QUALITY ASSURANCE PROJECT PLAN

Rapid Assessment Surveys

5-19-2020

New York State Department of Environmental Conservation
Division of Water
Bureau of Water Assessment and Management
Stream Monitoring and Assessment Section
Stream Biomonitoring Unit

Approval Signatures

Brian Duffy
Project Manager: Brian T. Duffy – Stream Biomonitoring
Date 5-19-20

Meredith Streeter
Program Manager: Meredith Streeter – Stream Monitoring and Assessment
Date 5/19/2020

Gavin Lemley
Project Quality Assurance Officer: Gavin Lemley – Stream Biomonitoring
Date 5/19/2020

RoseAnn Garry
Quality Assurance Officer: RoseAnn Garry – Division of Water
Date 05-19-2020

Rapid Assessment Surveys QAPP Update Log

Prepared/Revised By:	Date:	Revision No:	Summary of Changes:
Alexander Smith	05/2009	NA	Developed
Alexander Smith	05/2010	01	Updated waterbodies
Alexander Smith	05/2011	02	"
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Alexander Smith	05/2015	05	"
Alexander Smith	05/2016	06	"
Brian Duffy	06/2017	07	"
Brian Duffy	06/2018	08	Update waterbodies + depth integrated chemistry, discharge
Brian Duffy	06/2019	09	Update waterbodies + *in situ Chlorphyll A*
Brian Duffy	05/2020	10	Update waterbodies and add COVID mods

No substantive changes include updating references, correcting typographical errors, and clarifying certain language to make the document more useful and effective.

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DISTRIBUTION LIST

The following individuals must receive a copy of the approved QAPP in order to complete their role in this project. Note if copy will be electronic or hard copy.

Name	Title	Organization	Document type
Brian T. Duffy	Project Manager	NYSDEC, Division of Water, Stream Monitoring and Assessment Section	Hard Copy
Gavin Lemley	Project QA Officer	NYSDEC, Division of Water, Stream Monitoring and Assessment Section	Hard Copy
Meredith Streeter	Program Manager	NYSDEC, Division of Water, Stream Monitoring and Assessment Section	Electronic
RoseAnn Garry	DOW QA Officer	NYSDEC, Division of Water, Standards and Analytical Support Section	Electronic
Anthony Prestigiacomo	HUB Sampling Lead	NYSDEC, Division of Water, FL HUB	Electronic
Field Staff	Sampling Staff	NYSDEC Division of Water	Electronic

INTRODUCTION

This document has been prepared to meet the Quality Assurance/Quality Control (QAQC) requirements for Rapid Biological Assessment Surveys (RAS) conducted as part of the Division of Water Statewide Waters Monitoring Program, which are used for making waterbody assessments.

For 2020, special considerations will be taken into account regarding COVID-19 and associated health and safety concerns. Modifications have been made to Standard Operating Procedure: Collection of Ambient Water Quality Samples for the Rotating Integrated Basin Studies (RIBS) Program to reflect considerations regarding modifications to protocols to allow for social distancing (SOP #210-20.COV), Standard Operating Procedure: Calibration, Maintenance, and Storage of multiprobe meters used to measure water quality parameters (SOP #211-2020.COV), and Standard Operating Procedure: Sample Handling, Transport, and Chain of Custody (SOP #101-20.COV) are to be used in coordination with Division of Water Guidance for Field Work During COVID-19 Pandemic (SOP #603-20). Further reference to SOP #210-20, SOP #211-2020, and SOP #101-20 should be considered equivalent to versions modified to address sampling under COVID-19 (#XXX-20.COV). All other sampling according to SOP #208-19 and methodologies not explicitly modified under the COVID-19 pandemic should be conducted with consideration of social distancing recommendations.

Samplers may take one of two approaches to sampling under COVID-19; 1) Establish and maintain clearly defined job duties for individuals within a sampling crew and use of separate vehicles or 2) with consent of consent of samplers and program manager, paired sampling crews where social distancing protocols in the field may not be maintained. If field work is conducted under option 2, sampling pairs should be maintained for as long as possible during field season to limit interaction of individuals.

Field data, biological sample collection methodologies, and laboratory techniques follow the procedures detailed in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC SOP # 208-19), Standard Operating Procedure: Collection of Ambient Water Quality Samples (SOP # 210-20), Standard Operating Procedure: Calibration, Maintenance, and Storage of multiprobe meters used to measure water quality parameters (SOP #211-2020), and US Geological Survey's Discharge Measurements at Gaging Stations: Techniques and Methods 3-A8 (Turnipseed and Sauer, 2010) as well as the 2020 RIBS QAPP (NYSDEC 2020).

Rapid Assessment Surveys (RAS) are used in making water quality assessments for an entire or specific portion of a waterbody. RAS involve sampling several sites along the length of a stream or within a watershed. Many are conducted to at the request of a DEC Regional office or due to specific department interest. Some streams may also be sampled to provide background data on water quality. Reasons for requesting a survey include: documentation of severity of a perceived problem, documentation of possible improvement following upgraded treatment, problem track-down, collection of data in support of watershed plans, or collection of baseline data on a stream of unknown water quality. Some surveys include track-down of sources of xenobiotic substances, compliance monitoring to determine if significant biological impairment exists as the result of a discharge, and multi-disciplinary coordinated surveys. Surveys conducted as background data collection provide a screening tool for water quality problems alerting the department to issues of concern which may warrant more detailed investigation. The methods used in RAS surveys are dependent on the specific applicable conditions, but may include replicated sampling of biological communities, collection of organisms for tissue analysis, or application of biological impairment criteria (Bode et al., 1990). Additional supplemental RAS data collection, to help identify sources of impacts to aquatic life, include water column chemistry, physical habitat measurements, and stream discharge.

The best candidate streams for rapid assessment studies are those that include riffle habitats for the greatest biological diversity against which to measure alteration. An attempt is made to coordinate waterbody assessment surveys with the basins that are currently being sampled in the Rotating Integrated Basin Studies (RIBS) network. However, exceptions are made based on program priority and need.

In 2020, the surveys to be conducted are:

1. Monitoring in support 9 Element Plan development in Canandaigua and Keuka Lakes
2. Black Lake tributaries
3. Oneida Lake tributaries
4. Patroons Creek
5. Wallkill gage sites
6. Bellinger Brook
7. Ramapo River

I. PROJECT MANAGEMENT

1. Organization/Responsibilities

The following people and parties will actively participate in this project and its oversight:

Division of Water, Bureau of Water Assessment & Management
Stream Monitoring and Assessment Section
Stream Biomonitoring Unit (SBU)
Finger Lakes Hub

The primary activities of the Stream Biomonitoring Unit (SBU) are macroinvertebrate community assessment and ambient water chemistry sample analysis in support of the NYS ambient water quality monitoring program. Community analyses are conducted to determine water quality impairment and the attainment of aquatic life use support. Water quality data provides a link between community condition and chemical habitat. The SBU is responsible for conducting RAS surveys across NYS. RAS surveys fall under the RIBS program purview, procedures, and quality assurance measures covered in detail in Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC SOP # 208-20), Standard Operating Procedure: Collection of Ambient Water Quality Samples (SOP # 201-20), and US Geological Survey's Discharge Measurements at Gaging Stations: Techniques and Methods 3-A8 (Turnipseed and Sauer, 2010) as well as the 2020 RIBS QAPP (NYSDEC 2020). The SBU oversees the collection of samples and data, processing of samples, analysis of data and reporting findings.

SMAS sampling staff:

Brian T. Duffy
Research Scientist III
518-285-5682
brian.duffy@dec.ny.gov

General Duties: Quality Assurance Project Plan custodian; Overall project and staff coordination, research design, field sampling, macroinvertebrate identification, data quality review, reporting, grant writing.

Gavin Lemley
Environmental Program Specialist I
518-402-8202
Gavin.Lemley@dec.ny.gov

General Duties: Field sampling, data processing activities, data processing QC, oversight of project QA/QC, sample analysis, macroinvertebrate identification, secondary reporting.

Charles Stoll
Environmental Analyst

518-285-5699
Charles.Stoll@dec.ny.gov

General Duties: Field sampling, data processing activities, data processing QC, oversight of project QA/QC, sample analysis, macroinvertebrate identification, secondary reporting.

Keleigh Reynolds
Environmental Program Specialist I
518-402-8236
Keleigh.Reynolds@dec.ny.gov

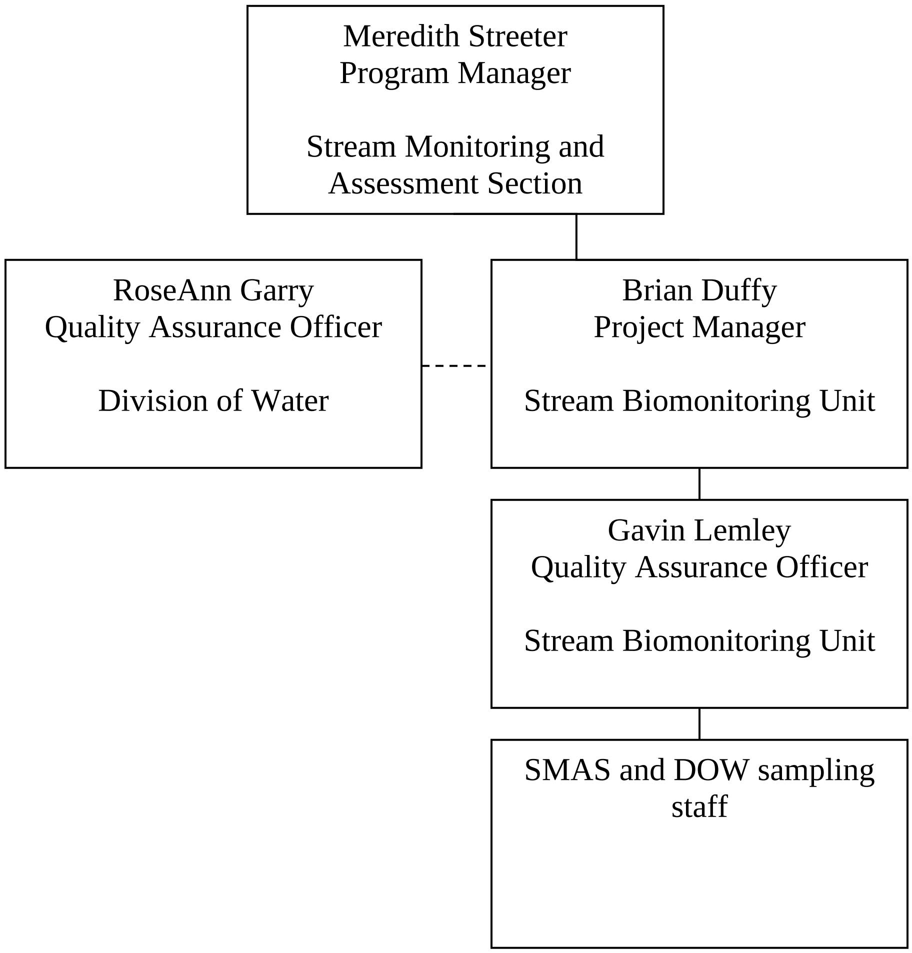
General Duties: Field sampling, sampling QC, sample analysis, macroinvertebrate identification, laboratory QC, equipment and supplies maintenance, secondary reporting.

Other Division of Water staff/ SBU Seasonal Technician(s) / Summer Intern(s)/

Additional DOW sampling staff:
Anthony Prestigiacamo – Research Scientist
Anthony.prestigiacamo@dec.ny.gov
Aimee Clinkhammer – Environmental Program Specialist
Aimee.clinkhammer@dec.ny.gov
Lewis McCaffery – Research Scientist
Lewis.mccaffery@dec.ny.gov
Andrea Conine – Research Scientist
Andrea.conine@dec.ny.gov

General Duties: Field sampling, equipment and supplies maintenance

Project Organization Chart



2. Background – Description of Problem

The biological assessment of water quality is conducted throughout NYS using survey methods described in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC SOP # 208-19). Water chemistry sampling is described in Standard Operating Procedure: Collection of Ambient Water Quality Samples (SOP # 210-20). Most samples are for single site assessments for the Rotating Integrated Basin Studies (RIBS) monitoring networks (NYSDEC 2020). The scale at which sampling in the RIBS network is conducted provides baseline and trend information on the extent and sources of pollution basin-wide. However, regional interests and the identification of water pollution problems require finer scale resolution sampling. This type of survey typically includes the assessment of a whole stream or watershed using multiple, closely-spaced sampling locations.

Water quality assessment data based on macroinvertebrate communities and water chemistry generated from the RAS surveys as well as the RIBS network are used to support monitoring and assessment functions within NYSDEC Division of Water (DOW), including the compilation of the Waterbody Inventory/Priority Waterbody List (WI/PWL), New York State's Clean Water Act Section 305(b) Water Quality Report, and Section 303(d) List of Impacted

Waters of the State. In addition, RAS surveys assist in the identification and resolution of local water pollution problems throughout NYS. Surveys will follow established NYSDEC protocols documented in SOP#208-19 and SOP#210-20. The parameter groups collected during RAS surveys is listed in Table 1 and a general schedule for completion of all work products is provided in Table 2. Table 5 indicates biological, physical, and chemical parameters applicable to each 2020 survey.

During the 2020/21 field and laboratory seasons, several focused sampling areas/watersheds have been identified as in need of a survey to document water quality conditions and inform watershed planning. These surveys are:

1. Monitoring in support 9 Element Plan development in Canandaigua and Keuka Lakes
2. Black Lake tributaries
3. Oneida Lake tributaries
4. Patroons Creek
5. Wallkill gage sites
6. Bellinger Brook
7. Ramapo River
8. Finger Lakes Advanced Harmful Algal Bloom (HAB) research tributary monitoring

1. Monitoring in support of 9 Element Plan development in Canandaigua and Keuka Lakes

Surveys will be conducted in the Finger Lakes region at the request of the Finger Lakes Water Hub in Region 7 in support of watershed planning. The lack of tributary chemistry data is a major gap when estimating nutrient loading for watershed or lake water quality models. Monitoring specifics are laid out in Tables 6 and 7 and describe the number of samples collected for each tributary/lake. A mix of baseline and event samples will be collected to characterize parameters of concern across a range of flow conditions.

2. Black Lake Tributaries

Black Lake is impaired and in need of water quality and loading data to inform watershed planning efforts in the basin. Data from the 5 most significant and largest tributaries to the lake will inform that process. This is the second of 2 years of monitoring conducted in support of watershed planning.

3. Oneida Lake Tributaries

Oneida Lake is in the process of developing a watershed plan and is in need of water quality data on tributaries flowing into the lake. Five locations were selected to capture the majority of the watershed area to best represent loading sources and to connect it to in lake monitoring. Quality data is needed to inform development of the plan. This is the second of 2 years of monitoring conducted in support of watershed planning.

4. Patroons Creek

At the request of Region 4 Division of Water staff, Patroons Creek follow-up sampling will we conducted after approximately 1000 feet of linear stream length have been daylighted. Pre-construction sampling was conducted in 2018 and as mid-2019, construction was complete. Macroinvertebrate community data and water chemistry will be collected to document potential improvements to water quality. 2020 data will represent post construction biological integrity and water quality.

5. Wallkill Gage Sites

The Wallkill survey will follow on intensive basin sampling conducted in 2017-2019 and include locations where USGS has installed stream gages. Water chemistry will be sampled 4 times. The intent is to continue to track long-term trends in water quality in support of development of a watershed TMDL (Table 3).

6. Ramapo River

The Ramapo River survey will provide a second year of data to characterize all three WI/PWL segments of the river and bracket impacts in the headwaters resulting from two wastewater treatment facilities (WWTF). Macroinvertebrate, water chemistry samples, and instantaneous discharge will be collected at 10 sampling locations including treatment plant outfalls (Table 3, Figure 1). The survey will update the WI/PWL, assist in SPDES permit modifications, and document point source impacts resulting from the WWTFs in the upper segment. This is second year of data required to meet minimum data requirements proposed in updates to the NYS Consolidated Assessment and Listing Methodology.

