Northeast Ohio Regional Sewer District

Flow and Rainfall Monitoring for Engineering and Construction Projects

Standards and Protocols

Version 2.0

Northeast Ohio Regional Sewer District

Version History

Version	Date	Description of Revisions
1.0	1/16/2015	Draft release for review.
1.1	1/21/2015	Official release for distribution with review comments addressed.
2.0	1/31/2017	Revisions summarized as follows: • Section 1.2: Section added to explain requirement to use the District's Online GIS • Section 1.3: Formerly Section 1.2, section edited to recognize that monitoring efforts will vary based on the project. The importance of the adherence to the standards for Consent Decree projects was also emphasized. • Section 2.0: Removed the Site Report from the requirements. Explains that any deviation from the originally agreed monitoring location must be detailed in the Installation Form of the newly selected site. Added clarification that site locations must be submitted for upload to the project GIS. • Section 3.0: Explains that the site install form must be uploaded to that monitoring location with in GIS. Removed "the District will generate and provide pipe tables for non-standard pipes." Added that pipe tables generated and used in the flow calculation must be submitted as a final deliverable. Added clarification that the Install Form must have details about the original agreed upon site if the site installed served as the alternate location. • Section 4.0: Emphasizes the requirement for automatic communication via a web browser. Explains the requirement of weekly downloads if communication is unable to be obtained. Explained that the District's Telog web browser could be used to support a project if needed. Added Section 4.1 to explain the up-time requirement for monitoring efforts. • Section 5.0: Clarifies expectations for daily, weekly, and monthly maintenance requirements. Explains the use of a Flow Monitor Maintenance Log • Section 6.0: Emphasizes the use of remote call-in for meters and that data must be downloaded to the web server daily. Elaborates on the web browser capabilities. Describes the Data Quality Summary. • Section 7.0: Removed weekly deliverables. Monthly data submittals must be received within 2 weeks from the end of the monitoring month. Explained that rain data must be shared monthly with the Districts Planning Department in addition to the project PM. • Appendix B: Removed Appendix B Site Report, therefore changing all Appendix titles • Appendix B (formerly Appendix C): Added section to describe field issues with installing the meter at the originally agreed location. • Appendix E: New Appendix, District Flow Monitoring Deliverables Reference Guide • Appendix F: New Appendix, Data Quality Summary Table Example • Appendix G: New Appendix, Final Flow Monitoring Report Outline • Appendix H: New Appendix, Site Selection Report Example

Table of Contents

List of Appendices

1.0 Introduction

1.1 Purpose of the Document

This document describes the standards and protocols to be used for the installation and maintenance of flow monitors and rain gauges in a manner that promotes the collection of sound data to support the needs of the Northeast Ohio Regional Sewer District (NEORSD/the District) Engineering and Construction Department projects. This document will be updated as needed to address the District's future modeling requirements and to adapt to future software updates throughout the course of modeling efforts.

1.2 District ArcGIS Online Geographical Information System

The District supports all monitoring efforts with the use of an internal ArcGIS Online Geographical Information System (AGOL). This will be made available to all consultants providing flow monitoring services in support of District projects. AGOL is available through any smart phone, tablet, or desktop computer with the use of an internet connection. AGOL training is available, as needed, for project personnel. Consultants will be required to post electronic deliverables to the AGOL.

1.3 Requests for Variance of Standards and Protocols

The flow monitoring standards and protocols have been developed to ensure consistency in monitoring practices to support achieving the District's Engineering and Construction project and Consent Decree objectives. It is understood that monitoring/data collection efforts will vary from project to project, therefore this document may not be suited for all monitoring/data collection efforts. Variances may be granted by the District in special cases if justification for a variance can be demonstrated. Due to the nature of Consent Decree related monitoring projects, variances from these standards are not generally considered for these projects. Any granted variances should be documented with the submittal of the final flow monitoring report.

2.0 Site Selection and Reconnaissance

The following steps must be followed when siting flow monitors and rain gauges.

