characterization of the system, the method for interpreting CSO events might already have been developed. If no metering had been done previously, the permittee should also discuss the method for interpreting the data and determining whether an overflow has occurred. For example with continuous metering data, a break in overflow discharge of 72 hours or longer is typically adopted to determine when one overflow event has ended and a new even has started.

4.1.1.2 Estimating CSO Frequency Using Modeling

Modeling can be a valuable tool for complex CSSs because it allows the permittee to be more confident in evaluating different circumstances and scenarios after calibration and validation of the model. With respect to estimating CSO frequencies, models can be especially useful in large or complex systems where it might be difficult to monitor individual outfalls or where it might be difficult to predict the response of the CSS to different rainfall events.

Many permittees have developed models of the CSS to evaluate different CSO control scenarios for evaluating control requirements in the LTCP. If the permittee has used the Presumption Approach of achieving no more than four overflows, on average annual basis, the model should already be designed to evaluate the frequency of overflows in the system. In such a case, the permittee should update the model to reflect the implementation of CSO controls, validate and/or recalibrate the model, and then run the model in a continuous simulation that is based on a sequence of storms. This accounts for the additive and antecedent effects of storms occurring close together. A continuous simulation also covers storms with a range of different characteristics. The permittee should then report the predicted number of overflows within the simulation period, and the NPDES authority can use these results to evaluate whether the permittee has achieved acceptable levels of CSO control. Note that such models are typically verified with some monitoring data (typically metered flow data). Permittees should include a discussion of how they will collect monitoring data to verify the model in the post construction compliance monitoring phase.

4.1.2 CSO Volume Control Targets

Criterion ii of the Presumption Approach states that the permittee will achieve the elimination or capture for treatment of no less than 85 percent by volume of the combined sewage collected in the CSS during precipitation events on an annual average basis. This type of CSO control can be evaluated by collecting and studying CSO volume data.

Many permittees will have completed flow monitoring during the characterization phase of their LTCP, and therefore the permittee may already have good information to use to evaluate CSO volume targets. Permittees are encouraged to use any existing data in their evaluations, and to use the data in this section to supplement their data collection efforts to ensure that the data is adequate to evaluate CSO volume control targets.

Communities that use modeling should integrate the results of their Post Construction Compliance Monitoring

CSS communities should assess whether their specific performance criteria have been achieved by verifying that the remaining CSO discharges are in compliance with the water quality goals of the CWA. In most cases, bacteria will be the pollutant of concern, and this will need to be quantified by the determination of the number of residual untreated overflows for a predefined “typical year.” For a community that has used a model to assist in the determination of the final alternative of the LTCP, the following steps would typically need to occur after LTCP implementation is complete to determine whether performance criteria have been achieved:

1. During precipitation events, the following data would be collected for each event: rainfall data; overflow volumes and frequency and duration at each CSO location; predefined water quality sampling in the receiving water (for predefined parameters and at predefined locations);
2. Run the hydraulic model (if applicable) to see if, using the rainfall data experienced during the monitoring period, the model is predicting the same number and magnitude of overflows as actually observed during the monitoring period;
3. Modify the model, if necessary, so it is again accurately calibrated so that it predicts what has been observed during the post construction monitoring program sampling. Note that this will be the first time the model will be verified with the design/measures specified in the LTCP, NPDES permit, consent decree or order implemented and the model might need to be adjusted until it is calibrated/validated to predict the same CSO activation frequency, duration, and volume as observed in the sampling results;
4. When the model has been verified to be accurately calibrated to the “actual future sewer hydraulic design” that was basis of the LTCP, NPDES permit, consent decree or order, then the model should be run again on the predefined “typical year” to see how many overflows are predicted to occur;
5. If the model simulation predicts, using the “typical year” rainfall data, that the number of overflows meets the specified performance of the LTCP, NPDES permit, consent decree or order (e.g., < 4 overflows in a typical year), then the performance criteria are deemed to be met;
6. Lastly, the residual overflows need to be evaluated if sampling has indicated the water quality goals of the CWA are still not being met. This will require coordination with state and federal regulators to determine if any additional work may be warranted or how otherwise to resolve the issues.

Since it is highly unlikely that the post construction compliance monitoring period in the future will experience the same rain event data as the predefined typical year, steps 2-5 (above) should be conducted to allow a properly calibrated/validated model to predict performance for the typical year after there may have been 10-15 years of modifications to the sewer system since the LTCP was finalized. EPA recognizes that the scope of an LTCP, including the characterization, monitoring and modeling, and evaluation of alternatives may be difficult for some small CSSs. At the discretion of the NPDES authority, jurisdictions with populations under 75,000 may not need to complete each of the formal steps outlined in Section II. C. of the CSO Control Policy (Long-Term CSO Control Plan). Permittees are encouraged to discuss the scope of their LTCP with their WQS authority and NPDES authority to ensure that their plan includes sufficient information to enable the permitting authority to identify the appropriate CSO controls.

4.1.2.1 Identifying Flows to the CSS

Permittees should ensure that the flow values used to evaluate compliance with CSO volume control targets include appropriate contributions of the various parts of the CSS and that the remaining CSO volumes are calculated correctly. For example, permittees should be sure to account for flows from upstream from separated areas, plus any infiltration and inflow that can be expected during critical periods (e.g., during rainfall events). Examples of the types of flows that should be accounted for to ensure that the flow volumes represent the CSS and all its contributing areas include the following:

- Flows from satellite communities that contribute to the CSS
- Separate sanitary flow to the CSS from non-CSS areas
- Infiltration and inflow in separate sanitary areas that contribute flow to the CSS
- Flow in key interceptors in the CSS
- Flow at key hydraulic control points (i.e., pump stations) in the CSS
- Flow at treatment facilities within the CSS
- Flow at the headworks of the publicly owned treatment works wastewater treatment plant (POTW WWTP)
- Flow at POTW WWTP outfalls, including allowable CSO-related bypasses
- Flow at CSO outfalls

4.1.2.2 Measuring Flows in the CSS

As discussed in the previous section, to evaluate compliance with criterion ii of the Presumption Approach, permittees should provide supporting data and calculations for the volume of combined sewage in the CSS during precipitation events. Once the permittee is sure that all flows are accounted for, a specific location or locations for measuring flow or for calculating flow with the CSS model should be identified. In a simple system, this could be at the influent wet well at the headworks of the WWTP where all the captured flow from the system is consolidated. In more complex systems, permittees might opt to evaluate the 85 percent control level by sewershed, so the permittee should choose a location that includes all the flows into that sewershed.

Once the correct locations for the evaluation of flow are identified, the permittee should evaluate the flow at that location. In an ideal situation, the permittee would monitor flow in the CSS in the location where all the flows have already entered the system, so as to account for the entire flow. However, in other cases, it might be necessary to determine the flow through the CSS model or by estimating the different flow components from monitoring results and adding them together to get a total flow of combined sewage in the CSS during precipitation events. Estimating the combined sewage in the CSS during precipitation events by adding the different flow components based on monitoring requires a full understanding of what flows each monitoring point represents. Permittees should have a good idea of the various flows in their system and what they represent from the system characterization phase of the LTCP. However, in situations where a permittee installs additional flow meters to collect monitoring data

to determine flow contributions from different parts of the system, the permittee should be sure to position the flow meters so as to be able to isolate the various significant flow components.

Flow measurements are generally made using automatic devices that can be installed in channels, storm drains, or CSO structures. These devices use a variety of sensor types, including pressure/depth sensors and acoustic measurements of stage height or Doppler effects from flow velocity. Data are stored in a computer chip that can be accessed and downloaded by a portable computer. Data are processed according to the appropriate pipe, flume, or weir hydraulic equations. Field calibration of such equations is important because these types of data can be influenced by surcharging, backwater, tidal flows, and other complex hydraulic conditions typical of wet-weather flows.

4.1.2.3 Modeling Flows in the CSS

Permittees could also use hydraulic modeling to evaluate flows in the CSS. Different hydraulic models may be appropriate for different purposes. Several types of models are summarized below:

- Models based on the kinetic wave approximation of the full hydrodynamic equations. These models can predict flow depths, and therefore flow and discharge volumes, in systems that are not subject to surcharging or backups (backwater effects). These models require the user to input hydrographs from runoff model results (the TRANSPORT block of SWMM is an example).
- Complex hydrodynamic models based on the full hydrodynamic equations. They simulate surcharging, backwater effects, or looped systems and represent all pertinent hydraulic processes. These models require the user to input hydrographs from runoff model results (the EXTRAN block of SWMM is an example).

EPA does not recommend using landside runoff models for determining flow volumes in the CSS. While many permittees have used runoff models in developing the LTCP, they are not appropriate for determining volume in the CSS. Runoff models are based on Soil Conservation Service runoff curve numbers, runoff coefficients, or other similar methods for the generation of flow. These models can estimate runoff flows delivered to the sewer system, and, to a lesser degree, flows at different points in the system. Runoff models generally do not by themselves adequately simulate flow within the system.

EPA's *Combined Sewer Overflows Guidance for Monitoring and Modeling* (1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) provides a full discussion of monitoring approaches to determine flow volumes in the CSS. For more information on flow monitoring, permittees should refer to that document.

4.1.2.4 Definitions and Calculations for CSO Volume Control Requirements

Criterion ii for the Presumption Approach requires the capture of 85 percent of combined sewage in the CSS during precipitation events on an annual average basis. This means that the permittee is to determine the flows in the CSS during *precipitation events* and then to conduct a volume balance to determine the volume of overflows from the system during these precipitation events. The requirement that this percent capture must be evaluated annually indicates that the permittee should use multiple years of

annual percent capture data in this analysis. The specific parameters that must be defined for the CSS to evaluate criterion ii are defined below.

4.1.2.4.1 Volume of Combined Sewage in the CSS during Precipitation Events

The “combined sewage in the CSS during precipitation events” is the sum of runoff plus sanitary sewage entering the CSS (or dry-weather flow). Runoff should either be modeled or calculated as the combined sewage entering the CSS during precipitation events. Sanitary sewage should either be metered or apportioned from the sanitary sewage in CSS during precipitation events. Delineating what should be included in sanitary sewage should be negotiated between the permittee and the NPDES authority. For example, NPDES authorities may expect systems with high I/I to reduce baseline sanitary sewage flow levels to account for excessive I/I.

The determination of combined sewage “during precipitation events” should include the time frame of the precipitation event that is producing runoff, plus some additional time period for the CSS to drain.

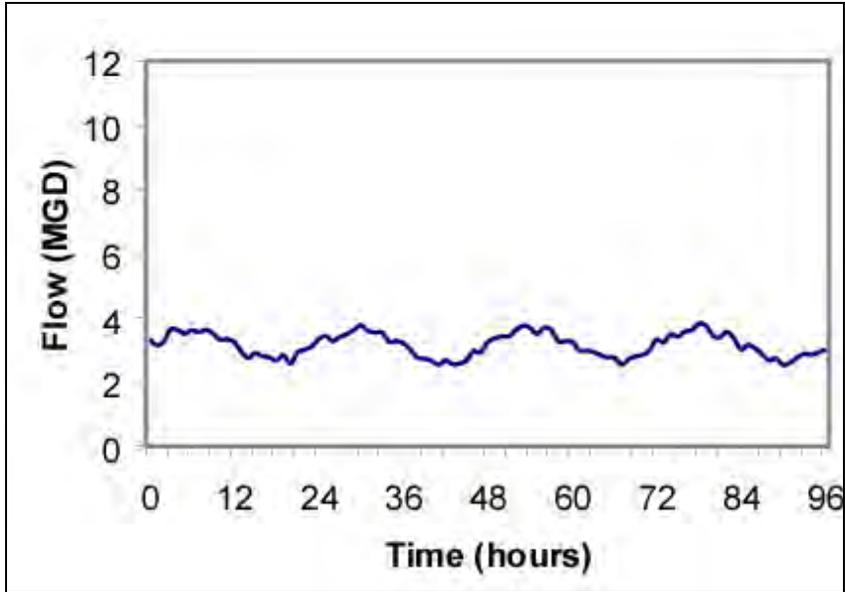
Options for determining the period required for the CSS to drain might include the following:

- The observed time for runoff to pass through CSS
- The time until flow in sewer returns to normal (i.e., time required until the CSS reaches approximately 110 to 120 percent of dry-weather flow)

It should be noted that different NPDES authorities might define the term “return to normal flow” differently and 110 to 120 percent of dry weather flow is provided as an example only. Some systems might experience increased I/I for several days after rainfall events, in which case NPDES authorities may require some other determinant of returning to “normal flows” other than 110-120 percent of dry weather flow. In all cases, the permittee and the NPDES authority should agree on a methodology for determining when a system has returned to “normal” flows.

Figure 2 shows a typical diurnal flow pattern in a CSS. Figure 3 shows the flow generated by a precipitation event. Figure 4 shows the flow in the CSS generated by the precipitation event superimposed on the baseline flow. The shaded areas under the curve represent the volume of combined sewage in the CSS during precipitation events. The actual combined sewage volume can be calculated through integrating the area under the curve between the two points representing the beginning and the end of the precipitation events.

Permittees can then add the volume of combined sewage in the CSS during individual precipitation events to get an annual total combined sewage in the CSS during precipitation events. For example, in Figure 4 above, if the first storm had 3 million gallons (MG) of flow, the second storm had 1 MG of flow, and the third storm had 4 MG of flow, the total for this period is $3 + 1 + 4 = 8$ MG of combined sewage in the CSS during precipitation events over this 96-hour period. Permittees would repeat this procedure as needed to determine the volume of combined sewage in the CSS during precipitation events for the entire year.



Note: MGD = million gallons per day.

Figure 2. Sanitary flow in CSS over time.

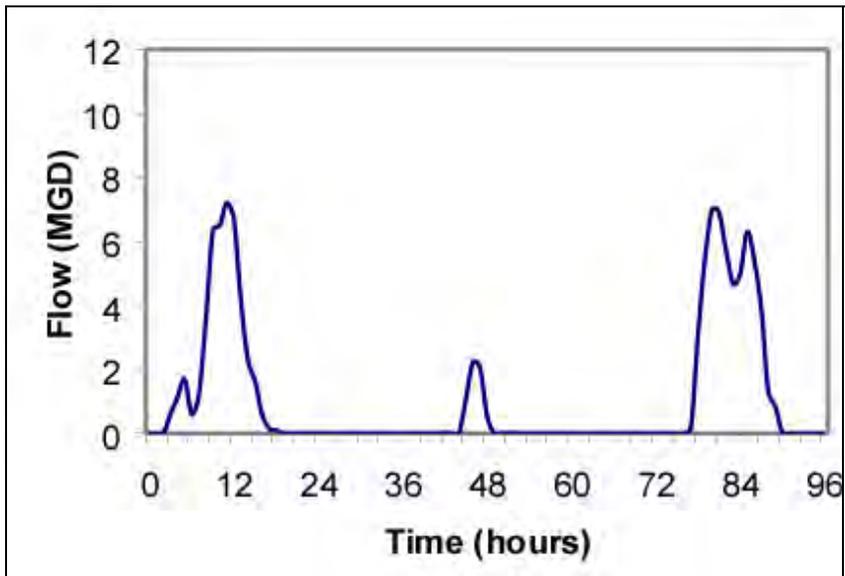


Figure 3. Runoff into the CSS over time caused by rainfall.

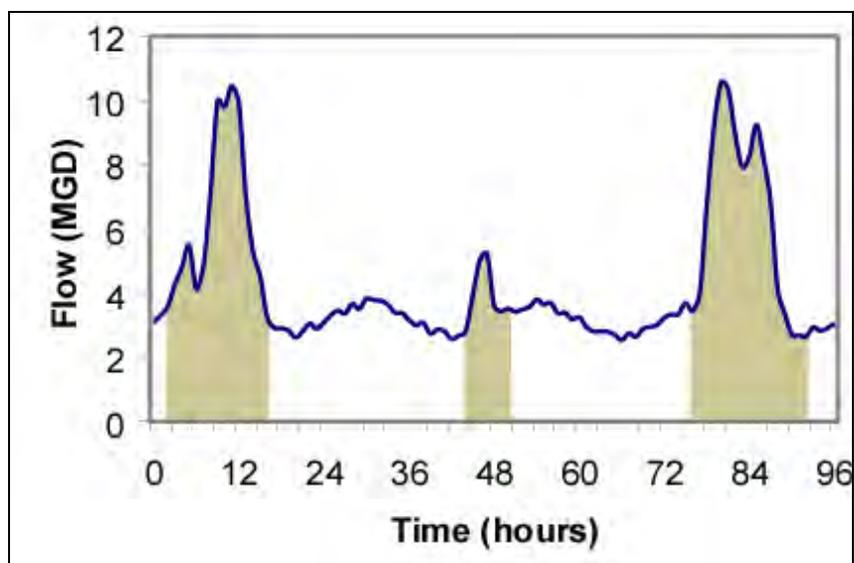


Figure 4. Sum of sanitary runoff flows in the CSS over time.
(Shaded areas indicate wet weather volumes used in assessing percent capture.)

Note that individual NPDES authorities can choose to set criteria or some sort of threshold for rainfall events that are counted with respect to quantifying “combined sewage in the CSS during precipitation events.” This might have the effect of eliminating small rainfall events as being counted towards the percent capture requirements. NPDES authorities can set these criteria through their own policies or through negotiation with permittees, but in all cases, the requirements should be clear so that the permittees know how to calculate these values. It is important to remember that any precipitation event creating an overflow within the CSS should be counted (i.e., it is not the size but presence of an overflow from the CSS that triggers the counting).

4.1.2.4.2 Volume of Combined Sewage Captured or Treated

To determine the percentage of combined sewage volume captured or treated in the CSS, the permittee must quantify the volume of combined sewage that is captured or treated. This includes the sum of all combined sewage that is treated through the WWTP during precipitation events, plus all combined sewage that is detained, stored, treated to acceptable levels, or otherwise captured and not discharged as CSOs during precipitation events. One method for determining this volume is to add together all the combined sewage flows to individual CSO controls, plus the peak flow of the WWTP effluent during precipitation events. This can be done through monitoring data, or through estimating flows with models, as described in previous sections. Another option is to measure the remaining CSO volumes after implementing CSO controls. Several examples of these types of calculations are provided below.

Example 1

The most straightforward method for calculating the volume of combined sewage in the CSS during precipitation events that is captured or treated is to determine the total CSO discharge volume for the year (either by monitoring or modeling) and subtract it from the total combined sewage flow in the CSS

during precipitation events for the year. The difference is the volume of combined sewage in the CSS during precipitation events that is captured or treated. For example:

Total combined sewage flow in the CSS during precipitation events for the year = 600 MG

Total CSO discharge volume for the year = 40 MG

Total CSO volume captured for treatment for the year = $600 - 40 = 540$ MG

Total percent capture = $100 \times (540/600) = 90\%$. Therefore this meets the 85 percent capture threshold for the Presumption Approach.

Example 2

A second method for determining the volume of combined sewage in the CSS during precipitation events that is captured or treated is to calculate a flow balance that sums the flows through each CSO control facility. For example, if the WWTP treated 50 MG of combined sewage during precipitation events for the year and an off-line storage facility received 30 MG of combined sewage during precipitation events for the year, the total volume of combined sewage in the CSS during precipitation events that is captured or treated is $50 \text{ MG} + 30 \text{ MG} = 80 \text{ MG}$. This calculation is shown below.

WWTP flow during precipitation events (includes baseline and wet-weather flows) = 50 MG
(metered over the year)

Off-line storage = 30 MG (metered over the year)

Total CSO volume captured for treatment = $50 + 30 = 80$ MG

This flow balance can become difficult to determine for some types of CSO controls. For example, in-line storage is difficult to measure directly. Therefore, modeling might be appropriate to determine the volumes of combined sewage in the CSS during precipitation events that are captured or treated.

4.1.2.4.3 Calculating a Volume Balance

The most straightforward method for evaluating whether a permittee has achieved 85 percent capture is to calculate a volume balance of combined sewage flow in the CSS after implementation of CSO controls. For example, one method of calculating the volume balance is:

Percent capture = $100 \times (\text{sum of volume delivered to acceptable treatment divided by the sum of inflow volumes to the CSS [sanitary+ runoff] over a representative time frame}$

A second option is:

Percent capture = $100 \times (1 - [\text{overflow volume divided by the sum of runoff and sanitary volume}])$ over a representative time frame

As described in Subsection 4.1.2.1 above, the permittee must take into account all appropriate flows when determining the average volume of combined sewage in the CSS during precipitation events. For example, Figure 5 below shows the flows being collected in the CSS on a particular day that significant rainfall has occurred. The figure shows an upstream combined area discharging an average of 100 MGD

to a CSS. This CSS also collects an average of 25 MGD from an upstream separate sewer area and receives an average of 10 MGD in infiltration and inflow. Therefore, the total flow in the CSS is

$$100 \text{ MGD} + 25 \text{ MGD} + 10 \text{ MGD} = 135 \text{ MGD}$$

Once a permittee has collected data on the flows in the CSS during precipitation events on an annual basis, the permittee can use a mass balance approach to provide data on whether they are meeting 85 percent capture. This can be a simple calculation of the ratio of the annual flow volume in the CSS during precipitation events divided by the volume of combined sewage treated or captured. Table 1 provides an example of calculating the percentage of combined sewage captured or treated in the CSS before and after implementing CSO controls.

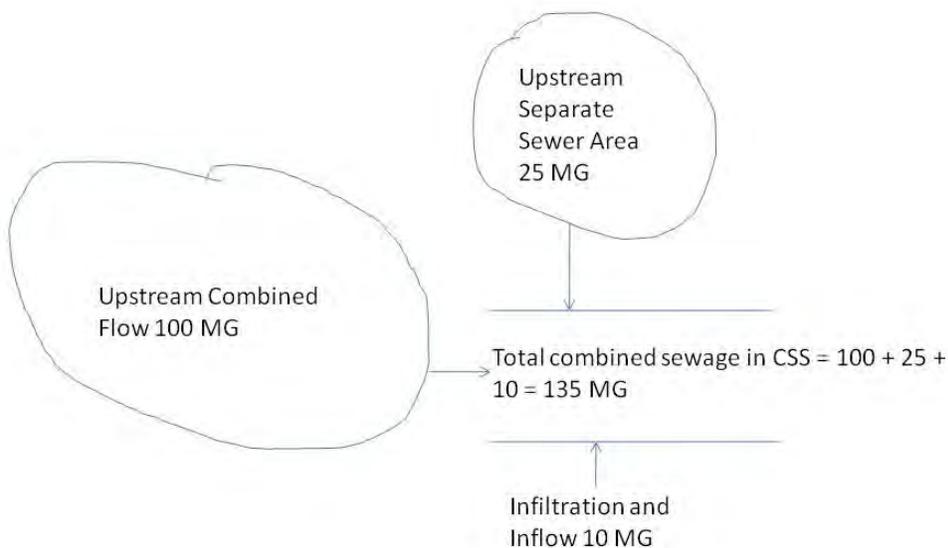


Figure 5. Flows to the CSS during a particular 24-hour precipitation event.

Table 1. Example calculation for percentage of combined sewage captured and/or treated in CSS

	No CSO control	LTCP (CSO retention basins)
Total volume of combined sewage collected in the CSS during precipitation events (MG)	1,220	1,220
Volume of combined sewage that is captured and/or sufficiently treated before discharge	756	1,037
Percentage of combined sewage captured and/or sufficiently treated before discharge	62%	85%
Volume of remaining untreated CSOs	464	183
Percentage of remaining untreated CSOs	38%	15%

In this example, there is an average of 1,220 MG of combined sewage in the CSS during precipitation events during one of the years analyzed. Before implementing CSO controls, approximately 756 MG of this flow, or 62 percent, is diverted to the WWTP for treatment. The remaining 38 percent of the flow, or 464 MG, overflows as CSOs. However, after implementing CSO control measures (in this case, CSO retention basins) through the LTCP, 1,037 MG of combined sewage (85 percent of the total) is treated or captured. Thus, the implementation of this LTCP can be considered adequate to meet criterion ii of the Presumption Approach.

4.1.2.4.4 Calculation of Annual Average Capture Volume

Criterion ii of the Presumption Approach states that the permittee will capture no less than 85 percent by volume of the combined sewage collected in the CSS during precipitation events on an *annual average basis*. Therefore, the permittee should present several years' worth of data on percent capture to allow an evaluation of compliance with this Approach. The permittee has calculated an annual percent capture for several years' worth of data, calculated the annual average over a several-year period for use in evaluating criterion ii of the Presumption Approach, and then would average these annual flow volumes to produce an annual average of flow in the CSS during precipitation events. Table 2 provides an example of calculating the annual average percentage of combined sewage captured or treated in the CSS over a time frame of 4 years.

In this example, the average annual percentage of combined sewage captured or treated is 87 percent. It is worth noting that in Year 2, the percentage of combined sewage captured or treated is 82 percent, which is below the threshold set under criterion ii of the Presumption Approach. However, the permittee still meets the criterion because the average annual percentage of combined sewage captured or treated over the 4- year period is above 85 percent.

To determine an appropriate period over which to calculate the annual average flow in the CSS during precipitation events, permittees should confer with the regulatory authorities. In general, the period chosen for determining the annual average should be representative of the same precipitation conditions for which the permittee planned in the LTCP so that the permittee can be reasonably sure that the LTCP is achieving the planned level of CSO control with respect to percent capture of flows.

Table 2. Example calculation for annual average of percentage of combined sewage captured or treated in an example CSS

Year	Volume of combined sewage collected in the CSS during precipitation events (MG)	Volume of sewage that was captured or adequately treated (MG)	Percentage of combined sewage considered captured or treated
Year 1	680	600	88%
Year 2	856	702	82%
Year 3	598	520	87%
Year 4	760	684	90%
Annual average	724	627	87%

4.1.3 Pollutant Mass Removal Control Targets

Criterion iii of the Presumption Approach states that the permittee will achieve the elimination or removal of no less than the mass of pollutants identified as causing water quality impairment through the sewer system characterization, monitoring, and modeling efforts for the volumes that would be eliminated or captured for treatment under criterion ii. Another way of stating this criterion is that the permittee will achieve the elimination or removal of 85 percent of the mass of pollutants in the CSS during precipitation events. Note that this criterion applies to pollutants “causing water quality impairment;” therefore, it should be applied only to the pollutants identified as being pollutants of concern during the characterization, monitoring, and modeling stage of LTCP development. For example, in many CSS systems, bacteria, sediment, and biochemical oxygen demand are the primary pollutants of concern.

In using this Approach, the permittee should use the mass-balance approach to determining flows in the CSS described under Section 4.1.2 above, and then add a corresponding pollutant load to evaluate the elimination or removal of pollutants. Derivation of average pollutant loads might have been completed during the characterization, modeling and monitoring of the CSS done during the development of the LTCP. If average pollutant loads have not been previously determined, permittees can use several different methods to assign them, including reviewing historical data from the CSS (including NPDES monitoring data, if it includes monitoring of specific pollutants) or other sources. Other sources of data might include the following:

- General treatment plant influent concentrations and operating data
- Treatment plant optimization studies
- Special studies done as a part of an NPDES permit application
- Pretreatment program data
- Collection system data gathered during NMC implementation
- Existing wet-weather CSS sampling and analysis
- Facility plans and designs

The permittee can potentially use national or regional stormwater data (e.g., Nationwide Urban Runoff Program [NURP data, USEPA 1983], National Stormwater Quality Database [NSQD data available from <http://rpitt.eng.ua.edu/Research/ms4/mainms4.shtml>]) to supplement its available data, although more recent localized data are preferred.

To obtain recent and reliable characterization data, the permittee might need to conduct limited sampling at locations in the CSS and at selected CSO outfalls. To be effective for characterizing pollutant mass removal control targets, this monitoring should include monitoring before and after implementation of CSO controls.

EPA’s *Combined Sewer Overflows Guidance for Monitoring and Modeling* (1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) and *Guidance for Long-Term Control Plan* (1995b;

<http://www.epa.gov/npdes/pubs/owm0272.pdf>) documents provide good information on developing and conducting a monitoring program, and on supplementing the monitoring data with modeling.

These documents also discuss data analysis to evaluate pollutant loads. Multiplying the flow measurements discussed in Section 4.1.2.2 above by pollutant concentration values gives an estimate of the total pollutant load handled by the CSS. If pollutant loads are estimated for several outfalls, they may be normalized to account for differences in rainfall and land area, and then these concentrations may be applied to other areas of the CSS that might not have been monitored.

Pollutant removal could be evaluated in several different ways. For example, if CSO control involves a flow-through treatment technology that removes pollutants, the permittee can use monitoring data from the CSO outfall, or perhaps design performance standards, to determine the pollutant concentrations or removals that should be applied to the discharge to calculate pollutant loads. For example, if a high-rate ballasted flocculation treatment system treats 150 MG of CSO flows in its first year of operation, and it starts from a raw TSS concentration of 414 mg/L and provides 90 percent removal, it would remove 466,122 lbs of TSS ($150 \text{ MG} \times 414 \text{ mg/L} \times 8.34 \times 0.9 = 466,122$). Applying the high rate treatment system that treats 150 MG of flow to an illustrative LTCP example, the mass balance is:

Mass balance before LTCP implementation

Mass of TSS in CSS during precipitation events = $1,220 \text{ MG} \times 414 \text{ mg/L TSS} \times 8.34$ (conversion factor) = 4,212,367 lbs TSS

Mass of TSS discharged from WWTP after treatment = $756 \text{ MG} \times 30 \text{ mg/L} \times 8.34 = 189,151$ lbs TSS

Mass of TSS in the untreated discharge = $464 \text{ MG} \times 414 \text{ mg/L TSS} \times 8.34 = 1,602,080$ lbs TSS

Total TSS discharged = $189,151 + 1,602,080 = 1,791,231$

Total TSS captured or treated = $4,212,367 - 1,791,231 = 2,421,136$

Percent of TSS captured or treated before LTCP implementation = $(2,421,136 / 4,212,367) = 57.5\%$

Mass balance after implementing LTCP (includes retention basins and high rate treatment)

Mass of TSS in CSS during precipitation events = 4,212,367 lbs TSS (same as before LTCP implementation)

Mass of TSS discharged from WWTP after treatment = $1,037 \text{ MG} \times 30 \text{ mg/L} \times 8.34 = 259,457$ lbs TSS (note change in volume treated from 756 MG to 1,037 MG due to implementation of retention basins in LTCP)

Mass of TSS treated through high-rate treatment = $150 \text{ MG} \times 414 \text{ mg/L TSS} \times 8.34 \times 0.1 = 51,791$ lbs TSS

Mass of TSS untreated = $33 \text{ MG} \times 414 \text{ mg/L TSS} \times 8.34 = 113,941$ lbs TSS

Total TSS discharged = 259,457 + 51,791 + 113,941 = 425,189 lbs TSS

TSS captured or treated = 4,212,367 – 425,189 = 3,787,178

Total TSS removed from system = (3,787,178/4,212,367) = 90%

This illustrative example shows that the implementation of CSO retention basins and high rate treatment would allow the permittee to meet the criterion of 85 percent capture of TSS.

4.1.4 Water Quality-Based Targets

While the Presumption Approach focuses on achieving certain end-of-pipe goals (e.g., number of overflows, percent capture of volume or pollutants), the CSO Control Policy also allows permittees to comply using water quality-based criteria under the Demonstration Approach. Under the Demonstration Approach, conducting appropriate post construction compliance monitoring involves collection of information sufficient to demonstrate each of the four criteria in the CSO Policy by the permittee (see box at page 27).

This approach focuses on the in-stream water quality in the receiving water; therefore, the majority of post construction compliance monitoring for the Demonstration Approach should focus on receiving water monitoring. Receiving water monitoring is discussed in Section 4.2. However, collecting receiving water monitoring data might not be sufficient to allow evaluation of compliance with the Demonstration Approach. For example, criterion ii discusses the situation in which CSOs for which WQS and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs. The permittee may use a receiving water model to help demonstrate the impact of its CSOs on the receiving water, and the post construction compliance monitoring plan may include using post construction monitoring data to model the receiving water after implementing CSO controls to demonstrate that remaining CSOs would not preclude attainment of WQS if upstream water quality met WQS.

4.1.5 Treatment Requirements

CSO permittees may have requirements to achieve specific levels of treatment of their CSO discharges. These may be expressed as numeric or narrative water quality-based effluent limits in NPDES permits, or they may be treatment requirements or performance standards negotiated with the NPDES authority and incorporated into an LTCP. For example, the CSO Control Policy also defines an overflow event for the purposes of criterion i of the Presumption Approach as one or more overflows from a CSS as the result of a precipitation event that does not receive the following minimum treatment:

- Primary clarification (Removal of floatables and settleable solids may be achieved by any combination of treatment technologies or methods that are shown to be equivalent to primary clarification);
- Solids and floatables disposal; and

- Disinfection of effluent, if necessary, to meet water quality standards, protect designated uses and protect human health, including removal of harmful disinfection chemical residuals, where necessary.

Therefore, to define the number of CSO events that have occurred at a facility, the permittee should evaluate whether flows have been treated to the levels defined above. If the flows have not been treated to the levels defined above, they are considered as CSOs and are counted in the number of CSOs in the system. The permittee's post construction monitoring plan should provide data to demonstrate that any flows that are not considered CSOs have achieved this level of treatment.

Permittees may also have treatment requirements associated with the specific control technologies they have implemented as part of their LTCPs. For example, a permittee that installed high-rate treatment may have performance or treatment requirements for that specific piece of equipment. As with the treatment requirements described above for criterion i of the Presumption Approach, the permittee should include monitoring to collect data for these performance or treatment requirements as part of its post construction compliance monitoring plan.

Providing data that allows the regulatory authority to evaluate compliance with treatment or performance requirements, or both, might be more straightforward than the data collection required under other parts of the post construction compliance monitoring plan because treatment or performance requirements are typically end-of-pipe measurements. Therefore, collecting data for these requirements can be as straightforward as collecting water samples at the end of the pipe and analyzing them for the pollutant to see if they have achieved the requirement.

Note that the requirements for achieving performance levels or treatment requirements should have been defined before developing and implementing the post construction compliance monitoring plan. It is critical that the permittee and the permit writer define and agree on performance standards or treatment requirements and the conditions under which they are to apply. Both permittee and the permit writer should take into account the design standards of the CSO control equipment that they are installing to ensure that the design standards can be achieved under the flow conditions expected during CSO events. For example, it would not make sense to the regulatory authority to require achievement of secondary treatment standards if the control technology is designed to achieve only secondary treatment as an average load under continuous flow conditions.

It might also be necessary for the permit writer and the permittee to ensure that the treatment requirements or performance standards can be compared to the WQS in the receiving water. For example, if the NPDES authority has required a permittee to achieve a treatment requirement related to the geometric mean of bacteria, is the permittee capable of demonstrating compliance with this requirement through collecting treatment data from storm events that will occur at unpredictable intervals?

4.1.6 Other CSO Control Targets

While the CSO Control Policy focuses on the Presumption and Demonstration Approaches for controlling CSOs and achieving CWA goals, there are other potential methods for achieving these goals, such as full sewer separation not developed under a traditional LTCP, or other levels of control under the Demonstration Approach. This section discusses several of these types of alternatives for complying with the CSO Control Policy and discusses several potential options for conducting post construction compliance monitoring for these alternatives.

4.1.6.1 Sewer Separation

Separation is the conversion of a CSS into separate stormwater and sanitary sewage collection systems. This method has historically been used by many communities as a way to eliminate CSOs and their effects altogether. Separation has been reconsidered in recent years because it typically results in increased loads of stormwater runoff pollutants (e.g., sediments, bacteria, metals, oils) being discharged to the receiving waters, is relatively expensive, and can disrupt traffic and other community activities during construction. Sewer separation is a positive means of eliminating CSOs and preventing sanitary flow from entering the receiving waters during wet-weather periods, however, and might still be applicable and cost-effective. It can also be considered in conjunction with the evaluation of sensitive areas in accordance with the CSO Control Policy, although storm drain discharges likely will still remain. In some cases, municipalities that separate their combined sewers might be required to file for NPDES stormwater permit coverage.

Note that this is a different approach than partial sewer separation, which some permittees use in certain parts of their CSS as part of a larger CSO control effort. In such situations, partial sewer separation should be evaluated in terms of the larger CSO control approach because it is used in conjunction with other control methods. It is only in cases of complete sewer separation that CSO control efforts should be evaluated based solely on the success of the separation in eliminating CSOs altogether. The goal of a complete sewer separation is the complete elimination of CSOs. This may be required to meet a water quality goal of meeting existing WQS at all times.

Post construction compliance monitoring for a permittee that has completely separated its sewer system should focus on the confirmation of the separation through collection system analysis than on receiving water monitoring. The goal of post construction monitoring is to ensure that there are no remaining sanitary connections to the storm system or storm connections to the sanitary system (investigations similar to municipal separate storm sewer system requirements to conduct an illicit discharge detection and elimination program). The permit writer might also wish to wrap any CSO post construction compliance monitoring requirements together with any municipal separate storm sewer system permit monitoring requirements to reduce potential redundancy and maximize the relevant data for the stormwater program.

The permit writer may also require modeling or monitoring of the newly separated system to demonstrate that the system no longer has CSOs. This could include monitoring the former CSO outfalls.

4.1.6.2 Other CSO Control Efforts

Because the CSO Control Policy was developed and implemented after CSO control efforts were already underway for some permittees, there might be permittees that have implemented only parts of the policy's recommendations to use either the Presumption or the Demonstration Approach to control CSOs; therefore, they could have different requirements for CSO planning and CSO control implementation than those typically formalized in LTCPs. EPA's previous guidance for CSO permit writers recognized that some permittees might have already undertaken planning efforts before the CSO Control Policy. The previous guidance states that the permit writer should consider the following efforts that a permittee might have taken before implementing NPDES permits that include CSO requirements, including the following:

1. Substantial completion of CSO controls that appear to provide for attainment of WQS
2. CSO control programs substantially developed or implemented pursuant to existing permits or enforcement orders
3. Previous construction of CSO facilities designed to provide for attainment of WQS but where WQS have not been attained because of remaining CSOs

The guidance goes on to state that, if the permittee has *substantially completed* construction of projects designed to provide for attainment of WQS, the permit conditions for LTCP development may be modified to reflect these efforts. The permit writer may choose not to require the initial planning and construction provisions of the LTCP. The permittee, however, should be required to complete the relevant components of the LTCP that might not have been addressed by the permittee's previous efforts or that represent ongoing commitments, including development of an operations and maintenance program and post construction compliance monitoring plan. If the permittee has substantially developed or is developing a CSO control program pursuant to an existing permit or enforcement order but has not completed construction of the selected CSO controls, and the control program is expected to provide for attainment of WQS and is consistent with the objectives of the CSO Control Policy, the permit writer should modify the permit to require evaluation of sensitive areas and financial capabilities, as well as development of a post construction monitoring plan.

This guidance makes it clear that all permittees should develop and implement a post construction compliance monitoring plan, no matter how their CSO program was developed. A post construction compliance monitoring plan developed for CSO control planning begun before implementing the CSO Control Policy should have the same goals as any post construction compliance monitoring program developed consistently with the Presumption or Demonstration Approach outlined in the CSO Control Policy, although the specific details of the plan could be different. These plans should still generate data that allow permit writers to verify the effectiveness of CSO controls and demonstrate compliance with WQS and protection of designated uses.

4.2 Ambient Monitoring for Assessing Compliance with Water Quality Standards

This monitoring requires an understanding of the water quality benefits expected to be realized by implementing the LTCP. Ideally, the ambient monitoring would build on monitoring carried out to characterize CSO impacts and the condition of receiving waters. Coordination with other state and local monitoring efforts is encouraged.

4.2.1 Who Should Conduct the Monitoring?

As described in EPA's CSO Control Policy, a permittee should develop and implement a post construction water quality monitoring plan adequate to verify compliance with WQS and protection of designated uses, as well as to ascertain the effectiveness of CSO controls. Each permittee should develop its plan in consultation with the NPDES authority. The post construction monitoring plan should detail the monitoring protocols to be followed, including the necessary effluent and ambient monitoring and, where appropriate, other monitoring protocols such as biological assessments, WET testing, and sediment sampling. To support their post construction compliance monitoring program the permittee may collect their own data, or if available, use monitoring data from other sources (e.g. federal and/or state agencies). Permittees need to make sure the secondary data used from other sources are quality data.

4.2.1.1 NPDES Watershed Framework

To help permittees reduce some of the costs involved in carrying out post construction compliance monitoring, it might be advantageous for the permitting community to apply the NPDES Watershed Framework (USEPA 2007b; http://www.epa.gov/npdes/pubs/watershed_techguidance_entire.pdf), where all interested parties are involved in designing and implementing watershed goals. It is also important to note that eliminating CSO discharges will not always ensure that WQS will be met because other pollution sources (e.g., sanitary sewer overflows, stormwater, pollution from upstream sources, concentrated animal feeding operations) can affect the receiving waterbody (OIG 2002; <http://epa.gov/oigearth/reports/2002/csfinal.pdf>). It is often necessary to limit all sources of pollutants to the watershed to ensure that WQS will be met.

As described in EPA's (2007b; http://www.epa.gov/npdes/pubs/watershed_techguidance_entire.pdf) *Watershed-based NPDES Permitting Technical Guidance*, the NPDES Watershed Framework includes a geographic focus, sound management techniques based on strong science and data, and partnerships/stakeholder involvement. Watershed teams might include representatives from all levels of government, public interest groups, industry, academic institutions, private landowners, concerned citizens, and others.

Integrating NPDES permits and the NPDES program into a watershed approach means developing and using a watershed-based analysis as part of the permitting process and using that analysis to identify a range of NPDES implementation options, and potentially other program options to achieve watershed

goals. This approach explicitly considers the impact of multiple pollutant sources and stressors, including nonpoint source contributions, when developing point source permits (USEPA 2007b; http://www.epa.gov/npdes/pubs/watershed_techguidance_entire.pdf).

EPA's (2007b; http://www.epa.gov/npdes/pubs/watershed_techguidance_entire.pdf) *Watershed-based NPDES Permitting Technical Guidance* provides descriptions of several potential NPDES implementation options. In cases where treatment plants, stormwater, CSOs and other municipally controlled point source activities are each under single ownership, the NPDES authority could consider one permit that covers and integrates all NPDES requirements. This would reduce the administrative burden for the permittee and NPDES authority and allow the NPDES authority to develop permit conditions (limitations and monitoring requirements) that specifically address existing watershed goals and watershed management plans. A watershed permitting approach accounts for upstream pollutant contributions and promotes early and continuous involvement of parties responsible for upstream sources.

A group using a coordinated, cooperative approach to collecting water quality data is referred to as a monitoring consortium. EPA has developed guidance on establishing monitoring consortiums within watersheds titled *Monitoring Consortiums: A Cost-Effective Means to Enhancing Watershed Data Collection and Analysis* (USEPA 1997; http://www.epa.gov/owow/watershed/wacademy/its03/mon_cons.pdf). A consortium offers a watershed-based method of implementing many monitoring needs (e.g., TMDL development, water quality trading, watershed-bounded multi-source permit development). In addition, monitoring consortiums help participants pool funds and share expertise while collecting data to identify trends, evaluate attainment of WQS, develop management strategies, and improve data consistency and comprehensiveness. NPDES authorities should consider whether a cooperative data collection effort by sources within the watershed would help permittees reduce their overall monitoring costs.

4.2.1.2 Watershed Teams

Most communities with CSSs (and therefore with CSOs) are in the Northeast and Great Lakes regions, and the Pacific Northwest. Several CSO communities have used a watershed approach to address water quality issues and associated receiving water quality monitoring, including the following:

- The Rouge River Gateway Partnership: As described on the Rouge River Project's Web site (<http://www.rougeriver.com/geninfo/new/gateway.html>), this partnership includes representatives from three counties, 48 Metro-Detroit communities and numerous stakeholders in Michigan.
- The Merrimack CSO Coalition (<http://www.nae.usace.army.mil/projects/ma/merrimack/merrimack.htm>) includes Massachusetts and New Hampshire communities along the Merrimack River, with assistance from the U.S. Army Corps of Engineers.
- The 3 Rivers Wet Weather Demonstration Program (<http://www.3riverswetweather.org/>) is made up of representatives from three geographically defined planning basins (Eastern,

Northern, and Southern) in Allegheny County, Pennsylvania, in a partnership with the Allegheny County Sanitary Authority and the Allegheny County Health Department.

- The Maumee River Basin Partnership (<http://www.mrbplg.org/>) includes several municipalities on the Maumee River in Indiana, Ohio, and Michigan, as well as watershed management groups, and the regional community. Several local watershed groups (<http://www.mrbplg.org/locwsgroups.html>) perform monitoring in this watershed.
- The City of Omaha's CSO Program (<http://www.omahacso.com/>) includes a CSO monitoring project, as described in the CSO Monitoring Plan for Omaha (<http://ne.water.usgs.gov/projects/cso.html>). The U.S. Geological Survey (USGS) Nebraska Water Science Center, in cooperation with the City of Omaha, will participate in the CSO monitoring project.
- Northeast Ohio Regional Sewer District Mill Creek Watershed CSO Monitoring (<http://pubs.usgs.gov/of/2007/1171/>): USGS, in cooperation with the Northeast Ohio Regional Sewer District performed *Escherichia coli* monitoring in the Mill Creek Watershed before and during sewer modifications implemented to eliminate or control (by reducing the number of overflows) all the CSOs in the Mill Creek watershed.
- Ohio River Valley Water Sanitation Commission (ORSANCO) Wet Weather Studies (<http://www.orsanco.org>): Several ORSANCO studies are being conducted to help government agencies better understand the local effects of CSOs and the development of effective bacteria reduction strategies. Study participants include EPA, states, and municipalities.

In many cases, CSO watershed team monitoring is partially funded through partnerships with federal or state agencies. A searchable catalog of federal funding sources (grants, loans, cost-sharing) for watershed protection, including monitoring, is on EPA's Web site at <http://cfpub.epa.gov/fedfund/>.

Permittees might be able to obtain assistance with monitoring from state, interstate, or tribal agencies. The six congressionally authorized interstate organizations are New England Interstate Water Pollution Control Commission, ORSANCO, Interstate Environmental Commission, Interstate Commission of the Potomac River Basin, Delaware River Basin Commission and Susquehanna River Basin Commission. If a state, interstate, or tribal agency is already conducting ongoing studies of the CSO receiving waterbody to be evaluated, the agency might be able to provide historical monitoring data to the permitting community, or if funding allows, include additional parameters or sample points in its upcoming monitoring plans to help evaluate the permittee's compliance with WQS and protection of designated uses.

Many academic institutions and volunteer community organizations also support CSO receiving water monitoring programs. Monitoring data from academic institutions and volunteer groups can have a high degree of credibility, particularly where quality assurance and quality control procedures are documented (USEPA 1997; http://www.epa.gov/owow/watershed/wacademy/its03/mon_cons.pdf).

Additional guidance on funding CSO monitoring programs is in EPA's *Combined Sewer Overflows Guidance for Funding Options* (USEPA 1995a; <http://www.epa.gov/npdes/pubs/owm0249.pdf>) and the

Office of Inspector General's (2002; <http://epa.gov/oigearth/reports/2002/csfinal.pdf>) *Wastewater Management Controlling and Abating Combined Sewer Overflows*.

4.2.2 What Should be Monitored?

The permittee, in consultation with the NPDES authority, should select the pollutants to be included in the post construction water quality monitoring program. The permittee should document these pollutants and the rationale for their selection in the facility's field sampling plan. The pollutants that should be selected (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) include those that are

- Suspected to be present in the combined sewage
- Discharging to a sensitive area
- Causing impairment of receiving waterbody designated uses
- Causing exceedances of receiving WQS
- Discharged by industrial users in quantities that are expected to adversely affect receiving water quality

The permittee, in consultation with the NPDES authority, should determine what EPA, state, and local water quality criteria or standards applicable to the specific designated use(s) of the receiving water are available for these pollutants. Information on designated uses and use attainability analyses is available from EPA's Designated Uses Web site (<http://www.epa.gov/waterscience/standards/uses>). In addition, links to state, tribal, and territorial WQS are at <http://www.epa.gov/waterscience/standards/wqslibrary/links.html>.

When determining the specific designated use(s) of the receiving water, permittees should consult with the NPDES authority to determine whether CSOs are discharged into sensitive areas. Sensitive areas are determined by the NPDES authority in coordination with state and federal agencies. As described in EPA's CSO Control Policy, sensitive areas include Outstanding National Resource Waters, National Marine Sanctuaries, waters with threatened or endangered species and their designated critical habitat, waters with primary contact recreation, public drinking water intakes or their designated protection areas and shellfish beds.

The permittee should also discuss with the NPDES authority the sampling protocols and analytical methods acceptable for analysis of pollutants in receiving waters. The permittee's field sampling plan should follow the sampling and analytical procedures in Title 40 of the *Code of Federal Regulations* (CFR) Part 136 (Appendix E), including the use of appropriate sample containers, sample preservation methods, maximum allowable holding times, described in Table II of Part 136.3, and analytical methods approved for NPDES compliance monitoring detailed in Tables IA – IH of Part 136.3. In addition, a discussion of how monitoring should be performed is presented in Section 4.2.5 and in EPA's (1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) *Combined Sewer Overflows Guidance for Monitoring and Modeling*. Appendix C of this guidance also provides a basic framework for addressing the technical issues associated with purchasing laboratory services for field sampling.

4.2.2.1 Pollutants Suspected to Be Present in the Combined Discharge

In-stream ambient water quality is typically affected by pathogens, oxygen demanding substances, nutrients, oils, floatables and solids from CSO discharges. In general, these parameters or their indicators should be included in the CSO post construction compliance monitoring program because they are suspected to be present in the combined sewage, and they could adversely affect the receiving waterbody.

4.2.2.2 Pollutants Causing Impairment of Waterbody Designated Uses/Pollutants Causing Exceedances of Receiving Water Quality Standards

The permittee, in consultation with the NPDES authority, should review applicable state CWA section 303(d) or 305(b) reports or lists to determine the parameters causing impairment in receiving and downstream waterbodies. In addition, permittees should evaluate any previous water quality monitoring performed on the receiving water during preparation of the LTCP. All parameters for which the waterbody is impaired or those exceeding WQS should be selected for field sampling.

4.2.2.3 Pollutants Discharged by Industrial Users in Quantities That Are Expected to Adversely Affect Receiving Water Quality

Permittees should review all available industrial pretreatment program data to determine what pollutants discharged by industrial users could adversely affect receiving water quality (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>).

4.2.2.4 Potential Receiving Water Monitoring Parameters

CSOs contain a variety of pollutants from domestic and industrial wastewater as well as from stormwater. As described in Section 4.1 of EPA's (2004b; http://cfpub.epa.gov/npdes/cso/cpolicy_report2004.cfm) *Report to Congress on the Impacts and Control of CSOs and SSOs*, pollutants in CSOs come from a variety of sources. Domestic wastewater contains microbial pathogens, oxygen demanding substances, suspended solids, and nutrients. Wastewater from industrial facilities, commercial establishments, and institutions can contribute additional pollutants such as oil and grease, toxic metals, and synthetic organic compounds. Although the concentration of pollutants in stormwater is generally more dilute than in wastewater, it can contain significant amounts of microbial pathogens, oxygen demanding substances, suspended solids, toxic metals, pesticides, nutrients, and floatables.

CSO pollutant concentrations vary within a given event as well as from event to event and community to community (USEPA 2004b; http://cfpub.epa.gov/npdes/cso/cpolicy_report2004.cfm). Depending on industrial pretreatment discharges and receiving waterbody and downstream designated uses and water quality impairments, post construction compliance monitoring parameters could include one or more of the following:

- Bacterial indicators (e.g., enterococcus, *E. coli*, fecal coliform bacteria)

- Dissolved oxygen
- Biochemical oxygen demand
- Nutrients
- Floatables
- Dissolved solids
- Suspended (or settleable) solids
- Oil and grease
- Flow (velocity)
- Temperature
- pH
- Turbidity
- Conductivity
- Toxic metals
- Pesticides
- Any *anticipated* CSO parameter subject to a TMDL wasteload allocation for CSOs or under a CWA section 303(d) listing
- Any other parameter that could affect public health or aquatic life

Bacterial Indicators

Fecal bacteria have been used as an indicator of the possible presence of pathogens in surface waters and the risk of disease, on the basis of epidemiological evidence of gastrointestinal disorders from ingesting contaminated surface water or raw shellfish. Contact with contaminated water can lead to ear or skin infections, and inhaling contaminated water can cause respiratory diseases. The pathogens responsible for these diseases can be bacteria, viruses, protozoans, fungi, or parasites that live in the gastrointestinal tract and are shed in the feces of warm-blooded animals (USEPA 2008; <http://www.epa.gov/waterscience/beaches/sanitarysurvey/pdf/user-manual.pdf>). Examples of pathogenic bacteria associated with untreated wastewater, CSOs, and SSOs include *Campylobacter*, *Salmonella*, *Shigella*, *Vibrio cholerae*, and *Yersinia* (USEPA 2004b; http://cfpub.epa.gov/npdes/cso/cpolicy_report2004.cfm).

Enterococci and *E. coli* are used as the primary indicators of fecal contamination and are recommended as the basis for bacterial WQS in EPA's 1986 *Ambient Water Quality Criteria for Bacteria* (<http://www.epa.gov/waterscience/beaches/files/1986crit.pdf>) document (both for fresh waters, enterococci for marine waters). The standards are defined as a concentration of the indicator above which the health risk from waterborne disease is unacceptably high.

Dissolved Oxygen and Biochemical Oxygen Demand

Dissolved oxygen is an important measure of the quantity of oxygen available to aquatic organisms in the receiving stream. Biochemical oxygen demand (measured as BOD₅, the amount of dissolved oxygen consumed within 5 days by biological processes breaking down organic matter) is widely used as a measure of the amount of oxygen-demanding organic matter in water. The organic matter in sewage includes human excreta, kitchen waste, and industrial waste (USEPA 2004b; http://cfpub.epa.gov/npdes/cso/cpolicy_report2004.cfm). Oxygen depletion that results from the discharge of CSOs containing oxygen-demanding substances can harm or kill fish and benthic invertebrates in streams and rivers.

Nutrients

Nitrogen in its ammonia/ammonium or nitrate/nitrite forms is a nutrient for aquatic vegetation. Nitrogen also is a limiting nutrient to algal production in marine and estuarine systems. Phosphorus is the limiting nutrient for growth of aquatic vegetation in freshwater rivers and lakes and, when discharged in high concentrations, can lead to eutrophication in waterbodies. Limiting the loading of nitrogen and phosphorus into receiving streams is critical to alleviating eutrophication in downstream coastal waters.

Floatables and Solids

Floatable debris causes problems because it can easily come into contact with aquatic animals, people, boats, fishing nets, and other objects. Communities also lose money when beaches must be closed or cleaned up, and the fishing industry and recreational and commercial boaters spend thousands of dollars every year to repair vessels damaged by floatable debris (USEPA 2002d; <http://www.epa.gov/owow/oceans/debris/floatingdebris/debris-final.pdf>). Floatable debris also can be a source of bacterial contamination to bathing beaches. Types of floatables present in water include street litter (e.g., cigarette butts, filters); medical items (e.g., syringes); resin pellets; food packaging; beverage containers; sewage-related items; pieces of wood and siding from construction projects; fishing equipment (e.g., nets, lures, lines); household trash; plastic bags and sheeting; and beverage yokes (six-pack rings for beverage containers) (USEPA 2002d; <http://www.epa.gov/owow/oceans/debris/floatingdebris/debris-final.pdf>).

TSS can injure or kill fish, shellfish, and other aquatic organisms in receiving waters by causing abrasions and by clogging gills. Indirectly, solids can screen out light and can contribute to the development of noxious conditions through oxygen depletion. Some nutrients bind to solids, and solids often include oxygen-demanding organic material. Solids also have the potential to settle on the bottom of the receiving waterbody and smother spawning beds or other habitats. Also, the presence of solids in receiving waters used as drinking water source waters can increase the cost of drinking water treatment.

Oil and Grease

Excessive oil and grease concentrations can be associated with high biochemical oxygen demand in a waterbody, and they can present other nuisance problems.

Flow, Temperature, pH, Turbidity, and Conductivity

Stream or river *discharge* is sometimes called *flow*. A discharge measurement is a combination of a velocity measurement and a cross-sectional area measurement. The units in these two measurements are as follows: velocity = length per unit time, and cross-sectional area = width x depth of the stream (units are length squared). When these two values are multiplied together, the resulting units are length cubed, or volume per unit time. Flow is generally measured in units of cubic feet per second or MGD. For a complete reference on measuring stream discharge, see USGS Water Supply Paper 2175 (USGS 1982; <http://pubs.usgs.gov/wsp/wsp2175>). Flow or discharge measurements are essential to most pollution management and control activities. High flows due to CSOs may cause stream bank erosion.

Water temperature is routinely measured for use in taking temperature-dependent measurements such as pH. Water temperature can also be important in assessing the quality of potential habitat for aquatic species and for some less-desirable pathogenic organisms.

The field parameter, pH, is a measure of the acidity (hydrogen/hydroxide ion concentration) of water in sampling locations identified for characterization and assessment. Most aquatic organisms have a preferred range of pH, usually pH 6 to 9. Beyond that range aquatic organisms begin to suffer stress, which can lead to death. High pH values also force dissolved ammonia into its toxic, un-ionized form, which can further stress fish and other organisms.

Turbidity is a measure of water cloudiness. Turbidity is not specific to the types of particles in the water. These particles can be suspended or colloidal matter, and they can be inorganic, organic, or biological. Waters that are unnaturally turbid can be harmful to fish and other aquatic life by clogging respiratory organs and impairing visual-based predators.

Conductivity is highly correlated with the concentration of dissolved solids in the water column. Aquatic organisms require a relatively constant concentration of the major dissolved ions in the water. Levels too high or too low can limit survival, growth, or reproduction. Also, salinity of a waterbody can be estimated by measuring conductivity because electric current passes much more easily through water with a higher salt content (USEPA 2008; <http://www.epa.gov/waterscience/beaches/sanitarysurvey/pdf/user-manual.pdf>).

Toxic Metals and Pesticides

Many metals are toxic to algae, aquatic invertebrates, and fish. The metals most commonly identified in wastewater include cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. Stormwater in CSSs can also contribute metals such as arsenic, cadmium, chromium, copper, lead, nickel, and zinc to receiving waters (USEPA 2004b; http://cfpub.epa.gov/npdes/cso/cpolicy_report2004.cfm).

Although pesticides and herbicides can serve useful purposes in backyard applications, some of these chemicals are bioaccumulative and retain their toxicity after they are discharged into receiving waters. Pesticide loading to receiving streams should be monitored to prevent impairment of downstream uses such as drinking water, wildlife habitat, and recreation. Chronic effects on aquatic communities from exposure to toxic metals and pesticides include lower productivity and biomass and reduced biological

diversity. Acute effects can be observed as immediate fish kills or severely reduced biological diversity (USEPA 2004b; http://cfpub.epa.gov/npdes/cso/cpolicy_report2004.cfm).