7. Bellinger Brook

The purpose of this study is to document the effects of channel restoration efforts on the aquatic life, habitat suitability, and water chemistry of Bellinger Brook. The village of Herkimer is undertaking an improvement project to ease the flooding potential in the brook. These improvements include increasing the size of a bridge and removing two large sections of concrete and stone lined channel in the stream. These improvements have a high potential to not only help with flooding issues, but to increase the water quality of the stream by improving the habitat and community composition of aquatic life. The pre-remediation sampling event will occur in 2020 and the post sampling will occur one year after the completion of construction (likely 2022).

8. Finger Lakes Advanced Monitoring

This survey will be conducted in the Finger Lakes region in support in-lake Harmful Algal Bloom (HAB) monitoring conducted by USGS and NYSDEC over 2019 and 2020. The lack of tributary chemistry data is a major gap when estimating nutrient loading for watershed or lake water quality models. Monitoring specifics are laid out in Tables 6 and 7 and describe the number of samples collected for each tributary/lake. Event samples will be collected to complete characterization of parameter concentrations at high flows.

Table 1. Parameter groups for sampling media in surveys described in this document

Parameters	**Analytes**
Biological Community	Species richness, Ephemeropta-Plecoptera-Trichoptera richness, Hilsenhoff's biotic index, percent model affinity, species diversity, non-Chironomidae and Oligochaeta richness, nutrient biotic index, percent mayfly richness, acid tolerance index, impact source determination, biological assessment profile
Substrate Composition	Percent of silt, sand, gravel, coarse gravel, rubble, rock, and bedrock; Periphyton cover, siltation cover.
Stream Physical Attributes	Depth, width, current speed, canopy cover, embeddedness, substrate type, aquatic vegetation present, habitat condition
Biota Habitat Conditions	Epifaunal substrate/available cover, embeddedness, velocity/depth regime, sediment deposition, channel flow status, channel alteration, frequency of riffles, bank stability, vegetative protection, riparian vegetative zone width, pool substrate characteristics, pool variability, channel sinuosity
Field Measured Water Quality Parameters	Temperature, specific conductance, pH, dissolved oxygen, percent saturation, chlorophyll A
Laboratory Measured Water Quality Parameters	RIBS screening chemistry suite (Table 2) or RIBS routine chemistry suite (Table 3) + (survey dependent) total organic carbon, dissolved organic carbon, dissolved orthophosphate, chlorophyll A

Table 2. Water chemistry suite and analytical specifications based on RIBS screening network parameter list.

Parameter	Analytical Lab	Standard Method	Precision	Accuracy	Calibration	Blanks	Method Detection Limit	Quantitation Limit
Temperature	In Situ	2550 B	± 1ºC	± 1.5ºC	Factory Set	~	(Range: -5 to 70˚C)	
Dissolved Oxygen	In Situ	4500-O G	± 1%	± 2%	Daily	~	(Range: 0 to 50 mg/L or 0 to 500%)	
pH	In Situ	4500-H+B	± .05 SU	± .2 SU	Weekly	~	(Range: 0 to 14 SU)	
Specific Conductance	In Situ	2510 B	± 1µs/cm	± 1%	Weekly	~	(Range: 0 to 200 mS/cm)	
Chlorophyll-*a*, phycocyanin	In Situ	10200 H	0 to 100 RFU	N/A	Weekly	~	(Range: 0 to 100 RFU or 0 to 100 µg/L)	
Ammonia	ALS	D6919-09	^	± 25%	~	Every 10	0.004 mg/L	0.01 mg/L
TKN	ALS	EPA 351.2	^	± 25%	~	Every 10	0.098 mg/L	0.1 mg/L
Nitrate	ALS	EPA 353.2	^	± 25%	~	Every 10	0.02 mg/L	0.05 mg/L
Nitrite	ALS	E353.2	^	± 25%	~	Every 10	0.007 mg/l	0.05 mg/L
Total Nitrogen	ALS	calculated	^	N/A	~	~	~	~
Total Phosphorus	ALS	EPA 365.1	^	± 25%	~	Every 10	0.004 mg/L	0.005 mg/L
Turbidity	ALS	EPA 180.1	^	N/A	~	Every 10	0.06 NTU	0.1 NTU
Alkalinity	ALS	SM 2320B	^	N/A	~	Every 10	1.8 mg/L	2.0 mg/L
Hardness	ALS	SM 2340C	^	± 25%	~	Every 10	NA	2.0 mg/L
Chloride	ALS	EPA 300.0	^	± 25%	~	Every 10	0.041 mg/L	0.2 mg/L
Magnesium	ALS	EPA 200.7	^	± 25%	~	Every 10	0.068 mg/L	1 mg/L
Total Iron	ALS	EPA 200.7	^	± 25%	~	Every 10	13 µg/L	100 µg/L
Total Arsenic	ALS	EPA 200.8	^	± 25%	~	Every 10	0.32 µg/L	1 µg/L
Total Silver	ALS	EPA 200.8	^	± 25%	~	Every 10	0.15 µg/L	1 µg/L
Total Aluminum	ALS	EPA 200.8	^	± 25%	~	Every 10	2.3 µg/L	10 µg/L
Total Cadmium	ALS	EPA 200.8	^	± 25%	~	Every 10	0.38 µg/L	1 µg/L
Total Copper	ALS	EPA 200.8	^	± 25%	~	Every 10	0.66 µg/L	1 µg/L
Total Lead	ALS	EPA 200.8	^	± 25%	~	Every 10	0.57 µg/L	1 µg/L
Total Nickel	ALS	EPA 200.8	^	± 25%	~	Every 10	0.26 µg/L	1 µg/L
Total Zinc	ALS	EPA 200.8	^	± 25%	~	Every 10	2.5 µg/L	5 µg/L
Microcystin**	UFI	EPA 546	N/A	N/A	~	Every 10	0.03 µg/l	0.03 µg/l
Chlorophyll a, unextracted**	UFI, ESF	Bbe Moldaenke, 2014	± 0.01 µg/L	± 20%L	~	Every 10	0.05 µg/L	0.02 µg/l
Microcystin congeners, anatoxin-a, additional cyanotoxins**	ESF	**	N/A	N/A	~	**	**	N/A

**HABs parameters are only run on HABs samples. Standard methods will differ among laboratories.
*** Chlorophyll-*a* is an add-on parameter for screening and will be submitted for most, but not all screening samples. The Chain of Custody has a separate checkbox for this.

Table 3. Water chemistry suite and analytical specifications based on RIBS routine network parameter list.

Parameter	Analytical Lab	Standard Method	Precision	Accuracy	Calibration	Blanks	Method Detection Limit	Quantitation Limit
Temperature	In Situ	2550 B	± 1°C	± 1.5°C	Factory Set	~	(Range: -5 to 70˚C)	
Dissolved Oxygen	In Situ	4500-O G	± 1%	± 2%	Daily	~	(Range: 0 to 50 mg/L or 0 to 500%)	
pH	In Situ	4500-H+B	± .05 SU	± .2 SU	Weekly	~	(Range: 0 to 14 SU)	
Specific Conductance	In Situ	2510 B	± 1µs/cm	± 1%	Weekly	~	(Range: 0 to 200 mS/cm)	
Ammonia	ALS	D6919-09	^	± 25%	~	Every 10	0.004 mg/L	0.01 mg/L
TKN	ALS	EPA 351.2	^	± 25%	~	Every 10	0.098 mg/L	0.1 mg/L
Nitrate	ALS	EPA 353.2	^	± 25%	~	Every 10	0.02 mg/L	0.05 mg/L
Nitrite	ALS	EPA 353.2	^	± 25%	~	Every 10	0.007 mg/l	0.05 mg/L
Total Nitrogen	ALS	calculated	^	~	~	~	~	~
Total Phosphorus	ALS	EPA 365.1	^	± 25%	~	Every 10	0.004 mg/L	0.005 mg/L
Ortho-phosphate	ALS	EPA 365.1	^	± 25%	~	Every 10	0.0049 mg/L	0.005 mg/L
Total Dissolved Solids	ALS	SM 2540C	^	N/A	~	Every 20	9.0 mg/L	10 mg/L
Turbidity	ALS	EPA 180.1	^	N/A	~	Every 20	0.06 NTU	0.1 NTU
Dissolved Organic Carbon	ALS	5310C	^	± 25%	~	Every 10	0.45 mg/L	1.0 mg/L
Alkalinity	ALS	SM 2320B	^	N/A	~	Every 10	1.8 mg/L	2.0 mg/L
Hardness	ALS	SM 2340C	^	± 25%	~	Every 10	NA	2.0 mg/L
Calcium	ALS	EPA 200.7	^	± 25%	~	Every 10	0.11 mg/L	1.0 mg/L
Magnesium	ALS	EPA 200.7	^	± 25%	~	Every 10	0.068 mg/L	1 mg/L
Potassium	ALS	EPA 200.7	^	± 25%	~	Every 10	0.180 mg/L	2.0 mg/L
Sodium	ALS	EPA 200.7	^	± 25%	~	Every 10	0.100 mg/L	1.0 mg/L
Chloride	ALS	EPA 300.0	^	± 25%	~	Every 10	0.041 mg/L	0.2 mg/L
Fluoride	ALS	EPA 300.0	^	± 25%	~	Every 10	0.0097 mg/L	0.1 mg/L
Sulfate	ALS	EPA 300.0	^	± 25%	~	Every 10	0.039 mg/L	0.2 mg/L
Iron	ALS	EPA 200.7	^	± 25%	~	Every 10	13 µg/L	100 µg/L
Manganese	ALS	EPA 200.7	^	± 25%	~	Every 10	1.7 µg/L	10 µg/L
Arsenic	ALS	EPA 200.8	^	± 25%	~	Every 10	0.32 µg/L	1 µg/L
Silver	ALS	EPA 200.8	^	± 25%	~	Every 10	0.15 µg/L	1 µg/L
Mercury	ALS	EPA 1631	^	± 25%	~	Every 10	0.24 ng/L	1 ng/L
Soluble Aluminum	ALS	EPA 200.8	^	± 25%	~	Every 10	2.3 µg/L	10 µg/L
Soluble Cadmium	ALS	EPA 200.8	^	± 25%	~	Every 10	0.38 µg/L	1 µg/L
Soluble Copper	ALS	EPA 200.8	^	± 25%	~	Every 10	0.66 µg/L	1 µg/L
Soluble Lead	ALS	EPA 200.8	^	± 25%	~	Every 10	0.57 µg/L	1 µg/L
Soluble Nickel	ALS	EPA 200.8	^	± 25%	~	Every 10	0.26 µg/L	1 µg/L
Soluble Zinc	ALS	EPA 200.8	^	± 25%	~	Every 10	2.5 µg/L	5 µg/L

^ Precision is calculated using the following equation: %RPD > (0.9465x^-0.344)100 +5, where: x = sample / detection limit %RPD = [diff(duplicate pair)/av(duplicate pair)]*100. See SOP 102-19: Data Handling and Archival for more details.

3. Project/Task Description

The SBU will sample stream/river locations in three focused sampling areas/watersheds using the Rapid Assessment Survey (RAS) design during 2020. A total of 61 sites (Figure 1, Table 3) will be sampled spanning several surveys

1. Monitoring in support 9 Element Plan development in Canandaigua and Keuka Lakes - 8
2. Black Lake tributaries - 5
3. Oneida Lake tributaries - 5
4. Patroons Creek - 5
5. Wallkill gage sites - 3
6. Bellinger Brook - 5
7. Ramapo River – 10
8. Finger Lakes Advanced Harmful Algal Bloom (HAB) research tributary monitoring - 20

These surveys consist of assessing and characterizing the benthic macroinvertebrate communities, collecting water column chemistry data, and collecting instantaneous discharge. Macroinvertebrate sampling will be conducted at most survey locations and be dictated by habitat present. The travelling kick method will be the primary method employed at most locations on each of the streams and rivers. Additionally, low-gradient stream samples will be collected where habitat necessitates it. All macroinvertebrate sampling methods and habitat applicability are detailed in the Standard Operating Procedure: Biological sampling Biological Monitoring of Surface Waters in New York State (NYSDEC SOP # 208-19). Generally, the indicators evaluated at each site will include a benthic macroinvertebrate community sample, stream physical attributes, substrate composition, instream and riparian habitat condition assessment, and basic *in-situ* water quality parameters. The NYSDEC SOP # 208-19 discusses the specific parameters, collection methods, calibration procedures, quality assurance/quality control measures, and validation procedures in detail. Replicated macroinvertebrate community samples (4) will be collected for each survey once during the 2020 index period (July-September).

For all surveys (except Patroons Creek, Bellinger Brook), water column chemistry will be collected using depth integrated, equidistant sampling methodologies with the DH-81 and wading rod as the primary equipment. When conditions dictate alternate sampling methods will be employed. Methodologies and possible sampling scenarios are covered in Standard Operating Procedure: Collection of Ambient Water Quality Samples (SOP # 210-20). NYSDEC SOP # 210-20 discusses the collection methods and NYSDEC Rotating Integrated Basins: Rivers and Streams 2020 QAPP (RIBS QAPP 2020) discusses specific quality assurance protocols for sample collection along with specific parameter lists and analytic QC specifications (Tables 2 and 3). Table 1, Parameter Groups for Sampling Media in the RAS Project, lists the parameters that will be studied at each of the sampling locations and refers to specific parameter suites in Tables 2 and 3. Staff will follow safety procedures outlined in program specific SOPs (SOP#208-19, #210-20) along with Division of Water Health and Safety Plan (DOW, 2019).

For each survey collecting depth integrated sampling, three to six water chemistry sampling events will be targeted for each survey depending on data needs. For the Canandaigua and Keuka Finger Lakes survey, a mix of baseline and wet weather events will be targeted to collect data across a range of hydrologic conditions. Table 4 contains the survey breakdown for baseline and wet weather events. Wet weather is defined as greater than 0.25 inches of rain as predicted by the NOAA Quantitative Prediction Forecast (http://www.wpc.ncep.noaa.gov/qpf/qpf2.shtml), cumulative, over the full study area on the day of sampling following a minimum antecedent dry period of 72 hours. When an event is predicted staff will mobilize for sampling, targeting the rising flow conditions to capture runoff constituent concentrations. For all other surveys, discharge will provide relative flow information. For Black Lake tributaries, Oneida Lake tributaries, Wallkill, and Ramapo River scheduled sampling will be conducted due to logistical limitations in 2020.

Unless elevated flows make sampling conditions unsafe, instantaneous discharge will also be measured as part of each survey to compliment depth integrated chemistry data as described in Turnipseed and Sauer (2010). Appendix I provides pertinent elements of Turnipseed and Sauer (2010). The velocity-area method is the most common method used to compute discharge. Discharge is calculated by subdividing a stream cross-section into segments and measuring depth and velocity within each segment and summing the products. Specifically, the Midsection Method, described in detail in Turnipseed and Sauer (2010) will be used. A top-set wading rod and MarsBirney Flo-Mate 2000 or Sontek FlowTracker will be used to measure flow at the midsection of 10 equally spaced segments coinciding with depth integrated water chemistry sampling points. Appendix II provides the field sheet to be used for collection of stream depth and velocity to be used in discharge calculations.

The additional surveys will include a single grab water chemistry samples collected alongside the macroinvertebrate community samples. This method is documented in SOP#210-20. Parameters to be analyzed are consistent with those of the RIBS screening network and included in Table 2.

Details for funding of this project are contained in the Quality Assurance Management Plan for the Statewide Waters Monitoring Strategy (NYSDEC 2019).

