PROTOCOL FOR THE VERIFICATION OF IN-DRAIN TREATMENT TECHNOLOGIES

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with support from the
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FOREWORD

In 1995, the U.S. Environmental Protection Agency (EPA) instituted a program, the Environmental Technology Verification Program (ETV), to verify the performance characteristics of commercial-ready environmental technologies through the evaluation of objective and quality-assured data. Managed by EPA's Office of Research and Development, ETV was created to substantially accelerate the entrance of innovative environmental technologies into the domestic and international marketplaces. ETV provides purchasers and permitters of technologies with an independent and credible assessment of the technology they are purchasing or permitting.

During its pilot phase, EPA has cooperatively managed twelve ETV pilots in conjunction with partner organizations, including states, federal laboratories, associations, and private sector testing and standards organizations. The pilots have focused on each of the major environmental media and various categories of environmental technologies and have been guided by the expertise of a Stakeholder Group. Stakeholder Groups consist of representatives of all verification customer groups for the particular technology sector, including buyers and users of technology, developers and vendors, state and federal regulatory personnel, and consulting engineers. All technology verification activities are based on testing and quality assurance protocols that have been developed with input from the major stakeholder/customer groups.

NSF International is an independent, not-for-profit organization, dedicated to public health, safety, and protection of the environment. NSF develops standards, provides educational services, and offers superior third-party conformity assessment services, while representing the interests of all stakeholders. In addition to well-established standards-development and certification programs, NSF specifically responds to and manages research projects, one-time evaluations and special studies.

NSF is the verification partner organization for three pilots under EPA's ETV Program: Drinking Water Systems, which has completed the pilot stage and is now a center, Wet Weather Flow Technologies, and Source Water Protection Technologies. This Protocol for the Verification of In-Drain Treatment Technologies was developed under the Source Water Protection Pilot, whose goal is to verify the performance of commercial-ready technologies used to protect ground and surface waters from contamination. Testing conducted under the ETV program using this protocol does not constitute an NSF or EPA certification of the product tested. Rather, it recognizes that the performance of the equipment has been determined and verified by these organizations.

Verification differs from certification in that it employs a broad, public distribution of test reports and does not use pass/fail criteria. In addition, there are differences in policy issues relative to certification versus verification. Certification, unlike verification, requires auditing of manufacturing facilities, periodic retesting, mandatory review of product changes and use of the NSF Mark. Both processes are similar, however, in regard to having standardized test methods and independent performance evaluations and test result preparation. This protocol is subject to revision; please contact NSF to confirm this revision is current.

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EPA and NSF acknowledge and thank those persons who participated in the preparation and review of this *Protocol for the Verification of In-Drain Treatment Technologies*. Without their hard work and dedication to the project, this document would not have been approved through the process that has been set forth for this ETV project.

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GLOSSARY OF TERMS

Accuracy - combination of bias and precision of an analytical procedure, which reflects the closeness of a measured value to a true value.

Bias - consistent deviation of measured values from the true value, caused by systematic errors in a procedure.

Effluent - the treated liquid stream produced by an in-drain treatment technology.

Influent - wastewater introduced to the in-drain treatment technology under evaluation for treatment.

Owner – the owner of a test site used for verification testing of an in-drain treatment technology.

Precision - a measure of the degree of agreement among replicate analyses of a sample usually expressed as the standard deviation.

Protocol – a written document that clearly states the objectives, goals, scope and procedures for the study. A protocol shall be used for reference during Vendor participation in the verification testing program.

Quality Assurance Project Plan – a written document that describes the implementation of quality assurance and quality control activities during the life cycle of the project.

Raw Data/Record – all data and information recorded in support of analytical and process measurements made during planning, testing, and assessing of the environmental technology, including support records such as computer printouts, instrument run charts, standards preparation records, field log records, technology operation logs, and monitoring records.

Representativeness - the degree to which the data accurately and precisely represent the conditions or characteristics of the parameter represented by the data.

Standard Operating Procedure – a written document containing specific instructions and protocols to ensure that quality assurance requirements are maintained while performing verification activities such as sample collection and analytical testing.

Start-Up - The period between the time the in-drain treatment technology is put on-line and when stable operating conditions are achieved.

Test Plan – a written document that describes the procedures for conducting a test or study according to the verification protocol requirements for the application of an in-drain treatment technology at a particular site. At a minimum, the Test Plan shall include detailed instructions for sample and data collection, sample handling and preservation, precision, accuracy, goals, and quality assurance and quality control requirements relevant to the particular site.

Testing Organization – an organization qualified to conduct studies and testing of in-drain treatment technologies in accordance with protocols and Test Plans.

Verification – To establish evidence on the performance of an in-drain treatment technology under specific conditions, following a predetermined study protocol(s) and Test Plan(s).

Verification Organization – the party responsible for overseeing test plan development, overseeing testing activities in conjunction with the Testing Organization, and overseeing the development and approval of the Verification Report and Verification Statement for the wastewater treatment technology. NSF is the Verification Organization for the ETV Source Water Protection Pilot.

Verification Report – a written document, often prepared by the Testing Organization, containing all raw and analyzed data, all QA/QC data sheets, descriptions of all collected data, a detailed description of all procedures and methods used in the verification testing, and all QA/QC results.

Verification Statement – A written document which is prepared for a verification test conducted under the ETV Source Water Protection Pilot and summarizes the content of the Verification Report.

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1. INTRODUCTION

This document provides the generic protocol for verification testing of in-drain treatment technologies. The protocol has been prepared under the Environmental Technology Verification Program.

1.1 ENVIRONMENTAL TECHNOLOGY VERIFICATION (ETV) PROGRAM

The Environmental Technology Verification (ETV) Program was established in 1995 by the United States Environmental Protection Agency (US EPA). The ETV program was created to accelerate the development and commercialization of improved environmental technologies through third party verification and reporting of performance.

The ETV Program is divided into 12 pilot projects, one of which is the Source Water Protection (SWP) Pilot. NSF International is the Partner Organization for the SWP Pilot and is responsible for the Pilot's administration and implementation. The goal of the SWP Pilot is to verify technologies that protect the quality of ground and surface waters by preventing or reducing contamination. The SWP Pilot is active in several technology areas, among which is in-drain treatment. A Technology Panel formed through NSF International advises on the design of the In-Drain Treatment Technologies protocol, and its subsequent implementation.

The Technology Panel recommended that a generic, broad-based protocol for testing in-drain treatment technologies should be written. This would specify the objectives and procedural approach to technology verification through the ETV Source Water Protection Pilot, and the procedures to be followed in order to meet specific technology verification objectives. This protocol, reviewed by the Technology Panel and a Source Water Protection Pilot Stakeholder Advisory Group (SAG), is then offered to technology vendors who may elect to participate in the pilot. A project and technology-specific Test Plan is written for each technology verification, refining the protocol to meet the technology's configuration and the test site conditions, but staying within the framework and objectives of the generic protocol.

1.1.1 ETV Pilot Objectives

The objectives of the ETV Source Water Protection Pilot are to verify performance of and gather operational data for commercial-ready technologies, following technically sound protocols and appropriate quality assurance and control. Another objective of the Pilot is to provide permit writers, buyers, and users with an independent and credible assessment of the technology. The key outputs of the Pilot will be quality test data and US EPA/NSF International-verified test reports. Additionally, protocols will have been developed by which different technologies can be evaluated in a consistent and scientific manner.

1.1.2 Purpose of this Protocol

The protocol that follows is meant to satisfy the "generic protocol" requirement for the In-Drain Treatment Technologies area. This protocol describes the steps that must be followed in order to ensure that the technology verification process is carried out in a consistent and objective manner. The protocol presents the technical approach for the verification and offers guidance for preparing a test plan that is specific to the test system offered by a vendor. The protocol also addresses guidance for testing and for the analysis and reporting of the verification results.

1.1.3 Verification Process

The verification process under the ETV program consists of three major steps:

1. **Planning**: The planning phase establishes the procedures to be followed for verification of a specific technology. A test plan is developed by the designated Testing Organization, with input from both the Vendor and the Verification Organization, in addition to any other reviewers. Once drafted and revised as necessary, it is submitted to the Verification Organization, which will obtain approvals from the EPA Pilot Manager and the Vendor. The Test Plan will include detailed site and equipment specifications, procedures for testing (including documentation for conformity to the generic protocol), and a quality assurance project plan for assuring valid data. Guidelines for this phase of the program are provided in Sections 2 and 3.

