Region 4 U.S. Environmental Protection Agency Laboratory Services and Applied Sciences Division Athens, Georgia	
Operating Procedure	
Title: Wastewater Flow Measurement	**ID: FSBPROC-109-R7**
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Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when conducting wastewater flow measurement.

Scope/Application

The procedures contained in this document are to be used by field personnel when conducting wastewater flow measurement. If LSASD field personnel determine that another procedure to conduct wastewater flow method needs to be used to obtain flow measurement data, the variant procedure and circumstances requiring its use will be documented in the project specific logbook. Trade names and commercial products mentioned in this operating procedure do not constitute endorsement or recommendation for use.

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1 General Information

1.1 Documentation/Verification

This procedure was prepared by personnel, deemed technically competent by LSASD management, based on knowledge, skills, and abilities and has been tested in practice and reviewed by a subject matter expert. The official copy of this procedure resides on the LSASD local area network (LAN). The Laboratory and Field Quality Control Manager is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.2 General Precautions

1.2.1 Safety

Proper safety precautions must be observed when collecting wastewater flow measurement data. Refer to the LSASD Health and Environmental Management Program Procedures and Policy (SHEMP) Manual and any pertinent site-specific Safety Plans for guidelines on safety precautions. Proper personal protective equipment (PPE) should be worn by all personnel conducting activities specified in this procedure.

1.2.2 Procedural Precautions

The following precautions should be considered when collecting flow measurement data:

- Awareness of open channels of wastewater,
- Awareness of uncovered and potentially loose metal grating throughout facility,
- Awareness of electrical lines overhead and on the ground, and
- Awareness of equipment and other loose items that could cause one to fall or trip.

2 Wastewater Flow Considerations

2.1 Introduction

The U.S. Department of the Interior (USDOI) Water Measurement Manual (1) is a standard reference for details on checking the installation of primary open channel flow devices. Basic guidance for making wastewater flow measurements and a basic description of all acceptable wastewater flow measurement systems are given in the EPA National Pollutant Discharge Elimination System (NPDES) Compliance Inspection Manual (2). This manual will be used by LSASD field investigators as guidance for such measurements.

2.2 Site Selection

It is the field investigator's responsibility to ensure that the facility’s influent or effluent wastewater flow measurement system or technique used measures the total wastewater discharged (described by the NPDES permit, if applicable). The location of influent wastewater flow measurement equipment should be prior to return activated sludge (RAS) unless that data is needed for the purposes of a diagnostic evaluation.

2.3 Flow Measurement Systems

Flow may be measured on an instantaneous or a continuous basis. A typical continuous system consists of a primary flow device, a secondary flow sensor, transmitter, flow recorder, and totalizer. Instantaneous flow measurements can be obtained by using the primary flow device. Techniques which are described later in this Section are available for measuring instantaneous flows with portable equipment.

The typical primary flow devices encountered are the Parshall flume v-notch weir, although there are a variety of flumes and weirs, as well as Venturi meters for closed flow conditions.

A secondary device such as a flow sensor measures the hydraulic responses of the primary flow measurement device and transmit the responses to the recording system. Typical sensors encountered include ultra-sonic transmitters, floats, pressure transducers, capacitance probes, differential pressure cells, electromagnetic cells, etc.

2.4 Field Investigation Procedures

The facility's flow measurement system should measure within ±10 percent of the actual flow determined by the primary flow device. The primary flow device and the secondary system will be checked to determine if they conform to the manufacturer's design and installation standards. Deviations from standard conditions will be documented. The facility chart recorder will be checked to verify that the time and scale are correct.

The accuracy of the flow measurement system is checked by making an instantaneous flow measurement and comparing this reading against the flow measurement system instantaneous flow reading. In addition, EPA flow equipment can be installed to confirm the facility's totalizer readings. This flow measurement device should be set up at the appropriate head measurement point (1,2,7). An instantaneous flow reading will be documented in the field book or on the flow chart recorder when possible.

Existing facility primary flow devices and flow measurement systems can be used when the accuracy of these devices and the system can be verified. The field investigator will verify that an existing facility flow measurement system (including primary flow device) utilized to measure wastewater flow conforms to recognized design and installation standards, and any deviation from standard conditions will be documented. The accuracy of the secondary system may be checked by making an independent flow measurement. If there is no usable or existing primary flow measuring device or if the device has been located in the wrong place, the investigator may, if so desired, install a portable primary flow device. The accuracy of flow sensors and recorders for open channel flow devices can be checked by making an instantaneous measurement utilizing the primary flow device and comparing this against the recorder reading. If the discharger's flow measurement system is accurate within ±10 percent of the actual flow, the investigator can use the existing system.