Table 4. Project Schedule

Task	Completion Date
Work plan	June 1, 2020
Final QAPP	June 10, 2020
Sample Collection	May-September 2020
Data Analysis	October 2020-April 2021
Draft Reports	May-September 2021
Final Reports	September 2021

Figure 1a. Map showing the approximate locations of the 2020 Canandaigua and Keuka Finger Lake tributary sites.

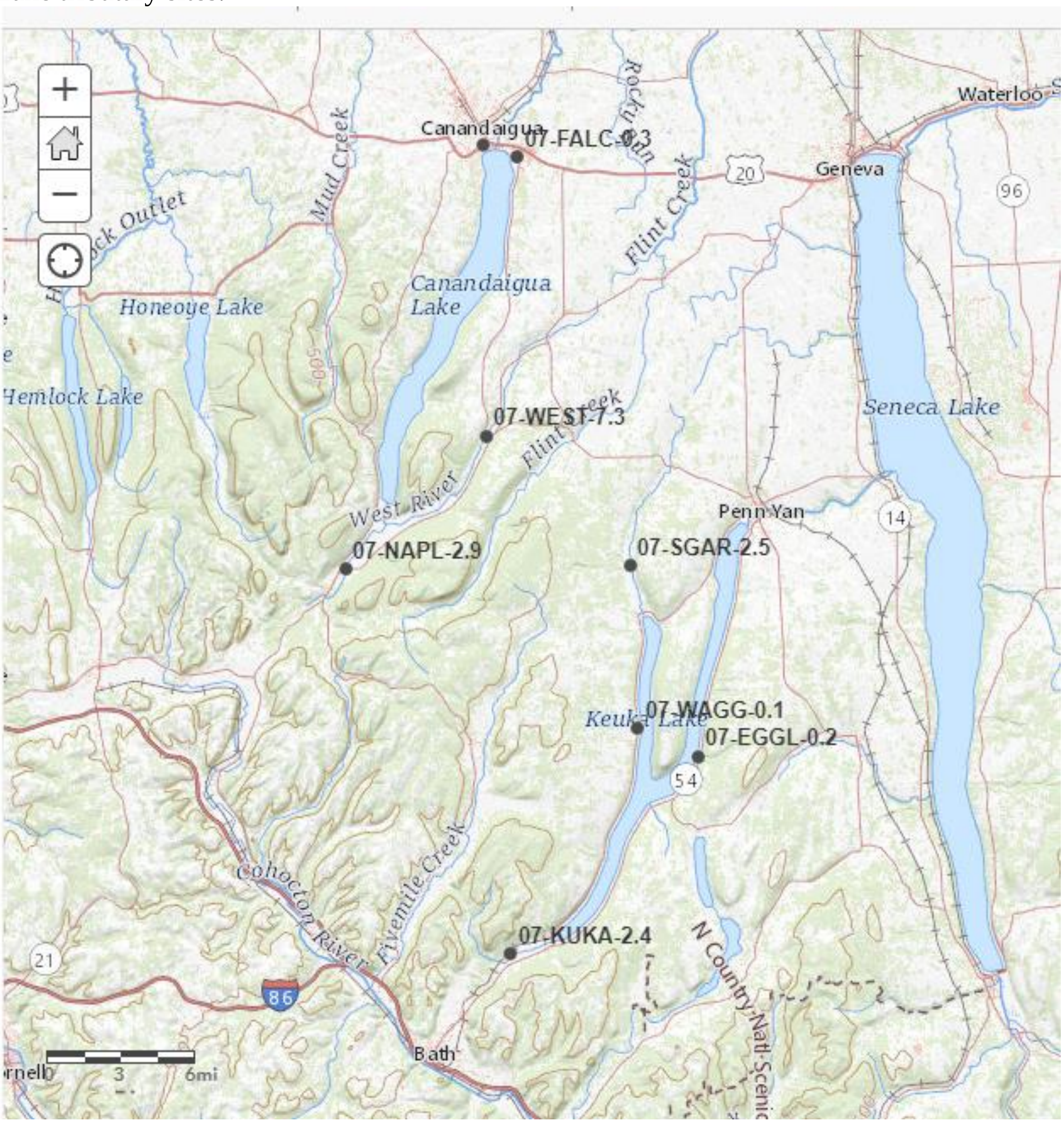


Figure 1b. Map showing the approximate locations of the 2020 Black Lake tributary sites.

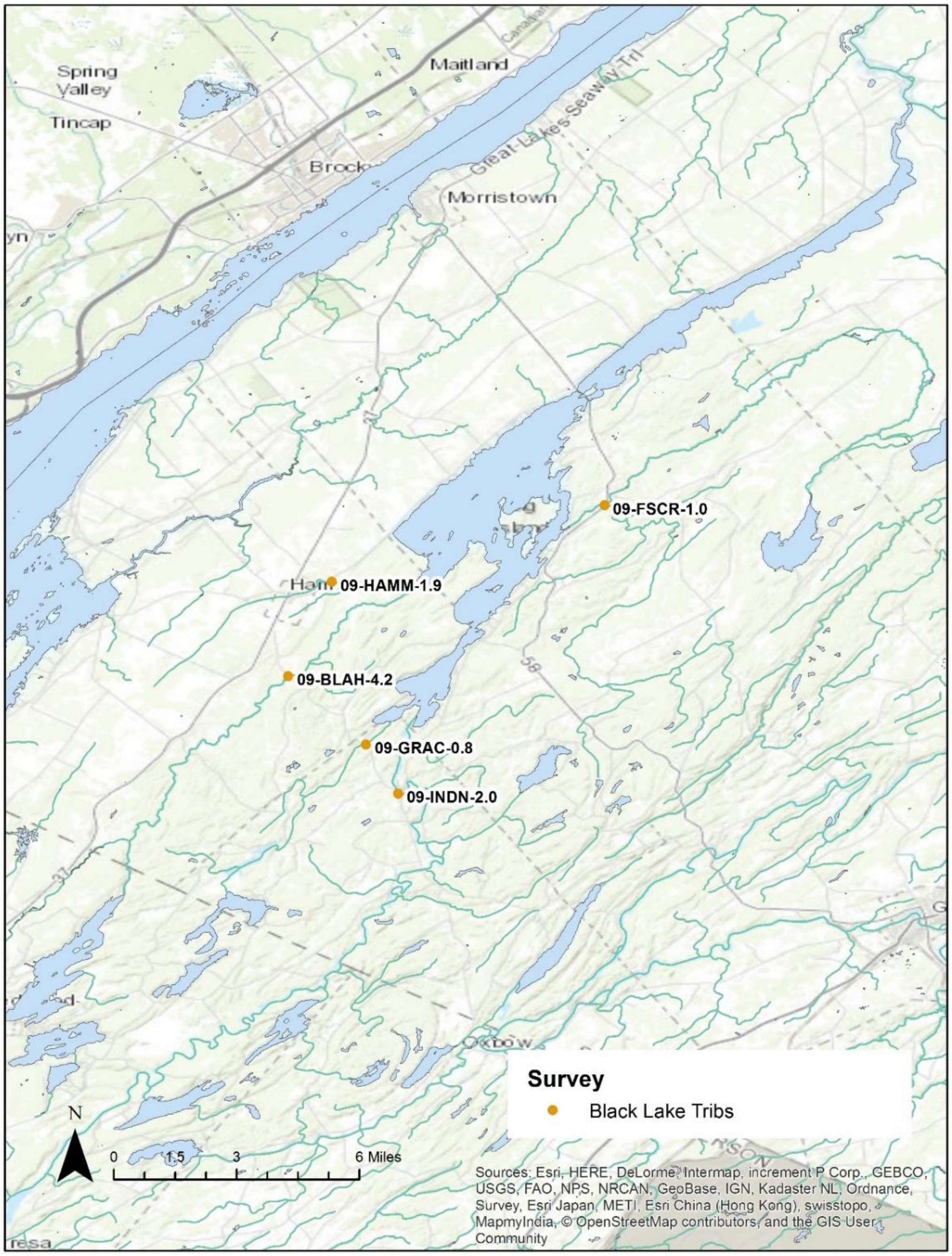


Figure 1c. Map showing the approximate locations of the 2020 Oneida Lake tributary sites.

Figure 1d. Map showing the approximate locations of the 2020 Patroon Creek sites.

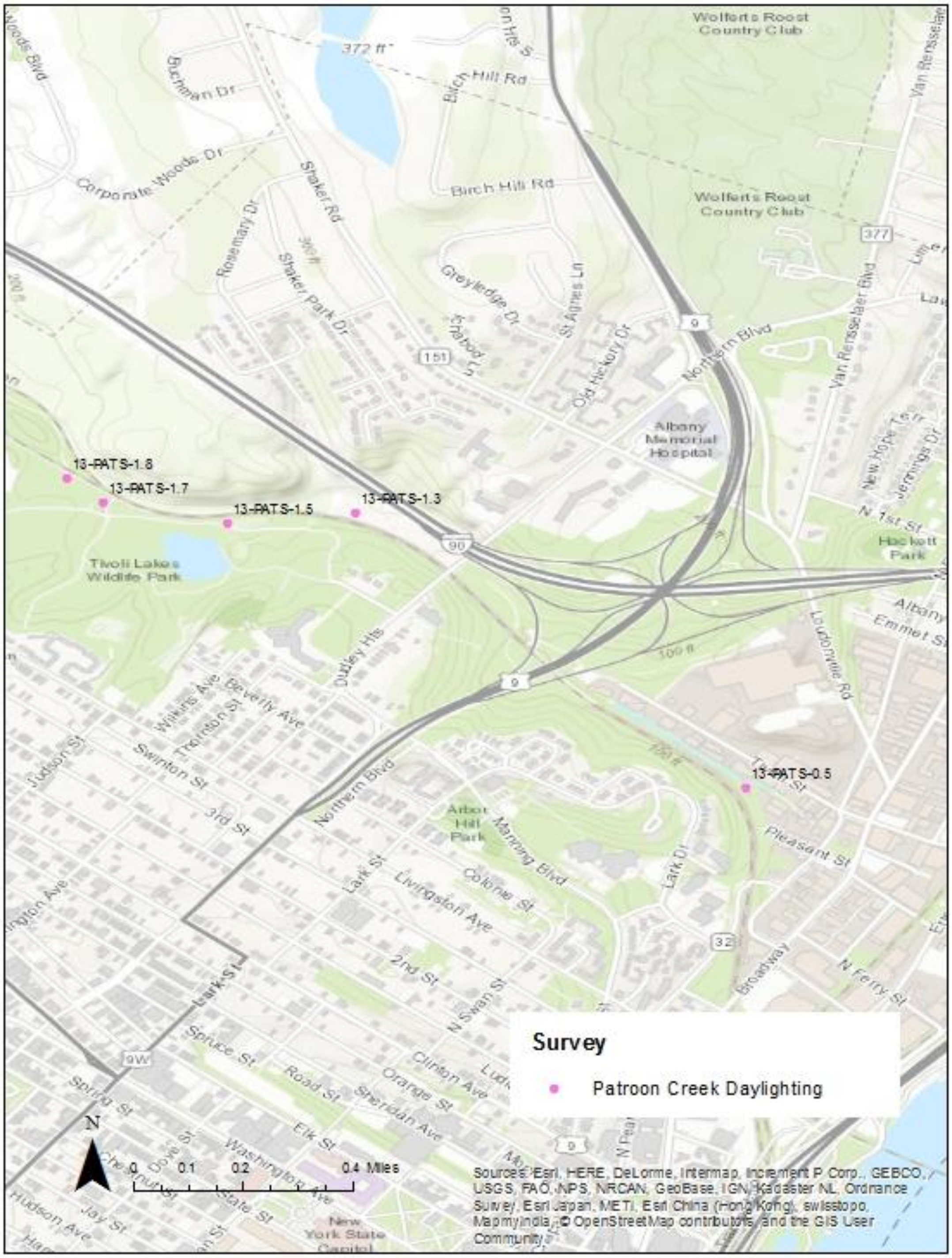


Figure 1e. Map showing the approximate locations of the 2020 Wallkill gage sites.

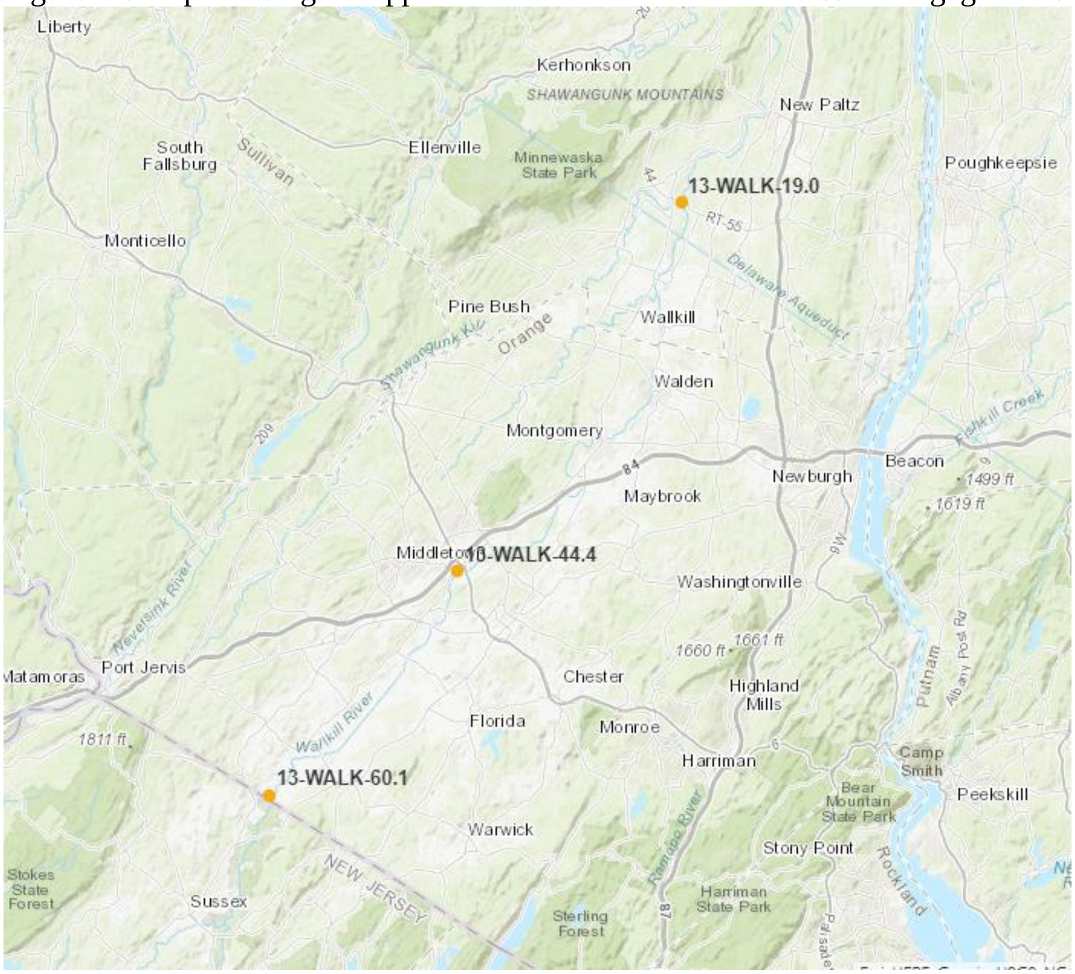


Figure 1f. Map showing the approximate locations of the 2020 Bellinger Brook sites.