Additional Parameters or Assessments

The permittee, in consultation with the NPDES authority, should determine whether any additional parameters or field monitoring should be selected for post construction compliance monitoring. These could include any *anticipated* CSO parameter subject to a TMDL wasteload allocation for CSOs or under a CWA section 303(d) listing or any other parameter that could affect public health or aquatic life.

Additional assessments could include biological assessments (Barbour et al. 1999; <http://www.epa.gov/owow/monitoring/rbp/index.html>), sediment monitoring (e.g., see EPA's Suspended and Bedded Sediments Web page at <http://www.epa.gov/waterscience/criteria/sediment/>) and WET testing (<http://www.epa.gov/waterscience/methods/wet/>).

Biological assessments can include a survey of the macroinvertebrate or fish community both up and downstream of the CSO. Comparison of pollution-sensitive metrics such as the number of certain taxa, life stages of fish present and the abundance of juvenile fish, species richness, and species diversity could indicate a significant difference between upstream and downstream communities. Biological impairment downstream of a CSO can indicate that the CSO is a potential source of pollutants that are causing the impairment and are not being measured. Another potential issue to consider is that differences in hydrological conditions (e.g., flow or velocity) between up and downstream of the CSO, rather than water quality impacts, could be responsible for differences observed in biological condition.

Typical biological assessments include the collection, identification, and assessment of macroinvertebrates, fish, or periphyton. Impairment to one or more types of biological communities could narrow the focus of source identification. For example, certain benthic invertebrate species (e.g., mayflies) are more sensitive to metals than most fish species, while certain fish species (e.g., trout, bluegill) are generally more sensitive to ammonia than invertebrates. Thus changes in one or more communities could aid in determining the specific cause of impairment.

If siltation carries significant levels of pathogens or chemical pollutants, it might preclude harvesting of shellfish for consumption. In inland receiving waters, siltation and sedimentation impair benthic habitats for fish and invertebrates, potentially limiting the presence of certain species or life stages. Evaluation of available habitat is often effectively conducted as part of EPA's Rapid Bioassessment Protocols (RBPs) (Barbour et al. 1999; <http://www.epa.gov/owow/monitoring/rbp/index.html>). The RBPs include visual-based assessment of a variety of characteristics of the prevailing habitat conditions among which is imbeddedness of the substrate critical to spawning and rearing of aquatic species. Because of the variety and comprehensiveness of habitat characteristics evaluated in the RBPs, they provide a cost-effective screening tool indicating the abundance and viability of habitats requisite to a number of designated uses and can assist in focusing investigations on areas of nonattainment or potentially at-risk habitats.

In addition to physical habitat quality impacts due to sediments, sediments can accumulate pollutants, particularly those that are less water soluble such as petroleum products, many pesticides, and PCBs.

This is especially the case in receiving waterbodies having fine particle sized sediments, such as silts and clays. The presence of toxic pollutants in sediments from a point source can be evaluated using whole sediment toxicity test protocols developed by EPA and ASTM. Samples of sediment up and downstream of a CSO outfall can be collected during base flow conditions and tested to evaluate potential pollutant effects of a CSO. Such monitoring might also help inform results of a bioassessment. However, pollutants accumulated in sediment may originate from many sources other than the CSO of interest and therefore interpretation of sediment toxicity results should be done with care. An important aspect of such testing is having a known reference site in the waterbody to characterize background conditions, in addition to an upstream site, which can then be compared to the CSO site results. Sediment toxicity testing of CSOs is probably best used in fairly small waterbodies where the source of sediment pollutants can be reasonably known.

Because the types and concentrations of chemical pollutants can vary, and they are often incompletely known, WET should also be considered as a monitoring parameter where aquatic life use protection is needed. WET has the advantage of providing a standardized measure of toxicity that takes into account all pollutants in the sample as well as the interactions between them. In addition, WET provides a direct measure of pollutant (e.g., metal) bioavailability because it includes the water quality characteristics (e.g., hardness, pH) of the sample.

The permitting community should also determine whether any additional measurements are required to calculate values for pollutants selected for post construction compliance monitoring for comparison to applicable WQS or criteria (e.g., hardness for calculating applicable criteria for several metals, pH for calculating applicable ammonia criteria).

Examples of parameters for which NPDES authorities might require CSO post construction monitoring are provided in Table 3.

Table 3. Example Parameters for which NPDES Authorities Might Require Post Construction Monitoring

Waterbody or CSO attribute	Example parameters to be monitored
Waterbody on 303(d) list for dissolved oxygen impairment	nutrients, BOD ₅ , dissolved oxygen
Waterbody on 303(d) list for sedimentation	settleable solids, turbidity, sediment survey
Waterbody designated uses include primary contact recreation	bacterial indicators
Waterbody zinc concentrations exceeding WQS	dissolved zinc, hardness ^a
Fish kills reported in waterbody	dissolved oxygen, BOD ₅ , oil and grease, pH, toxic metals, hardness, pesticides
CSS within a coastal system	sodium, chloride, total dissolved solids or conductivity ^b

^a Note that several metal criteria are hardness-dependent; therefore, it is required that samples analyzed for metals also be analyzed for hardness.

^b In coastal systems, these measurements can be used to detect the presence of sea water in the CSS, which might be the result of intrusion through failed tide gates (USEPA 1999 ; <http://www.epa.gov/npdes/pubs/sewer.pdf>).

4.2.3 Where Should Monitoring Be Performed?

When choosing sampling locations, the permittee should consider the following receiving water characteristics:

- Locations of sensitive areas
- Upstream and downstream of CSO outfalls
- Location and impacts of other sources of pollutant loadings; when possible, the permittee should select monitoring locations that have limited or known effects from other pollutant sources
- Location of historical monitoring locations used to initially characterize CSO impacts
- Size of the waterbody
- Horizontal and vertical variability in the waterbody
- Degree of resolution necessary to assess attainment of WQS
- Data needed to populate or validate water quality models
- Physical logistics (accessibility, whether water is navigable, if bridges are available from which to sample)
- Crew safety (see Section 4.2.5, How Should Monitoring Be Conducted?)

Potential receiving water sampling designs (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) include the following:

- Reference site samples collected at separate locations for comparison with the CSO study site to determine relative changes between the locations.
- Near-field studies to sample and assess receiving waters within the immediate mixing zone of CSOs. These studies can examine possible short-term toxicity impacts or long-term habitat alterations near the CSO.
- Far-field studies to sample and assess receiving waters outside the immediate vicinity of the CSO. These studies typically examine delayed impacts, including oxygen demand, nutrient-induced eutrophication, and changes in macroinvertebrate assemblages.
- Assessing WQS for recreation, where the NPDES authority could require determination of a maximum or geometric mean bacterial indicator concentration at point of discharge into river or mixing zone boundary.

The location of sampling points should be dependent on the type of waterbody receiving CSO discharges. In EPA's (2004b; http://cfpub.epa.gov/npdes/cso/cpolicy_report2004.cfm) *Report to Congress on the Impacts and Control of CSOs and SSOs*, EPA identified the types of waterbodies receiving CSO discharges by associating CSO outfall locations with USGS's National Hydrography Dataset (NHD) indexed waters.

Chapter 4 of EPA's (1999) *Combined Sewer Overflows Guidance for Monitoring and Modeling* (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) provides detailed information on determining sampling locations for rivers, streams, creeks, and similar waterbodies. The permitting community should select a reference site or sites (e.g., upstream of the CSO location, an adjacent reach) for comparison with water samples collected downstream of the CSO to evaluate relative changes between the locations. The permitting community should also determine whether mixing zones are applicable to the CSO discharges, and if so, whether monitoring locations should be selected both within the mixing zone to evaluate acute toxicity as well as outside the mixing zone to evaluate compliance with chronic water quality criteria. EPA has determined that mixing zones are not appropriate for pathogenic pollutants.

If the CSO permittee decides to take the watershed approach (see Section 4.2.1 of this guidance), in which NPDES authorities require other point sources in the watershed to perform reference site and downstream monitoring to assess the effect of other sources of pollution. This information could be used to compare relative pollutant contributions from each source. The permitting community should also consider making cooperative sampling arrangements when pollutants from multiple sources are discharged into a receiving water or when several agencies share the cost of the collection system and the POTW. The identification of new monitoring locations should account for sites that might already be part of an existing monitoring system used by local or state government agencies or research organizations (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>).

The permitting community should consider where samples will be collected at each sampling location. To obtain a sample from a well-mixed portion of a river or stream, it is generally recommended that the samples be obtained at mid-depth (avoiding collection of sediment from the bottom and any scum at the top) at the midpoint of the waterbody. In cases where there are sensitive areas of concern (e.g., drinking water source, primary contact recreation,), the NPDES authority should consider the users at risk (USEPA 2002e; <http://www.epa.gov/waterscience/beaches/technical.html>). More details on identifying sample locations for recreational waters are provided below.

Ideally, previous monitoring has been performed under the Phase I permit requirement to implement the NMCs to characterize baseline CSO impacts and the condition of receiving waters before CSO controls were implemented. In such cases, it is recommended that the permittee conduct monitoring at both the same and different sample locations used to initially characterize CSO impacts and the condition of receiving waters to test the accuracy of the assumptions used in modeling.

EPA recognizes that in many situations, budgetary constraints will affect the number of samples that can be collected and analyzed. Because variability is usually greater from storm to storm than site to site, it is generally preferable to select a set of representative locations at which samples can be collected during several storms and dry-weather events than it is to rotate between several receiving water locations. If only a few monitoring locations can be monitored, the permitting community should choose sampling locations that represent the worst-case scenario (areas that receive overflows most frequently or have the largest pollutant loading or flow volume, sensitive areas) (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>).

Recreational Waters

In many cases, monitoring at recreational waterbodies is already performed under the Beaches Environmental Assessment and Coastal Health (BEACH) Act. The BEACH Act was passed on October 10, 2000, and amended the CWA by adding section 406. The BEACH Act addresses pathogens and pathogen indicators in coastal recreation waters (USEPA 2002e). A complete copy of the BEACH Act is at <http://www.epa.gov/waterscience/beaches/technical.html>.

EPA recommends that the permittee coordinate CSO receiving water monitoring for primary and secondary contact recreation areas with existing water quality monitoring performed under the BEACH Act. Chapter 4 and Appendices H and J of EPA's (2002e; <http://www.epa.gov/waterscience/beaches/technical.html>) *National Beach Guidance and Required Performance Criteria for Grants* provides detailed information on monitoring at bathing beaches. When selecting monitoring locations at recreational waters, the permitting community should, at a minimum, consider selecting monitoring locations near the CSO outfall and typical bathing areas.

When determining the depth of sampling at recreational waters, the primary factor is identifying the users at risk (USEPA 2002e; <http://www.epa.gov/waterscience/beaches/technical.html>). Samples of ankle- or knee-depth water might be more appropriate for children and infants, whereas waist- or chest-depth samples might be more appropriate for adults. Sampling from boats is usually inadequate for beach monitoring because water depths would exceed those common to beach-related recreational activities, especially for young children (CADHS 1999). It might also be desirable to select monitoring locations away from the shore in areas where surfing, windsurfing, jet skiing, or other activities occur.

Areas Designated for the Protection of Fish, Shellfish, and Wildlife

Areas designated for protection of fish propagation and shellfish could require assessment of channel morphology because sediment loading and siltation can significantly affect fish spawning and rearing areas. Bedded substrates from siltation can prove to be unsuitable as spawning grounds for resident fishes or sensitive species.

Samples for WET testing should be collected from the CSO outfall if possible so as to evaluate the potential effects of the discharge on waterbody aquatic life. Another approach that could be used to evaluate CSO discharges is ambient toxicity testing using samples collected up and downstream of the CSO outfall. These WET tests are typically conducted as screening tests, with no dilution of samples. Note that it might not be possible to accurately assess the toxicity of the CSO discharge under high-flow conditions because there could be many other sources of pollutants between the up and downstream site. Also, as noted previously, upstream samples could be toxic in themselves because of influences further upstream; this would make toxicity comparisons between up and downstream samples problematic. In general it might be analytically more appropriate to evaluate the toxicity of wet-weather



CSO discharges using laboratory-based WET testing of the outfall rather than ambient testing using up and downstream samples.

Most biological and sediment assessments are designed as upstream vs. downstream or downstream vs. some known reference condition for the region. Therefore, if the original assessment was an upstream vs. downstream assessment, sampling should be completed in the same locations if feasible after implementing CSO controls. If the original assessment was conducted as a downstream assessment compared to a known reference condition for the region, downstream sampling in the same general vicinity would be necessary to demonstrate improvement with the implementation of the CSO controls. The downstream sampling location should be selected with care so that the biota or sediment being sampled is in fact exposed to the CSO plume during the flow condition being monitored, which could imply that the downstream location represents a certain degree of mixing of the CSO discharge with the receiving system. However, the location should not be so far downstream from the CSO outfall such that the biota or sediment is likely to be affected by other sources of pollutants (e.g., other point sources). Such monitoring would make it difficult to interpret CSO compliance. If there are many CSOs in a relatively small area or stretch of stream, it might be more feasible and more useful to monitor up and downstream of the group of CSOs in question. While this sampling design would not enable one to distinguish effects from specific CSO discharges, it provides a more useful assessment of the cumulative impacts of the group of CSOs. WET testing and pollutant monitoring of the individual CSO discharges could be used to distinguish relative impacts of the different CSOs and therefore relative contributions to cumulative impacts on biota or sediment.

Areas Designated for Public Water Supply

CSO discharges to waters designated for public water supply should be evaluated adjacent to intakes to ensure that any potential pollutants posing human health risk do not exceed treatment capacity of the distribution system. Discharges in such sensitive waters require exhaustive monitoring because of the potential for residential and agricultural pesticides and fertilizers in stormwater runoff. Further, heavy metals and trace organics might be present in runoff from roads and parking lots, which could require more advanced treatment than routine disinfection of sanitary discharges.

Rainfall Gage and Stream Gage Locations

It is recommended that rainfall be measured using rain gages throughout the CSS drainage area to evaluate local rainfall conditions and the impact of CSOs on receiving waters. The post construction monitoring plan should identify locations where rain gages will be placed to provide data representative of the entire CSS drainage area. The permittee should space gages closely enough to reduce variation in storm tracking and storm intensity measurements within the CSS area. As described in EPA's (1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) *Combined Sewer Overflows Guidance for Monitoring and Modeling*, rain gages are often spaced 6 to 8 kilometers apart; however, gages might need to be spaced more closely than that to provide sufficient data for analysis. Rain gages can provide valuable information and are usually relatively inexpensive.

and diurnal flow to the treatment plant (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>). When possible, the permitting community should be sure that most receiving water monitoring is performed during those seasons, flow regimes, and other critical conditions during which it is expected that CSOs would have the greatest potential for effects.

In addition to identifying the number of storm events needed to provide data for evaluating receiving water impacts, the permitting community should consider the following factors when determining the frequency, duration, and schedule of monitoring:

- WQS appropriate for the prevailing uses
- Classification of the waterbody
- Location of CSO outfalls
- Wet- and dry-weather monitoring needs
- Climate and season
- Duration and frequency of CSO discharges
- The need to maintain and apply water quality models (refer to Section 4.1 of this guidance document for additional information on when models might be applied)

Water Quality Standards

The permitting community should identify what water quality criteria or standards (see Appendix A of this guidance) are applicable to the parameters selected for monitoring (see Section 4.2.2 of this guidance) and designated use(s) of the receiving water. In general, it might be appropriate to more frequently monitor CSO discharges to sensitive areas or high-quality areas (e.g., drinking water intakes, primary or secondary contact recreational areas) (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>).

When one of the designated uses of the receiving waterbody is recreation, the permittee will need to collect and analyze samples for *E. coli* or enterococci during the recreational season (generally the end of May through the beginning of September). Note that EPA's criteria for full body contact recreation at recreational waters is based on a geometric mean of a statistically sufficient number of samples (generally not less than five samples equally spaced over a 30-day period) (USEPA 1986; <http://www.epa.gov/waterscience/beaches/rules/bacteria-rule.htm>). If the permitting community is interested in using a single sample maximum value to assess whether receiving water quality meets bacteria criteria, readers should refer to EPA's Web site on Using Single Sample Maximum Values in State Water Quality Standards, at <http://www.epa.gov/waterscience/beaches/rules/singe-sample-maximum-factsheet.htm>.

Wet- and Dry-Weather Monitoring Needs

To provide data for evaluating receiving water impacts and effectiveness of CSO controls, the permittee should consider collecting samples during the following conditions.

- Dry-weather events

- Wet-weather events during which a CSO is not expected to occur
- Wet-weather events during which a CSO is expected to occur

Monitoring during both dry-weather events as well as wet-weather events during which a CSO is not expected to occur should provide background data on conditions in the receiving waters and help the permitting community determine whether water quality criteria are being met or exceeded during dry-weather and wet-weather non-CSO events, respectively. In addition, monitoring during wet-weather events during which a CSO event is not expected to occur will provide data indicating whether CSO controls are working as designed.

In cases where the facility is using the Presumption Approach (CSO Control Policy Section II.C.4.a.i and ii), the permittee should consider collecting samples during dry-weather and wet-weather events during which a CSO is expected to occur.

Most monitoring should be targeted for wet-weather events during which a CSO event is expected to occur, so that the potential greatest impacts from CSOs on receiving water quality can be evaluated. These data can be used to characterize the effectiveness of technologies used to treat CSOs remaining after implementing the NMCs and within the criteria specified in Sections II.C.4.a.i or ii of the CSO Control Policy. These treatment technologies, as described in Section II.C.4.a.iii of the CSO Control Policy, include primary clarification (or equivalent method); solids and floatables disposal; and disinfection of effluent (if necessary) to meet WQS, protect designated uses, and protect human health, including removal of harmful disinfection residuals where necessary.

The permittee should also consider monitoring storms of varying intensity with a variety of pre-storm conditions (e.g., varying number of days since the last storm, varying intensity of the previous storms) and preceding dry days to represent a range of conditions experienced by the CSS (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>).

Climate and Season

As described earlier in this section of the guidance document, depending on the designated uses of the receiving waterbody, the NPDES authority might require seasonal monitoring (e.g., late spring-summer recreational season) to evaluate the effectiveness of CSO controls and receiving water quality. The permitting community should evaluate local historical weather data to determine the seasons when most high-intensity rain storms or stormwater runoff/snow melt events are likely to occur, so that monitoring can be targeted during this time.

Duration and Frequency of CSO Discharge

In most cases, CSO discharge will start after a rainfall event has begun and might continue for some time after rainfall has ceased. Many in-stream samples collected during a wet-weather event represent times either before or after the CSO *slug* has passed (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>). Because receiving waterbody hydrographs generally correspond only to the duration and intensity of rainfall in the watershed, the permittee will need additional information to more accurately predict when CSO sampling should begin and the duration

and frequency of sampling. Ideally this additional information should include the actual CSO discharge start and stop times and estimations of how long it will take for a CSO slug, once discharged, to reach the monitoring location(s).

It is expected that permittees will know when a CSO event begins and ends on the basis of flow measurements at the CSO outfalls (refer to Section 4.1.2 of this guidance document for additional information on determining flows). To identify when receiving water monitoring locations are affected by CSO discharges (so that samples can be collected during these times) the permittee could perform a time travel analysis (Langrangian analysis) (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>). The Rouge River National Wet Weather Demonstration Project performed several time-of-travel dye studies (using Rhodamine WT dye) for reaches of the Rouge River to evaluate how quickly a slug of dye introduced to the receiving water near a CSO outfall would take to reach the monitoring stations (Rouge River National Wet Weather Demonstration Project 2004; <http://www.rouge.com/pdfs/sampling/RPO-WMGT-TR55.pdf>).

Permittees could plan the frequency and duration of monitoring at a CSO event using information from the receiving water hydrographs, time travel analyses, and knowledge of when the CSO event begins and ends. For example, during a storm event, the permittee could collect a sample from the upstream and downstream receiving water locations before the CSO discharges, when the leading edge of CSO slug is expected to reach the downstream receiving water location, the expected mid-point of the CSO event, and when the trailing edge of the CSO slug is expected to reach the downstream receiving water location.

If performing a time travel study is not feasible because of budgetary constraints, it might be appropriate for the permittee to collect samples more frequently (e.g., collect samples every hour for the duration of CSO discharge and several hours after CSO discharge has ceased) throughout the first few wet-weather events during which a CSO is expected to occur, so that a CSO discharge *pollutograph* can be estimated. The information from the pollutograph could then be used to estimate when the leading edge of CSO slug is expected to reach the downstream receiving water location, the expected midpoint of the CSO event, and when the trailing edge of the CSO slug is expected to reach the downstream receiving water location for future sampling events. More information on pollutographs is provided in EPA's (1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) *Combined Sewer Overflows Guidance for Monitoring and Modeling*.

Evaluation of CSO controls using WET testing would include multiple wet-weather events of differing magnitude when there was an overflow. WET testing of wet-weather events over the course of a year would help determine if wet-weather event magnitude, duration, or seasonality affects water quality of the overflow from the CSO. Likewise, screening acute WET tests could be conducted on samples collected at different times during a wet-weather event to determine the relative toxicity of first flush versus later stages of the wet-weather event. Such monitoring might help inform CSO controls.

For bioassessments, samples should be collected during the state's index period for the assemblage of interest (e.g., fish, macroinvertebrates). Generally, bioassessment sampling is neither effective nor safe during periods of high flows. Sampling is typically conducted under base- or low-flow conditions. Ideally,

biological sampling should be conducted pre- and post-CSO control implementation so that an accurate baseline is established for biological expectations at the site. If pre-CSO control implementation data do not exist, post-CSO control implementation biological assessments should rely on site-specific reference site as well as perhaps ecoregional reference site biological data. The latter are often available from the state/tribe biological monitoring programs. Site-specific reference biological data would be collected at the same time as the downstream CSO biological data to assess effects of the CSO. Because some local impacts on downstream biota are likely after any project's construction, it is useful to conduct bioassessments periodically (annually or biannually) over a few (3–5) years, depending on the size of the receiving system relative to the CSO discharge, to determine whether CSO controls are not affecting biota and to track recovery of biota post construction. CSOs on small stream systems should be monitored more frequently (i.e., annually for 3–5 years) than those on larger systems because impacts are likely to be greater and recovery slower in the former situation.

Sediment monitoring, like bioassessments, should be conducted during periods of base flow because that is when sampling methods are most efficient, and sediment effects are likely to be greatest on biota. However, if certain aquatic life uses are designated such as anadromous fish spawning, sediment sampling should be associated with that season as well because sediments have profound effects on spawning behavior and egg survival. In instances where there are multiple aquatic life uses that can be affected by sediment from CSOs, multiple samplings in a given year might be desirable.

4.2.5 How Should Monitoring Be Conducted?

The permittee should document its monitoring procedures in the post construction water quality monitoring plan, QAPP, and SOPs (for more details on how to prepare these documents, see Sections 3.1 through 3.5). The permitting community should use the information in this section of the document and refer to discussions of who should monitor, what pollutants should be monitored and where and when to monitor, also provided in Section 4.2 of this document. In addition, for additional information on how to effectively perform post construction compliance receiving water quality monitoring, the permitting community should see Chapters 4 and 6 of EPA's *Combined Sewer Overflows Guidance for Monitoring and Modeling* (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>).

Permittees should consider the following elements when determining how samples will be collected from the chosen receiving water monitoring stations:

- Health and safety concerns
- Criteria for when samples will be collected (e.g., greater than x days between events, rainfall events greater than 0.4 inches to be sampled)
- Strategy for determining when to initiate wet-weather monitoring
- Stream velocity measurement considerations
- Sampling techniques
- Sampling personnel and equipment
- QA/QC procedures for sampling and analysis

The permittee should provide copies of the post construction water quality monitoring plan, QAPP, and SOPs to each field sampling team before initiating the sampling program. The field sampling team members should be sure to bring these documents into the field for each sampling event, so that they can refer to them as needed.

Health and Safety Concerns

The permittee should consider health and safety concerns when selecting sample locations and determining the schedule for collection. Ideally, sampling should be conducted in teams of two (buddy system) to ensure that additional personnel are available to initiate critical emergency communication and appropriate response in case of emergencies. The two-person team should include one person sampling and one person maintaining a line of sight from a safe distance from the banks during all sampling operations.

When selecting monitoring locations, the permittee should consider physical logistics (e.g., whether the water is navigable, if bridges are available from which to sample, the accessibility of the receiving waters and potential biological hazards [e.g., irritant poisonous plants, hazardous wildlife]) and crew safety (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>). The permittee should perform field observations before, during, and after wet-weather events at locations considered *wadeable* before sampling locations are finalized to determine whether flows of excessive velocity will prohibit field staff from safely wading into and out of the receiving water to collect samples. Note also the footing on or near the banks of the proposed sampling locations, and the degree of incision of the stream channel. Observe the riparian zones for indication of torrent, and evaluate the receiving water's banks for bankfull height indicators (Strahler 1957; Rosgen 1996 http://www.chelanpud.org/relicense/comm/meet2000/4854_1.pdf) and bank angles to ensure safe entry and escape from the waters under flashy storm conditions. This is of particular concern for rain events in urban and suburban watersheds (due to proportion of impervious surfaces) and in high gradient streams, as conditions can change from safe to unsafe in a matter of minutes. In case of uncertainty, err on the side of caution and ensure that sampling crews are appropriately staffed and equipped with personal floatation devices (life vest) where streams may be subject to sudden change.

Loss of footing while wading can pose a serious hazard even in smaller streams, when the slip and fall hazard is combined with the potential for waders to fill and further impede recovery. In cases of large (nonwadeable) rivers, it would be best to find a bridge from which to sample or to collect samples by boat. In cases of extreme high flow events in smaller streams, it might be best to collect samples using a sampling pole or some other device that allows for safe deployment and retrieval without entering the stream. Samplers should be aware that strong stream velocities can cause sampling poles to pull suddenly and become awkward to hold and retrieve. Even in bank sampling operations it may be advisable to don a personal floatation device as a preventive measure in case of deeply incised stream channels or poor footing.

When manual sampling is to be performed, it is recommended that receiving water samples be collected only during daylight hours due to health and safety concern. This should especially be a consideration when planning sampling events and determining when the next sampling event should occur according

to local weather forecast information. If it is forecasted that most of the rainfall and subsequent CSO discharge (from time travel analysis or earlier hydrograph or pollutograph results as described in Section 4.2.4 of this document) will occur primarily during non-daylight hours, it is recommended that manual sampling be rescheduled during a different storm event. Manual sampling during lightning events should also be avoided. If using only automated samplers to collect samples in cases where no grab sampling is required (e.g., no bacteria samples and no oil and grease samples need to be collected), sampling during non-daylight hours would not be considered a health and safety concern.

The rainfall, darkness, and cold temperatures that often accompany wet-weather field sampling events can make even small tasks difficult and sometimes unsafe. Contingency planning and extensive preparation can, however, minimize mishaps and help ensure safety. As described in EPA's *Combined Sewer Overflows Guidance for Monitoring and Modeling* (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>), before field sampling, the permittee should ensure that

- Sampling personnel are well trained and familiar with their responsibilities, as defined in the post construction water quality monitoring plan
- Personnel use appropriate safety procedures and equipment
- A health and safety plan or section in the post construction water quality management plan identifies the necessary emergency procedures, safety equipment, and nearby hospitals and emergency medical services
- Sample containers are clean and assembled, and bottle labels are filled out to the extent possible
- All necessary equipment is inventoried, and inspected, i.e., field monitoring equipment is calibrated and tested, and equipment such as boats, motors, automobiles, and batteries are checked
- Boat crews are used when landside and bridge sampling are infeasible or unsafe

It is recommended that a training session covering field monitoring equipment and safety concerns be held at the beginning of the project for all parties involved in sampling. In addition, the permittee should verify that field personnel are trained in first aid, cardiopulmonary resuscitation (CPR), and are current on their vaccinations (e.g., Hepatitis A or Hepatitis A and B combination vaccination) (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>). Additional good health and safety field practices include the following:

- Field personnel should work in pairs at all times.
- Field personnel should wear appropriate clothing such as rubber boots, waders, rubber gloves, and clothing to protect arms and legs.
- Field staff members should ensure that charged cellular phones are with them at all times.
- Persons working with acid preservatives will wear eye protection and nitrile or latex gloves. Any spilled acid will be neutralized with sodium bicarbonate and diluted with water until it is no longer hazardous.

- Insect repellent and sunscreen should be worn during the spring and summer months, although in a manner that insures that samples will not become contaminated (e.g., pesticide, oil and grease, volatile organics).

Criteria for When Samples Will Be Collected

The permittee should evaluate and determine the types of conditions under which samples will be collected (i.e., dry-weather events, wet-weather events during which a CSO is not expected to occur, wet-weather events during which a CSO is expected to occur). In general, dry-weather events are characterized as being preceded by a 72-hour period with no measurable rainfall (less than 0.1 inch rainfall). Wet-weather events are generally characterized as storm events that are greater than 0.1 inch and at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event (USEPA 1992; <http://www.epa.gov/npdes/pubs/owm0093.pdf>). For more information on planning the frequency, duration and scheduling of monitoring events, see Section 4.2.4 of this guidance document.

The wet-weather conditions under which a CSO is not expected to occur, as well as the wet-weather conditions for which a CSO is expected to occur, can be determined using storm hydrograph data and CSO control design specifications. For example, the permitting community could target rainfall events of different sizes under which a CSO is not expected to occur (e.g., small [0.35 to 0.49 inch] to medium [0.5 to 0.99 inch]) as well as rainfall events for which a CSO is expected to occur (large [> 1.0 inch]). It is recommended that the permitting community evaluate these examples to determine whether they are appropriate or whether they should be slightly modified for the receiving water to be monitored.

Note that there might be special circumstances such as large rainfalls on days preceding an overflow with less than 0.1 inch rainfall that could be the cause of a CSO. As described in the *Frequently Asked Questions About CSO DMRs* file available from the Indiana Department of Environmental Management Permitting Web site (<http://www.in.gov/idem/4897.htm>), the duration of an overflow after rainfall has ceased is a factor that the NPDES authority should evaluate when defining a dry-weather event.

Strategy for Determining When to Initiate Wet-Weather Monitoring

After determining when and where monitoring should be performed and the criteria for when samples should be collected, key elements to consider in determining whether to initiate sampling for a wet-weather event (ORSANCO 1998; <http://www.epa.gov/npdes/pubs/owm0093.pdf>) include the following:

- Identify local site conditions (e.g., ~~characterize stream conditions, historical climatic patterns~~)
- Identify local rain gage networks (airports, municipalities)
- Identify monitoring contact personnel (laboratory managers, field leaders)
- Identify weather sources (local meteorologist, National Weather Service, cable TV, Internet sites, local airports)
- Storm tracking (monitoring leader tracks weather and stream conditions; monitoring leader notifies personnel of potential events)

By developing a strategy for determining which storm events are most appropriate for wet-weather monitoring, the permittee can collect the needed data while limiting the number of times the field staff is mobilized and the number of sampling events. This can result in significant savings in personnel, equipment, and laboratory costs. It is recommended that the permittee develop a decision flow chart or checklist for initiating a wet-weather event. An example flow chart is provided in Exhibit 4-3 of EPA's (1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) *Combined Sewer Overflows Guidance for Monitoring and Modeling*.

Stream Velocity Measurement Considerations

As described in Section 4.2.3 of this guidance, the permittee should determine whether automated flow meters could be installed at locations upstream and downstream of the CSO. In addition, the permitting community should determine whether stream flow conditions from USGS gaging stations (accessible at <http://waterdata.usgs.gov/nwis/rt>) can be used to help determine receiving water flow.

When determining whether portable or installed automated stream velocity meters should be used for CSO post construction monitoring, the permittee should consider the following advantages and disadvantages of using each type of meter:

- Portable velocity meters are less expensive than automated velocity meters.
- Portable velocity meters generally do not provide print-outs of the storm hydrograph; storm hydrographs, when used in conjunction with information about the CSO discharge travel time, are useful for planning when samples should be collected.
- Automated velocity meters require installation and consideration of power sources.
- When using a portable velocity meter, a member of the field staff must read each velocity measurement from the display and record it on a field data sheet.
- When using a portable velocity meter, there is potential for data recording errors.
- When properly installed and maintained, automated velocity meters will provide constant, accurate velocity data.
- Portable velocity meters can be used to provide velocity data for the sampling event only.
- If desired, many automated velocity meters can be purchased as part of an automated field sampler that has the capability of collecting composite samples when triggered by a certain pre-set velocity rate (note that samples required to be collected as grab samples cannot be collected using an automated sampler).

For detailed information on receiving water hydraulic monitoring techniques, see Section 6.2 of EPA's (1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) *Combined Sewer Overflows Guidance for Monitoring and Modeling*.

Sampling Personnel and Equipment

After determining where and when samples will be collected, for what parameters the samples will be analyzed, the laboratory that will perform the analyses (refer to Appendix C of this document), the

permittee will determine the personnel and sampling equipment needs for performing post construction receiving water quality monitoring. As described above, it is recommended that field personnel work in pairs at all times, for safety reasons. If grab samples are being collected at upstream and downstream locations simultaneously, at least four sampling staff members are needed to perform the monitoring. Additional staff might be needed for recording flow measurements if portable flow meters are used and for delivering bacteria samples to the laboratory within holding times.

Field staff should follow the sampling protocols documented in the post construction water quality monitoring plan, QAPP, CSO control assessment plan, field sampling plan and SOPs, as described in Sections 3.1 through 3.5 of this document. The post construction water quality monitoring plan should include the following information to assist field staff in performing monitoring efficiently and correctly:

- Map of the watershed and the sampling locations.
- Names and phone numbers of the field sampling staff and laboratory personnel involved in the project.
- The number of samples and quality control samples (see discussion in the following section) to be analyzed for each parameter during each sampling event.
- The study target analytes and corresponding EPA analytical method or Standard Method.
- Types of sample bottles, preservatives, and holding times required as specified by the EPA analytical method or Standard Method; bacteria samples must be delivered to the analytical laboratory within 6 hours of collection.
- SOPs for calibration, setup and maintenance of equipment and for collection of samples.

On the basis of the analytical methods that will be used and field measurements (e.g., velocity, temperature, pH, rainfall) that will be collected, the permittee should determine what the equipment needs of the study are. For example, the permittee might determine that a probe should be purchased for measuring pH and specific conductance at the upstream and downstream monitoring locations. Equipment that might need to be purchased for a sampling event includes the following:

- Automated velocity meters or samplers
- Portable velocity meters
- Field probes and calibration standards
- Sample pole(s)
- Gloves (latex, nitrile)
- Boots
- Waders
- Certified clean sample bottles (note that these could be provided by the analytical laboratory)
- Sample preservatives required by analytical method (e.g., sulfuric acid, nitric acid)
- Coolers and ice/blue ice for storing samples on-site before delivery to laboratory

- Rain gages
- All-weather writing paper

Sampling Techniques

As described earlier in the document, both automated and grab sampling techniques can be used for post construction compliance receiving water monitoring. For each sampling event, the field staff should be sure to label all sample bottles and complete a chain-of-custody form, recording each of the samples for each sample location and *stage* of the CSO discharge, date and time of collection, type of preservative and analyses to be conducted. In addition, the field staff should coordinate with the laboratory throughout the sampling process, to ensure the laboratory will know when to expect samples to be delivered or shipped.

Field staff should ensure that one rain gage is placed at each monitoring station and that overall, a minimum of three rain gages be used in the watershed. In addition, flow monitoring should be performed at each sampling location. This information will be very useful in interpreting the analytical results (NRC 2008; http://www.epa.gov/npdes/pubs/nrc_stormwaterreport.pdf).

Automated Sampling

If automated samplers are used, the permittee should be sure to follow the manufacturer's instructions for installing, configuring and programming the units. After this has been accomplished, very little needs to be done to start the sampling process. One field staff member will need to make sure the samplers are turned on and that the flow meter plotters are turned on before the storm event. In addition, the field staff member will need to be sure that clean bottles have been loaded into the sampler before the storm event.

After the monitoring is complete, the staff member should review the hydrograph printout or portable flow meter readings, along with any information on the CSO slug travel time, to determine what bottles should be analyzed by the laboratory. As described in Section 4.2.4, it might be desirable to have the laboratory analyze samples representing receiving water conditions before the CSO discharges, when the leading edge of CSO slug is expected to reach the downstream receiving water location, the expected mid-point of the CSO event, and when the trailing edge of the CSO slug is expected to reach the downstream receiving water location.

Manual Collection of Samples

For manual collection of samples, the field staff will need to be sure their hands are clean (no lotions or sunscreens applied) and put on a pair of clean, powder-free gloves before collecting samples at each station. In addition, it might be appropriate for field staff to wear elbow-length gloves underneath the clean, powder-free gloves for health protection, but the permittee should check with the laboratory before sampling begins to determine whether the elbow-length gloves would contaminate samples for the analytes to be studied. Field staff should label each bottle or container with a label and permanent marker. Information that should be included on each label includes project name, sampling location, date, time, analyte(s), and whether it is preserved with acid or other chemical.

To determine when manual samples should be collected during a sampling event, a staff member should review the hydrograph printout or portable flow meter readings, along with any information on the CSO slug travel time. Field staff should collect sample(s) into the appropriate bottle(s). In cases where a sampling pole is needed, a field staff member should attach a clean bottle to the sampling pole, remove the cap and walk to a location of the receiving stream where there is adequate flow. If the stream level is too high, the field staff member should collect the sample(s) from a bridge over the middle of the channel. The sampling pole length can be extended as necessary to collect samples.

In cases where no preservatives are needed, the sample can be collected directly into the bottle to be delivered to the laboratory for analysis. In cases where preservatives are needed, the sample should be collected into a clean collection bottle from which the sample can be poured into the pre-preserved bottles to be delivered to the laboratory for analysis.

The field staff member should face upstream and tip the bottle into the water, allowing the water to flow into the bottle. The field staff member should rapidly submerge the bottle to the desired depth (refer to Section 4.2.3) and turn the bottle to an upward 45-degree angle until it is filled with water. The field staff member should raise the bottle straight up out of the water.

Biological Assessments

For bioassessments, grab samples are typically collected using various field collection devices depending on the assemblage being sampled and the physical characteristics of the waterbody (e.g., see Barbour et al. 1999 [<http://www.epa.gov/owow/monitoring/rbp/>]; ASTM field sampling methods). Wadeable streams have perhaps the most researched biological methods for macroinvertebrates and fish, and many states and tribes have their own sampling protocols, which include sampling and sample process methods. For stream macroinvertebrates, sampling devices include fixed area net devices, such as Surber and Hess samplers, that rely on physically disturbing the sediments causing invertebrates to passively flow directly downstream into the net sampler. Fish are generally captured by netting, traveling seine, or electrofishing. The type of gear used is often specific to the types of habitat being sampled and the characteristics of the receiving waterbody. Backpack electrofishing, for example is a fairly efficient sampling technique in wadeable streams but is inappropriate in boatable rivers and lakes. In general, sampling should be conducted such that subsequent sampling locations are not disturbed or otherwise affected by sampling. In streams, this usually entails sampling from downstream to upstream locations to ensure that sites sampled later in the day are not affected by earlier sampling.

The permitting community should consult appropriate state/tribe protocols before monitoring. By using standardized methods of collection, processing, and enumeration, the precision, accuracy, and comparability of biological data are improved. Biological sampling requires knowledge and experience using particular sampling equipment. Therefore, staff trained in the use of such samplers is necessary to obtain reliable data.

Sediment Sampling

Sediment sampling, where required, is conducted by manual collection of surface sediment using care to retrieve the sample without resuspending fine solids at the sediment/water interface. Samples can be

collected by hand or using specialized sampling devices developed specifically for sediment collection (see USEPA 2001b; <http://www.epa.gov/waterscience/cs/library/collection.html>).

In wadeable streams, manual samples can be collected using a stainless steel scoop or large stainless steel spoon in areas of sediment deposition. Surficial sediment is scooped off of the streambed and carefully raised through the water column being careful not to resuspend any of the fine sediments from the sample.

In larger streams, lakes, and marine environments, sediment samples are best collected using grab samplers such as a petite ponar or Van Veen sampling device. These devices are routinely deployed by winch and activated by gravity or by use of a weighted messenger to close the clam-shell jaws. Again, the device is slowly raised through the water column to avoid resuspension of fine solids in the sampling device and to prevent loss of the fine sediments from the sample. The permittee should use EPA's *Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual* (USEPA 2001b; <http://www.epa.gov/waterscience/cs/library/collection.html>) to help select an appropriate sediment sampling device and to identify proper ways to ensure that high-quality samples are collected.

WET Testing

Samples for WET testing should be collected from the CSO outfall if possible so as to evaluate the potential effects of the discharge on waterbody aquatic life. As described in Section 4.2.3 of this document, it might be analytically more appropriate to evaluate the toxicity of wet-weather CSO discharges using laboratory-based WET testing of the outfall rather than ambient testing using up and downstream samples.

Depending on state implementation procedures, WET tests are often conducted using multiple dilutions of the sample (including the undiluted sample itself). By testing multiple dilutions at the same time, it is possible to derive toxicity endpoints that can then be compared with actual flow/dilution conditions as well as other flow conditions of concern (e.g., 7Q10). However, multiple dilution WET tests are relatively more costly than bacterial or inorganic pollutant analyses, particularly chronic WET tests, which can affect the number of CSO or CSO outfalls that can be monitored for WET.

Some states conduct stormwater and CSO sampling using a screening WET approach that does not require sample dilution. In this approach, only two treatments are conducted: a laboratory water control and the undiluted CSO sample. This type of WET testing yields a *pass-fail* result. Such testing has the advantage of being cheaper and easier to conduct, which can allow more frequent testing of a CSO discharge or testing of more outfalls. However, screening tests cannot indicate the concentration of CSO discharge that would not be toxic.

The dilution water used for testing of CSOs could be EPA-approved laboratory water (i.e., reconstituted water or dilute mineral water) or upstream water. Using upstream water might be a more realistic approach for testing the toxicity of a CSO discharge because it already incorporates the prevailing background water quality conditions (e.g., hardness, pH, various ions), which, as explained in Section 4.2.2 of this document, affect certain water quality criteria as well as the toxicity of certain pollutants

(e.g., many priority pollutant metals). However, the upstream water itself could be toxic because of factors other than CSOs, which would make it a poor diluent in WET testing. Laboratory water, on the other hand, has the advantage of being a known, standardized diluent for WET testing, which enables one to obtain a definitive answer regarding toxicity of the CSO sample. However, laboratory water is not typically site-specific in composition and therefore, could under- or over-estimate toxicity of the CSO sample. One compromise might be to identify an upstream reference site that is known to be relatively free of anthropogenic influences, yet represents the natural background water quality condition. It is a good idea to subject water from such a site to WET testing before conducting CSO monitoring to confirm that it is a useful diluent for WET testing. Another compromise is to analyze several water samples during wet- and dry-weather events to characterize key water quality characteristics such as hardness, alkalinity, pH, and major ion concentrations (e.g., potassium, magnesium, calcium, sodium). Laboratory water can then be adjusted to match those characteristics as closely as possible.

QA/QC Procedures for Sampling and Analysis

The permittee should contact the laboratory before the start of the sampling event (24 hours is ideal) to notify them when samples might be arriving at the laboratory and to determine whether additional volumes of samples need to be collected for QC analyses in the laboratory. If a sampling trip is canceled, the permittee should notify the laboratory immediately.

The permittee should discuss with the analytical laboratory how often duplicate samples and blanks should be collected for analysis. Duplicate samples provide a check for precision in sampling equipment and techniques (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>). When duplicate grab samples are required, the duplicate should be collected at the same time as the sample by holding both bottles under water side by side, whenever possible. Field blanks, trip blanks and field duplicates should also be collected as specified by the laboratory.

Field blanks are samples that are collected to check for cross-contamination between samples. Cross-contamination can occur either during sample collection, during shipment, or during processing in the laboratory. When sampling for inorganic compounds, deionized or distilled water should be used to prepare the field blank. When sampling for organic compounds, field blanks should be prepared from high-performance liquid chromatography (HPLC)-grade water.

Trip blanks are samples that are collected to check for contamination that might occur during shipping between the field and the laboratory for samples to be analyzed for volatile organic contaminants. HPLC-grade water should be used to prepare trip blanks.

Equipment blanks are samples that are collected to check field equipment decontamination procedures. It is important to collect equipment blanks when sample collection equipment or sample collection vessels (e.g., bailers, clean bottles) are re-used for taking samples at different times or locations. When sampling for inorganic compounds, deionized or distilled water should be used to prepare the equipment blank. When sampling for organic compounds, equipment blanks should be prepared from HPLC-grade water. After field equipment is decontaminated, the field staff should rinse the equipment with the appropriate grade of water and collect the rinsing water in the sample containers.

Field staff should prevent contamination of samples by wearing clean, powder-free gloves and by making sure hands are clean. Field staff should also be sure to clean the sampling pole after each event and use only certified pre-cleaned bottles for sample collection. Also, field staff should wash hands thoroughly or use hand sanitizer after handling samples, especially before eating or drinking.

A second field staff member of each team should act as the QC officer by checking all records and forms to be sure they are complete and correct and that all samples have been taken and preserved correctly before leaving each sampling site.

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Appendix A – Supplemental QAPP Information

A QAPP is prepared to ensure that environmental and related data collected, compiled, or generated for a project are complete, accurate, and of the type, quantity, and quality required for their intended use. QAPPs are composed of standardized, recognizable elements covering the entire project from planning, through implementation, to assessment. The four groups of elements and their intent, as summarized in EPA's *Requirements for Quality Assurance Project Plans* (USEPA 2001a; <http://www.epa.gov/QUALITY/qs-docs/r5-final.pdf>) are as follows:

- A - Project Management
- B - Data Generation and Acquisition
- C - Assessment and Oversight
- D - Data Validation and Usability

Group A – Project Management

Addressing the elements in the Project Management group ensures that the project has a defined goal, that the participants understand the goal and the approach to be used, and that the planning outputs have been documented. The nine elements in this group are described below.

A1 Title and Approval Sheet: The permittee, in consultation with the NPDES authority, should determine who will be responsible for reviewing and approving the QAPP. Usually, the project manager and QA officer from each entity involved in the project (e.g., permittee, NPDES authority, laboratory responsible for analyzing samples, volunteer monitoring organizations) will need to approve the QAPP. The permittee should include the names and titles of persons who will be responsible for reviewing and approving the QAPP and other pertinent information (e.g., project title, date of preparation, version control number, organization preparing the QAPP) on the title and approval sheet.

A2 Table of Contents: The permittee should develop a table of contents for the document to enable document reviewers and project participants to easily locate pertinent information in the QAPP.

A3 Distribution List: The permittee should include the names and corresponding contact information for each person who is involved with post construction compliance monitoring. This should include project managers, QA officers, and representatives of all groups involved in the project who should receive a copy of the QAPP.

A4 Project/Task Organization: The permittee should include in this section a brief description of the post construction compliance monitoring project. In addition, the permittee should include a description of the key project management and QA staff names, titles, and responsibilities. This information should be illustrated using a project organization chart (see the example organization chart in Figure A-1).

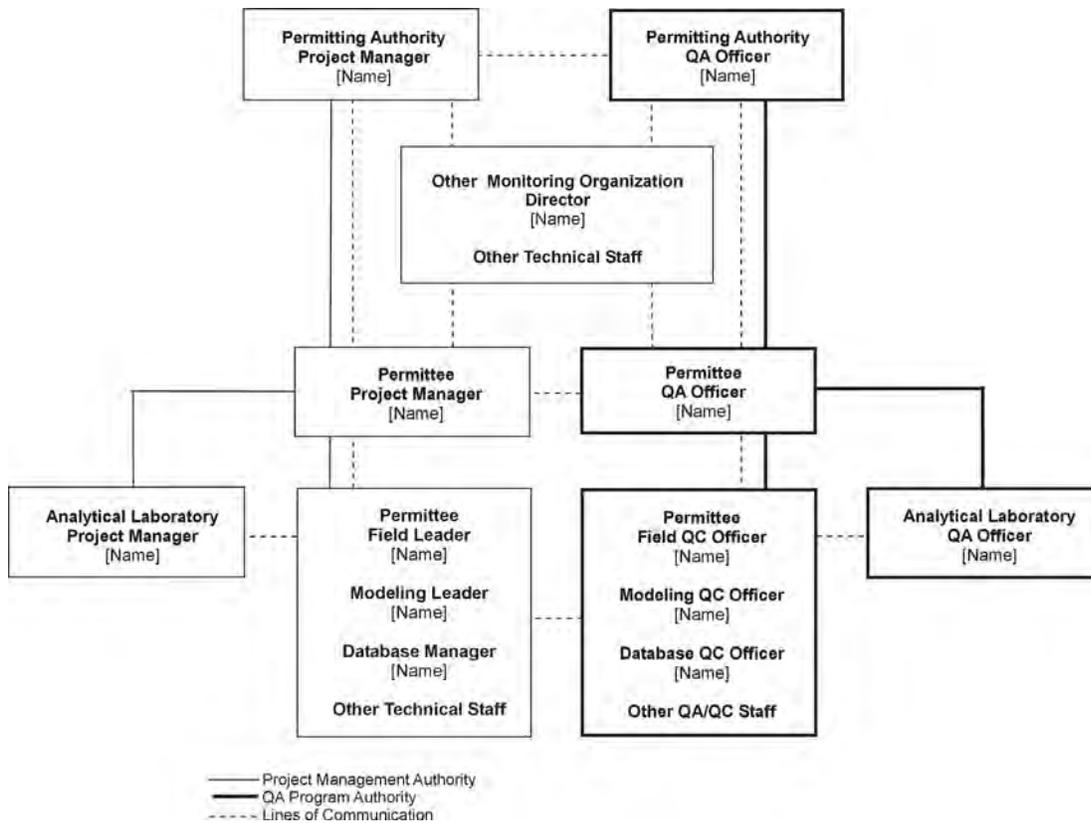


Figure A-1. Example QAPP organization chart.

A5 Problem Definition/Background: Here, the permittee should provide any pertinent background information about the history of the CSO problems in the receiving waterbody. A map of the study area can be included. Also, the permittee should identify the intended use (e.g., ascertaining the effectiveness of CSO controls, verifying compliance with WQS and protection of designated uses) of the post construction compliance monitoring data to be collected under the QAPP. Virtually all the sections of the QAPP that follow will contain information consistent with the information stated in this section (USEPA 2002a; <http://www.epa.gov/QUALITY/qs-docs/g5-final.pdf>).

A6 Project/Task Description: The permittee should provide an overall description of the work to be performed for the project. Examples of tasks that could be included in this section are describing the basic approach (i.e., Presumption Approach, Demonstration Approach) selected by the permittee in the LTCP to verify the effectiveness of CSO controls, preparing a CSO control assessment plan, preparing a field sampling plan, identifying whether some flows or pollutant loads will be modeled and what models will be used, identifying sample locations, obtaining sampling equipment and supplies, performing sampling, supporting analysis of samples and preparing sample reports and analyses. A description of the records and reports required for each task should be included. It is also recommended that a project schedule showing the dates by which major tasks will be performed is included in this section.

A7 Quality Objectives and Criteria: The purpose of this element (USEPA 2002a; <http://www.epa.gov/QUALITY/qs-docs/g5-final.pdf>) is to describe quality specifications at

- (1) the level of the decision or study question; and
- (2) the level of the measurements to support the decision or study question.

(1) Decision or Study Level Question Level

The outputs from EPA's data quality objectives process will help address "(1) the level of the decision or study question." Detailed guidance on the data quality objectives process is available from EPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA 2006; <http://www.epa.gov/QUALITY/qs-docs/g4-final.pdf>).

(2) Measurements to Support the Decision or Study Question Level

The section of the QAPP addressing "(2) the level of the measurements to support the decision or study question," should discuss the measurement performance criteria in terms of the expected level of uncertainty in data that will be used to address the study question or support the decision (USEPA 2002a; <http://www.epa.gov/QUALITY/qs-docs/g5-final.pdf>). When possible, it is desirable to state measurement performance criteria in quantitative terms, such as limits for field measurement and analytical laboratory precision, bias, and completeness. The permittee should determine in conjunction with the NPDES authority whether there are any performance criteria requirements for CSO post construction compliance monitoring.

It is a good idea for the permittee to check the operating manual for the equipment used to take field measurements (e.g., flow meter, turbidity meter, thermometer) and to check with the NPDES authority's and laboratory's QA officers to ensure that the results will be of quality adequate to answer the study questions. Some example measurement performance criteria for a CSO post construction compliance monitoring program are presented in Table A-1.

If a model will be used to predict the number of overflow events per year, the flow and volume of CSO events per year, or to evaluate reductions in pollutant loads, the permittee should address evaluating the quality of the data used for the model and assessing the results of the model application. The permittee should provide a list of data sources that will be used to populate, calibrate, and validate the model. The permittee should also describe the acceptance criteria against which data will be judged before being used as input to the modeling effort. For example, data might be checked for reasonableness (e.g., dates will be checked through queries to ensure that no mistyped dates are included [e.g., 8/24/1900]) and representativeness (e.g., sampling station data will be checked through queries and mapping to ensure that no mistyped geospatial data are used [e.g., locations outside the sewershed in question]).

Table A-1. Example performance criteria for a CSO post construction compliance monitoring program

Measurement parameter	Precision	Accuracy and bias	Completeness
Field parameters			
Time	± 5 minutes		≥ 90%
Flow	± 30%		
water temperature	± 1 °C		
pH	± 0.2 units		
Turbidity	± 2%		
specific conductance	± 2%		
Analytical laboratory parameters			
Total suspended solids	RPD ≤ 15	30%	≥ 90%
Ammonia as nitrogen			
Nitrate + nitrite			
Total phosphorus			
Dissolved phosphorus			
Hardness			
Enterococci using EPA Method 1600			

The permittee should use a systematic planning process to determine the type and quality of output needed from modeling projects. This should begin with a modeling needs and requirements analysis, which includes the following components:

- Assess the need(s) of the modeling project
- Define the purpose and objectives of the model and the model output specifications
- Define the quality objectives to be associated with model outputs

The permittee should describe model calibration and validation procedures, what data will be used for calibration and validation, how sensitivity analyses will be performed, and general percent error calibration/validation targets for the model(s) to be used. Also, the permittee should include a description of how the model will be verified through testing the model code, including program debugging, to ensure that the model implementation has been done correctly. For the purposes of assessing model outputs and usability, the permittee should describe how staff will review model predictions for reasonableness, relevance, and consistency with the requirements of the model development process.

For additional information on developing a modeling QAPP, the permittee should refer to EPA's (2002b; <http://www.epa.gov/QUALITY/qs-docs/g5m-final.pdf>) *Guidance for Quality Assurance Project Plans for Modeling*.

A8 Special Training/Certifications: In this section of the QAPP, the permittee should discuss training requirements, including any training sessions that will be held. For example, a training session covering field monitoring equipment and safety concerns might be held at the beginning of the project for all parties involved in sampling.

A9 Documentation and Records: The permittee should provide in this section of the QAPP a description of how field sampling collection and handling activities will be documented. For example, general observations and weather conditions could be documented in a field log notebook. It might be desirable to record flow information and specific sample parameters (e.g., pH, temperature, grab samples) on special field data forms. Also, the permittee will want to describe what information will be included on the sample identification labels (e.g., sample point, date and time of collection) and on the chain-of-custody forms. Example chain-of-custody forms, field data sheets and sample identification labels are generally referenced in this section as attachments to the QAPP.

An example EPA Chain-of-Custody form is available from EPA's NPDES Inspection Manual (USEPA 2004a) Web site at <http://www.epa.gov/oecaerth/resources/publications/monitoring/cwa/inspections/npdesinspect/npdesinspectappm.pdf>. As described in EPA's (1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) *Combined Sewer Overflows Guidance for Monitoring and Modeling*, chain-of-custody forms typically contain the following information:

- Name of project and sampling locations
- Date and time that each sample was collected
- Names of sampling personnel
- Sample identification names and numbers
- Types of sample containers
- Analyses to be performed on each sample
- Additional comments on each sample
- Names of all personnel transporting the samples

The sample label/field form(s) could include information (USEPA 1999; <http://www.epa.gov/npdes/pubs/sewer.pdf>) such as

- Name of project
- Date and time of sample collection
- Sample location
- Name or initials of sampler
- Analysis to be performed
- Sample identification (ID) number
- Preservative used
- Type of sample (grab, composite)

If modeling will be performed to evaluate the effectiveness of CSO controls, the permittee should describe how the modeling will be performed and documented, including quality control tests and how tracking of version control will be performed.

Group B - Data Generation and Acquisition

The elements in this group address all aspects of project design and implementation. Implementation of these elements ensures that appropriate methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are employed and are properly documented. The ten elements in this group are described below.

B1 Sampling Process Design (Experimental Design): This section should discuss the strategy and procedures that will be used to collect flow, water quality and other data. The permittee should also describe who will perform the sampling, how many sampling events are planned, when the sampling events will be performed and the parameters that will be monitored. A brief discussion or table (see example provided in Table A-2) of the sampling methods used (e.g., grab, composite, continuous monitoring), sample points, and analytical tests to be performed (e.g., EPA methods, Standard Methods) and number of samples to be analyzed for each parameter per event should also be included in this section.

Table A-2. Example sample collection and analyses at each sampling location

Sample point	Sample point description	<i>Escherichia coli</i>	TSS	BOD ₅
Upstream 1	Upstream of study area	5 + 1QC	5 + 1QC	5 + 1QC
Upstream 2	Mouth of tributary upstream of study	5 + 1QC	5 + 1QC	5 + 1QC
CSO Outfall	CSO effluent (end-of-pipe)	5 + 1QC	5 + 1QC	5 + 1QC
Downstream	Downstream of CSO	5 + 1QC	5 + 1QC	5 + 1QC
Total samples per field sampling event		20 + 4QC	20 + 4QC	20 + 4QC

B2 Sampling Methods: For methods of collecting samples, the permittee should refer to specific SOPs. For example, they might want to include SOPs for flow measurement; use of turbidity meter; sampling during CSO events; collection of field blanks, trip blanks, and equipment blanks; and equipment decontamination. Additional guidance on preparing SOPs was provided in Section 4.5 of this guidance.

B3 Sample Handling and Custody: The permittee should include a discussion of how samples will be packed (e.g., in boxes secured with packing tape) and shipped or delivered to the analytical laboratory with corresponding chain-of-custody forms, ensuring samples will be received by laboratory for analysis of samples within holding time requirements. This section should include a list or table of sample volumes and bottles that will be used for sample collection purposes. In addition, the permittee should include a table of sample handling requirements (see example Table A-3) in this section of the QAPP.

Table A-3. Example sample handling requirements for samples to be analyzed by the laboratory

Parameter	Maximum holding time	Preservation required
TSS	7 days	cool, 1–4 °C
BOD ₅	2 days	cool, 1–4 °C
Enterococci or <i>E. coli</i> ^a	≤ 6 hours between collection and initiation of analyses; processing (filtration and plating) will be completed no later than 8 hours after collection	cool, 1–4 °C

^a EPA (1986; <http://www.epa.gov/waterscience/beaches/files/1986crit.pdf>) recommends use of *E. coli* or enterococci as indicators of fecal contamination for freshwater and enterococci as an indicator of fecal contamination for marine water.