2. **Verification Testing**: This phase of the project involves the actual assembly, installation, and operation of the test facility, collection of the targeted samples, and completion of all analyses required under the Test Plan. Sections 4 and 5 present the protocols for the testing phase.

3. **Data Assessment and Reporting**: The final phase of the verification program includes analysis of the data generated during testing, and preparation of a Verification Report. Guidelines for this phase of the project are given in Sections 6 and 7.

1.2 IN-DRAIN TREATMENT TECHNOLOGY DESCRIPTION

In-drain treatment technologies are defined as inserts placed in floor or area drains to treat waters entering the drain for contaminant removal. Applications could include floor drains from machine repair, auto body shops, or other operations where floor areas are washed down to a drain. These technologies are similar to wet-weather flow, source-area treatment technologies, which include inserts and other structures that treat stormwater at the point it enters the catch basin or area drain. However, within the context of this protocol, in-drain treatment technologies are not designed to handle the large volume of water encountered with storm events. Contaminants of concern may include solids, metals and organics, particularly hydrocarbons.

Currently, commercially-available in-drain technologies utilize filtration and/or adsorption mechanisms. The processes are generally directed to the removal of particulates (and the metals and organics that may be bound to these particulates), hydrocarbons and other dissolved organics and organically-complexed metals. Specific units may be suited to a narrow class of contaminants and marketed as a component of a larger system. This is generally articulated in the vendor's claims for the equipment.

In-drain technologies are typically comprised of inserts with removable media cartridges, such as filters, adsorption pads, debris/contaminant traps, etc., and, as such, form the basis for this test protocol. If new emerging technology alternatives, which may not have been addressed by this protocol, are proposed for testing, the test plan shall specifically describe the attributes of the technology and any modifications made to the protocol to accommodate its testing.

1.2.1 Technology Application

The in-drain treatment technologies are applicable to closed, impermeable, and defined drainage areas, typically associated with, but not limited to, the following:

- Garages;
- Open and covered parking lots;
- Vehicle wash-down areas;
- Vehicle maintenance areas;
- Truck stops;
- Heavy construction equipment maintenance centers;
- Gas stations; and
- Machine shops and scrap storage areas.

Major contaminants typically observed with these applications are hydrocarbons and solids. Their removal should be the focus of the verification test. In addition, other contaminants of concern, such as metals, nutrients, and surfactants should be quantified as part of the test plan.

1.2.2 Technology Verification Approach

The protocol for verification of in-drain technologies uses a generic synthesized wastewater to challenge the offered equipment. The makeup of the wastewater is based on reported experience and analyses of targeted wastewaters, and covers a broad spectrum of known contaminants. The Test Unit shall be set-up in a controlled test facility. The wastewater shall be fed to the Test Unit under hydraulic loading conditions that match the rated capacity of the equipment. Its performance shall be measured by removal of targeted contaminants. The installation, operation and maintenance requirements of the Test Unit shall also be quantified.

2 VERIFICATION TEST PLAN

A detailed test plan shall be prepared before each technology verification. The Testing Organization will typically prepare this, with the participation of the Vendor. The test plan shall clearly present how, where, and by whom the testing is to be conducted. The Verification Organization shall review the Test Plan, offer comments, suggest modifications, and arrange for its additional review by one or more peer-reviewers. Final EPA and Vendor approval of the Test Plan shall be obtained before any testing is initiated. The format of the ETV Test Plan shall follow those offered by the Verification Organization and provide, at a minimum, the following information.

2.1 TEST PLAN OBJECTIVES

The objectives of the verification test shall be clearly explained, including those identified by the ETV Program and those claimed or identified by the Vendor.

2.2 PROJECT ORGANIZATION

The organization of the project shall be explained, including staff and management activities. Firms and individuals assigned to the project shall be identified, and their specific roles described. Key individuals must be identified, including a brief description of their relevant experience. General guidelines on the roles and responsibilities for the major parties are summarized in the following discussions.

2.2.1 Verification Organization

NSF International is the US EPA's Verification Partner and the Verification Organization for technology verifications performed under the ETV Source Water Protection Pilot. The Verification Organization's responsibilities shall include:

- Qualification of Testing Organizations and Laboratories;
- Coordination of Test Plan reviews by EPA, the Verification Organization, and peer-reviewers;
- Coordination of EPA and Vendor approvals of the Verification Test Plan;
- Oversight of project quality assurance, including on-site audit of test procedures, and technical system performance and data quality audits, as prescribed in this protocol and in the Quality Management Plan for the Verification Organization;
- Coordination of Verification Report peer-reviews; and
- Preparation, approval, and dissemination of the Verification Report and Verification Statement in conjunction with EPA.

Note that the Verification Organization may act as the Testing Organization and/or write the Verification Report.

2.2.2 U.S. Environmental Protection Agency (US EPA)

This protocol was developed with financial and quality assurance assistance from the Environmental Technology Verification (ETV) Program, which is overseen by the US EPA. Any Verification Report developed under the ETV Program using this protocol shall be subject

to the approval of the ORD laboratory director. The US EPA shall have technical and quality assurance review and approval responsibilities throughout the various phases of an environmental technology verification, including:

- Verification Test Plan development;
- Verification Report development;
- Verification Statement development; and
- Posting the Verification Report and Verification Statement on the US EPA web site.

2.2.3 Testing Organization

The Testing Organization must be qualified by the Verification Organization to conduct an in-drain treatment technology verification project. It shall have direct or comparable experience in the operation and evaluation of in-drain treatment technologies, in the performance of the various procedures comprising the protocol, and in the design and performance of pilot studies. The Testing Organization shall serve as the primary consultant for developing, implementing, and reporting the verification test. The responsibilities of the Testing Organization shall include, but not be limited to:

- Preparing a site-specific Test Plan in conformance with the generic protocol, and revising the Test Plan in response to comments made during the review period;
- Coordinating the Test Plan development with the Vendor and the Verification Organization, including documentation of equipment and facility information and specifications for the Test Plan;
- Contracting with sub-consultants and general contractors, as needed, to implement the test plan;
- Coordinating and contracting, as needed, with the owner of the test facility, and arranging the necessary logistics for activities at the test site, including controlling access to the area where verification testing is being carried out;
- Maintaining safe conditions at the test site for the health and safety of all personnel involved in with verification testing;
- Managing the communications, documentation, staffing, and scheduling activities necessary to successfully and efficiently complete the verification;
- Overseeing and/or performing the verification testing per the approved Test Plan; and
- Managing, evaluating, interpreting, and reporting the data generated during the verification testing.

2.2.4 In-Drain Treatment Technology Vendor

An ETV is initiated by an in-drain treatment technology vendor by submitting an application to the Verification Organization. In the case of testing to be performed under the ETV Source Water Protection Pilot, the application shall be submitted to NSF International. The application may offer suggested test sites and request a Testing Organization. The Vendor's responsibilities shall include, but not be limited to:

- Provide verification testing objectives to be incorporated into the Test Plan;
- Provide the test unit for verification, including all ancillary equipment, instrumentation, materials and supplies necessary to operate, monitor, maintain, and repair the system;

- Provide documentation and calculations necessary to demonstrate the system's conformity to commercial systems, hydraulic scalability, and to the requirements of this protocol;
- Provide descriptive details of the system, its operation and maintenance, its capabilities and intended function in in-drain treatment applications;
- Provide technical support for the installation and operation of the in-drain treatment system, including designation of technical support staff and of an on-site technician for training;
- Review and approve the Verification Test Plan; and
- Review and comment on the Verification Report and Verification Statement.

2.2.5 Support Organizations

The Test Plan may require support from other organizations, if certain activities cannot be provided by the Verification Organization, US EPA, Testing Organization, or Vendor. These activities include, but are not limited to, chemical analyses, instrumentation calibrations, mechanical construction, electrical installation, and operations. Any contractors brought into the project shall be subordinate to the Testing Organization and shall be identified as part of the Verification Test Plan, along with their roles and responsibilities.

2.2.6 In-Drain Treatment Peer-Review Group

The ETV In-Drain Treatment Peer Review Group will serve as a technical and professional resource during all phases of the verification, including the review of test plans and verification reports.