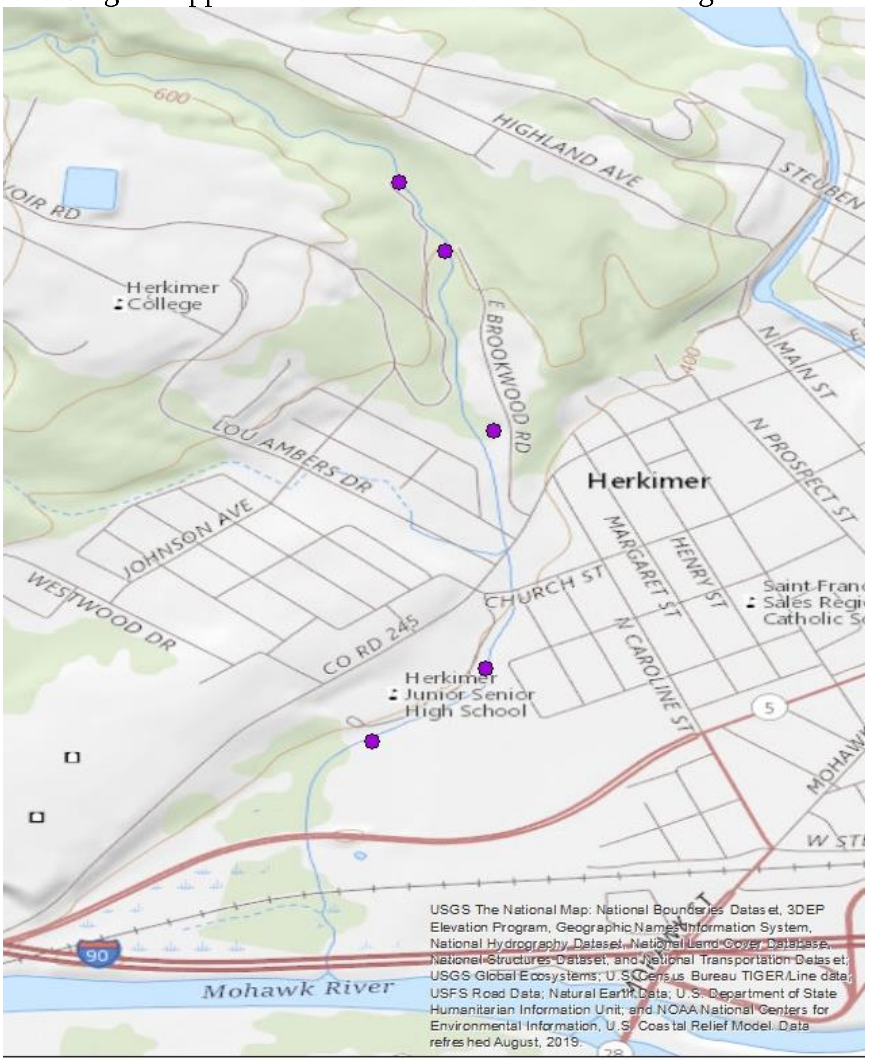


Figure 1g. Map showing the approximate locations of the 2020 Ramapo River sites.

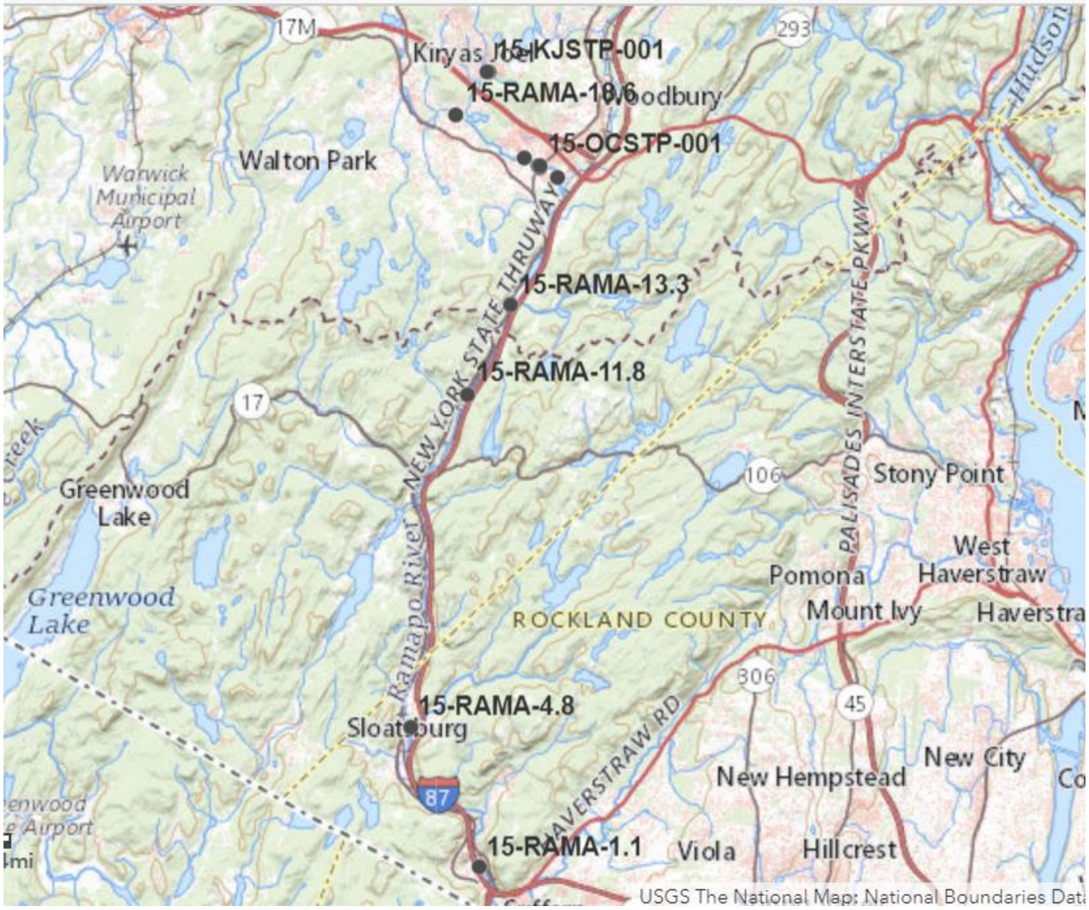


Figure 1h. Map showing the approximate locations of the 2020 Finger Lakes Advanced Monitoring Harmful Algal Bloom tributary locations.

Table 5. Site information for sampling locations of 2020 surveys. Frequency refers to number of water chemistry samples to be collected and targeted flow conditions for each are in parentheses. b = base flow, e = wet weather event flow. Type refers to expected macroinvertebrate sample method.

Site_ID	NAME	Description	Survey	Latitude	Longitude	Frequency	Type
FINGER LAKES TRIBS							
07-SUKE-0.3	Sucker Brook	Western Boulevard	Finger Lakes RAS	42.87800	-77.27800	6 (5b, 1e)	low gradient
07-NAPL-2.9	Naples Creek	SR 245	Finger Lakes RAS	42.62600	-77.39000	6 (5b, 1e)	kick
07-WEST-7.3	West River	Williams St.	Finger Lakes RAS	42.70500	-77.27600	6 (5b, 1e)	kick
07-FALC-0.3	Fall Brook	SR 364	Finger Lakes RAS	42.87100	-77.25100	6 (5b, 1e)	kick
07-SGAR-2.5	Sugar Creek	County House Rd.	Finger Lakes RAS	42.62800	-77.15900	6 (5b, 1e)	kick
07-KUKA-2.4	Keuka Inlet	100 m below CR 8	Finger Lakes RAS	42.39600	-77.25600	6 (5b, 1e)	kick
07-EGGL-0.2	Eggleston Glen	SR 54	Finger Lakes RAS	42.51400	-77.10400	6 (5b, 1e)	kick
07-WAGG-0.1	Wagener Glen	West Lake Rd.	Finger Lakes RAS	42.53100	-77.15300	6 (5b, 1e)	kick
BLACK LAKE TRIBS							
09-HAMM-1.9	Hammond Brook	At CR 6 bridge/culvert, rest of stream to lake appears quite swampy.	Black Lake Tribs	44.45390	-75.67880	4	chem only
09-BLAH-4.2	Black Creek (alternative)	At CR 3	Black Lake Tribs	44.42056	-75.69417	4	chem only
09-INDN-2.0	Indian River (alternative)	at old mill site on CR 8, above Brasie Corners-Rossie Rd bridge	Black Lake Tribs	44.37917	-75.65528	4	chem only
09-FSCR-1.0	Fish Creek (alternative)	SR 58 bridge	Black Lake Tribs	44.48086	-75.58247	4	chem only
09-GRAC-0.8	Grass Creek	at CR 3	Black Lake Tribs	44.39646	-75.66673	4	chem only
ONEDA LAKE TRIBS							
07-FSHO-2.3	Fish Creek	Higginsville rd, kemmerer sample from bridge	Oneida RAS	43.22289	-75.69930	4	kick
07-ONEI-2.2	Oneida Creek	rt 31 bridge access from west and south. Probably not wadable	Oneida RAS	43.15427	-75.71816	4	kick
07-SRAG-0.1	Canaseraga Creek	upstream of Lake Rd, access by boat from Briggs Bay DEC launch	Oneida RAS	43.14528	-75.86412	4	kick
07-CHIT-3.4	Chittenango Creek	At 31 bridge	Oneida RAS	43.15500	-75.97166	4	kick
07-SCRB-0.1	Scriba Creek	near fish hatchery upstream, park at hatchery	Oneida RAS	43.24841	-75.99866	4	kick
PATROONS CREEK							
13-PATS-1.8	Patroon Creek	upstream of daylighting, at railroad crossing	Patroon Creek Daylighting	42.67266	-73.76461	1	kick
13-PATS-1.7	Patroon Creek	Daylighted portion	Patroon Creek Daylighting	42.67198	-73.76367	1	kick
13-PATS-1.5	Patroon Creek	Daylighted portion	Patroon Creek Daylighting	42.67144	-73.76036	1	kick

13-PATS-1.3	Patroon Creek	just downstream of daylighting, before returning underground, between interstate and railway	Patroon Creek Daylighting	42.67174	-73.75699	1	kick
13-PATS-0.5	Patroon Creek	Downstream, biosite	Patroon Creek Daylighting	42.66444	-73.74667	1	kick
WALLKILL							
13-WALK-19	Wallkill River	Lazy River campground-20 m above Shawangunk confl.	Wallkill	41.68639	-74.16442	4	kick
13-WALK-44.4	Wallkill River	At Midway Road bridge	Wallkill	41.43879	-74.36565	4	kick
13-WALK-60.1	Wallkill River	Oil City Rd at USFWS Wildlife Refuge	Wallkill	41.28812	-74.53451	4	multiplate
BELLINGER BROOK							
12-BELN-1.4	Bellinger Brook	Upstream reference	Bellinger Brook	43.035093	-74.999879	1	kick
12-BELN-1.3	Bellinger Brook	Upper concrete section	Bellinger Brook	43.033519	-74.998828	1	kick
12-BELN-0.9	Bellinger Brook	Top of lower concrete section	Bellinger Brook	43.029434	-74.998213	1	kick
12-BELN-0.6	Bellinger Brook	Bottom of lower concrete section	Bellinger Brook	43.024005	-74.997916	1	kick
12-BELN-0.4	Bellinger Brook	Downstream reference	Bellinger Brook	43.022342	-75.000505	1	kick
RAMAPO							
15-RAMA_T25_3-0.2	Unnamed Tributary to Ramapo	downstream of KJ outfall at Bakertown Rd	Ramapo	41.335254	-74.16158	3	chem only
15-RAMA-18.6	Ramapo River	Freeland Street	Ramapo	41.323767	-74.172304	3	kick
15-RAMA-16.8	Ramapo River	20 m below River Rd. bridge	Ramapo	41.31222	-74.14889	3	kick
15-RAMA-16.7	Ramapo River	5 m below Monroe Park pond	Ramapo	41.31028	-74.14361	3	chem only
15-RAMA-16.5	Ramapo River	50 m downstream of Route 17 bridge	Ramapo	41.31	-74.14278	3	chem only
15-RAMA-16.1	Ramapo River	at Nepera plant bridge	Ramapo	41.30722	-74.13695	3	kick
15-RAMA-13.3	Ramapo River	0.2 mi south of Arden bridge; end of Water St	Ramapo	41.27361	-74.15334	3	kick
15-RAMA-11.8	Ramapo River	adjacent to State Hwy 17, downstream of Warwick Brook	Ramapo	41.250157	-74.168322	3	kick
15-RAMA-4.8	Ramapo River	Seven Lakes D	Ramapo	41.1621	-74.1887	3	kick
15-RAMA-1.1	Ramapo River	50 m above 4th St. bridge	Ramapo	41.12516	-74.16455	3	kick
Finger Lakes Advanced HAB Monitoring Tributaries							
07-OWLI-3.0	Owasco Inlet	USGS Gage at Rte. 38	HABs Advanced Monitoring	42.71600	-76.43700	1e	kick
07-DUCH-0.3	Dutch Hollow Brook	East Lake Rd	HABs Advanced Monitoring	42.86400	-76.50800	1e	kick
07-SCKR-0.1	Sucker Brook	100m upstream of SR 38A	HABs Advanced Monitoring	42.90200	-76.52700	1e	kick
07-VENE-0.3	Veness Brook	West off SR 38	HABs Advanced Monitoring	42.88800	-76.54800	1e	low gradient

07-OWAL_T46-0.1	Unnamed Trib to Owasco Lake	Off Fire Lane near SR 38	HABs Advanced Monitoring	42.82400	-76.52100	1e	kick
07-OWAL_T9-0.1	Unnamed Trib to Owasco Lake	Off Widewaters Rd	HABs Advanced Monitoring	42.80500	-76.49100	1e	kick
07-BGST-0.1	Big Stream	At South Glenora Rd	HABs Advanced Monitoring	42.49000	-76.91430	1e	kick
07-KASH-0.3	Kashong Creek	at West Lake Rd	HABs Advanced Monitoring	42.76525	-76.97615	1e	kick
07-THOL-0.3	Tug Hollow Creek	SR 414 bridge	HABs Advanced Monitoring	42.42620	-76.87000	1e	kick
07-CATH-0.6	Catherine Creek	South Genesee St bridge	HABs Advanced Monitoring	42.32827	-76.84394	1e	kick
07-KEUK-0.1	Keuka Outlet	0.5m u.s. of mouth	HABs Advanced Monitoring	42.68200	-76.94900	1e	non-wadeable
07-CSTL-0.1	Castle Creek	50m from trib mouth	HABs Advanced Monitoring	42.87300	-76.97300	1e	kick
07-GLNK-0.2	Glen Creek	Junction of McGee & Shannon Street	HABs Advanced Monitoring	42.37800	-76.86200	1e	kick
07-REED-0.1	Reeder Creek	East Lake Rd	HABs Advanced Monitoring	42.78589	-76.92806	1e	low gradient
07-SKAT_T2-0.1	Unnamed Tributary to Skaneateles Lake	East Lake Road	HABs Advanced Monitoring	42.92400	-76.40500	1e	kick
07-SKAT_T89-0.2	Unnamed Tributary to Skaneateles Lake	West Lake Rd bridge	HABs Advanced Monitoring	42.89800	-76.41900	1e	kick
07-DUCH-8.3	Dutch Hollow Brook	10 m above Old State Rd. bridge	HABs Advanced Monitoring	42.83200	-76.41200	1e	kick
07-GROU-1.5	Grout Brook	CR 101 at Sweeney Hill Rd bridge	HABs Advanced Monitoring	42.74200	-76.26500	1e	kick
07-SKAT_T93a-0.1	Unnamed Tributary to Skaneateles Lake	Country Club foot bridge	HABs Advanced Monitoring	42.93000	-76.42800	1e	kick
07-SKAT_T5-0.1	Unnamed Tributary to Skaneateles Lake	East Lake Rd bridge	HABs Advanced Monitoring	42.90400	-76.39400	1e	kick

Table 6. Applicable biological, physical, and chemical parameters for each 2020 survey.