- Perform a desktop analysis to identify initial monitoring and temporary rain gauge locations to support project needs. A initial Flow Monitoring Plan with a map of initial monitoring locations must be submitted to the District in hardcopy and in AGOL for review/approval.
    - See **Appendix A** for **Map of District Rain Gauge Network**.
    - The use of radar-rainfall to further define the rainfall distribution may be considered depending on project extent and is available through the District's current contract with Vieux, Inc. Consultants requiring access should contact their District Project Manager.
- Upon District approval, perform a site investigation to assess the suitability of each proposed monitoring site (flow meter and rain gauge). The District must notify member communities at least 7 business days prior to conducting site investigations.
- If the approved monitoring site is deemed suitable, then upon installation a flow monitor or rain gauge installation report must be completed. See **Appendix B** for **Flow Monitor and Rain Gauge Installation Report Example Templates** and **Section 3.0 Installation of Flow Monitors and Rain Gauges** for additional information.
- Complete a flow monitoring Selection Report that details modifications made to the preliminary Flow Monitoring Plan and explains changes. An example of the **Site Selection Report** can be found in **Appendix H**.

If the monitoring site is crucial to the monitoring effort, the District must be notified if debris or other issues are identified that may impact data collection and require cleaning and/or removal. The District will either remove debris, authorize cleaning by others or contact the responsible agency regarding sites not maintained by the District and request any necessary cleaning or repair of a manhole and/or sewer segment. If the responsible agency cannot perform the cleaning or repair, the monitor should be installed at an alternate location and details of the original location must be noted in the Installation Report.

3.0 Installation of Flow Monitors and Rain Gauges

Installation reports for the selected flow monitoring and rain gauge sites should be provided electronically in PDF format to the District after installation and must be uploaded to the AGOL project site. Flow Monitoring and Rain Gauge Installation Report Example Templates can be found in **Appendix B**.

Flow Monitoring Installation Reports must include, at a minimum, the following information:

- General site location map
- Basic connectivity sketch with pipe sizes
- Manhole depth
- Installation sketch
  - Sensor position/offset
  - Calibration data verifying monitor setup
  - Explanation of any variance from manufacturer recommended procedures
- Physical sewer pipe characteristics in which the sensors are installed
  - Pipe size and shape (diameter other measurements necessary to define the pipe cross-section)
  - Pipe material
  - Depth of silt
  - Depth of flow
- Site Photographs
  - Street View
  - Monitor Installation
  - Sensor Installation
- Weather conditions at time of installation
- Description of any adverse hydraulic conditions
- Flow monitor information
- Adjustments due to initial calibration

Rain Gauge Installation Report must include, at a minimum, the following:

- Location description and site photo(s)
- Contact information and instructions for access
- Rain gauge information

Default pipe geometries in the flow monitoring software for egg-shaped pipes must agree with geometries provided by the District, found in **Appendix D**, in order to properly calculate flow rates associated with observed depth and velocity readings. If field measurements indicate a deviation from values obtained from **Appendix D**, adjust the software to reflect the field measurements. If non-standard shape pipes are encountered, the pipe table generated from field measurements used for flow calculations must be submitted to the District in .csv format, see **Section 7.0 Documentation**.

Initial calibration of each flow monitor must be completed upon installation and activation by taking manual depth and velocity readings using independent instrumentation. The following steps must be followed for calibration:

- Obtain field depth measurements using a method that does not disrupt the flow regime.
- Obtain manual velocity readings of the cross-section of flow (velocity profile) using an industry accepted method to determine the pipe's hydraulic profile if site conditions allow.
- Compare field depth and velocity measurements to real-time monitor readings to determine if the monitor is recording data representative of field measurements.
- Use best practice methods to verify data in the field and document the methods used, the measurements obtained and any adjustments made must be detailed in the Flow Monitor Installation Report.