2.3 CAPABILITIES AND DESCRIPTION OF THE SYSTEM

2.3.1 SYSTEM DESCRIPTION

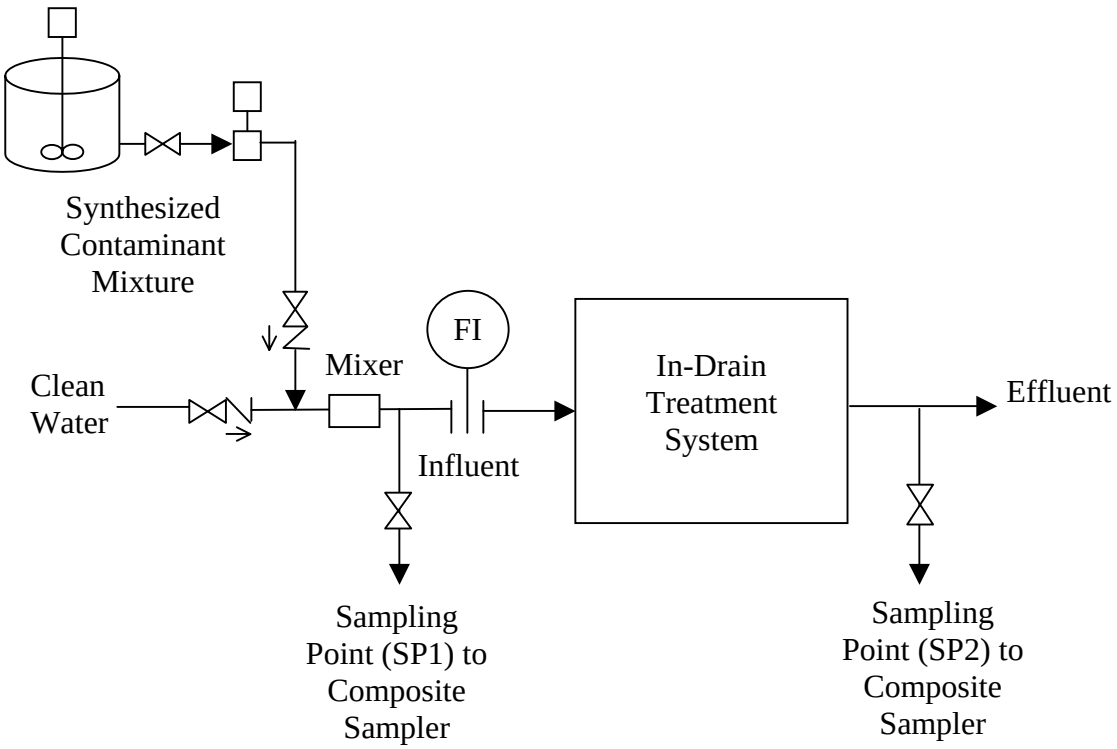
In this section, the Testing Organization, with input from the Vendor shall describe in detail all components of the in-drain treatment system, including the purpose for each component, the proposed equipment, and its application. This part of the Test Plan must also address the test unit's conformity with full-scale commercial systems offered by the Vendor.

The test equipment submitted for evaluation by the ETV protocol must be or must closely simulate the commercial unit offered by the vendor. It will be critical to clearly describe both the commercial unit and the test unit as part of the test plan, if there is any dissimilarity between the two. For an example, if the pilot-test equipment is not a full-scale commercial unit, then discussion of hydraulic scalability must be included in the Test Plan. For this reason, testing of other than full-scale equipment is not recommended by the ETV Program.

A process flow diagram illustrating the testing facility components shall be provided. Figure 1 presents an example schematic process flow diagram. The diagram shall show all components of the test facility, including supporting equipment, location of sampling points and flow metering. The facility description shall clearly delineate the test equipment components that are being verified and those that are being provided through the vendor and others to support the test facility. In addition, the following information shall be included:

- Detailed dimensional drawings of the equipment showing all components;
- A detailed description of physical characteristics of the equipment including its weight and size;
- A detailed drawing of the equipment layout;
- Utility requirements such as water and electricity;
- Identification of any special permitting requirements associated with the operation of the equipment, if appropriate; and
- Wastewater disposal method. The Test Plan shall state the method for disposal and verify that it is a permitted practice for the site.

Figure 1 – Example Schematic Process Flow Diagram



2.3.2 SYSTEM CAPABILITIES

Statements shall be made in the Test Plan regarding the appropriate applications for the equipment, its capabilities, limitations, and potential advantages. The statement of capabilities forms the basis of the equipment verification testing and should be chosen carefully. The statement of capabilities shall include, but not be limited to, the following:

- Contaminant(s) that can be removed or reduced by the candidate technology;
- Suitable applications for the technology;
- The operating envelope in terms of flow and contaminant loading;
- Instrumentation and control requirements;
- Equipment installation requirements;
- Operation and maintenance requirements, including replacement of treatment medium; and
- Residuals management, including options for disposal.

Both quantitative and qualitative performance measurements shall be evaluated to assess the system capabilities. The procedures for obtaining these measurements are described in Section 3.

2.4 EXPERIMENTAL DESIGN

The overall conceptual approach to the technology verification, including its compliance with the generic protocol, shall be summarized. The approach shall clearly describe the test, test location, and treatment component(s) that will be incorporated into the test facility. Any deviation from the generic protocol shall be highlighted and discussed, including justification for the alternative approach.

Reference is made to Section 4 for a detailed discussion of the experimental design. Within this framework, a Sampling and Analysis Plan (Section 5) must be prepared in support of the Experimental Design. This must address the procedures that will be followed for sampling, and references for all analytical methods. All monitoring equipment and instrumentation shall be described.

2.5 HEALTH AND SAFETY PLAN

The Verification Test Plan shall include a Health and Safety Plan, which addresses safety considerations that are appropriate to the test site, the equipment being tested, and storage, handling, and disposal of wastewater and residuals.

2.6 QUALITY ASSURANCE PROJECT PLAN (QAPP)

The Test Plan shall include a QAPP that specifies procedures to be used to ensure data quality and integrity. This should follow the generic outline presented separately in Section 6.

3 PERFORMANCE MEASUREMENTS

The performance objective of in-drain treatment technologies is to generate an effluent quality that meets local, state, or federal discharge limits to a receiving body of water or the discharge or pretreatment requirements of a local Publicly Owned Treatment Works (POTW). The performance capabilities of the test equipment shall be quantitatively and qualitatively measured as discussed below, and presented in the Verification Report and Statement. This shall also compare the observed performance measures against the vendor claims and within that context, discuss some potential applications of the equipment.

3.1 SYSTEM/COMPONENTS OPERATION AND MAINTENANCE (O&M)

The performance of the overall system and/or its components shall be measured by its range of operation and level of maintenance. The range of operation can be determined by hydraulics and mass removal of contaminants. The hydraulic capacity of the treatment system shall be measured by its hydraulic loading rate in volume of treated water/volume of medium or treatment volume, or volume of treated water/mass of treatment medium. Similarly, the mass removal of a contaminant shall be measured in mass of contaminant removed/volume of medium or treatment volume and/or mass of contaminant removed/mass of treatment medium.

In-drain technologies are generally expected to be passive, with minimal direct handling during their operational life cycles, except to the extent that a technology needs to be maintained. The system and its components shall be qualitatively measured by the level of maintenance required. The level of maintenance can be assessed by the relative ease of maintenance, and how often and how long the maintenance is required. This can be quantified by estimating the hours necessary for training and for specific maintenance tasks. The specifics of the O&M manual, access to pertinent parts of the system, and the number of parts for maintenance are factors included in assessing the test unit's maintenance requirements. The Verification Test Plan shall address the treatment medium, including installed indicators that alert users when to replace it, medium maintenance during operation (with or without flow), cleaning of clogged medium, gathering of loose elements of medium if dispersed, and other procedures and/or claims appropriate to the specific test equipment. In addition, the operation of instrumentation and controls, if they are part of an in-drain system, shall be described in detail.

3.2 CONTAMINANTS THAT CAN BE REMOVED OR REDUCED

As part of the Test Plan, the statement of capabilities shall name the contaminant(s) that will be tested for removal or reduction by the proposed technology. These are the "targeted contaminants". As a performance indicator, the level of removal of these targeted contaminants must be analyzed. In addition, a number of ancillary, or "secondary contaminants" that may or may not be affected by the technology, but are still of concern, shall also be analyzed. The combined lists of "targeted" and "secondary" contaminants comprise the "contaminants of concern." These generally encompass a practical listing of contaminants that can be found with the targeted applications (see Section 1.2.1. The following is a list of potential contaminants of concern.