If non-standard primary flow devices are being used, data supporting the accuracy and precision of the methods being employed should be provided by the permittee. Deficiencies found during the inspection will be recorded by the investigator, and the permittee will be informed that the equipment should be calibrated as soon as possible.

2.5 Specific Techniques

This section highlights the most commonly used methods for wastewater flow measurements and the primary devices that will be encountered during field studies. The following methods are included only to enable the field investigator to make accurate flow estimates when necessary.

2.5.1 Volumetric

Volumetric flow measurement techniques involve the measurement of volume and/or the measurement of time required to fill a container of known size.

2.5.1.1 Vessel Volume

Vessel volume is used to obtain flow data particularly applicable to batch wastewater discharges. Accurate measurement of the vessel volume and the frequency at which it empties is all that is required.

2.5.1.2 Sump Pump

This measurement is made by observing the sump levels when the pumps cycles on and off and calculating the volume contained between the two levels. This volume times the number of pump cycles provides an estimate of the daily wastewater flow. The quantity of wastewater that flows into the sump during the pumping cycle should be accounted for too.

2.5.1.3 Bucket and Stopwatch

The bucket and stopwatch technique is particularly useful for the measurement of low wastewater flows. The equipment required to make this measurement is a calibrated container (bucket, drum, tank, etc.) and a stopwatch. A minimum of 10 seconds to fill the container is recommended. Three consecutive measurements should be made, and the results should be averaged.

2.5.2 Dilution Methods

Dilution methods for water and wastewater flow measurements are based on the color, conductivity, fluorescence, or other quantifiable property of an injected tracer. Dilution methods are described in LSASD Operating Procedure for Hydrological Studies (LSASDPROC-501). (3)

2.6 Open Channel Flow Measurements

Measurement of wastewater flow in open channels is the most frequently encountered situation during field investigations. The most commonly encountered methods in measuring open channel wastewater flows are described in this section.

2.6.1 Weirs

A weir is an overflow structure built according to specific design standards across an open channel to measure the flow of water. Equations can be derived for weirs of specific geometry which relate static head to water flow. Weirs are classified into two general categories, broad crested and sharp crested.

Broad crested weirs take the following form; $Q=CLH^{3/2}$. Where C is the discharge coefficient, L is the length of the weir, and H is the hydraulic level at the time of measurement. Values for the coefficient C are given in hydraulic handbooks (4, 5). Broad crested weirs can only be used to calculate instantaneous flows.

Sharp crested weirs are constructed in a wide variety of shapes and the most commonly encountered are V-notch, rectangular, and Cipolletti weirs. If such weirs are constructed as outlined in the USDOI Water Measurement Manual (1), they are considered standard primary flow devices.

All weirs should be inspected to determine if the weir installation and construction conform to the conditions given in the USDOI Water Measurement Manual (1), and provide a uniform influent flow distribution, and that the weir is placed squarely across the channel perpendicular to the direction of flow. Useful tools for checking weir construction and installation include a carpenter's level, a framing square, a measuring tape, a staff gage, or surveyor's level and rod. Problems observed during the inspection or study should be noted in the field records or logbook.

A set of weir tables is necessary for calculating the flow. Some sources of these tables are the USDOI Water Measurement Manual (1), the Stevens Water Resources Data Book (6), and the ISCO® Open Channel Flow Measurement Handbook (7).

2.6.2 Flumes

There are several types of flumes (e.g., Parshall, Palmer-Bowlus, Cutthroat, and Trapezoidal). All flumes should be inspected to determine if entrance conditions provide a uniform influent flow distribution, the flume dimensions conform to those given in the USDOI Water Measurement Manual (1), the floor of the flume at the throat section is level, and the throat section walls are vertical. Useful tools for checking the construction and installation of Parshall (and other) flumes include a carpenter's level, a framing square, and a measuring tape. The flume should be closely examined to determine if it is discharging freely. If there is any question about free discharge, the downstream head (H_b) should be measured and compared to the head at the proper location (H_a) in the converging section. A staff gage is useful for making head measurements. Any problems observed during the inspection or study should be noted in the field logbook.

A set of flume tables is necessary for calculating flows. Sources are: the USDOI Water Measurement Manual (1), the Stevens Water Resources Data Book (6), and the ISCO® Open Channel Flow Measurement Handbook (7). The explanatory material accompanying these tables should be read and understood before they are used.