The following protocols must be used for the calibration of temporary rain gauges:

- Perform a field calibration check on each gauge after installation per the manufacturer's specification.
- If the calibration check falls outside of a tolerance that is acceptable, perform a second test.
- If the second test confirms the gauge is out of tolerance, return the gauge to the manufacturer for recalibration and notify the District as needed.

4.0 Data Collection

Flow monitors must be configured to record depth and velocity readings at five-minute intervals. Rain gauges must be configured to record rainfall in 0.01-inch increments and report data at five-minute intervals.

The flow monitors and rain gauges should be configurable to support automatic communications with a web server and must be supported by the major cellular providers. Data must be uploaded to the web server daily. The District must receive access to the web server at the start of the data collection period. The web server must allow viewing of data as hydrographs and scatter graphs with rain data overlain. See **Section 7.0 Documentation** for more information on data reporting requirements.

If the consultant does not have a web server available, the District's Telog Enterprise system in coordination with the Districts System's Integration Department can be utilized. If monitors do not have cellular communication capabilities or if a site does not allow for cellular communication, the District must be notified prior to installation and data must be collected and uploaded weekly to a web server within 48 hours of collection.

4.1 Uptime Requirements

Monitoring consultants shall collect useable flow data a minimum of 90% of the time throughout the monitoring period at each site. There is an "Uptime %" column in the **Data Quality Summary Table Example**, **Appendix F**, that should be populated to reflect the uptime for each monitor to be included in the monthly deliverables. A thorough explanation must be provided if the monitor is not meeting the up-time requirement. Monitor uptime shall be defined as number of 5-minute measurement intervals where a flow value can be calculated from a measured depth and a measured or inferred velocity for a common time interval divided by the total number of measurement intervals. The total number of measurement intervals shall coincide with the monitoring program duration.

The uptime requirement is to be generally satisfied with actual measured data. However, it is also recognized that there may be occurrences where a velocity measurement may not be required to develop accurate data. Accordingly, inferred data would not be considered downtime, if the monitoring firm documents to the satisfaction of the District that accurate data can be obtained without the velocity measurement and the loss of velocity data was not caused by maintenance neglect. In any case, however, no velocity data shall be inferred for any measurement interval where (1) a corresponding depth measurement has not been obtained for that measurement interval or (2) independent calibration measurements have not been acquired for the site. Monitoring consultant shall clearly identify all inferred velocity data or other data derived from inferred data in all reports and other deliverables.

5.0 Monitor Maintenance

A routine monitoring maintenance schedule must be developed and followed that complies with the minimum standards and protocols as described below:

Daily activities:

- In the case where automatic cellular communications is available, data must be reviewed daily for all sites to identify any potential sensor fouling or equipment malfunctions. Issues are to be remedied as soon as possible to minimizes lost or inaccurate data, but within 48 hours of identification.

Weekly activities:

- Weekly site visits are to be performed for flow monitor and rain gauge sites without cellular communication to download data and to assess any maintenance or monitor performance issues.

Monthly activities:

- Monthly site visits are to be performed for flow monitoring and rain gauge sites supported by cellular communication to assess maintenance needs and perform monitor confirmations.
- The following preventative maintenance activities must be performed during each site visit (monthly and any time the site is visited) and documented in a **Flow Monitor Maintenance Log** as appropriate, see **Appendix C** for example template:
  - Check battery charge, desiccants, and vent tubes
  - Confirm the clock time is accurate
  - Inspect sensors to ensure the installation is intact
  - Clean paper, rags, oil, and/or debris off the sensors in accordance with manufacturer's instructions
  - Remove sediment and debris when it interferes with proper operation of the monitoring devices
  - Monitor confirmation measurements if the manhole is entered during a site visit