B4 Analytical Methods: The permittee should include a list or table of target analytes and corresponding analytical methods (e.g., *E. coli* by EPA Method 1603; enterococci by EPA Method 1600) in this section of the QAPP. In addition, the permittee should discuss or reference the sample processing and analytical methods and method-specific criteria to be met for analysis; in most cases, this information can be found in the analytical laboratory’s QAPP. In many cases, it will be desirable to use a certified environmental laboratory to perform the analyses (for more information on contracting laboratory services, see Appendix C).

B5 Quality Control: This section should describe the checks that will be performed to estimate the variability for each measurement activity (USEPA 2002a; <http://www.epa.gov/QUALITY/qs-docs/g5-final.pdf>). Analysis of QC samples such as field blanks and duplicate samples can be used to perform these checks. Some example QC checks that could be used for samples analyzed for microbiological parameters are provided below.

- Duplicate sample: A second aliquot of a field sample that is prepared or analyzed exactly like a field sample. One duplicate will be prepared and analyzed for every 10 field samples for all parameters.
- Positive/negative controls: Positive and negative controls refer to control cultures that, when analyzed exactly like field samples, will produce a known positive or a known negative result for a given type of media. One media-specific positive control and one media-specific negative control will be prepared and analyzed for every 10 field samples, or one per sample set, whichever is more frequent. In addition, one positive control and one negative control will be prepared and analyzed with every confirmation test. Each control will be carried through the entire procedure and must exhibit the expected positive or negative result.
- Media check: Before use of newly prepared media, a representative portion of 5 percent of each media batch will be checked for correct response to positive and negative controls. Positive and negative controls will be analyzed exactly like field samples.
- Incubator/waterbath temperatures: Incubator or waterbath temperatures will be taken two times per day. Temperatures will be taken no less than 4 hours apart and will be within ± 0.5 °C of the desired temperature.

In addition, it is recommended that the permittee discuss completeness objectives and how the permittee plans to meet these objectives. Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and entered into the data management system. For example, it might be desirable to set a 90 percent completeness goal. A permittee might take measures such as storing and transporting samples in unbreakable (plastic) containers whenever possible or wrapping glass containers in bubble wrap for shipping.

B6 Instrument/Equipment Testing, Inspection, and Maintenance: The permittee should discuss how often equipment and instruments will be inspected to ensure their satisfactory performance. The permittee should also describe how maintenance activities will be performed (e.g., replacing internal desiccant and batteries in flow meters; replacing internal desiccant, replacing peristaltic pump tubing and calibrating the aliquot volume in autosamplers) and reference appropriate SOPs or user manuals. In addition, the permittee should describe whether backup equipment will be used in cases where equipment breaks or malfunctions.

B7 Instrument/Equipment Calibration and Frequency: This section should include the procedures and frequency of calibration and standards or apparatus to be used for instruments that need to be calibrated. The permittee should check the instrument user manuals to determine how often calibrations should be performed. For example, an autosampler might need to be calibrated several times a year, while a dissolved oxygen meter might need to be calibrated before each day it is used. Flow meters are usually factory-calibrated but should be tested (e.g., spin test to check condition of meter bearings) to ensure that they are working properly before use.

B8 Inspection/Acceptance of Supplies and Consumables: The permittee should describe what supplies and consumables will be checked before use and who will be responsible for checking them. For example, a field leader might ensure that only certified clean containers for bacterial analyses are used for sample collection and that only certified standard solutions that have not expired are used for turbidity probe calibration.

B9 Non-direct Measurements: The permittee should describe whether data previously collected for a purpose other than post construction compliance monitoring or collected by an organization not under the direction of the NPDES authority will be used. For example, the permittee might determine that the nondirect data in question will meet the data indicator requirements in the QAPP and be able to use the information to populate models to help evaluate CSO control effectiveness or to help evaluate receiving water quality. Alternatively, the permittee might determine that the nondirect data in question will not meet the data indicator requirements in the QAPP and decide to use the information for qualitative assessment purposes only.

B10 Data Management: In this section of the QAPP, the permittee should discuss how data generated from the project will be managed (USEPA 2002a; <http://www.epa.gov/QUALITY/qs-docs/g5-final.pdf>). For example, the permittee might document samples by using sample identification labels and chain-of-custody forms. It is recommended that the permittee discuss where hard copies for chain-of-custody forms and field data sheets will be stored and where electronic project spreadsheets, reports and laboratory files will be stored and backed up.

Group C - Assessment and Oversight

The elements in this group address the activities for assessing the effectiveness of the implementation of the project and associated QA and QC activities. The purpose of assessment is to ensure that the QAPP is implemented as approved (conformance/nonconformance), to increase confidence in the information obtained, and ultimately to determine whether the information may be used for their intended purpose (USEPA 2002a; <http://www.epa.gov/QUALITY/qs-docs/g5-final.pdf>). The two elements in this group are described below.

C1 Assessments and Response Actions: This element gives information concerning how a project's activities will be assessed during the project to ensure that the QAPP is being implemented as approved. A wide variety of internal (self) and external (independent) assessments can be conducted during a project (USEPA 2002a; <http://www.epa.gov/QUALITY/qs-docs/g5-final.pdf>). Detailed information on different types of assessments can be found in Appendix B of EPA's (2002a; <http://www.epa.gov/QUALITY/qs-docs/g5-final.pdf>) *Guidance for Quality Assurance Project Plans* and EPA's *Guidance on Technical Audits and Related Assessments (G-7)* (USEPA 2000; <http://www.epa.gov/QUALITY/qs-docs/g7-final.pdf>). An example of an internal assessment is the permittee's project manager periodically assessing field data collection efforts, field notes and laboratory data as part of the project to ensure that the data collected are usable for the purpose of the study.

For assessing field collection efforts, the permittee's project manager might check proper calibration of field equipment, consistent recording of data, accurate sample methodology, and appropriate distribution of samples to the laboratory. For review of field data, the permittee's project manager might review the field measurements to ensure that they are within the accepted range for each parameter (e.g., ± 1 °C for water temperature). A response to detecting inconsistencies in field procedures or measurements could be discussing field instrument calibration and data collection with field personnel to define potential causes. In the final data reports, the project manager will need to appropriately flag the questionable data, with discussion as to the nature and extent of the limiting observations.

For review of laboratory results, the permittee's project manager might verify that all the values are within the laboratories' acceptable ranges for each parameter. These ranges should be specified in the laboratory's Quality Management Plan or SOPs before sampling. Response actions could include discussing any discrepancies with the laboratory project manager to assess the need to re-test the sample. The laboratory should report outlier data in the data report and describe potential sources of error.

For review of model results, the modeling staff could generally check results to those obtained by other models or by comparing them to hand calculations. In addition, model calculations should be compared to field data. If the modeling staff determines that adjustments should be made to model parameters to obtain a fit to the data, the modeling staff should provide an explanation and justification that agree with scientific knowledge and fit within reasonable ranges of process rates as found in the literature.

C2 Reports to Management: After completing field sampling, laboratory and if necessary, modeling activities, the permittee should prepare and submit a draft report to the NPDES authority for review. The report should list all participants, sampling locations, samples collected, models used, and data used to populate, calibrate, and validate the models. In addition, the report should include results and conclude whether the CSO controls meet the compliance goals of the selected approach and whether the sampled receiving water quality at each measurement location was compliant with WQS and protection of designated uses.

Group D - Data Validation and Usability

The elements in this group address the QA activities that occur after the data collection or generation phase of the project is completed. These final checks are performed to check whether the data obtained from the project will conform to the project's objectives and to estimate the effect of any deviations (USEPA 2002a; <http://www.epa.gov/QUALITY/qs-docs/g5-final.pdf>). The three elements in this group are described below.

D1 Data Review, Verification, and Validation: This section of the QAPP should provide an overview of the final checks that will be performed. This could include reviewing data entries for completeness and correctness and checking results against performance criteria specified in the QAPP (see the description of A7 Quality Objectives and Criteria above). On the basis of the results of the final checks, the permittee should determine whether to accept, reject, or qualify the data.

D2 Verification and Validation Methods: This section of the QAPP should provide the processes that will be used to verify and validate the data generated, including the actual checks that will be performed and the person(s) responsible for performing them. For example, it could be stated that the "data collected in the field will be validated and verified by the permittee project manager." It generally is the laboratory's responsibility to validate and verify the analytical results (for more information on laboratory contracting considerations, see Appendix D). The permittee project manager should review the data verification and validation report(s) prepared by the laboratories to determine whether any data should be rejected or qualified.

D3 Reconciliation with User Requirements: This assessment represents the final determination of whether the data collected are of the correct type, quantity, and quality to support their intended use for the project. Any problems encountered in meeting the performance criteria (or uncertainties and limitations in the use of the data) should be discussed with the NPDES authority and reconciled, if possible.

Appendix B. Recommended Reporting Requirements

The permittee, in consultation with the NPDES authority, should determine how frequently post construction compliance monitoring reports should be prepared and submitted to the NPDES authority and other interested parties (e.g., federal agencies, regional commissions, volunteer groups). Monthly or quarterly reporting might be sufficient in cases where monitoring is performed several times each year for several years. In cases where modeling is performed to evaluate the effectiveness of CSO controls, it might be more appropriate for the permittee to submit one report documenting the modeling results when they are available.

The reports should include a discussion of whether the CSO controls are meeting the goals (e.g., frequency, volume) of the approach (i.e., Presumption Approach, Demonstration Approach) selected by the permittee in the LTCP to verify the effectiveness of CSO controls. The report should also assess whether CSO receiving water quality complies with WQS. The NPDES authority should consult with EPA to determine whether results should be entered into national databases (e.g., (PCS/ICIS, STORET).

The permitting community should consider including the following recommended data elements in the post construction compliance monitoring report for determining the effectiveness of CSO controls:

- Facility name and city
- Submittal mailing address, contact name
- Name of wastewater treatment facility normally receiving sewage
- NPDES permit number
- Monitoring period
- Duration of monitoring program
- Surface water(s) affected by the discharge(s)
- Identification of basic approach (i.e., Presumption Approach, Demonstration Approach) and identification of the criteria under the Presumption Approach (if selected) by the permittee in the LTCP to verify the effectiveness of CSO controls
- Description of method(s) used to evaluate the effectiveness of CSO controls
- The CSOs and areas within the CSS that were monitored (e.g., outfall identification number, location in CSS that includes all flows into a sewershed) and rationale for their selection (e.g., outfalls discharging the most frequently from previous observations, outfalls in sensitive areas, simple or complex system)
- Identifying representative overflows
- Event duration for each outfall for each day
- POTW WWTP influent flow for each day at a designated monitoring point in MGD
- Operational problems that reduced the capabilities of the POTW or the delivery/treatment system including natural or man-made disasters, power outages, equipment breakdown or

malfunction, biological problems, inadequate capacity because of antecedent conditions (previous rainfall, snowmelt, elevated groundwater and so on).

- Peak influent flow rate entering the POTW WWTP at a designated monitoring point in MG
- Peak influent design flow
- Chlorine residuals (max chlorine dose, chlorine residual in final effluent)
- Event discharge from each overflow or approved representative overflow in MG and as metered/measured or estimated
- If models were used, a description of the model(s) selected for the project and the data that were used to calibrate and validate the model(s)
- If the Presumption Approach, Criterion i was selected, a presentation of overflow data allowing for evaluation on an average annual basis (for additional information, see Section 4.1.1 of this guidance document) to evaluate whether no more than an average of four overflow events occurred per year (provided that the NPDES authority may allow up to two additional overflow events per year)
- If the Presumption Approach, Criterion ii was selected, flows in CSS during *precipitation events*, volume of overflows from the system during the precipitation events, and calculation of percent capture on an annual basis to evaluate whether 85 percent of combined sewage in the CSS during precipitation events is captured on an annual basis (for additional information, see Section 4.1.2 of this guidance document)
- If the Presumption Approach, Criterion iii was selected, calculation of average pollutant load removal (for examples, see Section 4.1.3 of this guidance) to show that the permittee will achieve the elimination or removal of no less than the mass of pollutants identified as causing water quality impairment through the sewer system characterization, monitoring, and modeling efforts for the volumes that would be eliminated or captured for treatment under the Presumption Approach, Criterion ii.
- If the Demonstration Approach was selected, methods used to demonstrate the impact of CSOs on the receiving water, such as receiving water model and water quality monitoring

In addition to the above data elements for evaluating the effectiveness of CSO controls, the permitting community should consider including the following recommended data elements in the post construction compliance monitoring report for assessing whether CSO receiving water quality complies with WQS:

- Monitoring locations
- Day of month, day of week
- Frequency of sampling and number of wet weather events sampled.
- Criteria for when samples were collected (e.g., greater than x days between events, rainfall events greater than 0.4 inch to be sampled)
- Description of flow measurement, rainfall measurement and sampling methods used

- General weather conditions (e.g., temperature)
- Precipitation in inches, measured to the closest 0.10-inch of precipitation event over a 1-day period
- Precipitation type
- Storm duration
- Flow measurements
- Time discharge begins
- Pollutant concentrations
- Compliance status of the municipality (e.g., overflow number out of *allowable* number of overflows per year)
- Statement confirming that reported CSO discharge and the level of treatment provided was in full compliance with final performance criteria in permit, order, or other enforceable document issued between the NPDES authority and the permittee, or by court action

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Appendix C. Resources Relevant to Applicable Water Quality Standards

As described earlier in this document, characterizing CSO impacts implicitly requires the permittee to identify the WQS of the receiving water and to evaluate how the CSO discharges are affecting the receiving waters with respect to such standards. The permitting community should determine what water quality criteria or standards applicable to the specific designated use(s) of the receiving water are available for the pollutants selected for analysis.

The WQS program, as envisioned in section 303(c) of the CWA, is a joint effort between the states and EPA. The CWA requires EPA to publish water quality criteria recommendations, and it requires states to adopt protective criteria into their standards. States can do this in one of three ways:

- Adopt EPA's recommended criteria
- Modify EPA's recommended criteria to reflect site-specific conditions
- Adopt criteria that are *as protective as* EPA's recommendation based on scientifically defensible methods

States adopt WQS to protect public health or welfare, enhance the quality of water, and protect biological integrity. EPA oversees states' activities to ensure that state-adopted standards are consistent with the requirements of the CWA and that WQS regulations (40 CFR Part 131) are met. Monitoring, assessments, and compliance determinations **must** also consider the **applicable** water quality criteria and standards **adopted** by the state, tribe or territory, and **approved** by EPA for the given location of the CSO project."

Environmental stressors can be chemical, physical or biological in nature, and likewise can impact the chemical, physical, and biological characteristics of an aquatic ecosystem. The interactions among chemical, physical, and biological stressors and their compounding impacts emphasize the need to directly detect and assess actual water quality impairments of the biota.

C.1 Indicators of Bacterial Contamination

C.1.1 Recreational Waters

Before the 1986 revision to EPA's national criterion for bacteria, EPA's 1976 recommended criteria for bathing waters was based on fecal coliform bacteria. In EPA's 1976 *Quality Criteria for Water* (<http://www.epa.gov/waterscience/criteria/library/redbook.pdf>), it was recommended that, based on a minimum of five samples taken over a 30-day period, "fecal coliform bacterial level should not exceed a log mean of 200 per 100 milliliters (mL), nor should more than 10 percent of the total samples taken during any 30-day period exceed 400 per 100 mL."

On the basis of results of studies EPA performed in the late 1970s and early 1980s, it was determined that enterococci and *E. coli* had a greater degree of association with outbreaks of certain diseases than fecal coliform bacteria. EPA, in its *1986 Ambient Water Quality Criteria for Bacteria*

(<http://www.epa.gov/waterscience/beaches/files/1986crit.pdf>, recommended enterococci and *E. coli* as the basis for bacterial WQS. EPA's (1986; <http://www.epa.gov/waterscience/beaches/files/1986crit.pdf>) recommended criteria for bacteria for bathing waters are as follows:

- Freshwater: On the basis of a statistically sufficient number of samples (generally not less than five samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following:
 - *E. coli* 126 per 100 mL
 - Enterococci 33 per 100 mL

No sample should exceed a one-sided confidence limit (C.L.) calculated using the following as a guidance:

Designated bathing beach 75% C.L.

Moderate use for bathing 82% C.L.

Light use for bathing 90% C.L.

Infrequent use for bathing 95% C.L.

On the basis of a site-specific log standard deviation, or if site data are insufficient to establish a log standard deviation, using 0.4 as the log standard deviation for both indicators.

- Marine water: On the basis of a statistically sufficient number of samples (generally not less than five samples equally spaced over a 30-day period), the geometric mean of the enterococci densities should not exceed 35 per 100 mL.

No sample should exceed a one-sided C.L. using the following as guidance:

Designated bathing beach 75% C.L.

Moderate use for bathing 82% C.L.

Light use for bathing 90% C.L.

Infrequent use for bathing 95% C.L.

On the basis of a site-specific log standard deviation, or if site data are insufficient to establish a log standard deviation, using 0.7 as the log standard deviation.

Under the CWA, EPA is required to approve state-adopted standards for waters of the United States, evaluate adherence to the standards, and oversee enforcement of standards compliance. As of the year 2000, many states had not adopted EPA's recommended bacteria criteria (USEPA 1986; <http://www.epa.gov/waterscience/beaches/files/1986crit.pdf>) or an *as protective as alternative* into their standards for coastal recreational waters. In response, Congress passed the *Beaches Environmental Assessment and Coastal Health Act of 2000* (BEACH Act; USEPA 2000 [<http://www.epa.gov/waterscience/beaches/files/beachbill.pdf>]), that required states to adopt protective bacteria criteria into their state standards by April 2004.

Through the BEACH Act, EPA established federal standards for those states and territories with coastal recreation waters that had not yet adopted bacteria criteria as protective of health as EPA's 1986 criteria into their WQS. The BEACH Act Rule (see 40 CFR 131.41) states that these standards apply to *E. coli* or enterococci regardless of origin unless a sanitary survey shows that sources of the indicator bacteria are non-human and an epidemiological study shows that the indicator densities are not indicative of a human health risk. For additional information on the status of standards development for coastal recreational waters, see EPA's *Final Nationwide Bacterial Standards Fact Sheet* at <http://www.epa.gov/waterscience/beaches/rules/bacteria-rule-final-fs.htm>.

C.1.1.1 Single Sample Maximum Values

EPA provides recommendations for those interested in using a single sample maximum (SSM) value to assess receiving water quality at <http://www.epa.gov/waterscience/beaches/rules/singe-sample-maximum-factsheet.htm#position>. The geometric mean is generally more relevant than the SSM because it is usually a more reliable measure of long-term water quality, being less subject to random variation, and more directly linked to the underlying studies on which the 1986 bacteria criteria were based. However, using an SSM is especially important for beaches and other recreational waters that are prone to short-term spikes in bacteria concentrations from CSO discharges or waters that are infrequently monitored.

It should be emphasized that SSM values in EPA's 1986 *Ambient Water Quality Criteria for Bacteria* (<http://www.epa.gov/waterscience/beaches/files/1986crit.pdf>) were not developed as acute criteria; rather, they were developed as statistical constructs to allow decision makers to make informed decisions to open or close beaches on the basis of small data sets. Treating the SSM as equivalent to acute criteria (i.e., with a specified duration of exposure of just one second) could impart a level of protection much more stringent than intended by the 1986 bacteria criteria document.

Therefore, EPA intends that states and territories covered by the BEACH Act Rule retain the discretion to use SSM values as they deem appropriate in the context of CWA implementation programs other than beach notification and closure, consistent with the CWA and its implementing regulations.

The BEACH Act Rule (see 40 CFR 131.41) provides calculated SSM values based on the 75, 82, 90, and 95 percent confidence levels in EPA's 1986 *Ambient Water Quality Criteria for Bacteria* (<http://www.epa.gov/waterscience/beaches/files/1986crit.pdf>). EPA recognizes that the log standard deviations observed in EPA's epidemiological studies might not coincide with that for a particular waterbody. If a state or territory is interested in calculating site-specific SSM values, the BEACH Act Rule requires the collection of at least 30 bacterial samples in a single recreation season (see 40 CFR 131.41(c)(3)) to capture the variability inherent in bacteria concentrations at a site over the period of a single season without introducing additional variability from extreme weather conditions such as drought or El Niño conditions.

EPA considers that for calculating site-specific SSM values, as specified in 40 CFR 131.41(c)(3), it provides enough detail on the calculation that states included in the BEACH Act Rule can implement this provision of the rule without needing to adopt it as a site-specific water quality criterion. As a result, states

included in the BEACH Act Rule do not need EPA review and approval under 40 CFR Part 131 in their application of 40 CFR 131.41(c)(3).

C.1.1.2 Future Recreational Water Standards

EPA's current (1986; <http://www.epa.gov/waterscience/beaches/files/1986crit.pdf>) criteria recommendations use *indicator* bacteria. Most strains of *E. coli* and enterococci do not cause human illness (that is, they are not human pathogens); rather, they indicate fecal contamination, and the assumption is that pathogens co-occur with incidences of fecal contamination (USEPA 2007a; <http://www.epa.gov/waterscience/criteria/recreation/experts/expertsWorkshop.pdf>).

Since publication of the 1986 criteria, many states have expressed concern that the current fecal indicator/illness rate relationships identified in the epidemiology studies leading up to the 1986 criteria are not appropriate or representative of all U.S. waters. For example, states have concerns that the most appropriate indicator in tropical waters could be different than in temperate waters, and that appropriate levels of indicators could be different in waters where human fecal waste predominates animal waste (USEPA 2007a; <http://www.epa.gov/waterscience/criteria/recreation/experts/expertsWorkshop.pdf>).

Since EPA issued its recreational criteria more than 20 years ago, there have been significant scientific advances, particularly in the areas of molecular biology, microbiology, and analytical chemistry. As described in EPA's (2007a; <http://www.epa.gov/waterscience/criteria/recreation/experts/expertsWorkshop.pdf>) *Report of the Experts Scientific Workshop on Critical Research Needs for the Development of New or Revised Recreational Water Criteria*, EPA believes that these new scientific and technical advances need to be factored into the development of new or revised CWA 304(a) criteria for recreation. To this end, EPA has been conducting research and assessing relevant scientific and technical information to provide the scientific foundation for developing new or revised criteria. The BEACH Act of 2000 requires EPA to conduct new studies and issue new or revised criteria, specifically for Great Lakes and coastal marine waters.

EPA's *Critical Path Science Plan* (USEPA 2007b; <http://www.epa.gov/waterscience/criteria/recreation/plan/index.html>) describes the high-priority research and science that EPA intends to conduct to establish the scientific foundation for developing new or revised recreational water quality criteria recommendations. EPA's *Critical Path Science Plan* (http://water.epa.gov/scitech/swguidance/waterquality/standards/criteria/health/recreation/plan_index.cfm) describes the overall research goals, key science questions associated with data gaps in the existing science, and the studies that EPA intends to conduct or support to develop new or revised water quality criteria for pathogens and pathogen indicators by the end of 2012.

Detailed information on the development of EPA's new or revised recreational water quality criteria is on EPA's Recreational Water Quality Criteria Web site: <http://www.epa.gov/waterscience/criteria/recreation/>.

C.1.1.3 Non-coastal or Inland Recreational Waters

Note that the BEACH Act Rule (see 40 CFR 131.41) is applicable to only coastal recreational waters. Section 502(21) of the CWA explicitly excludes from the definition of coastal recreation waters “inland waters; or water upstream of the mouth of a river or stream having an unimpaired natural connection with the open sea.”

EPA will approve pathogen standards for inland waters if the standards submitted by states to EPA for approval are found to be scientifically defensible for protecting the uses of these waterbodies. Parts of states with only inland waters are not subject to the BEACH Act requirements, as described on EPA’s *Frequent Questions - Final Water Quality Standards for Coastal and Great Lakes Recreation Waters* Web site, at <http://www.epa.gov/waterscience/beaches/rules/bacteria-rule-questions.htm#inland>.

C.2 Shellfish Harvesting Waters

EPA’s (1986; <http://www.epa.gov/waterscience/beaches/files/1986crit.pdf>) recommended criteria for bacteria for shellfish harvesting waters is

The median fecal coliform bacterial concentration should not exceed 14 MPN per 100 mL with not more than 10 percent of samples exceeding 43 MPN per 100 mL for the taking of shellfish.

In cases where CSOs are discharged into shellfish harvesting waters, it is expected that the NPDES authority will require the permittee to collect and analyze samples for fecal coliform bacteria for comparison to applicable state standards. If the receiving water also is classified as a coastal recreational water, it is expected that the NPDES authority will require the permittee to monitor for both fecal coliform bacteria (to evaluate compliance with shellfish harvesting WQS) and *E. coli* or enterococci to meet BEACH Act requirements.

C.3 Other Applicable Water Quality Criteria

A compilation of all EPA’s current recommended ambient water quality criteria for the protection of aquatic life and human health (USEPA 2005) are provided on EPA’s National Recommended Water Quality Criteria Table Web site (<http://www.epa.gov/waterscience/criteria/wqctable/>). In 2002 EPA published revisions to many of the ambient water quality criteria for human health as the *National Recommended Water Quality Criteria: 2002* (<http://www.epa.gov/waterscience/pc/revcom.pdf>). In 2003 EPA published an additional 15 revised human health criteria. The current *National Recommended Water Quality Criteria Table* (USEPA 2005; <http://water.epa.gov/scitech/swguidance/waterquality/standards/current/index.cfm>) reflects the compilation of the updated information already published by EPA in 2002 and 2003.

Great Lakes Requirements

Great Lakes regulatory requirements, known as the Great Lakes Initiative, or GLI, apply to all the streams, rivers, lakes and other bodies of water within the U.S. portion of the Great Lakes drainage basin. For those waters, a state or authorized tribe must adopt requirements (including water quality

criteria) that are consistent with (as protective as) regulations EPA promulgated on March 23, 1995. See 60 FR 15366 and 40 CFR 132.1(b) and 132.4.

State, Tribal, and Territorial Water Quality Standards

Because each state has its own WQS, individual post construction compliance monitoring plans will have to be designed to provide data to allow evaluation of CSO controls in achieving the specific WQS in the receiving water. In post construction monitoring plans, permittees should show a direct link between the WQS in the receiving water and the data they are collecting in the post construction compliance monitoring program. This can be straightforward in the case of waterbodies that have clearly identified water quality criteria, such as TSS, but it can be more challenging in the case of other standards, such as geometric means for bacteria.

State, tribal, and territorial WQS are available from EPA's state, tribal and territorial standards Web site (<http://www.epa.gov/waterscience/standards/wqslibrary/links.html>). Some state criteria are nonnumeric, qualitative guidelines that describe a desired water quality goal.

Data collection is potentially challenging for receiving waters that have narrative criteria related to biological communities or sediment quality. In such cases, as part of its post construction compliance monitoring plan, the permittee may be required to design and implement studies that provide data that allow the NPDES authority to assess the attainment of designated uses. Addressing narrative criteria can be an important aspect of any monitoring plan because effects on designated uses cannot always be accurately assessed using the relatively few pollutant-specific criteria available (e.g., metals, pH). For example, narrative criteria, such as "no toxics in toxic amounts," are written to account for any constituents not specifically measured. WET testing is able to determine compliance with such narrative criteria by testing the discharge as a whole. Often, constituents that are not specifically measured, or a combination of constituents, can cause toxicity and would not have been accounted for if not for WET testing. Similarly, bioassessment integrates effects of all pollutants associated with an effluent as well as hydrological impacts that could impair aquatic life habitats. Evaluating more holistic environmental parameters, such as bioassessment, WET, and sediments, addresses narrative criteria designed to protect and maintain designated uses. The methodology used in these studies should be consistent with any studies done before implementing CSO controls, during the characterization of the receiving water so that the data collected are consistent with, and comparable to, prior data, therefore allowing a comparison of pre-and post-CSO control implementation, to provide information on attainment of water quality goals.

C.3.1 Biocriteria

Sections 303 and 304 of the CWA require states to protect biological integrity as part of their WQS. This can be accomplished, in part, through the development and use of biological criteria. As part of a state or tribal WQS program, biological criteria can provide scientifically sound and detailed descriptions of the designated aquatic life use for a specific waterbody or segment. They fulfill an important assessment function in water quality-based programs by establishing the biological benchmarks for (1) directly

measuring the condition of the aquatic biota, (2) determining water quality goals and setting priorities, and (3) evaluating the effectiveness of implemented controls and management actions.

Additional information on EPA's bioassessment and biocriteria programs is available at <http://www.epa.gov/waterscience/biocriteria/>.

C.3.2 Sediment criteria

In 1976, EPA published a water quality criteria recommendation for solids and turbidity that is based on light reduction. This criterion is summarized in the 1986 EPA *Quality Criteria for Water* as

Solids (Suspended, Settleable) and Turbidity—Freshwater fish and other aquatic life: Settleable and suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life.

The criterion and a brief description of the rationale are at <http://www.epa.gov/waterscience/criteria/goldbook.pdf>. These criteria have not been frequently adopted or used by states. Many states have different criteria for different stream channel substrate types. When they are differentiated, states typically have more stringent criteria for streams with hard substrates (gravel, cobble, bedrock) and less stringent criteria for streams with soft substrates (sand, silt, clay). Cold water fisheries typically have more rigorous criteria than do warm water fisheries in states that differentiate between the two uses. A few states use biocriteria (e.g., biotic indices), and at least one uses soil loss as a criterion. Several states provide criteria for an averaging period (e.g., 30 days) as well as an allowed daily maximum concentration. Some states set an absolute value while others set a value over a background level.

Most states with numerical criteria use turbidity as a surrogate measure. Some use exceedances over background (e.g., "Not greater than 50 NTU over background," or "not more than 10 percent above background" or "no more than 5 NTUs above background"), while some use absolute values (e.g., "Not greater than 100 NTU"). Some states have established numeric standards that are basin-specific, while others vary with the presence of salmonids. In general, most states are concerned with the effects of water clarity and light scattering on aquatic life. The majority of states use EPA method 180.1 to measure turbidity and method 160.2 to measure TSS. Most states use optical backscatter or optical transmission technology for turbidity either by measuring in situ or in the lab after collecting grab or single point samples. Very few, if any states, attempt to correlate turbidity with TSS or biological impacts, and only a few states measure suspended sediment concentration. Very few states measure particle size distribution or bedload.

Only a few states use suspended solids as a criterion. Suspended solids criterion values vary from 30 mg/L up to 158 mg/L. At least one state uses transparency (> 90 percent of background) as a standard. A number of states have criteria based on sediment deposited over a period or during a storm event. Values are typically 5 mm during an individual event (e.g., during the 24 hours following a heavy rainstorm) for streams with hard substrates bottoms and 10 mm for streams with soft bottoms.

Additional information on sediment criteria is available from EPA's suspended and bedded sediments Web site (<http://www.epa.gov/waterscience/criteria/sediment/>).

C.3.3 WET Testing

At present, EPA has no national criteria developed under CWA section 304(a) for acute and chronic WET. In the absence of such criteria, according to EPA's (1991; <http://www.epa.gov/npdes/pubs/owm0264.pdf>) *Technical Support Document for Water Quality-Based Toxics Control* (TSD), recommended magnitudes for WET are for acute protection, the Criterion Maximum Concentration should be set at 0.3 acute toxic units (TU_a) to the most sensitive of at least two test species, where a TU_a = 100/LC50 (concentration that is lethal to 50 percent of the test organisms). For chronic protection, the criteria continuous concentration (CCC) should be set at 1.0 chronic toxic units (TU_c) to the most sensitive of at least three test species, where a TU_c = either 100/NOEC (where NOEC = the no observed effect concentration of a given sample) or 100/IC25 (where IC25 = the concentration at which the response of test organisms is 25 percent below that observed in the control). Some states have their own numeric WET criteria that are usually consistent with the level of protection afforded by the criteria expressions above.

Depending on state implementation procedures, for CSO wet-weather evaluations, acute WET criteria are typically more relevant than chronic WET criteria because the water quality event is often short in duration (e.g., < 48 hours). In such cases, acute WET tests (which are between 48 and 96 hours in duration) might be more appropriate than chronic tests (which are typically conducted over a 6–8 day period for most EPA-approved chronic test methods). However, some studies have reported latent toxicity effects of stormwater discharges (i.e., effects observed when continuing the test past the required acute test duration), which might not be identified using short duration acute WET tests. The decision to use acute versus chronic WET tests should rest in part on the magnitude and duration of the CSO event: high magnitude or long duration CSO events might warrant chronic WET testing. This decision could also depend on the relative dilution of the CSO flow in the receiving waterbody. If dilution is very high (e.g., > 100), chronic testing would probably not be appropriate: EPA's TSD notes that chronic WET testing is advisable when effluent dilution is > 1 percent of the receiving waterbody flow on the basis of the flow condition of concern. If chronic testing is conducted, test exposure concentrations should be renewed using fresh samples collected during the event rather than using the same sample for renewals during the 6–8 day period (i.e., using the first flush sample for the entire 6–8 day test duration). Using fresh samples collected throughout the wet-weather CSO event ensures that test organisms are exposed in a manner similar to the aquatic life in the receiving waterbody.

For dry-weather CSO samples, chronic WET criteria and chronic WET testing might be more appropriate than acute testing depending on the CSO dilution as noted above. If there is, indeed, dry-weather and lower waterbody flows, discharge from a CSO outfall during that condition might be expected to have the potential for water quality effects on aquatic life, suggesting the need for sensitive chronic WET testing.

Additional information on EPA's WET testing is available at <http://www.epa.gov/waterscience/methods/wet/>.

C.4 TMDLs

In receiving waters where bacterial TMDLs in coastal recreational waters have been based on fecal coliform bacteria standards, it is expected that the NPDES authority will require the permittee to monitor for both fecal coliform bacteria (to meet TMDL requirements) and *E. coli* or enterococci to meet BEACH Act requirements.

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Appendix D. CSS Contracting for Laboratory Services

Although many municipalities have established procedures and policies governing the purchase of services and supplies, these procedures might not lend themselves readily to the purchase of analytical services. This appendix provides a basic framework for municipal permittees to use in addressing the technical and contractual issues associated with purchasing laboratory services to support a compliance monitoring program, awarding contracts, and working with contract laboratories. In some cases, separate laboratories might be necessary for chemistry, toxicity (WET testing), and microbial indicators, depending on the accessibility and capabilities of qualified laboratory service providers.

Many laboratory service providers focus on chemical analysis alone, and can retain relationships with microbiological and WET laboratories to support programs that require those measurements. Further certification and accreditation of chemical and microbiological laboratories may be administered under different programs by different accrediting agencies. Microbiological laboratories have historically been accredited by local departments of health, while environmental chemistry and toxicity laboratories are accredited by local environmental offices or water agencies, or can take part in national accreditation programs. WET laboratories may be accredited or certified by the state in some cases or accredited by the National Environmental Laboratory Accreditation Conference (NELAC) in those states that participate in the NELAC program. Therefore solicitation, prequalification, and selection of best-value providers call for a more robust procurement process than many other commercially available services. Further, because CSO compliance monitoring in particular must, by design, include assessment of precipitation-triggered discharges, close coordination with the selected provider(s) after award is critical to the collection of valid data and the overall success of the monitoring program.

Successfully contracting for laboratory services for compliance monitoring relies on the following steps:

- Step 1:** Define the scope of your analytical requirements (analytical indicators, and measurement parameters including applicable WQS based on designated uses of the receiving waters) to develop a detailed contract
- Step 2:** Develop a standardized bid sheet/cost estimate
- Step 3:** Identify and solicit approved/certified laboratories
- Step 4:** Evaluate bidder qualifications and award contracts to a primary laboratory(ies) and a backup laboratory(ies)
- Step 5:** Work closely with your laboratory(ies) before monitoring begins and maintain communication throughout monitoring

These general steps, and details on the activities associated with each, are discussed in Sections D.1 through D.5. Whether you contract with one laboratory for both microbiological and chemical analyses or separate laboratories, the same general procedures apply.

Remember: you must use an approved laboratory for compliance monitoring, as described in Section D.3 below, and as described in the provisions of the CWA.

D.1 Defining Your Needs and Developing a Contract

The first step in developing an analytical services contract for analyses is identifying the *who*, *what*, *where*, *when*, of the project for your system (the *why* is the CSO Control Policy and requirement for post construction compliance monitoring), and the *how* will be defined through collaboration with your analytical services provider(s). A well-written contract will address minimally the *who* (is authorized to contact the laboratory and to collect and submit samples) and *when* (samples will be submitted for analysis) as well as the administrative issues, such as laboratory payments and adjustments. *When* and *where* samples will be collected are critical to identifying the number of overall number of samples that will be submitted for analysis in a given period of performance, and *what* parameters will be measured as necessary to develop the overall scope of the monitoring program to allow the potential bidders to more closely evaluate the analytical requirements and offer any potential volume discount schedules that could apply. Because of the nature of CSO post construction compliance monitoring and its focus on dry- and wet-weather monitoring, it will be necessary to identify the number of dry-weather (ambient) sampling events proposed and the conditions that will qualify an ambient sampling (i.e., 72 hours since last measureable rainfall). It is also necessary to identify the number of targeted wet-weather sampling events that will be proposed, and project within the wet-weather events how many additional CSO overflow samples might be submitted. During procurement, the variability of prevailing weather conditions could dictate the need for qualifying the bid sheet as the *maximum* number of events that will be sampled, but it should be clear in your solicitation that the actual number of sampling events rely on predictable weather events.

The best way to ensure that you get the data you need for compliance monitoring in the required period is to specify your requirements in detail in the contract. A well-written contract can minimize or eliminate many common problems in procuring analytical services and enable you to collect reliable and timely results. Recommendations on the factors to consider in defining the scope of the services you need, and the information you should be sure to include in your contract, are provided below.

D.1.1 Client Information

Who defines your CSS to the laboratories that you would like to submit bids for the project, and *who* will be collecting the samples (if you would like a bid on sampling services). After award, *who* will include your sampling coordination contact(s) for the program.

D.1.2 Sample Information

What describes the samples to be analyzed. As noted in Sections D.1. through D.5, this encompasses a variety of factors, each of which should be evaluated and defined before you develop the contract. However, one of the easiest descriptions to overlook is the required analytical sensitivity. Your CSO monitoring program will include assessment of ambient water quality. In conventional monitoring programs ambient water quality is assessed during dry-weather or base-flow sampling events, and it includes a direct comparison of analytical results from grab samples to prevailing WQS. Because a variety of WQS are available based on selected designated uses from outstanding natural resource waters and public drinking water supply to secondary contact recreation, analytical sensitivity

requirements can vary widely. In watershed-wide monitoring programs or in waterbodies or reaches with multiple designated uses, it is advantageous to select the most stringent WQS as your program goals. By selecting the most stringent standards there is less likelihood that there will be confusion at the laboratory as to the analytical objectives, thereby returning the application of the correct standards back to the user in the ultimate use of the data. Analytical interferences should be less prevalent in higher grade waters or those that are designated for enhanced water quality. Therefore, where a laboratory might be required to effect a dilution to render a meaningful measurement on a more complex sample, it will generally be on a sample from a lesser use designation, and should not affect the final assessment of attainment of standards.

D.1.2.1 Number of Samples

What is the total number of samples the laboratory(ies) will need to analyze during a sampling event, how many events are planned or proposed, and how many will be required during a contract period? If you are collecting primarily unit rates, and wish to award blanket purchase agreements or purchase orders, the extended numbers of samples are strictly for projecting the potential sample volume to the laboratory for volume consideration. Alternatively, if you are awarding a contract for a single permit period or some other period in accordance with purchasing policies, the laboratory should define your extended sample numbers.

Will your program include monitoring once per month or twice or more per month? This total includes not only routine monitoring samples (field [monitoring] samples) but also any field blanks, duplicates and *project-specific* quality control (QC; spiked matrix spike and matrix spiked duplicate [MS/MSD]) samples. Field (monitoring) samples and unique, field-generated, project-specific QC samples are generally considered *billable* samples (sample analyses for which the laboratory will be paid its per-sample cost). Some laboratories might offer MS/MSD analyses as value added services (at no cost), provided MS/MSD data are not expected to exceed 1 in 20 samples. Laboratories often offer a *batch QC* option that allows the laboratory to select the sample that they spike and report as MS/MSD for each batch; however, this could require additional tracking to ensure that your samples receive sufficient (1/20) site-specific QC samples to assess your data. This should be clear in your request and in your final contract, as well as in the bids received.

Internal laboratory QC samples, such as method blanks and ongoing precision and recovery (OPR), laboratory control samples (LCS) or certified standard reference materials (SRM) analyses should be considered *unbillable* samples—sample analyses that are required by the method but apply to multiple clients. Rather than charging clients for these samples directly, laboratories typically will distribute the costs of these samples across billable samples.

If a sample is collected and sent to the laboratory but cannot be submitted because of a problem unrelated to laboratory performance (such as shipping delays that violate the sample holding time), the CSS might be required to repeat the entire sampling event, because all measurements should be reported for parameters of interest on the same samples (representing the same site conditions, and spatial and temporal distributions). It is inappropriate to recollect a single parameter for analysis during a wet-weather event, because the final data requirement could be for multiple sites and multiple

parameters to gain a complete understanding of conditions during the event. In such cases, all samples should be cancelled, and another event should be scheduled to ensure a valid and representative assessment.

D.1.2.2 Sample Types

Two types of samples can be collected under a monitoring program—grab samples or composite samples.

D.1.2.2.1 Grab Samples

Grab samples are samples that are collected instantaneously (as rapidly as is practicable) directly from a discharge or from below the surface of a receiving stream directly into sample containers or into a larger device or container for dispensing into individual sample containers. Certain parameters (microbiological indicators, oil and grease, volatile constituents, and so on) must be collected directly into the containers to be submitted for analysis to preserve their integrity. Other parameters can be collected simultaneously in a large container or a sampling device and dispensed into multiple sample containers for shipment. Table 1060:I in *Standard Methods for the Examination of Water and Wastewater, Twentieth Edition* (APHA 1998; <http://www.umass.edu/tei/mwwp/acrobat/sm2320b.PDF>) or later include sample types allowable for compliance monitoring by parameter or indicator.

D.1.2.2.2 Composite Samples

Composite samples are either *time-weighted* or *flow-weighted* composites collected over a period of time to represent total pollutant discharge over time (for constant discharge rates), or total pollutant loading relative to flow. Composite samples are routinely collected automatically with automatic sampling devices triggered by some change in stage or by rain gage, or by change in pressure in the event of in-line pressure transducers.

Sample parameters not amenable to composite sampling (e.g., pathogens, oil and grease, and orthophosphate) are generally collected as individual manual grabs distributed throughout a discharge event. Grab sampling throughout a discharge event could include analysis of only three to four sample aliquots representing a first flush, rise, peak, and fall of the receiving water hydrograph, or they can be collected throughout the discharge event and analyzed to produce a pollutograph where the stream hydrograph and stage discharge relationship can be used to determine loading associated with each sample analyzed. Alternatively, composite sampling can be performed to proportionally sample or proportionally combine sample aliquots in accordance with average precipitation events or through use of the hydrograph to prepare a composite representative of the entire storm event. These sample composites can be submitted as a single stormwater sample whose result reflects an event mean concentration for estimating loads during a wet-weather event.

D.1.2.3 Required Sample Volume

On the basis of the full suite of measurements required at each sampling site, your sample volume requirements could vary. While it is not as critical at the time of solicitation what volumes will be

collected at each sampling station, solicitation might be a good time to request sample volume requirements from your potential providers. Laboratories generally prefer to describe which measurement parameters can share bottles, and they could specify additional volumes to ensure that sufficient sample volume is available for any required reanalyses. Regardless of the overall program scope, some samples (e.g., microbiological samples) always require grab sampling and will require separate containers. They will also dictate the shortest required holding time for laboratory analysis with a maximum 6-hour transit time to the analytical laboratory; thus, multiple deliveries can be anticipated in longer wet-weather events.

In addition, if your monitoring scope includes toxicity testing, the volume of sample required is greater than that required for all other chemical and microbiological indicators parameters in a monitoring event, and holding times for toxicity testing generally do not exceed 24 hours.

D.1.2.4 Extra Services

Will any additional services be required of the laboratory in addition to sample analyses? Possible services include the following:

- Sampling kit pre-preserved bottleware; filters, rental or purchase of on-site filtration equipment, if necessary
- Sample shipping containers
- Courier services (especially for microbiological samples)
- Training for sample collection personnel

Some laboratories might include these services in the sample analysis cost. Defining the specific services your program will need, and specifying these services clearly in the contract will enable the laboratories to better assess whether the requested services are included in the routine costs or are extra, and respond accordingly.

Clearly specify in your contract any services required in addition to routine sample analysis.

D.1.3 Sampling Schedules

CSO monitoring is difficult to schedule because of the need to capture variable weather and flow conditions (dry, wet-weather non-overflow, and wet-weather overflow events). However, your program should include some initial targets for its dry- and wet-weather sampling events, if only identified by the number of each per month, quarter, or year.

Indicate in your bid sheets and subcontract the month that you plan to begin monitoring and how frequently you will monitor. If possible, do not specify actual sample collection dates and days during the week, but work with the awarded laboratory to establish a schedule that meets your needs and does not present additional potential risk to sample integrity. Wet-weather sampling is obviously much less predictable, so planning for those events more within your control should reflect optimal consideration of routine delivery and workday schedules.

D.1.4 Analytical Methodologies

How describes the analytical method that the laboratory will use. All compliance monitoring must be conducted in accordance with methods prescribed at 40 CFR Part 136 in accordance with NPDES requirements (see Appendix E). Unless significant historical data exist and methodologies have been preselected for a program, your solicitation should include a place for providers to indicate what methods they routinely use in their various measurements. Because of the flexibility to use multiple methods, laboratories select those methods most applicable to support their clients' implementation of their respective monitoring plans. This allows multiple permittees' samples to be processed together, reduces laboratory operating costs, and generally manifests itself in lower costs to the clients. An online source to verify acceptance of the laboratory's proposed methods is available at:

<http://ecfr.gpoaccess.gov/>. (Note that the referenced site includes a disclaimer: that eCFR "is not an official legal edition of the CFR. The e-CFR is an editorial compilation of CFR material and *Federal Register* amendments produced by the National Archives and Records Administration's Office of the Federal Register (OFR) and the Government Printing Office.")

D.1.4.2 Container Types, Preservatives and Holding Times

Composition of sample containers for a specific laboratory measurement parameter can be an important part of preserving sample integrity. Just as analytical methods options are presented in Tables IA–IH of 40 CFR Part 136, container types, preservatives, and holding times are specified in Table II of Part 136. A similar resource for container type, preservation, and holding time can be found in Table 1060:I of Standard Methods as referenced in Section D.1.2.2.1. Container types and preservatives are generally specific to a measurement parameter; however, they are often linked to the specific method of measurement and the associated equipment. Some chemical preservation might not be amenable to some sample handling equipment or measurement systems, but the physical preservation (refrigeration to < 10 °C or < 6 °C) and the prescribed holding times are not variable. Thus, it is important to work with your selected laboratory regarding the container types and preservatives suitable to their preferred methods and measurement equipment.

D.1.4.3 Quality Control Requirements

Although most methods approved at Part 136 specify the QC requirements that must be met during performance of the method, your contract should reiterate that all QC requirements for the method must be met at the required frequency during processing and analysis of your samples, and that method compliance is a minimum performance standard for acceptance. As noted earlier in Section D.1.2.1, the costs for the method blank, OPR, LCS, or SRM analyses should be distributed by the laboratory across the cost of sample analysis and should not be considered billable. On the other hand, you can expect to pay for unique field QC samples that are submitted with the monitoring samples (blanks and duplicates), minimally. You might also expect some negotiation to take place regarding MS/MSD samples, if you require that they be batch-specific. Your laboratory could indicate that if you require MS/MSD on one of your monitoring stations with every event (regardless of the number of stations), they would be considered billable, but if you accept *batch QC* of only 1 spiked sample pair per 20 field samples, they might wave those additional costs. Different laboratories treat MS/MSD samples differently, and you

should make sure that you communicate your requirements and request that bids clearly specify how such QC samples are treated.

Reiterate in the contract that method blanks, ongoing precision and recovery tests, and staining controls must be performed at the frequency required in the method and that all holding times must be met.

D.1.6 Data Deliverables and Other Contract Issues

In addition to the *who*, *what*, *when*, and *how* questions that the contract should address, you should also provide details on data delivery, adjustments for lateness, and sample reanalysis cost issues. These issues are discussed in Sections D.1.6.1 through D.1.6.5.

D.1.6.1 Data Submission

The laboratory, at a minimum, should submit the results for each monitoring sample to you electronically and in hard copy form to ensure that there have been no transcription errors in transfer of data to final reporting formats, or for use in future analysis by the CSS.

Clearly indicate in your contract that the laboratory is required to submit data electronically and in hard copy. Specify that all laboratory data must be recorded on in laboratory logs and appropriate laboratory bench sheets and that all associated QC data and that an authorized data release be signed and submitted for separate, independent verification.

D.1.6.2 Hard Copy Data Deliverables

To demonstrate some due diligence and to ensure sufficient information to verify the analytical data provided electronically, your data deliverables should include results for all your monitoring (field) samples, field QC samples, and method QC samples. It is also helpful to request a statement of verification and validity and a data release signed by the laboratory QA manager or their designee indicating that the data have been reviewed and verified as being compliant with the requirements of the method and or any project QA guidance or QAPP.

Note: If you do not intend to review all the raw data generated by the laboratory, this section is not relevant and can be ignored.

If your project team intends to review all the raw data associated with your monitoring program samples, you should request copies of the forms used by the laboratory to record sample measurements, sample processing times, and sample examination results in addition to the information on the QC samples associated with your monitoring sample. (Original data forms should stay at the laboratory; copies can be submitted for further review by the project team. If bench sheets and raw data, and such, are requested on a batch basis or more frequently monthly basis, the CSS could expect additional charges from the laboratory). If your contract seeks to collect fully validatable data request the following:

- **Monitoring sample identification information.**
- **Monitoring sample results**, by parameter, in appropriate units defined in the contract, including quantitation and method detection limits.

- **Laboratory quality control batch** associated with the samples.
- **ID number and result for the blanks, OPRs, LCSs, or SRMs** analyzed for the batch.
- **Preparation logs or bench sheets** for all samples processed in the batch.
- **Data system printouts or forms** of calibration data, sample analyses, and results including appropriate evaluations of curve linearity and daily calibration verification, sample concentrations, QC results, and acceptance criteria.
- **Laboratory comments** describing any noteworthy observations made during analysis including description of any departures from standard procedures or method protocols, the rationale for those departures, and their overall effect on data quality or usability. If the laboratory provided comments on the sample analyses or results that require follow-up, contact the laboratory to discuss, if necessary. Comments could include any applicable data qualifiers. The following is a list of potential data qualification descriptions:
 - The recovery for the associated OPR sample did not meet method requirements (could indicate a measurement bias)
 - Analyte detected in the method or field blank
 - Positive and negative staining controls were not acceptable or not examined
 - Method holding times were not met.
 - Sample arrived at the laboratory in unacceptable condition

If you want the laboratory to submit full raw data with your hard copy results (this should not be requested unless you intend to validate all the raw data), clearly indicate in your contract the materials that are required. You can also choose to request a hard copy of only the sample and QC summary results (often referred to as a level 2 package).

D.1.6.3 Data Turnaround Requirements

In your contract, make sure that expectations for data delivery are clear. If your permit or other program requirements dictate specific data reporting or filing deadlines (perhaps during refinement of control measures), use those requirements to back-calculate how long will be needed to verify laboratory results, and, in turn when the laboratory should complete analyses and transmit results. The turnaround requirement for the laboratory should be short enough to provide the CSS project team time to review the data and request any necessary clarification before required submittal deadlines to the NPDES authority. The required data turnaround should be stated clearly in the contract. This turnaround time should be expressed in calendar days (not working days), and should start from the sample collection date. The data turnaround time calculations should consider the day that the sample is delivered *day zero*, and the following day as *day one*. (Data turnaround times in analytical contracts typically start from the receipt of the sample at the laboratory, but the laboratory must calculate analytical holding times from sample collection time.)

As a general rule, the data turnaround time should be less than 15 days. Using the 15 days allows for most sample analyses by the appropriate methods within their holding times (plus additional time to compile the data package and mail the results, if hard copies are required) as the shortest realistic turnaround time, determine when you will actually need the results. It might be advisable to request acceleration premiums (generally expressed as a percentage surcharge for a batch) in case some samples require expedited delivery to evaluate a specific control measure; are part of a corrective action investigation; or were collected to investigate an unusual or unexpected discharge event. Collection of accelerator premiums allows you to include those options in your contract without modification should those services be necessary. In most cases, the same turnaround time can be specified for both submission of electronic data and receipt of hard copy materials.

D.1.6.4 Liquidated Damages and Penalties

You should consider including penalty or damage clauses in your contract as incentives to preclude laboratories from submitting data late or performing analyses improperly. Because of the nature of the services provided, assessing actual damages caused by improperly performed analyses is often difficult. Liquidated damages often are used in analytical services contracts in lieu of actual damages. Liquidated damages typically specify that, if the laboratory fails to deliver the data specified in the deliverables section of the contract or fails to perform the services within the specified data turnaround time, the laboratory will pay a fixed, negotiated price to compensate the organization to whom the services should have been delivered. For example, some EPA contracts for analytical services specify that the laboratory will pay, as fixed, agreed, and liquidated damages, 2 percent of the analysis price per calendar day of delay, to a maximum reduction of 50 percent of the analysis price.

If liquidated damages or penalties are involved, they should

- (1) be based in terms of cost by each late day or in increments,
- (2) be strong enough to discourage late delivery, and
- (3) be reasonable enough that they will not discourage laboratories from bidding.

The contract should specify that the laboratory will not be charged with liquidated damages when the delay in delivery or performance arises out of causes beyond the control and without the fault or negligence of the laboratory. It also might be necessary to limit damages to a certain dollar value or scope.

Other types of damages that should be considered and can be included in the contract include costs for resampling and administrative costs associated with the evaluation and processing of unacceptable data (data that do not meet the requirements specified in the contract or the QC requirements specified in the analytical method).

Clearly indicate in your contract whether liquidated damages will be applied to late data or other problems, how these liquidated damages are calculated, and the limits and conditions associated with the damages. However, instituting penalties over a laboratory for late delivery remains at your discretion, and communication should be a consideration in the use of liquidated damages for late data. It is more important that you are able to plan for and project delivery of late data than to levy fines against a valued service provider. Also keep in mind that a portion of CSO monitoring includes wet-weather events, and working closely and cooperatively with the selected laboratory is key to successful data collection. There will be times beyond anyone's control that the program requires expedited laboratory support (from delivery of sampling kits to capture a storm event to additional staffing to initiate time-critical analysis) to ensure success.

D.1.6.5 Reanalysis Costs

Every laboratory periodically produces data that are associated with unacceptable QC data or are invalid for other reasons. The contract should stipulate that the laboratory will reanalyze samples at no cost if the problems are due to laboratory error. If the problems are due to an error outside of the laboratory's control (such as the laboratory's rejection of samples received at $> 20^{\circ}\text{C}$ that results in resampling), the laboratory should contact sampling personnel for direction before incurring costs, and they should not be responsible for the additional costs that could result.

Clearly indicate in your contract when the laboratory would be required to bear the costs of sample reanalysis and when these costs will be covered under the contract.

The contract also should state that you have the right to inspect the results, and if they do not meet the requirements in the contract, you have the right to reject the data, returning them to the laboratory without payment. Rejection of data should be based on sound technical review of the results. It also obligates you to make no use of those results without making some payment to the laboratory.

D.2 Developing a Bid Sheet

After all project requirements have been established, you should develop a bid sheet to accompany the analytical requirements summary during the solicitation. The bid sheet allows laboratories to submit bids in the same format, making bid evaluations easier, and helps to clarify the project. Development and use of a bid sheet is recommended regardless of whether you solicit the project competitively to multiple laboratories, or is simply requesting a quote from a laboratory you already know you will be using, because it provides a very clear vehicle for submitting and evaluating costs.

Clearly indicate in your contract that you have the right to inspect results and reject the results if they do not meet contract requirements.

The bid sheet format should include the following information in a formatted header:

- Project identifier (e.g. "CSO Compliance Monitoring Sample Analyses for [CSS name or facility name and permit number]").
- Space for laboratory identification and contact information (for when they submit the bid).

- Day, date, and time (including time zone) of the bid deadline.
- Procurement contact information (contact and mailing address, fax number, phone number, and email address).
- Estimated award date.
- Laboratory period of performance (includes the period of time during which the laboratory is obliged to resolve issues associated with analysis of the samples—generally 6 months after shipment of the last sample).
- Data turnaround times and surcharges (time from sample receipt to reporting results) 15 day (standard); surcharge (%) for 10 day; surcharge (%) for 5 day; surcharge (%) for 3 day.
- Bid validity period (period of time during which bid prices are considered valid—generally 45 days after the bid deadline; if the project is awarded after the period you specify, you must contact bidding laboratories to determine whether their bid is still valid, or needs to be revised).

Actual bid sheets for analytical services typically are formatted as a table, with descriptions of services and supplies identified in a single column down one side to define a row header; a column for requested or planned number of units; a column for required (WQS) or requested quantitation limits (where no apparent standards exist); and blank columns for laboratory input and responses.

Laboratory input should be requested for the following:

- Preferred methods (e.g., *E. coli* by *Standard Methods 9223B* or *TSS* by *SM 2540D*)
- Laboratory quantitation limits (next to the target limit for easy evaluation)
- Laboratory method detection limits (MDLs, as defined and required under 40 CFR Part 136 Appendix B), if applicable;
- Laboratory-defined acceptance criteria (for OPR, LCS, etc.);
- Unit rates
- Extended costs

The following are two examples of a bid sheet for nine stations with 25 dry-weather and 25 wet-weather events with field QC at the prescribed frequency:

Parameter	#	Laboratory method	Requested limit (WQS)	Lab quant limit	MDL	Acceptance	Unit rate	Extended cost
Stations	9							
Events	50							
Field Dups (1/20)	23						Incl. in total	
Blanks 1/20 or one per event	50						Incl. in total	
TSS	523	SM 2540D	20	5	2	90–110	20	10,460.00
Sample kits	50	NA	NA	NA	NA	NA	N/C	0.00

The above table assumes standard turnaround time of 15 calendar days, all method-required quality control data, and a type 2 report.

Parameter	#	Laboratory method	Requested limit (WQS)	Lab quant limit	MDL	Acceptance	Unit rate	Extended cost
TSS	523	SM 2540D	20	5	2	90–110	20	10,460.00
Sample kits	50	NA	NA	NA	NA	NA	N/C	0.00
Other (describe) MS/MSD 1 set per 20	46	SM 2540D	20	5	2	90–110	20	920.00
Totals								11,380.00

The above table includes analysis of samples collected from nine sampling station in 50 individual sampling events with 5 percent field duplicates (1 sample per 20 field samples; or 23 field duplicates), and project-specific MS and MSD (or MS and laboratory DUP, depending on method requirements) will be required at the same frequency as the field duplicates, while there will be an additional requirement for one field blank per 20 samples or one per event, whichever is more frequent (50).