2.6.3 Open Flow Nozzles

Open flow nozzles such as parabolic or Kennison nozzles are factory calibrated and are ordinarily supplied as part of a flow measurement system. Calibration and installation information for each nozzle should be supplied by or obtained from the manufacturer. The accuracy of these devices is reported to be often better than ± 5 percent of the indicated flow. A volumetric flow measurement may be used to check accuracy of this device if flow volumes are not excessive.

2.6.4 Velocity-Area Method

The basic principle of this method is that the flow in a channel (cubic feet/second) is equal to the average velocity (feet/second) times the cross-sectional area (square feet) of the channel. LSASD has two methods for determining flow using the area velocity method. The first method uses an area-velocity flow meter in which the probe senses velocity and water depth and converts these readings to a flow rate. In the second method, the velocity of the water or wastewater is determined with a current flow meter such as an Argonaut-SW® (which can also calculate cross-sectional area changes) or a current meter. The area of the channel is either measured or calculated using an approximation technique. Refer to the LSASD Operating Procedure for Hydrological Studies (LSASDPROC-501) (3) for Surface Water Flow Measurements.

2.7 Closed Conduit Flow Measurements

The accuracy of closed conduit flow measuring devices may be difficult to verify. However, the accuracy can be checked by making an independent flow measurement. Two of the available procedures are the Instruments Direct® F-100-902 Ultrasonic Doppler flow meter and a dilution technique. When applying the dilution technique, please refer to LSASD Operating Procedure for Hydrological Studies (LSASDPROC-501) (3).

Below are some of the more commonly used closed conduit devices.

2.7.1 Venturi Meter

The Venturi meter employs a conversion of static head to velocity head whereby a differential is created that is proportional to flow. The typical accuracy of a Venturi meter is at ±1 to 2 percent (9, 10, 11 and 12).

2.7.2 Orifice Meter

The orifice meter is a pressure differential device that measures flow by the difference in static head. They can be accurate, e.g., within ±0.5 percent, although their usable range is limited.

2.7.3 Flow Nozzle

The basic principle of operation is the same as that of the Venturi meter. The flow nozzle has an entrance section and a throat but lacks the diverging section of the Venturi meter. Flow nozzle accuracies can approach those of Venturi meters (9).

2.7.4 Electromagnetic Flow Meter

The electromagnetic flow meter operates according to Faraday's Law of Induction where the conductor is the liquid stream, and the field is produced by a set of electromagnetic coils. The accuracy of the device is within $\pm$1 percent of full scale (9).

2.7.5 Other Closed Conduit Devices

References for other closed conduit flow measurement methods such as acoustic flow meters, trajectory methods, pump curves, and water meters can be found in the EPA NPDES Compliance Inspection Manual (2).

3 Quality Assurance Procedures

The USDOI Water Measurement Manual (1), the EPA NPDES Compliance Inspection Manual (2), the ISCO flow handbook (7), and the USGS publication Discharge Measurements at Gaging Stations (8) are available for reference while in the field. Additional documentation pertaining to flow measurement systems can be referenced online as well.

Wastewater flow will be expressed in million gallons per day (mgd) or the metric equivalent (m^3/day). Time records associated with flow measurements will be kept in local time, will be made in military time format, and will be recorded to the nearest minute. All flow measurements conducted will be documented in the field logbook for the event. All measurements will be traceable both to the individual making the measurements and the equipment utilized. All field equipment will be operated, calibrated, and maintained according to manufacturer’s specifications. All equipment will be visually inspected prior to deployment to ensure proper operation.

3.1 Operational Check

A post-operation calibration check will be performed at the end of the flow measurement period according to manufacturer’s specifications. It is also recommended that a calibration check be conducted at least before leaving the facility to reduce the chance of having any operational errors arise during the flow measurement period.

4 Equipment

LSASD flow measurement equipment is categorized as follows: water level/stage hardware and recorders, velocity measuring equipment and assemblies, and direct flow measurement equipment and instrumentation.

LSASD currently has the following secondary devices: ISCO® Signature Flow Meters as well as ISCO® Models 4210, 4220, and 4250 flow meters and ultrasonic sensors. The Argonaut-SW® current flow meter is available to monitor current velocity and flow rates. The Argonaut-SW® can be installed in open channels and pipes without the use of primary devices. Flows in enclosed pipes can be measured using the Instruments Direct® F-100-902 Ultrasonic Doppler flow meter.

A limited number of primary devices are maintained by LSASD. The following primary devices are available for installation: V-notch weir plates, rectangular weir plates, and one small Parshall flume. Staff gages are available for direct instantaneous readings. Surveying levels and rods are available for use in calculating the head.