- Monitor confirmations must be performed to demonstrate equipment is collecting reliable/accurate data. Based on review of collected data, additional confirmations may be necessary if hydraulic conditions change or if confirmations result in inconsistent measurements. It is preferred that confirmations be scheduled during various flow conditions, this can be achieved by scheduling confirmations at different times of day and during varying weather conditions. This schedule can be adjusted to support the project/monitor site needs, all deviations from the preferred monthly confirmations must be approved by the District. Monitor confirmations must include the following activities similar to the initial calibration of the monitor during installation as referenced in **Section 3.0 Installation of Flow Monitors and Rain Gauges**:

- Take manual depth and velocity readings using independent instrumentation and compare to real-time monitor readings to verify that the installed monitor yields data representative of actual field conditions.
- Record the silt level in the pipe
- Log all measurements, adjustments and efforts undertaken in a **Flow Monitor Maintenance Log,** see **Appendix C** for example template
- Provide confirmation measurements to the District with data submittals, discussed in **Section 7.0 Documentation**, documenting the date and time they were performed for each monitoring site.
- Promptly notify District if site conditions are impacting data quality and corrective action is required.

6.0 Data Analysis

Periodic data analysis of the rainfall and flow monitoring data collected throughout a project's monitoring period must be performed to ensure data quality and reliability. This section summarizes the minimum activities and responsibilities in performing data analysis.

- Data analysis must include a comprehensive review of collected data and should consist of, but not be limited to, the following activities:
    - Identify and document periods of data gaps or equipment malfunctions
    - Monitor service needs and resolutions
    - Utilize weekly hydrographs of depth, velocity, and flow rate with rainfall and all calibration and confirmation measurements overlain
    - Utilize scatter graphs of depth and velocity/flow readings with all calibration and confirmation measurements overlain
    - Conversion of raw flow data into edited data
- Data should be reviewed to check for regular diurnal patterns in free flow, and reasonable depths and velocities for the site using data diagnostic tools such as hydrographs and scatter graphs.
- Data should be checked for data anomalies or unusual trends that are recognizable.
- Edited data must be created from the monthly raw data, see **Section 7.0 Documentation**. Major edits must be documented in a **Data Quality Summary Table**, see **Appendix F** for example. Edits to the raw data may include but is not limited to the following:
    - Adjustments to the level/velocity based on field verified measurements
    - Adjustments of the average/peak velocity ratio based on field verified measurements
    - Insertion of dry weather diurnal patterns in the case of data drop outs or poor data quality during confirmed dry weather conditions
    - Removal of a recorded level/velocity that is not typical to the flow pattern and is not recorded for a duration that would indicate an actual reading.
    - Identify data gaps/poor data quality due to equipment malfunction that cannot be edited due to a known rain event that took place during the data gap/poor data quality period. When these data cannot be edited the District recommends using null values.

7.0 Documentation

Periodic data submittals throughout the project's monitoring period must be provided to the District for review and to document progress. This section summarizes the monitoring documentation and submittal schedule that must be followed. The deliverable format will be determined at project implementation based on project needs. The **District Flow Monitoring Deliverables Reference Guide** is provided in **Appendix E**.

On a monthly basis, to be submitted within two (2) weeks after the end of the monitoring month:

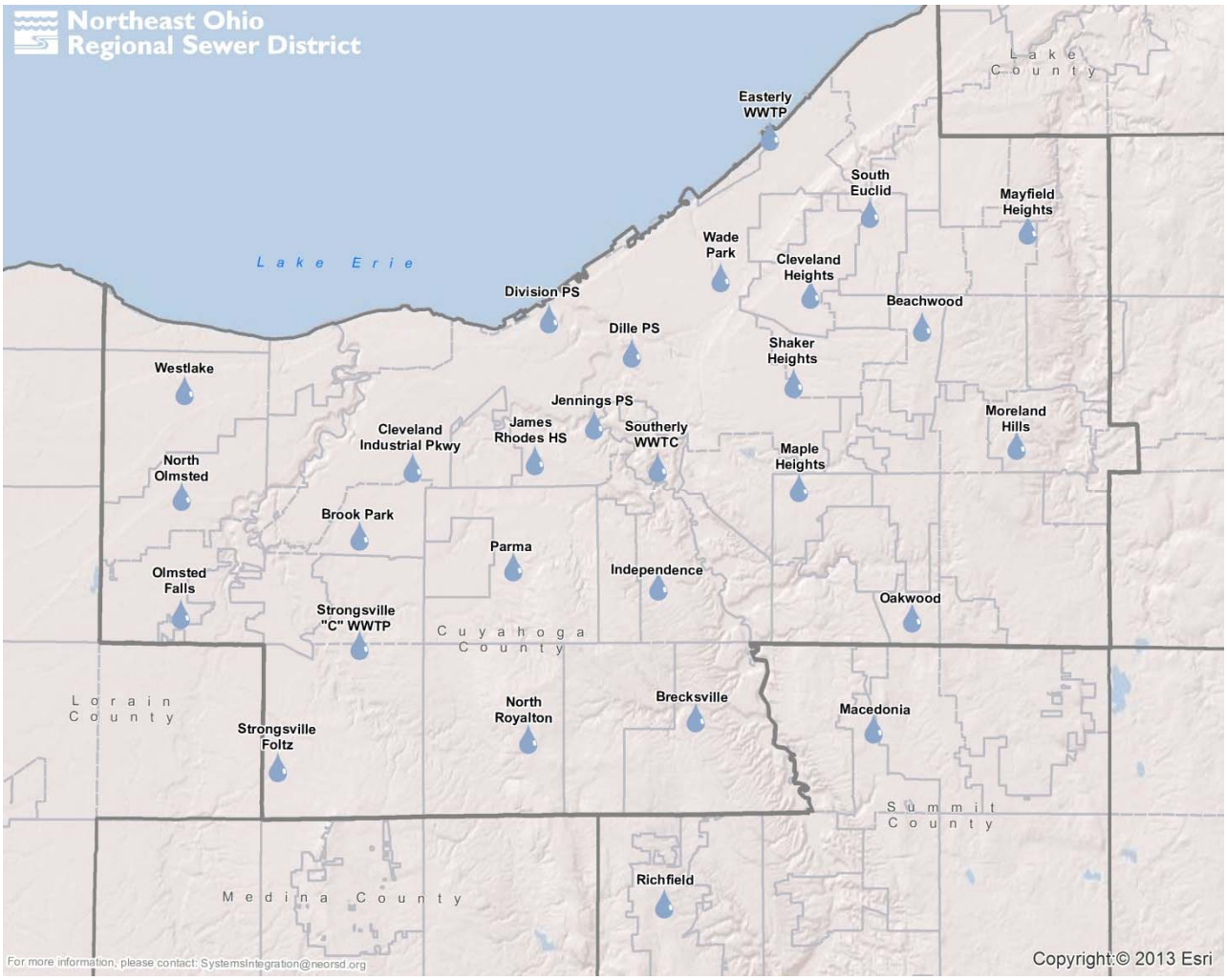
- Hydrographs: Time series plots of the entire month of depth, velocity, flow, and rainfall with confirmation measurements overlain
- Scatter graphs: Cumulative edited depth-velocity readings with confirmation measurements overlain
- Flow Monitor Maintenance Log: Summary table of calibration and confirmation measurements, documenting the date and time they were performed for each monitoring site, see **Section 5.0 Monitor Maintenance** for more information
- Summary table of daily minimum, maximum, and average depth and flow, and rain totals
- Data Quality Summary Table: Table of major edits made to the data and major data quality issues. An example template of the **Data Quality Summary Table Example** is available in **Appendix F.** See **Section 6.0 Data Analysis** for more information**.**
- Edited continuous time series including depth, velocity, calculated flow (.csv).
- Monthly rainfall data in electronic format (.csv). Additionally, email the electronic (.csv) file for any temporary rain gages directly to the District Planning Manager to support the radar rainfall contract.