D.3 Soliciting the Contract

Procedures for soliciting and awarding contracts to perform analytical services can vary, depending on the scope of the project and purchasing requirements within the organization that is issuing the contract. At one end of the spectrum are contracts that are awarded after placing a single phone call and obtaining a quote from a single laboratory. The opposite end of the spectrum are contracts awarded after a competitive solicitation and bidding process involving the distribution of a detailed project description and a formal bid sheet via fax or mail.

D.3.1 Approved Laboratories

Regardless of whether you will be soliciting the project to multiple laboratories or working with a single laboratory (although a backup laboratory is strongly recommended—see below), you must limit your laboratories to only those participating in the EPA Discharge Monitoring Report QA (DMR-QA) program for chemical analysis. National accreditation is offered through the National Environmental Laboratory Accreditation Program (NELAP) for most chemical analysis, but a local provider might not be interested in servicing clients from outside the state; therefore, they might not pursue the broad accreditation. However, you can find a list of NELAP-accredited labs at <http://www.nelac-institute.org/accred-labs.php>, which can be sorted by state for ease in finding a local laboratory. NELAP-accredited labs will have indication that they are approved for NP (nonpotable) water programs. To complete a good first screen of laboratories, you should check with your state water or environmental agency's laboratory certification specialist or list of approved laboratories on the Web. Both sources should include a phone number at minimum if not a contact name and number for initial inquiry. You will want to inquire as to

the laboratory's participation in DMR-QA and its ability to conduct microbiological analysis, because *E. coli* and enterococcus are likely to be a large part of your CSO monitoring program.

For WET testing, many states do not have accreditation or certification for WET laboratories. In such states, it is advisable to inquire about the WET laboratory's experience with the types of tests needed, their quality management program, and historic quality control data (e.g., reference toxicant test quality control charts) for the types of tests required. In addition, because WET testing is relatively labor intensive compared to chemical or microbiological analyses, it is wise to inquire about personnel training and experience performing the types of WET tests required. A review of the laboratory's personnel, equipment, and quality control can also help indicate the number of WET tests the laboratory can perform simultaneously while meeting the required project quality criteria. For more information about contracting WET laboratories, see EPA's WET test method manuals (e.g., *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*, 5th ed (USEPA 2002; <http://www.epa.gov/waterscience/methods/wet/disk2/atx.pdf>).

Microbiological laboratories might be approved through a local department of health, depending on the breadth of their offerings. Regardless, at the time of your initial discussion request a copy of certification or accreditation letters as part of your prequalification for the solicitation. EPA offers approval for microbiological assessment of drinking waters, which is at http://www.epa.gov/safewater/disinfection/lt2/lab_home.html. While drinking water certification is not required for CSO compliance monitoring, approved laboratories might also offer services to CSOs and other NPDES permittees as part of their routine business practice.

D.3.2 Primary and Backup Laboratory Contracts

Because a laboratory's approval status could change during the monitoring period, you should consider awarding a primary contract and a backup contract. If no performance problems or other problems are encountered during the monitoring period by the laboratory awarded the primary contract, that laboratory would provide uninterrupted sample analysis support for the entire monitoring period. However, if the laboratory encountered performance problems, was disapproved, or was otherwise unable to meet contract requirements, your CSS could switch sample analyses to the backup laboratory under the contract you established with the laboratory before monitoring began. You can discuss the award of primary and backup contracts with the laboratories in the contract solicitation.

D.4 Evaluating Bids

After the laboratories have received the solicitation and submitted their bids, you should evaluate the bids to identify the laboratory that will be awarded the analytical services contract. Specific procedures for evaluating bids can vary, depending on the requirements of your organization, but the bid evaluation process generally entails evaluation and comparison of each laboratory's proposed cost and capability to meet the analysis requirements.

D.4.1 Identifying Responsive Bidders

You should consult your legal or purchasing departments to identify any applicable requirements for evaluating competitive bids. Review all bids and recalculate subtotals and totals to ensure that the bidding laboratories did not make any mathematical errors. In addition, you might want to verify that there are no unacceptable contingencies associated with any of the bids. Either eliminate from consideration bids from laboratories that bid with contingencies or contact the laboratory(ies) to discuss the bid and verify that the laboratory cannot perform the specified services.

Of the remaining (responsive) bids, identify the lowest bidder (or the laboratory that best meets your requirements) to award the primary contract and a second bidder to award the backup contract. If additional assessments of a laboratory's performance or responsibility are needed, you might want to contact references.

D.4.2 References

If you have not worked with a particular laboratory before and would like to verify that it will meet your needs throughout the monitoring period, you can ask the laboratory to provide contacts and phone numbers of utility or government clients for whom the laboratory has performed services.

- Did the laboratory provide data by the required due date?
- Were the data provided by the laboratory of acceptable quality and compliant with contract requirements and in an easy to understand format?
- Were laboratory personnel easy to work with when problems arose during all phases of the project, including sample scheduling, sample analysis, and data review? If problems were noted during data review, was the laboratory prompt and responsive in addressing your concerns?
- Do you have any reservations in recommending this laboratory?

D.5 Communicating with the Laboratory

After the analytical services contract is awarded, request laboratory contact information for the following roles, and provide the laboratory with CSS contacts for the same roles:

- A technical contact for analytical questions or problems
- A sample control contact for shipping delays on the sampling end and sample receipt problems on the laboratory end
- An administrative contact for invoicing and payment

Maintaining communications with the laboratory is critical to identifying and resolving problems quickly and minimizing the need for resampling and reshipments. At a minimum, notify the laboratory of sample shipments the day you ship and confirm that the laboratory received the sample on time and in acceptable condition. You can alternatively request that the laboratory send a copy of the executed chain-of-custody form via fax to confirm sample receipt. You can also consider contacting the laboratory each week before you sample to verify that they know to expect samples.

Although most communications are typically conducted over the phone, these communications also can be conducted via e-mail, which has the added benefit of providing you and the laboratory with a written record of sample receipt confirmations, problem notifications, and problem resolutions.

References Appendix D.

APHA. 1998. Standard Methods for the Examination of Water and Wastewater. 20th ed. American Public Health Association, Washington, DC.

<http://www.umass.edu/tei/mwwp/acrobat/sm2320b.PDF>

USEPA (U.S. Environmental Protection Agency). 2002. *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*. 5th ed.

U.S. Environmental Protection Agency, Washington, DC.

<http://www.epa.gov/waterscience/methods/wet/disk2/atx.pdf>.

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Appendix E. 40 CFR - SUBCHAPTER D - Part 136

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SUBCHAPTER D—WATER PROGRAMS (CONTINUED)

PART 136—GUIDELINES ESTABLISHING TEST PROCEDURES FOR THE ANALYSIS OF POLLUTANTS

Sec.

136.1 Applicability.

136.2 Definitions.

136.3 Identification of test procedures.

136.4 Application for alternate test procedures.

136.5 Approval of alternate test procedures.

136.6 Method modifications and analytical requirements.

APPENDIX A TO PART 136—METHODS FOR ORGANIC CHEMICAL ANALYSIS OF MUNICIPAL AND INDUSTRIAL WASTEWATER

APPENDIX B TO PART 136—DEFINITION AND PROCEDURE FOR THE DETERMINATION OF THE METHOD DETECTION LIMIT—REVISION 1.11

APPENDIX C TO PART 136—INDUCTIVELY COUPLED PLASMA—ATOMIC EMISSION SPECTROMETRIC METHOD FOR TRACE ELEMENT ANALYSIS OF WATER AND WASTES METHOD 200.7

APPENDIX D TO PART 136—PRECISION AND RECOVERY STATEMENTS FOR METHODS FOR MEASURING METALS

AUTHORITY: Secs. 301, 304(h), 307 and 501(a), Pub. L. 95-217, 91 Stat. 1566, *et seq.* (33 U.S.C. 1251, *et seq.*) (the Federal Water Pollution Control Act Amendments of 1972 as amended by the Clean Water Act of 1977).

§ 136.1 Applicability.

(a) The procedures prescribed herein shall, except as noted in § 136.5, be used to perform the measurements indicated whenever the waste constituent specified is required to be measured for:

(1) An application submitted to the Administrator, or to a State having an approved NPDES program for a permit under section 402 of the Clean Water Act of 1977, as amended (CWA), and/or to reports required to be submitted under NPDES permits or other requests for quantitative or qualitative effluent data under parts 122 to 125 of title 40, and,

(2) Reports required to be submitted by dischargers under the NPDES established by parts 124 and 125 of this chapter, and,

(3) Certifications issued by States pursuant to section 401 of the CWA, as amended.

(b) The procedure prescribed herein and in part 503 of title 40 shall be used to perform the measurements required for an application submitted to the Administrator or to a State for a sewage sludge permit under section 405(f) of the Clean Water Act and for record-keeping and reporting requirements under part 503 of title 40.

[72 FR 14224, Mar. 26, 2007]

§ 136.2 Definitions.

As used in this part, the term:

(a) *Act* means the Clean Water Act of 1977, Pub. L. 95-217, 91 Stat. 1566, *et seq.* (33 U.S.C. 1251 *et seq.*) (The Federal Water Pollution Control Act Amendments of 1972 as amended by the Clean Water Act of 1977).

(b) *Administrator* means the Administrator of the U.S. Environmental Protection Agency.

(c) *Regional Administrator* means one of the EPA Regional Administrators.

(d) *Director* means the Director of the State Agency authorized to carry out an approved National Pollutant Discharge Elimination System Program under section 402 of the Act.

(e) *National Pollutant Discharge Elimination System (NPDES)* means the national system for the issuance of permits under section 402 of the Act and includes any State or interstate program which has been approved by the Administrator, in whole or in part, pursuant to section 402 of the Act.

(f) *Detection limit* means the minimum concentration of an analyte (substance) that can be measured and reported with a 99% confidence that the analyte concentration is greater than zero as determined by the procedure set forth at appendix B of this part.

[38 FR 28758, Oct. 16, 1973, as amended at 49 FR 43250, Oct. 26, 1984]

§ 136.3 Identification of test procedures.

(a) Parameters or pollutants, for which methods are approved, are listed together with test procedure descriptions and references in Tables IA, IB, IC, ID, IE, IF, IG, and IH. In the event

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of a conflict between the reporting requirements of 40 CFR Parts 122 and 125 and any reporting requirements associated with the methods listed in these tables, the provisions of 40 CFR Parts 122 and 125 are controlling and will determine a permittee's reporting requirements. The full text of the referenced test procedures are incorporated by reference into Tables IA, IB, IC, ID, IE, IF, IG, and IH. The incorporation by reference of these documents, as specified in paragraph (b) of this section, was approved by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. Copies of the documents may be obtained from the sources listed in paragraph (b) of this section. Documents may be inspected at EPA's Water Docket, EPA West, 1301 Constitution Avenue, NW., Room B102, Washington, DC (Telephone: 202-566-2426); or at the National Archives and Records Admin-

40 CFR Ch. I (7-1-10 Edition)

istration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to: http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html. These test procedures are incorporated as they exist on the day of approval and a notice of any change in these test procedures will be published in the FEDERAL REGISTER. The discharge parameter values for which reports are required must be determined by one of the standard analytical test procedures incorporated by reference and described in Tables IA, IB, IC, ID, IE, IF, IG, and IH or by any alternate test procedure which has been approved by the Administrator under the provisions of paragraph (d) of this section and §§ 136.4 and 136.5. Under certain circumstances paragraph (c) of this section, § 136.5(a) through (d) or 40 CFR 401.13, other additional or alternate test procedures may be used.

TABLE IA—LIST OF APPROVED BIOLOGICAL METHODS FOR WASTEWATER AND SEWAGE SLUDGE

Parameter and units	Method ¹	EPA	Standard methods 18th, 19th, 20th ed.	Standard methods on-line	AOAC, ASTM, USGS	Other	
Bacteria:	1. Coliform (fecal), number per 100 mL or number per gram dry weight.	p. 132 ³ 1680 ^{12,14} 1681 ^{12,19}	9221 C E	9221 C E-99.			
	2. Coliform (fecal) in presence of chlorine, number per 100 mL.	p. 124 ³	9222 D	9222 D-97	B-0050-85 ⁵ .		
	3. Coliform (total), number per 100 mL.	p. 132 ³	9221 C E	9221 C E-99.			
	4. Coliform (total), in presence of chlorine, number per 100 mL.	p. 124 ³ p. 114 ³	9222 D 9221 B	9222 D-97 9221 B-99.			
	5. <i>E. coli</i> , number per 100 mL.	p. 108 ³ p. 114 ³	9222 B 9221 B	9222 B-97 9221 B-99.	B-0025-8 ⁵ .		
	6. Fecal streptococci, number per 100 mL.	p. 111 ³	9222 (B+B.5c) 9223 B ¹³	9222 (B+B.5c) - 97. 9223 B-97 ¹³	991.15 ¹¹	Colilert [®] 13,17 Colilert-18 [®] 13,16,17 mColiBlue-24 [®] 18	
	7. Enterococci, number per 100 mL.	1603 ²¹ p. 139 ³	9230 B	9230 B-93.			
	8. <i>Salmonella</i> , number per gram dry weight ¹² .	p. 136 ³ p. 143 ³	9230 C	9230 C-93	B-0055-85 ⁵ .		
	9. Aquatic Toxicity: water organisms, LC ₅₀ , percent effluent.	1600 ²⁴ , 1682 ²² , 2002.0 ²⁵ .				D6503-99 ¹⁰	Enterolert [®] 13,23
		<i>Ceriodaphnia dubia</i> acute					
	<i>Daphnia pulex</i> and <i>Daphnia magna</i> acute.	2021.0 ²⁵ .					
	Fathead Minnow, <i>Pimephales promelas</i> , and Bannerfin shiner, <i>Cyprinella leedsi</i> , acute.	2000.0 ²⁵ .					
	Rainbow Trout, <i>Oncorhynchus mykiss</i> , and brook trout, <i>Salvelinus fontinalis</i> , acute.	2019.0 ²⁵ .					

TABLE IA—LIST OF APPROVED BIOLOGICAL METHODS FOR WASTEWATER AND SEWAGE SLUDGE—Continued

Parameter and units	Method ¹	EPA	Standard methods 18th, 19th, 20th ed.	Standard methods on-line	AOAC, ASTM, USGS	Other
10. Toxicity, acute, estuarine and marine organisms of the Atlantic Ocean and Gulf of Mexico, LC ₅₀ , percent effluent.	Mysid, <i>Mysidopsis bahia</i> , acute	2007.0 ²⁵ .				
	Sheepshead <i>Cyprinodon variegatus</i> , acute.	2004.0 ²⁵ .				
	Silverside, <i>Menidia beryllina</i> , <i>Menidia menidia</i> , and <i>Menidia peninsulae</i> , acute.	2006.0 ²⁵ .				
11. Toxicity, chronic, fresh water organisms, NOEC or IC ₂₅ , percent effluent.	Fathead minnow, <i>Pimephales promelas</i> , larval survival and growth.	1000.0 ²⁶ .				
	Fathead minnow, <i>Pimephales promelas</i> , embryo-larval survival and teratogenicity.	1001.0 ²⁶ .				
	Daphnia, <i>Ceriodaphnia dubia</i> , survival and reproduction.	1002.0 ²⁶ .				
	Green alga, <i>Selenastrum capricornutum</i> , growth.	1003.0 ²⁶ .				
12. Toxicity, chronic, estuarine and marine organisms of the Atlantic Ocean and Gulf of Mexico, NOEC or IC ₂₅ , percent effluent.	Sheepshead minnow, <i>Cyprinodon variegatus</i> , larval survival and growth.	1004.0 ²⁷ .				
	Sheepshead minnow, <i>Cyprinodon variegatus</i> , embryo-larval survival and teratogenicity.	1005.0 ²⁷ .				
	Inland silverside, <i>Menidia beryllina</i> , larval survival and growth.	1006.0 ²⁷ .				
	Mysid, <i>Mysidopsis bahia</i> , survival, growth, and fecundity.	1007.0 ²⁷ .				
	Sea urchin, <i>Arbacia punctulata</i> , fertilization.	1008.0 ²⁷ .				

¹ The method must be specified when results are reported.
² A 0.45 µm membrane filter (MF) or other pore size certified by the manufacturer to fully retain organisms to be cultivated and to be free of extractables which could interfere with their growth.
³ USEPA, 1978. Microbiological Methods for Monitoring the Environment, Water, and Wastes. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH. EPA/600/8-78/017.
⁴ [Reserved]

⁵ USGS, 1989. U.S. Geological Survey Techniques of Water-Resource Investigations, Book 5, Laboratory Analysis, Chapter A4, Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples, U.S. Geological Survey, U.S. Department of the Interior, Reston, VA.

⁶ Because the MF technique usually yields low and variable recovery from chlorinated wastewaters, the Most Probable Number method will be required to resolve any controversies.

⁷ Tests must be conducted to provide organism enumeration (density). Select the appropriate configuration of tubefiltrations and dilutions/volumes to account for the quality, character, consistency, and anticipated organism density of the water sample.

⁸ When the MF method has been used previously to test waters with high turbidity, large numbers of noncoliform bacteria, or samples that may contain organisms stressed by chlorine, a parallel test should be conducted with a multiple-tube technique to demonstrate applicability and comparability of results.

⁹ To assess the comparability of results obtained with individual methods, it is suggested that side-by-side tests be conducted across seasons of the year with the water samples routinely tested in accordance with the most current Standard Methods for the Examination of Water and Wastewater or EPA alternate test procedure (ATP) guidelines.

¹⁰ ASTM, 2000, 1999, 1996. Annual Book of ASTM Standards—Water and Environmental Technology, Section 11.02. ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

¹¹ AOAC, 1995. Official Methods of Analysis of AOAC International, 16th Edition, Volume I, Chapter 17. Association of Official Analytical Chemists International, 481 North Frederick Avenue, Suite 500, Gaithersburg, MD 20877-2417.

¹² Recommended for enumeration of target organism in sewage sludge.

¹³ These tests are collectively known as defined enzyme substrate tests, where, for example, a substrate is used to detect the enzyme β-glucuronidase produced by *E. coli*.

¹⁴ USEPA, July 2006. Method 1680: Fecal Coliforms in Sewage Sludge (Biosolids) by Multiple-Tube Fermentation Using Lauryl-Tryptose Broth (LTB) and EC Medium. US Environmental Protection Agency, Office of Water, Washington, DC EPA-821-R-06-012.

¹⁵ Samples shall be enumerated by the multiple-tube or multiple-well procedure. Using multiple-tube procedures, employ an appropriate tube and dilution configuration of the sample as needed and report the Most Probable Number (MPN). Samples tested with Colilert® may be enumerated with the multiple-well procedures, Quanti-Tray® 2000, and the MPN calculated from the table provided by the manufacturer.

¹⁶ Colilert-18® is an optimized formulation of the Colilert® for the determination of total coliforms and *E. coli* that provides results within 18 h of incubation at 35 °C rather than the 24 h required for the Colilert® test and is recommended for marine water samples.

¹⁷ Descriptions of the Colilert®, Colilert-18®, Quanti-Tray®, and Quanti-Tray®/2000 may be obtained from IDEXX Laboratories, Inc., 1 IDEXX Drive, Westbrook, ME 04092.

¹⁸ A description of the mColiBlueZ® test, Total Coliforms and *E. coli*, is available from Hach Company, 100 Dayton Ave., Ames, IA, 50010.

¹⁹ USEPA, July 2006. Method 1681: Fecal Coliforms in Sewage Sludge (Biosolids) by Multiple-Tube Fermentation using A-1 Medium. U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA-821-R-06-013.

²⁰ Recommended for enumeration of target organism in wastewater effluent.

²¹ USEPA, July 2006. Method 1603: *Escherichia coli* (*E. coli*) in Water by Membrane Filtration Using Modified membrane-Thermotolerant *Escherichia coli* Agar (modified mTEC), U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA-821-R-06-011.

²² USEPA, July 2006. Method 1682: *Salmonella* in Sewage Sludge (Biosolids) by Modified Semisolid Rappaport-Vassiliadis (MSRV) Medium. U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA-821-R-06-014.

²³ A description of the Enterolert® test may be obtained from IDEXX Laboratories, Inc., 1 IDEXX Drive, Westbrook, ME 04092.

²⁴ USEPA, July 2006. Method 1600: Enterococci in Water by Membrane Filtration Using membrane-Enterococcus Indoxyl-β-D-Glucoside Agar (mEI), U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA-821-R-06-009.

²⁵ USEPA, October 2002. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms. Fifth Edition. U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA/621/R-02/012.

²⁶ USEPA, October 2002. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. Fourth Edition. U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA/621/R-02/013.

²⁷ USEPA, October 2002. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms. Third Edition. U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA/621/R-02/014.

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES

Parameter	Methodology ⁵⁸	Reference (method number or page)				USGS/AOAC/ other	
		EPA ^{35, 52}	Standard meth- ods (18th, 19th)	Standard meth- ods (20th)	Standard meth- ods online		ASTM
1. Acidity, as CaCO ₃ , mg/L.	Electrometric endpoint or phenolphthalein endpoint.	.....	2310 B(4a)	2310 B(4a)	2310 B(4a)–97 ...	D1067–92, 02	I-1020–85 ²

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter	Methodology ⁵⁸	Reference (method number or page)						
		EPA ^{35, 52}	Standard meth-ods (18th, 19th)	Standard meth-ods (20th)	Standard meth-ods online	ASTM	USGS/AOAC/other	
2. Alkalinity, as CaCO ₃ , mg/L.	Electrometric or Col-orimetric titration to pH 4.5, manual, or automatic	.....	2320 B	2320 B	2320 B-97	D1067-92, 02	973.43 ³ , I-1030-85 ²
		310.2 (Rev. 1974) ¹,	.....	.....	.....	.....	I-2030-85 ²
3. Aluminum—Total, ⁴ mg/L.	Digestion ⁴ followed by:	.....	.....	.....	.....	.....	.....
	AA direct aspira-tion ³⁶ ,	3111 D	.....	.....	3111 D-99	.....	I-3051-85 ²
	AA furnace	3113 B	.....	.....	3113 B-99	.....	.....
	STGFAA	200.9, Rev. 2.2 (1994),	.....	.....	.....	.....	.....
	ICP/AES ³⁶	200.7, Rev. 4.4 (1994),	3120 B	3120 B	3120 B-99	.....	I-4471-9750
	ICP/MS	200.8, Rev. 5.4 (1994),	.....	.....	.....	D5673-03	993.14 ³
4. Ammonia (as N), mg/L	Direct Current Plas-ma (DCP) ³⁶,	.....	.....	.....	.....	D4190-94, 99	See footnote ³⁴
	Colorimetric (Eriochrome cyanine R).	3500-AI D	3500-AI B	3500-AI B	3500-AI B-01.	.....	.....
	Manual, distillation (at pH 9.5) fol-lowed by:	4500-NH B ₃	4500-NH ₃ B	4500-NH ₃ B	4500-NH ₃ B-97	.....	973.49 ³
	Nesslerization	4500-NH ₃ C (18th only),	.....	.....	.....	.....	.....
	Titration	4500-NH ₃ C (19th) and 4500-NH ₃ E (18th),	4500-NH ₃ C	4500-NH ₃ C	4500-NH ₃ C	4500-NH ₃ C-97.	D1426-98, 03 (A).	973.49 ³ , I-3520-85 ²
	Electrode	4500-NH ₃ D or E (18th) and 4500-NH ₃ F or G (18th).	4500-NH ₃ D or E.	4500-NH ₃ D or E.	4500-NH ₃ D or E-97.	D1426-98, 03 (B).	.....

Automated phenate, or.	350.1 ⁶⁰ , Rev. 2.0 (1993).	4500-NH ₃ G (19th) and 4500-NH ₃ H (18th).	4500-NH ₃ G ...	4500-NH ₃ G-97	.....	I-4523-85 ²
Automated electrode Ion Chromatography Digestion ⁴ followed by: AA direct aspiration ³⁶.	.....	.....	.....	.....	.....	See footnote 7
AA furnace	200.9, Rev. 2.2 (1994).	3111 B	.....	3111 B-99.	D6919-03.	
STGFAA	200.7, Rev. 4.4 (1994).	3113 B	.....	3113 B-99.		
ICP/AES ³⁶	200.8, Rev. 5.4 (1994).	3120 B	3120 B	3120 B-99.		
ICP/MS	206.5 (Issued 1978) ¹.	.....	.....	.....	D5673-03	993.14 ³
Digestion ⁴ followed by: AA gaseous hydride	.....	3114 B 4.d	.....	3114 B 4.d-97	D2972-97, 03 (B).	I-3062-85 ²
AA furnace	.....	3113 B	.....	3113 B-99	D2972-97, 03 (C).	I-4063-98 ⁴⁹
STGFAA	200.9, Rev. 2.2 (1994).	.....	.....	.....
ICP/AES ³⁶	200.7, Rev. 4.4 (1994).	3120 B	3120 B	3120 B-99.		
ICP/MS	200.8, Rev. 5.4 (1994).	.....	.....	.....	D5673-03	993.14 ³
Colorimetric (SDDC)	.....	3500-As C	3500-As B	3500-As B-97	D2972-97, 03 (A).	I-3060-85
Digestion ⁴ followed by: AA direct aspiration ³⁶	.....	3111 D	.....	3111 D-99	.....	I-3084-85 ²
AA furnace	200.7, Rev. 4.4 (1994).	3113 B	.....	3113 B-99	D4382-95, 02.	
ICP/AES ³⁶	200.8, Rev. 5.4 (1994).	3120 B	3120 B	3120 B-99.		
ICP/MS	.....	.....	.....	.....	D5673-03	993.14 ³
DCP ³⁶	.....	.....	.....	.....	.....	See footnote ³⁴
Digestion ⁴ followed by:	.....	.....	.....	.....	.....	.....
5. Antimony—Total, ⁴ mg/L.						
6. Arsenic—Total, ⁴ mg/L						
7. Barium—Total, ⁴ mg/L ..						
8. Beryllium—Total, ⁴ mg/L						

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter	Methodology ⁵⁸	Reference (method number or page)				ASTM	USGS/AOAC/ other
		EPA ^{35, 52}	Standard meth- ods (18th, 19th)	Standard meth- ods (20th)	Standard meth- ods online		
9. Biochemical oxygen de- mand (BOD ₅), mg/L.	AA direct aspiration	.....	3111 D .....	.....	3111 D-99	D3645-93 (88), 03 (A).	I-3095-85 ²
	AA furnace	.....	3113 B .....	.....	3113 B-99	D3645-93 (88), 03 (B).	.....
	STGFAA	200.9, Rev. 2.2 (1994).	.....	.....	3120 B-99 .....	.....	I-4471-97 ⁵⁰
	ICP/AES	200.7, Rev. 4.4 (1994).	3120 B	3120 B .....	.....	.....	993.14 ³
	ICP/MS	200.8, Rev. 5.4 (1994).	.....	.....	.....	D5673-03	See footnote ³⁴
10. Boron—Total, ³⁷ mg/L	DCP, or Colorimetric (aluminon).	.....	3500-Be D.	.....	.....	.....	.....
	Dissolved Oxygen Depletion.	.....	5210 B	5210 B	5210 B-01 .....	.....	973.44, ³ p. 17, ⁹ I-1578- 78, ⁸
11. Bromide, mg/L	Colorimetric (cur- cumin).	.....	4500-B B	4500-B B	4500-B B-00 .....	.....	I-3112-85 ²
	ICP/AES, or	200.7, Rev. 4.4 (1994).	3120 B	3120 B	3120 B99 .....	.....	I-4471-97 ⁵⁰
	DCP Titrimetric	.....	.....	.....	.....	D4190-94, 99 D1246-95, 99 (C).	See footnote ³⁴ p. S44. ¹⁰
12. Cadmium—Total, ⁴ mg/ L.	Ion Chromatography	300.0, Rev 2.1 (1993) and 300.1, Rev 1.0 (1997).	4110 B	4110 B	4110 B-00	D4327-97, 03	I-1125-85 ² 993.30 ³
	Digestion ⁴ followed by: AA direct aspira- tion ³⁶	3111 B or C	3111 B or C-99	D3557-95, 02 (A or B).	D6508, Rev. ² ₅₄ 974.27, ³ p. 37, ⁹ I-3135- 85 ² or I- 3136-85 ²

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AA furnace	3113 B	3113 B-99	D3557-95, 02 (D).	I-4138-89 ⁵¹
STGFAA	200.9, Rev. 2.2 (1994).			
ICP/AES ³⁶	200.7, Rev. 4.4 (1994).	3120 B		I-1472-85 ² or I-4471-97 ⁵⁰
ICP/MS	200.8, Rev. 5.4 (1994).		D5673-03	993.14 ³
DCP ³⁶				See footnote ³⁴
Voltametry ¹¹ , or				
Colorimetric (Dithione),	3500-Cd D.			
Digestion ⁴ followed by:				
AA direct aspiration	3111 B	3111 B-99	D511-93, 03(B)	I-3152-85 ²
ICP/AES	200.7, Rev. 4.4 (1994).	3120 B		I-4471-97 ⁵⁰
DCP, or				See footnote ³⁴
Titrimetric (EDTA)				
Ion Chromatography	3500-Ca B	3500-Ca B-97	D511-93, 03(A).	
Dissolved Oxygen			D6919-03.	
Depletion with nitric acid	5210 B	5210 B-01.		
Titrimetric				
Spectrophotometric, manual or automatic.	410.3 (Rev. 1978) ¹ .	5220 C	D1252-95, 00 (A).	973.46 ³ , p. 17 ⁹
Titrimetric: (silver nitrate) or (Mercuric nitrate)	410.4, Rev. 2.0 (1993).	5220 D	D1252-95, 00 (B).	I-3560-85 ²
Colorimetric: manual or.				See footnote ^{13,14} , I-3561-85 ²
Automated (Ferricyanide).		4500-Cl-B	D512-89(99)	I-1183-85 ²
Potentiometric Titration.		4500-Cl-C	D512-89 (99)	973.51 ³ , I-1184-85 ²
Ion Selective Electrode.				I-1187-85 ²
		4500-Cl-E		I-2187-85 ²
		4500-Cl-D		
			D512-89(99)(C).	

13. Calcium—Total,⁴ mg/L

14. Carbonaceous biochemical oxygen demand (CBOD₅), mg/L¹².

15. Chemical oxygen demand (COD), mg/L.

16. Chloride, mg/L

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter	Methodology ⁵⁸	Reference (method number or page)					USGS/AOAC/ other
		EPA ^{35, 52}	Standard meth- ods (18th, 19th)	Standard meth- ods (20th)	Standard meth- ods online	ASTM	
17. Chlorine—Total residual, mg/L; Titrimetric.	Ion Chromatography	300.0, Rev 2.1 (1993) and 300.1, Rev 1.0 (1997).	4110 B	4110 B	4110 B-00	D4327-97, 03	993.30 ³
	CIE/UV						D6508, Rev. 2 ⁵⁴
	Amperometric direct, or.		4500-CI D	4500-CI D	4500-CI D-00	D1253-86 (96), 03.	
	Amperometric direct (low level).		4500-CI E	4500-CI E	4500-CI E-00.		
	Iodometric direct		4500-CI B	4500-CI B	4500-CI B-00.		
	Back titration ether end-point ¹⁵ or.		4500-CI C	4500-CI C	4500-CI C-00.		
	DPD-FAS		4500-CI F	4500-CI F	4500-CI F-00.		
	Spectrophotometric, DPD or.		4500-CI G	4500-CI G	4500-CI G-00.		
	Electrode						See footnote ¹⁶
	0.45-micron Filtration followed by:						
18. Chromium VI dissolved, mg/L.	AA chelation-extraction or.		3111 C		3111 C-99		I-1232-85
	Ion Chromatography	218.6, Rev. 3.3 (1994).	3500-Cr E	3500-Cr C	3500-Cr C-01	D5257-97	993.23
	Colorimetric (Di-phenyl-carbazide). Digestion ⁴ followed by:		3500-Cr D	3500-Cr B	3500-Cr B-01	D1687-92, 02 (A).	I-1230-85
19. Chromium—Total, mg/L.	AA direct aspiration ³⁶ .		3111 B		3111 B-99	D1687-92, 02 (B).	974.27 ³ , I-3236-85 ²
	AA chelation-extraction.		3111 C		3111 C-99.		
	AA furnace		3113 B		3113 B-99	D1687-92, 02 (C).	I-3233-93 ⁴⁶
	STGFAA	200.9, Rev. 2.2 (1994).					

20. Cobalt—Total, ⁴ mg/L	ICP/AES ³⁶	200.7, Rev. 4.4 (1994).	3120 B	3120 B	3120 B-99.	D5673-03	993.14 ³
	ICP/MS	200.8, Rev. 5.4 (1994).	.....	.....	.....	D4190-94, 99	See footnote ³⁴
	DCP, ³⁶ or Colorimetric (Di-phenyl-carbazide), Digestion ⁴ followed by: AA direct aspiration	.....	3500-Cr D	3500-Cr B	3500-Cr B-01.	.....	.....
	AA furnace .....	.....	3111 B or C .....	.....	3111 B or C-99	D3558-94, 03 (A or B),	p. 37 ⁹ , I-3239-85 ²
	STGFAA	200.9, Rev. 2.2 (1994).	3113 B .....	.....	3113 B-99	D3558-94, 03 (C).	I-4243-89 ⁵¹
	ICP/AES	200.7, Rev. 4.4 (1994).	3120 B	3120 B	3120 B-99 .....	.....	I-4471-97 ⁵⁰
	ICP/MS	200.8, Rev. 5.4 (1994).	.....	.....	.....	D5673-03	993.14 ³
	DCP .....	.....	2120 E	2120 E .....	.....	.....	See footnote ³⁴
21. Color, platinum cobalt units or dominant wavelength, hue, luminance purity.	Colorimetric (ADMI), or .....	.....	.....	2120 C .....	.....	.....	See footnote ¹⁸
	(Platinum cobalt), or Spectrophotometric Digestion ⁴ followed by: AA direct aspiration ³⁶.	.....	2120 B	2120 B	2120 B-01 .....	.....	I-1250-85 ²
	AA furnace .....	.....	3111 B or C .....	.....	3111 B or C-99	D1688-95, 02 (A or B),	974.27 ³ p. 37 ⁹ , I-3270-85 ² or I-3271-85 ²
	STGFAA	200.9, Rev. 2.2 (1994).	3113 B .....	.....	3113 B-99	D1688-95, 02 (C).	I-4274-89 ⁵¹
	ICP/AES ³⁶	200.7, Rev. 4.4 (1994).	3120 B	3120 B	3120 B-99 .....	.....	I-4471-97 ⁵⁰
	ICP/MS	200.8, Rev. 5.4 (1994).	.....	.....	.....	D5673-03	993.14 ³
	DCP ³⁶ or Colorimetric (Neocuproine) or. (Bicinchoninate) .....	.....	3500-Cu D	3500-Cu B	3500-Cu B-99.	.....	See footnote ³⁴
	.....	.....	3500-Cu E	3500-Cu C	3500-Cu C-99 ..	.....	See footnote ¹⁹
22. Copper—Total, ⁴ mg/L	.....	.....	.....	.....	.....	.....	.....

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter	Methodology ⁵⁸	Reference (method number or page)					ASTM	USGS/AOAC/ other
		EPA ^{35, 52}	Standard meth- ods (18th, 19th)	Standard meth- ods (20th)	Standard meth- ods online			
23. Cyanide—Total, mg/L	Automated Distillation and Colorimetry, or.						Kelada-01 ⁵⁵	
	Manual distillation with MgCl ₂ followed by: Titrimetric or Spectrophotometric, manual or. Automated ²⁰ or	335.4, Rev. 1.0 (1993) ⁵⁷ .	4500-CN-C	4500-CN-C		D2036-98(A)	10-204-00-1-X ⁵⁶	
24. Available Cyanide, mg/L.	Ion Selective Electrode.						p. 22 ⁹ I-3300-85	
	Cyanide Amenable to Chlorination (CATC); Manual distillation with MgCl ₂ followed by Titrimetric or Spectrophotometric.	335.4, Rev. 1.0 (1993) ⁵⁷ .	4500-CN-D 4500-CN-E	4500-CN-D 4500-CN-E	4500-CN-D-99 4500-CN-E-99	D2036-98(A)	10-204-00-1-X ⁵⁶ , I-4302-85 ²	
25. Fluoride—Total, mg/L	Flow injection and ligand exchange, followed by amperometry ⁶¹ .						OIA-1677 ⁴⁴	
	Automated Distillation and Colorimetry. Manual distillation ⁶ followed by: Electrode, manual or Automated Colorimetric, (SPADNS) or.		4500-F-B 4500-F-B 4500-F-D	4500-F-B 4500-F-B 4500-F-D	4500-F-B-97. 4500-F-C-97 4500-F-D-97	D6888-04 D1179-93, 99 (B). D1179-93, 99 (A).	Kelada-01 ⁵⁵ I-4327-85 ²	

Automated complexone. Ion Chromatography	4500-F-E	4500-F-E	4500-F-E	4500-F-E-97.	D4327-97.03	993.30 ³
CIE/UV	4110 B	4110 B	4110 B	4110 B-00		D6508, Rev. 2 ⁵⁴
Digestion ⁴ followed by: AA direct aspiration, or AA furnace, or	3111 B	3111 B	3111 B	3111 B-99.		See footnote ³⁴
DCP						
Automated colorimetric.	130.1 (Issued 1971) ¹ .	130.1 (Issued 1971) ¹ .	130.1 (Issued 1971) ¹ .	2340 B or C-97	D1126-86(92), 02.	973.5 2B ³ , I-1338-85 ²
Titrimetric (EDTA) or Ca plus Mg as their carbonates, by inductively coupled plasma or AA direct aspiration. (See Parameters 13 and 33).	2340 B or C	2340 B or C	2340 B or C	2340 B or C-97		
Electrometric measurement or. Automated electrode	4500-H ⁺ B	4500-H ⁺ B	4500-H ⁺ B	4500-H ⁺ B-00	D1293-84 (90), 99 (A or B).	973.41. ³ , I-1586-85 ² See footnote ²¹ , I-2587-85 ²
Digestion ⁴ followed by: AA direct aspiration or. AA furnace	3111 B	3111 B	3111 B	3111 B-99.		
Digestion ⁴ followed by: AA direct aspiration ³⁶ . AA furnace	3111 B or C	3111 B or C	3111 B or C	3111 B or C-99	D1068-96, 03 (A or B), D1068-96, 03 (C).	974.27 ³ , I-3381-85 ²
STGFAA	200.9, Rev. 2.2 (1994).	200.9, Rev. 2.2 (1994).	200.9, Rev. 2.2 (1994).			

26. Gold—Total,⁴ mg/L

27. Hardness—Total, as CaCO₃, mg/L.

28. Hydrogen ion (pH), pH units.

29. Iridium—Total,⁴ mg/L

30. Iron—Total,⁴ mg/L

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter	Methodology ⁵⁸	EPA ^{35, 52}	Reference (method number or page)				ASTM	USGS/AOAC/ other
			Standard meth- ods (18th, 19th)	Standard meth- ods (20th)	Standard meth- ods online			
31. Kjeldahl Nitrogen ⁵ — Total, (as N), mg/L.	ICP/AES ³⁶	200.7, Rev. 4.4 (1994).	3120 B	3120 B	3120 B-99 .....	.....	I-4471-97 ⁵⁰
	DCP ³⁶ or .....	.....	.....	.....	.....	D4190-94, 99	See footnote ³⁴
	Colorimetric (Phenanthroline). Digestion and distillation followed by ²⁰ .....	.....	3500-Fe D	3500-Fe B	3500-Fe B-97	D1068-96, 03	See footnote ²²
	Titration or .....	.....	4500-N _{org} B or C and 4500- NH ₃ B.	4500-N _{org} B or C and 4500- NH ₃ B.	4500-N _{org} B or C-97 and 4500-NH ₃ B- 97.	D3590-89, 02 (A). .....	.....
32. Lead—Total, ⁴ mg/L	Nesslerization or .....	.....	4500-NH ₃ C (19th) and 4500-NH ₃ E (18th).	4500-NH ₃ C	4500-NH ₃ C-97 (A).	D3590-89, 02 (A).	973.48 ³
	Electrode .....	.....	4500-NH ₃ C (18th Only). .....	.....	.....	D3590-89, 02 (A). .....	.....
	Automated phenate colorimetric.	351.1 (Rev. 1978) ¹. .....	.....	.....	.....	.....	I-4551-78 ⁸
	Semi-automated block digester col- orimetric.	351.2, Rev. 2.0 (1993). .....	.....	4500-NH ₃ D or E. .....	.....	.....	I-4515-91 ⁴⁵ (B).
32. Lead—Total, ⁴ mg/L	Manual or block digester potenti- ometric. .....	.....	.....	.....	.....	D3590-89, 02 (A). .....	.....
	Block digester, fol- lowed by Auto dis- tillation and Titr- ation, or .....	.....	.....	.....	.....	.....	See footnote ³⁹
	Nesslerization, or .....	.....	.....	.....	.....	.....	.....
	Flow injection gas diffusion.	See footnote ⁴⁰ See footnote ⁴¹	
Digestion ⁴ followed by:	

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AA direct aspiration ³⁶	3111 B or C-99	D3559-96, 03 (A or B).	974.27 ³ , I-3399-85 ²
AA furnace	3113 B-99	D3559-96, 03 (D).	I-4403-89 ⁵¹
STGFAA	200.9, Rev. 2.2 (1994).	3120 B-99	.....	I-4471-97 ⁵⁰
ICP/AES ³⁶	200.7, Rev. 4.4 (1994).	.....	D5673-03	993.14 ³
ICP/MS	200.8, Rev. 5.4 (1994).	.....	.....	See footnote ³⁴
DCP ³⁶	.....	.....	D4190-94, 99	.....
Voltametry ¹¹ or	.....	.....	D3559-96, 03 (C).	.....
Colorimetric (Dithionite zone).	.....	3500-Pb B	.....	.....
Digestion ⁴ followed by:	.....	.....	.....	.....
AA direct aspiration	.....	3111 B	D511-93, 03(B)	974.27 ³ , I-3447-85 ²
ICP/AES	200.7, Rev. 4.4 (1994).	3120 B-99	.....	I-4471-97 ⁵⁰
DCP or	.....	.....	.....	See footnote ³⁴
Gravimetric	.....	.....	D6919-03.	.....
Ion Chromatography	.....	.....	.....	.....
Digestion ⁴ followed by:	.....	.....	.....	.....
AA direct aspiration ³⁶.	.....	3111 B	D858-95, 02 (A or B).	974.27 ³ , I-3454-85 ²
AA furnace	.....	3113 B-99	D858-95, 02 (C).	.....
STGFAA	200.9, Rev. 2.2 (1994).	3120 B-99	.....	I-4471-97 ⁵⁰
ICP/AES ³⁶	200.7, Rev. 4.4 (1994).	.....	D5673-03	993.14 ³
ICP/MS	200.8, Rev. 5.4 (1994).	.....	.....	See footnote ³⁴
DCP36, or	.....	.....	D4190-94, 99	920.203 ³
Colorimetric (Persulfate), or.	.....	3500-Mn B	.....	.....
(Periodate)	.....	.....	.....	.....
Cold vapor, manual or.	245.1, Rev. 3.0 (1994).	3112 B-99	D3223-97, 02	See footnote ²³
Automated	245.2 (Issued 1974).	.....	.....	977.22 ³ , I-3462-85 ²

33. Magnesium—Total,⁴ mg/L.

34. Manganese—Total,⁴ mg/L.

35. Mercury—Total⁴, mg/L.

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter	Methodology ⁵⁸	Reference (method number or page)					USGS/AOAC/ other	
		EPA ^{35, 52}	Standard meth- ods (18th, 19th)	Standard meth- ods (20th)	Standard meth- ods online	ASTM		
36. Molybdenum—Total, ⁴ mg/L.	Cold vapor atomic fluorescence spec- trometry (CVAFS). Purge and Trap CVAFS. Digestion ⁴ followed by: AA direct aspiration AA furnace ICP/AES ICP/MS DCP Digestion ⁴ followed by: AA direct aspira- tion ³⁶ . AA furnace STGFAA ICP/AES ³⁶ ICP/MS DCP ³⁶ , or Colorimetric (heptoxime). Ion Chromatography	245.7 Rev. 2.0 (2005) ⁵⁹ . 1631E ⁴³ .						
			3111 D		3111 D-99		I-3490-85 ²	
			3113 B		3113 B-99		I-3492-96 ⁴⁷	
			3120 B		3120 B-99		I-4471-97 ⁵⁰	
						D5673-03	993.14 ³	
							See footnote ³⁴	
			3111 B or C		3111 B or C-99	D1886-90, 94 (98) (A or B).	I-3499-85 ²	
			3113 B		3113 B-99	D1886-90, 94 (98) (C).	I-4503-89 ⁵¹	
			3120 B		3120 B-99		I-4471-97 ⁵⁰	
						D5673-03	993.14 ³	
37. Nickel—Total, ⁴ mg/L ...	Ion Chromatography			4110 B	4110 B-00	D4327-97, 03	993.30 ³	
							See footnote ³⁴	
							D6508, Rev. 2 ⁵⁴	
38. Nitrate (as N), mg/L ...	Colorimetric (heptoxime). Ion Chromatography	300.0, Rev 2.1 (1993) and 300.1, Rev 1.0 (1997).	4110 B	4110 B	4110 B-00	D4327-97, 03	993.30 ³	

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter	Methodology ⁵⁸	Reference (method number or page)						USGS/AOAC/ other
		EPA ^{35, 52}	Standard meth- ods (18th, 19th)	Standard meth- ods (20th)	Standard meth- ods online	ASTM		
42. Organic carbon—Total (TOC), mg/L. 43. Organic nitrogen (as N), mg/L.	Combustion or oxidation. Total Kjeldahl N (Parameter 31) minus ammonia N (Parameter 4). Ascorbic acid method. Automated, or .....	.....	5310 B, C, or D	5310 B, C, or D	5310 B, C, or D—00.	D2579-93 (A or B).	973.47, ³ p. 14 ²⁴
		365.1, Rev. 2.0 (1993).	4500-P F	4500-P F	.....	.....	973.56 ³ , I-4601-85 ² 973.55 ³
44. Orthophosphate (as P), mg/L.	Manual single reagent. Manual two reagent Ion Chromatography	365.3 (Issued 1978) ¹ .	4110 B	4110 B	4110 B-00	D4327-97, 03	993.30 ³	
		300.0, Rev 2.1 (1993) and 300.1, Rev 1.0 (1997).	.....	.....	.....	.....	D6508, Rev. 2 ⁵⁴
45. Osmium—Total ⁴ , mg/L.	Digestion ⁴ followed by: AA direct aspiration, or. AA furnace	.....	3111 D	.....	3111 D-99.	.....	.....
		252.2 (Issued 1978) ¹ .	4500-O C	4500-O C	4500-O C-01	D888-92, 03 (A). D888-92, 03 (B).	973.4 5B ³ , I-1575-78 ⁸ I-1576-78 ⁸	
46. Oxygen, dissolved, mg/L.	Electrode	.....	4500-O G	4500-O G	4500-O G-01	.....	.....
		
47. Palladium—Total, ⁴ mg/L.	Digestion ⁴ followed by: AA direct aspiration, or. AA furnace	.....	3111 B	.....	3111 B-99	.....	p. S27 ¹⁰
		253.2 ¹ (Issued 1978).	.....	.....	.....	.....	p. S28 ¹⁰

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter	Methodology ⁵⁸	Reference (method number or page)					ASTM	USGS/AOAC/ other
		EPA ^{35, 52}	Standard meth- ods (18th, 19th)	Standard meth- ods (20th)	Standard meth- ods online			
58. Rhodium—Total, ⁴ mg/ L.	Digestion ⁴ followed by: AA direct aspiration, or: AA furnace	.....	3111 B .....	.....	3111 B-99.	.....	.....
		265.2 ¹.	.....	.....	.....	.....	.....
59. Ruthenium—Total, ⁴ mg/L.	Digestion ⁴ followed by: AA direct aspiration, or: AA furnace	.....	3111 B .....	.....	3111 B-99.	.....	.....
		267.2 ¹.	.....	.....	.....	.....	.....
60. Selenium—Total, ⁴ mg/ L.	Digestion ⁴ followed by: AA furnace	.....	3113 B .....	.....	3113 B-99	D3859-98, 03 (B).	I-4668-98 ⁴⁹
		200.9, Rev. 2.2 (1994).
61. Silica—Dissolved, ³⁷ mg/L.	0.45 micron filtration followed by: Colorimetric, Manual or: Automated (Molybdosilicate), or: ICP/AES	200.7, Rev. 4.4 (1994).	3120 B	3120 B	3120 B-99.	D5673-03	993.14 ³	
		200.8, Rev. 5.4 (1994).	3114 B	3114 B-97	D3859-98, 03 (A).	I-3667-85 ²
62. Silver—Total, ^{4, 31} mg/ L.	Digestion ^{4, 29} fol- lowed by: AA direct aspiration	.....	4500-Si D	4500-SiO ₂ C ...	4500-SiO ₂ C-97	D859-94, 00 ...	I-1700-85 ²
		200.7, Rev. 4.4 (1994).	3120 B	3120 B	3120 B-99	I-2700-85 ²
		.....	3111 B or C ...	.....	3111 B or C-99	.....	I-4471-97 ⁵⁰
		.....	.....	.....	.....	.....	974.27 ³ , p. 37 ⁹ , I-3720- 85 ²

AA furnace STGFAA	200.9, Rev. 2.2 (1994).	3113 B	3113 B-99	.....	.....	I-4724-89 ⁵¹
ICP/AES	200.7, Rev. 4.4 (1994).	3120 B	3120 B	3120 B	.....	I-4471-97 ⁵⁰
ICP/MS	200.8, Rev. 5.4 (1994).	.....	.....	.....	D5673-03	993.14 ³
DCP Digestion ⁴ followed by: AA direct aspiration	.....	.....	.....	.....	.....	See footnote ³⁴
ICP/AES	200.7, Rev. 4.4 (1994).	3111 B	3111 B-99	3120 B	.....	973.54 ³ , I- 3735-85 ² I-4471-97 ⁵⁰
DCP, or Flame photometric Ion Chromatography	.....	3500-Na D	3500-Na B	3500-Na B-97.	.....	See footnote ³⁴
Wheatstone bridge	120.1 ¹ (Rev. 1982).	2510 B	2510 B	2510 B-97	D 6919-03, D1125-95 (99) (A).	973.40 ³ , I- 2781-85 ²
Automated colorimetric.	375.2, Rev. 2.0 (1993).	4500-SO ₄ ²⁻ C or D.	4500-SO ₄ ²⁻ C or D.	4110 B	.....	925.54 ³
Gravimetric	.....	4110 B	4110 B-00	.....	D516-90, 02 ... D4327-97, 03	426C ³⁰ 993.30 ³
Turbidimetric Ion Chromatography	300.0, Rev 2.1 (1993) and 300.1, Rev 1.0 (1997).	.....	.....	.....	.....	D6508, Rev. 2 ⁶⁴ I-3840-85 ²
CIE/UV	.....	.....	.....	.....	.....	.....
Titrimetric (iodine), or	.....	4500-S ²⁻ F (19th) 4500-S ²⁻ E (18th).	4500-S ²⁻ F	4500-S ²⁻ F-00	.....	.....
Colorimetric (methylene blue).	.....	4500-S ²⁻ D	4500-S ²⁻ D	4500-S ²⁻ D-00.	.....	.....
Ion Selective Electrode.	.....	4500-S ²⁻ G	4500-S ²⁻ G	4500-S ²⁻ G-00	D4658-03.	.....
Titrimetric (iodate).	.....	4500-SO ₃ ²⁻ B	4500-SO ₃ ²⁻ B	4500-SO ₃ ²⁻ B-00.	.....	.....
Colorimetric (methylene blue).	.....	5540 C	5540 C	5540 C-00	D2330-88, 02.	.....
Thermometric Digestion ⁴ followed by:	.....	2550 B	2550 B	2550 B-00	.....	See footnote ³²
63. Sodium—Total, ⁴ mg/L						
64. Specific conductance, micromhos/cm at 25 °C.						
65. Sulfate (as SO ₄), mg/L						
66. Sulfide (as S), mg/L						
67. Sulfite (as SO ₃), mg/L						
68. Surfactants, mg/L						
69. Temperature, °C						
70. Thallium—Total, ⁴ mg/L						

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter	Methodology ⁵⁶	Reference (method number or page)					ASTM	USGS/AOAC/ other
		EPA ^{35, 52}	Standard meth- ods (18th, 19th)	Standard meth- ods (20th)	Standard meth- ods online			
71. Tin—Total, ⁴ mg/L	AA direct aspiration AA furnace .....	..... 279.21 (Issued 1978).	3111 B .....	.....	3111 B-99.	.....	.....
	STGFAA	200.9, Rev. 2.2 (1994).	.....	.....	.....	.....	.....
	ICP/AES	200.7, Rev. 4.4 (1994).	3120 B	3120 B	3120 B-99.	D5673-03	993.14 ³	
	ICP/MS	200.8, Rev. 5.4 (1994).	.....	.....	.....	.....	.....
	Digestion ⁴ followed by: AA direct aspiration AA furnace, or STGFAA .....	..... 200.9, Rev. 2.2 (1994).	3111 B .....	.....	3111 B-99 .....	.....	I-3850-78 ⁸
72. Titanium—Total, ⁴ mg/ L	ICP/AES	200.7, Rev. 4.4 (1994).	3113 B .....	.....	3113 B-99.	.....	.....
	Digestion ⁴ followed by: AA direct aspiration AA furnace .....	..... 283.21 (Issued 1978).	3111 D .....	.....	3111 D-99.	.....	.....
73. Turbidity, NTU ⁵³	DCP	180.1, Rev. 2.0 (1993).	2130 B	2130 B	2130 B-01	D1889-94, 00	See footnote ³⁴ I-3860-85 ²	
	Nephelometric .....	.....	.....	.....	.....	.....	.....
74. Vanadium—Total, ⁴ mg/L	Digestion ⁴ followed by: AA direct aspiration AA furnace .....	..... 200.7, Rev. 4.4 (1994).	3111 D .....	.....	3111 D-99.	D3373-93, 03.	I-4471-97 ⁵⁰
	ICP/AES	200.8, Rev. 5.4 (1994).	3120 B	3120 B	3120 B-99	D5673-03	993.14 ³	
	ICP/MS .....	.....	.....	.....	.....	D4190-94, 99	See footnote ³⁴
	DCP, or Colorimetric (Gallic Acid) .....	.....	3500-V D	3500-V B	3500-V B-97.	.....	.....

75. Zinc—Total ⁴ , mg/L	Digestion ⁴ followed by: AA direct aspiration ³⁶ .....	.....	3111 B or C .....	.....	3111 B or C-99	D1691-95, 02 (A or B)	974.27 ³ , p. 37 ⁹ , I-3900-85 ²
	AA furnace	289.2 ¹ (Issued 1978) .....	.....	.....	3120 B-99 ⁸⁹ .....	.....	I-4471-97 ⁵⁰
	ICP/AES ³⁶	200.7, Rev. 4.4 (1994)	3120 B .....	.....	.....	D5673-03	993.14 ³
	ICP/MS	200.8, Rev. 5.4 (1994) .....	.....	.....	.....	D4190-94, 99	See footnote ³⁴
	DCP ³⁶ or .....	.....	3500-Zn E .....	.....	.....	.....	.....
	Colorimetric (Dithi- zone) or .....	.....	3500-Zn F .....	.....	.....	.....	.....
	(Zincon) .....	.....	3500-Zn B .....	.....	3500-Zn B-97 .....	.....	See footnote ³³

Table 1B Notes:

¹“Methods for Chemical Analysis of Water and Wastes,” Environmental Protection Agency, Environmental Monitoring Systems Laboratory—Cincinnati (EMSL-CI), EPA-600/4-79-020 (NTIS PB 84-128677), Revised March 1983 and 1979 where applicable.

²Fishman, M. J., et al. “Methods for Analysis of Inorganic Substances in Water and Fluvial Sediments,” U.S. Department of the Interior, Techniques of Water-Resource Investigations of the U.S. Geological Survey, Denver, CO, Revised 1989, unless otherwise stated.

³“Official Methods of Analysis of the Association of Official Analytical Chemists,” Methods Manual, Sixteenth Edition, 4th Revision, 1998.

⁴For the determination of total metals (which are equivalent to total recoverable metals) the sample is not filtered before processing. A digestion procedure is required to solubilize analytes in suspended material and to break down organic-metal complexes (to convert the analyte to a detectable form for colorimetric analysis). For non-plateform graphite furnace atomic absorption determinations a digestion using nitric acid (as specified in Section 4.1.3 of Methods for the Chemical Analysis of Water and Wastes) is required prior to analysis. The procedure used should subject the sample to gentle, acid refluxing and at no time should the sample be taken to dryness. For direct aspiration flame atomic absorption determinations (FLAA) a combination acid (nitric and hydrochloric acids) digestion is preferred prior to analysis. The approved total recoverable digestion is described as Method 200.2 in Supplement I of “Methods for the Determination of Metals in Environmental Samples” EPA/600R-94/111, May, 1994, and is reproduced in EPA Methods 200.7, 200.8, and 200.9 from the same Supplement. However, when using the gaseous hydride technique or for the determination of certain elements such as antimony, arsenic, selenium, silver, and tin by non-EPA graphite furnace atomic absorption methods, mercury by cold vapor atomic absorption, the noble metals and titanium by FLAA, a specific or modified sample digestion procedure may be required and in all cases the referenced method write-up should be consulted for specific instruction and/or cautions. For analyses using inductively coupled plasma-atomic emission spectrometry (ICP-AES), the direct current plasma (DCP) technique or the EPA spectrochemical techniques (plateform furnace AA, ICP-AES, and ICP-MS) use EPA Method 200.2 or an approved alternate procedure (e.g., CEM microwave digestion, which may be used with certain analytes as indicated in Table 1B); the total recoverable digestion procedures in EPA Methods 200.7, 200.8, and 200.9 may be used for those respective methods. Regardless of the digestion procedure, the results of the analysis after digestion procedure are reported as “total” metals.

⁵Copper sulfate may be used in place of mercuric sulfate.

⁶Manual distillation is not required if comparability data on representative effluent samples are on file to show that this preliminary distillation step is not necessary; however, manual distillation will be required to resolve any controversies.

⁷Ammonia, Automated Electrode Method, Industrial Method Number 379-75 WE, dated February 19, 1976, Bran & Luebbe (Technicon) Auto Analyzer II, Bran & Luebbe Analyzing Technologies, Inc., Elmsford, NY 10523.

⁸The approved method is that cited in “Methods for Determination of Inorganic Substances in Water and Fluvial Sediments”, USGS TWRI, Book 5, Chapter A1 (1979).

