NEW YORK STATE OF OPPORTUNITY.

Department of Environmental Conservation

RAMAPO RIVER

Stream Assessment Survey – Data Report

July 1, 2019

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Stream Assessment Survey – Data Report

Ramapo River
Orange and Rockland County, New York
Ramapo River Drainage Basin

Survey date: June to October 2018
Report date: July 1, 2019

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BACKGROUND

The Ramapo River flows south and drains approximately 94 square miles within southeastern New York State. Overall, 14 percent of the basin land use is identified as developed with a concentrated area of development and impervious surface in the most upstream and northernmost portion of the basin. Primary water quality concerns relate to waste water discharges, nutrients, and stormwater runoff in the densely populated areas of the watershed.

In 2018, a Stream Assessment Survey was conducted by the Rotating Integrated Basin Studies (RIBS) Program on the Ramapo River and tributaries (Figure 1). The RIBS Program operates on a five-year, rotational schedule to generate statewide water quality data in support of the Waterbody Inventory/Priority Waterbody List (WI/PWL) towards the goal of protection and restoration of water quality resources (RIBS QAPP, 2018). The RIBS Program also conducts special surveys outside of this five-year cycle to support Department-initiated priorities related to water quality (RIBS QAPP, 2018). The objective of the Ramapo survey was to update condition assessments for Waterbody Inventory/Priority Waterbody List (WI/PWL) segments 1501-0012, 1501-0036, and 1501-0037 and document potential impacts to the Ramapo River resulting from two State Pollutant Discharge Elimination System (SPDES) permitted waste water treatment facility (WWTF) (RAS QAPP, 2018).

Thirteen sampling locations (2 tributary, 2 WWTF outfalls, 9 mainstem Ramapo) were selected to characterize the biological and chemical conditions within each WI/PWL segment of the Ramapo River and to isolate potential impacts of point sources in the most upstream WI/PWL segment (1501-0037). Two sampling locations were located in each WI/PWL segment for condition assessments in both the downstream and middle WI/PWL segments (1501-0012 and 1501-0036, respectively), and nine sampling locations were distributed throughout the upstream WI/PWL segment (1501-0037) where the WWTFs of interest are located (Table 1, Figure 1 and Figure 2). The upstream WI/PWL locations, coupled with WWTF outfall sampling[1] for Kiryas-Joel (KJSTP-001) and Orange County Sewer District (OCSDSTP-001), were included to bracket discharge outfalls for select WWTFs, and to characterize relative influence of those facilities on water quality in the mainstem river. A reference site was also selected upstream of all selected WWTFs for this evaluation to provide background condition information (Table 1, Figure 1 and Figure 2). Additional WWTF discharge locations were identified throughout the watershed but not selected for sampling. Locations are identified for reference (Table 1 and Figure 2).

To characterize the Ramapo River, the Bureau of Water Assessment and Management's Stream Monitoring and Assessment Section (SMAS) collected several measures of water quality at each of the thirteen sampling locations between the months of July and October in 2018 (Table 1, Figure 1 and Figure 2). Measures of water quality included:

A) Water Chemistry and Stream Discharge

B) Benthic Macroinvertebrate Community

C) Stream Reach Physical Habitat Characteristics

D) Observer Ranking of Recreational Ability

[1] OUTFALL SAMPLES WERE COLLECTED AT THE POINT OF DISCHARGE TO THE RECEIVING WATER

E) Sediment and Porewater Microtox® Analysis

This data report provides water quality information in a format designed to update the WI/PWL and document water quality violations. It has been structured into two primary sections: I) an overview to convey results from the five measures of water quality described above at the watershed and WI/PWL scale, and II) a site-specific data summary to present all major findings for each sampling location. Additional sections (III, IV) include literature cited and appendices covering all references and additional source material.

Table 1. Ramapo River (RAMA) sampling locations (2018). Locations are ordered from upstream to downstream according to river mile and mainstem confluence. Hashed red cell borders indicate the location of WWTF discharges between sampling locations and site location IDs in red indicate WWTF outfalls that were directly sampled as part of this survey. WWTF outfall numbers are included in the WWTF Location ID. *Locations sampled on a tributary to the mainstem river.

	Location ID	River Mile	WI/PWL	Waterbody Classification	Description	Latitude	Longitude
Upstream Sampling	RAMA	18.6	1501-0037	B	Freeland Street	41.3237700	-74.1723000
	RAMA_T25_3*	0.3	1501-0037	C	Upstream of KJ outfall at Bakertown Rd	41.3324300	-74.1542600
WWTF	KFSTP-001	0.25	1501-0037	C	Plant discharge entering Unnamed Trib to Ramapo	41.3330690	-74.1588700
Locations between select WWTF	RAMA_T25_3*	0.2	1501-0037	C	Downstream of KJ outfall at Bakertown Rd	41.3350300	-74.1614600
	RAMA	16.8	1501-0037	B	20 m below River Rd. bridge	41.3122200	-74.1488900
	RAMA	16.7	1501-0037	B	5 m below Monroe Park pond	41.3102800	-74.1436100
WWTF	OCSDSTP-001	16.6	1501-0037	C	Plant discharge entering Ramapo	41.3104996	-74.1431091
Locations downstream of selected WWTF outfalls	RAMA	16.5	1501-0037	C	50 m downstream of Route 17 bridge	41.3100000	-74.1427800
	RAMA	16.1	1501-0037	C	At Nepera plant bridge	41.3072200	-74.1369500
	RAMA	13.3	1501-0036	A(T)	0.2 mi south of Arden bridge; end of Water St	41.2736100	-74.1533400
	RAMA	11.8	1501-0036	A(T)	Adjacent to State Hwy 17, downstream of Warwick Brook	41.2501600	-74.1683200
	RAMA	4.8	1501-0012	A(T)	Seven Lakes D	41.1621000	-74.1887000
	RAMA	1.1	1501-0012	A	50 m above 4th St. bridge	41.1251600	-74.1645500

Figure 1. Map of 2018 Ramapo River (RAMA) sampling locations. Site names reference the Location ID and River Mile presented in Table 1.

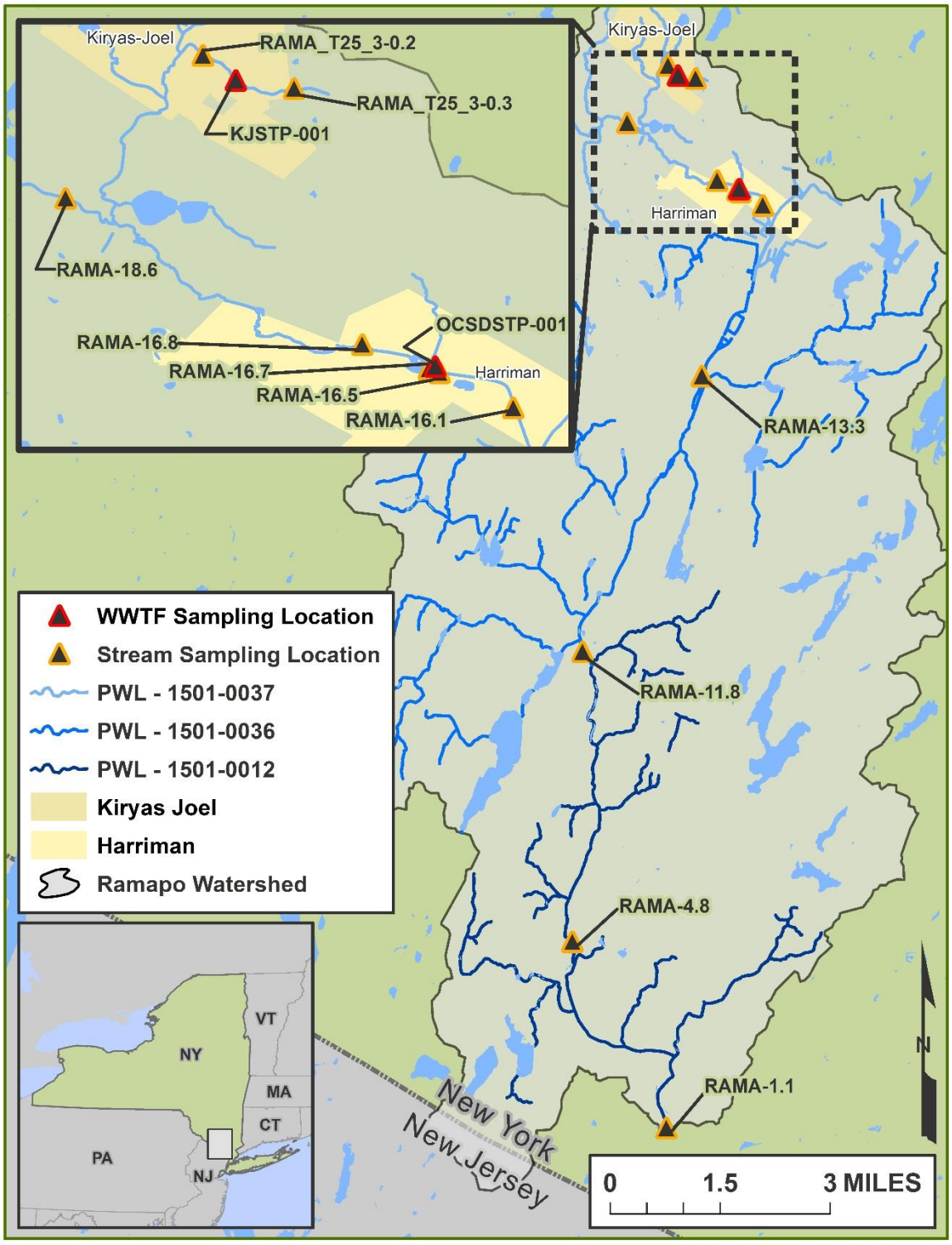
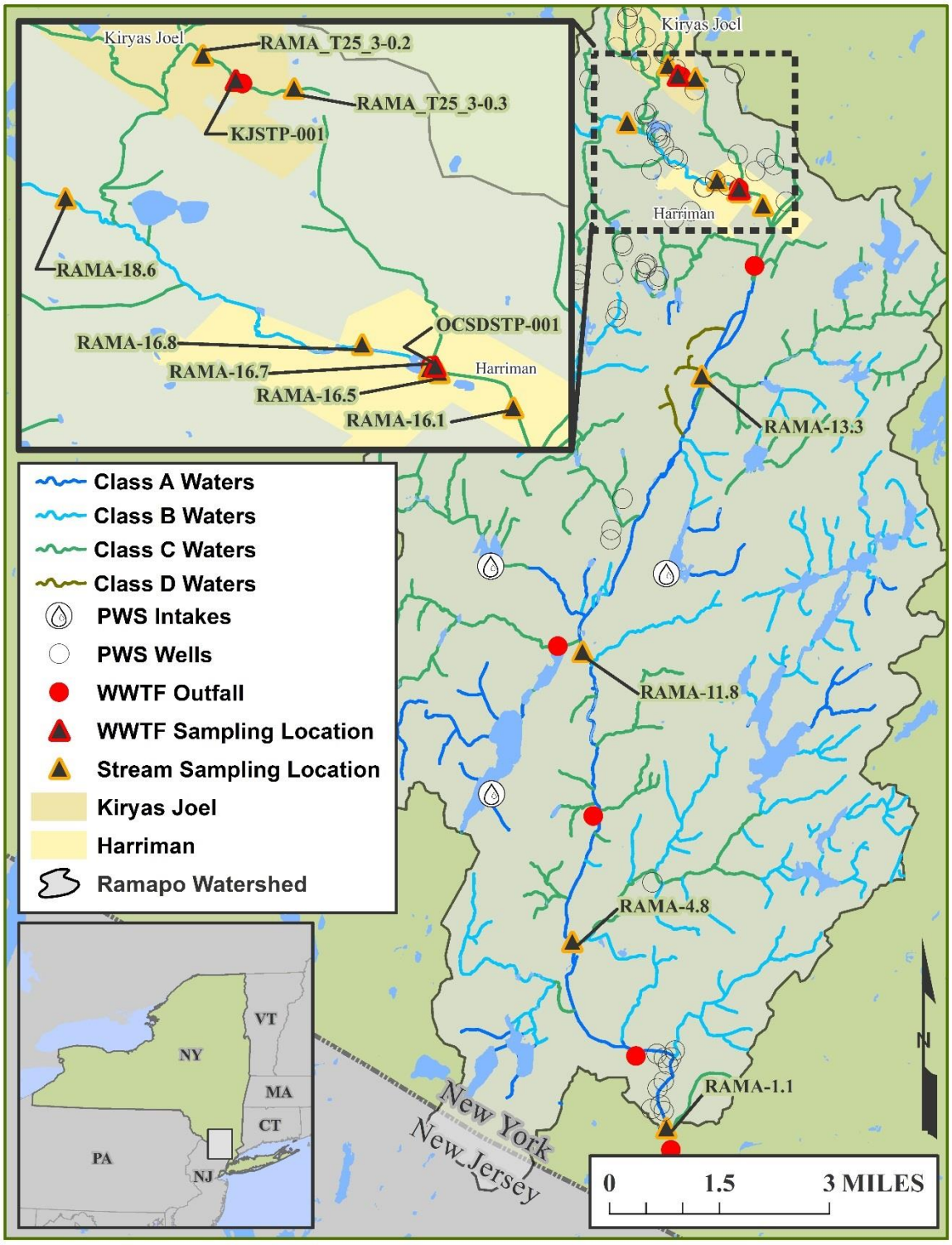


Figure 2. Map of WWTF discharges, public water supply intakes and well locations. Site names reference the Location ID and River Mile presented in Table 1.