Survey	Biomonitoring	Depth Integrated Water Chemistry	Grab Sample Water Chemistry	Discharge	Field Parameters	Water Chemistry Parameters	Additional Chemical Parameters
FINGER LAKES TRIBS	X	X		X	X	RIBS Screening	TSS, TOC, OPO4
BLACK LAKE TRIBS	X	X		X	X	RIBS Screening	
ONEIDA TRIBS	X	X		X	X	RIBS Screening	TSS, TOC, OPO4, DOC
WALLKILL	X	X		X	X	RIBS Screening	
BELLINGER Brook	X		X		X	RIBS Screening	
PATROON CREEK	X		X		X	RIBS Screening	
RAMAPO	X	X		X	X	RIBS Routine	total metals
FL Adv HABS		X		X	X	RIBS Screening	

4. Quality Objectives and Criteria

The biological assessment of water quality relies on the use of multiple benthic macroinvertebrate community metrics applied in a 4-tiered assessment framework. Based on the results of the community metrics applied to raw species data, samples are assigned an overall water quality assessment of non-, slight, moderate, or severely impacted. Details on this tiered assessment framework can be found in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC SOP # 208-19). The action level associated with this framework is moderate impairment. Sampling stations assessed as moderate or severe are considered not supporting of aquatic life use. Waters with these assessments are typically listed on the NYS Impaired Waterbodies 303(d) List. Exact listing methodologies can be found in the NYSDEC Division of Water Consolidated Assessment and Listing Methodology (CALM) (NYSDEC 2020 - expected). Measurements of physical site attributes are meant for characterization purposes only and do not adhere to a separate set of action levels or criteria at this time. However, water quality parameters collected using field multi-probes do have standard sampling methods, precision and accuracy limits associated. These are listed in completeness in the (NYSDEC SOP # 208-19).

Parameters to be collected for water chemistry are consistent with RIBS screening network and routine network parameters. Quality assurance measures for water column parameters to be collected as part of RAS survey include calibration schedule, detection and reporting limits, precision, and accuracy are listed in the 2020 RIBS QAPP (NYSDEC 2020) and listed in Tables 2 and 3. The schedule for QC samples is shown in Table 6. Assessment and listing methodologies are covered in the CALM (NYSDEC 2020 - expected).

Table 7. QC sample schedule for RAS surveys planned for summer 2020.

Survey	# SITES	Equipment Blank	Matrix Spike/ Matrix Spike Duplicate	Field Duplicate	Dates
FINGER LAKES TRIBS - 9E	8	1	1		15-May
	8				15-Jun
	8			1	15-Jul
	8				15-Aug
	8	1	1	1	15-Sep
	8				TBD
BLACK LAKE TRIBS	5	1			TBD
	5	1	1		TBD
	5	1			TBD
	5	1		1	TBD
ONEIDA TRIBS	5	1			22-Jun
	5	1	1		TBD-Jul
	5	1		1	TBD-Aug
	5	1	1		TBD-Sep
WALLKILL	3	1	1		8-Jun
	3	1		1	20-Jul
	3	1	1		31-Aug
	3	1			28-Sep
BELLINGER BROOK	5	1	1		26-Aug
PATROONS CREEK	5	1			8-Jul
RAMAPO River	10	1	1		18-May
	10	2	1	1	10-Jun
	10	1	1		15-Sep
FL Adv HABS	20	1	1		TBD

5. Training Requirements/Certifications

Training is conducted annually for all field staff to review standard operating procedures and to introduce any new methods. The training is conducted in accordance with the procedures outlined in the Quality Assurance Project Plan for the Rotating Integrated Basin Studies (NYSDEC 2020).

All SBU laboratory staff must first meet established quality assurance / quality control standards for the processing of benthic macroinvertebrate samples. Details and QA/QC standards for laboratory sample processing are maintained in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC SOP # 208-19). Training for water chemistry analytical laboratory staff is the responsibility of the analytical laboratory management and is consistent with requirements described in PAP-5, Exhibit E, Section II.F.

The Project Manager will ensure that all individuals involved with the project receive and are familiar with this document to ensure proper adherence to the procedures in it.

6. Documentation and Records

Laboratory data and results will be entered and stored in the SBU's Microsoft Access Database. Results are reported to the Project Manager in accordance with the requirements of NYSDEC SOP # 208-19. This complete document package will allow for data validation. Field notes will be entered by SBU staff into the database. Station photographs will be stored electronically in separate project folders. All field data will be entered directly into electronic handheld devices while in the field for transfer and storage into the SBU database directly. All field notes will be printed and saved in hard copy. Any non-electronic field notes will be scanned for electronic archiving. Details on the SBU's electronic data management system can be found in NYSDEC SOP # 208-19. All results will be summarized in a final report to be prepared by the project manager or designated staff. An evaluation of the precision, accuracy, and completeness based upon replicate sample analysis will be accomplished when replicates have been collected and once samples have been processed and initial metrics have been calculated (See NYSDEC SOP # 208-19 for details on evaluation of precision, accuracy, and completeness for replicated sampling). A summary section on how QA/QC objectives were or were not met will be included in the final report. The final report will include a summary and discussion of analytical results for those parameters included in Table 1.

II. DATA GENERATION AND ACQUISITION

1. Rationale of Monitoring Design

The selection of sampling locations for whole waterbody assessment surveys otherwise known as rapid assessment surveys (RAS) uses a combination of historical data when available, information on known pollution sources, and desktop and field reconnaissance. Sites selected represent upstream/watershed conditions and provide data to inform watershed management, planning, updates to WI/PWL assessment status, to provide pollutant loading information, and to document either baseline conditions or response to changes

The number of sampling locations is based on the approximate stream length to be surveyed, trying to split the stream into segments of even length or to represent major sub-watersheds within a larger watershed assessment. A good starting point is placing 2 sites in each WI/PWL segment, placing certain sites closer together if known sources of pollution or landscape targets warrant it. Additionally, when focusing on a watershed-wide assessment, if possible, sub-watersheds should be included in the survey when they represent 10% or more of the total drainage area of the major watershed. Proposed CALM data objectives indicate eight samples over two years are required to update WI/PWL assessment status (CALM 2020 – expected).

If previous surveys have been conducted the historical sites should be used. The general location of each site should be determined by desktop reconnaissance with the specific location for the sample collection determined in the field. In general, sampling locations should bracket completely any known sources of inputs to the stream that may have triggered the investigation.

A. Sample Distribution/Map

Details on sampling locations are provided in Figure 1 and Table 3.

B. Sampling Schedule

Sampling is conducted during the months of May through October. Biological collections are conducted during July through September as dictated by the sampling index period (SOP #208-19) Specific dates for each survey are scheduled based on water conditions and staff availability but subject to change based on weather, streamflow, and survey objectives. Decisions regarding conducting RAS are made by the Project Manager providing a one week minimum lead time for study design and equipment preparation. RAS are slotted for sampling during the off weeks between the screening surveys of the NYSDEC DOW Rotating Integrated Basin Studies Program.

2. Sampling Methods

All biological sample collection, processing, and data management methods for RAS are described in detail within the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC SOP # 208-19). Water chemistry sampling collection methods are detailed in the Standard Operating Procedure: Collection of Ambient Water Quality Samples (SOP # 210-20). Discharge measurement methods are detailed in Turnipseed and Sauer (2010).

3. Sample Custody Procedures

All sample handling, transport, and custody procedures for biological samples are detailed in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC SOP # 208-19). Field notes will be taken to document sample collection times, locations, dates, and sampling personnel. Individual sample containers will be marked to identify each station number, collection time, date, and location. Macroinvertebrate sample processing laboratory bench sheets will also include this information along with a description of the specific type of processing to be performed and the date of sample arrival to the SBU lab. Original lab sheets will be maintained as well as all sorted benthic macroinvertebrate sample material for future reference. The project manager will also maintain a copy of all lab sheets in the project file. Processing and analysis of samples will begin upon completion of the field season or sooner, if the nature of the survey warrants. Some conditions such as legal suits or department priority may expedite the completion of sample processing and reporting.

For water chemistry sampling, all sample handling, transport, and custody procedures are detailed in NYSDEC-DOW SOP #101-19, Sample Handling, Transport, and Chain of Custody. A Chain of Custody Form will be completed by sampling personnel and submitted to the analytical laboratory with each cooler containing samples. Samples are delivered to the appropriate analytical laboratory for analysis within twenty-four hours of shipping, by courier service (UPS), pick up by the laboratory or delivery by sampling staff. Upon arrival at the laboratory, samples must be refrigerated at <6° C until all analyses are completed. Processing and analysis of samples will begin immediately upon receipt. Upon receipt at the analytical laboratory, the time of sample receipt and start of analysis along with any problems encountered with equipment or samples will be recorded, and subsequently reported in the data package.

4. Sample Processing Methods

All benthic macroinvertebrate samples are processed in-house by SBU staff. Sample processing includes the sorting of organisms from detritus and the identification and enumeration of sorted organisms. Information is stored on electronic lab datasheets and then imported into a database where community metrics are calculated to define overall water quality.

All water chemistry samples are processed by ALS according to methods and specifications outlined in the RIBS 2020 QAPP.

5. Quality Control

The following measurements will be used to assess the quality of data being generated in the project. The target acceptance limits for these quality control procedures are listed in NYSDEC SOP # 208-19 and SOP # 210-20.

A. Precision

Macroinvertebrate: Precision can be defined as the relative uncertainty about a given measurement. Benthic samples will be collected according to established methods, with set sampling time and distance, as detailed in NYSDEC SOP #208-19. In the laboratory, precision is maintained by internal quality control measures, described in NYSDEC SOP #208-19, which include calculation of percent similarities of sample identifications by several taxonomists. In addition, 10% of all invertebrate samples collected during one sampling season are sent to a contract laboratory for QAQC identification and enumeration. Precision is evaluated by comparison of 2 randomly selected samples processed by 2 different taxonomists to determine their similarity (Stribling *et al* 2003; Stribling *et al* 2008). A goal of 85% sample identification similarity is to be met.

Water Chemistry: Matrix duplicate samples are collected at 5% of the total number of sites. Matrix duplicates are analyzed for nutrients, solids, turbidity, conductivity, hardness, metals, and minerals (SOP #210-20).

B. Accuracy

Macroinvertebrate: Accuracy can be defined as the absolute uncertainty about the true value. Accuracy of sampling results for benthic macroinvertebrate samples and the community metrics used to describe water quality are summarized in Smith and Bode (2004).

Water Chemistry: Matrix spike samples are collected along with regular water quality samples and spiked in the analytic laboratory with a known concentration of analyte. The samples are then analyzed to determine the accuracy (percent recovery) of the analytic results for a given matrix. Matrix spike samples are collected for 5% of the total samples. Matrix spikes are analyzed for nutrients, metals, and minerals.

C. Representativeness and Comparability

Macroinvertebrates: Representativeness and comparability are achieved by using a set area and time interval to carry out the collection of benthic invertebrates. A traveling kick sample requires that the collector disturb the substrate of the stream over a 5-minute period over a 5-meter diagonal transect through a riffle zone. Samples are always collected from a riffle area where current speed is greater than 0.4 meters per second. Examination of substrate type, land-use, current speed and canopy cover among sites results in maximum comparability of the data. In addition, the contents of the samples are field inspected before preservation to ensure sample representativeness and comparability.

Water Chemistry: Representativeness in water column samples is attained by selection of proper sampling location and equipment to obtain a sample meeting the goals of the project and by collecting field duplicate samples for approximately 5% of the total samples (SOP 210-20).

D. Blanks

Water chemistry equipment blanks will be collected at a rate of 10% of total samples collected. Equipment blanks are analyzed for nutrients, solids, turbidity, conductivity, hardness, metals, and minerals (SOP 210-20).

E. Completeness

Completeness can be defined as the percentage of acceptable data necessary to accomplish the study objectives. Completeness for surveys is determined by having sufficient samples collected to fully meet the specific objectives of the individual RAS. Completeness is judged by the Project Manager. Completeness will be met by collecting one sample at each of the sampling locations identified in Table 3. Sampling locations are set before entering the field. During the survey certain constraints such as posted property, wadeability, or other access restrictions may prohibit sampling at any one of the locations. In these events additional sites are investigated as replacements while in the field. However, if additional sites are not found that adequately replace lost sites, then sampling in these areas will not be conducted. This reduces the total number of samples collected for the survey. Analysis of the results and final reports summarize the data that was made available through the sampling efforts. The loss of sites may result in the final report suggesting additional sampling or a different type of sampling. Water chemistry should be collected with all macroinvertebrate samples

6. Instrument/Equipment Testing, Maintenance, and Calibration Procedures

Field instrumentation is used to collect basic water column parameters. Specifically, the SBU uses a Yellow Springs Instruments (YSI) Pro Plus mini-sonde and handheld display unit. Project technical staff is responsible for its maintenance and calibration on a weekly basis. The probe measures Temperature, pH, dissolved oxygen, percent oxygen saturation, specific conductance, and chlorophyll A. Calibrations hold accurate for one week. Every Monday during the field season project technical staff hold a calibration session to calibrate collectively all YSI units for pH and specific conductance. pH uses a two point calibration of 4 and 7. Specific conductance is a one point calibration using either 100 µsiemen/cm or 500 µsiemen/cm depending on the survey location and perceived stream values for the week. Dissolved oxygen is calibrated to 100% saturation using an internal barometer in the YSI Pro Plus and is calibrated the morning of each survey. Chlorophyll A is calibrated weekly. All calibration records are recorded in a log book specific to the individual YSI Pro Plus units. Additional probe electrolytes and oxygen membranes are kept in the unit's carrying case. Further calibration details are provided in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC SOP # 208-19) and the Standard Operating Procedure: Use, Calibration, Maintenance and Storage of multi-probe meters used to measure water quality parameters (NYSDEC SOP # 211-19).

7. Supplies and Consumables

Inspection of supplies and consumables must be made upon arrival of new materials and immediately before their use in the field or laboratory. For newly arrived supplies and consumables all materials must be in their original packaging and free of noticeable damages. For materials already obtained and ready for use, no noticeable defects will be allowed. The Project technical staff is responsible for ensuring the quality of all supplies and consumables. A complete list of consumables required for the collection of biological samples is provided in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC SOP # 208-19), Appendix 17.16. A list of equipment and supplies is included for water chemistry collection in Standard Operating Procedure: Collection of Ambient Water Quality Samples (SOP # 210-20).

8. Data Management

Data handling and archival will follow the procedures of the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC SOP # 208-19) and the Biomonitoring Data Management System User Manual (Smith et al 2007). The SBU will store electronic transcripts of field notes indefinitely. Electronic data packages will be delivered according to the 2020 RIBS QAPP (NYSDEC 2020). The 2020 RIBS QAPP also describes the procedure for quality control and storage of the electronic data from the contract laboratory for water chemistry data.

III. ASSESSMENT AND OVERSIGHT

1. Performance and System Audits

Macroinvertebrates: Frequent internal audits, consisting of two or more SBU laboratory personnel conferring on identification occur on average, once daily. In addition, the SBU laboratory has participated in external performance evaluation studies by the U.S. EPA.

Identification of macroinvertebrate test samples have been evaluated by the U.S. EPA, and samples are sent to an outside laboratory yearly for audit. The laboratory has also been evaluated by on-site visits and field audits by the U.S. EPA.

Water Chemistry: NYSDEC contract laboratories are audited on an annual basis by the NYSDEC DOW Laboratory Contract Coordinator to determine the laboratory's compliance with the requirements of the PAP for all DEC programs submitting samples. According to NYS Public Health Law 502, the laboratories contractors also must be certified by the New York State Department of Health. This program involves semi-annual performance evaluation samples and periodic onsite audits. NYSDEC audits subcontractor laboratories on an as-needed basis. The NYSDEC QA officer will conduct project specific field audits for both Central and Regional Office sampling personnel and report the results of these audits to the Program Manager.