⁹American National Standard on Photographic Processing Effluents, April 2, 1975. Available from ANSI, 25 West 43rd st., New York, NY 10036.

¹⁰“Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency,” Supplement to the Fifteenth Edition of *Standard Methods for the Examination of Water and Wastewater*, (1981).

¹¹The use of normal and differential pulse voltage ramps to increase sensitivity and resolution is acceptable.

- ¹²Carbonaceous biochemical oxygen demand (CBOD₅) must not be confused with the traditional BOD₅ test method which measures "total BOD." The addition of the nitrification inhibitor is not a procedural option, but must be included to report the CBOD₅ parameter. A discharger whose permit requires reporting the traditional BOD₅ may not use a nitrification inhibitor in the procedure for reporting the results. Only when a discharger's permit specifically states CBOD₅ is required can the permittee report data using a nitrification inhibitor.
- ¹³OIC Chemical Oxygen Demand Method, Oceanography International Corporation, 1978, 512 West Loop, P.O. Box 2980, College Station, TX 77840.
- ¹⁴Chemical Oxygen Demand, Method 8000, Hach Handbook of Water Analysis, 1979, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.
- ¹⁵The back titration method will be used to resolve controversy.
- ¹⁶Orion Research Instruction Manual, Residual Chlorine Electrode Model 97–70, 1977, Orion Research Incorporated, 840 Memorial Drive, Cambridge, MA 02138. The calibration graph for the Orion residual chlorine method must be derived using a reagent blank and three standard solutions, containing 0.2, 1.0, and 5.0 mL 0.00281 N potassium iodate/100 mL solution, respectively.
- ¹⁷The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*, 14th Edition, 1976.
- ¹⁸National Council of the Paper Industry for Air and Stream Improvement, Inc., Technical Bulletin 253, December 1971.
- ¹⁹Copper, Biocinchonate Method, Method 8506, Hach Handbook of Water Analysis, 1979, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.
- ²⁰When using a method with block digestion, this treatment is not required.
- ²¹Hydrogen ion (pH) Automated Electrode Method, Industrial Method Number 378–75WA, October 1976, Bran & Luebbe (Technicon) Autoanalyzer II. Bran & Luebbe Analyzing Technologies, Inc., Elmsford, NY 10523.
- ²²Iron, 1,10-Phenanthroline Method, Method 8008, 1980, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.
- ²³Manganese, Periodate Oxidation Method, Method 8034, Hach Handbook of Wastewater Analysis, 1979, pages 2–113 and 2–117, Hach Chemical Company, Loveland, CO 80537.
- ²⁴Wershaw, R. L., et al., "Methods for Analysis of Organic Substances in Water," Techniques of Water-Resources Investigation of the U.S. Geological Survey, Book 5, Chapter A3, (1972 Revised 1987) p. 14.
- ²⁵Nitrogen, Nitrite, Method 8507, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.
- ²⁶Just prior to distillation, adjust the sulfuric-acid-preserved sample to pH 4 with 1 + 9 NaOH.
- ²⁷The approved method is cited in *Standard Methods for the Examination of Water and Wastewater*, 14th Edition. The colorimetric reaction is conducted at a pH of 10.0±0.2. The approved methods are given on pp 576–81 of the 14th Edition: Method 510A for distillation, Method 510B for the manual colorimetric procedure, or Method 510C for the manual spectrometric procedure.
- ²⁸R.F. Addison, and R. G. Ackman, "Direct Determination of Elemental Phosphorus by Gas-Liquid Chromatography," *Journal of Chromatography*, Vol. 47, No.3, pp. 421–426, 1970.
- ²⁹Approved methods for the analysis of silver in industrial wastewaters at concentrations of 1 mg/L and above are inadequate where silver exists as an inorganic halide. Silver halides such as the bromide and chloride are relatively insoluble in reagents such as nitric acid but are readily soluble in an aqueous buffer of sodium thiosulfate and sodium hydroxide to pH of 12. Therefore, for levels of silver above 1 mg/L, 20 mL of sample should be diluted to 100 mL by adding 40 mL each of 2 M Na₂S₂O₃ and NaOH. Standards should be prepared in the same manner. For levels of silver below 1 mg/L the approved method is satisfactory.
- ³⁰The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*, 15th Edition.
- ³¹For samples known or suspected to contain high levels of silver (e.g., in excess of 4 mg/L), cyanogen iodide should be used to keep the silver in solution for analysis. Prepare a cyanogen iodide solution by adding 4.0 mL of concentrated NH₄OH, 6.5 g of KCN, and 5.0 mL of a 1.0 N solution of I₂ to 50 mL of reagent water in a volumetric flask and dilute to 100.0 mL. After digestion of the sample, adjust the pH of the digestate to >7 to prevent the formation of HCN under acidic conditions. Add 1 mL of the cyanogen iodide solution to the sample digestate and adjust the volume to 100 mL with reagent water (NOT acid). If cyanogen iodide is added to sample digestates, then silver standards must be prepared that contain cyanogen iodide as well. Prepare working standards by diluting a small volume of a silver stock solution with water and adjusting the pH>7 with NH₄OH. Add 1 mL of the cyanogen iodide solution and let stand 1 hour. Transfer to a 100-mL volumetric flask and dilute to volume with water.
- ³²Stevens, H.H., Ficke, J. F., and Smoot, G. F., "Water Temperature—Influential Factors, Field Measurement and Data Presentation," Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 1, Chapter D1, 1975.
- ³³Zinc, Zinccon Method, Method 8009, Hach Handbook of Water Analysis, 1979, pages 2–231 and 2–333, Hach Chemical Company, Loveland, CO 80537.
- ³⁴"Direct Current Plasma (DCP) Optical Emission Spectrometric Method for Trace Elemental Analysis of Water and Wastes, Method AES0029," 1986—Revised 1991, Thermo Jarrell Ash Corporation, 27 Forge Parkway, Franklin, MA 02038
- ³⁵Precision and recovery statements for the atomic absorption direct aspiration and graphite furnace methods, and for the spectrophotometric SDCC method for arsenic are provided in Appendix D of this part titled, "Precision and Recovery Statements for Methods for Measuring Metals."
- ³⁶Microwave-assisted digestion may be employed for this metal, when analyzed by this methodology. "Closed Vessel Microwave Digestion of Wastewater Samples for Determination of Metals", CEM Corporation, P.O. Box 200, Matthews, NC 28106–0200, April 16, 1992. Available from the CEM Corporation.
- ³⁷When determining boron and silica, only plastic, PTFE, or quartz laboratory ware may be used from start until completion of analysis.

- ³⁸ Only use n-hexane extraction solvent when determining Oil and Grease parameters—Hexane Extractable Material (HEM), or Silica Gel Treated HEM (analogous to EPA Method 1664A). Use of other extraction solvents (e.g., those in the 18th and 19th editions) is prohibited.
- ³⁹ Nitrogen, Total Kjeldahl, Method PAI-DK01 (Block Digestion, Steam Distillation, Titrimetric Detection), revised 12/22/94, OI Analytical/ALPKEM, P.O. Box 9010, College Station, TX 77842.
- ⁴⁰ Nitrogen, Total Kjeldahl, Method PAI-DK02 (Block Digestion, Steam Distillation, Colorimetric Detection), revised 12/22/94, OI Analytical/ALPKEM, P.O. Box 9010, College Station, TX 77842.
- ⁴¹ Nitrogen, Total Kjeldahl, Method PAI-DK03 (Block Digestion, Automated FIA Gas Diffusion), revised 12/22/94, OI Analytical/ALPKEM, P.O. Box 9010, College Station, TX 77842.
- ⁴² Method 1664, Revision A "n-Hexane Extractable Material (HEM: Oil and Grease) and Silica Gel Treated n-Hexane Extractable Material (SGT-HEM: Non-polar Material) by Extraction and Gravimetry" EPA-821-R-98-002, February 1999. Available at NTIS, PB-121949, U.S. Department of Commerce, 5285 Port Royal, Springfield, VA 22161.
- ⁴³ USEPA, 2001. Method 1631, Revision E, "Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry," September 2002, Office of Water, U.S. Environmental Protection Agency (EPA-821-R-02-024). The application of clean techniques described in EPA's draft Method 1669: *Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels* (EPA-821-R-96-011) are recommended to preclude contamination at low-level, trace metal determinations.
- ⁴⁴ Available Cyanide, Method OIA-1677, "Available Cyanide by Flow Injection, Ligand Exchange, and Amperometry," ALPKEM, A Division of OI Analytical, P.O. Box 9010, College Station, TX 77842-9010.
- ⁴⁵ "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Ammonia Plus Organic Nitrogen by a Kjeldahl Digestion Method," Open File Report (OFR) 00-170.
- ⁴⁶ "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Chromium in Water by Graphite Furnace Atomic Absorption Spectrophotometry," Open File Report (OFR) 93-449.
- ⁴⁷ "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Molybdenum by Graphite Furnace Atomic Absorption Spectrophotometry," Open File Report (OFR) 97-198.
- ⁴⁸ "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Total Phosphorus by Kjeldahl Digestion Method and an Automated Colorimetric Finish That Includes Dialysis," Open File Report (OFR) 92-146.
- ⁴⁹ "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Arsenic and Selenium in Water and Sediment by Graphite Furnace-Atomic Absorption Spectrometry," Open File Report (OFR) 98-639.
- ⁵⁰ "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Elements in Whole-water Digests Using Inductively Coupled Plasma-Optical Emission Spectrometry and Inductively Coupled Plasma-Mass Spectrometry," Open File Report (OFR) 98-165.
- ⁵¹ "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Inorganic and Organic Constituents in Water and Fluvial Sediment," Open File Report (OFR) 93-125.
- ⁵² All EPA methods, excluding EPA Method 300.1, are published in "Methods for the Determination of Metals in Environmental Samples," Supplement I, National Exposure Risk Laboratory-Cincinnati (NERL-CI), EPA/600/R-94/111, May 1994; and "Methods for the Determination of Inorganic Substances in Environmental Samples," NERL-CI, EPA/600/R-93/100, August, 1993. EPA Method 300.1 is available from <http://www.epa.gov/safewater/methods/pdfs/mel300b.pdf>.
- ⁵³ Styrene divinyl benzene beads (e.g., AMCO-AEPA-1 or equivalent) and stabilized formazin (e.g., Hach Stab/CatTM or equivalent) are acceptable substitutes for formazin.
- ⁵⁴ Method D6508, Rev. 2, "Test Method for Determination of Dissolved Inorganic Anions in Aqueous Matrices Using Capillary Ion Electrophoresis and Chromate Electrolyte," available from Waters Corp, 34 Maple St., Milford, MA, 01757, Telephone: 508/482-2131, Fax: 508/482-3625.
- ⁵⁵ Kelada-01, "Kelada Automated Test Methods for Total Cyanide, Acid Dissociable Cyanide, and Thiocyanate," EPA 821-B-01-009, Revision 1.2, August 2001, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161 [Order Number PB 2001-108275]. The toll free telephone number is: 800-553-6847. Note: A 450-W UV lamp may be used in this method instead of the 550-W lamp specified if it provides performance within the quality control (QC) acceptance criteria of the method in a given instrument. Similarly, modified flow cell configurations and flow conditions may be used in the method, provided that the QC acceptance criteria are met.
- ⁵⁶ QuikChem Method 10-204-00-1-X, "Digestion and Distillation of Total Cyanide in Drinking and Wastewaters using MICRO DIST and Determination of Cyanide by Flow Injection Analysis," is available from Lachat Instruments 6645 W. Mill Road, Milwaukee, WI 53218, Telephone: 414-358-4200.
- ⁵⁷ When using sulfide removal test procedures described in Method 335.4, reconstitute particulate that is filtered with the sample prior to distillation.
- ⁵⁸ Unless otherwise stated, if the language of this table specifies a sample digestion and/or distillation "followed by" analysis with a method, approved digestion and/or distillation are required prior to analysis.
- ⁵⁹ Method 245.7, Rev. 2.0, "Mercury in Water by Cold Vapor Atomic Fluorescence Spectrometry," February 2005, EPA-821-R-05-001, available from the U.S. EPA Sample Control Center (operated by CSC), 6101 Stevenson Avenue, Alexandria, VA 22304, Telephone: 703-461-2100, Fax: 703-461-8056.

⁶⁰The use of EDTA may decrease method sensitivity in some samples. Analysis may omit EDTA provided that all method specified quality control acceptance criteria are met.
⁶¹Samples analyzed for available cyanide using Methods OIA-1677 or D6888-04 that contain particulate matter may be filtered only after the ligand exchange reagents have been added to the samples, because the ligand exchange process converts complexes containing available cyanide to free cyanide, which is not removed by filtration. Analysis are further cautioned to limit the time between the addition of the ligand exchange reagents and sample analysis to no more than 30 minutes to preclude settling of materials in samples.

TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS

Parameter ¹	EPA method number ^{2,7}				Other approved methods		
	GC	GC/MS	HPLC	Standard Methods [Edition(s)]	Standard Methods Online	ASTM	Other
1. Acenaphthene	610	625, 1625B	610	6440 B [18th, 19th, 20th].	.....	D4657-92 (99)	See footnote ⁹ , p. 27
2. Acenaphthylene	610	625, 1625B	610	6410 B, 6440 B, [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	See footnote ⁹ , p. 27
3. Acrolein	603	624 ⁴ , 1624B.	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	See footnote ⁹ , p. 27
4. Acrylonitrile	603	624 ⁴ , 1624B.	.....	6200 B [20th] and 6210 B	6200 B and C-97.	.....	.....
5. Anthracene	610	625, 1625B .....	.....	[18th, 19th], 6200 C [20th] and 6220 B	.....	.....	.....
6. Benzene	602	624, 1624B .....	.....	[18th, 19th].	.....	.....	.....
7. Benzidine .....	.....	625 ⁵ , 1625B ..	605	.....	.....	.....	See footnote ³ , p.1
8. Benzo(a)anthracene ..	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	See footnote ⁹ , p. 27
9. Benzo(a)pyrene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	See footnote ⁹ , p. 27
10. Benzo(b)fluoranthene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	See footnote ⁹ , p. 27
11. Benzo(g,h,i) perylene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	See footnote ⁹ , p. 27
12. Benzo(k) fluoranthene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	See footnote ⁹ , p. 27
13. Benzyl chloride .....	.....	.....	.....	.....	.....	.....	See footnote ³ , p. 130; See footnote ⁶ , p. S102
14. Benzyl butyl phthalate	606	625, 1625B .....	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ⁹ , p. 27

15. Bis(2-chloroethoxy) methane.	611	625, 1625B	6410 B [18th, 19th, 20th].	6410 B-00	See footnote ⁹ , p. 27
16. Bis(2-chloroethyl) ether.	611	625, 1625B	6410 B [18th, 19th, 20th].	6410 B-00	See footnote ⁹ , p. 27
17. Bis(2-ethylhexyl) phthalate.	606	625, 1625B	6410 B [18th, 19th, 20th].	6410 B-00	See footnote ⁹ , p. 27
18. Bromodichloro-methane.	601	624, 1624B	6200 C [20th] and 6230 B [18th, 19th], 6200 B [20th] and 6210 B [18th, 19th].	6200 B and C-97.	
19. Bromoform	601	624, 1624B	6200 C [20th] and 6230 B [18th, 19th], 6200 B [20th] and 6210 B [18th, 19th].	6200 B and C-97.	
20. Bromomethane	601	624, 1624B	6200 C [20th] and 6230 B [18th, 19th], 6200 B [20th] and 6210 B [18th, 19th].	6200 B and C-97.	
21. 4-Bromophenyl phenyl ether.	611	625, 1625B	6410 B [18th, 19th, 20th].	6410 B-00	See footnote ⁹ , p. 27
22. Carbon tetrachloride	601	624, 1624B	6200 C [20th] and 6230 B [18th, 19th].	6200 C-97	See footnote ³ , p. 130
23. 4-Chloro-3-methyl phenol.	604	625, 1625B	6410 B, 6420 B [18th, 19th, 20th].	6410 B-00, 6420 B-00.	See footnote ⁹ , p. 27
24. Chlorobenzene	601, 602	624, 1624B	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97	See footnote ³ , p. 130
25. Chloroethane	601	624, 1624B	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.	

TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS—Continued

Parameter ¹	EPA method number ^{2,7}			Other approved methods		
	GC	GC/MS	HPLC	Standard Methods Online	ASTM	Other
26. 2-Chloroethylvinyl ether.	601	624, 1624B	.....	6200 B and C-97.	.....	See footnote ³ , p. 130
27. Chloroform	601	624, 1624B	.....	6200 B and C-97	.....	See footnote ³ , p. 130
28. Chloromethane	601	624, 1624B	.....	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.	.....
29. 2-Chloronaphthalene	612	625, 1625B	.....	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6410 B-00	See footnote ⁹ , p. 27
30. 2-Chlorophenol	604	625, 1625B	.....	6410 B, 6420 B [18th, 19th, 20th].	6410 B(00, 6420 B-00.	See footnote ⁹ , p. 27
31. 4-Chlorophenyl phenyl ether.	611	625, 1625B	.....	6410 B [18th, 19th, 20th].	6410 B-00	See footnote ⁹ , p. 27
32. Chrysene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00	See footnote ⁹ , p. 27
33. Dibenz(a,h)anthracene.	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	D4657-92 (99)	See footnote ⁹ , p. 27
34. Dibromochloromethane.	601	624, 1624B	.....	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	D4657-92 (99)	See footnote ⁹ , p. 27
35. 1,2-Dichlorobenzene	601, 602	624, 1625B	.....	6200 C [20th] and 6220 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97	See footnote ⁹ , p. 27

36. 1,3-Dichloro-benzene	601, 602	624, 1625B	6200 C [20th] and 6220 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 C-97	See footnote ⁹ , p. 27
37. 1,4-Dichloro-benzene	601, 602	624, 1625B	6220 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 C-97	See footnote ⁹ , p. 27
38. 3,3-Dichloro-benzidine.		625, 1625B	6410 B [18th, 19th, 20th].	6410 B-00.	
39. Dichlorodifluoro-methane.	601		6200 C [20th] and 6230 B [18th, 19th].	6200 C-97.	
40. 1,1-Dichloroethane	601	624, 1624B	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.	
41. 1,2-Dichloroethane	601	624, 1624B	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.	
42. 1,1-Dichloroethene	601	624, 1624B	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.	
43. trans-1,2-Dichloroethene.	601	624, 1624B	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.	
44. 2,4-Dichlorophenol	604	625, 1625B	6410 B, 6420 B [18th, 19th, 20th].	6410 B-00, 6420 B-00.	See footnote ⁹ , p. 27
45. 1,2-Dichloro-propane	601	624, 1624B	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.	

TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS—Continued

Parameter ¹	EPA method number ^{2,7}				Other approved methods			
	GC	GC/MS	HPLC	Standard Methods [Edition(s)]	Standard Methods Online	ASTM	Other	
46. cis-1,3-Dichloro-propene.	601	624, 1624B	.....	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.	.....	.....
47. trans-1,3-Dichloro-propene.	601	624, 1624B	.....	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.	.....	.....
48. Diethyl phthalate	606	625, 1625B	.....	6410 B [18th, 19th, 20th].	6410 B-00	.....	See footnote ⁹ , p. 27
49. 2,4-Dimethylphenol	604	625, 1625B	.....	6410 B, 6420 B [18th, 19th, 20th].	6410 B-00, 6420 B-00.	.....	See footnote ⁹ , p. 27
50. Dimethyl phthalate	606	625, 1625B	.....	6410 B [18th, 19th, 20th].	6410 B-00	.....	See footnote ⁹ , p. 27
51. Di-n-butyl phthalate	606	625, 1625B	.....	6410 B [18th, 19th, 20th].	6410 B-00	.....	See footnote ⁹ , p. 27
52. Di-n-octyl phthalate	606	625, 1625B	.....	6410 B [18th, 19th, 20th].	6410 B-00	.....	See footnote ⁹ , p. 27
53. 2,3-Dinitrophenol	604	625, 1625B	.....	6410 B, 6420 B [18th, 19th, 20th].	6410 B-00, 6420 B-00.	.....	.....
54. 2,4-Dinitrotoluene	609	625, 1625B	.....	6410 B [18th, 19th, 20th].	6410 B-00	.....	See footnote ⁹ , p. 27
55. 2,6-Dinitrotoluene	609	625, 1625B	.....	6410 B [18th, 19th, 20th].	6410 B-00	.....	See footnote ⁹ , p. 27
56. Epichlorohydrin	.....	.....	.....	.....	.....	.....	See footnote ³ , p. 130; See footnote ⁶ , p. S102
57. Ethylbenzene	602	624, 1624B	.....	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6220 B [18th, 19th].	6200 B and C-97	.....	.....
58. Fluoranthene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	..... See footnote ⁹ , p. 27

59. Fluorene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	See footnote ⁹ , p. 27
60. 1,2,3,4,6,7,8- Heptachloro- dibenzofuran.	.....	1613B ¹⁰.	.....	.....	.....	.....	.....
61. 1,2,3,4,7,8,9- Heptachloro- dibenzofuran.	.....	1613B ¹⁰.	.....	.....	.....	.....	.....
62. 1,2,3,4,6,7,8- Heptachlorodibenzo- p- dioxin.	.....	1613B ¹⁰.	.....	.....	.....	.....	.....
63. Hexachlorobenzene ..	612	625, 1625B .....	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ⁹ , p. 27
64. Hexachloro-butadiene	612	625, 1625B .....	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ⁹ , p. 27
65. Hexachlorocyclo- pentadiene.	612	625 ⁵ , 1625B ..	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ⁹ , p. 27
66. 1,2,3,4,7,8- Hexachlorodibenzofura- n.	.....	1613B ¹⁰.	.....	.....	.....	.....	.....
67. 1,2,3,6,7,8- Hexachlorodibenzofura- n.	.....	1613B ¹⁰.	.....	.....	.....	.....	.....
68. 1,2,3,7,8,9- Hexachlorodibenzofura- n.	.....	1613B ¹⁰.	.....	.....	.....	.....	.....
69. 2,3,4,6,7,8- Hexachlorodibenzofura- n.	.....	1613B ¹⁰.	.....	.....	.....	.....	.....
70. 1,2,3,4,7,8- Hexachlorodibenzo- p- dioxin.	.....	1613B ¹⁰.	.....	.....	.....	.....	.....
71. 1,2,3,6,7,8- Hexachlorodibenzo- p- dioxin.	.....	1613B ¹⁰.	.....	.....	.....	.....	.....
72. 1,2,3,7,8,9- Hexachlorodibenzo- p- dioxin 1613B ¹⁰.	.....	1613B ¹⁰.	.....	.....	.....	.....	.....
73. Hexachloroethane	612	625, 1625B .....	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ⁹ , p. 27
74. Ideno(1,2,3-cd) py- rene.	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	See footnote ⁹ , p. 27
75. Isophorone	609	625, 1625B .....	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ⁹ , p. 27

TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS—Continued

Parameter ¹	EPA method number ^{2,7}				Other approved methods		
	GC	GC/MS	HPLC	Standard Methods [Edition(s)]	Standard Methods Online	ASTM	Other
76. Methylene chloride	601	624, 1624B ....	.....	6200 C [20th] and 6230 B [18th, 19th].	6200 C-97 .....	.....	See footnote ³ , p. 130
77. 2-Methyl-4,6-dinitrophenol.	604	625, 1625B ....	.....	6410 B, 6420 B [18th, 19th, 20th].	6410 B-00, 6420 B-00.	.....	See footnote ⁹ , p. 27
78. Naphthalene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ⁹ , p. 27
79. Nitrobenzene	609	625, 1625B ....	.....	6410 B [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	See footnote ⁹ , p. 27
80. 2-Nitrophenol	604	625, 1625B ....	.....	6410 B, 6420 B [18th, 19th, 20th].	6410 B-00, 6420 B-00.	.....	See footnote ⁹ , p. 27
81. 4-Nitrophenol	604	625, 1625B ....	.....	6410 B, 6420 B [18th, 19th, 20th].	6410 B-00, 6420 B-00.	.....	See footnote ⁹ , p. 27
82. N-Nitrosodimethylamine.	607	6255, 1625B ...	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ⁹ , p. 27
83. N-Nitrosodi-n-propylamine.	607	6255, 1625B ...	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ⁹ , p. 27
84. N-Nitrosodiphenylamine.	607	6255, 1625B ...	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ⁹ , p. 27
85. Octachlorodibenzofuran.	.....	1613B ^{10*}.	.....	.....	.....	.....	.....
86. Octachlorodibenzo-p-dioxin.	.....	1613B ¹⁰.	.....	.....	.....	.....	.....
87. 2,2'-Oxybis(2-chloropropane) [also known as bis(2-chloroisopropyl) ether].	611	625, 1625B ....	.....	6410 B [18th, 19th, 20th].	6410 B-00.	.....	See footnote ³ , p. 43; See footnote ⁸
88. PCB-1016	608	625 .....	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ³ , p. 43; See footnote ⁸
89. PCB-1221	608	625 .....	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ³ , p. 43; See footnote ⁸
90. PCB-1232	608	625 .....	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	See footnote ³ , p. 43; See footnote ⁸

91. PCB-1242	608	625	6410 B [18th, 19th, 20th].	6410 B-00	.....	See footnote ³ , p. 43; See footnote ⁸
92. PCB-1248	608	625.	6410 B [18th, 19th, 20th].	6410 B-00	.....	See footnote ³ , p. 43; See footnote ⁸
93. PCB-1254	608	625	6410 B, 6630 B [18th, 19th, 20th].	6410 B-00	.....	See footnote ³ , p. 43; See footnote ⁸
94. PCB-1260	608	625	6410 B, 6630 B [18th, 19th, 20th].	6410 B-00	.....	See footnote ³ , p. 43; See footnote ⁸
95. 1,2,3,7,8-Pentachloro-dibenzofuran	.....	1613B ¹⁰.	.....	.....	.....	.....
96. 2,3,4,7,8-Pentachloro-dibenzofuran	.....	1613B ¹⁰.	.....	.....	.....	.....
97. 1,2,3,7,8-Pentachlorodibenzo- <i>p</i> -dioxin.	.....	1613B ¹⁰.	.....	.....	.....	.....
98. Pentachlorophenol	604	625, 1625B	6410 B, 6630 B [18th, 19th, 20th].	6410 B-00	.....	See footnote ³ , p. 140; See footnote ⁹ , p. 27
99. Phenanthrene	610	625, 1625B	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	See footnote ⁹ , p. 27
100. Phenol	604	625, 1625B	6410 B, 6420 B [18th, 19th, 20th].	6410 B-00, 6420 B-00.	.....	See footnote ⁹ , p. 27
101. Pyrene	610	625, 1625B	6410 B, 6440 B [18th, 19th, 20th].	6410 B-00	D4657-92 (99)	See footnote ⁹ , p. 27
102. 2,3,7,8-Tetra-chlorodibenzofuran.	.....	1613B ¹⁰.	.....	.....	.....	.....
103. 2,3,7,8-Tetra-chlorodibenzo- <i>p</i> -dioxin.	.....	613, 625 ^{5a} , 1613B ¹⁰.	.....	.....	.....	.....
104. 1,1,2,2-Tetra-chloro ethane	601	624, 1624B	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97	.....	See footnote ³ , p. 130
105. Tetrachloroethene	601	624, 1624B	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97	.....	See footnote ³ , p. 130

TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS—Continued

Parameter ¹	EPA method number ^{2,7}				Other approved methods			
	GC	GC/MS	HPLC	Standard Methods [Edition(s)]	Standard Methods Online	ASTM	Other	
106. Toluene	602	624, 1624B .....	.....	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6220 B [18th, 19th].	6200 B and C-97.	.....	See footnote ³ , p. 130; See footnote ⁹ , p. 27
107. 1,2,4-Trichlorobenzene.	612	625, 1625B .....	.....	6410 B [18th, 19th, 20th].	6410 B-00 .....	.....	
108. 1,1,1-Trichloroethane.	601	624, 1624B .....	.....	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.	.....	
109. 1,1,2-Trichloroethane.	601	624, 1624B	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th]	6200 B and C-97	.....	See footnote ³ , p. 130.	
110. Trichloroethene	601	624, 1624B .....	.....	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.	.....	
111. Trichlorofluoro-methane.	601	624 .....	.....	6200 B [20th] and 6210 B [18th, 19th], 6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.	.....	
112. 2,4,6-Trichlorophenol.	604	625, 1625B .....	.....	6410 B, 6420 B [18th, 19th, 20th].	6410 B-00, 6420 B-00.	.....	See footnote ⁹ , p. 27

113. Vinyl chloride	601	624, 1624B	6200 B [20th] and 6210 B [18th, 19th], ≤6200 C [20th] and 6230 B [18th, 19th].	6200 B and C-97.
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¹All parameters are expressed in micrograms per liter (µg/L) except for Method 1613B in which the parameters are expressed in picograms per liter (pg/L).
²The full text of Methods 601-613, 624, 625, 1624B, and 1625B, are given at Appendix A, "Test Procedures for Analysis of Organic Pollutants," of this part 136. The full text of Method 1613B is incorporated by reference into this part 136 and is available from the National Technical Information Services as stock number PB95-104774. The standardized test procedure to be used to determine the method detection limit (MDL) for these test procedures is given at Appendix B, "Definition and Procedure for the Determination of the Method Detection Limit," of this part 136.
³Methods for Benzidine: Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastewater," U.S. Environmental Protection Agency, September, 1978.
⁴Method 624 may be extended to screen samples for Acrolein and Acrylonitrile. However, when they are known to be present, the preferred method for these two compounds is Method 603 or Method 1624B.
⁵Method 625 may be extended to include benzidine, hexachlorocyclopentadiene, N-nitrosodimethylamine, and N-nitrosodiphenylamine. However, when they are known to be present, Methods 605, 607, and 612, or Method 1625B, are preferred methods for these compounds.
^{5a}625, screening only.
⁶"Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency," Supplement to the *Fifteenth Edition of Standard Methods for the Examination of Water and Wastewater* (1981).
⁷Each analyst must make an initial, one-time demonstration of their ability to generate acceptable precision and accuracy with Methods 601-603, 624, 625, 1624B, and 1625B (See appendix A of this part 136) in accordance with procedures each in Section 8.2 of each of these methods. Additionally, each laboratory, on an on-going basis must spike and analyze 10% (5% for methods 624 and 625 and 100% for methods 1624B and 1625B) of all samples to monitor and evaluate laboratory data quality in accordance with Sections 8.3 and 8.4 of these methods. When the recovery of any parameter falls outside the warning limits, the analytical results for that parameter in the unspiked sample are suspect. The results should be reported, but cannot be used to demonstrate regulatory compliance. These quality control requirements also apply to the Standard Methods, ASTM Methods, ASTM Methods, and other methods cited.
⁸"Organochlorine Pesticides and PCBs in Wastewater Using Empore™ Disk," 3M Corporation Revised 10/28/94.
⁹USGS Method 0-3116-87 from "Methods of Analysis by U.S. Geological Survey National Water Quality Laboratory—Determination of Inorganic and Organic Constituents in Water and Fluvial Sediments," U.S. Geological Survey, Open File Report 93-125.
¹⁰Analysts may use Fluid Management Systems, Inc. PowerPrep system in place of manual cleanup provided that the analysis meet the requirements of Method 1613B (as specified in Section 9 of the method) and permitting authorities.

TABLE ID—LIST OF APPROVED TEST PROCEDURES FOR PESTICIDES 1

Parameter	Method	EPA ^{2,7}	Standard Methods 18th, 19th, 20th Ed.	Standard Methods Online	ASTM	Other
1. Aldrin	GC	608	6630 B & C .....	.....	D3086-90,	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
	GC/MS	625	6410 B	6410 B-00.	D5812-96 (2002) ..	
2. Ametryn	GC .....		.....	.....	.....	See footnote ³ , p. 83; See footnote ⁶ , p. S68
3. Aminocarb	TLC .....		.....	.....	.....	See footnote ³ , p. 94; See footnote ⁶ , p. S16
4. Atraton	GC .....		.....	.....	.....	See footnote ³ , p. 83; See footnote ⁶ , p. S68

TABLE ID—LIST OF APPROVED TEST PROCEDURES FOR PESTICIDES¹—Continued

Parameter	Method	EPA ^{2,7}	Standard Methods 18th, 19th, 20th Ed.	Standard Methods Online	ASTM	Other
5. Atrazine	GC					See footnote ³ , p. 83; See footnote ⁶ , p. S68; See footnote ⁹
6. Azinphos methyl	GC					See footnote ³ , p. 25; See footnote ⁶ , p. S51
7. Barban	TLC					See footnote ³ , p. 104; See footnote ⁶ , p. S64
8. α-BHC	GC	608	6630 B & C		D3086-90, D5812-96(02)	See footnote ³ , p. 7; See footnote ⁸
9. β-BHC	GC/MS	625 ⁵	6410 B	6410 B-00.	D3086-90, D5812-96(02)	See footnote ⁸
	GC	608	6630 C			
10. δ-BHC	GC/MS	625 ⁵	6410 B	6410 B-00.	D3086-90, D5812-96(02)	See footnote ⁸
	GC	608	6630 C			
11. γ-BHC (Lindane)	GC/MS	625 ⁵	6410 B	6410 B-00.	D3086-90, D5812-96(02)	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
	GC	608	6630 B & C			
12. Captan	GC/MS	625	6410 B	6410 B-00.	D3086-90, D5812-96(02)	See footnote ³ , p. 7
	GC		6630 B			
13. Carbaryl	TLC					See footnote ³ , p. 94; See footnote ⁶ , p. S60
14. Carbo-phenthothion	GC					See footnote ⁴ , p. 27; See footnote ⁶ , p. S73
	GC	608	6630 B & C		D3086-90, D5812-96(02)	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
15. Chlordane	GC	625	6410 B	6410 B-00.		See footnote ³ , p. 104; See footnote ⁶ , p. S64.
	GC/MS					See footnote ³ , p. 115; See footnote ⁴ , p. 40
16. Chloro-propham	TLC					See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
17. 2,4-D	GC					
	GC	608	6630 B & C		D3086-90, D5812-96(02)	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
18. 4,4'-DDD	GC	625	6410 B	6410 B-00.		See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
	GC	608	6630 B & C		D3086-90, D5812-96(02)	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
19. 4,4'-DDE	GC/MS	625	6410 B	6410 B-00.		See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
	GC	608	6630 B & C		D3086-90, D5812-96(02)	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
GC/MS	GC/MS	625	6410 B	6410 B-00.		
	GC	608	6630 B & C		D3086-90, D5812-96(02)	

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20. 4,4'-DDT	GC	608	6630 B & C		D3086-90, D5812-96(02)	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
21. Demeton-O	GC/MS GC	625	6410 B	6410 B-00.		See footnote ³ , p. 25; See footnote ⁶ , p. S51
22. Demeton-S	GC					See footnote ³ , p. 25; See footnote ⁶ , p. S51
23. Diazinon	GC					See footnote ³ , p. 25; See footnote ⁴ , p. 27; See footnote ⁶ , p. S51
24. Dicamba	GC					See footnote ³ , p. 115
25. Dichlofen-thion	GC					See footnote ⁴ , p. 27; See footnote ⁶ , p. S73
26. Dichloran	GC		6630 B & C		D3086-90, D5812-96(02)	See footnote ³ , p. 7
27. Dicolof	GC					See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
28. Dieldrin	GC	608	6630 B & C			See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
29. Dioxathion	GC/MS GC	625	6410 B	6410 B-00.		See footnote ⁴ , p. 27; See footnote ⁶ , p. S73
30. Disulfoton	GC					See footnote ³ , p. 25; See footnote ⁶ , p. S51
31. Diuron	TLC					See footnote ³ , p. 104; See footnote ⁶ , p. S64
32. Endosulfan I	GC	608	6630 B & C		D3086-90, D5812-96(02)	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
33. Endosulfan II	GC/MS GC	625 ⁵ 608	6410 B 6630 B & C	6410 B-00.		See footnote ³ , p. 7; See footnote ⁸
34. Endosulfan Sulfate	GC/MS GC	625 ⁵ 608	6410 B 6630 C	6410 B-00.		See footnote ⁸
35. Endrin	GC/MS GC	625 608	6410 B 6630 B & C	6410 B-00.	D3086-90, D5812-96(02)	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
36. Endrin aldehyde	GC/MS GC	625 ⁵ 608	6410 B	6410 B-00.		See footnote ⁸
37. Ethion	GC/MS GC	625 608				See footnote ⁴ , p. 27; See footnote ⁶ , p. S73
38. Fenuron	TLC					See footnote ³ , p. 104; See footnote ⁶ , p. S64
39. Fenuron-TCA	TLC					See footnote ³ , p. 104; See footnote ⁶ , p. S64

TABLE ID—LIST OF APPROVED TEST PROCEDURES FOR PESTICIDES¹—Continued

Parameter	Method	EPA ^{2,7}	Standard Methods 18th, 19th, 20th Ed.	Standard Methods Online	ASTM	Other
40. Heptachlor	GC	608	6630 B & C	6410 B-00	D3086-90,	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
	GC/MS	625	6410 B		D5812-96(02)	
41. Heptachlor epoxide	GC	608	6630 B & C	6410 B-00	D3086-90,	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁶ , p. S73; See footnote ⁸
	GC/MS	625	6410 B		D5812-96(02)	
42. Isodrin	GC					See footnote ⁴ , p. 27; See footnote ⁶ , p. S73
43. Linuron	GC					See footnote ³ , p. 104; See footnote ⁶ , p. S64
44. Malathion	GC		6630 C			See footnote ³ , p. 25; See footnote ⁴ , p. 27; See footnote ⁶ , p. S51
45. Methiocarb	TLC					See footnote ³ , p. 94; See footnote ⁶ , p. S60
46. Methoxy-chlor	GC		6630 B & C		D3086-90,	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
47. Mexacar-bate	TLC				D5812-96(02)	See footnote ³ , p. 94; See footnote ⁶ , p. S60
48. Mirex	GC		6630 B & C			See footnote ³ , p. 7; See footnote ⁴ , p. 27
49. Monuron	TLC					See footnote ³ , p. 104; See footnote ⁶ , p. S64
50. Monuron-TCA	TLC					See footnote ³ , p. 104; See footnote ⁶ , p. S64
51. Nuburon	TLC					See footnote ³ , p. 104; See footnote ⁶ , p. S64
52. Parathion methyl	GC		6630 C			See footnote ³ , p. 25; See footnote ⁴ , p. 27
53. Parathion ethyl	GC		6630 C			See footnote ³ , p. 25; See footnote ⁴ , p. 27
54. PCNB	GC		6630 B & C			See footnote ³ , p. 7
55. Perthane	GC				D3086-90,	See footnote ⁴ , p. 27
					D5812-96(02)	
56. Prometon	GC					See footnote ³ , p. 83; See footnote ⁶ , p. S68; See footnote ⁹
57. Prometryn	GC					See footnote ³ , p. 83; See footnote ⁶ , p. S68; See footnote ⁹
58. Propazine	GC					See footnote ³ , p. 83; See footnote ⁶ , p. S68; See footnote ⁹

59. Propham	TLC .....	.....	.....	.....	.....	.....	See footnote ³ , p. 104; See footnote ⁶ , p. S64
60. Propoxur	TLC .....	.....	.....	.....	.....	.....	See footnote ³ , p. 94; See footnote ⁶ , p. S60
61. Sebumeton	TLC .....	.....	.....	.....	.....	.....	See footnote ³ , p. 83; See footnote ⁶ , p. S68
62. Siduron	TLC .....	.....	.....	.....	.....	.....	See footnote ³ , p. 104; See footnote ⁶ , p. S64
63. Simazine	GC .....	.....	.....	.....	.....	.....	See footnote ³ , p. 83; See footnote ⁶ , p. S68; See footnote ⁹
64. Strobane	GC .....	.....	6630 B & C .....	.....	.....	.....	See footnote ³ , p. 7
65. Swep	TLC .....	.....	.....	.....	.....	.....	See footnote ³ , p. 104; See footnote ⁶ , p. S64
66. 2,4,5-T	GC .....	.....	6640 B .....	.....	.....	.....	See footnote ³ , p. 115; See footnote ⁴ , p. 40
67. 2,4,5-TP (Silvex)	GC .....	.....	6640 B .....	.....	.....	.....	See footnote ³ , p. 115; See footnote ⁴ , p. 40
68. Terbutylazine	GC .....	.....	.....	.....	.....	.....	See footnote ³ , p. 83; See footnote ⁶ , p. S68
69. Toxaphene	GC	608	6630 B & C .....	.....	.....	D3086-90, D5812-96(02).	See footnote ³ , p. 7; See footnote ⁴ , p. 27; See footnote ⁸
70. Trifluralin	GC/MS	625	6410 B .....	.....	6410 B-00.	.....	See footnote ³ , p. 7; See footnote ⁹
	GC	6630 B	6630 B .....	.....	.....	.....	.....

¹ Pesticides are listed in this table by common name for the convenience of the reader. Additional pesticides may be found under Table I.C, where entries are listed by chemical name.

² The full text of Methods 608 and 625 are given at Appendix A, "Test Procedures for Analysis of Organic Pollutants," of this part 136. The standardized test procedure to be used to determine the method detection limit (MDL) for these test procedures is given at Appendix B, "Definition and Procedure for the Determination of the Method Detection Limit," of this part 136.

³ "Methods for Benzidine, Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastewater," U.S. Environmental Protection Agency, September 1978. This EPA publication includes thin-layer chromatography (TLC) methods.

⁴ "Methods for Analysis of Organic Substances in Water and Fluvial Sediments," Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 5, Chapter A3 (1987).

⁵ The method may be extended to include α -BHC, γ -BHC, endosulfan I, and endrin. However, when they are known to exist, Method 608 is the preferred method.

⁶ "Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency," Supplement to the Fifteenth Edition of *Standard Methods for the Examination of Water and Wastewater* (1981).

⁷ Each analyst must make an initial, one-time, demonstration of their ability to generate acceptable precision and accuracy with Methods 608 and 625 (See appendix A of this part 136) in accordance with procedures given in Section 8.2 of each of these methods. Additionally, each laboratory, on an on-going basis, must spike and analyze 10% of all samples analyzed with Method 608 or 5% of all samples analyzed with Method 625 to monitor and evaluate laboratory data quality in accordance with Sections 8.3 and 8.4 of these methods. When the recovery of any parameter falls outside the warning limits, the analytical results for that parameter in the unspiked sample are suspect. The results should be reported, but cannot be used to demonstrate regulatory compliance. These quality control requirements also apply to the Standard Methods, ASTM Methods, and other methods cited.

⁸ "Organochlorine Pesticides and PCBs in Wastewater Using Empore™ Disk", 3M Corporation, Revised 10/28/94.

⁹ USGS Method 0-3106-93 from "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Triazine and Other Nitrogen-containing Compounds by Gas Chromatography with Nitrogen Phosphorus Detectors" U.S. Geological Survey Open File Report 94-37.

TABLE IE—LIST OF APPROVED RADIOLOGIC TEST TEST PROCEDURES

Parameter and units	Method	Reference (method number or page)				
		EPA ¹	Standard Methods 18th, 19th, 20th Ed.	Standard Methods On-line	ASTM	USGS ²
1. Alpha-Total, pCi per liter ...	Proportional or scintillation counter.	900.0	7110 B	7110 B-00	D1943-90, 96	pp. 75 and 78 ³
2. Alpha-Counting error, pCi per liter.	Proportional or scintillation counter.	Appendix B	7110 B	7110 B-00	D1943-90, 96	p. 79
3. Beta-Total, pCi per liter ...	Proportional counter	900.0	7110 B	7110 B-00	D1890-90, 96	pp. 75 and 78 ³
4. Beta-Counting error, pCi ...	Proportional counter	Appendix B	7110 B	7110 B-00	D1890-90, 96	p. 79
5. (a) Radium Total pCi per liter.	Proportional counter	903.0	7500-Ra B	7500-Ra B-01	D2460-90, 97	
(b) Ra, pCi per liter	Scintillation counter	903.1	7500-Ra C	7500-Ra C-01	D3454-91, 97	p. 81

¹ Prescribed Procedures for Measurement of Radioactivity in Drinking Water, EPA-600/4-80-032 (1980), U.S. Environmental Protection Agency, August 1980.
² Fishman, M. J. and Brown, Eugene. "Selected Methods of the U.S. Geological Survey of Analysis of Wastewaters," U.S. Geological Survey, Open-File Report 76-177 (1976).
³ The method found on p. 75 measures only the dissolved portion while the method on p. 78 measures only the suspended portion. Therefore, the two results must be added to obtain the "total."

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TABLE IF—LIST OF APPROVED METHODS FOR PHARMACEUTICAL POLLUTANTS

Pharmaceuticals pollutants	CAS registry No.	Analytical method number
acetonitrile	75-05-8	1666/1671/D3371/D3695.
n-amyl acetate	628-63-7	1666/D3695.
n-amyl alcohol	71-41-0	1666/D3695
benzene	71-43-2	D4763/D3695/502.2/524.2.
n-butyl-acetate	123-86-4	1666/D3695.
tert-butyl alcohol	75-65-0	1666.
chlorobenzene	108-90-7	502.2/524.2.
chloroform	67-66-3	502.2/524.2/551.
o-dichlorobenzene	95-50-1	1625C/502.2/524.2.
1,2-dichloroethane	107-06-2	D3695/502.2/524.2.
diethylamine	109-89-7	1666/1671.
dimethyl sulfoxide	67-68-5	1666/1671.
ethanol	64-17-5	1666/1671/D3695.
ethyl acetate	141-78-6	1666/D3695.
n-heptane	142-82-5	1666/D3695.
n-hexane	110-54-3	1666/D3695.
isobutyraldehyde	78-84-2	1666/1667.
isopropanol	67-63-0	1666/D3695.
isopropyl acetate	108-21-4	1666/D3695.
isopropyl ether	108-20-3	1666/D3695.
methanol	67-56-1	1666/1671/D3695.
Methyl Cellosolve Δ	109-86-4	1666/1671
methylene chloride	75-09-2	502.2/524.2
methyl formate	107-31-3	1666.
4-methyl-2-pentanone (MIBK)	108-10-1	1624C/1666/D3695/D4763/524.2.
phenol	108-95-2	D4763.
n-propanol	71-23-8	1666/1671/D3695.
2-propanone (acetone)	67-64-1	D3695/D4763/524.2.
tetrahydrofuran	109-99-9	1666/524.2.
toluene	108-88-3	D3695/D4763/502.2/524.2.
triethylamine	121-44-8	1666/1671.
xylene	(Note 1)	1624C/1666.

TABLE 1F NOTE:
 1. 1624C: m-xylene 108-38-3, o,p-xylene E-14095 (Not a CAS number; this is the number provided in the Environmental Monitoring Methods Index (EMMI) database.); 1666: m,p-xylene 136777-61-2, o-xylene 95-47-6.

TABLE IG—TEST METHODS FOR PESTICIDE ACTIVE INGREDIENTS

EPA Survey Code	Pesticide name	CAS No.	EPA Analytical Method No.(s)
8	Triadimefon	43121-43-3	507/633/525.1/1656
12	Dichlorvos	62-73-7	1657/507/622/525.1
16	2,4-D; 2,4-D Salts and Esters [2,4-Dichloro-phenoxyacetic acid].	94-75-7	1658/515.1/615/515.2/555
17	2,4-DB; 2,4-DB Salts and Esters [2,4-Dichlorophenoxybutyric acid].	94-82-6	1658/515.1/615/515.2/555
22	Mevinphos	7786-34-7	1657/507/622/525.1
25	Cyanazine	21725-46-2	629/507
26	Propachlor	1918-16-7	1656/508/608.1/525.1
27	MCPA; MCPA Salts and Esters [2-Methyl-4-chlorophenoxyacetic acid].	94-74-6	1658/615/555
30	Dichlorprop; Dichlorprop Salts and Esters [2-(2,4-Dichlorophenoxy) propionic acid].	120-36-5	1658/515.1/615/515.2/555
31	MCPA; MCPA Salts and Esters [2-(2-Methyl-4-chlorophenoxy) propionic acid].	93-65-2	1658/615/555
35	TCMTB [2-(Thiocyanomethylthio) benzo-thiazole].	21564-17-0	637
39	Pronamide	23950-58-5	525.1/507/633.1
41	Propanil	709-98-8	632.1/1656
45	Metribuzin	21087-64-9	507/633/525.1/1656
52	Acephate	30560-19-1	1656/1657

TABLE IG—TEST METHODS FOR PESTICIDE ACTIVE INGREDIENTS—Continued

EPA Survey Code	Pesticide name	CAS No.	EPA Analytical Method No.(s)
53	Acifluorfen	50594–66–6	515.1/515.2/555
54	Alachlor	15972–60–8	505/507/645/525.1/1656
55	Aldicarb	116–06–3	531.1
58	Ametryn	834–12–8	507/619/525.1
60	Atrazine	1912–24–9	505/507/619/525.1/1656
62	Benomyl	17804–35–2	631
68	Bromacil; Bromacil Salts and Esters.	314–40–9	507/633/525.1/1656
69	Bromoxynil	1689–84–5	1625/1661
69	Bromoxynil octanoate	1689–99–2	1656
70	Butachlor	23184–66–9	507/645/525.1/1656
73	Captafol	2425–06–1	1656
75	Carbaryl [Sevin]	63–25–2	531.1/632/553
76	Carbofuran	1563–66–2	531.1/632
80	Chloroneb	2675–77–6	1656/508/608.1/525.1
82	Chlorothalonil	1897–45–6	508/608.2/525.1/1656
84	Stirofos	961–11–5	1657/507/622/525.1
86	Chlorpyrifos	2921–88–2	1657/508/622
90	Fenvalerate	51630–58–1	1660
103	Diazinon	333–41–5	1657/507/614/622/525.1
107	Parathion methyl	298–00–0	1657/614/622
110	DCPA [Dimethyl 2,3,5,6-tetra-chloro-terephthalate].	1861–32–1	508/608.2/525.1/515.1/515.2/1656
112	Dinoseb	88–85–7	1658/515.1/615/515.2/555
113	Dioxathion	78–34–2	1657/614.1
118	Nabonate [Disodium cyanodithioimidocarbonate].	138–93–2	630.1
119	Diuron	330–54–1	632/553
123	Endothall	145–73–3	548/548.1
124	Endrin	72–20–8	1656/505/508/608/617/525.1
125	Ethalfuralin	55283–68–6	1656/627 See footnote 1
126	Ethion	563–12–2	1657/614/614.1
127	Ethoprop	13194–48–4	1657/507/622/525.1
132	Fenarimol	60168–88–9	507/633.1/525.1/1656
133	Fenthion	55–38–9	1657/622
138	Glyphosate [N(Phosphonomethyl) glycine].	1071–83–6	547
140	Heptachlor	76–44–8	1656/505/508/608/617/525.1
144	Isopropalin	33820–53–0	1656/627
148	Linuron	330–55–2	553/632
150	Malathion	121–75–5	1657/614
154	Methamidophos	10265–92–6	1657
156	Methomyl	16752–77–5	531.1/632
158	Methoxychlor	72–43–5	1656/505/508/608.2/617/525.1
172	Nabam	142–59–6	630/630.1
173	Naled	300–76–5	1657/622
175	Norflurazon	27314–13–2	507/645/525.1/1656
178	Benfluralin	1861–40–1	11656/1627
182	Fensulfothion	115–90–2	1657/622
183	Disulfoton	298–04–4	1657/507/614/622/525.1
185	Phosmet	732–11–6	1657/622.1
186	Azinphos Methyl	86–50–0	1657/614/622
192	Organo-tin pesticides	12379–54–3	Ind-01/200.7/200.9
197	Bolstar	35400–43–2	1657/622
203	Parathion	56–38–2	1657/614
204	Pendimethalin	40487–42–1	1656
205	Pentachloronitrobenzene	82–68–8	1656/608.1/617
206	Pentachlorophenol	87–86–5	625/1625/515.2/555/515.1/ 525.1
208	Permethrin	52645–53–1	608.2/508/525.1/1656/1660
212	Phorate	298–02–2	1657/622
218	Busan 85 [Potassium dimethyldithiocarbamate].	128–03–0	630/630.1

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TABLE IG—TEST METHODS FOR PESTICIDE ACTIVE INGREDIENTS—Continued

EPA Survey Code	Pesticide name	CAS No.	EPA Analytical Method No.(s)
219	Busan 40 [Potassium N-hydroxymethyl-N-methyldithiocarbamate].	51026-28-9	630/630.1
220	KN Methyl [Potassium N-methyldithiocarbamate].	137-41-7	630/630.1
223	Prometon	1610-18-0	507/619/525.1
224	Prometryn	7287-19-6	507/619/525.1
226	Propazine	139-40-2	507/619/525.1/1656
230	Pyrethrin I	121-21-1	1660
232	Pyrethrin II	121-29-9	1660
236	DEF [S,S,S-Tributyl phosphorotrithioate].	78-48-8	1657
239	Simazine	122-34-9	505/507/619/525.1/1656
241	Carbam-S [Sodium dimethyldithiocarbamate].	128-04-1	630/630.1
243	Vapam [Sodium methyldithiocarbamate].	137-42-8	630/630.1
252	Tebuthiuron	34014-18-1	507/525.1
254	Terbacil	5902-51-2	507/633/525.1/1656
255	Terbufos	13071-79-9	1657/507/614.1/525.1
256	Terbutylazine	5915-41-3	619/1656
257	Terbutryn	886-50-0	507/619/525.1
259	Dazomet	533-74-4	630/630.1/1659
262	Toxaphene	8001-35-2	1656/505/508/608/617/525.1
263	Merphos [Tributyl phosphorotrithioate].	150-50-5	1657/507/525.1/622
264	Trifluralin	1582-09-8	1656/508/617/627/525.1
268	Ziram [Zinc dimethyldithiocarbamate].	137-30-4	630/630.1

¹ Monitor and report as total Trifluralin.

TABLE IH—LIST OF APPROVED MICROBIOLOGICAL METHODS FOR AMBIENT WATER

Parameter and units	Method ¹	EPA	Standard methods 18th, 19th, 20th Ed.	Standard methods online	AOAC, ASTM, USGS	Other
Bacteria: 1. <i>E. coli</i> , number per 100 mL	MPN ^{6,8,14} multiple tube,		9221 B.1/9221 F ^{11,13}	9221 B.1–99/9221 F ^{11,13}	991.15 ¹⁰	Colilert [®] 12,16 Colilert-18 [®] 12,15,16,
	Multiple tube/multiple well,		9223 B ¹²	9223 B–97 ¹²	D5392–93 ⁹	mColiBlue-24 [®] 17,
	MF ^{2,5,6,7,8} two step, or	1103.1 ¹⁹	9222 B/9222 G ¹⁹ , 9213 D,	9222 B–97/9222 G ¹⁸		Enterolert [®] 12,22,
	Single step	1603 ²⁰ , 1604 ²¹	9230 B	9230 B–93		
2. Enterococci, number per 100 mL.	Multiple tube/multiple well	1106.1 ²³			D6503–99 ⁹	
	MF ^{2,5,6,7,8} two step	1600 ²⁴	9230 C	9230 C–93	D5259–92 ⁹	
	Single step, or	p. 143 ³ ,				
Plate count		1622 ²⁵ , 1623 ²⁶ ,				
		1623 ²⁶ ,				
Protozoa: 3. <i>Cryptosporidium</i> 4. <i>Giardia</i>	Filtration/IMS/FA					
	Filtration/IMS/FA					

¹ The method must be specified when results are reported.
² A 0.45 µm membrane filter (MF) or other pore size certified by the manufacturer to fully retain organisms to be cultivated and to be free of extractables which could interfere with their growth.
³ USEPA, 1978. Microbiological Methods for Monitoring the Environment, Water, and Wastes. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH. EPA/600/8-78/017.
⁴ [Reserved]
⁵ Because the MF technique usually yields low and variable recovery from chlorinated wastewaters, the Most Probable Number method will be required to resolve any controversies, consistency, and anticipated organism density of the water sample.
⁶ Tests must be conducted to provide organism enumeration (density). Select the appropriate configuration of tubes/filtrations and dilutions/volumes to account for the quality, character, and consistency of the water sample.
⁷ When the MF method has not been used previously to test waters with high turbidity, large number of noncoliform bacteria, or samples that may contain organisms stressed by chlorine, a parallel test should be conducted with a multiple-tube technique to demonstrate applicability and comparability of results.
⁸ To assess the comparability of results obtained with individual methods, it is suggested that side-by-side tests be conducted across seasons of the year with the water samples routinely tested in accordance with the most current Standard Methods for the Examination of Water and Wastewater or EPA alternate test procedure (ATP) guidelines.
⁹ ASTM, 2000, 1999, 1996. Annual Book of ASTM Standards—Water and Environmental Technology, Section 11.02. ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428.
¹⁰ AOAC, 1985. Official Methods of Analysis of AOAC International, 16th Edition, Volume I, Chapter 17. Association of Official Analytical Chemists International. 481 North Frederick Avenue, Suite 500, Gaithersburg, MD 20877–2417.
¹¹ The multiple-tube fermentation test is used in 9221B.1. Lactose broth may be used in lieu of lauryl tryptose broth (LTB), if at least 25 parallel tests are conducted between this broth and LTB using the water samples normally tested, and this comparison demonstrates that the false-positive rate and false-negative rate for total coliform using lactose broth is less than 10 percent. No requirement exists to run the completed phase on 10 percent of all total coliform-positive tubes on a seasonal basis.
¹² These tests are collectively known as defined enzyme substrate tests, where, for example, a substrate is used to detect the enzyme β-glucuronidase produced by *E. coli*.
¹³ After prior enrichment in a presumptive medium for total coliform using 9221B.1, all presumptive tubes or bottles showing any amount of gas, growth or acidity within 48 h ± 3 h of incubation shall be submitted to 9221F. Commercially available EC-MUG media or EC media supplemented in the laboratory with 50 µg/mL of MUG may be used.
¹⁴ Samples shall be enumerated by the multiple-tube or multiple-tube procedures, employ an appropriate tube and dilution configuration of the sample as needed and report the Most Probable Number (MPN). Samples tested with Colilert[®] may be enumerated with the multiple-well procedures, Quanti-Tray[®] 2000, and the MPN calculated from the table provided by the manufacturer.
¹⁵ Colilert-18[®] is an optimized formulation of the Colilert[®] for the determination of total coliforms and *E. coli* that provides results within 18 h of incubation at 35 °C rather than the 24 h required for the Colilert[®] test and is recommended for marine water samples.
¹⁶ Descriptions of the Colilert[®], Colilert-18[®], Quanti-Tray[®], and Quanti-Tray[®] 2000 may be obtained from IDEXX Laboratories, Inc., 1 IDEXX Drive, Westbrook, ME 04092.
¹⁷ A description of the mColiBlue24[®] test, Total Coliforms and *E. coli*, is available from Hach Company, 100 Dayton Ave., Ames, IA 50010.
¹⁸ Subject total coliform positive samples determined by 9222B or other membrane filter procedure to 9222G using NA–MUG media.