- Hydrocarbon Related:
  - Total Petroleum Hydrocarbon (TPH)

  - Total Organic Carbon (TOC)
  - Oil & Grease (O&G)
  - Benzene, Toluene, Ethylbenzene, and Xylene (BTEX)
  - Total Phenol
  - Methyl tertiary butyl ether (MTBE)
- Total Suspended Solids (TSS)
- Heavy metals: Al, Cd, Cr, Cu, Fe, Pb, Zn
- Surfactants (MBAS)
- Chemical Oxygen Demand (COD)
- Nutrients:
  - Phosphate (PO_4-P)
  - Total Kjeldahl Nitrogen (TKN)
  - Ammonia (NH_3 –N)
  - Nitrates (NO_3-N)

All of the above are potential contaminants or measures of contaminants generated from washing vehicles, or found in floor areas of auto body shops, machine repair shops, or in the residue in parking garages or other automotive traffic areas. The hydrocarbon related contaminants, solids, metals, and surfactants are typically major targeted contaminants for in-drain treatment applications. On the other hand, nutrients are likely to be found in measurable quantities and are parameters of concern for source water protection. COD is a bulk parameter that is easy and quick to analyze, can be used as a measure of general organic contaminant removal, and may be appropriate for long-term system performance monitoring.

Note that in certain cases, the in-drain device may have been designed to trap and remove floatable materials such as leaves, sticks, paper litter, etc. If this is a specific claim for the device, the wastewater matrix constructed for the Verification Test shall include introduction of a floatables matrix and measurement of its removal through the device. The Test Plan shall address the claim, the matrix composition and any special sampling that would be directed to quantifying floatables removal through the Test Unit.

All contaminants of concern must be included in the sampling and analysis plan for monitoring and quantifying the performance of the proposed test equipment. The Test Plan must state which contaminants of concern are targeted by the technology and which are secondary to its performance.

3.3 EFFLUENT QUALITY THAT CAN BE ACHIEVED

As essential performance measurements, the effluent concentrations of the targeted contaminants must be measured. In addition, although not claimed by Vendor, the removal of secondary contaminants must be analyzed and reported. The analysis for both targeted and secondary contaminants will help in understanding the full capability of the tested technology.

3.4 QUANTIFICATION OF RESIDUALS

The in-drain treatment technologies will generate residuals, including the removed contaminants, spent media inserts, traps, etc. The quantity of residuals for disposal shall be a factor in

performance measurement. Examples of residual quantification may include the total mass and volume of residuals, mass of residual disposed per volume of water treated, and mass of residual disposed per mass of a specific contaminant removed. The Test Plan shall include the quantification of equipment related residuals, such as media inserts and traps, that must be disposed or serviced. This shall be in terms of replacement or servicing rates as a function of the quantity of water treated and/or mass of contaminant removed. The Test Plan and Verification Report shall present a discussion of the handling of these residuals and their ultimate disposal.

4 EXPERIMENTAL DESIGN

The experimental design defines the technical approach to verify the stated capabilities of the treatment system. It includes test conditions, measurement requirements, and data quality indicators for verification testing. Standard Operating Procedures (SOPs) for testing equipment and procedures should be presented with the experimental design and incorporated into the Test Plan.

The verification test of in-drain treatment technologies will be a controlled pilot test, in which a known synthesized wastewater will be used as feed water. The use of the synthetic wastewater has several advantages, including independence from the application site, and control with respect to quantity and quality.

Because the use of synthetic wastewater is independent of a test site, the test can be conducted virtually anywhere. The test site shall be large enough to accommodate the test equipment, and utilities such as water and electricity shall be readily available. One potential test location is a POTW. Pilot testing would not be conspicuous and the plant would allow for direct discharge of effluent. Certainly, this would be dependent on the characteristics of the discharge, but one would expect that the relatively minor flows from the pilot unit could be discharged to the headworks of the WWTP. It shall be verified that the POTW is large enough to handle the discharges from the test unit without any significant impact on plant operations or performance. Other test sites can be offered by the Testing Organization. In all cases, there must be written approval by the site owner, if different from the Testing Organization, and the testing must be in conformance with all permits and discharge requirements associated with the site.

The amount of wastewater generated at the targeted application sites such as garages and truck stops is typically not high, as it excludes stormwater runoff and is confined to the area or operation serviced by a single drain. In addition, it is characterized by intermittent flow. By using a synthesized wastewater, the feed wastewater would always be available for testing, and in sufficient volume. This significantly reduces the required testing period.

The fact that synthetic wastewater is not a real wastewater may be viewed as a disadvantage. However, given the wide variation in wastewater quality that is associated with the potential application sites, one can also understand that there would be difficulty in identifying a "representative" site. Using a carefully constructed wastewater, with characteristics that can represent multiple applications, offers both flexibility and reproducibility to the verification test. Vendors' specific claims can be directly quantified across a broad spectrum of contaminants in an efficient and cost-effective manner, and users have a consistent benchmark for the selection of appropriate technologies. These factors outweigh the fact that the test is not being performed under "real-time" conditions.

The Testing Organization and Vendor can offer an alternative direct site application to conduct the verification test. The Test Plan must clearly state the justification for such a site in comparison to the controlled test, and must address the contaminants of concern included within this protocol.

4.1 EXPERIMENTAL SET-UP -- TEST FACILITY

The Testing Organization shall provide a complete description of the test site and amenities to the project, the test equipment and the experimental setup. These shall be in the form of equipment specifications, layouts, sizing calculations and engineering drawings. In general, as discussed earlier, the Verification Test will be conducted under a controlled condition using an engineered test facility. An example-schematic of such a facility is provided in Figure 1.

4.2 TEST PHASES

The primary operational characteristics of the targeted in-drain technology shall be addressed within the experimental design. These shall include, but need not be limited to:

1. Performance under intermittent flow conditions;
2. Performance at different hydraulic loadings, including at peak flow;
3. Performance at different contaminant loadings, including at peak concentration of targeted contaminants;
4. Capacity of the equipment with respect to contaminant mass; and
5. Maintenance logistics with respect to cleanout and/or insert replacement.

The Test Plan shall address these performance and operational elements, and others that may be identified by the Verification Organization, USEPA and Testing Organization, or claimed by the Vendor at the time of application for an ETV. A phased testing approach shall be used, allowing for isolation and direct testing of the specific verification objectives. To assure that sufficient data are obtained, the Testing Organization must clearly provide a sampling and analysis program for each test element and the schedule for testing.

Four phases of testing shall be included in the Test Plan, unless otherwise offered by the Testing Organization and approved by the Verification Organization. The following is a generic outline of these Test Phases, assuming that the technology involves a filtration/adsorption-type medium insert. Modifications and rearrangement of these Test Phases can be made and presented in the specific Test Plan; the following is meant to identify test elements that should be addressed in the Test Plan.

Test Phase 1. Performance Under Intermittent Flow Conditions

In Phase 1, the system shall operate intermittently to simulate actual in-drain treatment applications. Phase 1 shall consist of an alternating sequence for a one-week (5-day) period: an 8-hour-on/16-hour-off cycle. When the system is “on”, there is normal flow through the system, simulating the operating or active period for a possible facility, while the system’s “off” period represents no flow and no activity, that is, the system is at “rest”. The normal flow is defined as typical average flows intercepted by the in-drain treatment technology, as determined by the Testing Organization and claimed by the Vendor. It is recommended that during this on cycle the flow should be at a constant, predetermined rate, but intermittent; for example, flow for 15 minutes and no flow for 15 minutes. The flow should be from a well-mixed feed tank, with the wastewater adjusted to known targeted characteristics, as discussed in Section 4.2. The flow rates shall be measured and cumulative volumes treated shall be recorded. The flow should be introduced to the test unit in a manner that reflects actual operating conditions. Thus, if the flow is normally introduced by gravity from an overhead floor drain, then the test configuration

should be configured as such. The Test Plan shall demonstrate how the test unit simulates proper field-scale installations. Sampling shall be conducted on the influent once per day at minimum, while a flow-proportioned effluent sample shall be accumulated for each 8-hr operating period during the 5-day period. Additionally, one-hour composites shall be collected every hour in the eight-hour period on two days and measured for TSS and COD, at minimum. Physical observations shall be made regarding the operation of the equipment. These should include head losses through the media, the appearance of discoloration, debris accumulation (if included as part of the wastewater matrix), oil sheens, and possible release of contaminants (e.g., solids and oils) during a transition from no-flow to flow. Head loss measurements can be elevation differentials, if appropriate, or simple manometers can be placed in the upstream flow stream. The Test Plan shall detail the method to be used for head loss measurements.

Test Phase 2. Determination of the Capacity of the Equipment

In Phase 2, the objective is to operate the system to "exhaustion", as defined by the need to replace the medium insert and/or to perform clean-out maintenance of the equipment. The system shall be operated in a continuous mode, 24-hours per day during this phase until the maximum amount of contaminant(s) have been filtered/adsorbed by the treatment medium, and performance fails. By changing the flow mode from intermittent to continuous, the use of the medium is accelerated, which facilitates reaching exhaustion in a reasonable amount of time.