Section I: **OVERVIEW**

A) Water Chemistry and Stream Discharge

Methods used for water chemistry data collection are described by NYSDEC standard operating procedures (SOP). The collection of water chemistry samples followed procedures described in SOP #210-18 *Collection of Water Column Samples for the Rotating Integrated Basin Studies (RIBS) Program*. Where the depth of water permitted, water chemistry samples were collected using the depth-integrating suspended sediment sampler – wading (DH-81) method (SOP #210-18, section 11.2). Where the depth of water was too shallow and when sampling WWTF outfalls, water chemistry samples were collected using the direct grab method (SOP #210-18, section 11.6). Water samples were processed using a contract lab with NYS Environmental Laboratory Approval Program (ELAP) certification.

Stream discharge was measured using the velocity-area method according to Turnipseed and Saur (2010). The velocity-area method (Midsection Method) calculates discharge by subdividing a stream cross-section into 10 equally spaced stations and measuring depth and velocity within each station and summing the products (Turnipseed and Saur, 2010). A top-set wading rod and Sontek FlowTracker was used. Methods are described in detail in Turnipseed and Sauer (2010) and Appendix I provides pertinent elements. Appendix II provides the field sheet used in collection of stream depth and velocity for discharge calculations.

The collection of water chemistry samples and stream discharge included six sampling events at all locations across a range of discharge conditions. Two sampling events (July 23, 2018 and October 1-2, 2018) were aimed at capturing the influence of a chicken processing facility in Kiryas-Joel by sampling during planned plant shut-downs. Remaining sampling events were conducted to document stream conditions at baseflow discharge. Ambient water chemistry sampling included *in situ* and lab measured water quality analytes (Table 2). Chemistry results were analyzed for exceedances of state water quality standards and summarized below using R programing software (R Core Team, 2017). All raw chemistry results (*in situ* and lab reported) with all applicable standards and exceedance determinations accompany this report as Attachment I.

All Ramapo River survey data were subjected to the quality assurance/quality control (QA/QC) protocols detailed in Appendix III. For water chemistry, an evaluation of the precision, accuracy, and completeness of processed water chemistry samples after lab analyses were performed following the methods detailed in part A of Appendix III of this report. Appendix III.B includes a compilation of quality assurance results for each site. Only data meeting the highest data quality standard are reported and used in this report (Appendix III).

Table 2. Water chemistry analytes sampled as part of the Ramapo River Stream Assessment Survey. Table lists sampled analytes and analytical specifications. ^ Precision objectives are defined by results of duplicate samples as described in Appendix III.A

Analytes	Analytical Lab	Standard Method	Precision	Accuracy	Calibration			Method Detection Limit	Reporting Limit
					Initial	Ongoing	Blanks		
Temperature	*in situ*	2550 B	± 1^{oC}	± 1.5^{oC}	Factory Set	~	~	~	~
Dissolved Oxygen	*in situ*	4500-O G	± 1%	± 2%	Daily	~	~	~	~
pH	*in situ*	4500-H+B	± .05 SU	± .2 SU	Weekly	~	~	~	~
Salinity	*in situ*	Calculated	0.001 ppt	± 1%	N/A	~	~	~	~
Specific Conductance	*in situ*	2510 B	± 1µs/cm	± 1%	Weekly	~	~	~	~
Nitrogen, Ammonia	ALS	D6919-09	^	± 20%	As needed	Every 10	Every 10	0.008 mg/L	0.01 mg/L
Total Kjeldahl Nitrogen	ALS	EPA 351.2	^	± 20%	Daily	Every 10	Every 10	0.08 mg/L	0.1 mg/L
Nitrogen, Nitrate	ALS	EPA 353.2	^	± 20%	Daily	Every 10	Every 10	0.02 mg/L	0.05 mg/L
Nitrogen, Total	ALS	Calculated	^						
Total Phosphorus	ALS	EPA 365.1	^	± 20%	Daily	Every 10	Every 10	0.002 mg/L	0.003 mg/L
Ortho-phosphate	ALS	EPA 365.1	^	± 20%	Daily	Every 10	Every 10	0.001 mg/L	0.005 mg/L
Total Dissolved Solids	ALS	SM 2540C	^	± 20%	Daily	Every 20	Every 20	4.0 mg/L	10 mg/L
Turbidity	ALS	EPA 180.1	^	± 10%	Daily	Every 10	Every 10	0.06 NTU	0.1 NTU
Dissolved Organic Carbon	ALS	5310C	^	± 20%	As needed	Ever 10	Every 10	0.4 mg/L	10 mg/L
Alkalinity	ALS	SM 2320B	^	± 20%	Daily	Every 10	Every 10	1.0 mg/L	2.0 mg/L
Hardness	ALS	SM 2340C	^	± 20%	Daily	Every 10	Every 10	0.3 mg/L	2.0 mg/L
Calcium	ALS	EPA 200.7	^	± 20%	Daily	Every 10	Every 10	0.1 mg/L	1.0 mg/L
Magnesium	ALS	EPA 200.7	^	± 20%	Daily	Every 10	Every 10	0.04 mg/L	1.0 mg/L
Potassium	ALS	EPA 200.7	^	± 20%	Daily	Every 10	Every 10	0.06 mg/L	2.0 mg/L

Table 2. Water chemistry analytes sampled as part of the Ramapo River Stream Assessment Survey. Table lists sampled analytes and analytical specifications.

Analytes	Analytical Lab	Standard Method	Precision	Accuracy	Calibration			Method Detection Limit	Reporting Limit
					Initial	Ongoing	Blanks		
Sodium	ALS	EPA 200.7	^	± 20%	Daily	Every 10	Every 10	0.03 mg/L	1.0 mg/L
Chloride	ALS	EPA 300.0	^	± 20%	As needed	Every 10	Every 10	0.02 mg/L	0.2 mg/L
Fluoride	ALS	EPA 300.0	^	± 20%	As needed	Every 10	Every 10	0.004 mg/L	0.1 mg/L
Sulfate	ALS	EPA 300.0	^	± 20%	As needed	Every 10	Every 10	0.02 mg/L	0.2 mg/L
Iron (total)	ALS	EPA 200.7	^	± 20%	Daily	Every 10	Every 10	6 µ/L	100 µ/L
Manganese (total)	ALS	EPA 200.7	^	± 20%	Daily	Every 10	Every 10	0.5 µ/L	10 µ/L
Arsenic (total)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	0.3 µ/L	1 µ/L
Silver (total)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	0.07 µ/L	1 µ/L
Aluminum (total)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	4.0 µ/L	50 µ/L
Cadmium (total)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	0.03 µ/L	1 µ/L
Copper (total)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	0.04 µ/L	1 µ/L
Lead (total)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	0.08 µ/L	1 µ/L
Nickel (total)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	0.04 µ/L	1 µ/L
Zinc (total)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	0.7 µ/L	10 µ/L
Aluminum (dissolved)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	0.9 µ/L	10 µ/L
Cadmium (dissolved)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	0.02 µ/L	1 µ/L
Copper (dissolved)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	0.02 µ/L	1 µ/L
Lead (dissolved)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	0.02 µ/L	1 µ/L
Nickel (dissolved)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	0.1 µ/L	1 µ/L
Zinc (dissolved)	ALS	EPA 200.8	^	± 20%	Daily	Every 10	Every 10	3 µ/L	5 µ/L

Exceedances of Water Quality Standards

Exceedances of water quality standards occurred at every sampling location for several of the analytes tested. A total of 30 lab-measured, and 6 *in situ* water quality analytes, were analyzed at each of the 13 sampling locations. Out of the 1,444 lab-measured records and 396 *in situ* water quality records, there were 73 exceedances of established water quality standards (6 NYCRR Part 703). There were exceedances in Aluminum (dissolved), Chloride, Copper (dissolved), Dissolved Oxygen, Iron (total), Nitrite (expressed as Nitrogen), pH, and Total Dissolved Solids. Nutrients are regulated by a narrative water quality standard stating: "*None in amounts that result in growths of algae, weeds, and slimes that will impair the waters for their best usages"* (6 NYCRR 703.2). There were instances of nutrient concentrations (Nitrate (expressed as Nitrogen), Total Nitrogen, or Total Phosphorus) exceeding thresholds shown to cause impacts to aquatic life (Smith et al. 2007; Smith and Tran 2010; Smith et al. 2013; Smith et al. 2014). Exceedances varied in magnitude and were generally greater at sampling locations closer to Kiryas-Joel and Orange County WWTFs.

Plots illustrating the range of analyte concentration values at each sampling location, in river mile sequence from upstream to downstream, are included in this report (Figures 3 – 20). Locations on a tributary are inserted between mainstem river mile locations. Analytes selected for presentation were subset to those of specific interest to the study and those, as described above, with exceedances of water quality standards and thresholds shown to impact aquatic life (Smith et al. 2014). Therefore, the analytes presented here include: Aluminum (dissolved); Chloride; Specific Conductance (*in situ*); Copper (total & dissolved); Dissolved Oxygen (*in situ*); Iron (total); Lead (total); Nickel (dissolved); Nitrate, Nitrite, Total Nitrogen; pH (*in situ*); Sodium; Total Phosphorus; Total Dissolved Solids; Zinc (total & dissolved). Site specific exceedances are quantified in Section II.

Figure 3, Aluminum, Dissolved. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and QA/QC procedures. Descriptions of removed records are presented in Appendix III.