- ¹⁹ USEPA, July 2006, Method 1103.1: *Escherichia coli* (*E. coli*) in Water by Membrane Filtration Using membrane-Thermotolerant *Escherichia coli* Agar (mTEC), U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA-821-R-06-010.
- ²⁰ USEPA, July 2006, Method 1603: *Escherichia coli* (*E. coli*) in Water by Membrane Filtration Using Modified membrane-Thermotolerant *Escherichia coli* Agar (Modified mTEC), U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA-821-R-06-011.
- ²¹ Preparation and use of M1 agar with a standard membrane filter procedure is set forth in the article, Brenner et al. 1993, "New Medium for the Simultaneous Detection of Total Coliform and *Escherichia coli* in Water," Appl. Environ. Microbiol. 59:3534-3544 and in USEPA, September 2002.: Method 1604: Total Coliforms and *Escherichia coli* (*E. coli*) in Water by Membrane Filtration by Using a Simultaneous Detection Technique (M1 Medium), U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA 821-R-02-024.
- ²² A description of the Enterolert® test may be obtained from IDEXX Laboratories, Inc., 1 IDEXX Drive, Westbrook, ME 04092.
- ²³ USEPA, July 2006, Method 1106.1: Enterococci in Water by Membrane Filtration Using membrane-Enterococcus-Esculin Iron Agar (mE-EIA), U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA-821-R-06-008.
- ²⁴ USEPA, July 2006, Method 1600: Enterococci in Water by Membrane Filtration Using membrane-Enterococcus Indoxyl- β -D-Glucoside Agar (mEI), U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA-821-R-06-009.
- ²⁵ Method 1622 uses filtration, concentration, immunomagnetic separation of oocysts from captured material, immunofluorescence assay to determine concentrations, and confirmation through vital dye staining and differential interference contrast microscopy for the detection of *Cryptosporidium*. USEPA, 2001. Method 1622: *Cryptosporidium* in Water by Filtration/IMS/FA, U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA-821-R-01-026.
- ²⁶ Method 1623 uses filtration, concentration, immunomagnetic separation of oocysts and cysts from captured material, immunofluorescence assay to determine concentrations, and confirmation through vital dye staining and differential interference contrast microscopy for the simultaneous detection of *Cryptosporidium* and *Giardia* oocysts and cysts. USEPA, 2001. Method 1623: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA, U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA-821-R-01-025.

(b) The full texts of the methods from the following references which are cited in Tables IA, IB, IC, ID, IE, IF, IG and IH are incorporated by reference into this regulation and may be obtained from the source identified. All costs cited are subject to change and must be verified from the indicated source. The full texts of all the test procedures cited are available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to: http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.

REFERENCES, SOURCES, COSTS, AND
TABLE CITATIONS:

- (1) The full texts of Methods 601–613, 624, 625, 1613, 1624, and 1625 are printed in appendix A of this part 136. The full text for determining the method detection limit when using the test procedures is given in appendix B of this part 136. The full text of Method 200.7 is printed in appendix C of this part 136. Cited in: Table IB, Note 5; Table IC, Note 2; and Table ID, Note 2.
- (2) USEPA. 1978. Microbiological Methods for Monitoring the Environment, Water, and Wastes. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio. EPA/600/8-78/017. Available at <http://www.epa.gov/clariton/srch.htm> or from: National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161, Pub. No. PB-290329/A.S. Table IA, Note 3; Table IH, Note 3.
- (3) “Methods for Chemical Analysis of Water and Wastes,” U.S. Environmental Protection Agency, EPA-600/4-79-020, March 1979, or “Methods for Chemical Analysis of Water and Wastes,” U.S. Environmental Protection Agency, EPA-600/4-79-020, Revised March 1983. Available from: ORD Publications, CERL, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268, Table IB, Note 1.
- (4) “Methods for Benzidine, Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastewater,” U.S. Environmental Protection Agency, 1978. Available from: ORD Publications, CERL, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268, Table IC, Note 3; Table D, Note 3.
- (5) “Prescribed Procedures for Measurement of Radioactivity in Drinking Water,” U.S. Environmental Protection Agency, EPA-600/4-80-032, 1980. Available from: ORD Publications, CERL, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268, Table IE, Note 1.
- (6) American Public Health Association. 1992, 1995, and 1998. Standard Methods for the Examination of Water and Wastewater. 18th, 19th, and 20th Edition (respectively). Available from: American Public Health Association, 1015 15th Street, NW., Washington, DC 20005. Standard Methods Online is available through the Standard Methods Web site (<http://www.standardmethods.org>). Tables IA, IB, IC, ID, IE, and IH.
- (7) Ibid, 15th Edition, 1980. Table IB, Note 30; Table ID.
- (8) Ibid, 14th Edition, 1975. Table IB, Notes 17 and 27.
- (9) “Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency,” Supplement to the 15th Edition of Standard Methods for the Examination of Water and Wastewater, 1981. Available from: American Public Health Association, 1015 Fifteenth Street NW., Washington, DC 20036. Cost available from publisher. Table IB, Note 10; Table IC, Note 6; Table ID, Note 6.
- (10) ASTM International. Annual Book of ASTM Standards, Water, and Environmental Technology, Section 11, Volumes 11.01 and 11.02, 1994, 1996, 1999, Volume 11.02, 2000, and individual standards published after 2000. Available from: ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, or <http://www.astm.org>. Tables IA, IB, IC, ID, IE, and IH.
- (11) USGS. 1989. U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Laboratory Analysis, Chapter A4, Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples, U.S. Geological Survey, U.S. Department of the Interior, Reston, Virginia. Available

from USGS Books and Open-File Reports Section, Federal Center, Box 25425, Denver, Colorado 80225. Table IA, Note 5; Table IH.

(12) "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments," by M.J. Fishman and Linda C. Friedman, Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 5 Chapter A1 (1989). Available from: U.S. Geological Survey, Denver Federal Center, Box 25425, Denver, CO 80225. Cost: \$108.75 (subject to change). Table IB, Note 2.

(13) "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments," N.W. Skougstad and others, editors. Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 5, Chapter A1 (1979). Available from: U.S. Geological Survey, Denver Federal Center, Box 25425, Denver, CO 80225. Cost: \$10.00 (subject to change), Table IB, Note 8.

(14) "Methods for the Determination of Organic Substances in Water and Fluvial Sediments," Wershaw, R.L., et al, Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 5, Chapter A3 (1987). Available from: U.S. Geological Survey, Denver Federal Center, Box 25425, Denver, CO 80225. Cost: \$0.90 (subject to change). Table IB, Note 24; Table ID, Note 4.

(15) "Water Temperature—Influential Factors, Field Measurement and Data Presentation," by H.H. Stevens, Jr., J. Ficke, and G.F. Smoot, Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 1, Chapter D1, 1975. Available from: U.S. Geological Survey, Denver Federal Center, Box 25425, Denver, CO 80225. Cost: \$1.60 (subject to change). Table IB, Note 32.

(16) "Selected Methods of the U.S. Geological Survey of Analysis of Wastewaters," by M.J. Fishman and Eugene Brown; U.S. Geological Survey Open File Report 76-77 (1976). Available from: U.S. Geological Survey, Branch of Distribution, 1200 South Eads Street, Arlington, VA 22202. Cost: \$13.50 (subject to change). Table IE, Note 2.

(17) AOAC-International. Official Methods of Analysis of AOAC-International, 16th Edition, (1995). Available from: AOAC-International, 481 North Frederick Avenue, Suite 500, Gaithers-

burg, MD 20877. Table IB, See footnote 3.

(18) "American National Standard on Photographic Processing Effluents," April 2, 1975. Available from: American National Standards Institute, 1430 Broadway, New York, New York 10018. Table IB, Note 9.

(19) "An Investigation of Improved Procedures for Measurement of Mill Effluent and Receiving Water Color," NCASI Technical Bulletin No. 253, December 1971. Available from: National Council of the Paper Industry for Air and Stream Improvements, Inc., 260 Madison Avenue, New York, NY 10016. Cost available from publisher. Table IB, Note 18.

(20) Ammonia, Automated Electrode Method, Industrial Method Number 379-75WE, dated February 19, 1976. Technicon Auto Analyzer II. Method and price available from Technicon Industrial Systems, Tarrytown, New York 10591. Table IB, Note 7.

(21) Chemical Oxygen Demand, Method 8000, Hach Handbook of Water Analysis, 1979. Method price available from Hach Chemical Company, P.O. Box 389, Loveland, Colorado 80537. Table IB, Note 14.

(22) OIC Chemical Oxygen Demand Method, 1978. Method and price available from Oceanography International Corporation, 512 West Loop, P.O. Box 2980, College Station, Texas 77840. Table IB, Note 13.

(23) ORION Research Instruction Manual, Residual Chlorine Electrode Model 97-70, 1977. Method and price available from ORION Research Incorporation, 840 Memorial Drive, Cambridge, Massachusetts 02138. Table IB, Note 16.

(24) Bicinchoninate Method for Copper. Method 8506, Hach Handbook of Water Analysis, 1979, Method and price available from Hach Chemical Company, P.O. Box 300, Loveland, Colorado 80537. Table IB, Note 19.

(25) Hydrogen Ion (pH) Automated Electrode Method, Industrial Method Number 378-75WA. October 1976. Bran & Luebbe (Technicon) Auto Analyzer II. Method and price available from Bran & Luebbe Analyzing Technologies, Inc. Elmsford, N.Y. 10523. Table IB, Note 21.

(26) 1,10-Phenanthroline Method using FerroVer Iron Reagent for Water,

Hach Method 8008, 1980. Method and price available from Hach Chemical Company, P.O. Box 389 Loveland, Colorado 80537. Table IB, Note 22.

(27) Periodate Oxidation Method for Manganese, Method 8034, Hach Handbook for Water Analysis, 1979. Method and price available from Hach Chemical Company, P.O. Box 389, Loveland, Colorado 80537. Table IB, Note 23.

(28) Nitrogen, Nitrite—Low Range, Diazotization Method for Water and Wastewater, Hach Method 8507, 1979. Method and price available from Hach Chemical Company, P.O. Box 389, Loveland, Colorado 80537. Table IB, Note 25.

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(30) “Direct Determination of Elemental Phosphorus by Gas-Liquid Chromatography,” by R.F. Addison and R.G. Ackman, Journal of Chromatography, Volume 47, No. 3, pp. 421–426, 1970. Available in most public libraries. Back volumes of the Journal of Chromatography are available from Elsevier/North-Holland, Inc., Journal Information Centre, 52 Vanderbilt Avenue, New York, NY 10164. Cost available from publisher. Table IB, Note 28.

(31) “Direct Current Plasma (DCP) Optical Emission Spectrometric Method for Trace Elemental Analysis of Water and Wastes”, Method AES 0029, 1986-Revised 1991, Fison Instruments, Inc., 32 Commerce Center, Cherry Hill Drive, Danvers, MA 01923. Table B, Note 34.

(32) “Closed Vessel Microwave Digestion of Wastewater Samples for Determination of Metals, CEM Corporation, P.O. Box 200, Matthews, North Carolina 28106-0200, April 16, 1992. Available from the CEM Corporation. Table IB, Note 36.

(33) “Organochlorine Pesticides and PCBs in Wastewater Using Empore™ Disk” Test Method 3M 0222, Revised 10/28/94. 3M Corporation, 3M Center Building 220-9E-10, St. Paul, MN 55144-1000. Method available from 3M Corporation. Table IC, Note 8 and Table ID, Note 8.

(34) USEPA. October 2002. Methods for Measuring the Acute Toxicity of

Effluents and Receiving Waters to Freshwater and Marine Organisms. Fifth Edition. U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA 821-R-02-012. Available at <http://www.epa.gov/epahome/index/sources.htm> or from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161, Pub. No. PB2002-108488. Table IA, Note 25.

(35) “Nitrogen, Total Kjeldahl, Method PAI-DK01 (Block Digestion, Steam Distillation, Titrimetric Detection)”, revised 12/22/94. Available from Perstorp Analytical Corporation, 9445 SW Ridder Rd., Suite 310, P.O. Box 648, Wilsonville, OK 97070. Table IB, Note 39.

(36) “Nitrogen, Total Kjeldahl, Method PAI-DK02 (Block Digestion, Steam Distillation, Colorimetric Detection)”, revised 12/22/94. Available from Perstorp Analytical Corporation, 9445 SW Ridder Rd., Suite 310, P.O. Box 648, Wilsonville, OK 97070. Table IB, Note 40.

(37) “Nitrogen, Total Kjeldahl, Method PAI-DK03 (Block Digestion, Automated FIA Gas Diffusion)”, revised 12/22/94. Available from Perstorp Analytical Corporation, 9445 SW Ridder Rd., Suite 310, P.O. Box 648, Wilsonville, OK 97070. Table IB, Note 41.

(38) USEPA. October 2002. Short-Term Methods for Measuring the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. Fourth Edition. U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA 821-R-02-013. Available at <http://www.epa.gov/epahome/index/sources.htm> or from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161, Pub. No. PB2002-108489. Table IA, Note 26.

(39) USEPA. October 2002. Short-Term Methods for Measuring the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms. Third Edition. U.S. Environmental Protection Agency, Office of Water, Washington, DC EPA 821-R-02-014. Available at <http://www.epa.gov/epahome/index/sources.htm> or from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161, Pub. No. PB2002-108490. Table IA, Note 27.

(40) EPA Methods 1666, 1667, and 1671 listed in the table above are published in the compendium titled Analytical Methods for the Determination of Pollutants in Pharmaceutical Manufacturing Industry Wastewaters (EPA 821-B-98-016). EPA Methods 502.2 and 524.2 have been incorporated by reference into 40 CFR 141.24 and are in Methods for the Determination of Organic Compounds in Drinking Water, EPA-600/4-88-039, December 1988, Revised, July 1991, and Methods for the Determination of Organic Compounds in Drinking Water-Supplement II, EPA-600/R-92-129, August 1992, respectively. These EPA test method compendia are available from the National Technical Information Service, NTIS PB91-231480 and PB92-207703, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161. The toll-free number is 800-553-6847. ASTM test methods D3371, D3695, and D4763 are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

(41) USEPA. 2002. Method 1631, Revision E, "Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry." September 2002. Office of Water, U.S. Environmental Protection Agency (EPA-821-R-02-019). Available from: National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. Publication No. PB2002-108220. Cost: \$25.50 (subject to change).

(42) [Reserved]

(43) Method OIA-1677, Available Cyanide by Flow Injection, Ligand Exchange, and Amperometry. August 1999. ALPKEM, OI Analytical, Box 648, Wilsonville, Oregon 97070 (EPA-821-R-99-013). Available from: National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. Publication No. PB99-132011. Cost: \$22.50. Table IB, Note 44.

(44) "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory Determination of Ammonium Plus Organic Nitrogen by a Kjeldahl Digestion Method and an Automated Photometric Finish that Includes Digest Cleanup by Gas Diffusion", Open File Report (OFR) 00-170. Available from: U.S. Geological Sur-

vey, Denver Federal Center, Box 25425, Denver, CO 80225. Table IB, Note 45.

(45) "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Chromium in Water by Graphite Furnace Atomic Absorption Spectrophotometry", Open File Report (OFR) 93-449. Available from: U.S. Geological Survey, Denver Federal Center, Box 25425, Denver, CO 80225. Table IB, Note 46.

(46) "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Molybdenum in Water by Graphite Furnace Atomic Absorption Spectrophotometry", Open File Report (OFR) 97-198. Available from: U.S. Geological Survey, Denver Federal Center, Box 25425, Denver, CO 80225. Table IB, Note 47.

(47) "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Total Phosphorus by Kjeldahl Digestion Method and an Automated Colorimetric Finish That Includes Dialysis" Open File Report (OFR) 92-146. Available from: U.S. Geological Survey, Denver Federal Center, Box 25425, Denver, CO 80225. Table IB, Note 48.

(48) "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Arsenic and Selenium in Water and Sediment by Graphite Furnace—Atomic Absorption Spectrometry" Open File Report (OFR) 98-639. Table IB, Note 49.

(49) "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Elements in Whole-Water Digests Using Inductively Coupled Plasma-Optical Emission Spectrometry and Inductively Coupled Plasma-Mass Spectrometry", Open File Report (OFR) 98-165. Available from: U.S. Geological Survey, Denver Federal Center, Box 25425, Denver, CO 80225. Table IB, Note 50.

(50) "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Triazine and Other Nitrogen-containing Compounds by Gas Chromatography with Nitrogen Phosphorus Detectors" U.S. Geological Survey Open File Report 94-37. Available from: U.S.

Geological Survey, Denver Federal Center, Box 25425, Denver, CO 80225. Table ID, Note 9.

(51) “Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Inorganic and Organic Constituents in Water and Fluvial Sediments”, Open File Report (OFR) 93-125. Available from: U.S. Geological Survey, Denver Federal Center, Box 25425, Denver, CO 80225. Table IB, Note 51; Table IC, Note 9.

(52) IDEXX Laboratories, Inc. 2002. Description of Colilert®, Colilert-18®, Quanti-Tray®, Quanti-Tray®/2000, Enterolert® methods are available from IDEXX Laboratories, Inc., One Idexx Drive, Westbrook, Maine 04092. Table IA, Notes 17 and 23; Table IH, Notes 16 and 22.

(53) Hach Company, Inc. Revision 2, 1999. Description of m-ColiBlue24® Method, Total Coliforms and *E. coli*, is available from Hach Company, 100 Dayton Ave, Ames IA 50010. Table IA, Note 18; Table IH, Note 17.

(54) USEPA. July 2006. Method 1103.1: *Escherichia coli* (*E. coli*) in Water by Membrane Filtration Using membrane-Thermotolerant *Escherichia coli* Agar (mTEC). U.S. Environmental Protection Agency, Office of Water, Washington DC EPA-621-R-06-010. Available at <http://www.epa.gov/waterscience/methods/>. Table IH, Note 19.

(55) USEPA. July 2006. Method 1106.1: Enterococci in Water by Membrane Filtration Using membrane-Enterococcus-Esculin Iron Agar (mE-EIA). U.S. Environmental Protection Agency, Office of Water, Washington DC EPA-621-R-06-008. Available at <http://www.epa.gov/waterscience/methods/>. Table IH, Note 23.

(56) USEPA. July 2006. Method 1603: *Escherichia coli* (*E. coli*) in Water by Membrane Filtration Using Modified membrane-Thermotolerant *Escherichia coli* Agar (Modified mTEC). U.S. Environmental Protection Agency, Office of Water, Washington DC EPA-821-R-06-011. Available at <http://www.epa.gov/waterscience/methods/>. Table IH, Note 19; Table IH, Note 20.

(57) Brenner *et al.* 1993. New Medium for the Simultaneous Detection of Total Coliforms and *Escherichia coli* in Water. *Appl. Environ. Microbiol.*

59:3534–3544. Available from the American Society for Microbiology, 1752 N Street NW., Washington DC 20036. Table IH, Note 21.

(58) USEPA. September 2002. Method 1604: Total Coliforms and *Escherichia coli* (*E. coli*) in Water by Membrane Filtration Using a Simultaneous Detection Technique (MI Medium). U.S. Environmental Protection Agency, Office of Water, Washington DC EPA-821-R-02-024. Available at <http://www.epa.gov/waterscience/methods/>. Table IH, Note 20.

(59) USEPA. July 2006. Method 1600: Enterococci in Water by Membrane Filtration Using membrane-Enterococcus Indoxyl-β-D-Glucoside Agar (mEI). U.S. Environmental Protection Agency, Office of Water, Washington DC EPA-821-R-06-009. Available at <http://www.epa.gov/waterscience/methods/>. Table IA, Note 24; Table IH, Note 24.

(60) USEPA. April 2001. Method 1622: *Cryptosporidium* in Water by Filtration/IMS/FA. U.S. Environmental Protection Agency, Office of Water, Washington DC EPA-821-R-01-026. Available at <http://www.epa.gov/waterscience/methods/>. Table IH, Note 25.

(61) USEPA. April 2001. Method 1623: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA. U.S. Environmental Protection Agency, Office of Water, Washington DC. EPA-821-R-01-025. Available at <http://www.epa.gov/waterscience/methods/>. Table IH, Note 26.

(62) AOAC. 1995. Official Methods of Analysis of AOAC International, 16th Edition, Volume I, Chapter 17. AOAC International, 481 North Frederick Avenue, Suite 500, Gaithersburg, Maryland 20877-2417. Table IA, Note 11; Table IH.

(63) Waters Corporation. Method D6508, Rev. 2, “Test Method for Determination of Dissolved Inorganic Anions in Aqueous Matrices Using Capillary Ion Electrophoresis and Chromate Electrolyte,” available from Waters Corp, 34 Maple Street, Milford, MA 01757, Telephone: 508/482-2131, Fax: 508/482-3625, Table IB, See footnote 54.

(64) Kelada-01, “Kelada Automated Test Methods for Total Cyanide, Acid Dissociable Cyanide, and Thiocyanate,” EPA 821-B-01-009 Revision 1.2, August 2001 is available from

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National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161 [Order Number PB 2001-108275]. Telephone: 800-553-6847. Table IB, See footnote 55.

(65) QuikChem Method 10-204-00-1-X, "Digestion and Distillation of Total Cyanide in Drinking and Wastewaters using MICRO DIST and Determination of Cyanide by Flow Injection Analysis" Revision 2.2, March 2005 is available from Lachat Instruments 6645 W. Mill Road, Milwaukee, WI 53218, Telephone: 414-358-4200. Table IB, See footnote 56.

(66) "Methods for the Determination of Metals in Environmental Samples," Supplement I, National Exposure Risk Laboratory-Cincinnati (NERL-CI), EPA/600/R-94/111, May 1994; and "Methods for the Determination of Inorganic Substances in Environmental Samples," NERL-CI, EPA/600/R-93/100, August, 1993 are available from National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161. Telephone: 800-553-6847. Table IB.

(67) "Determination of Inorganic Ions in Drinking Water by Ion Chromatography," Rev. 1.0, 1997 is available from <http://www.epa.gov/safewater/methods/met300.pdf>. Table IB.

(68) Table IG Methods are available in "Methods For The Determination of Nonconventional Pesticides In Municipal and Industrial Wastewater, Volume I," EPA 821-R-93-010A, August 1993 Revision I, and "Methods For The Determination of Nonconventional Pesticides In Municipal and Industrial Wastewater, Volume II," EPA 821-R-93-010B (August 1993) are available from National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161. Telephone: 800-553-6847.

(69) Method 245.7, Rev. 2.0, "Mercury in Water by Cold Vapor Atomic Fluorescence Spectrometry," February 2005, EPA-821-R-05-001, available from the U.S. EPA Sample Control Center (operated by CSC), 6101 Stevenson Avenue, Alexandria, VA 22304, Telephone: 703-461-8056. Table IB, See footnote 59.

(70) USEPA. July 2006. Method 1680: Fecal Coliforms in Sewage Sludge (Biosolids) by Multiple-Tube Fermentation using Lauryl Tryptose Broth (LTB) and EC Medium. U.S. Environmental Protection Agency, Office of Water, Wash-

ington DC. EPA 821-R-06-012. Available at <http://www.epa.gov/waterscience/methods/>.

(71) USEPA. July 2006. Method 1681: Fecal Coliforms in Sewage Sludge (Biosolids) by Multiple-Tube Fermentation using A-1 Medium. U.S. Environmental Protection Agency, Office of Water, Washington DC. EPA 821-R-06-013. Available at <http://www.epa.gov/waterscience/methods/>.

(72) USEPA. July 2006. Method 1682: *Salmonella* in Sewage Sludge (Biosolids) by Modified Semisolid Rappaport-Vassiliadis (MSRV) Medium. U.S. Environmental Protection Agency, Office of Water, Washington DC. EPA 821-R-06-014. Available at <http://www.epa.gov/waterscience/methods/>.

(c) Under certain circumstances, the Regional Administrator or the Director in the Region or State where the discharge will occur may determine for a particular discharge that additional parameters or pollutants must be reported. Under such circumstances, additional test procedures for analysis of pollutants may be specified by the Regional Administrator, or the Director upon recommendation of the Alternate Test Procedure Program Coordinator, Washington, DC.

(d) Under certain circumstances, the Administrator may approve additional alternate test procedures for nationwide use, upon recommendation by the Alternate Test Procedure Program Coordinator, Washington, DC.

(e) Sample preservation procedures, container materials, and maximum allowable holding times for parameters are cited in Tables IA, IB, IC, ID, IE, IF, IG and IH are prescribed in Table II. Information in the table takes precedence over information in specific methods or elsewhere. Any person may apply for a variance from the prescribed preservation techniques, container materials, and maximum holding times applicable to samples taken from a specific discharge. Applications for variances may be made by letters to the Regional Administrator in the Region in which the discharge will occur. Sufficient data should be provided to assure such variance does not adversely affect the integrity of the sample. Such data will be forwarded by

the Regional Administrator, to the Alternate Test Procedure Program Coordinator, Washington, DC, for technical review and recommendations for action on the variance application. Upon receipt of the recommendations from the Alternate Test Procedure Program Co-

ordinator, the Regional Administrator may grant a variance applicable to the specific discharge to the applicant. A decision to approve or deny a variance will be made within 90 days of receipt of the application by the Regional Administrator.

TABLE II—REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter No./name	Container ¹	Preservation ^{2,3}	Maximum holding time ⁴
Table IA—Bacterial Tests:			
1-5. Coliform, total, fecal, and <i>E. coli</i>	PA, G	Cool, <10 °C, Na ₂ S ₂ O ₃ ⁵	6 hours. ^{22,23}
6. Fecal streptococci	PA, G	Cool, <10 °C, Na ₂ S ₂ O ₃ ⁵	6 hours. ²²
7. Enterococci	PA, G	Cool, <10 °C, Na ₂ S ₂ O ₃ ⁵	6 hours. ²²
8. Salmonella	PA, G	Cool, <10 °C, Na ₂ S ₂ O ₃ ⁵	6 hours. ²²
Table IA—Aquatic Toxicity Tests:			
9-11. Toxicity, acute and chronic	P, FP, G	Cool, ≤6 °C ¹⁶	36 hours.
Table IB—Inorganic Tests:			
1. Acidity	P, FP, G	Cool, ≤6 °C ¹⁸	14 days.
2. Alkalinity	P, FP, G	Cool, ≤6 °C ¹⁸	14 days.
4. Ammonia	P, FP, G	Cool, ≤6 °C ¹⁸ , H ₂ SO ₄ to pH<2	28 days.
9. Biochemical oxygen demand	P, FP, G	Cool, ≤6 °C ¹⁸	48 hours.
10. Boron	P, FP, or Quartz	HNO ₃ to pH<2	6 months.
11. Bromide	P, FP, G	None required	28 days.
14. Biochemical oxygen demand, carbonaceous	P, FP, G	Cool, ≤6 °C ¹⁸	48 hours.
15. Chemical oxygen demand	P, FP, G	Cool, ≤6 °C ¹⁸ , H ₂ SO ₄ to pH<2	28 days.
16. Chloride	P, FP, G	None required	28 days.
17. Chlorine, total residual	P, G	None required	Analyze within 15 minutes.
21. Color	P, FP, G	Cool, ≤6 °C ¹⁸	48 hours.
23-24. Cyanide, total or available (or CATC).	P, FP, G	Cool, ≤6 °C ¹⁸ , NaOH to pH>12 ⁶ , reducing agent ⁵ .	14 days.
25. Fluoride	P	None required	28 days.
27. Hardness	P, FP, G	HNO ₃ or H ₂ SO ₄ to pH<2	6 months.
28. Hydrogen ion (pH)	P, FP, G	None required	Analyze within 15 minutes.
31, 43. Kjeldahl and organic N	P, FP, G	Cool, ≤6 °C ¹⁸ , H ₂ SO ₄ to pH<2	28 days.
Table IB—Metals:⁷			
18. Chromium VI	P, FP, G	Cool, ≤6 °C ¹⁸ , pH = 9.3-9.7 ²⁰	28 days.
35. Mercury (CVAA)	P, FP, G	HNO ₃ to pH<2	28 days.
35. Mercury (CVAFS)	FP, G; and FP-lined cap ¹⁷ .	5 mL/L 12N HCl or 5 mL/L BrCl ¹⁷ .	90 days. ¹⁷
3, 5-8, 12, 13, 19, 20, 22, 26, 29, 30, 32-34, 36, 37, 45, 47, 51, 52, 58-60, 62, 63, 70-72, 74, 75. Metals, except boron, chromium VI, and mercury.	P, FP, G	HNO ₃ to pH<2, or at least 24 hours prior to analysis ¹⁹ .	6 months.
38. Nitrate	P, FP, G	Cool, ≤6 °C ¹⁸	48 hours.
39. Nitrate-nitrite	P, FP, G	Cool, ≤6 °C ¹⁸ , H ₂ SO ₄ to pH<2	28 days.
40. Nitrite	P, FP, G	Cool, ≤6 °C ¹⁸	48 hours.
41. Oil and grease	G	Cool to ≤6 °C ¹⁸ , HCl or H ₂ SO ₄ to pH<2.	28 days.
42. Organic Carbon	P, FP, G	Cool to ≤6 °C ¹⁸ , HCl, H ₂ SO ₄ , or H ₃ PO ₄ to pH<2.	28 days.
44. Orthophosphate	P, FP, G	Cool, ≤6 °C ¹⁸	Filter within 15 minutes; Analyze within 48 hours.
46. Oxygen, Dissolved Probe	G, Bottle and top	None required	Analyze within 15 minutes.
47. Winkler	G, Bottle and top	Fix on site and store in dark	8 hours.
48. Phenols	G	Cool, ≤6 °C ¹⁸ , H ₂ SO ₄ to pH<2	28 days.
49. Phosphorous (elemental)	G	Cool, ≤6 °C ¹⁸	48 hours.
50. Phosphorous, total	P, FP, G	Cool, ≤6 °C ¹⁸ , H ₂ SO ₄ to pH<2	28 days.
53. Residue, total	P, FP, G	Cool, ≤6 °C ¹⁸	7 days.
54. Residue, Filterable	P, FP, G	Cool, ≤6 °C ¹⁸	7 days.
55. Residue, Nonfilterable (TSS)	P, FP, G	Cool, ≤6 °C ¹⁸	7 days.
56. Residue, Settleable	P, FP, G	Cool, ≤6 °C ¹⁸	48 hours.

TABLE II—REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES—Continued

Parameter No./name	Container ¹	Preservation ^{2,3}	Maximum holding time ⁴
57. Residue, Volatile	P, FP, G	Cool, ≤6 °C ¹⁸	7 days.
61. Silica	P or Quartz	Cool, ≤6 °C ¹⁸	28 days.
64. Specific conductance	P, FP, G	Cool, ≤6 °C ¹⁸	28 days.
65. Sulfate	P, FP, G	Cool, ≤6 °C ¹⁸	28 days.
66. Sulfide	P, FP, G	Cool, ≤6 °C ¹⁸ , add zinc acetate plus sodium hydroxide to pH>9.	7 days.
67. Sulfite	P, FP, G	None required	Analyze within 15 minutes.
68. Surfactants	P, FP, G	Cool, ≤6 °C ¹⁸	48 hours.
69. Temperature	P, FP, G	None required	Analyze.
73. Turbidity	P, FP, G	Cool, ≤6 °C ¹⁸	48 hours.
Table IC—Organic Tests ⁸			
13, 18–20, 22, 24–28, 34–37, 39–43, 45–47, 56, 76, 104, 105, 108–111, 113. Purgeable Halocarbons.	G, FP-lined septum ...	Cool, ≤6 °C ¹⁸ , 0.008% Na ₂ S ₂ O ₃ ⁵ .	14 days.
6, 57, 106. Purgeable aromatic hydrocarbons.	G, FP-lined septum ...	Cool, ≤6 °C ¹⁸ , 0.008% Na ₂ S ₂ O ₃ ⁵ , HCl to pH 2 ⁹ .	14 days. ⁹
3, 4. Acrolein and acrylonitrile	G, FP-lined septum ...	Cool, ≤6 °C ¹⁸ , 0.008% Na ₂ S ₂ O ₃ ⁵ , pH to 4–5 ¹⁰ .	14 days. ¹⁰
23, 30, 44, 49, 53, 77, 80, 81, 98, 100, 112. Phenols ¹¹ .	G, FP-lined cap	Cool, ≤6 °C ¹⁸ , 0.008% Na ₂ S ₂ O ₃ ⁵ .	7 days until extraction, 40 days after extraction.
7, 38. Benzidines ^{11,12}	G, FP-lined cap	Cool, ≤6 °C ¹⁸ , 0.008% Na ₂ S ₂ O ₃ ⁵ .	7 days until extraction. ¹³
14, 17, 48, 50–52. Phthalate esters ¹¹ .	G, FP-lined cap	Cool, ≤6 °C ¹⁸	7 days until extraction, 40 days after extraction.
82–84. Nitrosamines ^{11,14}	G, FP-lined cap	Cool, ≤6 °C ¹⁸ , store in dark, 0.008% Na ₂ S ₂ O ₃ ⁵ .	7 days until extraction, 40 days after extraction.
88–94. PCBs ¹¹	G, FP-lined cap	Cool, ≤6 °C ¹⁸	1 year until extraction, 1 year after extraction.
54, 55, 75, 79. Nitroaromatics and isophorone ¹¹ .	G, FP-lined cap	Cool, ≤6 °C ¹⁸ , store in dark, 0.008% Na ₂ S ₂ O ₃ ⁵ .	7 days until extraction, 40 days after extraction.
1, 2, 5, 8–12, 32, 33, 58, 59, 74, 78, 99, 101. Polynuclear aromatic hydrocarbons ¹¹ .	G, FP-lined cap	Cool, ≤6 °C ¹⁸ , store in dark, 0.008% Na ₂ S ₂ O ₃ ⁵ .	7 days until extraction, 40 days after extraction.
15, 16, 21, 31, 87. Haloethers ¹¹	G, FP-lined cap	Cool, ≤6 °C ¹⁸ , 0.008% Na ₂ S ₂ O ₃ ⁵ .	7 days until extraction, 40 days after extraction.
29, 35–37, 63–65, 107. Chlorinated hydrocarbons ¹¹ .	G, FP-lined cap	Cool, ≤6 °C ¹⁸	7 days until extraction, 40 days after extraction.
60–62, 66–72, 85, 86, 95–97, 102, 103. CDDs/CDFs ¹¹ .	G	Cool, ≤6 °C ¹⁸ , 0.008% Na ₂ S ₂ O ₃ ⁵ , pH<9.	1 year.
Aqueous Samples: Field and Lab Preservation.	G	Cool, ≤6 °C ¹⁸	7 days.
Solids and Mixed-Phase Samples: Field Preservation.	G	Cool, ≤6 °C ¹⁸	24 hours.
Tissue Samples: Field Preservation	G	Freeze, ≤ -10 °C	1 year.
Solids, Mixed-Phase, and Tissue Samples: Lab Preservation.	G		
Table ID—Pesticides Tests:			
1–70. Pesticides ¹¹	G, FP-lined cap	Cool, ≤6 °C ¹⁸ , pH 5–9 ¹⁵	7 days until extraction, 40 days after extraction.
Table IE—Radiological Tests:			
1–5. Alpha, beta, and radium	P, FP, G	HNO ₃ to pH<2	6 months.
Table IH—Bacterial Tests:			
1. <i>E. coli</i>	PA, G	Cool, <10 °C, 0.0008% Na ₂ S ₂ O ₃ ⁵ .	6 hours. ²²
2. Enterococci	PA, G	Cool, <10 °C, 0.0008% Na ₂ S ₂ O ₃ ⁵ .	6 hours. ²²
Table IH—Protozoan Tests:			
8. Cryptosporidium	LDPE; field filtration ..	0–8 °C	96 hours. ²¹

TABLE II—REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES—Continued

Parameter No./name	Container ¹	Preservation ^{2,3}	Maximum holding time ⁴
9. Giardia	LDPE; field filtration ..	0–8 °C	96 hours. ²¹

¹“P” is polyethylene; “FP” is fluoropolymer (polytetrafluoroethylene (PTFE; Teflon®), or other fluoropolymer, unless stated otherwise in this Table II; “G” is glass; “PA” is any plastic that is made of a sterilizable material (polypropylene or other autoclavable plastic); “LDPE” is low density polyethylene.

²Except where noted in this Table II and the method for the parameter, preserve each grab sample within 15 minutes of collection. For a composite sample collected with an automated sampler (e.g., using a 24-hour composite sampler; see 40 CFR 122.21(g)(7)(i) or 40 CFR part 403, Appendix E), refrigerate the sample at ≤6 °C during collection unless specified otherwise in this Table II or in the method(s). For a composite sample to be split into separate aliquots for preservation and/or analysis, maintain the sample at ≤6 °C, unless specified otherwise in this Table II or in the method(s), until collection, splitting, and preservation is completed. Add the preservative to the sample container prior to sample collection when the preservative will not compromise the integrity of a grab sample, a composite sample, or an aliquot split from a composite sample; otherwise, preserve the grab sample, composite sample, or aliquot split from a composite sample within 15 minutes of collection. If a composite measurement is required but a composite sample would compromise sample integrity, individual grab samples must be collected at prescribed time intervals (e.g., 4 samples over the course of a day, at 6-hour intervals). Grab samples must be analyzed separately and the concentrations averaged. Alternatively, grab samples may be collected in the field and composited in the laboratory if the compositing procedure produces results equivalent to results produced by arithmetic averaging of the results of analysis of individual grab samples. For examples of laboratory compositing procedures, see EPA Method 1664A (oil and grease) and the procedures at 40 CFR 141.34(f)(14)(iv) and (v) (volatile organics).

³When any sample is to be shipped by common carrier or sent via the U.S. Postal Service, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of Table II, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO₃) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H₂SO₄) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

⁴ Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before the start of analysis and still be considered valid (e.g., samples analyzed for fecal coliforms may be held up to 6 hours prior to commencing analysis). Samples may be held for longer periods only if the permittee or monitoring laboratory has data on file to show that, for the specific types of samples under study, the analytes are stable for the longer time, and has received a variance from the Regional Administrator under § 136.3(e). For a grab sample, the holding time begins at the time of collection. For a composite sample collected with an automated sampler (e.g., using a 24-hour composite sampler; see 40 CFR 122.21(g)(7)(i) or 40 CFR part 403, Appendix E), the holding time begins at the time of the end of collection of the composite sample. For a set of grab samples composited in the field or laboratory, the holding time begins at the time of collection of the last grab sample in the set. Some samples may not be stable for the maximum time period given in the table. A permittee or monitoring laboratory is obligated to hold the sample for a shorter time if it knows that a shorter time is necessary to maintain sample stability. See § 136.3(e) for details. The date and time of collection of an individual grab sample is the date and time at which the sample is collected. For a set of grab samples to be composited, and that are all collected on the same calendar date, the date of collection is the date on which the samples are collected. For a set of grab samples to be composited, and that are collected across two calendar dates, the date of collection is the dates of the two days; e.g., November 14–15. For a composite sample collected automatically on a given date, the date of collection is the date on which the sample is collected. For a composite sample collected automatically, and that is collected across two calendar dates, the date of collection is the dates of the two days; e.g., November 14–15.

⁵Add a reducing agent only if an oxidant (e.g., chlorine) is present. Reducing agents shown to be effective are sodium thiosulfate (Na₂S₂O₃), ascorbic acid, sodium arsenite (NaAsO₂), or sodium borohydride (NaBH₄). However, some of these agents have been shown to produce a positive or negative cyanide bias, depending on other substances in the sample and the analytical method used. Therefore, do not add an excess of reducing agent. Methods recommending ascorbic acid (e.g., EPA Method 335.4) specify adding ascorbic acid crystals, 0.1–0.6 g, until a drop of sample produces no color on potassium iodide (KI) starch paper, then adding 0.06 g (60 mg) for each liter of sample volume. If NaBH₄ or NaAsO₂ is used, 25 mg/L NaBH₄ or 100 mg/L NaAsO₂ will reduce more than 50 mg/L of chlorine (see method “Kelada-01” and/or Standard Method 4500-CN— for more information). After adding reducing agent, test the sample using KI paper, a test strip (e.g. for chlorine, SenSafe™ Total Chlorine Water Check 480010) moistened with acetate buffer solution (see Standard Method 4500-Cl.C.3e), or a chlorine/oxidant test method (e.g., EPA Method 330.4 or 330.5), to make sure all oxidant is removed. If oxidant remains, add more reducing agent. Whatever agent is used, it should be tested to assure that cyanide results are not affected adversely.

⁶ Sample collection and preservation: Collect a volume of sample appropriate to the analytical method in a bottle of the material specified. If the sample can be analyzed within 48 hours and sulfide is not present, adjust the pH to > 12 with sodium hydroxide solution (e.g., 5% w/v), refrigerate as specified, and analyze within 48 hours. Otherwise, to extend the holding time to 14 days and mitigate interferences, treat the sample immediately using any or all of the following techniques, as necessary, followed by adjustment of the sample pH to > 12 and refrigeration as specified. There may be interferences that are not mitigated by approved procedures. Any procedure for removal or suppression of an interference may be employed, provided the laboratory demonstrates that it more accurately measures cyanide. Particulate cyanide (e.g., ferric ferrocyanide) or a strong cyanide complex (e.g., cobalt cyanide) are more accurately measured if the laboratory holds the sample at room temperature and pH > 12 for a minimum of 4 hours prior to analysis, and performs UV digestion or dissolution under alkaline (pH=12) conditions, if necessary.

(1) Sulfur: To remove elemental sulfur (S₈), filter the sample immediately. If the filtration time will exceed 15 minutes, use a larger filter or a method that requires a smaller sample volume (e.g., EPA Method 335.4 or Lachat Method 01). Adjust the pH of the filtrate to > 12 with NaOH, refrigerate the filter and filtrate, and ship or transport to the laboratory. In the laboratory, extract the filter with 100 mL of 5% NaOH solution for a minimum of 2 hours. Filter the extract and discard the solids. Combine the 5% NaOH-extracted filtrate with the initial filtrate, lower the pH to approximately 12 with concentrated hydrochloric or sulfuric acid, and analyze the combined filtrate. Because the detection limit for cyanide will be increased by dilution by the filtrate from the solids, test the sample with and without the solids procedure if a low detection limit for cyanide is necessary. Do not use the solids procedure if a higher cyanide concentration is obtained without it. Alternatively, analyze the filtrates from the sample and the solids separately, add the amounts determined (in µg or mg), and divide by the original sample volume to obtain the cyanide concentration.

(2) Sulfide: If the sample contains sulfide as determined by lead acetate paper, or if sulfide is known or suspected to be present, immediately conduct one of the volatilization treatments or the precipitation treatment as follows: Volatilization—Headspace expelling. In a fume hood or well-ventilated area, transfer 0.75 liter of sample to a 4.4 L collapsible container (e.g., Cubitainer™). Acidify with concentrated hydrochloric acid to pH < 2. Cap the container and shake vigorously for 30 seconds. Remove the cap and expel the headspace into the fume hood or open area by collapsing the container without expelling the sample. Refill the headspace by expanding the container. Repeat expelling a total of five headspace volumes. Adjust the pH to > 12, refrigerate, and ship or transport to the laboratory. Scaling to a smaller or larger sample volume must maintain the air to sample volume ratio. A larger volume of air will result in too great a loss of cyanide (> 10%). Dynamic stripping: In a fume hood or well-ventilated area, transfer 0.75 liter of sample to a container of the material specified and acidify with concentrated hydrochloric acid to pH < 2. Using a calibrated air sampling pump or flowmeter, purge the acidified sample into the fume hood or open area through a fritted glass aerator at a flow rate of 2.25 L/min for 4 minutes. Adjust the pH to > 12, refrigerate, and ship or transport to the laboratory. Scaling to a smaller or larger sample volume must maintain the air to sample volume ratio. A larger volume of air will result in too great a loss of cyanide (> 10%). Precipitation: If the sample contains particulate matter that would be removed by filtration, filter the sample prior to treatment to assure that cyanide associated with the particulate matter is included in the measurement. Ship or transport the filter to the laboratory. In the laboratory, extract the filter with 100 mL of 5% NaOH solution for a minimum of 2 hours. Filter the extract and discard the solids. Combine the 5% NaOH-extracted filtrate with the initial filtrate, lower the pH to approximately 12 with concentrated hydrochloric or sulfuric acid, and analyze the combined filtrate. Because the detection limit for cyanide will be increased by dilution by the filtrate from the solids, test the sample with and without the solids procedure if a low detection limit for cyanide is necessary. Do not use the solids procedure if a higher cyanide concentration is obtained without it. Alternatively, analyze the filtrates from the sample and the solids separately, add the amounts determined (in µg or mg), and divide by the original sample volume to obtain the cyanide concentration. For removal of sulfide by precipitation, raise the pH of the sample to > 12 with NaOH solution, then add approximately 1 mg of powdered cadmium chloride for each mL of sample. For example, add approximately 500 mg to a 500-mL sample. Cap and shake the container to mix. Allow the precipitate to settle and test the sample with lead acetate paper. If necessary, add cadmium chloride but avoid adding an excess. Finally, filter through 0.45 micron filter. Cool the sample as specified and ship or transport the filtrate and filter to the laboratory. In the laboratory, extract the filter with 100 mL of 5% NaOH solution for a minimum of 2 hours. Filter the extract and discard the solids. Combine the 5% NaOH-extracted filtrate with the initial filtrate, lower the pH to approximately 12 with concentrated hydrochloric or sulfuric acid, and analyze the combined filtrate. Because the detection limit for cyanide will be increased by dilution by the filtrate from the solids, test the sample with and without the solids procedure if a low detection limit for cyanide is necessary. Do not use the solids procedure if a higher cyanide concentration is obtained without it. Alternatively, analyze the filtrates from the sample and the solids separately, add the amounts determined (in µg or mg), and divide by the original sample volume to obtain the cyanide concentration. If a ligand-exchange method is used (e.g., ASTM D6888), it may be necessary to increase the ligand-exchange reagent to offset any excess of cadmium chloride.

(3) Sulfite, thiosulfate, or thiocyanate: If sulfite, thiosulfate, or thiocyanate is known or suspected to be present, use UV digestion with a glass coil (Method Kelada-01) or ligand exchange (Method OIA-1677) to preclude cyanide loss or positive interference.

(4) Aldehyde: If formaldehyde, acetaldehyde, or another water-soluble aldehyde is known or suspected to be present, treat the sample with 20 mL of 3.5% ethylenediamine solution per liter of sample.

(5) Carbonate: Carbonate interference is evidenced by noticeable effervescence upon acidification in the distillation flask, a reduction in the pH of the absorber solution, and incomplete cyanide spike recovery. When significant carbonate is present, adjust the pH to ≥ 12 using calcium hydroxide instead of sodium hydroxide. Allow the precipitate to settle and decant or filter the sample prior to analysis (also see Standard Method 4500-CN.B.3.d).

(6) Chlorine, hypochlorite, or other oxidant: Treat a sample known or suspected to contain chlorine, hypochlorite, or other oxidant as directed in footnote 5.

⁷For dissolved metals, filter grab samples within 15 minutes of collection and before adding preservatives. For a composite sample collected with an automated sampler (e.g., using a 24-hour composite sampler; see 40 CFR 122.21(g)(7)(i) or 40 CFR part 403, appendix E), filter the sample within 15 minutes after completion of collection and before adding preservatives. If it is known or suspected that dissolved sample integrity will be compromised during collection of a composite sample collected automatically over time (e.g., by interchange of a metal between dissolved and suspended forms), collect and filter grab samples to be composited (footnote 2) in place of a composite sample collected automatically.

⁸Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

⁹If the sample is not adjusted to pH 2, then the sample must be analyzed within seven days of sampling.

¹⁰The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

¹¹When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity (i.e., use all necessary preservatives and hold for the shortest time listed). When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to ≤ 6 °C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6–9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (regarding the requirement for thiosulfate reduction), and footnotes 12, 13 (regarding the analysis of benzidine).

¹²If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0 ± 0.2 to prevent rearrangement to benzidine.

¹³Extracts may be stored up to 30 days at < 0 °C.

¹⁴For the analysis of diphenylnitrosamine, add 0.008% Na₂S₂O₃ and adjust pH to 7–10 with NaOH within 24 hours of sampling.

¹⁵The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% Na₂S₂O₃.

¹⁶Sufficient ice should be placed with the samples in the shipping container to ensure that ice is still present when the samples arrive at the laboratory. However, even if ice is present when the samples arrive, it is necessary to immediately measure the temperature of the samples and confirm that the preservation temperature maximum has not been exceeded. In the isolated cases where it can be documented that this holding temperature cannot be met, the permittee can be given the option of on-site testing or can request a variance. The request for a variance should include supportive data which show that the toxicity of the effluent samples is not reduced because of the increased holding temperature.

¹⁷Samples collected for the determination of trace level mercury (<100 ng/L) using EPA Method 1631 must be collected in tightly-capped fluoropolymer or glass bottles and preserved with BrCl or HCl solution within 48 hours of sample collection. The time to preservation may be extended to 28 days if a sample is oxidized in the sample bottle. A sample collected for dissolved trace level mercury should be filtered in the laboratory within 24 hours of the time of collection. However, if circumstances preclude overnight shipment, the sample should be filtered in a designated clean area in the field in accordance with procedures given in Method 1669. If sample integrity will not be maintained by shipment to and filtration in the laboratory, the sample must be filtered in a designated clean area in the field within the time period necessary to maintain sample integrity. A sample that has been collected for determination of total or dissolved trace level mercury must be analyzed within 90 days of sample collection.

¹⁸Aqueous samples must be preserved at ≤ 6 °C, and should not be frozen unless data demonstrating that sample freezing does not adversely impact sample integrity is maintained on file and accepted as valid by the regulatory authority. Also, for purposes of NPDES monitoring, the specification of “≤ °C” is used in place of the “4 °C” and “< 4 °C” sample temperature requirements listed in some methods. It is not necessary to measure the sample temperature to three significant figures (1/100th of 1 degree); rather, three significant figures are specified so that rounding down to 6 °C may not be used to meet the ≤ 6 °C requirement. The preservation temperature does not apply to samples that are analyzed immediately (less than 15 minutes).

¹⁹An aqueous sample may be collected and shipped without acid preservation. However, acid must be added at least 24 hours before analysis to dissolve any metals that adsorb to the container walls. If the sample must be analyzed within 24 hours of collection, add the acid immediately (see footnote 2). Soil and sediment samples do not need to be preserved with acid. The allowances in this footnote supersede the preservation and holding time requirements in the approved metals methods.

²⁰To achieve the 28-day holding time, use the ammonium sulfate buffer solution specified in EPA Method 218.6. The allowance in this footnote supersedes preservation and holding time requirements in the approved hexavalent chromium methods, unless this supersession would compromise the measurement, in which case requirements in the method must be followed.

²¹Holding time is calculated from time of sample collection to elution for samples shipped to the laboratory in bulk and calculated from the time of sample filtration to elution for samples filtered in the field.

²²Samples analysis should begin immediately, preferably within 2 hours of collection. The maximum transport time to the laboratory is 6 hours, and samples should be processed within 2 hours of receipt at the laboratory.

²³For fecal coliform samples for sewage sludge (biosolids) only, the holding time is extended to 24 hours for the following sample types using either EPA Method 1680 (LTB–EC) or 1681 (A–1): Class A composted, Class B aerobically digested, and Class B anaerobically digested.

[38 FR 28758, Oct. 16, 1973]

EDITORIAL NOTE: For FEDERAL REGISTER citations affecting §136.3, see the List of CFR Sections Affected, which appears in the Finding Aids section of the printed volume and on GPO Access.

§136.4 Application for alternate test procedures.

(a) Any person may apply to the Regional Administrator in the Region where the discharge occurs for approval of an alternative test procedure.

(b) When the discharge for which an alternative test procedure is proposed occurs within a State having a permit program approved pursuant to section 402 of the Act, the applicant shall submit his application to the Regional Administrator through the Director of the State agency having responsibility for issuance of NPDES permits within such State.

(c) Unless and until printed application forms are made available, an application for an alternate test procedure may be made by letter in triplicate. Any application for an alternate test procedure under this paragraph (c) shall:

(1) Provide the name and address of the responsible person or firm making the discharge (if not the applicant) and the applicable ID number of the existing or pending permit, issuing agency, and type of permit for which the alternate test procedure is requested, and the discharge serial number.

(2) Identify the pollutant or parameter for which approval of an alternate testing procedure is being requested.

(3) Provide justification for using testing procedures other than those specified in Table I.

(4) Provide a detailed description of the proposed alternate test procedure, together with references to published studies of the applicability of the alter-

nate test procedure to the effluents in question.

(d) An application for approval of an alternate test procedure for nationwide use may be made by letter in triplicate to the Alternate Test Procedure Program Coordinator, Office of Science and Technology (4303), Office of Water, U.S. Environmental Protection Agency, 1200 Pennsylvania Ave., NW., Washington, DC 20460. Any application for an alternate test procedure under this paragraph (d) shall:

(1) Provide the name and address of the responsible person or firm making the application.

(2) Identify the pollutant(s) or parameter(s) for which nationwide approval of an alternate testing procedure is being requested.

(3) Provide a detailed description of the proposed alternate procedure, together with references to published or other studies confirming the general applicability of the alternate test procedure to the pollutant(s) or parameter(s) in waste water discharges from representative and specified industrial or other categories.

(4) Provide comparability data for the performance of the proposed alternate test procedure compared to the performance of the approved test procedures.

[38 FR 28760, Oct. 16, 1973, as amended at 41 FR 52785, Dec. 1, 1976; 62 FR 30763, June 5, 1997; 72 FR 11239, Mar. 12, 2007]

§136.5 Approval of alternate test procedures.

(a) The Regional Administrator of the region in which the discharge will

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occur has final responsibility for approval of any alternate test procedure proposed by the responsible person or firm making the discharge.

(b) Within thirty days of receipt of an application, the Director will forward such application proposed by the responsible person or firm making the discharge, together with his recommendations, to the Regional Administrator. Where the Director recommends rejection of the application for scientific and technical reasons which he provides, the Regional Administrator shall deny the application and shall forward this decision to the Director of the State Permit Program and to the Alternate Test Procedure Program Coordinator, Office of Science and Technology (4303), Office of Water, U.S. Environmental Protection Agency, 1200 Pennsylvania Ave., NW., Washington, DC 20460.

(c) Before approving any application for an alternate test procedure proposed by the responsible person or firm making the discharge, the Regional Administrator shall forward a copy of the application to the Alternate Test Procedure Program Coordinator, Office of Science and Technology (4303), Office of Water, U.S. Environmental Protection Agency, 1200 Pennsylvania Ave., NW., Washington, DC 20460.

(d) Within ninety days of receipt by the Regional Administrator of an application for an alternate test procedure, proposed by the responsible person or firm making the discharge, the Regional Administrator shall notify the applicant and the appropriate State agency of approval or rejection, or shall specify the additional information which is required to determine whether to approve the proposed test procedure. Prior to the expiration of such ninety day period, a recommendation providing the scientific and other technical basis for acceptance or rejection will be forwarded to the Regional Administrator by the Alternate Test Procedure Program Coordinator, Washington, DC. A copy of all approval and rejection notifications will be forwarded to the Alternate Test Procedure Program Coordinator, Office of Science and Technology (4303), Office of Water, U.S. Environmental Protection Agency, 1200 Pennsylvania Ave., NW.,

Washington, DC 20460, for the purposes of national coordination.

(e) *Approval for nationwide use.* (1) As expeditiously as is practicable after receipt by the Alternate Test Procedure Program Coordinator, Washington, DC, of an application for an alternate test procedure for nationwide use, the Alternate Test Procedure Program Coordinator, Washington, DC, shall notify the applicant in writing whether the application is complete. If the application is incomplete, the applicant shall be informed of the information necessary to make the application complete.

(2) As expeditiously as is practicable after receipt of a complete package, the Alternate Test Procedure Program Coordinator shall perform any analysis necessary to determine whether the alternate test procedure satisfies the applicable requirements of this part, and the Alternate Test Procedure Program Coordinator shall recommend to the Administrator that he/she approve or reject the application and shall also notify the application of the recommendation.

(3) As expeditiously as practicable, an alternate method determined by the Administrator to satisfy the applicable requirements of this part shall be proposed by EPA for incorporation in subsection 136.3 of 40 CFR part 136. EPA shall make available for review all the factual bases for its proposal, including any performance data submitted by the applicant and any available EPA analysis of those data.

(4) Following a period of public comment, EPA shall, as expeditiously as practicable, publish in the FEDERAL REGISTER a final decision to approve or reject the alternate method.

[38 FR 28760, Oct. 16, 1973, as amended at 41 FR 52785, Dec. 1, 1976; 55 FR 33440, Aug. 15, 1990; 62 FR 30763, June 5, 1997; 72 FR 11239, Mar. 12, 2007]

§ 136.6 Method modifications and analytical requirements.

(a) *Definitions of terms used in this section.*

(1) *Analyst* means the person or laboratory using a test procedure (analytical method) in this Part.

(2) *Chemistry of the method* means the reagents and reactions used in a test

procedure that allow determination of the analyte(s) of interest in an environmental sample.

(3) *Determinative technique* means the way in which an analyte is identified and quantified (e.g., colorimetry, mass spectrometry).

(4) *Equivalent Performance* means that the modified method produces results that meet the QC acceptance criteria of the approved method at this part.

(5) *Method-defined analyte* means an analyte defined solely by the method used to determine the analyte. Such an analyte may be a physical parameter, a parameter that is not a specific chemical, or a parameter that may be comprised of a number of substances. Examples of such analytes include temperature, oil and grease, total suspended solids, total phenolics, turbidity, chemical oxygen demand, and biochemical oxygen demand.

(6) *QC* means “quality control.”

(b) *Method modifications*—(1) *Allowable changes*. Except as set forth in paragraph (b)(3) of this section, an analyst may modify an approved test procedure (analytical method) provided that the chemistry of the method or the determinative technique is not changed, and provided that the requirements of paragraph (b)(2) of this section are met.

(i) Potentially acceptable modifications regardless of current method performance include changes between automated and manual discrete instrumentation; changes in the calibration range (provided that the modified range covers any relevant regulatory limit); changes in equipment such as using similar equipment from a vendor other than that mentioned in the method (e.g., a purge-and-trap device from OIA rather than Tekmar), changes in equipment operating parameters such as changing the monitoring wavelength of a colorimeter or modifying the temperature program for a specific GC column; changes to chromatographic columns (treated in greater detail in paragraph (d) of this section); and increases in purge-and-trap sample volumes (provided specifications in paragraph (e) of this section are met). The changes are only allowed provided that all the requirements of paragraph (b)(2) of this section are met.

(ii) If the characteristics of a wastewater matrix prevent efficient recovery of organic pollutants and prevent the method from meeting QC requirements, the analyst may attempt to resolve the issue by using salts as specified in *Guidance on Evaluation, Resolution, and Documentation of Analytical Problems Associated with Compliance Monitoring* (EPA 821-B-93-001, June 1993), provided that such salts do not react with or introduce the target pollutant into the sample (as evidenced by the analysis of method blanks, laboratory control samples, and spiked samples that also contain such salts) and that all requirements of paragraph (b)(2) of this section are met. Chlorinated samples must be dechlorinated prior to the addition of such salts.