If the test unit uses a media insert, the same media insert as used in the first test phase may be continued through this phase. The insert shall have been characterized as to weight (dry- and drained-wet weights) before any testing or operations began in the first Test Phase. Otherwise, the equipment itself shall be thoroughly cleaned and a new, pre-weighed insert shall be installed. The Test Plan shall clearly indicate this procedure.

The flow rate through the system during Test Phase 2 shall be at the rated flow of the test unit, as determined and specified in the Test Plan by the Testing Organization and Vendor. The feed to the system shall be the mixed synthesized wastewater, with continuous recording of flow rate and cumulative feed volume. Effluent sampling during this period shall be regularly scheduled, representing performance at progressively higher cumulative treated volumes (for example, every 5,000 or 10,000 gallons of water treated). Analysis shall include the targeted contaminants on a regular basis, and the full listing of contaminants of concern on a limited number of samples (at minimum this shall be at the beginning and end, and at some representative intermediate point). The influent mixture shall be measured for all contaminants at least twice and more frequently for TSS and COD, at minimum. The sampling and analysis shall include daily influent and effluent monitoring for TSS and COD. The complete sampling plan shall be described in the Test Plan.

Throughout this Test Phase, observations shall be regularly made and recorded with respect to head loss through the system; appearance of the media and unit with respect to discoloration, debris, oil sheen, and other visible characteristics; clogging of all or a portion of the media; flow patterns and evidence of short-circuiting; and other conditions as may be identified in the Test Plan.

The determination of when media exhaustion and/or the need for change-out or cleaning occurs shall be established in the Test Plan, with assistance from the Vendor and the O&M manual. In addition, quantification of such conditions shall be recorded. At minimum, the drained wet weight of the filtration/adsorption media insert shall be measured, and any accumulated debris removed from the equipment upon cleanout. This accumulation of weight in the media and or traps can then be related to the volume of water treated and the removals determined from the influent and effluent sampling.

The Test Plan shall present the methods that will be used to characterize the spent inserts, the maintenance efforts associated with the changeout and cleaning, and the disposal of the residuals generated from the equipment's operations. The methods for determining media exhaustion and/or the need for change-out or cleaning shall be compared with the Vendor's product literature and/or O&M manual for the technology.

Test Phase 3. Performance Under Varied Hydraulic and Concentration Loading

In this phase, the testing shall center on the device's ability to handle hydraulic throughput, and the impact of spike increases in contaminant concentration. This Test Phase shall be conducted in three parts, each of which can likely be conducted in one day. Since the treatment medium has been spent in Phase 2, a new treatment medium shall be inserted at the beginning of Phase 3.

Part 1. Hydraulic Throughput with Clean Water

In the first part of this test phase, clean water shall be used, and, the flow rate shall be progressively increased to test for hydraulic throughput capacity. Based on the statement of capability, the system shall be started at approximately one-half the vendor-rated average operating flow rate. Progressive increases in flow rate shall then be made (for example, at steps that are 25 percent higher than the preceding step). At each step increase, allow the system to stabilize (this can be done by allowing about 10 volume changes), and then record the head loss through the system, and observations with respect to flow patterns and any evidence of short-circuiting. The Test Plan shall provide the method for measuring the head loss through the unit. The step flow increases should be continued until there is evidence of flooding due to excessive headloss. In effect, flooding will occur at the drain because the unit is no longer capable of passing the liquid at the given flow rate.

Part 2. Hydraulic Throughput with Wastewater Matrix

The feed water shall then be switched to the synthesized wastewater matrix, and the entire progressive-hydraulic-throughput test repeated. At each step increase, allow time (e.g., equivalent to 10 volume changes) for the system to adjust to the new flow and then sample the effluent, in addition to the flow, headloss and other observations discussed earlier. The effluent should be analyzed for COD and TSS, at minimum (other targeted contaminants may be included, depending on the effort and costs). The objective is to demonstrate the impact of the progressive increases in throughput rate (and consequent decreases in retention time) on removal efficiency.

Part 3. Impact of Spike Increases in Concentration

Due to spills or other variances in activities, contaminant spikes will likely occur. This will be tested in the Verification by selecting specific target contaminants (for example, petroleum

hydrocarbons) and spiking the feed matrix with these contaminants by a predetermined factor. This factor shall be four, or as otherwise specified and approved in the Test Plan. Once the feed matrix has been adjusted, the same progressive hydraulic throughput test shall be conducted, and effluent samples collected. The samples can then be analyzed for the spiked contaminants. The intent is to gain an understanding of impact of the higher concentrations on removal efficiencies, coupled with variable retention times.

Test Phase 4. Contaminant Capacity at Higher Hydraulic Throughput

Test Phase 4 is a replicate of Test Phase 2, except that the system shall be operated in a continuous mode at the maximum acceptable flow rate determined in Phase 3. This shall be 85 percent of the highest flow rate demonstrated in Part 2 of Phase 3 that can be accepted by the system without flooding. Similar to Phase 2, the saturation of the treatment medium will be tested. Since the flow rate is much higher than that of Phase 2, the time to exhaustion should be faster. The same testing and monitoring protocols delineated for Phase 2 should be applied to Phase 4.

4.3 INFLUENT CHARACTERIZATION

The verification test shall be conducted under controlled conditions using a synthesized wastewater. As such, the characteristics of the synthetic contaminant matrix that is to be diluted with clean water are critical. To closely simulate actual wastewater characteristics, the synthetic contaminant mixture should come from actual products that may contribute to the wastewater. Based on expectations for typical in-drain treatment applications, the following readily available products can be used to formulate the synthetic contaminant mixture:

- Regular unleaded gasoline, with MTBE additive;
- Truck diesel fuel;
- 10W-30 motor oil;
- Brake fluid;
- Antifreeze/coolant (glycol based);
- Vehicle washing detergent;
- Windshield washer fluid; and
- Standard soil of various grain sizes.

The gasoline, diesel fuel, motor oil, brake fluids, and antifreeze/coolant are contributors to hydrocarbon contamination, while detergents and washer fluids will generate surfactants. Certain products will also contain nutrients, in the form of organic nitrogen compounds, ammonia, and/or phosphate. In real applications, emulsified dirt and grime washed from trucks, automobiles, and floors of garages produce suspended solids. Unfortunately, such dirt is not a product that can be bought or easily synthesized. Therefore, standard soil of various grain sizes shall be used instead.

The standard soil mixture shall include the following:

- Sand (33.3% by weight);
- Silt (30.0% by weight)
- Top soil (21.0% by weight)
- Clay (15.7% by weight)
  - Montmorillonite (5.7%)
  - Kaolinite (10.0%)

As a guideline, Table 1 lists suggested characteristics of the synthesized feed wastewater. Suggestions for alternative characteristics may be offered to the Verification Organization prior to finalizing the Test Plan. According to vendors, a typical oil and grease concentration in in-drain treatment applications is about 100 mg/L. An approximate BTEX concentration in gasoline has been pro-rated to the oil & grease concentration in synthetic wastewater. Estimates of surfactants from windshield washer fluids and vehicle wash detergents have been also included. The COD, TSS, phenols, PO_4, TKN, and NH_3 levels are concentrations found in commercial paved parking lots. The heavy metal concentration data are from a car wash facility, and include those metals normally found in traffic areas.

Table 1 – Suggested Synthetic Wastewater Characteristics

Parameter	Concentration
TPH	120 mg/L
TOC	100 mg/L
Oil & Grease	100 mg/L
Benzene	5 mg/L
Toluene	7 mg/L
Ethylbenzene	< 1 mg/L
Total Xylenes	6 mg/L
Total Phenols	10 mg/L
MTBE	7 µg/L
Total Suspended Solids	300 mg/L
Total Metals (Al + Cd + Cr + Cu + Fe + Pb + Zn)	9 mg/L
Surfactants (MBAS)	10 mg/L
COD	200 mg/L
PO_4-P	1 mg/L
TKN	5 mg/L
NH_3-N	1 mg/L

The Test Plan shall provide the formulation of the wastewater matrix for testing, and shall include demonstration of the expected characterization by direct analysis of the matrix, based on the prescribed makeup. The characterization of an acceptable matrix shall be within a range of plus or minus 50 percent of the suggested averages given in Table 1. With the exception of the standard soil, the Testing Organization and Vendor are encouraged use real wastes in place of the commercial products listed above to formulate this matrix. Sources of real wastes may include waste diesel and motor oils from an automotive repair shop or oil recovery facility, spent washwaters from a truck washing operation or car wash, and spent cutting oils from a machine

shop. These can be collected in sufficient quantity such that, upon combination and dilution, they will be more than adequate for the full ETV verification test (all phases). Initial testing within the Test Plan development phase of the Verification is advised. In the case of either using commercial products or appropriate wastes, dilute solutions of the major inputs (e.g., 100:1 aqueous dilution of a gasoline or detergent) can be analyzed for the key parameters. These data can then be used to derive the formulation for the stock mixture.