2. Corrective Action

Major sources of errors may include analytical and equipment problems and those resulting from the deviation from intended plans and procedures. Procedures the SBU laboratory and/or field staff follow when problems are encountered are outlined in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC SOP # 208-19).

Any person observing a deviation from intended plans and procedures will report such deviation to the project staff person responsible for the operation or analysis in question. The appropriate project personnel shall then:

1. Develop a corrective action plan to ensure that future sampling, analyses, etc. are conducted in accordance with the QA procedures presented in this QAPP;
2. Rerun procedures in the appropriate manner and re-analyze samples if sufficient sample material is available and holding times are not exceeded;
3. Report all problems and deviations to the principal investigator. The principal investigator shall also be consulted during the development of any proposed corrective action plans and;
4. Record all deviations from intended plans and procedures in the appropriate field or laboratory notebooks.

3. Reports to Management

Monthly reports are issued to inform appropriate management personnel of progress in the execution of the RAS surveys identified in this QAPP. The reports include major accomplishments or findings and outstanding problems associated with the rivers surveyed.

Individual water quality assessment reports are written for streams studied as RAS. These reports contain raw species information, assessment results, comparisons to data collected previously, and a detailed discussion of the meaning of the findings.

Data analysis and incorporation of data into the Stream Biomonitoring Unit data management system are executed by programs in the database. Elements of many of the reports are automatically generated by the program’s database after field, tissue, and sample data have been entered. Calculations performed by the database include the biological community and water quality metrics described in NYSDEC SOP # 208-19. Report elements automatically generated by the database include sampling location maps, macroinvertebrate species data reports, laboratory data summary reports and field data summary reports. These data reports can be exported from the database in multiple electronic formats including Microsoft Word and PDF and incorporated into RAS reports.

As soon as possible after receipt of data packages from the analytical laboratories, data are reviewed, compiled, and assessed using the established criteria in Section I, 4 of this QAPP and other procedures defined in the CALM (2020 - expected) and individual data reports.

Final assessment reports are distributed to other DOW staff and the public upon request. Electronic and hard copies are maintained for each report and stored in the Centralized Electronic Document Repository (CEDR).

Project Fiscal Information

Fiscal information for RAS is combined as part of the Statewide Waters Monitoring Program. Details on the specific project fiscal information for that program can be found in the Quality Assurance Management Plan for the Statewide Waters Monitoring Program (NYSDEC 2019).

4. Data Validation and Usability

Data Review

Macroinvertebrates: All data will be reviewed by the project manager or designated staff to determine its validity prior to use. Those data not meeting the previously identified criteria for precision and accuracy (Section 5) will be re-analyzed where possible, or flagged if additional sample material is not available (in the case of replicated sampling where a fourth replicate may not have been retained). An indication as to why flagged data did not meet the minimum QA criteria will be provided. This information will be noted in the final report.

Laboratory QA sample evaluation follows the procedures in NYSDEC SOP # 208-19. Percent Taxonomic Disagreement (PTD) and Percent Difference in Enumeration (PDE) are calculated on 10% of SBU samples collected in a sampling season to quantify the precision, and accuracy of data resulting from this project. Results from these statistical calculations will be useful in determining whether data quality requirements presented in Section 5 and in the NYSDEC SOP # 208-19 have been met.

Water Chemistry: Laboratory QA sample evaluation shall include analysis of (1) surrogate spikes to determine the average percent recovery and standard deviation and (2) equipment blanks, which will be compared to respective batch results. Performing matrix spike duplicate analyses and comparing results will evaluate laboratory precision. Laboratory duplicate analysis will be conducted to evaluate inorganic and conventional parameters. The quality control results are evaluated using evaluation criteria that are appropriate for the type of sample collected and the objective for collecting it. These various calculations used to determine the precision, accuracy, and overall quality of the water quality data results and qualify the use of those data.

Program staff review data results during the processing of the electronic data files. This review includes confirmation of suspect values and the possible qualification of data results. Those data not meeting the previously identified criteria for precision, accuracy and blank values will be re-analyzed where possible, or flagged if additional sample material is not available. An indication as to why flagged data did not meet the minimum QA criteria will be provided. Additional details on data review can be found the 2020 RIBS QAPP (NYSDEC 2020).

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Appendix I. Instantaneous Discharge Measurements Methods taken from Turnipseed and Sauer (2010)

A. Midsection Method (p2-3)

Discharge Measurements at Gaging Stations

Procedures for making most types of current-meter [mechanical meters, electromagnetic meters, ADV meters, acoustic digital current meters (ADCs), and so forth)], moving-boat ADCP, and ADCP midsection measurements are described in the following sections. For much of the discussion of moving-boat ADCP, the reader is referenced to Mueller and Wagoner (2009). The chapter includes discussions on the selection of a measuring section, laying out the stationing for subsection verticals, width measurements, depth measurements, velocity measurements, direction of flow measurements, and recording of field notes. Additional details that pertain to instrumentation and specific types of measurements, such as wading, cableway, bridge, boat, and ice, are described in subsequent sections. Special procedures such as networks of current meters, measurement of deep, swift streams, and measurements during rapidly changing stage are also described.

Velocity-Area Method

The most practical method of measuring the discharge of a stream is the velocity-area method. Discharge is computed as the product of the area and velocity. The measurement is made by subdividing a stream cross section into segments (sometimes referred to as partial areas, sections, subareas, verticals, stations, profiles, panels, or ensembles), and by measuring the depth and velocity in a vertical within each segment. The total discharge is the summation of the products of the partial areas of the stream cross section and their respective average velocities. This computation is classically expressed by the equation

$$Q = \sum_{i=1}^{n} a_i v_i, \qquad (1)$$

where Q total discharge, in cubic feet per second,
a_i cross-section area, in square feet, for the *i*th segment of the *n* segments into which the cross section is divided, and
v_i the corresponding mean velocity, in feet per second of the flow normal to the *i*th segment, or vertical.

Midsection Method

The current-meter midsection method of making a current-meter discharge measurement is used by the USGS and others. The method assumes that the mean velocity in each vertical represents the mean velocity in a partial rectangular area (segment). The mean velocity in each vertical is determined by measuring the velocity at one or more selected points in that vertical, as described in a later section of this chapter. The cross-section area for a segment extends laterally from half the distance from the preceding vertical to half the distance to the next vertical, and vertically, from the water surface to the sounded depth as shown in figure 1.

The cross section in figure 1 is defined by depths at locations 1, 2, 3, 4, . . . , *n*. At each location, the velocities are sampled by current meter to obtain the mean of the vertical distribution of velocity. The partial discharge is now computed for any partial section (segment) at location *i* as

$$q_i = v_i \left[\frac{\left(b_i - b_{(i-1)}\right)}{2} + \frac{\left(b_{(i+1)} - b_i\right)}{2} \right] d_i, \text{ or} \qquad (2)$$

$$= v_i \left[\frac{b_{(i+1)} - b_{(i-1)}}{2} \right] d_i, \qquad (3)$$

where q_i discharge through partial section *i*,
v_i mean velocity at location *i*,
b_i distance from initial point to location *i*,
$b_{(i-1)}$ distance from initial point to preceding location,
$b_{(i+1)}$ distance from initial point to next location, and
d_i depth of water at location *i*.

Thus, for example, the discharge through partial section 4 (heavily outlined in figure 1) is

$$q_4 = v_4 \left[\frac{b_5 - b_3}{2} \right] d_4. \qquad (4)$$

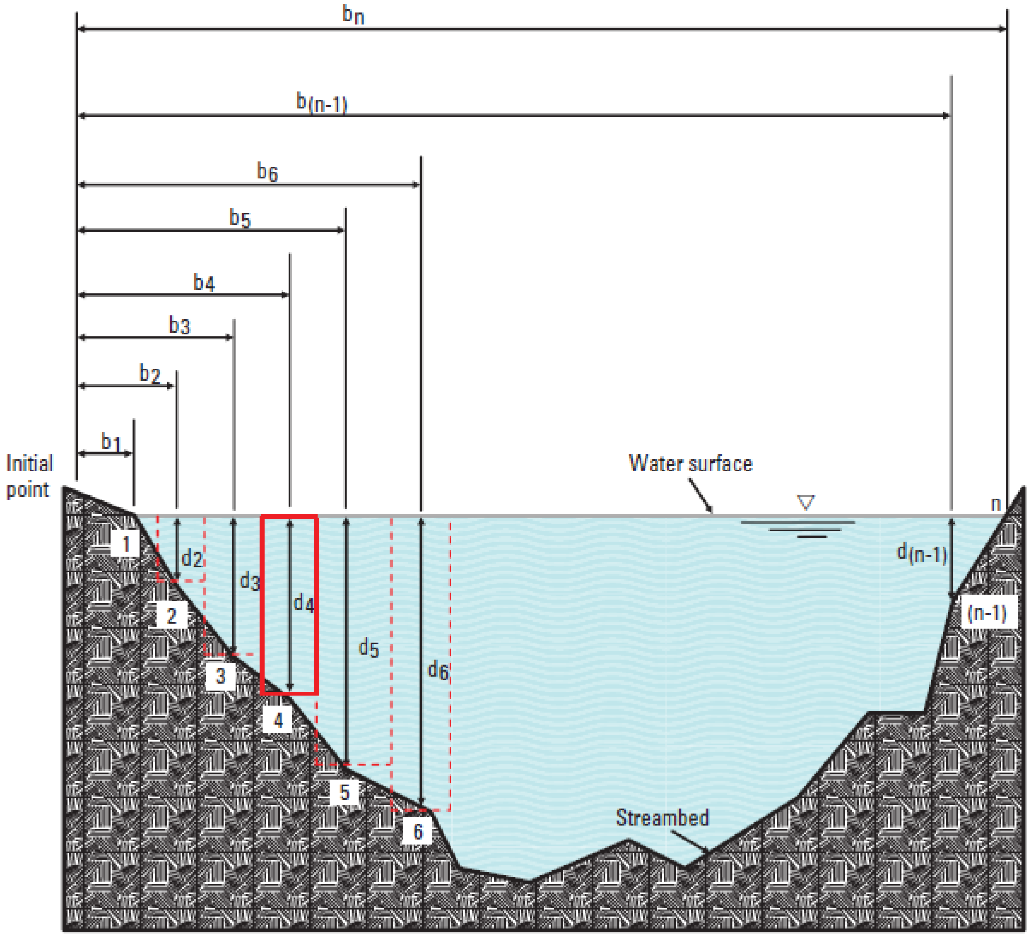
The procedure is similar when *i* is at an end section. The "preceding location" at the beginning of the cross section is considered coincident with location 1; the "next location" at the end of the cross section is considered coincident with location *n*. Thus,

$$q_1 = v_1 \left[\frac{b_2 - b_1}{2} \right] d_1, \text{ and} \qquad (5)$$

$$q_n = v_n \left[\frac{b_n - b_{(n-1)}}{2} \right] d_n. \qquad (6)$$

For the example shown in figure 1, q_1 is zero because the depth at observation point 1 is zero. However, when the cross-section boundary is a vertical line at the edge of the water as at location *n*, the depth is not zero and velocity at the end section may or may not be zero. Equations 5 and 6 are used whenever there is water only on one side of an observation point, such as at the edge of the stream, piers, abutments, and islands. It usually is necessary to estimate the velocity at an end section because it normally is impossible to measure the velocity accurately with the current meter close to a boundary. There also is the possibility of damage to the equipment if the flow is turbulent. The estimated velocity is usually made as a percentage of the adjacent section.

The summation of the discharges for all the partial sections is the total discharge of the stream. An example of the measurement notes is shown in figure 2*A*. In the hydraulic properties reported, the summation of discharges from an ADV discharge



EXPLANATION

1, 2, 3,............... n	Observation points
b_1, b_2, b_3,........... b_n	Distance, in feet, from the initial point to the observation point
d_1, d_2, d_3,........... d_n	Depth of water, in feet, at the observation point
- - - - - - - - - - - -	Boundary of partial sections; one heavily outlined discussed in text

Figure 1. Definition sketch of the current-meter *midsection* method of computing cross-section area for discharge measurements.

measurement (fig. 2*B*) is similar to that of a current meter; however, it is designed to report the properties inherent to the ADV software and signal processing necessary to compute discharge using acoustic Doppler technology. A program written by staff in the USGS Maine Water Science Center entitled Surface Water Measurements and Inspections (SWAMI) has become common in use in the USGS with a PDA, and may be used to record discharge measurements, inspections, differential level surveys, and other field measurements (fig. 2*C*).

Included here for convenience is a typical, well-documented ADCP discharge measurement (fig. 2*D*). This measurement serves as an example of how an ADCP measurement note should be kept in the field. Further discussion of ADCP measurements can be found in subsequent sections of this chapter.

B. Site Selection and Tag Lines (p8-9)

The mean-section method used by the USGS prior to 1950 differs from the midsection method in computation procedure. Partial discharges are computed for partial sections between successive verticals. The velocities and depths at successive verticals are each averaged, and each partial section extends laterally from one vertical to the next. Discharge is the product of the average of two mean velocities, the average of two depths, and the distance between verticals. A study by Young (1950) concluded that the midsection method is simpler to compute and is a slightly more accurate procedure than the mean-section method.

Site Selection

The first and most critical step in making a midsection current-meter or ADV measurement, or an ADCP measurement is to select a measurement cross section of desirable qualities. If the stream cannot be waded, nor high-water measurements made from a bridge, moving or tethered boat, or cableway, the hydrographer may have little or no choice in selecting a measurement cross section. If the stream can be waded or the measurement can be made from a boat, the hydrographer should look for a cross section with the following characteristics:

- There is a reasonably straight channel with streamlines parallel to each other; a stable streambed free of large rocks, weeds, and obstructions that would create eddies, slack water, and turbulence; and desirable measurement sections that are roughly parabolic, trapezoidal, or rectangular. These conditions are obviously not always possible, but remember that most current meters are rated in a still water tank by towing them through the tank at a known speed. With that in mind, these are conditions a hydrographer should seek in the field: a smooth, mirror-like water surface with steady, uniform, nonvarying flow conditions in the stream reach where the discharge measurement will be taken.
- The velocities are, for the most part, greater than 0.5 ft/s, and depths that are greater than about 0.5 ft. These conditions are not always possible to find in the field.
- The measurement section is relatively close to the gaging station control to avoid the effect of tributary and (or) intervening drainage area inflows between the measurement section and the control, and to avoid the effect of channel storage between the measurement section and the control during periods of changing stage.

It is usually not possible to satisfy all of these conditions. Select the best possible reach using these criteria and then select a cross section. For a further discussion regarding site selection when using a mechanical or other point-velocity current meter refer to Rantz and others (1982).

For convenience, special site-selection considerations for an ADCP discharge measurement are presented as follows, and further discussion of ADCP methods and instruments is presented in subsequent sections of this chapter:

- The minimum depth near the left and right edges of water at the measurement site should allow for the measurement of velocity in two or more depth cells while being close enough to minimize the estimated edge discharges.
- Make sure velocities are, for the most part, greater than 0.5 ft/s, and depths are greater than the minimum depth required by the ADCP. Although measurements can be made in low velocities, keep boat speeds extremely slow (if possible, less than or equal to the average water velocity), which requires special techniques for boat control (Simpson, 2002).
- Avoid measurement sections having local magnetic fields, especially if a moving bed is present and a Global Positioning System with differential corrections (DGPS) or the Loop Method (Mueller and Wagoner, 2006) is used. For example, during measuring, avoid overhead truss bridges, low steel-beam spans, power lines, and other sources of magnetic fields. Just as with ADCP mounts and boats, the presence of ferrous metals will result in ADCP compass errors.
- If possible, avoid asymmetric channel geometries (for example, deep on one side and shallow on the other; Simpson, 2002) and avoid cross sections with abrupt changes in channel-bottom slope. The streambed cross section should be as uniform as possible and free from debris and vegetation or plant growth.
- When using DGPS with an ADCP, avoid cross-section locations where multipath interference, such as riparian vegetation (low-hanging trees and large bushes on river or stream banks), buildings at or near the river banks, bridges, and other flow-control structures, could impede or block signals from GPS satellites.