(iii) If the characteristics of a wastewater matrix result in poor sample dispersion or reagent deposition on equipment and prevents the analyst from meeting QC requirements, the analysts may attempt to resolve the issue by adding an inert surfactant (*i.e.* a surfactant that will not affect the chemistry of the method), which may include Brij-35 or sodium dodecyl sulfate (SDS), provided that such surfactant does not react with or introduce the target pollutant into the sample (as evidenced by the analysis of method blanks, laboratory control samples, and spiked samples that also contain such surfactant) and that all requirements of paragraph (b)(2) of this section are met. Chlorinated samples must be dechlorinated prior to the addition of such surfactant.

(2) *Requirements*. A modified method must produce equivalent performance to the approved methods for the analyte(s) of interest, and the equivalent performance must be documented.

(i) *Requirements for establishing equivalent performance*

(A) If the approved method contains QC tests and QC acceptance criteria, the modified method must use these QC tests and the modified method must meet the QC acceptance criteria. The Analyst may only rely on QC tests and QC acceptance criteria in a method if it includes wastewater matrix QC tests and QC acceptance criteria (e.g., as matrix spikes) and both initial (start-up)

and ongoing QC tests and QC acceptance criteria.

(B) If the approved method does not contain QC tests and QC acceptance criteria, or if the QC tests and QC acceptance criteria in the method do not meet the requirements of paragraph (b)(2)(i)(A) of this section, the analyst must employ QC tests specified in *Protocol for EPA Approval of Alternate Test Procedures for Organic and Inorganic Analytes in Wastewater and Drinking Water* (EPA-821-B-98-002, March 1999) and meet the QC provisions specified therein. In addition, the Analyst must perform on-going QC tests, including assessment of performance of the modified method on the sample matrix (e.g., analysis of a matrix spike/matrix spike duplicate pair for every twenty samples of a discharge analyzed), and analysis of an ongoing precision and recovery sample and a blank with each batch of 20 or fewer samples.

(C) Calibration must be performed using the modified method and the modified method must be tested with every wastewater matrix to which it will be applied (up to nine distinct matrices; as described in the ATP Protocol, after validation in nine distinct matrices, the method may be applied to all wastewater matrices), in addition to any and all reagent water tests. If the performance in the wastewater matrix or reagent water does not meet the QC acceptance criteria the method modification may not be used.

(D) Analysts must test representative effluents with the modified method, and demonstrate that the results are equivalent or superior to results with the unmodified method.

(ii) *Requirements for documentation.* The modified method must be documented in a method write-up or an addendum that describes the modification(s) to the approved method. The write-up or addendum must include a reference number (e.g., method number), revision number, and revision date so that it may be referenced accurately. In addition, the organization that uses the modified method must document the results of QC tests and keep these records, along with a copy of the method write-up or addendum, for review by an auditor.

(3) *Restrictions.* An analyst may not modify an approved analytical method for a method-defined analyte. In addition, an analyst may not modify an approved method if the modification would result in measurement of a different form or species of an analyte (e.g., a change to a metals digestion or total cyanide distillation). An analyst may also may not modify any sample preservation and/or holding time requirements of an approved method.

(c) *Analytical requirements for multi-analyte methods (Target Analytes).* For the purpose of NPDES reporting, the discharger or permittee must meet QC requirements only for the analyte(s) being measured and reported under the NPDES permit.

(d) The following modifications to approved methods are authorized in the circumstances described below:

(1) *Capillary column.* Use of a capillary (open tubular) GC column rather than a packed column is allowed with EPA Methods 601-613, 624, 625, and 1624B in Appendix A to this part, provided that all QC tests for the approved method are performed and all QC acceptance criteria are met. When changing from a packed column to a capillary column, retention times will change. Analysts are not required to meet retention time specified in the approved method when this change is made. Instead, analysts must generate new retention time tables with capillary columns to be kept on file along with other startup test and ongoing QC data, for review by auditors.

(2) *Increased sample volume in purge and trap methodology.* Use of increased sample volumes, up to a maximum of 25 mL, is allowed for an approved method, provided that the height of the water column in the purge vessel is at least 5 cm. The analyst should also use one or more surrogate analytes that are chemically similar to the analytes of interest in order to demonstrate that the increased sample volume does not adversely affect the analytical results.

[72 FR 11239, Mar. 12, 2007]

¹ Native/labeled.
² Analysis of this pollutant is approved only for the Centralized Waste Treatment industry.
³ Analysis of this pollutant is approved only for the Centralized Waste Treatment and Landfills industries.

TABLE 6—ACID EXTRACTABLE COMPOUND CHARACTERISTIC M/Z'S

Compound	Labeled Ana- log	Primary m/z ¹
p-cresol ²	d ₇	108/116

m/z = mass to charge ratio.
¹ Native/labeled.
² Analysis of this pollutant is approved only for the Centralized Waste Treatment and Landfills industries.

TABLE 7—ACCEPTANCE CRITERIA FOR PERFORMANCE TESTS

EGD No.	Compound	Acceptance criteria			Calibration verification sec. 12.5 µg/mL	On-going accuracy sec. 12.7 R (µg/L)
		Initial precision and accu- racy section 8.2 (µg/L)		Labeled compound recovery sec. 8.3 and 14.2 F (percent)		
		s (µg/L)	X			
758	acetophenone ¹	34	44-167	.....	85-115	45-162
658	acetophenone-d ₅ ¹	51	23-254	45-162	85-115	22-264
757	aniline ²	32	30-171	.....	85-115	33-154
657	aniline-d ₇ ²	71	15-278	33-154	85-115	12-344
771	o-cresol ¹	40	31-226	.....	85-115	35-196
671	o-cresol-d ₇ ¹	23	30-146	35-196	85-115	31-142
1744	p-cresol ²	59	54-140	.....	85-115	37-203
1644	p-cresol-d ₇ ²	22	11-618	37-203	85-115	16-415
578	2,3-dichloroaniline ¹	13	40-160	.....	85-115	44-144
1330	pyridine ²	28	10-421	.....	83-117	18-238
1230	pyridine-d ₅ ²	ns	7-392	19-238	85-115	4-621

s = Standard deviation of four recovery measurements.
X = Average recovery for four recovery measurements.
EGD = Effluent Guidelines Division.
ns = no specification; limit is outside the range that can be measured reliably.
¹ Analysis of this pollutant is approved only for the Centralized Waste Treatment industry.
² Analysis of this pollutant is approved only for the Centralized Waste Treatment and Landfills industries.

[49 FR 43261, Oct. 26, 1984; 50 FR 692, 695, Jan. 4, 1985, as amended at 51 FR 23702, June 30, 1986; 62 FR 48405, Sept. 15, 1997; 65 FR 3044, Jan. 19, 2000; 65 FR 81295, 81298, Dec. 22, 2000]

APPENDIX B TO PART 136—DEFINITION AND PROCEDURE FOR THE DETERMINATION OF THE METHOD DETECTION LIMIT—REVISION 1.11

Definition

The method detection limit (MDL) is defined 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.

Scope and Application

This procedure is designed for applicability to a wide variety of sample types ranging from reagent (blank) water containing analyte to wastewater containing analyte. The MDL for an analytical procedure may vary as a function of sample type. The procedure requires a complete, specific, and well defined analytical method. It is essential that all sample processing steps of the ana-

lytical method be included in the determination of the method detection limit.

The MDL obtained by this procedure is used to judge the significance of a single measurement of a future sample.

The MDL procedure was designed for applicability to a broad variety of physical and chemical methods. To accomplish this, the procedure was made device- or instrument-independent.

Procedure

1. Make an estimate of the detection limit using one of the following:

- (a) The concentration value that corresponds to an instrument signal/noise in the range of 2.5 to 5.
- (b) The concentration equivalent of three times the standard deviation of replicate instrumental measurements of the analyte in reagent water.
- (c) That region of the standard curve where there is a significant change in sensitivity, i.e., a break in the slope of the standard curve.

(d) Instrumental limitations.

It is recognized that the experience of the analyst is important to this process. However, the analyst must include the above considerations in the initial estimate of the detection limit.

2. Prepare reagent (blank) water that is as free of analyte as possible. Reagent or interference free water is defined as a water sample in which analyte and interferent concentrations are not detected at the method detection limit of each analyte of interest. Interferences are defined as systematic errors in the measured analytical signal of an established procedure caused by the presence of interfering species (interferent). The interferent concentration is presupposed to be normally distributed in representative samples of a given matrix.

3. (a) If the MDL is to be determined in reagent (blank) water, prepare a laboratory standard (analyte in reagent water) at a concentration which is at least equal to or in the same concentration range as the estimated method detection limit. (Recommend between 1 and 5 times the estimated method detection limit.) Proceed to Step 4.

(b) If the MDL is to be determined in another sample matrix, analyze the sample. If the measured level of the analyte is in the recommended range of one to five times the estimated detection limit, proceed to Step 4.

If the measured level of analyte is less than the estimated detection limit, add a known amount of analyte to bring the level of analyte between one and five times the estimated detection limit.

If the measured level of analyte is greater than five times the estimated detection limit, there are two options.

(1) Obtain another sample with a lower level of analyte in the same matrix if possible.

(2) The sample may be used as is for determining the method detection limit if the analyte level does not exceed 10 times the MDL of the analyte in reagent water. The variance of the analytical method changes as the analyte concentration increases from the MDL, hence the MDL determined under

these circumstances may not truly reflect method variance at lower analyte concentrations.

4. (a) Take a minimum of seven aliquots of the sample to be used to calculate the method detection limit and process each through the entire analytical method. Make all computations according to the defined method with final results in the method reporting units. If a blank measurement is required to calculate the measured level of analyte, obtain a separate blank measurement for each sample aliquot analyzed. The average blank measurement is subtracted from the respective sample measurements.

(b) It may be economically and technically desirable to evaluate the estimated method detection limit before proceeding with 4a. This will: (1) Prevent repeating this entire procedure when the costs of analyses are high and (2) insure that the procedure is being conducted at the correct concentration. It is quite possible that an inflated MDL will be calculated from data obtained at many times the real MDL even though the level of analyte is less than five times the calculated method detection limit. To insure that the estimate of the method detection limit is a good estimate, it is necessary to determine that a lower concentration of analyte will not result in a significantly lower method detection limit. Take two aliquots of the sample to be used to calculate the method detection limit and process each through the entire method, including blank measurements as described above in 4a. Evaluate these data:

(1) If these measurements indicate the sample is in desirable range for determination of the MDL, take five additional aliquots and proceed. Use all seven measurements for calculation of the MDL.

(2) If these measurements indicate the sample is not in correct range, reestimate the MDL, obtain new sample as in 3 and repeat either 4a or 4b.

5. Calculate the variance (S^2) and standard deviation (S) of the replicate measurements, as follows:

$$S^2 = \frac{1}{n-1} \left[\frac{\sum_{i=1}^n x_i^2 - \left(\frac{\sum_{i=1}^n x_i}{n} \right)^2}{n} \right]$$

$$s = (S^2)^{\frac{1}{2}}$$

where:

X_i ; $i=1$ to n , are the analytical results in the final method reporting units obtained from

the n sample aliquots and Σ refers to the sum of the X values from i=1 to n.

6. (a) Compute the MDL as follows:

$$MDL = T_{(n-1, 1-\alpha=0.99)} (S)$$

where:

MDL = the method detection limit

$t_{(n-1, 1-\alpha=0.99)}$ = the students' t value appropriate for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom. See Table.

S = standard deviation of the replicate analyses.

(b) The 95% confidence interval estimates for the MDL derived in 6a are computed according to the following equations derived from percentiles of the chi square over degrees of freedom distribution (χ^2/df).

LCL = 0.64 MDL

UCL = 2.20 MDL

where: LCL and UCL are the lower and upper 95% confidence limits respectively based on seven aliquots.

7. Optional iterative procedure to verify the reasonableness of the estimate of the MDL and subsequent MDL determinations.

(a) If this is the initial attempt to compute MDL based on the estimate of MDL formulated in Step 1, take the MDL as calculated in Step 6, spike the matrix at this calculated MDL and proceed through the procedure starting with Step 4.

(b) If this is the second or later iteration of the MDL calculation, use S^2 from the current MDL calculation and S^2 from the previous MDL calculation to compute the F-ratio. The F-ratio is calculated by substituting the larger S^2 into the numerator S^2_A and the other into the denominator S^2_B . The computed F-ratio is then compared with the F-ratio found in the table which is 3.05 as follows: if $S^2_A/S^2_B < 3.05$, then compute the pooled standard deviation by the following equation:

$$S_{\text{pooled}} = \left[\frac{6S_A^2 + 6S_B^2}{12} \right]^{1/2}$$

if $S^2_A/S^2_B > 3.05$, respike at the most recent calculated MDL and process the samples through the procedure starting with Step 4. If the most recent calculated MDL does not permit qualitative identification when samples are spiked at that level, report the MDL as a concentration between the current and previous MDL which permits qualitative identification.

(c) Use the S_{pooled} as calculated in 7b to compute The final MDL according to the following equation:

MDL=2.681 (S_{pooled})

where 2.681 is equal to $t_{(12, 1-\alpha=0.99)}$.

(d) The 95% confidence limits for MDL derived in 7c are computed according to the following equations derived from percentiles of the chi squared over degrees of freedom distribution.

LCL=0.72 MDL

UCL=1.65 MDL

where LCL and UCL are the lower and upper 95% confidence limits respectively based on 14 aliquots.

TABLES OF STUDENTS' T VALUES AT THE 99 PERCENT CONFIDENCE LEVEL

Number of replicates	Degrees of freedom (n-1)	$t_{(n-1, .99)}$
7	6	3.143

TABLES OF STUDENTS' T VALUES AT THE 99 PERCENT CONFIDENCE LEVEL—Continued

Number of replicates	Degrees of freedom (n-1)	$t_{(n-1, .99)}$
8	7	2.998
9	8	2.896
10	9	2.821
11	10	2.764
16	15	2.602
21	20	2.528
26	25	2.485
31	30	2.457
61	60	2.390
00	00	2.326

Reporting

The analytical method used must be specifically identified by number or title and the MDL for each analyte expressed in the appropriate method reporting units. If the analytical method permits options which affect the method detection limit, these conditions must be specified with the MDL value. The sample matrix used to determine the MDL must also be identified with MDL value. Report the mean analyte level with the MDL and indicate if the MDL procedure was iterated. If a laboratory standard or a sample that contained a known amount analyte was used for this determination, also report the mean recovery.

If the level of analyte in the sample was below the determined MDL or exceeds 10 times the MDL of the analyte in reagent water, do not report a value for the MDL.

[49 FR 43430, Oct. 26, 1984; 50 FR 694, 696, Jan. 4, 1985, as amended at 51 FR 23703, June 30, 1986]

APPENDIX C TO PART 136—INDUCTIVELY COUPLED PLASMA—ATOMIC EMISSION SPECTROMETRIC METHOD FOR TRACE ELEMENT ANALYSIS OF WATER AND WASTES METHOD 200.7

1. *Scope and Application*

1.1 This method may be used for the determination of dissolved, suspended, or total elements in drinking water, surface water, and domestic and industrial wastewaters.

1.2 Dissolved elements are determined in filtered and acidified samples. Appropriate steps must be taken in all analyses to ensure that potential interferences are taken into account. This is especially true when dissolved solids exceed 1500 mg/L. (See Section 5.)

1.3 Total elements are determined after appropriate digestion procedures are performed. Since digestion techniques increase the dissolved solids content of the samples, appropriate steps must be taken to correct for potential interference effects. (See Section 5.)

1.4 Table 1 lists elements for which this method applies along with recommended wavelengths and typical estimated instrumental detection limits using conventional pneumatic nebulization. Actual working detection limits are sample dependent and as the sample matrix varies, these concentrations may also vary. In time, other elements may be added as more information becomes available and as required.

1.5 Because of the differences between various makes and models of satisfactory instruments, no detailed instrumental operating instructions can be provided. Instead, the analyst is referred to the instruction provided by the manufacturer of the particular instrument.

2. *Summary of Method*

2.1 The method describes a technique for the simultaneous or sequential multielement determination of trace elements in solution. The basis of the method is the measurement of atomic emission by an optical spectroscopic technique. Samples are nebulized and the aerosol that is produced is transported to the plasma torch where excitation occurs. Characteristic atomic-line emission spectra are produced by a radio-frequency inductively coupled plasma (ICP). The spectra are dispersed by a grating spectrometer and the intensities of the lines are

monitored by photomultiplier tubes. The photocurrents from the photomultiplier tubes are processed and controlled by a computer system. A background correction technique is required to compensate for variable background contribution to the determination of trace elements. Background must be measured adjacent to analyte lines on samples during analysis. The position selected for the background intensity measurement, on either or both sides of the analytical line, will be determined by the complexity of the spectrum adjacent to the analyte line. The position used must be free of spectral interference and reflect the same change in background intensity as occurs at the analyte wavelength measured. Background correction is not required in cases of line broadening where a background correction measurement would actually degrade the analytical result. The possibility of additional interferences named in 5.1 (and tests for their presence as described in 5.2) should also be recognized and appropriate corrections made.

3. *Definitions*

3.1 *Dissolved*—Those elements which will pass through a 0.45 μm membrane filter.

3.2 *Suspended*—Those elements which are retained by a 0.45 μm membrane filter.

3.3 *Total*—The concentration determined on an unfiltered sample following vigorous digestion (Section 9.3), or the sum of the dissolved plus suspended concentrations. (Section 9.1 plus 9.2.)

3.4 *Total recoverable*—The concentration determined on an unfiltered sample following treatment with hot, dilute mineral acid (Section 9.4).

3.5 *Instrumental detection limit*—The concentration equivalent to a signal, due to the analyte, which is equal to three times the standard deviation of a series of ten replicate measurements of a reagent blank signal at the same wavelength.

3.6 *Sensitivity*—The slope of the analytical curve, *i.e.*, functional relationship between emission intensity and concentration.

3.7 *Instrument check standard*—A multielement standard of known concentrations prepared by the analyst to monitor and verify instrument performance on a daily basis. (See 7.6.1)

3.8 *Interference check sample*—A solution containing both interfering and analyte elements of known concentration that can be used to verify background and interelement correction factors. (See 7.6.2.)

3.9 *Quality control sample*—A solution obtained from an outside source having known, concentration values to be used to verify the calibration standards. (See 7.6.3)

3.10 *Calibration standards*—A series of known standard solutions used by the analyst for calibration of the instrument (*i.e.*, preparation of the analytical curve). (See 7.4)

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Appendix F. Case Studies

The case studies included in this appendix present some post construction compliance monitoring issues. Please note that inclusion of these case studies does not constitute an endorsement by EPA of the approaches taken in these cases.

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Case Study: Flushing Bay, New York

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New York State Department of Environmental Conservation

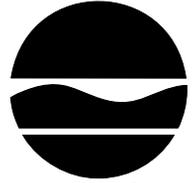
Division of Water

Bureau of Water Compliance, 4th Floor

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Alexander B. Grannis
Commissioner

December 18, 2007

Mr. James G. Mueller, P.E.
Director
Facilities Planning and Design
Bureau of Engineering Design and Construction
NYC Department of Environmental Protection
59-17 Junction Boulevard
Flushing, New York 11373-5108

Dear Mr. Mueller:

Re: Order on Consent (CSO Order)
DEC Case #CO2-20000107-8
Flushing Bay/Creek and Spring Creek Retention Facilities - Interim Post-
Construction Compliance Monitoring Plans

The Department received your revised Interim Post-Construction Compliance Monitoring (IPCM) Plans for the Flushing Bay/Creek and Spring Creek Retention Facilities on September 5, 2007 which addressed the Departments comments dated July 24, 2007. The Department has an additional specific comment that DEP should address separate from the IPCMs.

In regard to your response to our General Comment #6: DEP expressed concern regarding variability in precipitation dynamics and CSO control performance which may require longer than five years of post-construction monitoring to statistically validate the models. The Department understands that this variability is a concern but believes the data is fundamental to verifying the 1988 rainfall data as the average year in all of the models. The Department plans to review the data and updated models on a five-year basis, including the first five years, as required by the USEPA guidance on Long Term Control Planning. Therefore, DEP must submit a summary of the post construction monitoring and modeling verification, including the data, every five years as a part of the required re-evaluation of the Long Term Control Plans (LTCP). This information will be used to identify areas of significant water quality non-compliance and gaps in the water quality modeling, and measure progress with the LTCP goals.

If you have any questions or concerns regarding this letter, please contact Mr. Gary E. Kline, P.E. at (518) 402-9655.

Sincerely,

Joseph DiMura, P.E.
Director
Bureau of Water Compliance

cc: G. Kline, P.E.
S. McCormick, P.E.
C. Webber, P.E.
S. Crisafulli, Esq.
R. Elburn, P.E., Region 2
T. Burns, P.E., NYS EFC
K. Mahoney, P.E., NYCDEP
P. Young, P.E., Hazen and Sawyer

SM:ab

bc: BWC Daybook

FLUSHING BAY/CREEK INTERIM POST-CONSTRUCTION COMPLIANCE MONITORING PROGRAM

January 25, 2008

Introduction

Post-construction compliance monitoring will be integral to the optimization of the Flushing Bay CSO Retention Facility, providing data for model validation, feedback to facility operations, and an assessment metric for the effectiveness of these facilities. Each year's data set will be compiled and evaluated to refine the understanding of the interaction between Flushing Bay/Creek and the CSO retention facility, with the ultimate goal of fully attaining compliance with current water quality standards or for supporting a UAA to revise such standards. The data collection monitoring will contain three basic components:

1. The CSO retention facility monitoring requirements contained in the Tallman Island WPCP SPDES permit;
2. NYCDEP Harbor Survey program data collection in Flushing Creek and Flushing Bay; and
3. Modeling of the associated receiving waters to characterize water quality.

The Flushing Bay CSO Retention Facility was placed into service in the spring of 2007, and monitoring in Flushing Bay/Creek has already commenced. The Flushing Bay/Creek Interim Post-Construction Compliance Monitoring Program is described herein at the direction of NYSDEC to provide documentation of the interim program. The full details of the program are being developed under the City-Wide LTCP, including monitoring and laboratory protocols, QA/QC, and other aspects, to ensure adequate spatial coverage, consistency, and a technically sound sampling program for the entire New York Harbor. The details provided herein are limited to the Flushing Bay/Creek Interim Post-Construction Compliance Monitoring Program and may be modified as the City-Wide program takes form. Any further modifications to the Monitoring Program will be submitted to NYSDEC for review and approval as part of the drainage specific LTCPs.

SPDES Facility Monitoring Requirements

The Tallman Island WPCP SPDES Permit requires monitoring of certain effluent overflow parameters at the Flushing Bay CSO Retention Facility, a CSO regional facility that discharges to outfall TI-010. Such monitoring results will be reported on a monthly basis as an addendum to the Tallman Island WPCP monthly operating report, and on an annual basis in the CSO BMP report. Sampling results and summary statistics will be provided in the monthly operating report, including the number of overflow events, the volume of overflow during each event, and the volume retained and pumped to the Tallman Island WPCP. Table 1 summarizes the relevant permit-required parameters from the current SPDES permit.

Receiving Water Monitoring

The New York City Harbor Survey primarily measures four parameters related to water quality: dissolved oxygen, fecal coliform, chlorophyll “a”, and secchi depth. These parameters have been used by the City to identify historical and spatial trends in water quality throughout New York Harbor. Secchi depth and chlorophyll “a” have been monitored since 1986; DO and fecal coliform have been monitored since before 1972. Recently, enterococci analysis has been added to the program. Except for secchi depth and pathogens, each parameter is collected and analyzed at surface and bottom locations, which are three feet from the surface and bottom, respectively, to eliminate influences external to the water column chemistry itself, such as wind and precipitation influences near the surface or benthic and near-bottom suspended sediments and aquatic vegetation near the bottom. Pathogens are analyzed in surface samples only. NYCDEP regularly samples 33 open water stations annually, which is supplemented each year with approximately 20 rotating tributary stations or periodic special stations sampled in coordination with capital projects, planning, changes in facility operation, or in response to regulatory changes.

The post-construction compliance monitoring program will continue along the protocols of the Harbor Survey initially, including laboratory protocols listed in Table 2. As shown on Figure 1, Flushing Creek contains two locations (mid-channel and mouth) that were added to the Harbor Survey program in the fall of 2006 in anticipation of the CSO Retention Facility coming on-line. In addition, three stations in Flushing Bay will be monitored regularly, in part to provide boundary water quality conditions and benchmarking for observed changes in Flushing Bay water quality during the survey. All stations related to the Interim Flushing Bay Post-Construction Monitoring Program will be sampled a minimum of twice per month from May through September and a minimum of once per month during the remainder of the year. The program commenced monitoring in May 2007. Sampling stations FLC1, FLC2, and E15 may be covered with ice during cold weather. DEP personnel will not be engaging in sampling where access is restricted by ice conditions.

Data collected during this program will be used primarily to verify the East River Tributaries Model (ERTM) that will be used to demonstrate relative compliance levels in Flushing Bay. Therefore, during each annual cycle of compliance monitoring, the data collected will be evaluated for its utility in model verification, and stations may be added, eliminated, or relocated depending on this evaluation. Similarly, the parameters measured will be evaluated for their utility and appropriateness for verifying the receiving water model calibration. At a minimum, the program will collect those parameters with numeric WQS (i.e., DO, fecal coliform, and enterococci). In addition, moored instrumentation may be added or substituted at one or more of these locations if continuous monitoring is determined to be beneficial to model verification, or if logistical considerations preclude the routine operation of the program (navigational limits, laboratory issues, etc.).

Floatables Monitoring

The Flushing Bay/Creek Interim Post-Construction Compliance Monitoring Program incorporates by reference the City-Wide Comprehensive CSO Floatables Plan Modified Facility Planning Report (NYCDEP, 2005a) and Addendum I – Pilot Floatables Monitoring Program

(December 2005) to the Floatables Plan. These documents contain a conceptual framework for the monitoring of floatables conditions in New York Harbor and a work plan for the ongoing pilot program to develop and test the monitoring methodology envisioned in the framework before the program transitions to full scale in 2008. The objectives set forth in the Floatables Plan provides a metric for LTCP performance, and floatables monitoring will be conducted in conjunction with post-construction compliance monitoring with regard to staffing, timing, and location of monitoring sites. The program will include the collection of basic floatables presence / absence data from monitoring sites throughout the harbor that will be used to rate and track floatables conditions, correlate rating trends to floatables control programs where applicable, and trigger investigations into the possible causes of consistently poor ratings should they occur. Actions based on the floatables monitoring data and investigations could include short-term remediation in areas where monitored floatables conditions create acute human or navigation hazards and, as appropriate, longer-term remediation actions and modifications to the Flushing Bay/Creek Waterbody/Watershed Facility Plan if monitored floatables trends indicate impairment of waters relative to their intended uses.

Meteorological Conditions

The performance of any CSO control facility cannot be fully evaluated without a detailed analysis of precipitation, including the intensity, duration, total rainfall volume, and precipitation event distribution that led to an overflow or, conversely, the statistical bounds within which the facility may be expected to control CSO completely. NYCDEP has established 1988 as representative of long-term average conditions and therefore uses it for analyzing facilities where “typical” conditions (rather than extreme conditions) serve as the basis for design. The comparison of rainfall records at JFK airport from 1988 to the long-term rainfall record is shown in Table 3, and includes the return period for 1988 conditions.

In addition to its aggregate statistics indicating that 1988 was representative of overall long-term average conditions, 1988 also includes critical rainfall conditions during both recreational and shellfishing periods. Further, the average storm intensity for 1988 is greater than one standard deviation from the mean so that using 1988 as a design rainfall year would be conservative with regard to water quality impacts since CSOs and stormwater discharges are driven primarily by rainfall intensity. However, considering the complexity and stochastic nature of rainfall, selection of any year as “typical” is ultimately qualitative, and performance is not expected to simply correlate to annual rainfall volume or any other single statistic. The performance of the Flushing Bay CSO Retention Facility and the response of Flushing Bay with respect to widely varying precipitation conditions will be evaluated with respect to observed rainfall, and will be summarized in a manner similar to that shown in Table 3.

Multiple Sources of rainfall data will be compiled as part of the final City-Wide Post-Construction Monitoring Program. On an interim basis, however, the primary source of rainfall data will be from La Guardia Airport and from any NYCDEP gauges that may be available. The use of NEXRAD cloud reflectivity data as proposed in the Waterbody/Watershed Facility Plan will be limited to testing implementation techniques until its utility is fully understood. Any data sets determined to be of limited value in the analysis of compliance may be discontinued.

Analysis

The performance of the Flushing Bay CSO Retention Facility will be evaluated on an annual basis using a landside mathematical computer model as approved by NYSDEC. In addition, NYCDEP believes that the analysis of water quality compliance is best accomplished using computer modeling supported and verified with a water quality monitoring program. Modeling has several advantages over monitoring:

1. Modeling provides a comprehensive vertical, spatial, and temporal coverage that cannot reasonably be equaled with a monitoring program;
2. Modeling provides the data volume necessary to compute aggregate statistical compliance values, such as a geometric mean, an absolute limit (e.g., “never-less-than” or “not-to-exceed”), or a cumulative statistic (e.g., the 66-day deficit-duration standard for dissolved oxygen to be promulgated by NYSDEC in the near future);
3. Discrete grab sampling for data collection is necessarily biased to locations and periods of logistical advantage, such as navigable waters, safe weather conditions, daylight hours, etc.; and
4. Quantification of certain chemical parameters must be performed in a laboratory setting which either (a) complicates the use of a smaller sampling vessel that is necessary to access shallower waters not navigable by a vessel with on-board laboratory facilities or (b) limits the number sampling locations that can be accessed due to holding times and other laboratory quality assurance requirements if remote laboratory (non-vessel mounted) facilities are used.

The InfoWorks collection system model of the Tallman Island WPCP service area was developed under the LTCP project based in part on historical models used in facility planning. InfoWorks is a state-of-the-art modeling package that includes the ability to represent retention tank dynamics, hydraulic analyses and other sophisticated aspects of performance within the collection system. Overflow volumes will be quantitatively analyzed on a monthly basis to isolate any periods of performance issues and their impact on water quality. Water quality modeling re-assessment will be conducted every two years based on the previous two years water quality field data. Modeling conditions will be based on the hydrodynamic and meteorological conditions for the study year, documented operational issues that may have impacted the facility performance, and water quality boundary conditions based on the Harbor Survey data from outside Flushing Bay. Results will be compared to the Harbor Survey data collected within Flushing Bay and Creek to validate the water quality modeling system, and performance will be expressed in a quantitative attainment level for applicable numerical criteria based on the receiving water model. Should this analysis indicate that progress towards the desired results is not being made, the analysis will:

- Re-verify all model inputs, collected data and available QA/QC reports;
- Consult with operations personnel to ensure unusual operational problems (e.g., screening channel o/s, pump repair, etc.) were adequately documented;
- Evaluate specific periods of deviations from modeled performance.

- Confirm that all operational protocols were implemented, and that these protocols are sufficient to avoid operationally-induced underperformance;
- Re-evaluate protocols as higher frequency and routine problems reveal themselves; and finally
- Revise protocols as appropriate and conduct Use Attainability Analysis (UAA) and if necessary, revise LTCP.

Because of the dynamic nature of water quality standards and approaches to non-compliance conditions, a period of ten years of operation will be necessary to generate the minimal amount of data necessary to perform meaningful statistical analyses for water quality standards review and for any formal use attainability analysis (UAA) that may be indicated. Following completion of the tenth annual report containing data during facility operation, a more detailed evaluation of the capability of the Flushing Bay CSO Retention Facility to achieve the desired water quality goals will take place, with appropriate weight given to the various issues New York City identified during the evaluations documented in the annual reports. If it is determined that the desired results are not achieved, NYCDEP will revisit the feasibility of cost-effective improvements. Alternately, the water quality standards revision process may commence with a UAA that would likely rely in part on the findings of the post-construction compliance monitoring program. The approach to future improvements beyond the 10-year post-construction monitoring program will be dictated by the findings of that program as well as the input from NYSDEC SPDES permit and CSO Consent Order administrators. This schedule is not intended to contradict the 5-year cycle used for updating SPDES permits.

Reporting

Post-construction compliance monitoring will be added to the annual BMP report submitted by NYCDEP in accordance with their SPDES permits. The monitoring report will include an overview of the performance of the Flushing Bay CSO Retention Facility, although the official facility overflow reporting will remain in the monthly operating report as required by the SPDES permits. Summary statistics on rainfall, the amount of combined sewage, and the proportions directed to the WPCP, passed through the facility overflow, and bypassed above the head end of the facility will be provided in the Annual BMP Report. Verification and refinement of the model framework as necessary will be documented, and modeling results will be presented to assess water quality impacts in lieu of high-resolution sampling. Analyses of precipitation, temperature effects, and other conditions external to the CSO Facility performance will also be included in the Annual BMP Report.

In addition to the information to be provided in the Annual BMP Report, NYCDEP will submit a summary of the monitoring and modeling, including the data, once every five years. NYSDEC has acknowledged that the variability in precipitation dynamics may require more than five successive years of data to statistically validate the models used for evaluating compliance, but have nonetheless stated that this information will be used to identify areas of significant water quality non-compliance and gaps in the water quality modeling, and measure progress with the LTCP goals. They have also stated that they intend to verify the 1988 rainfall data as the "average" year.

Table 1. SPDES Permit Monitoring Parameters

PARAMETER	REPORT	UNITS	FREQUENCY	TYPE	NOTE
Overflow Volume	Event total	MG	Per event	Calculated	-
Retained Volume	Monthly total	MG	Per month	Totalized	Flow to WPCP
BOD, 5-day	Event average	mg/L	Per event-day	Composite	Every 4 hr
TSS	Event average	mg/L	Per event-day	Composite	Every 4 hr
Settleable Solids	Event average	ml/L	Per event-day	Grab	Every 4 hr when manned
Oil & Grease	Event average	mg/L	Per event-day	Grab	-
Screenings	Monthly total	cu. yd	---	Calculated	-
Fecal Coliform	Event geo. mean	No/100mL	Per event-day	Grab	Every 4 hr when manned
Precipitation	Event total	inches	Hourly	Rain Gauge	-

See most recent Tallman Island WPCP SPDES Permit (NY0026239) for exact descriptions and definitions.

Table 2. Current Harbor Survey Laboratory Protocols

Parameter	Method
Ammonia (as N)	EPA 350.1
Chlorophyll 'a'	EPA 445.0, modified for the Welschmeyer Method
Dissolved Oxygen	SM 4500-O C, Azide Modification (Winkler Method)
Dissolved Silica	SM 18-19 4500-Si D or USGS I-2700-85
Enterococcus	EPA Method 1600, Membrane Filter
Fecal Coliform	SM 18-20 9222D, Membrane Filter
Nitrate (as N)	EPA 353.2 or SM 18-20 4500-NO ₃ F
Orthophosphate (as P)	EPA 365.1
pH	SM 4500-H B, Electrometric Method
Total Kjeldahl Nitrogen	EPA 351.2
Total Phosphorus	EPA 365.4
Total Suspended Solids	SM 18-20 2540D

Notes: SM – Standard Methods for the Examination of Water and Wastewater; EPA – EPA's Sampling and Analysis Methods. Field instrumentation also includes an SBE 911 Sealogger CTD which collects salinity, temperature, and conductivity, among other parameters.

Table 3. Rainfall Statistics, JFK Airport, 1988 and Long-Term Average

Statistic	1970-2002 Median	1988	
		Value	Return Period (years)
Total Volume (inches)	39.4	40.7	2.6
Intensity, (in/hr)	0.057	0.068	11.3
Number of Storms	112	100	1.1
Storm Duration (hours)	6.08	6.12	2.1

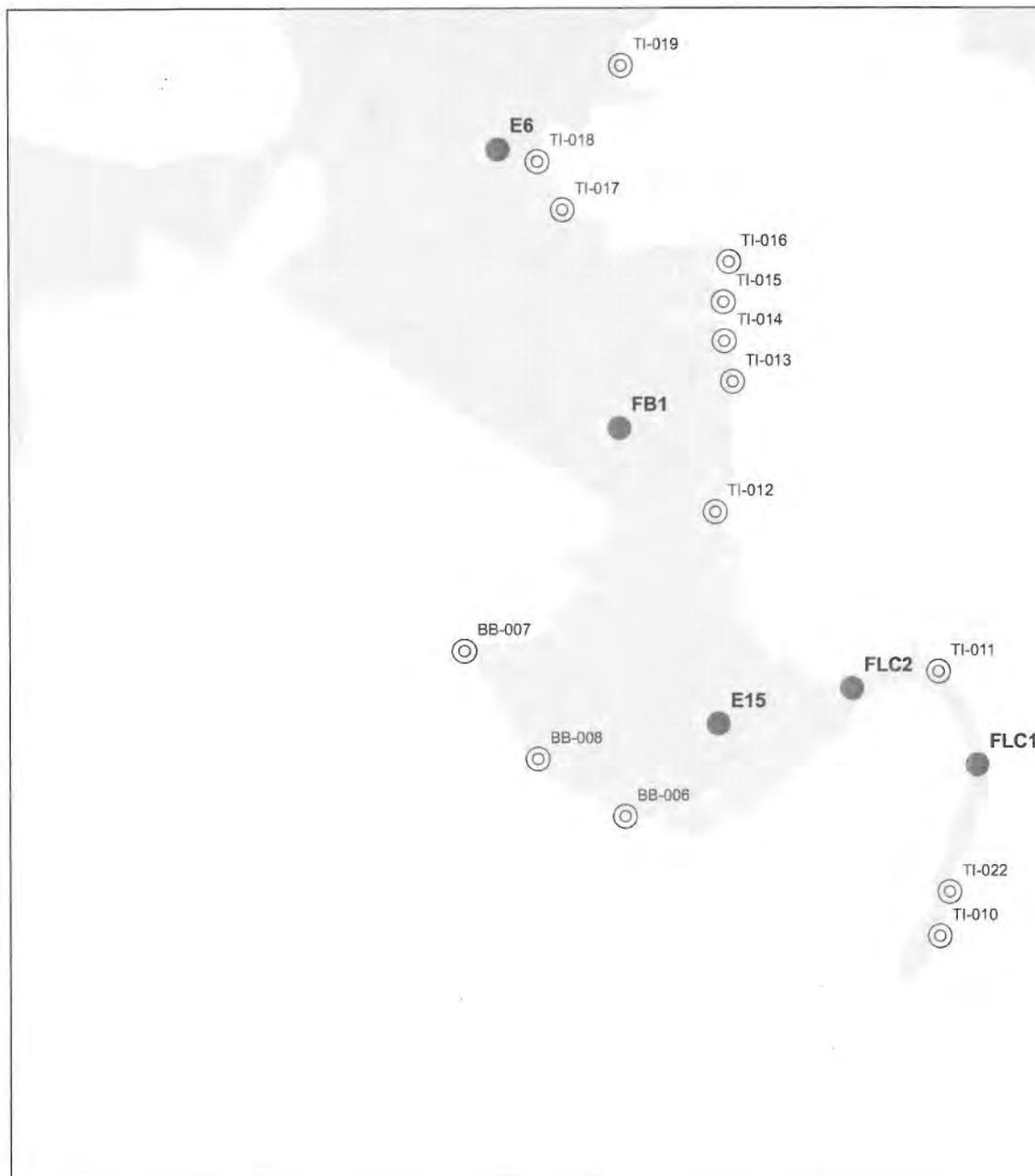


Figure 1. Harbor Survey Sampling Locations to be incorporated into Flushing Bay Interim Post-Construction Monitoring Program

SPRING CREEK INTERIM POST-CONSTRUCTION COMPLIANCE MONITORING PROGRAM

January 25, 2008

Introduction

The Spring Creek Interim Post-Construction Compliance Monitoring Program will be integral to the optimization of the Spring Creek Auxiliary Water Pollution Control Plant (AWPCP), providing data for model validation, feedback to facility operations, and an assessment metric for the effectiveness of these facilities. Each year's data set will be compiled and evaluated to refine the understanding of the interaction between Spring Creek and the CSO controls, with the ultimate goal of fully attaining compliance with current water quality standards or for supporting a UAA to revise such standards. The data collection monitoring will contain three basic components:

1. The CSO Facility monitoring requirements contained in the 26th Ward WPCP SPDES permit;
2. Receiving water data collection in Spring Creek and Jamaica Bay using existing NYCDEP Harbor Survey locations and adding stations as necessary; and
3. Modeling of the associated receiving waters to characterize water quality.

The improvements to the Spring Creek Auxiliary Water Pollution Control Plant were substantially completed by the spring of 2007, and monitoring in Spring Creek has already commenced. The Spring Creek Interim Post-Construction Compliance Monitoring Program is described herein at the direction of NYSDEC to provide documentation of the interim program. The full details of the program are being developed under the City-Wide LTCP, including monitoring and laboratory protocols, QA/QC, and other aspects, to ensure adequate spatial coverage, consistency, and a technically sound sampling program for the entire New York Harbor. The details provided herein are limited to the Spring Creek Interim Post-Construction Compliance Monitoring Program and may be modified as the City-Wide program takes form. Any further modifications to the Monitoring Program will be submitted to NYSDEC for review and approval as part of the drainage basin specific LTCPs.

SPDES Facility Monitoring Requirements

The 26th Ward WPCP SPDES Permit requires monitoring for certain effluent overflow parameters from the Spring Creek Auxiliary WPCP, a CSO regional facility that discharges to outfall 26-005. This outfall will be monitored in accordance with the SPDES Permit, and results will be reported on a monthly basis as an addendum to the 26th Ward WPCPs monthly operating report, and on an annual basis in the CSO BMP report. Sampling results and summary statistics will be provided in the monthly operating report, including the number of overflow events, the volume of overflow during each event, and the volume retained and pumped to the 26th Ward WPCP. Table 1 summarizes the relevant required parameters from the current SPDES permit.

Receiving Water Monitoring

The post-construction compliance monitoring program will continue along the protocols of the Harbor Survey initially, including laboratory protocols listed in Table 2. This program primarily measures four parameters related to water quality: dissolved oxygen, fecal coliform, chlorophyll a, and secchi depth. These parameters have been used by the City to identify historical and spatial trends in water quality throughout New York Harbor. Secchi depth and chlorophyll a have been monitored since 1986; DO and fecal coliform have been monitored since before 1972. Recently, enterococci analysis has been added to the program. Except for secchi depth and pathogens, each parameter is collected and analyzed at surface and bottom locations, which are three feet from the surface and bottom, respectively, to eliminate influences external to the water column chemistry itself, such as wind and precipitation influences near the surface or benthic and near-bottom suspended sediments and aquatic vegetation near the bottom. Pathogens are analyzed in surface samples only. NYCDEP regularly samples 33 open water stations annually, which is supplemented each year with approximately 20 rotating tributary stations or periodic special stations sampled in coordination with capital projects, planning, changes in facility operation, or in response to regulatory changes.

Historically, the Spring Creek waterbody has not been monitored due primarily to difficult logistics. The waterbody is very shallow and much of it is intertidally dry, rendering it navigationally hazardous. Sampling from the shoreline is infeasible as well because the shallow slopes and surrounding marshland make it virtually impossible to access water with sufficient depth to collect a representative sample. Limited sampling has occurred from the top of the AWPCP discharge structure, but sampling at this location is not believed to be reliably representative of the water quality in the upper reaches of the waterbody.

Because of these limitations, the Harbor Survey has located one station (J8) just outside the mouth of the Creek in Jamaica Bay, as shown on Figure 1. An additional location will be included at the Belt Parkway Bridge, which has a pedestrian path protected from parkway traffic from which sampling can be performed. Spring Creek will be monitored regularly at Station J8 and from the Belt Parkway Bridge, with an additional Jamaica Bay sampling location to be used to provide boundary water quality conditions and benchmarking for observed changes in Spring Creek water quality during the survey. All stations related to the Interim Spring Creek Post-Construction Monitoring Program will be sampled a minimum of twice per month from May through September and a minimum of once per month during the remainder of the year. If sampling stations are covered with ice during cold weather, NYCDEP personnel will not be engaging in sampling where access is restricted by ice conditions. The program commenced monitoring in May 2007.

Data collected during this program will be used primarily to verify the North Channel Model that will be used to demonstrate relative compliance levels in Spring Creek. The North Channel Model was developed from the Jamaica Eutrophication Model (JEM). The hydrodynamic and chemical kinetic processes are computed in the same manner as JEM, but the North Channel Model was constructed specifically to quantify water quality in Spring Creek, Fresh Creek, and Hendrix Creek, so it has a much higher resolution in these areas. The calibrated North Channel Model will be used to measure compliance, and will be verified annually with the post-construction compliance monitoring data collected.

Because the data will be used in this manner, the data collected will be evaluated for its utility in model verification during each annual cycle of compliance monitoring, and stations may be added, eliminated, or relocated depending on this evaluation. Similarly, the parameters measured will be evaluated for their utility and appropriateness for verifying the receiving water model calibration. At a minimum, the program will collect those parameters with numeric WQS (i.e., DO, fecal coliform, and enterococci). In addition, moored instrumentation may be added or substituted at one or more of these locations if continuous monitoring is determined to be beneficial to model verification, or if logistical considerations preclude the routine operation of the program (navigational limits, laboratory issues, etc.).

Floatables Monitoring

The Spring Creek Interim Post-Construction Compliance Monitoring Program incorporates by reference the City-Wide Comprehensive CSO Floatables Plan Modified Facility Planning Report (NYCDEP, 2005a) and Addendum 1 – Pilot Floatables Monitoring Program (December 2005) to the Floatables Plan. These documents contain a conceptual framework for the monitoring of floatables conditions in New York Harbor and a work plan for the ongoing pilot program to develop and test the monitoring methodology envisioned in the framework before the program transitions to full scale in 2008. The objectives set forth in the Floatables Plan provides a metric for LTCP performance, and floatables monitoring will be conducted in conjunction with post-construction compliance monitoring with regard to staffing, timing, and location of monitoring sites. The program will include the collection of basic floatables presence / absence data from monitoring sites throughout the harbor that will be used to rate and track floatables conditions, correlate rating trends to floatables control programs where applicable, and trigger investigations into the possible causes of consistently poor ratings should they occur. Actions based on the floatables monitoring data and investigations could include short-term remediation in areas where monitored floatables conditions create acute human or navigation hazards and, as appropriate, longer-term remediation actions and modifications to the Spring Creek Waterbody/Watershed Facility Plan if monitored floatables trends indicate impairment of waters relative to their intended uses.

Meteorological Conditions

The performance of any CSO control facility cannot be fully evaluated without a detailed analysis of precipitation, including the intensity, duration, total rainfall volume, and precipitation event distribution that led to an overflow or, conversely, the statistical bounds within which the facility may be expected to control CSO completely. NYCDEP has established 1988 as representative of long-term average conditions and therefore uses it for analyzing facilities where “typical” conditions (rather than extreme conditions) serve as the basis for design. The comparison of rainfall records at JFK airport from 1988 to the long-term rainfall record is shown in Table 3, and includes the return period for 1988 conditions.

In addition to its aggregate statistics indicating that 1988 was representative of overall long-term average conditions, 1988 also includes critical rainfall conditions during both recreational and shellfishing periods. Further, the average storm intensity for 1988 is greater than

one standard deviation from the mean so that using 1988 as a design rainfall year would be conservative with regard to water quality impacts since CSOs and stormwater discharges are driven primarily by rainfall intensity. However, considering the complexity and stochastic nature of rainfall, selection of any year as “typical” is ultimately qualitative, and performance is not expected to simply correlate to annual rainfall volume or any other single statistic. The performance of the Spring Creek AWPCP and the response of Spring Creek with respect to widely varying precipitation conditions will be evaluated with respect to observed rainfall, and will be summarized in a manner similar to that shown in Table 3.

Multiple sources of rainfall data will be compiled as part of the final City-Wide Post-Construction Monitoring Program. On an interim basis, however, the primary source of rainfall data will be from JFK Airport and from any NYCDEP gauges that may be available. The use of NEXRAD cloud reflectivity data as proposed in the Waterbody/Watershed Facility Plan will be limited to testing implementation techniques until its utility is fully understood. Any data sets determined to be of limited value in the analysis of compliance may be discontinued.

Analysis

The performance of the Spring Creek AWPCP will be evaluated on an annual basis using a landside mathematical computer model as approved by NYSDEC. In addition, NYCDEP believes that the analysis of water quality compliance is best accomplished using computer modeling supported and verified with a water quality monitoring program. Modeling has several advantages over monitoring:

1. Modeling provides a comprehensive vertical, spatial, and temporal coverage that cannot reasonably be equaled with a monitoring program;
2. Modeling provides the data volume necessary to compute aggregate statistical compliance values, such as a geometric mean, an absolute limit (e.g., “never-less-than” or “not-to-exceed”), or a cumulative statistic (e.g., the 66-day deficit-duration standard for dissolved oxygen to be promulgated by NYSDEC in the near future);
3. Discrete grab sampling for data collection is necessarily biased to locations and periods of logistical advantage, such as navigable waters, safe weather conditions, daylight hours, etc.; and
4. Quantification of certain chemical parameters must be performed in a laboratory setting which either (a) complicates the use of a smaller sampling vessel that is necessary to access shallower waters not navigable by a vessel with on-board laboratory facilities or (b) limits the number sampling locations that can be accessed due to holding times and other laboratory quality assurance requirements if remote laboratory (non-vessel mounted) facilities are used.

The InfoWorks collection system model of the 26th Ward WPCP service area was developed under the LTCP project based in part on historical models used in facility planning. InfoWorks is a state-of-the-art modeling package that includes the ability to represent retention tank dynamics and other sophisticated aspects of performance. Overflow volumes will be quantitatively analyzed on a monthly basis to isolate any periods of performance issues and their

impact on water quality. Water quality modeling re-assessment will be conducted every two years based on the previous two years water quality field data. Modeling conditions will be based on the hydrodynamic and meteorological conditions for the study year, documented operational issues that may have impacted the facility performance, and water quality boundary conditions based on the Harbor Survey data from Jamaica Bay. Results will be compared to the Harbor Survey data collected within Spring Creek to validate the water quality modeling system, and performance will be expressed in a quantitative attainment level for applicable numerical criteria based on the receiving water model. Should this analysis indicate that progress towards the desired results is not being made, the analysis will:

- Re-verify all model inputs, collected data and available QA/QC reports;
- Consult with operations personnel to ensure unusual operational problems (e.g., screening channel o/s, pump repair, etc.) were adequately documented;
- Evaluate specific periods of deviations from modeled performance;
- Confirm that all operational protocols were implemented, and that these protocols are sufficient to avoid operationally-induced underperformance;
- Re-evaluate protocols as higher frequency and routine problems reveal themselves; and finally
- Revise protocols as appropriate and conduct Use Attainability Analysis (UAA) and if necessary, revise LTCP.

Because of the dynamic nature of water quality standards and approaches to non-compliance conditions, a period of ten years of operation will be necessary to generate the minimal amount of data necessary to perform meaningful statistical analyses for water quality standards review and for any formal use attainability analysis (UAA) that may be indicated. Following completion of the tenth annual report containing data during facility operation, a more detailed evaluation of the capability of the Spring Creek AWPCP to achieve the desired water quality goals will take place, with appropriate weight given to the various issues identified during the evaluations documented in the annual reports. If it is determined that the desired results are not achieved, NYCDEP will revisit the feasibility of cost-effective improvements. Alternately, the water quality standards revision process may commence with a UAA that would likely rely in part on the findings of the post-construction compliance monitoring program. The approach to future improvements beyond the 10-year post-construction monitoring program will be dictated by the findings of that program as well as the input from NYSDEC SPDES permit and CSO Consent Order administrators. This schedule is not intended to contradict the 5-year cycle used for updating SPDES permits.

Reporting

Post-construction compliance monitoring will be added to the annual BMP report submitted by NYCDEP in accordance with their SPDES permits. The monitoring report will include an overview of the performance of the Spring Creek AWPCP, although the official facility overflow reporting will remain in the monthly operating report, as required by the SPDES permits. Summary statistics on rainfall, the amount of combined sewage, and the

proportions directed to the WPCP, passed through the facility overflow, and bypassed above the head end of the facility will be provided in the Annual BMP report. Verification and refinement of the model framework as necessary will be documented, and modeling results will be presented to assess water quality impacts in lieu of high-resolution sampling. Analyses of precipitation, temperature effects, and other conditions external to the CSO Facility performance will also be included in the BMP report.

In addition to the information to be provided in the Annual BMP Report, NYCDEP will submit a summary of the monitoring and modeling, including the data, once every five years. NYSDEC has acknowledged that the variability in precipitation dynamics may require more than five successive years of data to statistically validate the models used for evaluating compliance, but have nonetheless stated that this information will be used to identify areas of significant water quality non-compliance and gaps in the water quality modeling, and measure progress with the LTCP goals. They have also stated that they intend to verify the 1988 rainfall data as the "average" year.

Table 1. SPDES Permit Monitoring Parameters

PARAMETER	REPORT	UNITS	FREQUENCY	TYPE	NOTE
Overflow Volume	Event total	MG	Per event	Calculated	-
Retained Volume	Monthly total	MG	Per month	Totalized	Flow to WPCP
BOD, 5-day	Event average	mg/L	Per event-day	Composite	Every 4 hr
TSS	Event average	mg/L	Per event-day	Composite	Every 4 hr
Settleable Solids	Event average	ml/L	Per event-day	Grab	Every 4 hr when manned
Oil & Grease	Event average	mg/L	Per event-day	Grab	-
Screenings	Monthly total	cu. yd	---	Calculated	-
Fecal Coliform	Event geo. mean	No/100mL	Per event-day	Grab	Every 4 hr when manned
Precipitation	Event total	inches	Hourly	Rain Gauge	-

See most recent 26th Ward WPCP SPDES Permit (NY0026212) for exact descriptions and definitions.

Table 2. Current Harbor Survey Laboratory Protocols

Parameter	Method
Ammonia (as N)	EPA 350.1
Chlorophyll 'a'	EPA 445.0, modified for the Welschmeyer Method
Dissolved Oxygen	SM 4500-O C, Azide Modification (Winkler Method)
Dissolved Silica	SM 18-19 4500-Si D or USGS I-2700-85
Enterococcus	EPA Method 1600, Membrane Filter
Fecal Coliform	SM 18-20 9222D, Membrane Filter
Nitrate (as N)	EPA 353.2 or SM 18-20 4500-NO3 F
Orthophosphate (as P)	EPA 365.1
pH	SM 4500-H B, Electrometric Method
Total Kjeldahl Nitrogen	EPA 351.2
Total Phosphorus	EPA 365.4
Total Suspended Solids	SM 18-20 2540D

Notes: SM – Standard Methods for the Examination of Water and Wastewater; EPA – EPA's Sampling and Analysis Methods. Field instrumentation also includes an SBE 911 Sealogger CTD which collects salinity, temperature, and conductivity, among other parameters.

Table 3. Rainfall Statistics, JFK Airport, 1988 and Long-Term Average

Statistic	1970-2002 Median	1988	
		Value	Return Period (years)
Total Volume (inches)	39.4	40.7	2.6
Intensity, (in/hr)	0.057	0.068	11.3
Number of Storms	112	100	1.1
Storm Duration (hours)	6.08	6.12	2.1



Figure 1. Spring Creek IPCM Sampling Locations

Case Study: Northeast Ohio Regional Sewer District

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*United States and State of Ohio v. Northeast Ohio
Regional Sewer District*

Consent Decree
Appendix 2

Post-Construction Monitoring Program

Appendix 2 - Post-Construction Monitoring Program

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- 2.1 Introduction
- 2.2 Performance Criteria
- 2.3 Post-Construction Monitoring and Data Collection
- 2.4 Performance Assessment
- 2.5 Quality Assurance/Quality Control
- 2.6 Progress Reporting
- 2.7 Summary

2.1 Introduction

The purpose of the Post-Construction Monitoring Program (PCMP) is to verify that projects constructed as part of the Long Term Control Plan (LTCP) meet the Performance Criteria stipulated in Table 1.1 of Appendix 1 and the water quality goals established during the development of the CSO Phase II Facilities Plans for the Easterly, Westerly and Southerly combined sewer Districts. Terms used in this Appendix that are defined herein, or in the Consent Decree or any other Appendix thereto shall have the meanings assigned to them in such documents.

NEORS D developed LTCPs for systems tributary to the Easterly, Southerly and Westerly wastewater treatment plants. NEORS D's CSO program was developed with water quality monitoring and modeling components in order to identify water quality impairments attributable to wet weather discharges from the system. The results of these studies were coupled with extensive hydrologic and hydraulic modeling activities to understand the systems' response to wet weather events. In order to calibrate these models, NEORS D also completed several flow monitoring programs to quantify sewer flows. These monitoring programs, model development and application as well as evaluation of control alternatives to meet water quality goals were completed with specific LTCP project recommendations.

The last series of these studies was completed in March 2002 as required by the CSO NPDES Permits for the Easterly and Southerly combined sewer service areas. Following the submission of these plans NEORS D has continued with the design and construction of some of the recommended facilities including early action projects in the Westerly, Easterly and Southerly Districts, and an initial LTCP project in the Easterly District. In addition, NEORS D engaged in negotiations with the United States and Ohio EPAs and the U.S. Department of Justice to agree upon a consent decree that would govern the scope and implementation schedule of the remaining LTCP recommendations.

The recommended LTCP projects depicted in Appendix 1 (treatment facilities, tunnels, pump stations, relief sewers, etc) comprise “Gray Infrastructure” control measures. In addition, NEORS will also be developing “Green Infrastructure” control measures for wet weather control providing stormwater inflow reduction and/or detention to reduce overflow volumes. These control measures have not been developed in terms of location and type(s) of Green Infrastructure control measures although the general performance criteria and conditions for the program are outlined in Appendices 3 and 4. It is NEORS’s intent to implement these Green Infrastructure control measures subsequent to a Green Infrastructure Feasibility Study and concurrent with the LTCP projects as a means to provide additional CSO control and provide for credits where Green Infrastructure can be substituted for Gray Infrastructure control measures, in whole or in part, in accordance with the provisions governing Tier 1b and Green for Gray substitutions under the Consent Decree. If this objective is accomplished, the projects selected will complement the LTCP projects and would be integrated into the PCMP monitoring and evaluation for both the Gray and Green Infrastructure components.

The main elements of the PCMP include the following:

- A process to determine whether the CSO control measures are meeting the Performance Criteria identified in Appendix 1.
- A process for assessing environmental benefits attributable to the CSO control measures.
- A monitoring schedule, initial sampling locations, associated monitoring, modeling procedures to collect data related to the Performance Criteria, and the impacts from CSOs on E. coli levels in CSO impacted receiving streams and Lake Erie; and
- Evaluation and analysis of the monitoring data to determine whether CSO control measures are achieving desired outcomes and for reporting progress to the regulatory agencies and general public.