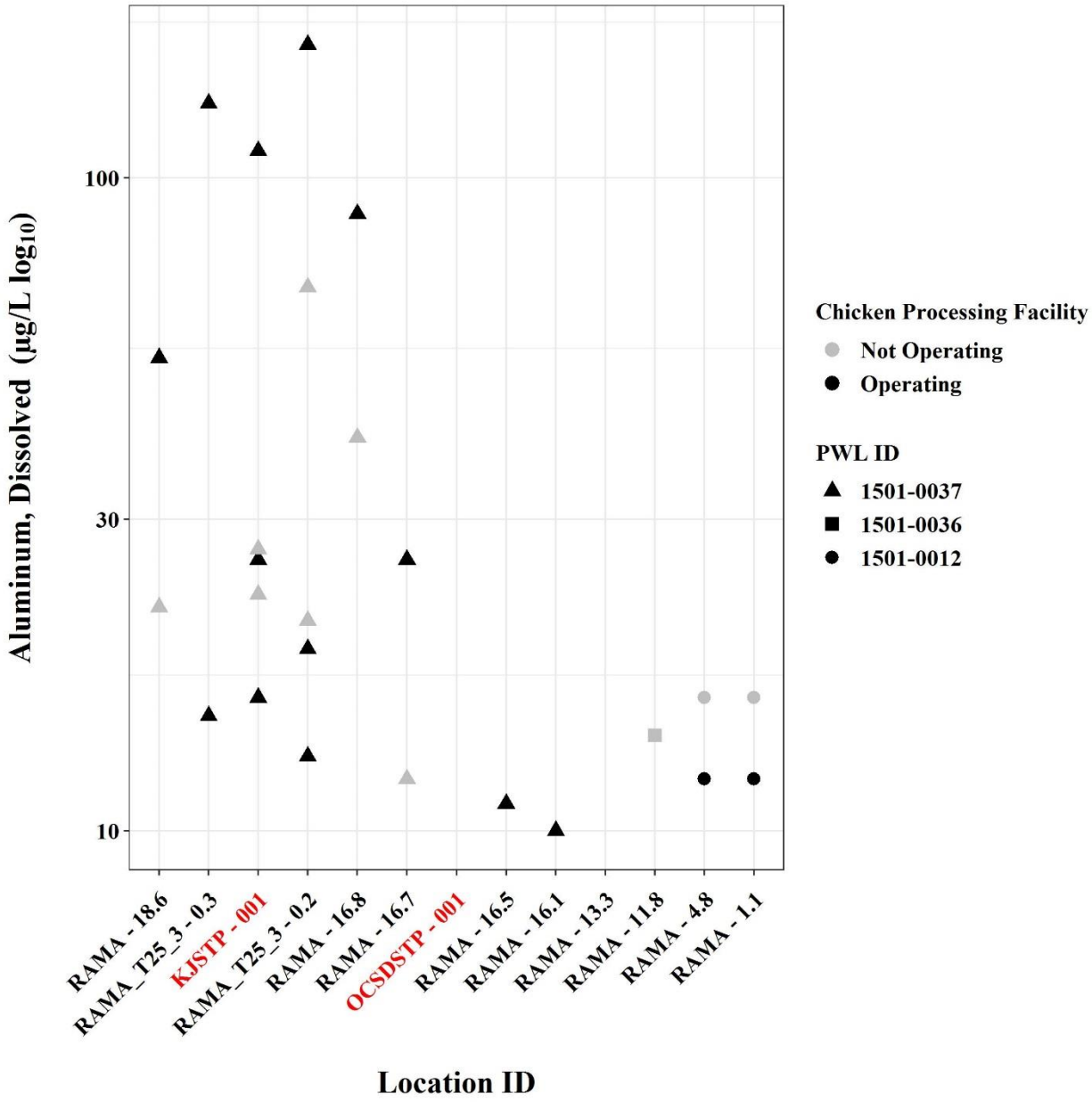


Figure 4, Chloride. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

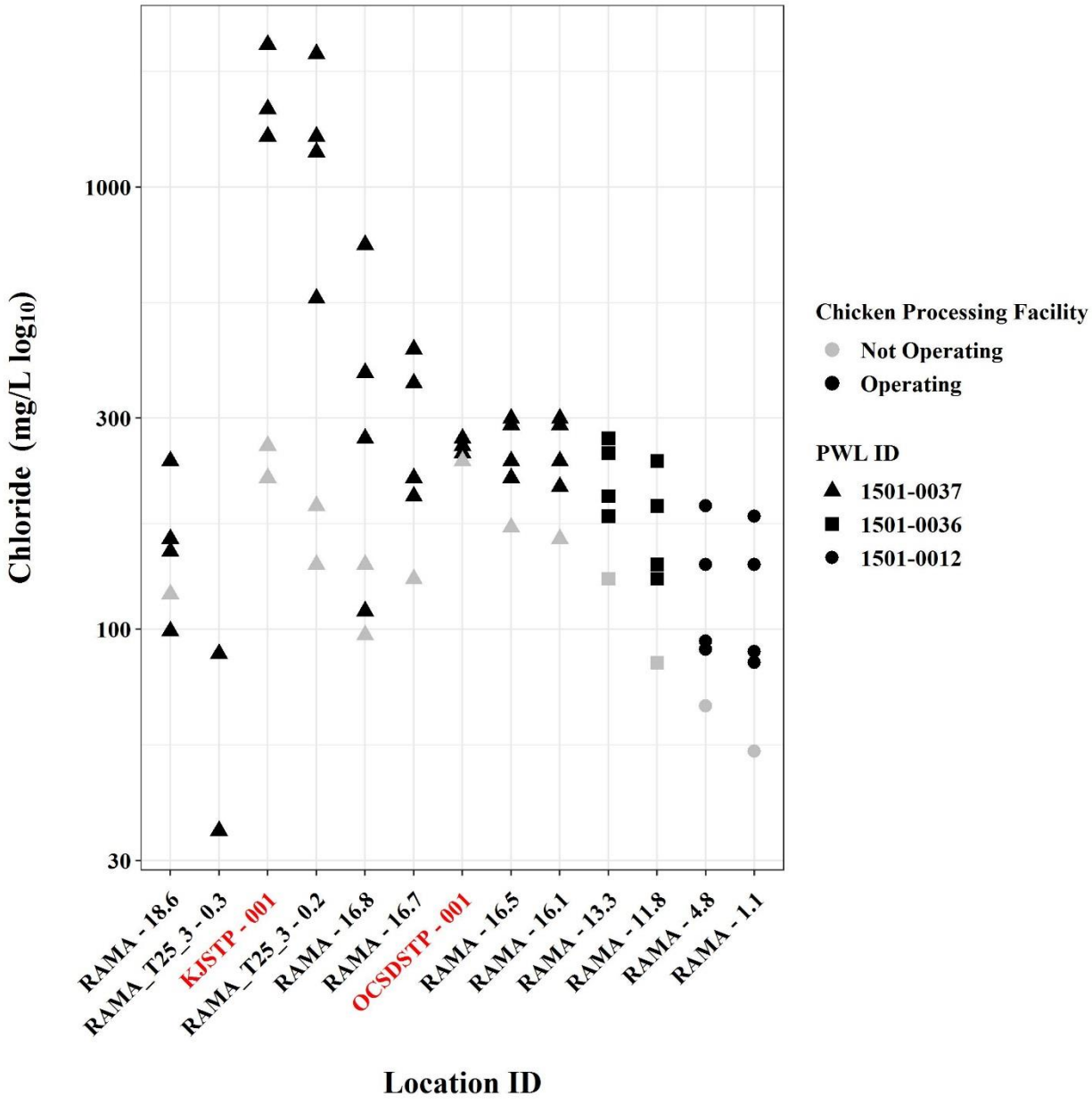


Figure 5, Copper, Dissolved. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

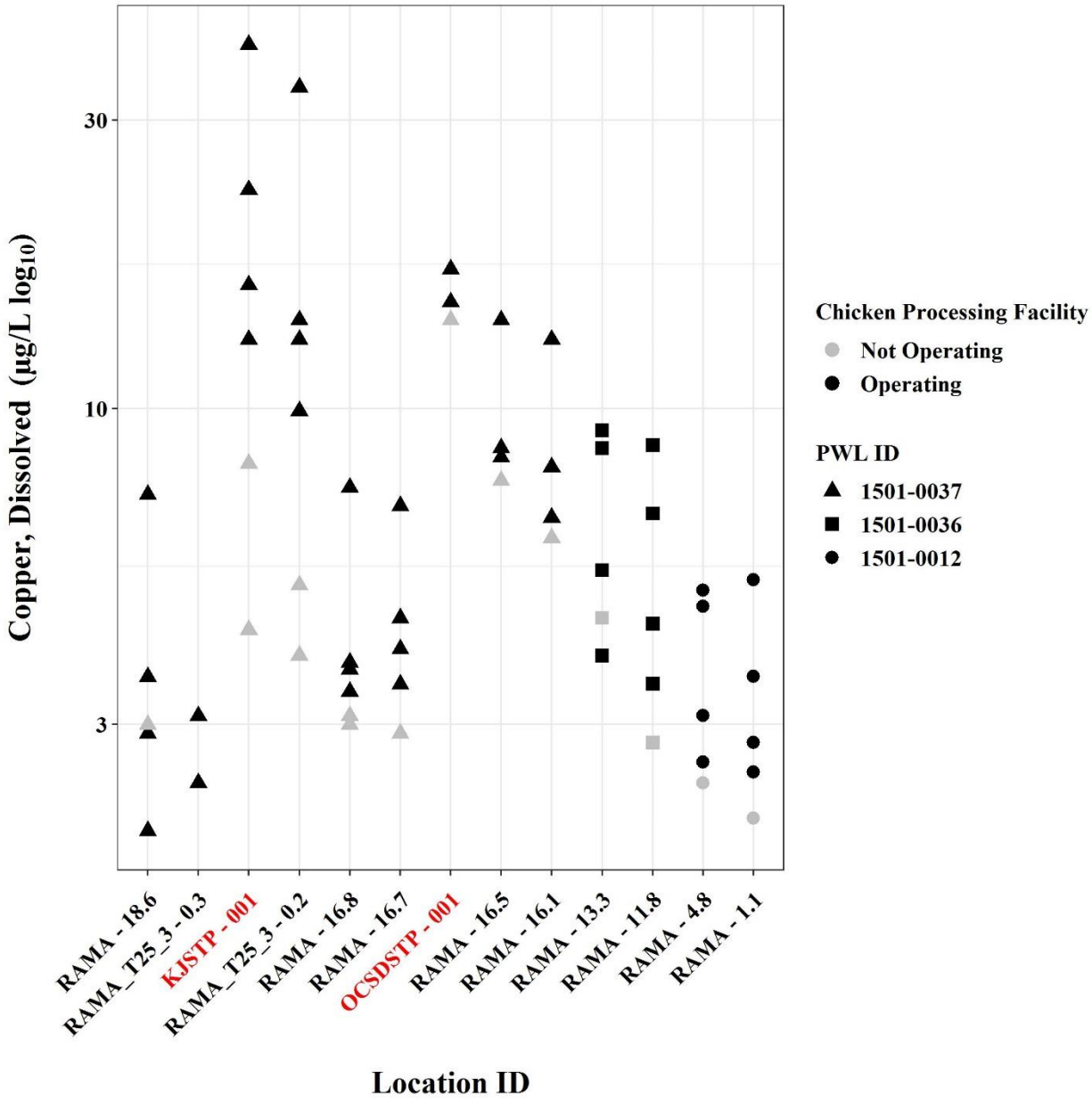


Figure 6, Copper, Total. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

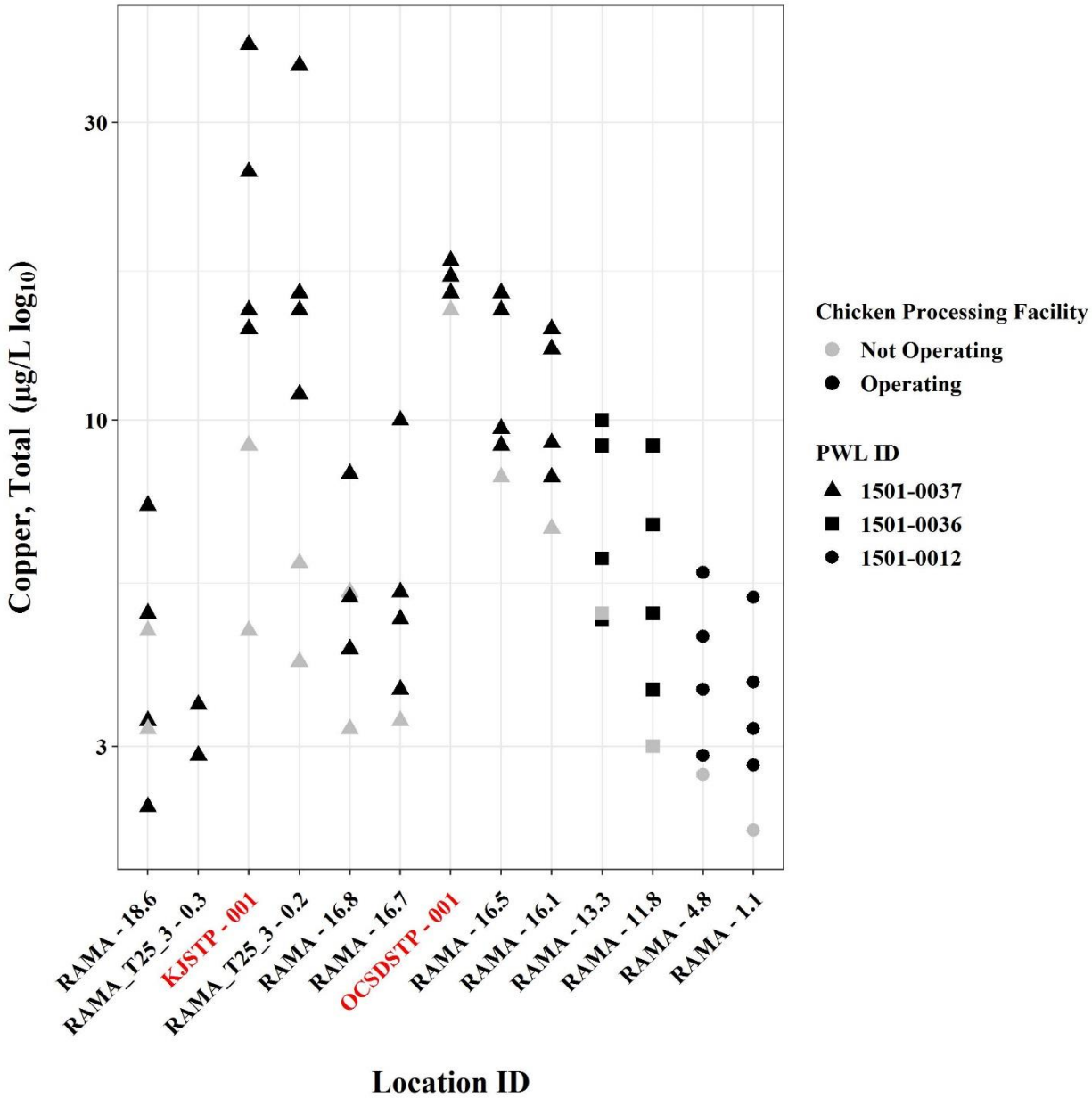


Figure 7, Dissolved Oxygen (*in situ*). The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