It is usually not possible to attain all of these conditions, but site selection cannot be understated as a critical part of a discharge measurement. Select the best possible reach using these criteria and then select a cross section. For more discussion regarding site selection when using an ADCP, refer to Mueller and Wagner (2009).

Layout and Stationing of Partial Sections and Verticals in a Midsection Current-Meter Discharge Measurement

After the cross section has been selected, determine the width of the stream. For a mechanical current-meter or other point-velocity measurement, string a tag line or measuring tape for measurements made by wading, from a boat, from ice cover, or from an unmarked bridge. Except for bridges, string the line at right angles to the direction of flow to avoid horizontal angles in the cross section. For cableway or bridge measurements, use the graduations painted on the cable or bridge rail. Next, determine the spacing of the verticals, generally using about 25 to 30 partial sections. With a smooth cross section and even velocity distribution, fewer partial sections may be used. Space the partial sections so that no partial section has more than 10 percent of the total discharge in it. The ideal measurement is one in which no partial section has more than 5 percent of the total discharge in it; this can be challenging when only 25 partial sections are used. For example, the discharge measurement shown in figure 2*A* had 6.5 percent of the total discharge in the partial section with the greatest discharge. Equal widths of partial sections across the entire cross section are not recommended unless the discharge is evenly distributed. Lessen the width of the partial sections as depths and velocities become greater. Usually an approximate or expected total discharge can be obtained from the stage-discharge curve. Space the verticals so the discharge in each partial section is about 5 percent of the expected total discharge from the rating curve. When using an electronic field notebook [such as the JBS Instruments Aquacalc Pro Discharge Measurement Computer (Aquacalc), a PDA with the Hydrological Services Current Meter Counter signal processor (CMCsp), or the SonTek FlowTracker], the expected total discharge can be entered prior to starting the discharge measurement. During the measurement, a warning message will be displayed if a partial discharge exceeds 10 percent of the expected total discharge. When using an ADV or other acoustic point-velocity instrument, make sure the instrument is appropriately aligned and plumbed to the tag line because slight variations in the alignment of the instrument can result in large errors in the measurement of point velocity. See further discussion of the use of acoustic point-velocity instruments in this chapter.

For a standard mechanical current-meter discharge measurement, the usual procedure, after selecting and laying out the section, is to measure and record at each vertical (1) the distance from the initial point, (2) the depth, (3) the meter position, (4) the number of revolutions, (5) the time interval, and (6) the horizontal angle of flow. The starting point can be either bank. The edge of water, which may have a depth of zero, is considered to be the first vertical. The hydrographer should move to each of the verticals in succession and repeat the procedure until the measurement is completed at the opposite bank.

Measurement of Width

The first measurement made in a discharge measurement is usually the determination of horizontal stationing (width) in the cross section being measured. Width needs to be measured using the proper equipment and procedures that apply to the type of measurement being made (that is, wading, bridge, cableway, boat, or ice). Details of measuring width using a variety of equipment, and under different flow conditions, are described in subsequent sections of this chapter.

The horizontal distance to any vertical in a cross section is measured from an initial point on the bank. Cableways and bridges used regularly for making discharge measurements are commonly marked at 2-, 5-, 10-, and (or) 20-ft intervals by paint marks. Distance between markings is interpolated, or measured with a rule or pocket tape. Steel or Kevlar tag lines and metallic tapes are used for measurements made by wading, from boats, or from unmarked bridges. For wide streams of about 2,500 ft or more, where conventional measuring methods cannot be used, surveying methods and Global Positioning Systems (GPS) can be used.

Tapes and Tag Lines

Tag lines used for wading measurements are usually made of either galvanized steel aircraft cord with solder beads at measured intervals, or Kevlar, which is marked with black ink and waxed to resist abrasion. A Kevlar tag line consists of a Kevlar core with a nylon jacket.

The standard arrangement of solder beads on steel tag lines is shown in table 1. The standard markings for Kevlar tag lines is one mark every 2 ft, two marks every 10 ft, and three marks every 100 ft. The standard lengths of tag lines are 300, 400, and 500 ft, but other sizes are available.

Four types of tag-line reels typically used for the steel tag lines are the Lee-Au, Pakron, Columbus type A, and the USGS Stainless Steel Tag line as shown in figure 3. The reel used for the Kevlar tag line is shown in figure 4.

Larger reels, used for boat measurements, are designed to hold up to 3,000 ft of ⅛-inch (in.) diameter steel tag line. These reels and boat measurement methods have largely been replaced by the ADCP technology. Two different types of reels still available are as follows:

- A heavy-duty, horizontal-axis reel without a brake, and with a capacity of 5,000 ft of ⅛-in. beaded tag line or 3,000 ft of $^{3}/_{16}$-in. Kevlar boat tag line, as shown in figure 5.
- A vertical-axis reel without a brake (fig. 6), and with a capacity of 1,500 ft of ⅛-in diameter steel tag line (800 ft tag lines are standard) or up to 900 ft of 3/16-in. Kevlar boat tag-line cable.

Table 1. Standard markings for steel tag lines.

Distance from initial point (zero mark), in feet	Distance between marks, in feet	Number of solder beads, or tags
0 to 50	2	1 (single bead)
50 to 100	5	1
150 to 500	10	1
0 to 50	10	2 (double bead)
50 to 450	100	2
0 to 500	100	3 (triple bead)

C. Use of a Wading Rod (p12)

Accuracy of GPS coordinates will vary depending on the type of GPS unit used and whether or not differential corrections are made. Coordinates without differential corrections can be in error by as much as ±300 ft because of various errors in the system. Obviously, this is not acceptable for discharge measurements. However, if care is taken in making observations, and then making differential corrections, errors can be reduced to as little as ±3 ft, and even less in ideal conditions. This method is acceptable for wide flood plains and inaccessible estuaries with open skies and minimal reflective surfaces, which can result in multipath errors.

Measurement of Depth

The second measurement normally made at a vertical is the stream depth. Depth should be measured using the proper equipment and procedures that apply to the type of measurement being made (that is, wading, bridge, cableway, boat, or ice). Details of measuring depth using various equipment and under different flow conditions are described in the following sections of this chapter. The water depth of a stream at a selected vertical can be measured in several ways, depending on the type of measurement being made, the total depth of the stream, and the velocity of the stream. Stream depth is usually measured by use of a wading rod, sounding lines and weights, acoustic Doppler sensor, or another sonic sounder, as described in the following sections of this chapter.

Use of Wading Rod

Use a wading rod for measuring stream depth when depth is shallow enough, or when measuring from a low footbridge or other supportive structure over the stream. Likewise, use the wading rod for measuring from ice cover for shallow depths. Wading rods can even be used from a boat if depths are not too great. The top-setting wading rod can be used for depths up to 4 ft, but greater depths can be measured with 6-, 8-, and 10-ft top-setting wading rods. The round wading rod, which is assembled with 1-ft sections, can be made up into any length, but generally is not used for depths greater than about 10 ft. Velocity of flow is also a consideration because high velocity may not allow for keeping a long wading rod in place.

Wading rods have a small foot on the bottom to allow the rod to be placed firmly on the streambed, and yet not sink into the streambed under most conditions. In sand-bottom streams, or in soft muck, it is sometimes difficult to keep the wading rod from sinking into the streambed as the weight of the rod and meter and the eroding power of the flowing water cause the foot of the wading rod to sink. The hydrographer must use care in these conditions to be sure the measured water depth, as well as the depth of the current-meter placements, are accurately based on the surface of the streambed. In some cases, the wading rod may need to be supported in some manner other than resting on the streambed.

When using a wading rod in streams with moderate-to-high velocity, there will be a velocity-head build-up of water on the wading rod. The stream depth should be based on where the surface of the stream intersects the wading rod, and not on the top of the velocity-head build-up. Wading rods are graduated in tenths-of-a-foot, and stream depths are generally measured or estimated and recorded to the nearest 0.01 ft.

Use of Sounding Lines and Weights

Water depth is measured with sounding lines and weights when the depth is too great to use a wading rod, and when measuring conditions require measuring from a bridge, cableway, or boat. This section will describe the measurement of depth when using sounding reels and handlines. It also discusses the procedures used to correct observed depths when high velocity causes the weight and meter to drift downstream.

Use of Sounding Reels

When using one of the sounding reels described in a subsequent section of this chapter, a counter or dial is used to determine the length of cable that has been dispensed. Depths are measured to the nearest 0.1 ft when using a sounding line and weight.

The size of the sounding weight used in current-meter measurements depends on the maximum depth and velocity in a cross section. A rule of thumb is that the size of the weight in pounds should be greater than the maximum product of velocity and depth in the cross section. If insufficient weight is used, the sounding line will be dragged at an angle downstream. If debris or ice is flowing or if the stream is shallow and swift, a heavier weight can be used than the rule designates. The rule is not rigid but it does provide a starting point for deciding on the size of the weight that is needed. If available, notes can be examined of previous measurements at a site to help determine the size of the weight needed at various stages.

Some sounding reels are equipped with a computing depth indicator, or spiral. To use the computing spiral, the dial pointer must be set at zero when the center of the current-meter rotor is at the water surface. After the sounding weight and meter are lowered until the weight touches the streambed, and the indicated depth should be read. The distance that the meter is mounted above the bottom of the weight should be added. For example, if a 30 C .5 (that is, a 30-pound Columbus weight is being used and the center of the meter cups is 0.5 ft above the bottom of the weight) suspension is used and the dial pointer reads 18.5 ft when the sounding weight touches the streambed, the depth would be 19.0 ft (18.5 + 0.5). To move the meter to the 0.8-depth position, merely raise the weight and the meter until the pointer is at the 19-ft mark on the graduated spiral, which will correspond to 15.2 ft on the main dial (0.8 × 19.0). To set the meter at the 0.2-depth position, raise the weight and meter until the pointer is at 3.8 ft on the main dial (0.2 × 19.0).

Tags can be placed on the sounding line a known distance above the center of the meter cups as an aid in determining depth. The tags, which are usually streamers of

D. Current-Meter Measurement by Wading (p26)

Current-Meter Measurements by Wading

Current-meter measurements by wading are preferred, if conditions permit. Wading measurements offer the advantage over measurements from bridges and cableways because the hydrographer can usually chose the best of several available cross sections for the measurement. Figure 17 shows a wading measurement being made with a top-setting rod.

Use the type AA, pygmy, or ADV meter for wading measurements. Table 6 lists the type of meter and velocity method to use for wading measurements at various depths.

If a type AA meter is being used in a cross section where most of the depths are greater than 1.5 ft, do not change to the pygmy meter for a few depths less than 1.5 ft or vice versa. The Price AA meter is not recommended for depths of 1.0 ft or less because the registration of the meter is affected by its proximity to the water surface and to the streambed. However, it can be used at depths as shallow as 0.5 ft to avoid changing meters if only a few verticals of this depth are required. The type AA meter or the pygmy meter should not be used in velocities less than 0.2 ft/s unless it is absolutely necessary.

Figure 17. Wading measurement using a top-setting rod.

Table 6. Current meter and velocity-measurement method for various depths.

Depth, in feet	Current meter	Velocity method
2.5 and greater	Price Type AA	0.2 and 0.8
1.5 - 2.5	Price Type AA	0.6
0.3 - 1.5	Price Pygmy	0.6
1.5 and greater	Price Pygmy	0.2 and 0.8
0.3 - 1.5	ADV	0.6
1.5 and greater	ADV	0.2 and 0.8

It is no longer recommended to use coefficients given by Pierce (1941) for the performance of current meters in water of shallow depth and low velocities.

When natural conditions for measuring are in the range considered undependable, modify the measuring cross section, if practical, to provide acceptable conditions. Often it is possible in small streams to build dikes to cut off dead water and shallow flows in a cross section, or to improve the cross section by removing the rocks and debris within the section and from the reach of stream immediately upstream from it. After modifying a cross section, allow the flow to stabilize before starting the discharge measurement.

Stand in a position that least affects the velocity of the water passing the current meter by facing the bank, with the water flowing against the side of the leg. Holding the wading rod at the tag line, stand from 1 to 3 in. downstream from the tag line and 18 in. or more from the wading rod. Avoid standing in the water if feet and legs would occupy a considerable percentage of the cross section of a narrow stream. In small streams where the width permits, stand on a plank or other support above the water rather than in the water. Velocity bias caused by effects of the hydrographer's position can be significant. Observance of these conditions is important while using mechanical meters, ADVs, and any wading measurement where an obstacle could interfere with the natural flow conditions of the stream.

When using a Price meter, keep the wading rod in a vertical position and the meter parallel to the direction of flow while observing the velocity. If the flow is not at right angles to the tag line, measure the angle coefficient carefully. When using an ADV or other instrument that can measure the *x* component velocity, the instrument should be aligned more precisely with the tag line. See the discussion of FlowTracker use and flow angles in the "Measurement of Velocity" section of this chapter.

During measurements of streams with shifting beds, the scoured depressions left by the hydrographer's feet can affect soundings or velocities. Generally, place the meter ahead of and upstream from the hydrographer's body and feet. Record an accurate description of streambed and water-surface configuration each time a discharge measurement is made in a sand-channel stream.

For discharge measurements of flow too small to measure with a current meter, use a volumetric method, Parshall flume, or weir plate. Those methods are described in subsequent sections of this chapter.

Recording Field Notes

Field notes for a discharge measurement may be recorded on standard paper note sheets (for example, USGS Forms 9-275-F, 9-275-I, and other special field forms). With the ADCP discharge measurement, the software attached to each instrument contains digital forms for the recording of some of the field data. The USGS has developed a paper form for recording field data observed during an ADCP discharge measurement (fig. *2D*). With a current-meter discharge measurement, field forms can be recorded using an electronic notebook, such as the Aquacalc or a Personal Digital Assistant (PDA). With an ADV measurement, there are special field forms to accommodate its specifications and details. These methods are described in more detail in subsequent paragraphs in this section. The SWAMI program with a PDA (commonly used by the USGS) can be used to record discharge measurements, inspections, differential level surveys, and other field measurements. SWAMI has an interface with the National Water Information System (NWIS), so measurements are easily uploaded to NWIS (fig. *2C*).