In addition to quality characterization, flow characterization of influent will also be required. A flow meter in the influent line, with a totalizer, will provide the necessary flow information. Details of flow monitoring methods, calibration procedures, and data editing and evaluation procedures shall be documented in the Test Plan.

4.4 EFFLUENT CHARACTERIZATION

As described in Section 3.3, the effluent quality of the targeted contaminants and the secondary contaminants, as identified by the Vendor and Testing Organization in the Test Plan, shall be determined and reported.

4.5 RESIDUALS MANAGEMENT

In-drain treatment technologies will produce residuals, in the form of spent filtration and/or adsorption treatment media, and any debris trapped by the device. The residuals shall be quantified as a part of its performance measurement (see Section 3.4). Before its disposal, a sample of the spent medium residual shall be tested using the Toxicity Characteristic Leaching Procedure (TCLP)[13] to determine its classification.

4.6 OPERATION AND MAINTENANCE (O&M)

The Testing Organization shall be responsible for the operation of the system. As a part of the Test Plan, a procedure for routine checks shall be developed. A log of daily activities, including the time and date of all events, shall be maintained.

An O&M manual shall be provided by the Vendor with the equipment. The manual shall include, but not be limited to:

- Clear and concise recommendations for procedures related to proper operation of the in-drain treatment systems and equipment, including startup and shutdown procedures;
- Clear and concise procedures for performing maintenance on the system and its components, including the replacement and/or cleaning of the treatment medium insert, if used;
- A list of spare parts to be kept on hand, if required;
- A list of special tools and equipment; and
- Disposal requirements.

5 SAMPLING AND ANALYTICAL PLAN

The Test Plan shall include a Sampling and Analysis Plan in conformance with the specific experimental design for the Verification Test. The primary objective of a sampling and analysis plan is to obtain representative data that accurately reflect the treatment and operating performance of the technology being tested. The plan shall include:

- Selection of field sampling and flow monitoring equipment and their operational parameters, as appropriate;
- Selection of sampling and analytical methodologies;
- Sample types, numbers, quantities, handling, packaging, shipping, and custody, if applicable;
- Sampling location, storage, and holding times;
- Requirements for field and laboratory QA/QC activities;
- Protection of health and safety of test personnel;
- Data reporting requirements; and
- Methods for validating and verifying the data.

5.1 CHAIN OF CUSTODY

An essential part of any sampling/analytical plan is ensuring the integrity of the sample from collection to data reporting. The possession and handling of samples shall be traceable from the time of collection through analysis and final disposition. To establish the documentation necessary to trace sample possession from the time of collection, a chain-of-custody record shall be filled out for and accompany every sample. The Test Plan shall provide sample forms and outline procedures for adequate chain-of-custody tracking.

5.2 SAMPLING LOCATIONS

As shown in Figure 1, the example test facility includes two aqueous sampling locations: SP1 and SP2. SP1 (Sampling Point 1) represents the influent stream to the in-drain treatment system and is the combined stream of clean water and synthetic contaminant mixture. SP2 (Sampling Point 2) represents the effluent from the in-drain treatment system. At each of these locations, an automatic composite sampler shall be provided.

5.3 SAMPLING FREQUENCY

The sampling plan shall detail the number and type of samples to be collected, as dictated by the experimental design of the Verification Test. For targeted contaminants, frequent sampling and analysis shall be required. For all secondary contaminants, less frequent sampling and analysis will suffice and shall be indicated in the site-specific Test Plan. When the test phase is in intermittent flow mode (8-hour-on / 16-hour-off), an 8-hour composite sample during the “on” period shall be collected. When the test phase is in continuous flow mode, a 24-hour composite shall be collected. Oil and grease (O/G) and volatile organic compounds (TPH and BTEX) samples shall be grab samples, collected at the end of a particular operating or compositing period.

5.4 SAMPLE PRESERVATION AND STORAGE

Special precautions are necessary for samples containing organic compounds and trace metals. Because many constituents may be present at low concentrations, they may be totally or partially lost or easily contaminated when proper sampling and preservation procedures are not followed. A summary of special sampling and handling requirements for targeted and secondary contaminants is provided in Table 2.

Table 2 – Summary of Special Sampling and Handling Requirements

Determination	Container (1)	Min. Sample Size, mL	Sample type (2)	Preservation (3)	Max. Holding Time
TPH	G	1000	g	Refrigerate, add H_2SO_4 to pH < 2	28d
TOC	G (B)	100	g, c	Add H_2SO_4 to pH < 2	14d
Oil & Grease	G	1000	g	Refrigerate, add H_2SO_4 to pH < 2,	28d
BTEX	G, PTFE-lined cap	4 x 40	g	Collect with no head space. Add HCl to pH < 2, add 1000 mg ascorbic acid/L if residual chlorine present, refrigerate	14d
Phenol	P,G, PTFE-lined cap	500	g, c	Refrigerate, add H_2SO_4 to pH < 2	28d
MTBE	G, PFTE-lined cap	4 x 40	g	Collect with no head space. Add HCl to pH < 2, add 1000 mg ascorbic acid/L if residual chlorine present, refrigerate	14d
Solids (TSS)	P,G	100	g, c	Refrigerate	7d
Surfactants (MBAS)	P,G	250	g, c	Refrigerate	48h
Metals, general	P(A), G(A)	1000	g, c	For dissolved metals filter immediately, add HNO_3 to pH < 2	6 mth
COD	P,G	100	g, c	Add H_2SO_4 to pH < 2; refrigerate	7d
Phosphate	P,G	100	g, c	Add H_2SO_4 to pH < 2; refrigerate	28d
TKN	P,G	500	g, c	Refrigerate, add H_2SO_4 to pH < 2	28d
Ammonia	P,G	500	g, c	Refrigerate, add H_2SO_4 to pH < 2.	28d

Notes:
1) P = plastic (PE or equivalent), G = glass, G(A) or P(A) = rinsed with 1 + 1HNO_3; G(B) = glass, borosilicate
2) g = grab, c = composite
3) Refrigerate = storage at 4°C ± 2°C; in the dark; analyze immediate = analyze usually within 15 min of sample collection

5.5 ANALYTICAL METHODOLOGY

The analytical methodology shall follow the most recent version of EPA's "Methods and Guidance for Analysis of Water". Where EPA does not provide an analytical method, standard procedures such as "Standard Methods for the Examination of Water and Wastewater, 20th Edition" shall be used. Table 3 lists parameters for analysis and recommended analytical methods.

Table 3 – Parameters for Lab Analysis and Analytical Methods

Parameter	**5.5.1.1.1 Methodology**
TPH	EPA 1664A SGT-HEM
TOC	EPA 415.2
Oil & Grease	SW846-1664
BTEX (benzene, toluene, ethylbenzene, xylene)	EPA 502.2, 524.2
Phenol	EPA 420.4
MTBE	EPA 502.2, 524.2
Total Suspended Solids (TSS)	EPA 160.2
Heavy Metals: Al, Cd, Cr, Cu, Fe, Pb, Zn	EPA 200.7, 200.8, 200.9
Surfactants	EPA 425.1
COD	EPA 410.4
PO_4-P	EPA 365.2
TKN	EPA 351.2
NH_3-N	EPA 350.1

6 QUALITY ASSURANCE PROJECT PLAN (QAPP)

Every Test Plan developed for a technology verification shall include a Quality Assurance Project Plan (QAPP). The QAPP for this verification testing specifies procedures that shall be used to ensure data quality and integrity. Careful adherence to these procedures will ensure that data generated from the verification testing will provide sound analytical results that can serve as the basis for performance verification.

6.1 PURPOSE AND SCOPE

The purpose of this section is to outline steps that shall be taken by operators of the equipment and by the analytical laboratory to ensure that data resulting from this verification testing are of known quality and that a sufficient number of critical measurements are taken.