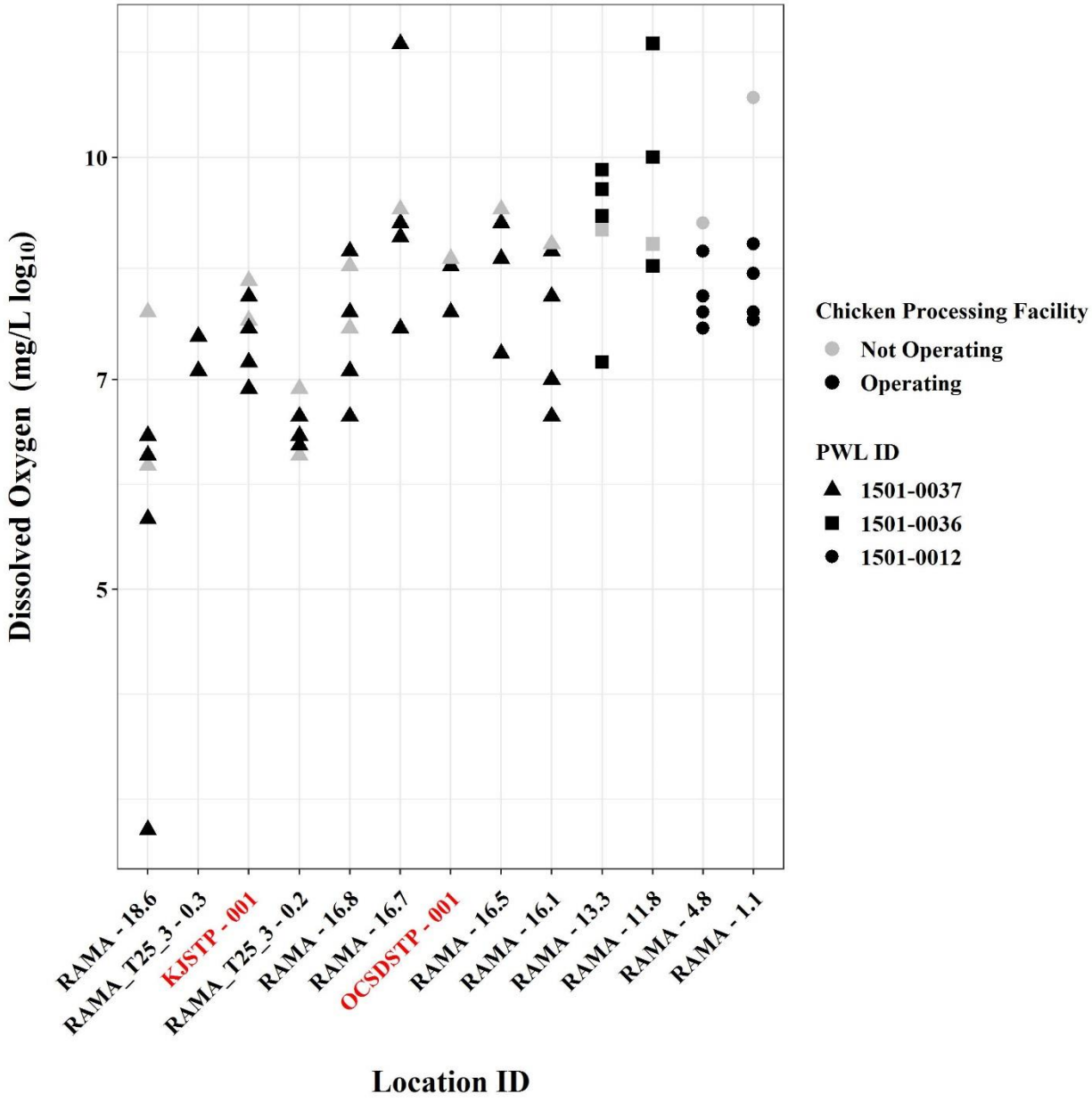


Figure 8, Iron, Total. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

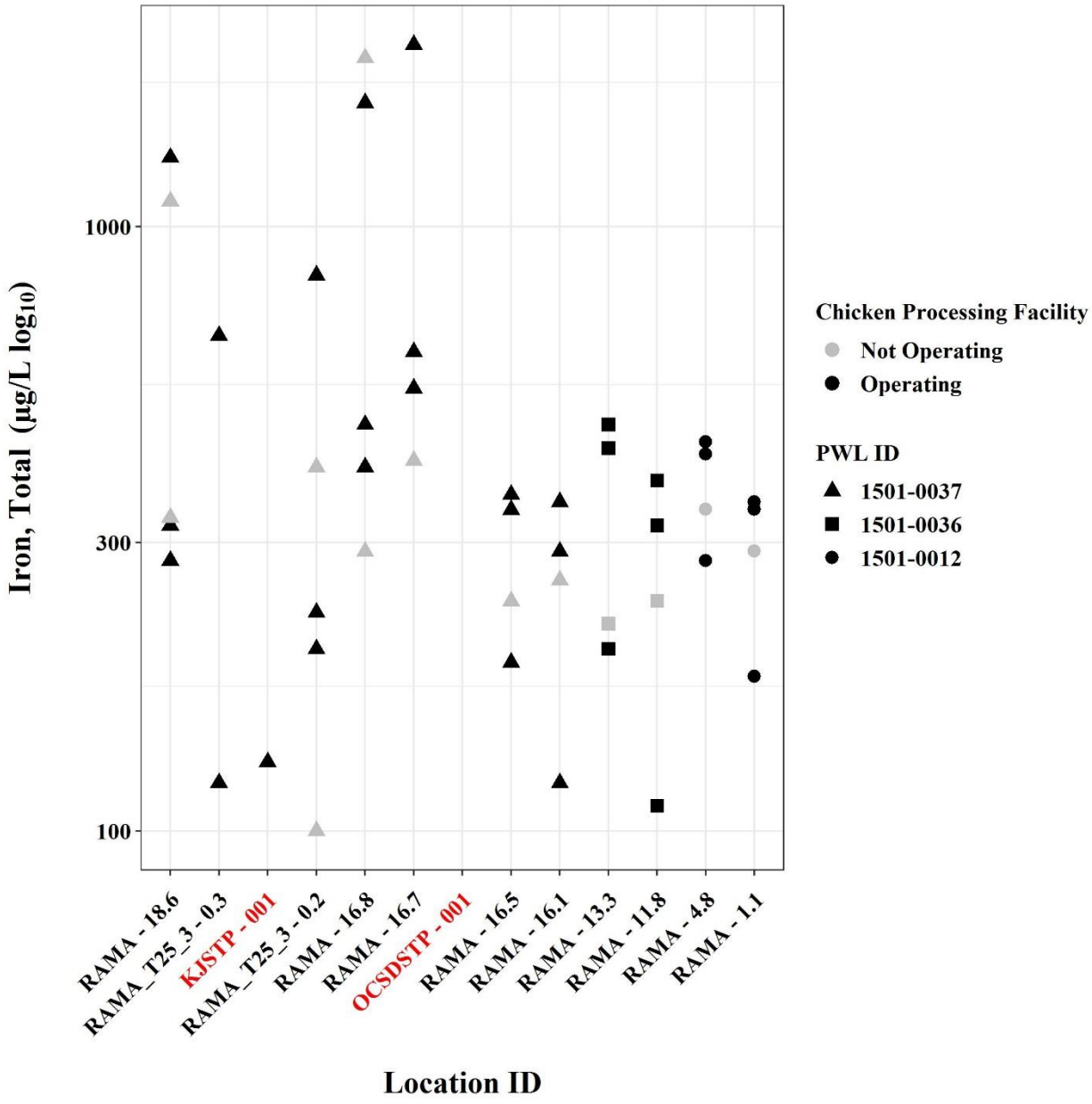


Figure 9, Lead, Total. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

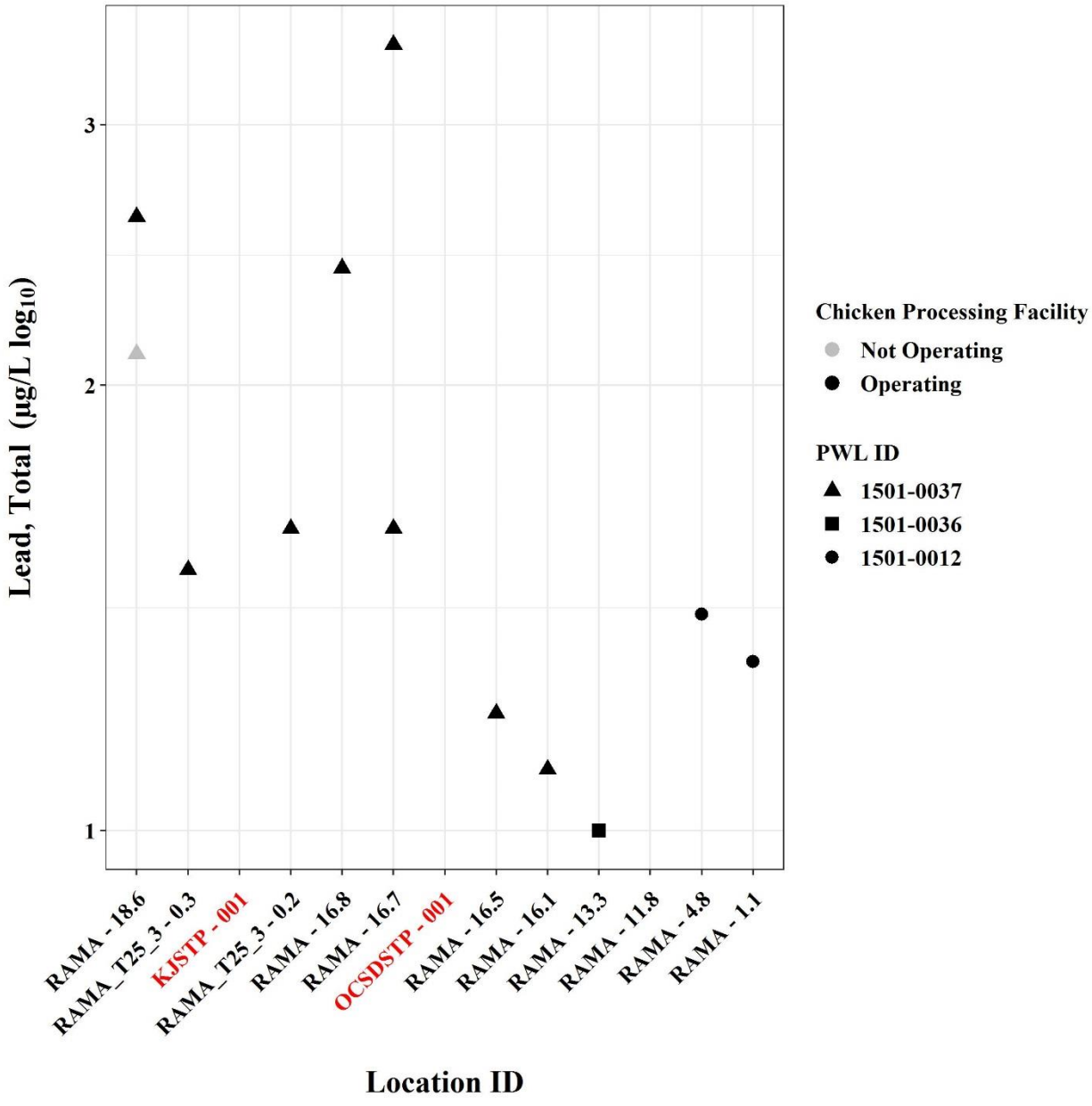


Figure 10, Nickel, Dissolved. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

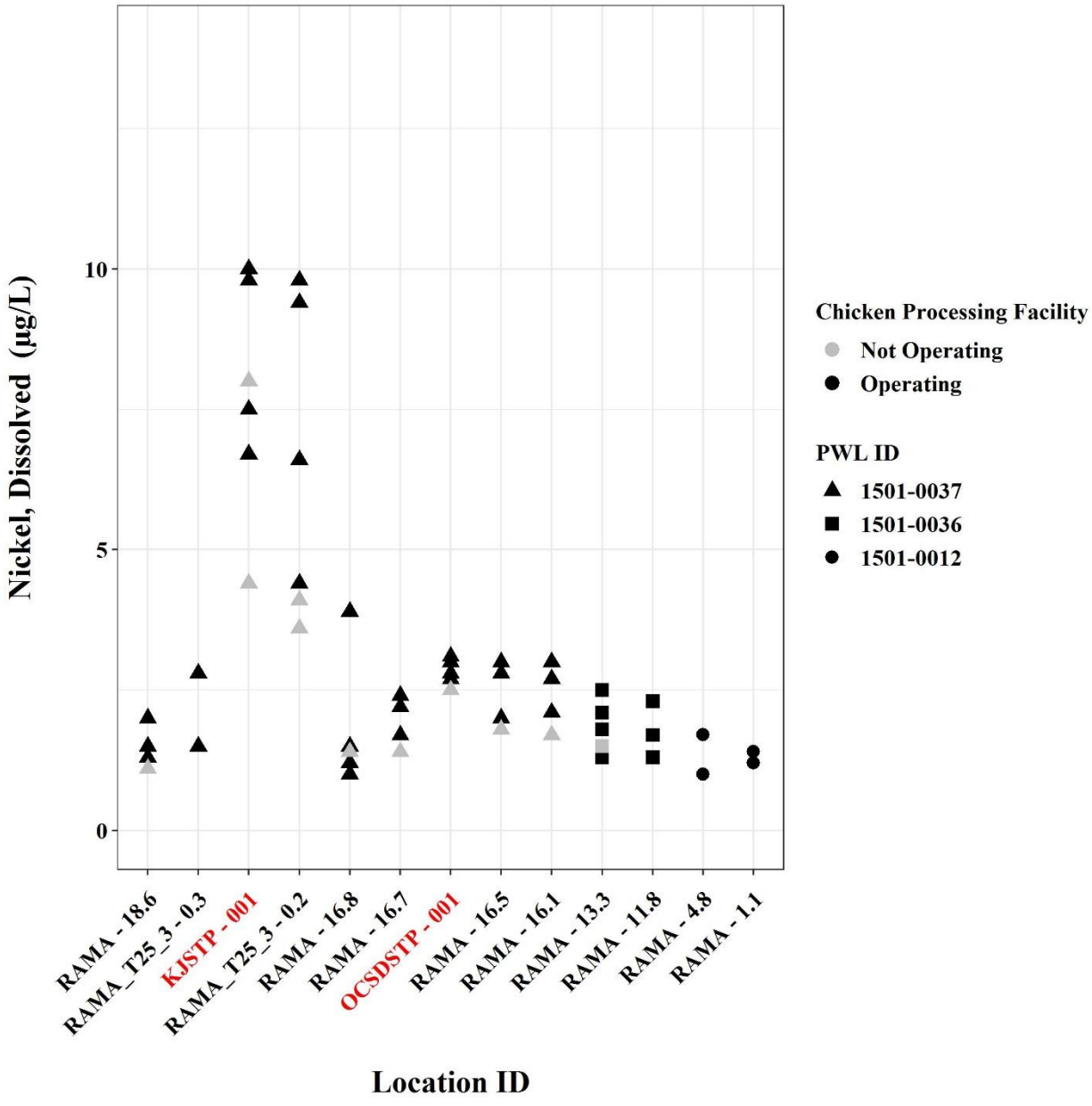


Figure 11, Nitrogen, Nitrate. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