2.1.1 Regulatory Requirements

U.S.EPA requires CSO communities to conduct a post-construction monitoring program during and after LTCP implementation “to help determine the effectiveness of the overall program in meeting [Clean Water Act] requirements and achieving local water quality goals.”¹ This program should collect data that measure the effectiveness of CSO controls and their impact on water quality, and should utilize existing monitoring stations used in previous studies of the waterways and sewer system in order to compare results to conditions before controls were put in place. The program should include a map of monitoring stations, a record of sampling frequency at each station, a list of data to be collected, and a quality assurance/quality control (QA/QC) plan.

In U.S.EPA’s December 2001 Report to Congress: Implementation and Enforcement of the Combined Sewer Overflow Control Policy, the agency noted the difficulty of establishing a monitoring and tracking program for CSO control programs. “Monitoring programs need to be targeted and implemented in a consistent manner from year to year to be able to establish pre-

¹ *Combined Sewer Overflows, Guidance for Long-Term Control Plan* (EPA 832-B-95-002, August 1995) p. 4-15.

control baseline conditions and to identify meaningful trends over time as CSO controls are implemented,” the report said. “In practice, it is often difficult, and in some instances impossible, to link environmental conditions or results to a single source of pollution, such as CSOs. In most instances, water quality is impacted by multiple sources, and trends over time reflect the change in loadings on a watershed scale from a variety of environmental programs.” The report also noted that weather conditions and rainfall totals vary significantly from storm to storm and year to year, making comparisons difficult.

2.1.2 Purpose and Scope

The Post-Construction Monitoring Program will collect data needed to document receiving streams and Lake Erie improvements that can be attributed to the implementation of the control measures identified in the LTCP, to evaluate whether CSO control measures have met the Performance Criteria, and whether NEORSD’s CSOs comply with the NPDES permits. In order to enable comparisons to historic data, NEORSD will integrate the required CSO post-construction monitoring program into its current monitoring programs. The general scope of the post-construction monitoring program will include preparation and execution of the monitoring plan, as well as evaluation of the effectiveness of CSO control measures. The combined sewer districts included in this plan include the Easterly, Southerly and Westerly Districts. The following receiving waters are covered by this PCMP - Lake Erie, Cuyahoga River, Big Creek, Burke Brook, Doan Brook, Dugway Brook, Euclid Creek, Green Creek Culvert, Kingsbury Run, Morgana Run, Nine Mile Creek, Rocky River, Shaw Brook Culvert, West Creek, Spring Creek and Treadway Creek. The monitoring program has been developed based upon the following scope of work:

- **Document Current Baseline Conditions:** During the CSO Phase II Facilities Plans for the Easterly, Southerly and Westerly Districts, NEORSD performed a comprehensive assessment of the baseline conditions for CSO frequency and volumes for the “typical year” as well as baseline conditions for water quality within the receiving streams and Lake Erie. These assessments will be used as the baseline conditions for comparing the post-construction performance of the various control measures within the LTCP.
- **Identify Parameters of Concern:** NEORSD evaluated CSO control measures to analyze their ability to improve receiving streams and Lake Erie water quality for specific parameters of concern. During the development of the LTCPs and subsequent discussions with the U.S. EPA and Ohio EPA, NEORSD identified E. coli bacteria as the main parameter of concern. NEORSD will use E. coli bacteria to measure the effect of its LTCP CSO control measures on its receiving streams and Lake Erie.
- **Prepare and Execute Post-Construction Monitoring:** The monitoring program will evaluate whether specific CSO control measures are performing as designed and constructed to meet its Performance Criteria. The program will identify how NEORSD will collect data needed to document receiving waters improvements and any pollutant reduction achieved through implementation of these control measures. Sections 2.2 through 2.5 further describe NEORSD’s PCMP.

- Report results to State and Federal Agencies: The results of the PCMP will be reported to the U.S. EPA and the Ohio EPA. Upon completion of each CSO control measure, NEORSD will prepare a Control Measure Report that evaluates whether the constructed projects that comprise that Control Measure have achieved the desired results. Section 2.6 presents NEORSD’s approach for tracking and reporting on the achievement of Performance Criteria described in Table 1.1 of Appendix 1.
- Provide Public Information on Water Quality: Information from the monitoring program will be available to the general Cleveland area public and interested parties. This information will allow the public to be informed and educated relative to NEORSD’s water quality improvement programs and water quality issues.

2.2 Performance Criteria

The Performance Criteria developed during the CSO Control Program by NEORSD were based on number of overflows per a “typical year” as defined in the CSO Phase II Facilities Plans for the Easterly, Southerly and Westerly Districts. The original LTCP recommended numbers of overflows that have been updated through subsequent discussions with the U.S. EPA and the Ohio EPA. Appendix 1 shows the Performance Criteria for the various control measures comprising the current LTCP, design criteria, critical milestones and provides information on outfalls controlled.

2.3 Post-Construction Monitoring and Data Collection

An important element of the PCMP is the type, location and frequency of monitoring. The intent is not to replicate the extent of intense monitoring that was performed during the development of the LTCP. To the extent possible, these monitoring locations will be used again for the performance monitoring. The difference is that density of monitoring locations will be reduced; however, the duration of monitoring will likely be longer on average than what was done during the planning phase. These locations will be reviewed prior to installation of new monitoring for the PCMP. This section describes the various types of monitoring to be performed.

Flow and activation monitoring will be performed for a one-year post-construction monitoring period following “Achievement of Full Operation” for each control measure as indicated in Table 2.1 and discussed in Section 2.3.1, and CSO activation monitoring will again be performed for a one year period following implementation of all Control Measures for each district (Easterly, Southerly, Westerly).

In-stream monitoring will be performed on a continued system-wide basis for the duration of the LTCP implementation beginning at the Achievement of Full Operation of the first control measure to monitor stream improvements over time, as discussed in Section 2.3.2.

General performance criteria and monitoring approaches for the green infrastructure projects will be integrated into the PCMP during planning of the green infrastructure projects as discussed in Appendices 3 and 4.

2.3.1 Flow Monitoring

Numerous temporary flow monitors were installed during the development of the CSO LTCP to calibrate the hydraulic models. These monitors have since been removed. NEORSRD will install flow and/or activation monitors at numerous locations and utilize, where applicable, existing permanent flow meters to validate and calibrate the models, as described in Section 2.4.1, during the post-construction phase of the CSO control measure implementation. These locations were considered to reflect overflow monitoring in all priority outfall locations, including at least one CSO location within each control measure and represent the CSOs contributing 86% of the current baseline CSO volume and 96% of the CSO volume expected following implementation of the CSO controls required by this Consent Decree. These locations are listed in Table 2.2. CSOs not monitored have remaining volumes less than 1 MG each.

The flow meter locations listed in Table 2.2 are identified by outfall. However, the actual flow monitors would be placed within the new diversion structures that divert flow to either the associated control facility (i.e., tunnel, storage tank, etc.) or the CSO outfall if the capacity of the control measure is exceeded. These diversion structures are situated downstream of the combined sewer regulator structures, on the outfall conduits. When the control facility exceeds its capacity, these structures divert overflow to this existing conduit, and a flow monitor would be placed within this structure to measure these overflows. For some outfalls, such as the Dugway Brook (CSO-230), multiple diversion structures would be constructed upstream of the permitted outfall location diverting flow to the control facility. In these cases, each diversion structure would be equipped with a flow monitor to measure the total overflow activation event in a cumulative manner. These locations will be confirmed and additional monitoring will be performed as deemed necessary as the program design advances to ensure that the appropriate data to validate and/or calibrate the model and subsequently prove achievement of the Performance Criteria is collected. Augmentation of the monitoring locations will proceed with approval from Ohio EPA and U.S. EPA.

Planning, design and construction of the control measures will take place over several years. Consequently, the dates for “Achievement of Full Operation” will vary by project. Table 2.1 summarizes the Achievement of Full Operation for these control measures, which is the year that would initiate the post-construction monitoring for each control measure, and how the CSO control measures in Appendix 1 will be assessed. NEORSRD will perform this evaluation by collecting precipitation and CSO outfall monitoring data for a one-year post-construction monitoring period following Achievement of Full Operation of each CSO control measure as identified in Appendix 1. Following collection system hydraulic model validation using the selected monitoring data, a “typical year” simulation will determine performance relative to the overflow frequency for each control measure.

2.3.2 In-stream Monitoring

NEORSRD performed an analysis of water quality conditions, for baseline conditions and for conditions after the implementation of the recommended LTCP projects. This analysis was performed to establish levels of CSO controls that would result in water quality benefits. The

analysis was performed primarily through the simulation of fecal coliform bacteria loads in the receiving streams, rivers and lake. The analysis involved the following streams: Big Creek, Burke Brook, Doan Brook, Dugway Brook, Euclid Creek, Green Creek Culvert, Kingsbury Run, Mill Creek, Morgana Run, Nine Mile Creek, Rocky River, Shaw Brook Culvert, West Creek, Spring Creek and Treadway Creek. These streams were modeled and the outputs from these models were used to estimate impacts on either the Cuyahoga River or Lake Erie, or both, depending on which is the downstream receiving water.

The LTCP identified fecal coliform bacteria loads for dry weather, storm water and CSOs. This was done to document the specific contribution of CSOs to violations of the in-stream bacteria standards. Through discussions with the U.S. EPA and Ohio EPA, E. coli bacteria were identified as the pollutant of concern to measure during the post-construction monitoring period. NEORSD will measure E. coli bacteria counts in order to identify trends in water quality. Biological and other monitoring data (to the extent that these are already being collected by NEORSD) can be used as a check since NEORSD is already routinely monitoring the lake and points along tributary rivers and streams. NEORSD has performed several special lake monitoring projects. Among these are fish tissue sampling, which contributed to the State's basis for issuing safe fish consumption advice, and the ongoing daily sampling at two area beaches for bacteriological analysis, which provides the State's basis for posting safe swimming advice at these locations.

Based on the requirements of the CSO permits issued to NEORSD, in-stream monitoring of biological water quality indicators in Big Creek, Doan Brook, Euclid Creek and Mill Creek have been collected for use in establishing baseline conditions prior to implementation of the recommended CSO LTCP. NEORSD will continue to monitor for E.coli in these streams. NEORSD proposes additional sites for E. coli monitoring in the Cuyahoga River, Dugway Brook, Nine Mile Creek, Ohio Canal, Rocky River, Shaw Brook, Spring Creek, West Creek and Treadway Creek. These sites are appropriate for the purposes of the Post-Construction Monitoring Program to document achievement of Performance Criteria and to document improvements to water quality over time. These sites are listed in Table 2.2 and illustrated in Figure 2.2. NEORSD may add, modify, remove or relocate monitoring stations, as necessary, during or after implementation of control measures to address any changes that may be necessary as a result of planning, design and construction, provided NEORSD obtains approval from the U.S. EPA and Ohio EPA.

2.3.3 Outfall Monitoring for Activations

Pursuant to the EPA's CSO permit and EPA's CSO Nine Minimum Controls Guidance, NEORSD provides public notification of CSO occurrences at various CSO locations. NEORSD monitors CSO activations on a continuous basis at these locations. NEORSD will continue to monitor and collect this type of data at the relevant locations which are listed in Table 2.2 as "activation only" and illustrated in Figure 2.1 Following implementation of all control measures for each district (Easterly, Southerly, Westerly), NEORSD shall conduct one year of activation monitoring at all CSO monitoring locations listed in Table 2.2. These data will be used to validate the models and demonstrate achievement of the Performance Criteria.

2.3.4 Outfall Monitoring for CSO Treatment Facilities

The current list of projects includes Chemically Enhanced High Rate Treatment (CEHRT) facilities at the Easterly and Westerly WWTPs to control CSO-001 and CSO-002, respectively. The monitoring plan for these projects will be developed separately and used to demonstrate effectiveness of the CEHRT facilities. These facilities will include monitoring systems to measure E. coli, total suspended solids and chlorine residual in the treated effluent to demonstrate achievement of their respective Performance Criteria. In addition, these facilities will monitor the overflows that exceed the peak treatment capacity of the CEHRTs. For informational purposes, NEORS D will also measure CBOD, nitrogen, and phosphorus.

2.3.5 Wastewater Treatment Plant Monitoring

Routine WWTP monitoring will be used to demonstrate compliance for control measures that require increased secondary capacity in order to eliminate primary effluent bypasses (PEB) (in a typical year). PCMP compliance of the increased secondary treatment capacity can be performed within the normal plant monitoring contained in their respective NPDES permits. NEORS D will continue to flow monitor the PEB.

2.3.6 Rainfall Monitoring

NEORS D currently maintains a rain gauge network within the service area. Table 2.3 and Figure 2.3 show these existing rain gauges. These rain gauges will be utilized in each Control Measure post-construction monitoring period and in the district-by-district post-construction monitoring periods to measure rainfall within the service area for each CSO control measure. If required, additional rain gauges will be installed to ensure accurate measurement of rainfall, and NEORS D will consider the use of radar-rainfall measurements to improve accuracy of rainfall estimates, and particularly where rain gage coverage is not adequate or difficult to implement.

Table 2.3 NEORS D’s Rain Gauges

Site ID	
RNT	North Olmsted
RWF	Westlake
RST	Strongsville
ROA	Oakwood
RJA	James Rhodes H.S.
RBT	Brook Park
RSG	Shaker Heights
RNR	North Royalton
ROL	Olmsted Falls
RBC	Brecksville
RIN	Independence
RMA	Maple Heights
RJO	John Marshall H.S.
RPM	Parma
RSY	Southerly WWTP
RMY	Mayfield
RBH	Beachwood
RDA	Division Ave P.S.
RDR	Dille P.S.
RWK	Wade Park
RCL	Cleveland Heights
REA	Easterly WWTP
RMN	Moreland Hills
RMD	Macedonia P.S.
RSO	South Euclid

2.3.7 Data Management

NEORS D currently maintains its data within various data management systems for the collection system and its three wastewater plants. Considering the number of monitoring locations and types of data that are being collected, the retrieval, record keeping and analysis of the data is essential in maintaining an effective monitoring program. Field procedures and QA/QC approaches to ensure that the collected data are suitable for the intended analysis are also a critical component of this program. This PCMP will use the existing NEORS D data management systems to store the data. The effectiveness of the CSO control measures will be evaluated using appropriate modeling tools. The PCMP will be designed to ensure collection of appropriate data; establish consistency of sampling methods and data acquisition; and define performance standards for maintaining data integrity. All measures necessary will be taken to validate, track, store and manage the collected data to ensure that monitoring objectives are achieved.

Sampling and modeling protocols will be administered and conducted by experienced personnel responsible for the existing database and model. As data are generated during the PCMP, the program may need to be revised to accommodate alternative data collection techniques or data evaluation approaches to meet monitoring objectives. Any revisions or additions to the data retrieval or management aspects of the PCMP will be submitted to the U.S. EPA and Ohio EPA for review and approval.

2.4 Performance Assessment

2.4.1 Model-Based Approach to Assessing Compliance

Under the model based approach to demonstrate compliance, NEORS D plans to update and utilize the various CSO models that were prepared during the development of the LTCP. The models will be used to perform appropriate simulations to demonstrate compliance with the performance criteria for each CSO control measure identified in Appendix 1. Models will also be used in conjunction with monitoring data to assess the performance of Green Infrastructure control measures installed pursuant to Appendices 3 and 4. This approach is outlined in the following steps:

1. Collect selected rainfall and CSO outfall data for the post-construction monitoring period of each CSO control measure upon completion, and rainfall data and activation data for all selected CSO outfalls following implementation of all control measures for each district (Easterly, Southerly, Westerly).
2. Perform quality assurance and quality control of the data collected in Step 1.
3. Utilize the appropriate LTCP CSO model and rainfall data collected during the monitoring period to run simulations of CSO discharges for the post-construction monitoring period.
4. Adjust precipitation/runoff information used in the model to take into account the effects of green infrastructure implementation, reflecting green infrastructure monitoring data.
5. Compare the simulation outputs to the CSO monitoring data for the post-construction monitoring period to determine whether re-calibration of the hydraulic model is required. Model re-calibration will not be required if the model-predicted activations are not less than the monitored CSO activations for each remaining CSO outfall for the post-construction monitoring period. Otherwise, model re-calibration will be required in accordance with Steps 6 -8 below.
6. For re-calibration, select two or more appropriate rainfall events from the post-construction monitoring period.
7. Develop an initial data set for use with the model and perform successive applications of the model with appropriate parameter adjustments until the degree of agreement between the model output and the CSO monitoring data for the post-construction monitoring period meets the criteria set forth in Step 5, above. In making re-parameterization adjustments, NEORS D will consider the inherent variability in both the collection system model and in

flow monitoring data, and will exercise sound engineering judgment and best industry practices so as to not compromise the overall representativeness of the model.

8. Upon completion of Step 7, NEORS shall run an additional continuous simulation for the entire post-construction monitoring period to verify the recalibrated model. Thereafter, NEORS shall compare the continuous simulation outputs to the CSO monitoring data described in Step 5 to determine whether additional recalibration is needed. If so, NEORS shall conduct recalibration in accordance with steps 6 through 7 until the model achieves the criteria described in Step 5, above.
9. Overflow frequency performance criterion is based upon a “typical year” developed as part of the CSO Phase II Facilities Plans. The “typical year” was comprised of actual rain events recorded at Cleveland Hopkins Airport based on an analysis of 46 years of rainfall recorded at this site. Table C-1 - Storm Events for Typical Year Continuous Year Simulation from the *CSO Facilities Planning Summary Report, March 2005* is attached to the PCMP. This table lists all the typical year storms, the dates, the hour, duration, depth and intensity of rainfall.
10. NEORS will utilize the validated, and/or re-calibrated, hydraulic models to run the “typical year” to determine whether the CSO control measures have achieved the Performance Criteria identified in Appendix 1. If the modeled overflow frequency exceeds this level for any of the CSO control measures, NEORS shall submit an analysis that will include: (1) the factors causing the additional overflow frequency, (2) any impact on water quality from the additional overflow frequency, (3) control options, including green infrastructure improvements, to reduce the overflow frequency to meet the Performance Criteria levels, (4) associated costs from the additional control options, (5) any expected benefits from such control options and (6) a recommendation of additional control measures necessary to meet water quality requirements.

2.4.2 Evaluating the Performance of Green Infrastructure CSO Control Measures

NEORS will submit its proposed Tier 1 green infrastructure post-construction monitoring program in accordance with Appendix 3. NEORS may also submit proposals to substitute green infrastructure CSO control volumes for gray infrastructure control volumes in accordance with Appendix 4. Once approved by U.S. EPA and Ohio EPA, NEORS shall perform green infrastructure post construction monitoring (GIPCM) for the green infrastructure control as described in Appendices 3 and 4.

2.4.3 Control Measures Reports

Following Achievement of Full Operation of each CSO Control Measure listed in Appendix 1, NEORS shall submit a Control Measures Report to the U.S EPA and Ohio EPA for their approval. The Control Measures Report will be submitted within 24 months of the date of Achievement of Full Operation for each control measure. The reports will include information for the completed control measures implemented and data related to the following:

- Description of the area served by the particular CSO Control Measure, affected receiving waters, and CSO Control Measures being evaluated
- CSO Monitoring and Rainfall Monitoring Results
- Evaluation of the CSO Control Measures
- Significant Variances and Impacting Factors (with regard to verification of level of control)
- Re-evaluation and Corrective Actions as outlined in section 2.4.4 (if necessary)

The green infrastructure improvements schedule for Control Measure reporting would be developed as part of the Green Infrastructure Feasibility Study and would be reviewed and approved upon completion of the study. NEORSD can submit the Control Measures Report for the Big Creek Tunnel System as part of the Final Post Construction Monitoring Program Report pursuant to section 2.6.1.

2.4.4 Corrective Action Plans

If, following post construction monitoring, the analysis conducted pursuant to Sections 2.4.2 and 2.4.3 above fails to demonstrate that the CSO control measures, combined with any Green for Gray substitutions if applicable, have met the pertinent performance criteria in a typical year set forth in Appendix 1, NEORSD shall submit to EPA and Ohio EPA for their approval, a Corrective Action Plan (“CAP”) as part of the Control Measure Report. The CAP shall describe: (1) the specific measures to be carried out to address performance shortcomings and ensure the performance criteria in Appendix 1 are met; (2) a schedule, as expeditious as possible, for implementation of the corrective measures and (3) how the improvements when fully constructed shall be evaluated in accordance with this Appendix. The corrective measures described in the CAP shall achieve the performance criteria set forth in Appendix 1.

U.S. EPA and Ohio EPA shall review each CAP submitted by NEORSD. The Agencies may request clarifications or supplemental information to make informed decisions on each CAP. Upon the conclusion of reviews of the CAP, the Agencies will approve the CAP, approve with conditions, or disapprove the CAP. If a CAP is disapproved, NEORSD must submit a revised CAP addressing the deficiencies identified by U.S. EPA and Ohio EPA in the initial CAP. NEORSD shall implement those measures set forth in the approved CAP in accordance with the schedule in the approved CAP

2.4.4.1 Green Infrastructure Measures Implemented Pursuant to Appendix 4

Proposals to substitute green infrastructure control measures for gray infrastructure control measures will include a description of post-construction monitoring and modeling to be performed to determine whether the performance criteria set forth in Appendix 1 will be met upon completion and implementation of the control measures outlined in the Proposal. NEORSD shall implement the post-construction monitoring of green and gray infrastructure as described in approved proposals. If green infrastructure post-construction monitoring does not demonstrate that constructed green infrastructure components are meeting the performance criteria in a typical year on which the substitution was based, NEORSD may implement early corrective measures to address identified deficiencies. Early correction actions may include

measures such as constructing additional green infrastructure capacity or increasing the size and/or capacity of gray infrastructure control measures. Stipulated Penalties will not accrue and become payable if an individual green infrastructure control measure is not meeting the criteria on which the substitution was based beginning at the time the green infrastructure control measure begins operation. However, stipulated penalties will accrue and become payable as of the date of Achievement of Full Operation as defined in Appendix 1 if at the time the pertinent green and gray control measures together are not meeting the performance criteria for a typical year.

2.5 Quality Assurance/Quality Control

An important component of any CSO quality sampling effort includes sample preservation, handling, and shipping; chain of custody documentation; and quality assurance and quality control (QA/QC) procedures. The QA/QC procedures are essential to ensure that data collected in environmental monitoring programs are useful and reliable. NEORS D will employ quality control procedures to ensure consistent delivery of quality work and products for all aspects of the PCMP. The quality control procedures include documentation for the following:

- Monitoring and field measurement activities
- CSO outfall monitoring activities including installation activities, calibration records, field truthing equipment and maintenance, and data downloads
- Field sampling activities
- Laboratory analysis activities
- Rainfall monitoring activities
- Data retrieval, management and analysis activities
- Quality control reviews of all internal and external deliverables

Flow Monitoring Data

Data will be reviewed continually throughout the monitoring program by a data analyst to identify data gaps, questionable data, estimate uncertainty in flow data, and monitor service or gage maintenance needs. The data will be reviewed for the following items:

- consistent diurnal patterns, as applicable
- consistent flow vs. level patterns
- consistent level vs. velocity patterns (i.e., scatter graphs)
- correspondence with field points and wet weather responses to rainfall

Questionable data will be flagged and the raw data will be converted into final data by editing questionable data, where possible.

Upon installation and activation of each flow meter, field crews will take manual depth and velocity readings (when there is a reasonable amount of flow present) using independent instrumentation to confirm that the monitor in-situ yields data representative of actual field conditions, and to quantify uncertainty in the instrument's measurement of flow. All measurements, adjustments, and efforts undertaken during site visits will be logged. In addition to the manual measurements taken at installation, routine calibrations will be performed throughout the flow monitoring period including at least two wet weather calibrations. These routine calibrations will provide an independent confirmation that the meters are working properly.

Water Quality Data

The NEORSD Analytical Services Quality Manual and associated Standard Operating Procedures are on file with Ohio EPA. The Quality Assurance Officer at Analytical Service will send updates, revisions and any information on document control to Ohio EPA as needed.

2.6 Progress Reporting and Final Post Construction Monitoring Procedures

The post-construction monitoring program will evaluate whether CSO control measures are achieving the Performance Criteria. It will also assess water quality conditions in CSO receiving waters within the NEORSD combined sewer service areas against the baseline conditions identified in the CSO Phase II Facilities Plans for the Easterly, Southerly and Westerly districts. This section discusses how progress will be reported to the U.S. EPA, Ohio EPA and the public.

2.6.1 Final Post-Construction Monitoring Program Report

Within three years following Achievement of Full Operation for all of the LTCP projects, NEORSD shall submit a Final PCMP Report to the U.S. EPA and Ohio EPA for their approval, containing a consolidation of all of the information identified in Section 2.4.3 for each control measure, the results of the final district-by-district rainfall and activation monitoring of all CSOs listed in Table 2.2, a re-validation of the collection system models using the aforementioned CSO activation monitoring results for the outfalls listed in Table 2.2 for each District, water quality monitoring results, effluent testing results, plus any additional relevant information

collected since submittal of the Control Measures Reports. The purpose of the Final PCMP Report shall be to evaluate and document the performance of NEORSD's fully implemented LTCP CSO control measures on a system-wide basis (based upon CSO activation data and water quality monitoring). The report shall include an assessment of whether the improvements are meeting the Performance Criteria in accordance with Appendix 1 (CSO activation frequencies, bypass frequencies) and water quality based numeric and/or narrative effluent limitations applicable to CSO discharges in NEORSD's NPDES Permits. NEORSD shall also provide a further assessment of the long-term trends in water quality of NEORSD's receiving waters. If the Final PCMP Report fails to demonstrate that the Performance Criteria are met, NEORSD shall include in the report whatever further re-evaluation or corrective action necessary to meet the Performance Criteria as well as a schedule for such re-evaluation or corrective action. NEORSD shall then implement any further re-evaluations or corrective actions in accordance with the approved Final PCMP Report.

2.6.2 Progress Reports to Public

Public involvement, information and education is an important part of the overall LTCP Program development approach recommended by U.S. EPA's CSO Control Policy and utilized by NEORSD in the development of the control program. As part of the PCMP, public outreach activities will continue with periodic updates using various media available to NEORSD. Available media will include the NEORSD website, local newsprint, radio and television. Updates will include status of remaining construction projects, improvements or trends in monitored water quality parameters any available anecdotal evidence from public's interaction with the waterways.

2.7 Summary

NEORSD's Post-Construction Monitoring Program will determine the effectiveness of the CSO control program in achieving its performance requirements and water quality objectives. The program includes the following elements:

- Implementation of a defined monitoring program designed to measure reductions in overflow activations and changes in stream water quality
- Analysis and assessment of monitoring data and/or model simulation results to determine whether implemented CSO Control Measures are meeting the Performance Criteria in Appendix 1
- Analysis and assessment of in-stream monitoring data to establish trends in stream improvements
- Preparation of Control Measures Reports and a Final PCMP Report to document the success of the LTCP implementation or identify any shortcomings and necessary corrective action
- Dissemination of information on the LTCP implementation to NEORSD's rate payers and Cleveland area general public

NEORSD's Post-Construction Monitoring Program addresses the U.S. EPA and Ohio EPA requirements for monitoring the performance of the CSO control measures. NEORSD will use the Performance Criteria in Appendix 1 as performance measures to determine the effectiveness

of the overall LTCP CSO control measures, augmented by any additional green infrastructure improvements. NEORS D will use existing monitoring systems, augmented as necessary, to collect and evaluate data. This includes flow and/or activation monitoring, in-stream sampling, plant sampling and rain gauge monitoring. NEORS D shall also use the appropriate LTCP CSO hydraulic models to measure performance of the CSO control measures as described in Section 2.4. NEORS D shall submit Control Measures Reports to the U.S. EPA and Ohio EPA, as required, to demonstrate performance and achievement of LTCP objectives. In addition, NEORS D shall prepare public information reports to educate the public on the advancement of the program and the effectiveness of the control measures being implemented.

Table 2.1 – Post-Construction Performance Tracking

District	Control Measure	CSOs Controlled	Achievement of Full Operation Year (Commencement of Data Collection)	Expected Typical Year Performance (Overflow Frequency by Control Measure)	Post-Construction Performance (Overflow Frequency by Control Measure)	Overflow Frequency Criteria Achieved (Yes/No)
Easterly Plant						
Easterly	Treatment and Disinfection of CSO 001 using CEHRT	Outfall 001	Dependent on the approved pilot program schedule.	2 partially treated overflows/year		
Westerly Plant						
Westerly	Treatment and Disinfection of CSO 002 using CEHRT in all 6 Quadrants (quads).	Outfall 002	Dependent on the approved pilot program schedule.	3 partially treated overflows/year		
Southerly Plant						
Southerly	Increase Secondary Treatment Capacity and Treat Primary Effluent Bypass with CEHRT	PEB	Dependent on the approved pilot program schedule.	1 or less		
Easterly CSO Projects						
Easterly	Euclid Creek Tunnel/Dugway Storage System	Outfalls 206, 208, 209, 210, 211, 212, 214, 230, 231, 232, 239, 242	2020	2 or less		
Easterly	Shoreline Tunnel System	Outfalls 093, 094, 095, 096, 097, 098, 200, 201, 202, 203, 204, and 205	2027	2 or less		
Easterly	Doan Valley Tunnel System	Outfalls 073, 217, 218, 219, 220, 221, 222, 223/224, 226, and 234	2021	Priority outfalls = 2 or less; Nonpriority = 3 or less		
Easterly	Superior Avenue Pump Station Upgrade	Outfalls 090, W. 11th/Superior Pump Station CSO	2016 ²	2 or less		
Easterly	Stones Levee Pump Station Upgrade	Outfalls 235, Stones Levee Pump Station CSO; surcharging relief	2017	3 or less		
Easterly	Canal Road In-Line Storage	Outfalls 090, 235; Additional storage capacity and flow attenuation	2018	3 or less		
Westerly CSO Projects						
Westerly	Westerly Tunnel System	Outfalls 074, 075, 080, 087	2024	Priority outfalls = 2 or less; Nonpriority = 3 or less		
Westerly	Columbus Road Storage Tank	Outfall 078	2019	0		
Westerly	Center Street Storage Tank	Outfall 076	2024	0		
Westerly	West Third Street Storage Tank	Outfall 082	2025	4 or less		
Westerly	Mary Street Pump Station Upgrade	Outfall 086	2017	4 or less		

² Commencement of first flow monitoring for control measure and system-wide in-stream monitoring.

District	Control Measure	CSOs Controlled	Achievement of Full Operation Year (Commencement of Data Collection)	Expected Typical Year Performance (Overflow Frequency by Control Measure)	Post-Construction Performance (Overflow Frequency by Control Measure)	Overflow Frequency Criteria Achieved (Yes/No)
Westerly	Jefferson Avenue Separation	Outfall 240	2028	0		
Westerly	West 3rd St/Quigley Parallel Storage System	Outfall 089	2021	2 or less		
<i>Southerly CSO Projects</i>						
Southerly	Southerly Tunnel System	Outfalls 033, 035, 036, 039, 040, and 072	2030	3 or less		
Southerly	Big Creek Tunnel System	Outfalls 043, 044, 049, 050, 051, 053, 054, 055, 056, 057, 058, 059, 233, 238, & Cooley Avenue	2035	Priority outfalls = 3 or less; Nonpriority = 4 or less		
Southerly	CSO-045 Storage Tank	Outfalls 045, 088	2023	4 or less		

Table 2.2
CSO and Stream Monitoring

Site ID	Location	Receiving Stream	Rationale	Real-time Discharge	Water Quality	Monitoring Frequency (during compliance)	Monitoring Protocols
Easterly System CSOs							
CSO-001	Easterly WWTP	Lake Erie	Priority CSO Point, CSO Treatment Facility Effluent	x		Continuous	Flow, Level, Velocity, Onset, Duration
					x	During discharge	E.Coli, TSS
CSO-098	North of E. 33rd St. & Lakeside Ave.	Lake Erie	Non-priority CSO within Shoreline Tunnel System	x		Continuous	Flow, Level, and activation
CSO-206	North end of E. 156th St. @ Lake Erie	Lake Erie	Priority CSO within Euclid Creek/Dugway Storage System	x		Continuous	Flow, Level, and activation
CSO-209	West side of Euclid Creek & Lake Shore Blvd.	Euclid Creek	Priority CSO within Euclid Creek/Dugway Storage System	x		Continuous	Flow, Level, and activation
CSO-210	East of Nottingham R. and St. Clair Ave	Euclid Creek	Priority CSO within Euclid Creek/Dugway Storage System	x		Continuous	Flow, Level, and activation
CSO-211	Nine Mile Creek east of Coit Rd.	Nine Mile	Priority CSO within Euclid Creek/Dugway Storage System	x		Continuous	Flow, Level, and activation
CSO-230	Dugway Brook approx. 600-ft from Lakeshore Blvd.	Dugway Brook	Priority CSO within Euclid Creek/Dugway Storage System	x		Continuous	Flow, Level, and activation
CSO-232	East of Eddy Rd. @ Shaw Brook	Shaw Brook	Priority CSO within Euclid Creek/Dugway Storage System	x		Continuous	Flow, Level, and activation
CSO-239	Lakeshore Blvd. @ Euclid Creek	Euclid Creek	CSO currently monitored tributary to the Euclid Creek/Dugway Storage System	x		Continuous	Activation only
CSO-242	E. 142nd St. & Lakeshore Blvd.	Lake Erie	CSO currently monitored tributary to the Euclid Creek/Dugway Storage System	x		Continuous	Activation only
CSO-090	End of Superior Avenue @ Cuyahoga River	Cuyahoga River	Non-priority CSO controlled by Superior Avenue Pump Station Upgrade and Canal Road In-line Storage	x		Continuous	Flow, Level, and activation
CSO-200	North of E. 40th St. & King Ave.	Lake Erie	Priority CSO within Shoreline Tunnel System	x		Continuous	Flow, Level, and activation
CSO-202	E. 55th St. & Lake Erie	Lake Erie	Priority CSO within Shoreline Tunnel System	x		Continuous	Flow, Level, and activation
CSO-204	West of E. 72nd St. @ Lake Erie	Lake Erie	Priority CSO within Shoreline Tunnel System	x		Continuous	Flow, Level, and activation
W. 11th/Superior P.S.	End of Superior Avenue @ Cuyahoga River	Cuyahoga River	Non-priority CSO controlled by Superior Avenue Pump Station Upgrade	x		Continuous	Flow, Level, and activation

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Table 2.2
CSO and Stream Monitoring

Site ID	Location	Receiving Stream	Rationale	Real-time Discharge	Water Quality	Monitoring Frequency (during compliance)	Monitoring Protocols
Stones Levee P.S.	W. 3rd at Canal East Side of River	Cuyahoga River	Non-priority CSO controlled by Stones Levee Pump Station Upgrade	x		Continuous	Flow, Level, and activation
CSO-073	Giddings Brook @ Doan Brook NE of Baldwin Rd. & Fairhill Rd.	Doan Brook	Priority CSO within Doan Valley Tunnel System	x		Continuous	Flow, Level, and activation
CSO-221	E. 105th St. & Hough Ave	Doan Brook	Priority CSO within Doan Valley Tunnel System	x		Continuous	Flow, Level, and activation
CSO-222	E. 105th St. & Doan Brook	Doan Brook	Priority CSO within Doan Valley Tunnel System	x		Continuous	Flow, Level, and activation
Westerly System CSOs							
CSO-002	Westerly WWTP	Lake Erie	Priority CSO Point, CSO Treatment Facility Effluent	x		Continuous	Flow, Level, Velocity, Onset, Duration
					x	During discharge	E.Coli, TSS
CSO-067	West of 3870 Rocky River Dr., northwest corner of Kamm's Plaza	Rocky River	CSO currently monitored within Westerly Tunnel System	x		Continuous	Activation only
CSO-069	Upper Edgewater Park, approx. 300 yds. west of beach	Lake Erie	CSO currently monitored within Westerly Tunnel System	x		Continuous	Activation only
CSO-071	Harborview Dr. & W 117th St., behind 11644 Harborview Dr.	Lake Erie	CSO currently monitored within Westerly Tunnel System	x		Continuous	Activation only
CSO-075	River Rd. & Elm St.	Cuyahoga River	CSO currently monitored within Westerly Tunnel System	x		Continuous	Activation only
CSO-076	Center St. & Cuyahoga River	Cuyahoga River	Non-priority CSO controlled by Center Street Storage Tank	x		Continuous	Flow, Level, and activation
CSO-078	Columbus Rd. & Cuyahoga River	Cuyahoga River	Non-priority CSO controlled by Columbus Road Storage Tank	x		Continuous	Flow, Level, and activation
CSO-080	SE of Scranton Rd. @ University Rd.	Cuyahoga River	Priority CSO within Westerly Tunnel System	x		Continuous	Flow, Level, and activation
CSO-082	Under Bridge @ W. 3rd St. & Cuyahoga River	Cuyahoga River	Non-priority CSO controlled by West Third Street Storage Tank	x		Continuous	Flow, Level, and activation
CSO-086	Mary St. east of W. 3rd St. @ Cuyahoga River	Cuyahoga River	Non-priority CSO controlled by Mary Street Pump Station Upgrade	x		Continuous	Flow, Level, and activation
CSO-089	East of W. 3rd St. Pump Station	Cuyahoga River	Non-priority CSO controlled by West 3rd St./Quigley Parallel Storage System	x		Continuous	Flow, Level, and activation
Southerly System CSOs							
CSO-035	Burke Brook @ Cuyahoga River	Burke Brook	CSO currently monitored within Southerly Tunnel System	x		Continuous	Activation only
CSO-036	West of Campbell Rd. & Independence Intersection	Cuyahoga River	Priority CSO within Southerly Tunnel System	x		Continuous	Flow, Level, and activation

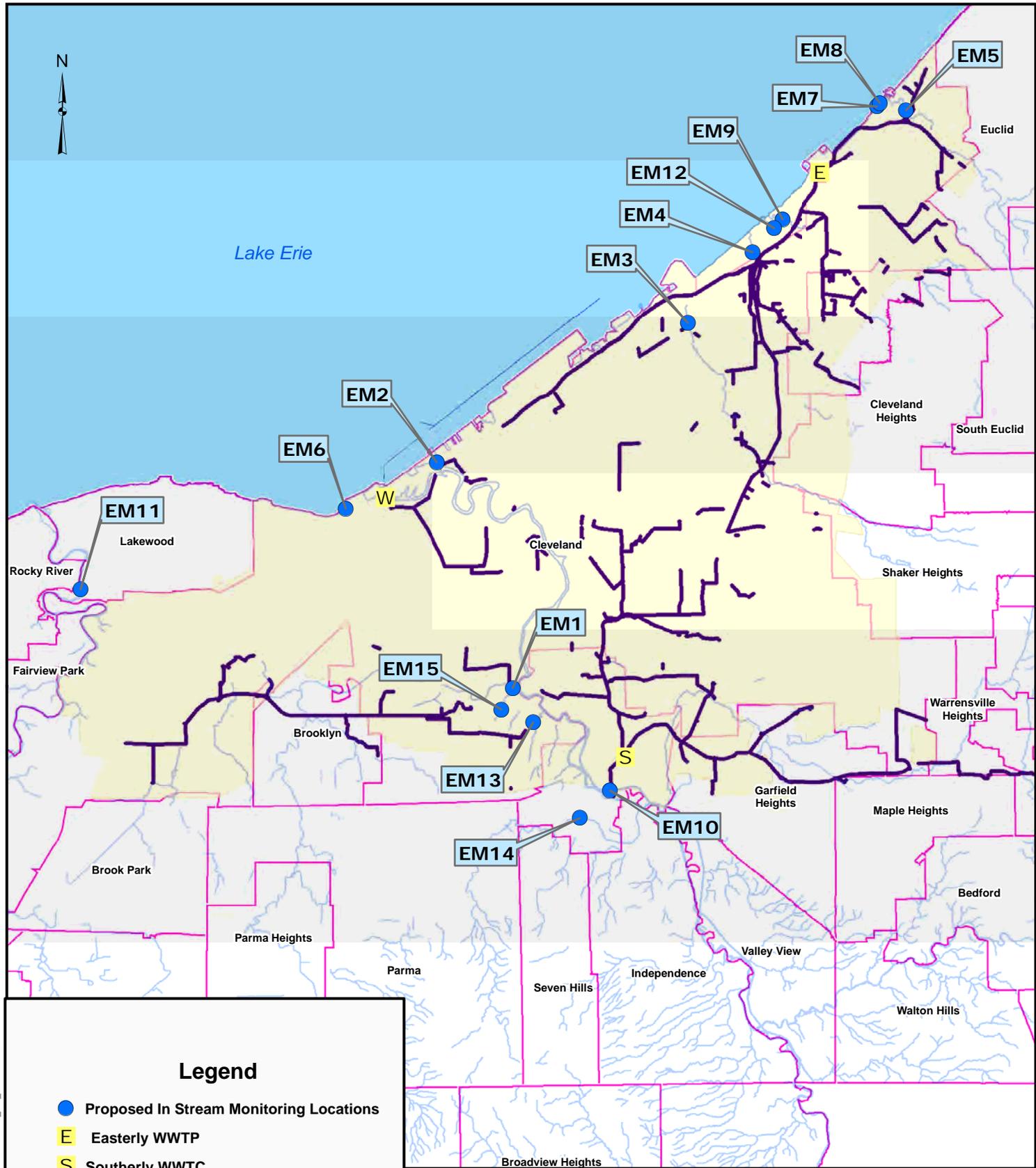
Table 2.2
CSO and Stream Monitoring

Site ID	Location	Receiving Stream	Rationale	Real-time Discharge	Water Quality	Monitoring Frequency (during compliance)	Monitoring Protocols
CSO-038	600' Southwest of E 26th St. & Independence Rd.	Cuyahoga River	CSO currently monitored within Southerly Tunnel System	x		Continuous	Activation only
CSO-040	Kingsbury Run @ Cuyahoga River - North of Jefferson Rd.	Cuyahoga River	Priority CSO within Southerly Tunnel System	x		Continuous	Flow, Level, and activation
CSO-043	East of Intersection of Tarlton Ave. & W. 15th St.	Treadway Creek	CSO currently monitored within Big Creek Tunnel System	x		Continuous	Activation only
CSO-044	North of Intersection of Irving Ave. & South Hills Dr.	Treadway Creek	CSO currently monitored within Big Creek Tunnel System	x		Continuous	Activation only
CSO-045	Northeast of Intersection of Jennings Ave. & Valley Ave.	Big Creek	Non-priority CSO controlled by CSO-045 Storage Tank	x		Continuous	Flow, Level, and activation
CSO-051	Brookside Dr. at mouth of triple culvert	Big Creek	CSO currently monitored within Big Creek Tunnel System	x		Continuous	Activation only
CSO-055	Under Bridge East of Bellaire Rd. & Kensington Rd.	Big Creek	CSO currently monitored within Big Creek Tunnel System	x		Continuous	Activation only
CSO-056	Under Bridge East of Bellaire Rd. & Kensington Rd.	Big Creek	CSO currently monitored within Big Creek Tunnel System	x		Continuous	Activation only
CSO-057	Under Interstate @ Memphis & I-71	Big Creek	Priority CSO within Big Creek Tunnel System	x		Continuous	Flow, Level, and activation
CSO-058	W. 114th St. & Peony Ave.	Big Creek	Priority CSO within Big Creek Tunnel System	x		Continuous	Flow, Level, and activation
CSO-059	Spring Rd. @ Jennings Rd.	Spring Creek	CSO currently monitored within Big Creek Tunnel System	x		Continuous	Activation only
CSO-063	Southeast of Brookpark R. & W. 10th St. Intersection	West Creek	Priority CSO within Southerly Tunnel System	x		Continuous	Flow, Level, and activation
Stream Monitoring							
EM1	Big Creek mile 0.15. Approximately 330 feet downstream of Jennings Road (41.4460, -81.6865)*	Big Creek	Track receiving water conditions downstream of CSO control measures		x	Following significant rainfall events	E. coli
EM2	Cuyahoga River mile 0.25. River left, approximately 200 feet downstream of railroad bridge (41.5002, -81.7100)	Cuyahoga River	Track receiving water conditions downstream of CSO control measures		x	Following significant rainfall events	E. coli
EM3	Doan Brook mile 0.75. Approximately 170 feet downstream of St.Clair Avenue (41.5330, -81.6296)	Doan Brook	Track receiving water conditions downstream of CSO control measures		x	Following significant rainfall events	E. coli
EM4	Dugway Brook mile 0.37. Approximately 200 feet downstream of culvert opening (41.5497, -81.6088)	Dugway Brook	Track receiving water conditions downstream of CSO control measures		x	Following significant rainfall events	E. coli
EM5	Euclid Creek mile 0.55. Approximately 500 feet downstream of Lake Shore Blvd. (41.5833, -81.5594)	Euclid Creek	Track receiving water conditions downstream of CSO control measures		x	Following significant rainfall events	E. coli

Table 2.2
CSO and Stream Monitoring

Site ID	Location	Receiving Stream	Rationale	Real-time Discharge	Water Quality	Monitoring Frequency (during compliance)	Monitoring Protocols
EM6	Edgewater Beach East (41.4893, -81.7392)	Lake Erie	Track receiving water conditions downstream of CSO control measures		x	Routinely during recreation season	E. coli
EM7	Euclid Beach East (41.5843, -81.5686)	Lake Erie	Track receiving water conditions downstream of CSO control measures		x	Routinely during recreation season	E. coli
EM8	Villa Angela Beach East (41.5851, -81.5677)	Lake Erie	Track receiving water conditions downstream of CSO control measures		x	Routinely during recreation season	E. coli
EM9	Nine Mile mile 0.40. Approximately 325 feet upstream of Lake Shore Blvd. (41.5575, -81.5991)	Nine Mile	Track receiving water conditions downstream of CSO control measures		x	Following significant rainfall events	E. coli
EM10	Ohio Canal at the bridge at Kurtz Broz access road, approximately 275 feet southwest of intersection of Canal Road and East 49th Street (41.4213, -81.6559)	Ohio Canal	Track receiving water conditions downstream of CSO control measures		x	Following significant rainfall events	E. coli
EM11	Rocky River mile 2.40. Approximately 230 feet upstream of Hilliard Road bridge (41.4705, -81.8238)	Rocky River	Track receiving water conditions downstream of CSO control measures		x	Following significant rainfall events	E. coli
EM12	Shaw Brook mile 0.10. Approximately 100 feet upstream of Lake Shore Blvd (41.5554, -81.6018)	Shaw Brook	Track receiving water conditions downstream of CSO control measures		x	Following significant rainfall events	E. coli
EM13	Spring Creek mile 0.30. Approximately 650 feet downstream of CSO 059 outfall (41.4378, -81.6801)	Spring Creek	Track receiving water conditions downstream of CSO control measures		x	Following significant rainfall events	E. coli
EM14	West Creek mile 1.95. Upstream side of Lancaster Road Bridge (41.4148, -81.6655)	West Creek	Track receiving water conditions downstream of CSO control measures		x	Following significant rainfall events	E. coli
EM15	Treadway Creek mile 0.40. Approximately 285 feet east of intersection of Tarlton Avenue and West 15th Street (41.4409, -81.6902)	Treadway Creek	Track receiving water conditions downstream of CSO control measures		x	Following significant rainfall events	E. coli

*Latitude and longitude coordinates are taken from hand-digitized GIS maps and are not surveyed.



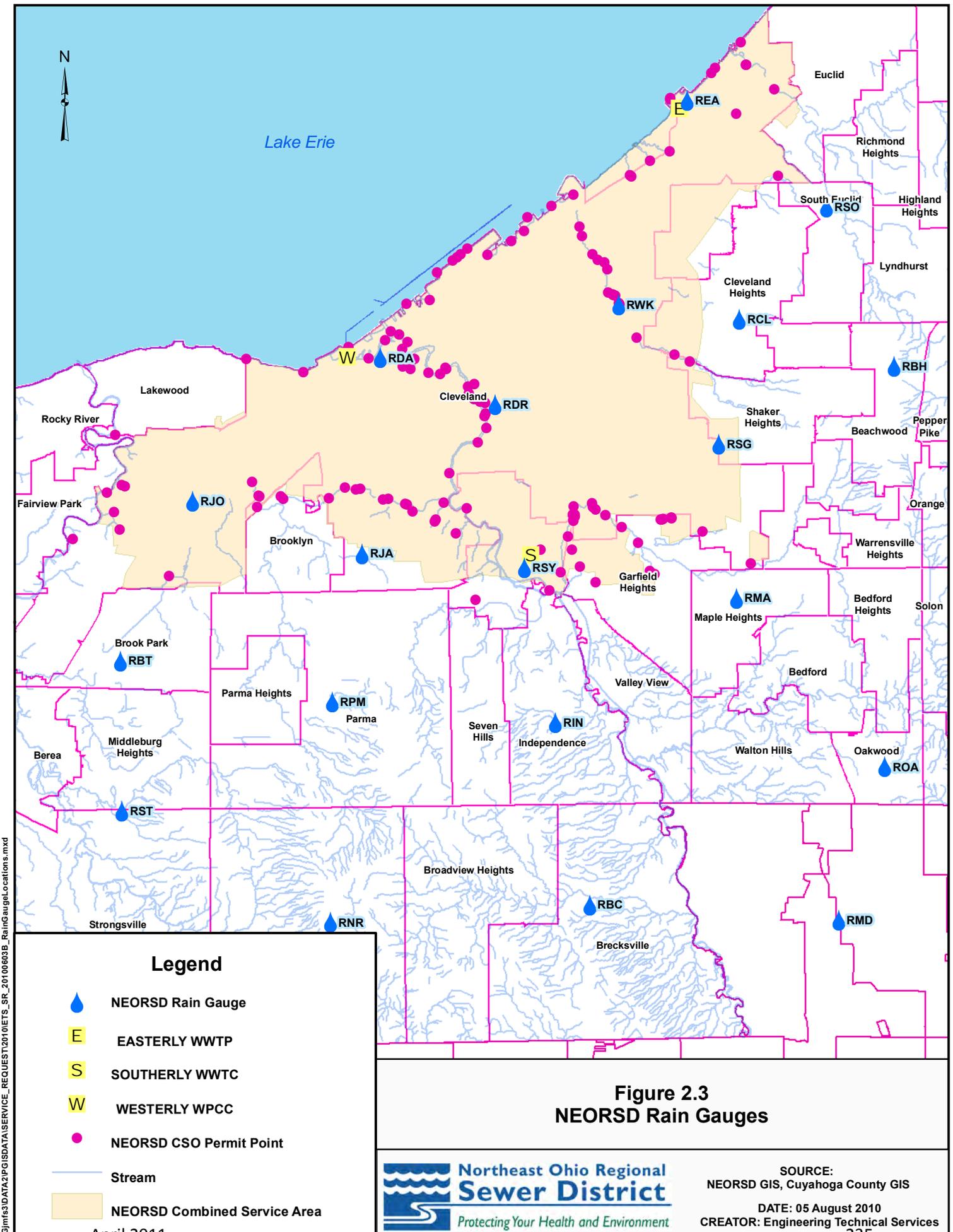
Legend

- Proposed In Stream Monitoring Locations
- E Easterly WWTP
- S Southerly WWTC
- W Westerly WPC
- Stream
- NEORSD Long Term Control Plan
- NEORSD Combined Service Area

Figure 2.2
Proposed In Stream Monitoring Locations



SOURCE:
 NEORSD GIS, Cuyahoga County GIS
 DATE: 05 July 2010
 CREATOR: Engineering Technical Services
 April 2011



Lake Erie

Legend

-  NEORSD Rain Gauge
-  EASTERLY WWTP
-  SOUTHERLY WWTC
-  WESTERLY WPCC
-  NEORSD CSO Permit Point
-  Stream
-  NEORSD Combined Service Area

**Figure 2.3
NEORSD Rain Gauges**



SOURCE:
NEORSD GIS, Cuyahoga County GIS

DATE: 05 August 2010
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April 2011

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Table C-1. Storm Events for Typical Year Continuous Year Simulation

Storm Number	Date	Hour	Duration (Hrs)	Depth (In)	Average Intensity (In/Hr)	Maximum Intensity (In/Hr)	Storm Number	Date	Hr	Duration (Hrs)	Depth (In)	Average Intensity (In/Hr)	Maximum Intensity (In/Hr)
1	1/3/91	12	1	0.01	0.01	0.01	62	7/3/93	2	1	0.01	0.01	0.01
2	1/5/91	13	10	0.18	0.02	0.03	63	7/4/93	16	1	0.44	0.44	0.44
3	1/9/91	13	2	0.03	0.02	0.02	64	7/6/93	16	1	0.47	0.47	0.47
4	1/11/91	4	19	0.39	0.02	0.09	65	7/11/93	20	3	0.35	0.12	0.24
5	1/12/91	12	21	0.04	0	0.01	66	7/19/93	14	2	0.14	0.07	0.13
6	1/15/91	24	8	0.33	0.04	0.08	67	7/26/93	6	2	0.04	0.02	0.02
7	1/16/91	19	10	0.17	0.02	0.03	68	7/28/93	17	9	1.08	0.12	0.72
8	1/20/91	13	30	0.53	0.02	0.05	69	7/29/93	20	3	0.67	0.22	0.31
9	1/26/91	7	10	0.03	0	0.01	70	8/2/93	5	2	0.42	0.21	0.41
10	1/27/91	19	4	0.08	0.02	0.03	71	8/3/93	21	10	0.42	0.04	0.2
11	1/29/91	20	11	0.37	0.03	0.1	72	8/6/93	19	4	0.1	0.03	0.06
12	1/30/91	18	1	0.01	0.01	0.01	73	8/7/93	13	1	0.13	0.13	0.13
13	1/31/91	14	1	0.01	0.01	0.01	74	8/10/93	16	2	0.02	0.01	0.01
14	2/5/91	7	1	0.01	0.01	0.01	75	8/11/93	4	4	0.24	0.06	0.23
15	2/6/91	15	9	0.1	0.01	0.02	76	8/12/93	17	1	0.02	0.02	0.02
16	2/10/91	15	20	0.73	0.04	0.09	77	8/16/93	4	1	0.07	0.07	0.07
17	2/13/91	14	59	1.53	0.03	0.16	78	8/20/93	9	1	0.01	0.01	0.01
18	2/16/91	24	14	0.18	0.01	0.04	79	8/28/93	2	1	0.06	0.06	0.06
19	2/18/91	15	13	0.08	0.01	0.04	80	8/31/93	13	6	0.03	0.01	0.02
20	2/19/91	17	7	0.29	0.04	0.1	81	9/2/93	8	21	1.02	0.05	0.67
21	2/26/91	4	40	0.08	0	0.01	82	9/6/93	13	1	0.35	0.35	0.35
22	2/28/91	9	4	0.04	0.01	0.02	83	9/7/93	9	1	0.01	0.01	0.01
23	3/2/91	1	14	0.06	0	0.02	84	9/10/93	1	1	0.01	0.01	0.01
24	3/3/91	13	24	0.7	0.03	0.1	85	9/10/93	13	1	0.01	0.01	0.01
25	3/6/91	6	14	0.83	0.06	0.13	86	9/15/93	20	16	2.38	0.15	0.4
26	3/9/91	18	2	0.07	0.04	0.05	87	9/22/93	24	16	0.12	0.01	0.05
27	3/10/91	12	4	0.08	0.02	0.03	88	9/25/93	16	20	1.63	0.08	0.29
28	3/17/91	21	31	0.5	0.02	0.07	89	9/27/93	13	9	0.15	0.02	0.06
29	3/22/91	6	4	0.32	0.08	0.18	90	9/28/93	10	3	0.23	0.08	0.12
30	3/22/91	24	3	0.14	0.05	0.08	91	9/29/93	10	17	0.97	0.06	0.24
31	3/23/91	24	10	0.23	0.02	0.06	92	10/1/93	10	1	0.01	0.01	0.01
32	3/26/91	13	1	0.02	0.02	0.02	93	10/1/93	23	6	0.58	0.1	0.22
33	3/27/91	24	1	0.62	0.62	0.62	94	10/9/93	6	13	0.43	0.03	0.13
34	3/31/91	19	6	0.07	0.01	0.03	95	10/16/93	22	16	0.6	0.04	0.18
35	4/1/93	23	5	0.16	0.03	0.07	96	10/19/93	15	1	0.04	0.04	0.04
36	4/2/93	17	12	0.06	0.01	0.02	97	10/20/93	15	6	0.04	0.01	0.02
37	4/9/93	14	16	0.77	0.05	0.09	98	10/27/93	22	4	0.15	0.04	0.1
38	4/11/93	16	1	0.09	0.09	0.09	99	10/30/93	10	39	1.67	0.04	0.12
39	4/14/93	19	2	0.03	0.02	0.02	100	11/1/91	17	1	0.01	0.01	0.01
40	4/15/93	23	3	0.34	0.11	0.16	101	11/7/91	9	12	0.12	0.01	0.02
41	4/19/93	17	13	0.27	0.02	0.11	102	11/11/91	2	7	0.69	0.1	0.14
42	4/20/93	16	18	0.61	0.03	0.13	103	11/12/91	11	12	0.21	0.02	0.06
43	4/24/93	12	2	0.03	0.02	0.02	104	11/15/91	1	31	0.62	0.02	0.1
44	4/25/93	8	15	0.46	0.03	0.16	105	11/18/91	17	21	0.3	0.01	0.1
45	4/30/93	1	6	0.1	0.02	0.03	106	11/20/91	17	19	0.46	0.02	0.14
46	5/4/93	13	25	0.63	0.03	0.22	107	11/23/91	20	3	0.24	0.08	0.12
47	5/19/93	4	6	0.15	0.03	0.07	108	11/24/91	17	8	0.03	0	0.01
48	5/23/93	16	1	0.01	0.01	0.01	109	11/25/91	14	1	0.01	0.01	0.01
49	5/24/93	6	6	0.08	0.01	0.04	110	11/28/91	6	8	0.19	0.02	0.05
50	5/28/93	24	2	0.03	0.02	0.02	111	11/30/91	6	1	0.04	0.04	0.04
51	5/31/93	23	2	0.16	0.08	0.08	112	12/2/91	16	17	1.19	0.07	0.29
52	6/3/93	23	2	0.07	0.04	0.04	113	12/3/91	21	11	0.06	0.01	0.02
53	6/5/93	5	6	0.37	0.06	0.25	114	12/12/91	15	17	0.16	0.01	0.06
54	6/7/93	16	9	1.56	0.17	0.67	115	12/14/91	7	6	0.15	0.03	0.12
55	6/9/93	10	1	0.21	0.21	0.21	116	12/15/91	16	16	0.07	0	0.01
56	6/9/93	24	1	0.24	0.24	0.24	117	12/18/91	3	2	0.02	0.01	0.01
57	6/19/93	6	2	0.31	0.16	0.22	118	12/18/91	16	16	0.03	0	0.01
58	6/20/93	13	26	0.54	0.02	0.15	119	12/20/91	22	8	0.22	0.03	0.07
59	6/25/93	20	1	0.08	0.08	0.08	120	12/23/91	7	6	0.1	0.02	0.03
60	6/27/93	18	1	0.94	0.94	0.94	121	12/28/91	22	35	0.26	0.01	0.03
61	7/1/93	21	4	0.05	0.01	0.02							
Total											37.51		