6.2 QUALITY ASSURANCE RESPONSIBILITIES

The Testing Organization shall prepare a QAPP for the verification test, to be included in the Test Plan, that specifies procedures to be followed to ensure the validity of test results and their use as the basis for equipment performance verification. The QAPP applies to all organizations involved in the Equipment Verification Testing, including the Testing Organization and laboratories qualified by the Verification Organization. The Testing Organization, having been qualified by the Verification Organization and with the Verification Organization's oversight, shall have the primary responsibility for ensuring that the QAPP is implemented during the verification testing activities. Both the Vendor and the EPA Pilot Manager, for evaluations under the Environmental Technology Verification Program, must approve the entire test plan, including the QAPP, before the verification testing can proceed.

If problems arise or any data appear unusual during the course of verification testing, they shall be thoroughly documented and corrective actions shall be implemented, as specified in the QAPP.

6.3 CONTENTS OF THE QAPP IN TEST PLAN

The Testing Organization shall be responsible for including the following elements in the QAPP:

- Description of methodology for measurement of accuracy and precision;
- Description of the methodology for use of blanks, the materials used, the frequency, the criteria for acceptable method blanks, and the actions to be taken if criteria are not met;
- Description of any specific procedures appropriate to the analysis of the performance evaluation samples. It has to be clear how these samples are going to be used in the verification testing;
- Outline of the procedure for determining samples to be analyzed in duplicate, the frequency, and approximate number;
- Description of the procedures used to assure that the data are correct;
- Listing of equations used for any data quality indicator calculations;
- Development of a corrective action plan in the test plan;

- Provision of all QC information such as calibrations, blanks and reference samples in an appendix. All raw analytical data shall also be reported in an appendix; and
- Provision of all data in hard copy and electronic form in a common spreadsheet or database format.

6.4 QUALITY CONTROL CHECKS

Quality control checks provide a means of measuring the quality of data produced. The checks to be used in the Verification shall be stated and their selection justified with respect to the equipment, experimental design, and performance goals.

6.4.1 Quality Control for Equipment Operation

This section shall explain the methods to be used to check on the accuracy of equipment operating parameters and the frequency with which these quality control checks shall be made. An essential aspect of the technology verification testing program is to provide acceptable and verifiable operating results. Examples may include a secondary method for flow measurement (alternate meter, dilution method), a reference pressure gauge, etc.

6.4.2 Water Quality Data

The quality of water sample analytical results is as important as the quality of the equipment operating data. Important aspects of sampling and analytical QA include:

- **Duplicate Samples:** Duplicate samples shall be collected at specified frequencies in order to document precision. The precision resulting from duplicate samples is a function of the variance of water composition, of the sampling and analytical techniques. The number of duplicate samples shall be specified in the Test Plan and shall comprise at least one for every 20 samples collected. The actual number of duplicates shall depend on the frequency of analysis and the approximate number of samples.
- **Field Blanks:** Field blanks should be collected at specified frequencies, which will vary according to the probability of contamination or cross-contamination. Field blanks are often metal and/or organic-free water aliquots that contact sampling equipment under field conditions and are analyzed to detect any contamination from sampling equipment, cross-contamination from previously collected samples, or from conditions during sampling (e.g., airborne contaminants).

6.4.3 Data Quality Indicators

The data obtained during the verification testing must be of sound quality for conclusions to be drawn on the equipment. Data quality parameters shall include four indicators:

- **Accuracy**: combination of bias and precision of an analytical procedure, which reflects the closeness of a measured value to a true value.
- **Bias**: consistent deviation of measured values from the true value, caused by systematic errors in a procedure.
- **Precision**: a measure of the degree of agreement among replicate analyses of a sample usually expressed as the standard deviation.
- **Representativeness**: the degree to which the data accurately and precisely represent the conditions or characteristics of the parameter represented by the data.

6.5 DATA REDUCTION, VALIDATION, AND REPORTING

To maintain good data quality, specific procedures shall be followed during data reduction validation, and reporting. These procedures are detailed below.

6.5.1 Data Reduction

Data reduction refers to the process of converting the raw results from the equipment test into a form that can be used to evaluate the performance and operating characteristics of the system. The procedures to be used will be equipment dependent. The purpose of this step is to provide data that shall be used to verify the statement of performance capabilities. These data shall be obtained from logbooks, instrument outputs, and computer outputs as appropriate.

6.5.2 Data Validation

The Testing Organization shall verify the completeness of the appropriate data forms and the completeness and correctness of data acquisition and reduction. In addition, calculations and laboratory logbooks and data sheets will be reviewed to verify accuracy and completeness. The individual operators and the laboratory supervisor shall examine calibration and QC data. Laboratory and project managers shall verify that all instrument systems are in control and those QA objectives for accuracy, completeness, and method detection limits have been met.

Analytical outlier data are defined as those QC data lying outside a specific QC objective window for precision and accuracy for a given analytical method. Should QC data be outside of control limits, the analytical laboratory or field team supervisor shall investigate the cause of the problem. If the problem involves an analytical problem, the sample shall be reanalyzed.

If the problem can be attributed to the sample matrix, the result shall be flagged with a data qualifier. This data qualifier shall be included and explained in the final analytical report.

6.5.3 Data Reporting

The results of the entire verification testing process shall be presented in a Verification Report. The report shall include all results from influent and effluent water quality analyses from in-drain treatment technology start-up to the conclusion of the verification testing, including all monitoring and maintenance activities and any changes in performance over time. All QC information such as calibrations, blanks and reference samples are to be included in an appendix. All raw analytical data shall also be reported in an appendix. Refer to Section 7.3 for additional information on reporting requirements.

7 DATA MANAGEMENT AND DOCUMENTATION

Verification testing will generate a significant amount of data/records. Data to be generated by verification testing include, but are not limited to, water and wastewater flow data, wastewater quality data, treatment performance of the in-drain treatment technology under specific operating conditions, and O&M parameters. Records consist of both paper and electronic data. Paper records such as field notebooks, bench sheets, field data sheets, custody sheets, and instrument printouts are part of the raw data test record.

7.1 GENERATED DATA

The types of data generated from the Verification Test are both quantitative and qualitative. Flow rates at specified time intervals are examples of quantitative data, while observations of the treatment medium, such as its appearance and potential clogging problems, are examples of qualitative data. In addition, the data may be classified as raw or analyzed/calculated data. Raw data are obtained directly from the test unit, such as flow rates, pressures, and concentrations of contaminants of concern. Analyzed or calculated data are obtained from mathematical analysis transformation of raw data. An example is the computed hydraulic loading rate, in Lpm/m^3.

In the Verification Report, all types of data (qualitative, quantitative, raw, and analyzed/calculated) shall be presented. When possible, tabular and graphical formats should be used for clarity and ease of presentation. It is suggested that data be ordered chronologically and by test phase.

Examples of generated data for verification testing in-drain treatment technologies are:

- Raw data:
  - Flow rate and cumulative flow rate
  - Headloss data
  - Influent and effluent concentrations of contaminants of concern
  - Handling of the treatment medium, e.g., appearance, clogging problems, etc.
  - Flow pattern, e.g., short-circuiting
  - Maintenance record
- Analyzed/Calculated data:
  - Hydraulic capacity
  - Mass removal for contaminants of concern
  - Residuals management

7.1.1 Raw Data

Raw data as listed above is self-explanatory, in that the data are generated from instruments or directly observed during the test. However, the maintenance data can be broad in definition and further explanation is warranted:

The maintenance data from the tested treatment system shall include all maintenance activities performed during the verification test. They shall include descriptions of the performed maintenance tasks, the reason they were done, and the duration of the maintenance activity. It is acknowledged that the verification test represents an accelerated operation of the treatment

system. Hence, the performed maintenance during the test may not represent typical maintenance procedures or frequencies for long-term use of the treatment system. The verification report shall clearly discuss and present normalization of these data to long-term applications. For example, one can suggest that inserts have to be removed and replaced every 30,000 gallons processed, rather than suggest that the task is performed within a certain timeframe.

7.1.2 Analyzed/Calculated Data

Design criteria such as hydraulic and mass removal capacities are two essential analyzed data requirements to size commercial in-drain treatment systems. As part of the Test Plan, the Vendor and Testing Organization would have estimated the size of the equipment based on feed water rate and qualities outlined in the test plan. In the Verification Report, the hydraulic and mass removal capacities shall be calculated using actual flow rates and feed water qualities measured within the verification test. These calculations will be compared against the Vendor-claimed design capacities.