Within 6 weeks of the end of the project flow monitoring period, a Final Flow Monitoring Report must be submitted and include the monthly deliverables referenced above and the following items for each flow monitoring site for the entire flow monitoring period. An outline of the preferred **Final Flow Monitoring Report** can be found in **Appendix G**:

- Installation Reports, see **Section 3.0 Installation of Flow Monitors and Rain Gauges**
- Summary by rainfall event including total rainfall depth, duration, peak 5-minute, and 1-hour intensities
- Pipe Tables used for flow calculations for non-standard pipes, see **Section 3.0 Installation of Flow Monitors and Rain Gauges,** as a hardcopy and digital attachment to the flow monitoring report
- Final data in standard electronic format (.csv)
    - Note: If data is edited during the modelling phase or beyond 6 weeks from the end of the monitoring period final data must be resubmitted to the District
- Raw data in standard electronic format (.csv)
- Documentation of any variances that were granted

Within 6 weeks of the end of the flow monitoring period, the Final Data (.csv) and final Installation Reports (.pdf) should be uploaded to the project AGOL for each monitoring site.

Appendix A
Map of District Rain Gauge Network


Northeast Ohio
Regional Sewer District
Lake Erie
Lake County
Easterly WWTP
South Euclid
Mayfield Heights
Wade Park
Cleveland Heights
Beachwood
Division PS
Dille PS
Shaker Heights
Westlake
Jennings PS
Moreland Hills
Cleveland Industrial Pkwy
James Rhodes HS
Southerly WWTC
Maple Heights
North Olmsted
Brook Park
Parma
Independence
Olmsted Falls
Oakwood
Strongsville "C" WWTP
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Brecksville
Macedonia
Strongsville Foltz
Summit County
Richfield
Medina County
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Appendix B
Flow Monitor Installation Report
Rain Gauge Installation Report
Example Templates

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Appendix C
Flow Monitor Maintenance Log Example Template

Northeast Ohio Regional Sewer District

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Appendix D
Egg-shaped Sewer Geometries

Appendix E
District Flow Monitoring Deliverables Reference Guide

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Appendix F
Data Quality Summary Table Example

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Appendix G
Final Flow Monitoring Report Outline

Final Flow Monitoring Report Outline

This attachment provides the recommended flow monitoring report outline. A summary of the information to be discussed but not limited to in each section.

Report Outline

Overview

- Detail the project the monitoring effort is supporting
- Intended use of the data
- Monitoring duration
- Monitoring firms involved and their respective responsibilities
- Description of data handling
- Any key findings from the monitoring

Site Selection, Installation, and Operation

- Describe the site selection process
- Flow monitoring and rain gauge map
- Site naming convention used
- Installation methodology
- Description of equipment used to perform monitoring
- Summary table of all the meters installed illustrating installation type, manhole ID, pipe size/shape (AGOL vs. field measured), and purpose.

Data Collection and Analysis

- Describe the rainfall data collected
- Description and summary table of the rain events based on an inter-event duration of 12-hours, event duration, total rainfall, peak 1-hr intensity and peak 5-min. intensity
- The Data Quality Summary (example presented in **Attachment F**) summarizing the flow monitoring data quality should also be presented and discussed in this section

- Description of the editing of flow data and any flow volume analysis/mass balance reviews that were performed
- A flow meter schematic should be included to support the mass balance analysis
- Discussion of individual monitoring issues
- Discussion of on whether the 90% uptime requirement was met

Presentation of Final Flow Data

- Describe what data will be shared as part of this report

Summary and Key Findings

Attachments

Attachment A – Monitoring Equipment, Installation, and Operation
Attachment B – Confirmation Points and Service History Reports
Attachment C – Dry and Wet weather mass balance review for selected meters and events
Attachment D – Meter Installation report, Daily Summary, Time Series plots and Scattergraphs
Attachment E – Pipe Tables

Digital Submittal

- Meter Raw Data in CSV Format
- Meter Final Data in CSV Format
- Pipe Tables in excel Format

Appendix H
Site Selection Report Example