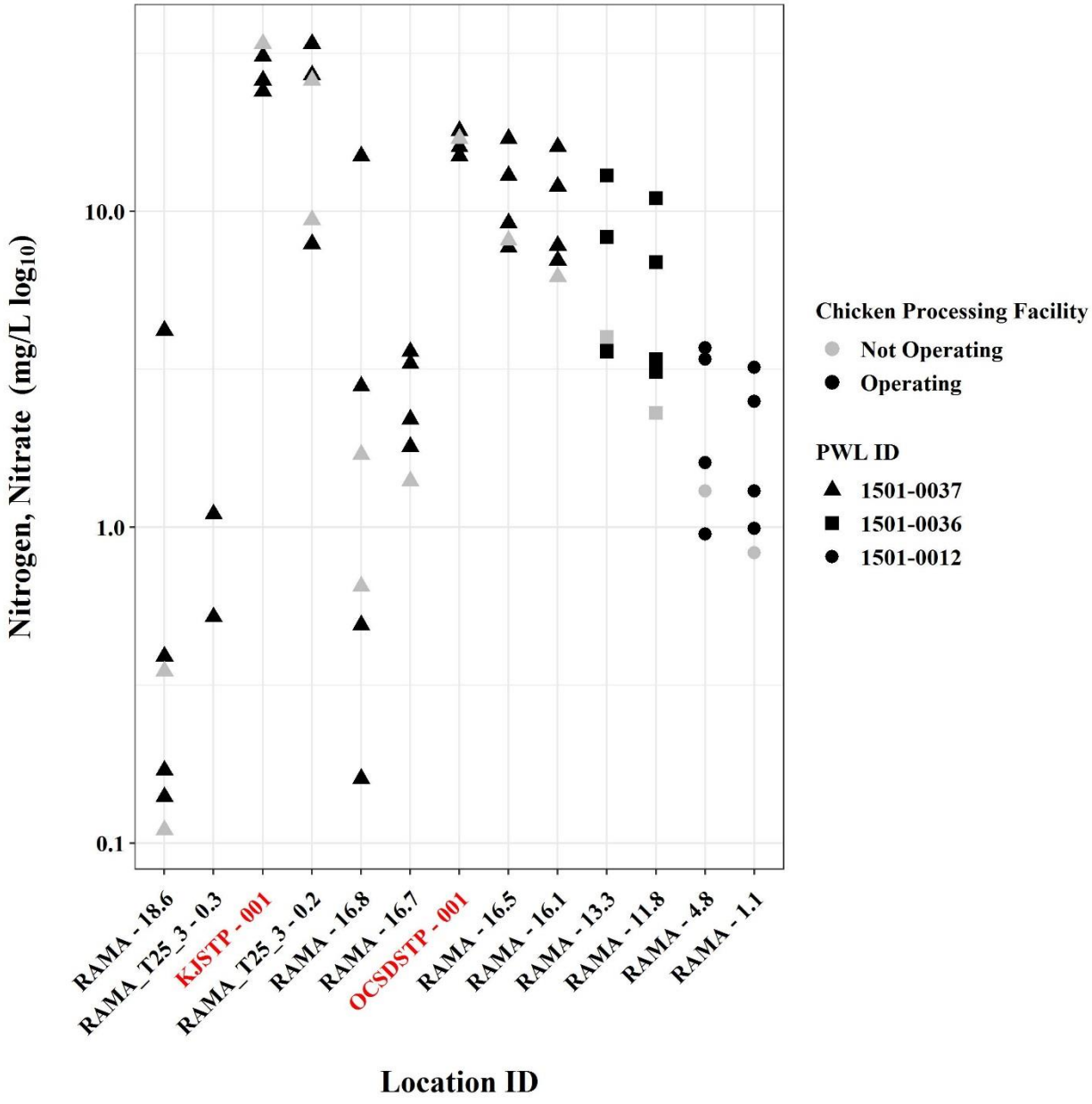


Figure 12, Nitrogen, Nitrite. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

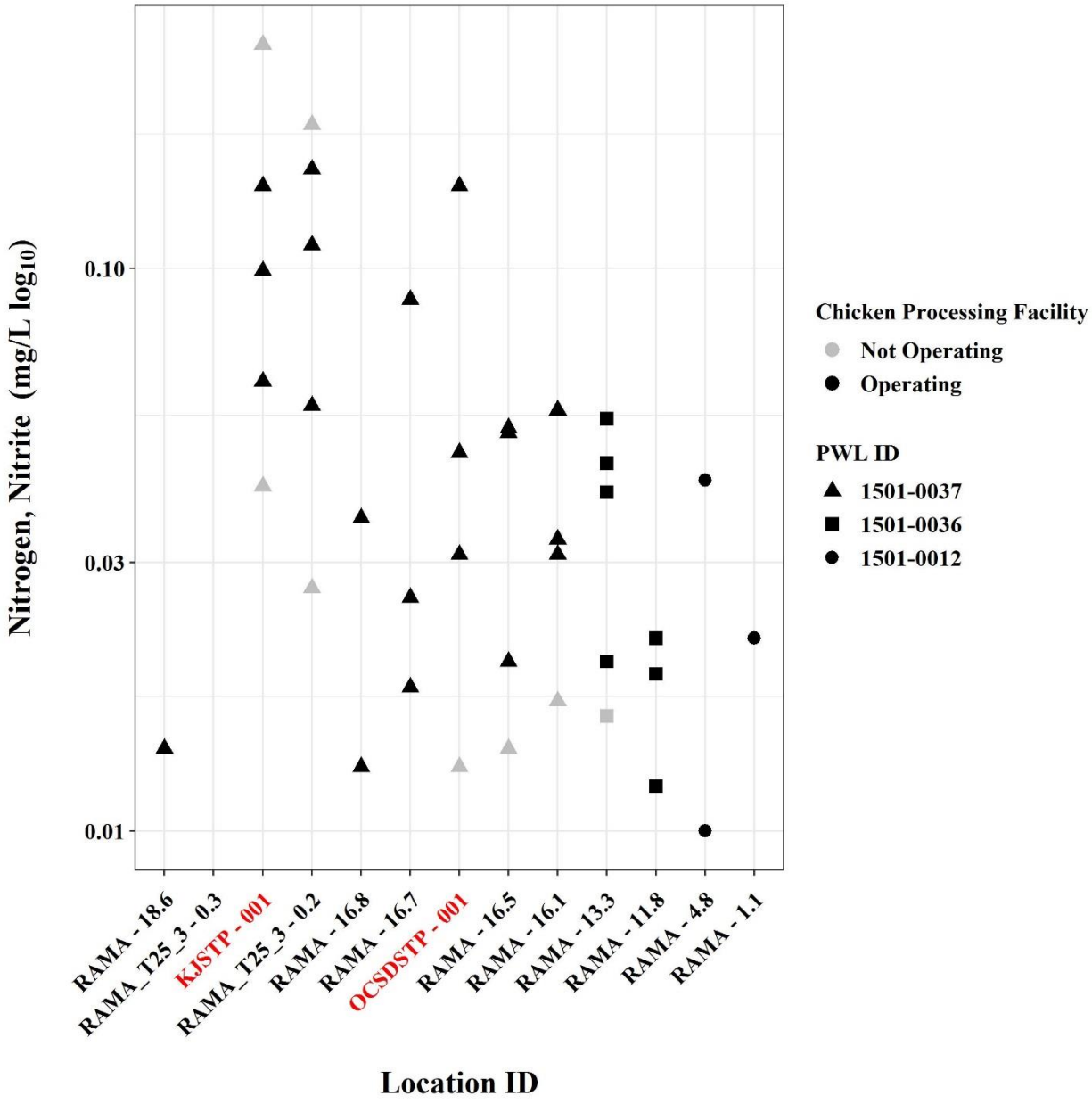


Figure 13, Nitrogen, Total. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

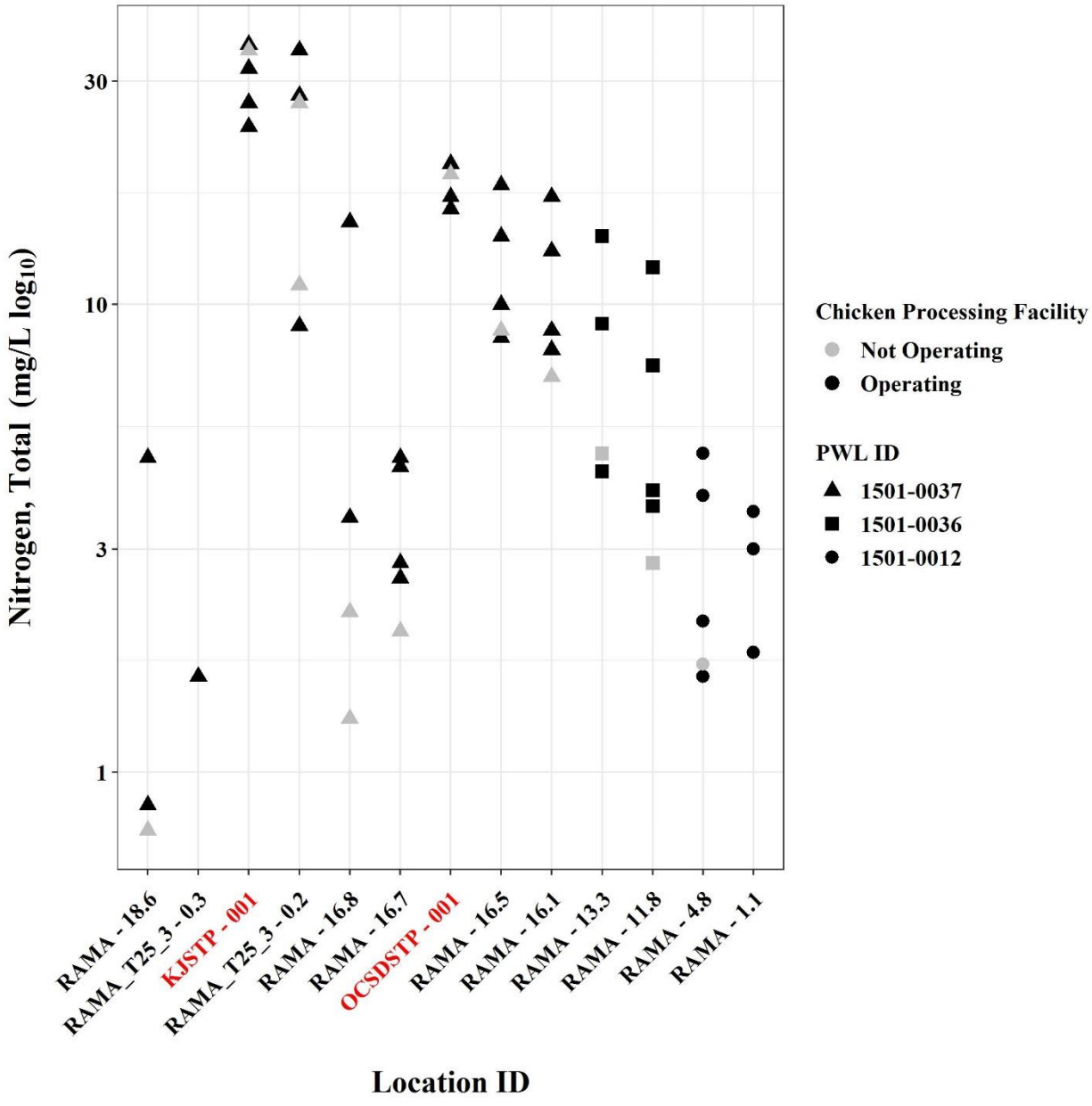


Figure 14, pH (*in situ*). The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