5 Records

Information generated or obtained by the field investigator will be organized and accounted for in accordance with the LSASD Operating Procedure for Control of Records (LSASDPROC-002) (15). Field notes recorded in a logbook will be generated as documentation according to the procedures found in LSASD Operating Procedure for Logbooks (LSASDPROC-010) (14).

6 References

1. Water Measurement Manual, U.S. Department of the Interior, Bureau of Reclamation, Most Recent Edition.

2. National Pollutant Discharge Elimination System (NPDES) Compliance Inspection Manual, U.S. Environmental Protection Agency, Most Recent Version.

3. LSASD Operating Procedure for Hydrological Studies, LSASDPROC-501, Most Recent Version.

4. King, H. W., and E. F. Brater, Handbook of Hydraulics, Sixth Edition, McGraw-Hill; New York, 1976.

5. Davis, C. V., and K. E. Sorenson, Handbook of Applied Hydraulics, Third Edition, McGraw-Hill: New York, 1969.

6. Stevens Water Resources Data Book, Stevens Water Monitoring Systems, Inc., Portland, Oregon, Most Recent Edition.

7. ISCO® Open Channel Flow Measurement Handbook, Teledyne ISCO, Inc., Lincoln, Nebraska, Most Recent Edition.

8. "Discharge Measurements at Gaging Stations," Chapter 8 of Book 3, Section A, U.S. Department of Interior, U.S. Geological Survey, Reston, Virginia, 2010.

9. "Sewer Flow Measurement: A State-of-the-Art Assessment," Municipal Environmental Research Laboratory, Office of Research and Development, U. S. Environmental Protection Agency: Cincinnati, Ohio, 600-275027.

10. A Guide to Methods and Standards for the Measurement of Water Flow, U.S. Department of Commerce, National Bureau of Standards, NBS Special Publication 421, 1975.

11. Wells, E. A. and H. B. Gotaas, "Design of Venturi Flumes in Circular Conduits," American Society of Civil Engineers, 82, Proc. Paper 928, April 1956.

12. American Society of Testing Materials, 1985 Annual Book of ASTM Standards, Volume 11 - Water, American Society of Testing Materials: Philadelphia, Pennsylvania, 1985.

13. US EPA Region 4 Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM), November 2001.

14. LSASD Operating Procedure for Logbooks, LSASDPROC-010, Most Recent Version.

15. LSASD Operating Procedure for Control of Records, LSASDPROC-002, Most Recent Version.

16. US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 LSASD, Athens, GA, Most Recent Version.

7 Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the LSASD Document Control Coordinator on the LSASD local area network (LAN).

History	Section Supervisor Initials	Effective Date
Set to FSBPROC-109-R7, No procedural changes required.	GW	January 30, 2025
Set to LSASDPROC-109-R6, Updated Chief to Supervisor		April 4, 2023
LSASDPROC-109-R5, Wastewater Flow Measurement Replaces SESDPROC-109-R4 Updated to reflect new division name LSASD throughout. Updated to cover pages names. Updated outdated references to procedures no longer used.		June 11, 2020
SESDPROC-109-R4, *Wastewater Flow Measurement*, Replaces SESDPROC-109-R3 **Cover Page:** SESD's reorganization was reflected in the authorization section by making John Deatrick the Chief of the Field Services Branch. The FQM was changed from Liza Montalvo to Hunter Johnson. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. **Section 2.4:** First Paragraph – Omitted the following sentence "This flow measurement device should be set up as close as possible to the facility's flow measurement equipment and in the same water or wastewater stream." Added "This flow measurement device should be set up at the appropriate head measurement point. Second Paragraph – Omitted the "The accuracy of the primary flow device…" and added "The accuracy of the secondary system…"		August 27, 2015

Section 2.6.1: Second Paragraph – Added "Where C is the discharge coefficient, L is the length of the weir, and H is the hydraulic level at the time of measurement." and "This is due to the variation of the C value when the H value changes." **Section 4:** Third Paragraph – Added "A limited number of primary devices are maintained by SESD."		
SESDPROC-109-R3, *Wastewater Flow Measurement*, Replaces SESDPROC-109-R2		August 12, 2011
SESDPROC-109-R2, *Wastewater Flow Measurement*, Replaces SESDPROC-109-R1		June 13, 2008
SESDPROC-109-R1, *Wastewater Flow Measurement*, replaces SESDPROC-109-R0		November 1, 2007
SESDPROC-109-R0, Wastewater Flow Measurement, Original Issue		February 05, 2007