The **hydraulic capacity** is calculated by the relationship between the volume of treated water processed and treatment volume (or treatment medium). In other words, a calculation of liters of treated water/m^3 of medium or treatment volume should be performed. Another format of hydraulic capacity is the relationship between the volume of treated water and mass of treatment medium, or liters of treated water/kg of medium. If a specific in-drain treatment technology requires different format to calculate their hydraulic capacity, this should be described in the Test Plan and calculated in the Verification Report. The **hydraulic loading rate** should also be presented as a function of the equipment volume or medium mass. This parameter should be analyzed with respect to the observed operating range as it compares to the Vendor's rating for the system. Defining the **hydraulic operating range** of the unit shall incorporate an analysis of headlosses under clean and contaminated water conditions.

The **mass removal capacity** is defined either as mass of contaminant removed per volume of medium (or treatment volume) or mass of contaminant removed per mass of treatment medium. These mass removal capacities should be calculated for all targeted contaminants and compared to vendor claims. In addition, the mass removal of secondary contaminants should be calculated to measure the overall performance of the treatment system.

In addition to the capacity data, there are other types of analyzed/calculated data, which should be discussed in the Results and Discussion section of the Verification Report. Examples of analyzed/calculated data are graphical relationship of the following:

1. **Flow rate and time** – this relationship shows feed flow variations, including the intermittent flows and fluctuations, during each test phase. It also shows the various flows tested from one test phase to another. **Headlosses** can be incorporated into this analysis and graphical presentation.

2. **Cumulative flow and time** – this relationship shows the operating time to reach a certain cumulative flow, which is to be used in the evaluation of the capacity of the equipment.

3. **Percent removal and time for each contaminant of concern** – the percent removal is defined as $(C_{inf} - C_{eff}) / C_{inf}$, where C_{inf} and C_{eff} are contaminant concentrations of contaminants in the influent and effluent, respectively. This relationship will graphically show the percent removal over time for each contaminant of concern at each test phase. It will also demonstrate the time when the spent medium needs to be replaced, as noted by deterioration in effluent quality.

4. **Effluent concentrations and time for each contaminant of concern** – this relationship is very similar to the above relationship between percent removal and time. However, it will use the actual effluent concentrations for each contaminant of concern and for each test period. This can also be graphically display as a function of cumulative volume processed.

5. **Influent and effluent concentrations for each contaminant of concern** – Parts 2 and 3 of Test Phase 3 are identical to each other, except that the feed water in Part 3 is spiked with synthesized contaminant mixture by a pre-determined factor. Therefore, the influent and effluent concentrations for these two test periods will be compared in this graphical relationship.

6. **Actual effluent concentrations for each contaminant of concern** –The actual test effluent concentrations will be compared to the vendor's targeted effluent concentration and removals.

In addition to the above graphically analyzed data, several forms of calculated data in reference to residual measurements should be performed:

1. Mass of residuals (e.g., kg) per volume of treated water (e.g., liters);
2. Volume of residuals (e.g., m^3) per volume of treated water (e.g., liters);
3. Mass of targeted contaminant removed (e.g. kg) per mass of residuals generated (e.g., kg);
4. Classification of residuals, e.g., spent treatment medium, based on TCLP analysis.

The Testing Organization and Vendor can use the above examples as guidance in setting the manner in which the results of the testing will be presented and discussed in the Final Report. These will require approval and may be modified and supplemented by the Verification Organization.

7.1.3 Manual Data

When manual data recording is employed, the Testing Organization shall record all data and calculations by hand in laboratory notebooks with carbon copies. Daily measurements shall be recorded on specially prepared data log sheets, as appropriate. The original notebooks shall be stored onsite and the carbon copy sheets shall be forwarded to the project manager of the Testing Organization at least once per week. Logs shall include a description of the system, dates and times, any problems or issues, names of visitors, calculations, and other pertinent items.

7.1.4 Electronic Data

Data in electronic format shall be included in commercially available programs for word processing, spreadsheet or database processing, or commercial software developed especially for

data collection and processing on a specific hardware instrument or piece of equipment. Backup of the computer databases should be performed on a daily basis, if possible.

7.1.4.1 Verification Testing Database

A database for the project shall be set up in the form of custom-designed spreadsheets. The spreadsheets shall be capable of storing and manipulating the wastewater quality data from each sampling event along with the corresponding operational parameters, sampling location, day and time, etc.

All data shall be kept and maintained in a central location. All manually entered data from the laboratory notebooks and data log sheets shall be entered into the appropriate spreadsheet on a weekly basis at minimum. All recorded calculations shall also be checked at this time. Following data entry, the spreadsheet shall be printed out and the printout shall be checked against the handwritten data sheet, preferably by Testing Organization personnel not involved with the data entry. Any corrections shall be noted on the hardcopies and corrected on the screen, and then a corrected version of the spreadsheet shall be printed out. The printouts shall be initialed and dated by the Testing Organization personnel performing the checking and data verification. The printouts shall be stored in chronological order in a project binder. Copies of the checked and corrected printouts shall be forwarded to the project manager of the Testing Organization at least once per week. At least two electronic backups of the data spreadsheets shall be kept (e.g., one copy on computer hard drive and one copy on disk).

Formulae and functions written into the spreadsheets for data manipulation and calculations shall be checked periodically to ensure that they are being used and entered correctly. The spreadsheets shall undergo a monthly audit, at minimum, by the Testing Organization to ensure the formulae and functions are being used and are entered correctly. The checking may involve reviewing sample formulae and making sure the correct cells are referenced, the formula is entered correctly (e.g., parenthesis and operations are correct), as well as performing a few random hand calculations and comparing the results to those calculated by the spreadsheet program. The spreadsheet audits shall be recorded in a log with the date, reviewer initials, name and timeframe of data set inspected for identification, audit findings, and any modifications made to the spreadsheets.

Each sampling event shall be assigned a specific identification number that will be tied to all data from that sampling event through each step of data entry and analysis. The data from a sampling event shall include the wastewater quality data as well as system/operational settings and conditions, flow rates, sampling locations, day, time, personnel involved, etc. Samples delivered to Verification Organization-qualified analytical laboratories, along with the results in the laboratory reports, shall be tracked by the identification numbers. Laboratory reports shall be received and reviewed by the Testing Organization. These data will be entered into the data spreadsheets, cross-checked, and verified in the same manner as previously discussed.

The QA/QC procedures for managing, reviewing and checking data shall be presented in the QAPP contained in the Test Plan. The means to obtain, record, check, and store data obtained manually and electronically (data loggers, computers, etc.) shall be discussed in the QAPP. Refer to Section 6.0 for further QA/QC information.

7.2 DATA ANALYSIS AND PRESENTATION

The data obtained in the verification testing shall be statistically analyzed, reduced, and presented in tables, graphs and/or charts in a clear and concise manner. Raw data shall be included as an appendix to the final verification testing report.

Note that it must be possible to tie the results as presented to the original raw data and test conditions under which the results were obtained. The QAPP contained in the Test Plan shall address this requirement.

A detailed discussion of the results shall accompany the tables, graphs, and charts and shall be presented in the final verification testing report. The Testing Organization shall provide and discuss conclusions drawn from the test results.

7.3 VERIFICATION REPORT

The Verification Report shall present the results of the verification testing such that the testing demonstrates the capability and performance of the in-drain treatment technology.

The draft Verification Report shall be reviewed by the Verification Organization, the US EPA and peer-reviewers (for evaluations conducted under the Environmental Technology Verification Program). For verification testing performed against this protocol outside of the ETV Program, the draft Verification Report shall be reviewed by a peer-review group with no real or perceived bias concerning the technology. For all technology verifications, the Vendor shall also review the draft Verification Report and provide comments. For testing conducted under the ETV Source Water Protection Pilot, the Verification Report and Verification Statement, once approved, will be posted on the Internet on both the USEPA/ETV and NSF web sites.

The report shall include the following topics:

- Executive Summary
- Introduction and Background
- Identification and Description of In-Drain Treatment Technology
  Include in-drain treatment technology capabilities.
- Experimental Setup and In-Drain Treatment Technology Configuration
  Include site plan with in-drain treatment technology layout shown.
- Test Procedures and Methods
  Include methods and procedures for characterization, start-up, verification testing, field analyses, and laboratory analyses.
- Verification Testing Period
  Include observations, conditions, reduced influent and effluent data in graphs and/or tables, results.
- Final Results and Discussion
  Discuss final results. Present reduced data in graphs and/or tables.
- Statement of Verification

Provide a final statement regarding the treatment performance of the in-drain treatment technology under specific test conditions.

- References
- Appendices

  Test Plan
  Vendor-Supplied O&M Manual(s)
  QA/QC Procedures and Results
  Laboratory Reports with QA/QC Records, Chain of Custody Forms
  Monitoring and Maintenance Records/Logs
  Raw Data

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