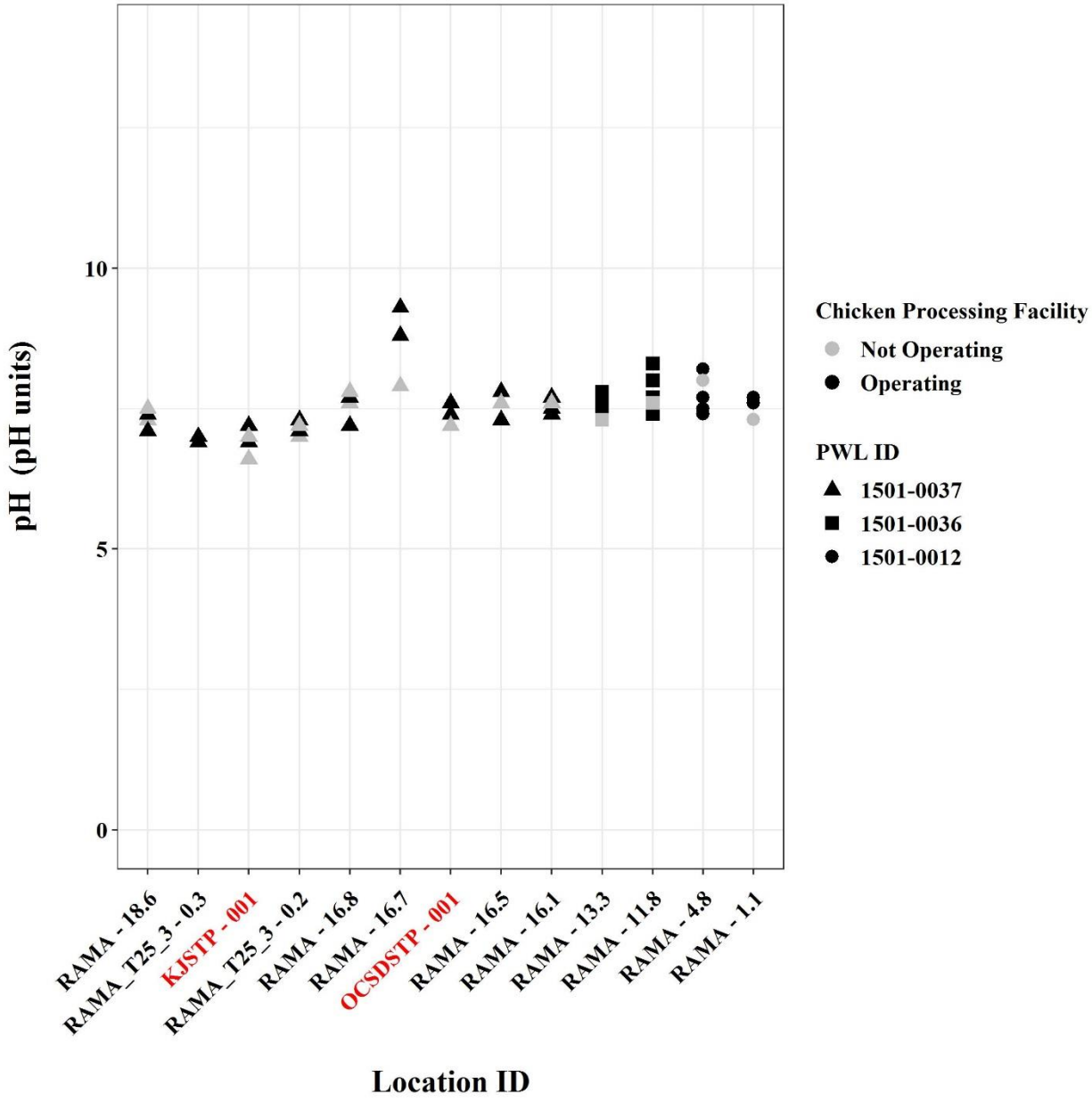


Figure 15, Sodium. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

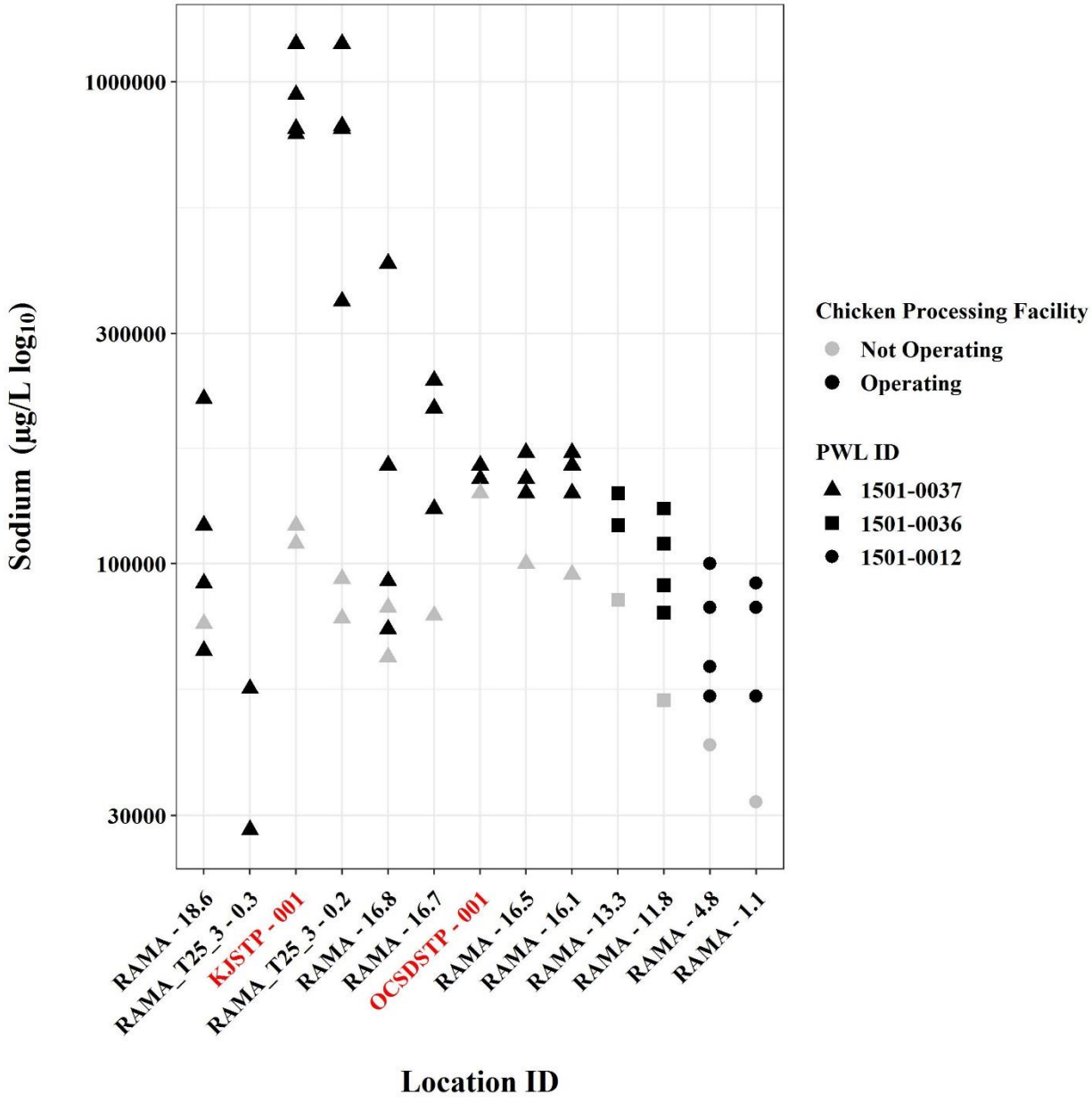


Figure 16, Specific conductance (in situ). The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

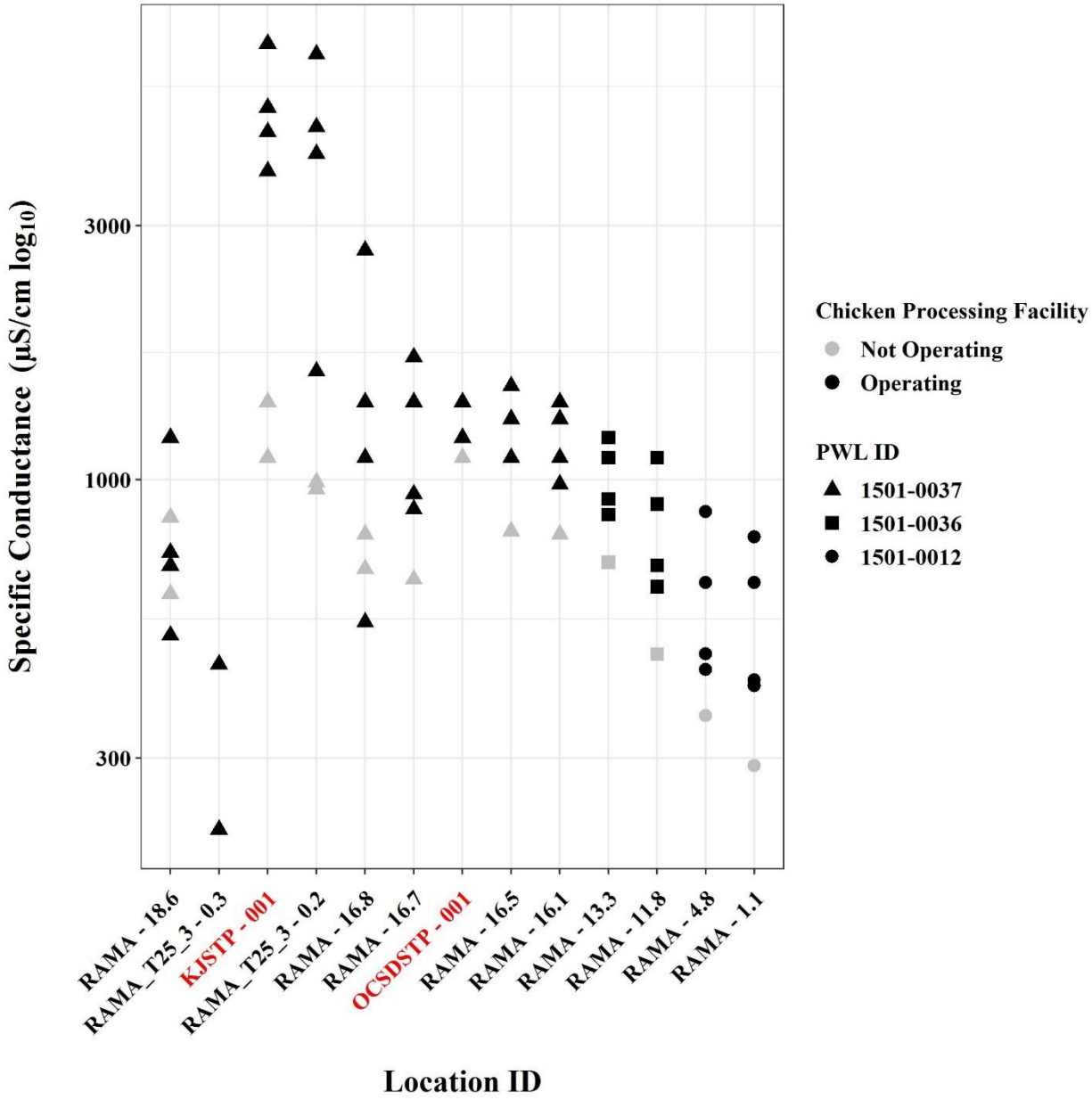


Figure 17, Phosphorus, Total. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

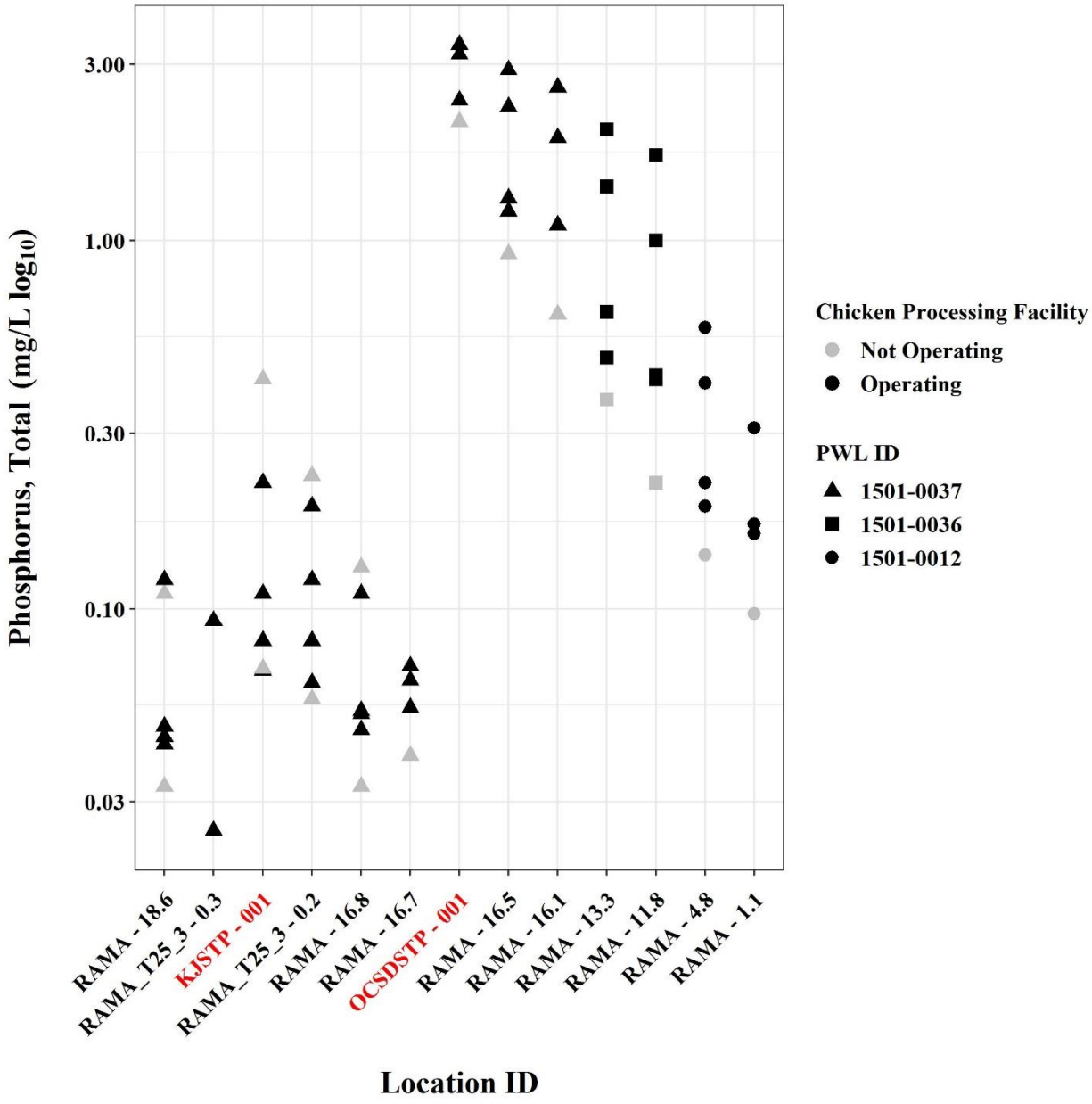


Figure 18, Total Dissolved Solids. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