Standard Paper Note Keeping for a Mechanical Current-Meter Discharge Measurement

Paper note sheets, as shown in figure *2A*, are the traditional way to record the field observations for a mechanical current meter, ADV, or ADCP discharge measurement. Generally, for each discharge measurement, the hydrographer should record the following information, at a minimum, on the front sheet of the measurement notes (the information may vary, depending on the meter and method being used):

- Measurement number, who computed, and who checked the measurement;
- Downstream station identification number and station name (station name includes stream name and location, to correctly identify an established gaging station). For a miscellaneous measurement, record the stream name and exact location of site;
- Date of measurement and members of measurement party (initials and last name);
- Measured channel width, area, average velocity (computed as a ratio of the measured discharge/measured area), average gage height, and discharge;
- Vertical velocity method(s) of measurement, number of sections, and change in gage height during the discharge measurement;
- Measurement method coefficient, horizontal-angle coefficient, type of meter suspension (for example, rod, 100#C, and so forth) and whether tags were checked;
- Type of meter (for example, AA or pygmy), the current meter's serial number; and the elevation of the meter above the channel bottom;
- Meter rating used (for example, Standard Rating No. 2) and the most recent spin test results;
- Measurement percentage (after computed) from the existing stage-discharge rating, and the indicated shift in feet from that rating;
- GAGE READINGS: Do not erase inside this block on the front sheet. If an error is made, cross through the error and write the correct reading.
  - Start time measurement using 24-hour clock time, and record the time zone (that is, EST, CST, EDT, and so forth).
  - Record inside and outside gage, and also readings from recording devices (for example, data logger, graphic, and so forth).
  - Compute weighted mean gage height either by averaging readings, or if sufficient change in gage height occurred, by using methods for weighting gage height discussed in this chapter.
  - Compute gage-height correction caused by difference in true gage height (reference gage) and recorder or other gage that is reading incorrectly.
  - Record the correct mean gage height.
- Samples collected: Indicate type of water-quality measurements and samples [that is, water-quality, sediment, and (or) biological], and indicate if the measurements are documented on separate sheets (that is, water quality, aux./base gage, other);
- Indicate whether the rain gage (if applicable) was serviced/calibrated;
- Briefly describe the weather (for example, sunny, cloudy, rainy, cold, or other);
- Record the air temperature in degrees Celsius and the time of the reading;
- Record the water temperature in degrees Celsius and the time of the reading;
- Record the check bar reading (if a wire weight is present), time of the reading, and any adjustments in elevation made to the check bar.
- Indicate the type of measurement (wading, cable, ice boat, and so forth) and location of measurement relative to the gage (upstream, downstream, and so forth).
- Rate the measurement based on the hydrologic/hydraulic conditions in which the measurement was made [that is, excellent (2 percent), good (5 percent), fair (8 percent), or poor (more than 8 percent)].
- Flow: Document the hydraulic condition of the flow (steady, unsteady, where the flow was within the cross section, and so forth).
- Cross section: Geomorphologically describe the cross section (that is, sand, clay, cobble, and so forth), shape, presence of vegetation, and any other roughness affecting flow.

E. Current Meters (p56-58)

Electromagnetic Current Meters

Electromagnetic current meters, with no moving parts, are commercially available for measuring point velocities. These meters are based on the principle that a conductor (in this case, water) moving through a magnetic field will produce an electric current. The velocity of the moving water can be related to the electric current produced, and the distortion created in the magnetic field. The electromagnetic meters can be accurately calibrated in a tow tank, similar to the calibration of mechanical meters; however, tests have shown that the electromagnetic meters are less accurate than the Price AA meters, especially at low velocities (less than about 0.5 ft/s). The Price AA meters also have less variance than the electromagnetic meters at all velocities. Advantages of the electromagnetic current meter are as follows: no moving parts; direct readout of velocity; and, in oblique flow, the velocity measured is normal to the measuring section when the meter is held normal to it.

Marsh-McBirney 2000

An electromagnetic current meter successfully used by the USGS for making discharge measurements is the Model 2000, produced by Marsh-McBirney. This meter, as shown in figure 38, is designed to mount on a standard round or top-setting wading rod. The meter is not designed for cable suspension.

A display meter, also shown in figure 38, shows a direct readout of the velocity. No conversion equation or table is necessary. The meter must be kept clean for accurate readings, and it is recommended that the rating be occasionally spot checked to verify that it is still accurate. This can be done in two ways. First, submerge the meter in a bucket of still water to verify the zero point of the rating. Second, place the meter in close proximity to a Price AA meter, in flowing water, to verify that it gives the same velocity reading. If there are differences, rate the electromagnetic meter again in the tow tank.

Figure 38. Marsh-McBirney Model 2000 electromagnetic flowmeter and display meter.

Ott Electromagnetic Current Meter

An Ott electromagnetic current meter is available; however, it has not been used extensively in the United States. The Ott meter, shown in figure 39, works in a manner similar to the Marsh-McBirney meter.

Figure 39. Ott electromagnetic current meter.

Acoustic Current Meters

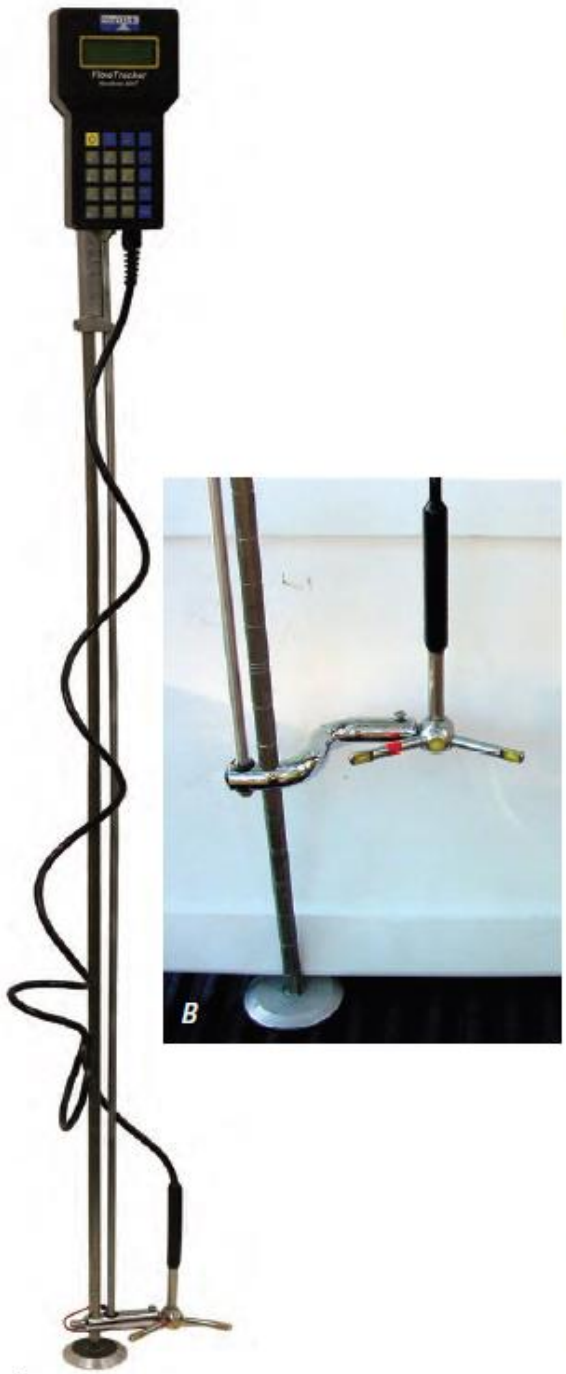
Acoustic Doppler current meters, with no moving parts, are commercially available for measuring point velocities. These meters are based on the Doppler principle. The velocity of the moving water is measured using the transmitted and received signals from sound pulses reflecting off particles in the moving water column. These acoustic meters can be accurately calibrated in a tow tank, similar to the calibration of mechanical meters. Advantages of an acoustic Doppler current meter are as follows: no moving parts; direct readout of velocity; and ability to sense very low velocities less than the rated velocities in standard mechanical current meters.

Acoustic Doppler Velocimeter (ADV)

The SonTek/YSI FlowTracker handheld ADV ("FlowTracker" and "ADV" are used interchangeably in this chapter) is designed as an alternative to the Price AA and pygmy meters for wading discharge measurements. The FlowTracker operates at an acoustic frequency of 10 MHz and measures the phase change caused by the Doppler shift in acoustic frequency that occurs when a transmitted acoustic signal reflects off particles in the flow. The magnitude of the phase change is proportional to the flow velocity. The phase difference can be positive or negative, allowing ADVs to measure positive and negative velocities. The FlowTracker measures the velocity at a rate of approximately 10 MHz, averages the data, and records 1-second velocity-vector data.

The maximum velocity the FlowTracker can measure is reduced when measuring flow that is not perpendicular to the transmitting transducer. The receiving transducers can measure a velocity range of only ±1.15 m/s (3.77 ft/s). A velocity component placed directly toward or away from the receiving transducers larger than 1.15 m/s (3.77 ft/s) will result in erroneous velocities. Because of the geometric arrangement of the transmitting and receiving transducers, a velocity of 4.5 m/s flowing perpendicular to the transmitting transducer face will result in the maximum velocity towards a receiving transducer of 1.15 m/s (3.77 ft/s).

The FlowTracker probe is mounted to a standard top-setting wading rod with a special offset-mounting bracket (fig. 40). This bracket is designed to locate the FlowTracker probe at the front of the wading rod, with the sampling volume



A

Figure 40. *A*, SonTek/YSI FlowTracker acoustic Doppler velocimeter (ADV) mounted on a standard top-setting wading rod and *B*, closer view of transmitting and receiving transducers and offset-mounting bracket.

about 2 in. (5 cm) to the right of the wading rod. Although the probe is inserted into the flow, the sampling volume is about 4 in. (10 cm) away from all physical parts of the probe, to minimize flow disturbance in the sampling volume.

FlowTrackers have several unique data-processing requirements because of their method of operation and some of the inherent limitations of the acoustic Doppler measurement technique. Unlike mechanical meters that use the momentum of the water to turn a propeller and directly measure the velocity of the water, the FlowTracker does not measure the velocity of the water. The FlowTracker measures the velocity of particles (sediment, small organisms, and bubbles) suspended in the flow, assuming that these particles travel at the same velocity as the water. Therefore, the quality of the measurement is dependent on the presence of particles within the sampling volume that reflect a transmitted signal. The FlowTracker records the signal-to-noise ratio (SNR), standard error of velocity (based on 1-second data), angle of the measured flow (relative to the x-axis of the FlowTracker probe), number of filtered velocity spikes, and a boundary quality-control flag. These velocity and quality-assurance data may be used to evaluate the measurement conditions. Few similar quality-assurance data are available for Price current-meter measurements.

Although a FlowTracker can measure within about 1.2 in. (3 cm) of a boundary, the velocity measurement might be affected by acoustic interference when the sampling volume is close to boundaries or underwater objects, even when the sampling volume is not directly on or past the boundary. At the start of each velocity measurement, if the probe detects nearby acoustic boundaries that could cause interference with the velocity measurement, a boundary adjustment is automatically made. The boundary adjustment attempts to overcome the possible interference by reducing the lag times of the acoustic signals transmitted by the FlowTracker, causing a reduction of the velocity range that can be measured. Any changes are noted in the boundary quality-control flag. Because the sampling volume is located about 4 in. (10 cm) from the transmitting transducer it can be difficult to ascertain the precise location of the sampling volume. If the sampling volume is on or past a boundary, the velocity data will be erroneous. Be careful to avoid boundaries while making measurements in depths less than 3.54 in. (9 cm), especially in channels with irregular bottoms.

Spikes in velocity data occur with any acoustic Doppler velocity sensor such as the FlowTracker. Spikes may have a variety of causes (for example, large particles in the flow, air bubbles, or acoustic anomalies). Velocity data from each FlowTracker measurement are evaluated to look for spikes. The FlowTracker spike filter is a variation on a method called "Tukey's Outlier." In this method, a histogram of each velocity component is calculated. The FlowTracker determines the lower quartile (*Q1*; 25 percent of samples are less than this value), the upper quartile (*Q3*; 75 percent of samples are less than this value), and the interquartile range (*IQR* = *Q3*-*Q1*). If the *IQR* is less than 0.015 m/s (0.049 ft/s), *IQR* is set to

0.015 m/s (0.049 ft/s). Any value less than (*Q1–2*IQR*) or greater than (*Q3+2*IQR*) is considered a spike and is not used for mean-velocity calculations.

The FlowTracker measures magnitude and direction of velocity. The operator must keep the wading rod perpendicular to the tag line so that the pulse generated by the transmitter is parallel to the tag line, regardless of flow direction. To compute discharge, the FlowTracker uses the component of velocity perpendicular to the transmitting transducer and reports the flow angle from the FlowTracker's x-axis as a quality-control value. A flow angle measured by the FlowTracker may be the result of flow that is not perpendicular to the tag line, or a wading rod that is not being held perpendicular to the tag line (operator error). Flow angles of less than 20 degrees with small variations between verticals are not unusual. Large fluctuations of flow angles between verticals, however, may indicate a poorly measured cross section. If there is angular flow, and the wading rod is oriented with the flow, the velocity used and resulting discharge would be biased high. If the flow is truly perpendicular to the cross section, but the wading rod is erroneously held at an angle, the velocity and resulting discharge would be biased low. To avoid possible errors in the measured velocities, it is important that the operator always carefully and accurately aligns the wading rod.

Signal-to-Noise Ratio (SNR)

Adequate signal-to-noise ratio is needed to obtain an accurate measurement of the flow velocity. SNR is a measure of the strength of the reflected acoustic signal relative to the ambient noise level of the instrument. SNR is a function of the concentration and size distribution of the particles that reflect the acoustic signal. SNR is recorded for each beam with each 1-second sample. The manufacturer states that optimal SNR is 10 decibels (dB) or above (SonTek/YSI, 2002). USGS policy is that FlowTrackers should not be used for measuring discharge if the SNR for any single beam is less than 4 dB.

Speed of Sound

The accuracy of hydroacoustics instruments like the FlowTracker is dependent on an accurate speed of sound. The speed of sound is primarily a function of the temperature and salinity of the water. The FlowTracker has a built-in temperature sensor. To verify that the temperature sensor is working correctly, take an independent water-temperature measurement prior to each discharge measurement. If the FlowTracker has been stored in an environment with a different ambient temperature from the water, the probe may need to be placed in the water for a period of time, allowing it to equilibrate with the water temperature. A 5°F error in temperature will result in approximately a 1-percent bias in the measured velocity. The speed of sound is also sensitive to salinity. A 5-part-per-thousand error in salinity would result in an approximate velocity bias of 1 percent, when used in saline environments like estuaries; therefore, the operator needs to measure the salinity and input the value into the FlowTracker.

Maintenance and Care

Although the built-in QCTest is reliable for detecting issues, a BeamCheck stores more system performance data and still may be needed to evaluate the unit in more detail when there is a potential issue.

QCTests and BeamChecks

- Perform a QCTest and store it with each measurement. When a QCTest is completed as part of a measurement, it will print out on the measurement summary.
- Complete a QCTest in flowing water with the sample volume away from any boundaries.
- Perform a BeamCheck if you notice any anomalies in the QCTest. Any failures in a QCTest require a BeamCheck.
- Perform a BeamCheck after any possible physical damage (drop, and so forth), firmware upgrade, or repair.

As stated previously, the FlowTracker is an acoustic Doppler velocimeter (ADV) that has been adapted to fit on a typical USGS streamgaging wading rod, developed by the USGS in cooperation with the SonTek/YSI Inc., and is widely used by the USGS. The FlowTracker has undergone extensive testing to evaluate differences between the FlowTracker performance and vertical-axis current meters (that is, Price AA, pygmy, and so forth).

The USGS Office of Surface Water, through the HIF, has put into place a process that will check and recalibrate each FlowTracker approximately every 3 years to ensure the quality assurance/quality control of this instrument in the measurement of the Nation's surface-water resources. For additional details, see Office of Surface Water Memorandum 2010.02 (2010).

Appendix II. Discharge fieldsheet used for collection of flow data

Discharge Field Sheet
Project:

	Point#	Distance (ft)	Depth (ft)	Vel. @ 6/10ths depth (ft/s)
	0 (water edge)			
	1			
Site ID:	2			
Date/Time:	3			
Crew:	4			
Weather:	5			
Flow: Baseline or Event	6			
Discharge:	7			
	8			
	9			
	10			
	11 (water edge)			
Additional Notes:				

	Point#	Distance (ft)	Depth (ft)	Vel. @ 6/10ths depth (ft/s)
	0 (water edge)			
	1			
Site ID:	2			
Date/Time:	3			
Crew:	4			
Weather:	5			
Flow: Baseline or Event	6			
Discharge:	7			
	8			
	9			
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Additional Notes:				

	Point#	Distance (ft)	Depth (ft)	Vel. @ 6/10ths depth (ft/s)
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	1			
Site ID:	2			
Date/Time:	3			
Crew:	4			
Weather:	5			
Flow: Baseline or Event	6			
Discharge:	7			
	8			
	9			
	10			
	11 (water edge)			
Additional Notes:				