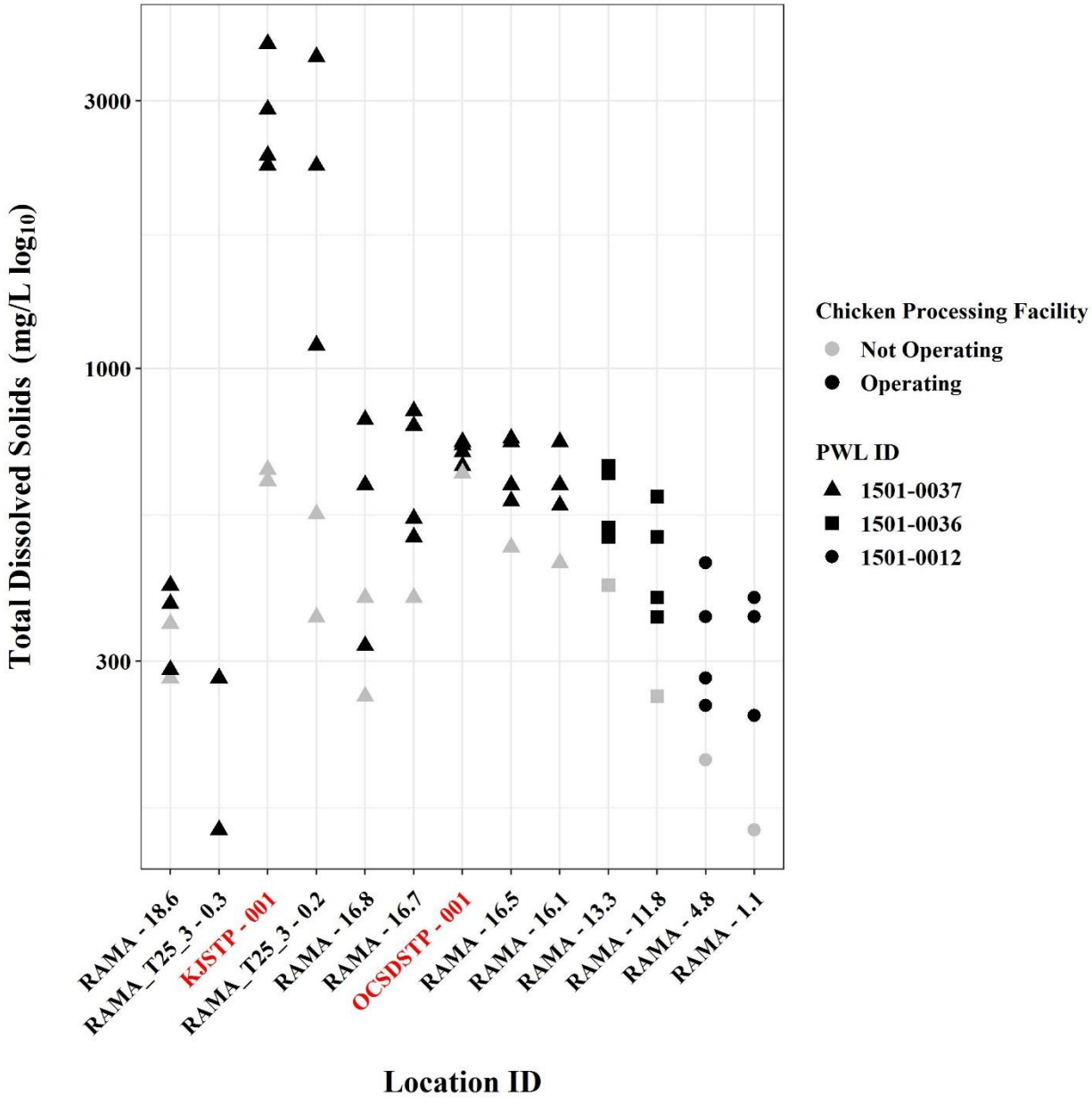


Figure 19, Zinc, Dissolved. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.

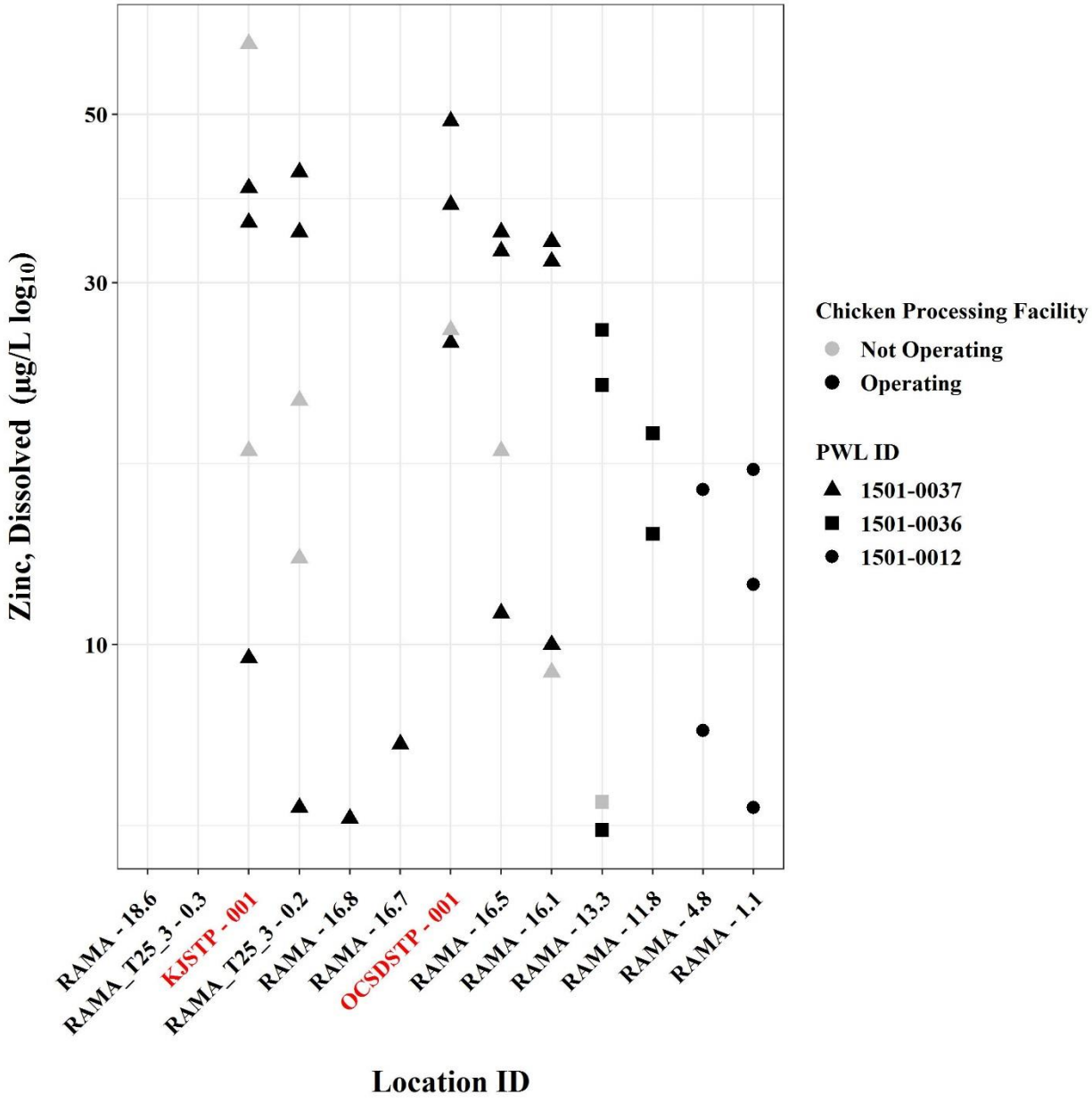
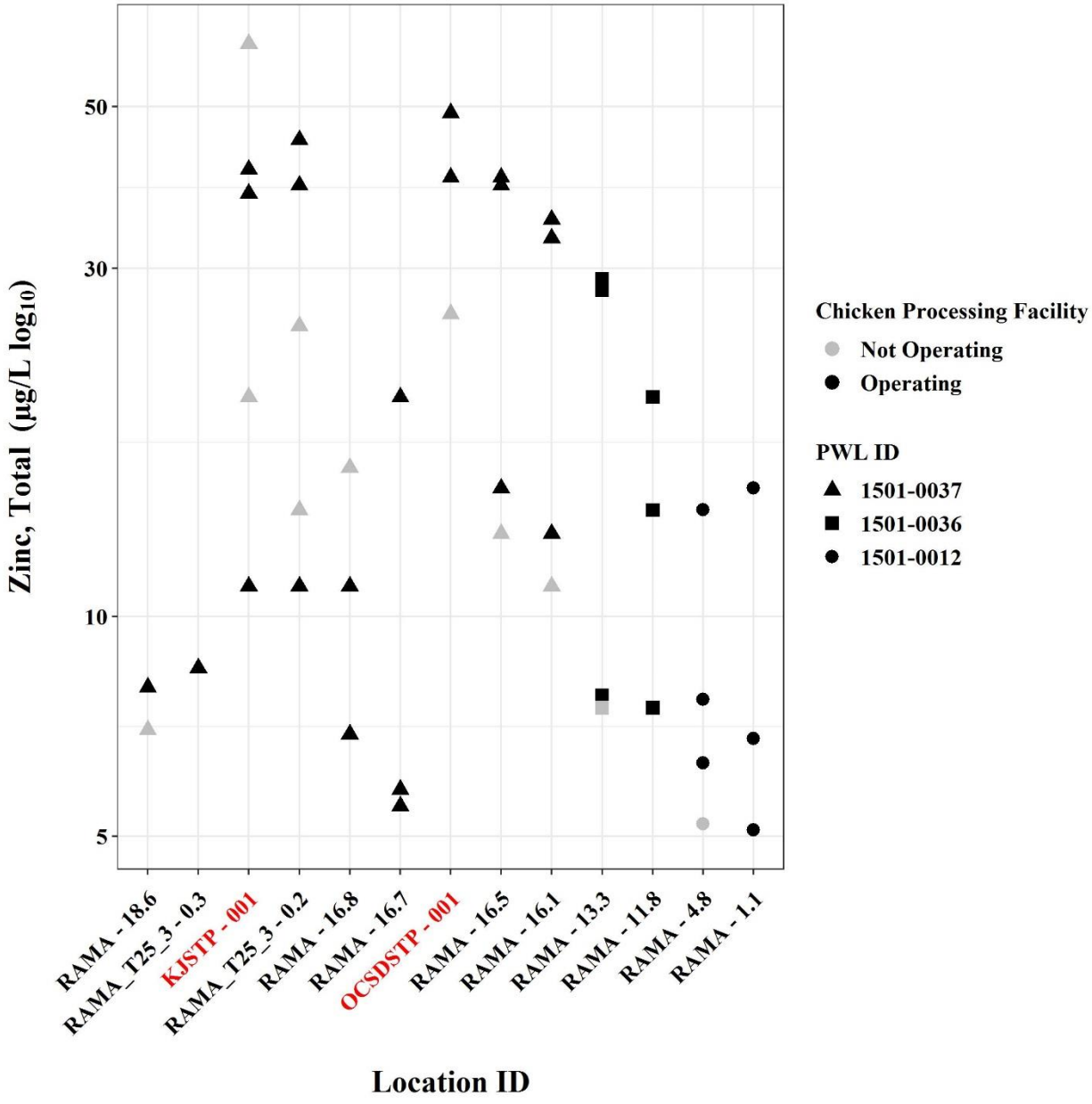


Figure 20, Zinc, Total. The X-axis presents sampling locations from upstream to downstream and axis labels correspond with Table 1, Figure 1 and Figure 2. The y-axis represents base log10 analyte concentrations. Point symbols match with WI/PWL segmentation as indicated in the plot legend. Gray symbols depict sampling dates (July 23, Oct 1-2) corresponding to shut down of the chicken processing facility and black corresponds to all other sample dates. The total number of reported values illustrated for each sampling location can vary due to non-detection and the QA/QC procedures. Descriptions of removed records are presented in Appendix III. Where there are applicable standards and exceedances they are listed in Section II.



B) Benthic Macroinvertebrate Community

Benthic macroinvertebrate communities were sampled to evaluate water quality impacts to the aquatic life use. Where appropriate riffle habitat was present, collection of macroinvertebrates was preformed using the kick method described in section 9.4 of SOP #208-18 *Biological Monitoring of Surface Waters in New York State*. The two WWTF outfalls and one mainstem Ramapo River site (RAMA-16.7), situated immediately downstream of a ponded area in Mary Harriman Park, Harriman, NY, where excluded from collection of macroinvertebrates.

Replicate (n=4/site) macroinvertebrate samples were collected once at base flow discharge at each sampled location. The contents of replicate kick samples for each site were field-inspected to determine major groups of organisms present, and then preserved in alcohol for lab inspection and identification of 100-specimen subsamples. Specimens were identified to lowest possible taxonomic resolution, typically genus or species.

Biological assessments of water quality are generated from Biological Assessment Profile (BAP) scores (SOP #208-18). BAP scores are calculated by taking the average of five normalized 10-scale community metrics and assigning that score to a four-tiered system of impact category of non (7.5-10), slight (5.0-7.5), moderate (2.5-5.0), or severe (0-2.5) impacts (Figure 21). A final BAP score below 5 suggests that the sampled stream is not achieving its aquatic life use goals (Figure 21; SOP #208-18). A BAP score above 5 indicates that the sampled stream is attaining its aquatic life use goals (Figure 21; SOP #208-18). Expected variability in the results of benthic macroinvertebrate community samples is presented in Smith and Bode (2004).

On average, Biological Assessment Profile (BAP) scores ranged from moderately to slightly impacted across all sites on the Ramapo River and tributaries (SOP #208-18; Figure 22). The three locations in closest downstream proximity to Kiryas-Joel (RAMA_T2-3-0.2) and Orange County WWTFs (RAMA-16.5, RAMA-16.1) were below the BAP impairment threshold (Figure 22). The three most downstream sites in the watershed (RAMA-11.8, RAMA-4.8, RAMA-1.1) fell above the impairment threshold (Figure 22). Ninety-five percent confidence intervals suggest inconclusive results for RAMA-18.6 and RAMA-13.3 (Figure 22).

Figure 21. Biological Assessment Profile (BAP) score impact categories based on the macroinvertebrate community. Scores below 5 suggest impairment to aquatic life and scores above 5 indicate attainment of aquatic life of use.

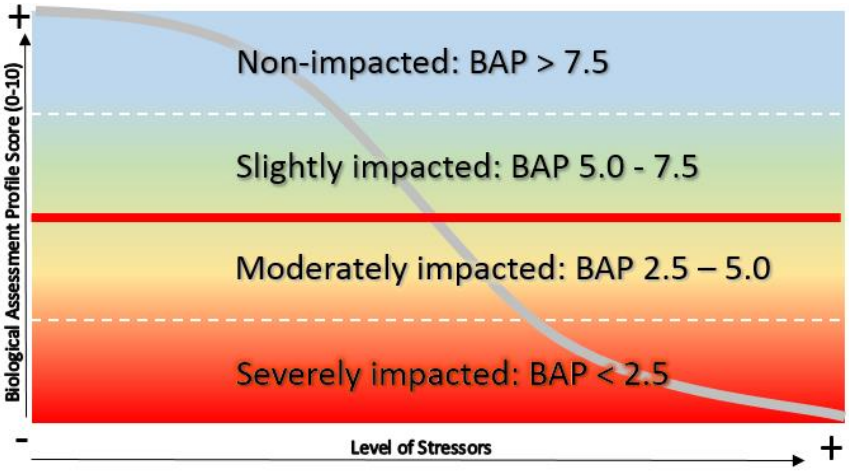
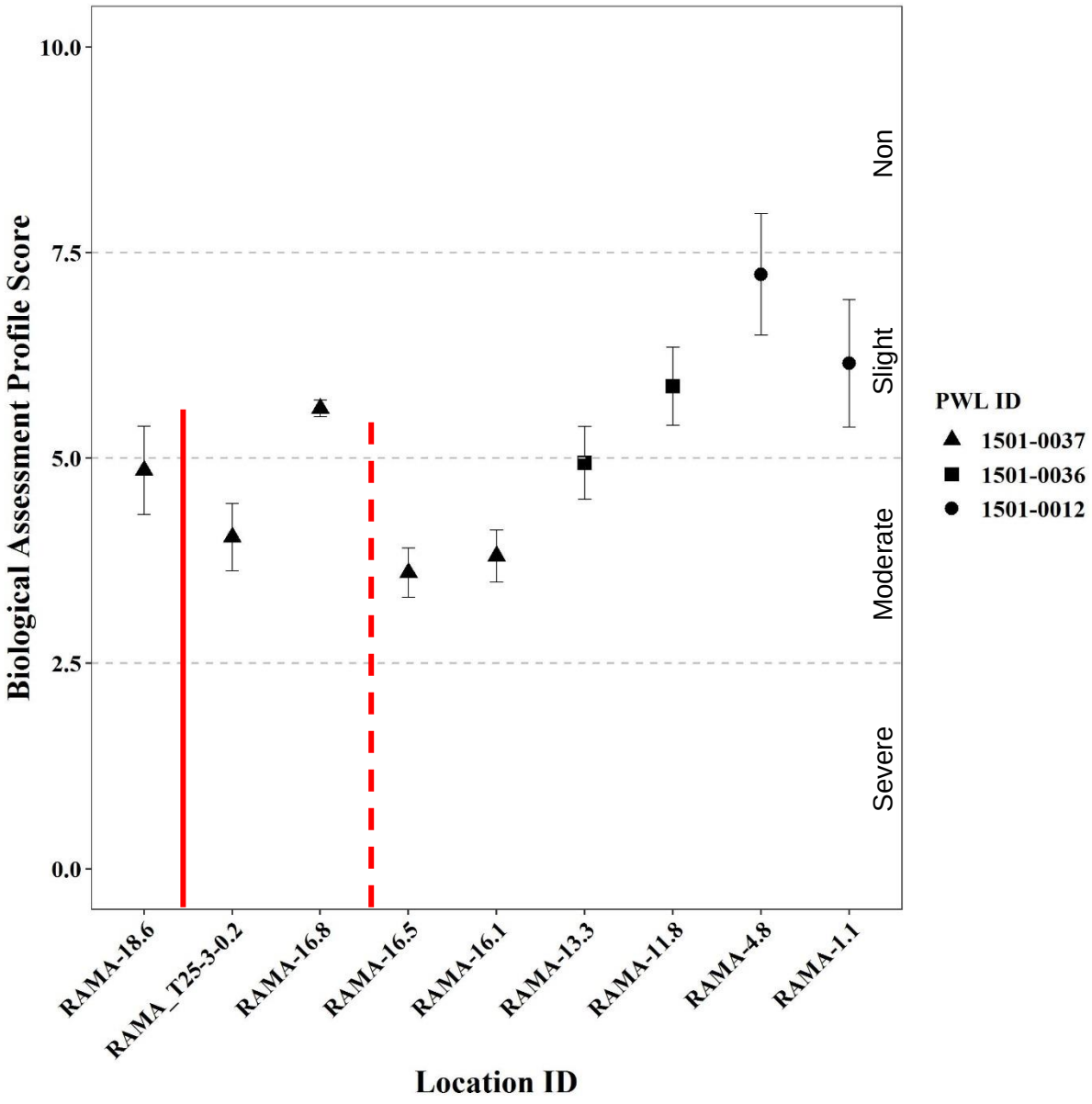


Figure 22**.** Biological Assessment Profile (BAP) Scores and 95% confidence intervals for benthic macroinvertebrate community assessment data for the Ramapo River Survey, 2018. Symbology corresponds with WI/PWL segmentation as indicated in the plot legend. Solid and dashed red lines correspond to the Kiryas-Joel and Orange County WWTF discharge locations, respectively.



C) Stream Reach Physical Habitat Characteristics

Assessments of physical habitat conditions were performed by field crews at all sites during macroinvertebrate collections following the methods detailed in section 9.10 of SOP #208-18. The information collected in these assessments are used to calculate the Habitat Model Affinity (HMA) (Table 3), an overall estimate of habitat quality which describes potential habitat stress on aquatic life. The HMA is based on rankings of individual habitat characteristics on a scale from 0 (poor) to 20 (optimal) which are then compared to a statewide reference condition (Appendix IV). HMA scores are used to make final physical habitat assessments; Natural (80-100), Altered (70 – 80), Moderate (60 – 70), and Severe (< 60). Results are described in terms of percent similarity to the reference condition.

Habitat model affinity (HMA) scores and resulting final physical habitat assessments ranged from natural to severe alteration across all sites (SOP #208-18; Table 3). Physical habitat final assessments demonstrate that habitat was not a determining factor influencing benthic communities at most sampling locations where macroinvertebrates were collected (Table 3); natural (n=5), altered (n=3), moderate (n=1), severe (n=1). This was, in part, due to the extent of undeveloped areas surrounding stream reaches near selected sites. Similarly, while many of the sampling locations in the upstream WI/PWL segment (1501-0037) were situated in urbanized areas, the physical habitat directly surrounding sampling locations is protected from development due to land ownership; i.e. municipal and state property.

Table 3. Ranked habitat characteristics and calculated HMA for the Ramapo River Survey, 2018. Epifaunal substrate (Epi. Cover); Embeddedness/Pool Substrate Characterization (Embed. Pool.); Velocity Depth Regime/Pool Variability (Vel/Dep Reg.); Sediment Deposition (Sed. Dep.); Channel Flow Status (Flow Status); Channel Alteration (Chan. Alt.); Riffle Frequency/Stream Sinuosity (Rif. Freq.); Left/Right Bank Stability (L/R Bank Stab.); Left/Right Bank Vegetative Cover (L/R Bank Veg.); Left/Right Bank Riparian Vegetative Zone Width (L/R Rip. Width).

Location ID	Collection Date	Gradient	Epi. Cover	Embed. Pool.	Vel/Dep Reg.	Sed. Dep.	Flow Status	Chan. Alt.	Rif. Freq.
RAMA-18.6	9/6/2018	High	15	15	16	16	8	15	16
RAMA_T25_3-0.3	8/22/2018	High	16	12	12	10	15	4	15
RAMA_T25_3-0.2	8/22/2018	High	11	12	16	15	20	10	12
RAMA-16.8	9/6/2018	High	12	8	7	10	15	15	5
RAMA-16.5	8/21/2018	High	15	13	20	20	20	18	19
RAMA-16.1	8/21/2018	High	20	3	18	14	19	17	10
RAMA-13.3	8/21/2018	High	10	15	15	20	18	5	16
RAMA-11.8	8/21/2018	High	15	14	15	20	20	20	4
RAMA-4.8	8/21/2018	High	19	17	20	20	20	18	13
RAMA-1.1	8/21/2018	High	16	13	15	15	20	16	18

Location ID	Collection Date	Gradient	L Bank Stab.	R Bank Stab.	L Bank Veg.	R Bank Veg.	L Rip. Width	R Rip. Width	HMA Score	Final Assessment
RAMA-18.6	9/6/2018	High	6	5	6	8	6	8	77.35	Altered
RAMA_T25_3-0.3	8/22/2018	High	6	8	8	8	3	8	69.06	Altered
RAMA_T25_3-0.2	8/22/2018	High	10	10	10	10	7	10	81.77	Natural
RAMA-16.8	9/6/2018	High	8	6	4	6	2	3	55.8	Severe
RAMA-16.5	8/21/2018	High	10	10	10	10	10	10	96.69	Natural
RAMA-16.1	8/21/2018	High	4	6	8	8	10	10	78.45	Altered
RAMA-13.3	8/21/2018	High	6	6	6	6	2	1	68.51	Moderate
RAMA-11.8	8/21/2018	High	7	7	9	9	10	10	84.53	Natural
RAMA-4.8	8/21/2018	High	10	10	10	10	6	5	92.82	Natural
RAMA-1.1	8/21/2018	High	10	10	10	10	7	3	87.29	Natural

D) Observer Ranking of Recreational Ability

Perceptions of recreational ability were ranked at all sampling locations during each site visit as per standard site visit protocols (SOP #208-18). The observer ranking of recreational ability is a method of evaluating impacts to recreational use of a stream segment. Impacts to recreational use have been correlated with "impairment of aquatic life use from nutrient enrichment" and rankings below slightly impacted are indicative of significant impacts to recreational ability (Smith et al. 2014). The ranking assesses primary (1°) and secondary (2°) contact recreation, as well as a user's desire to fish.

The first two questions of the recreational use evaluation describe the observers perceived ability to participate in 1° and 2° contact recreation (Appendix V). Results of this ranking are the primary gauge of whether the Ramapo River is achieving its designated recreational uses. Figure 22 illustrates the average observer ranking for desire to participate in 1° and 2° contact recreation at each sampling location. Results of this survey suggest observers (NYSDEC field staff) considered the desire to participate in 1° and 2° contact recreation to be slightly impacted at sampling locations RAMA-13.3 south to RAMA 1.1, the Ramapo sampling location directly above the pond in Mary Harriman Park, Harriman, NY (RAMA-16.8), and the upstream reference site (RAMA-18.6). Sampling locations located in the upper WI/PWL segment (1501-0037), especially those in proximity to WWTF, were largely considered impossible for 1° and 2° contact recreation.

Additional questions on a scale of 0-10 (0 – Best/Natural; 10 Worst/Severe) help determine the factors influencing the user's perception. Those factors are: 1) Water Clarity; 2) Trash; 3) Periphyton; 4) Odor; 5) Discharge Pipes. Table 4 shows the mean recorded value for these factors at each sampling location and Figure 23 shows the most commonly selected factors reducing an observer's desire to participate in 1° and 2° contact recreation. Other factors described by observers were: 1) Low Dissolved Oxygen; 2) Proximity to Road; 3) Proximity to a State Superfund Site; 4) Proximity to WWTF effluent discharge.

Figure 23. Mean observer ranking of recreational ability for Ramapo River sampling locations. Columns represent observer rankings for the desire to participate in 1° and 2° contact recreation. Ranking of recreation ability was performed for all locations during each site visit.

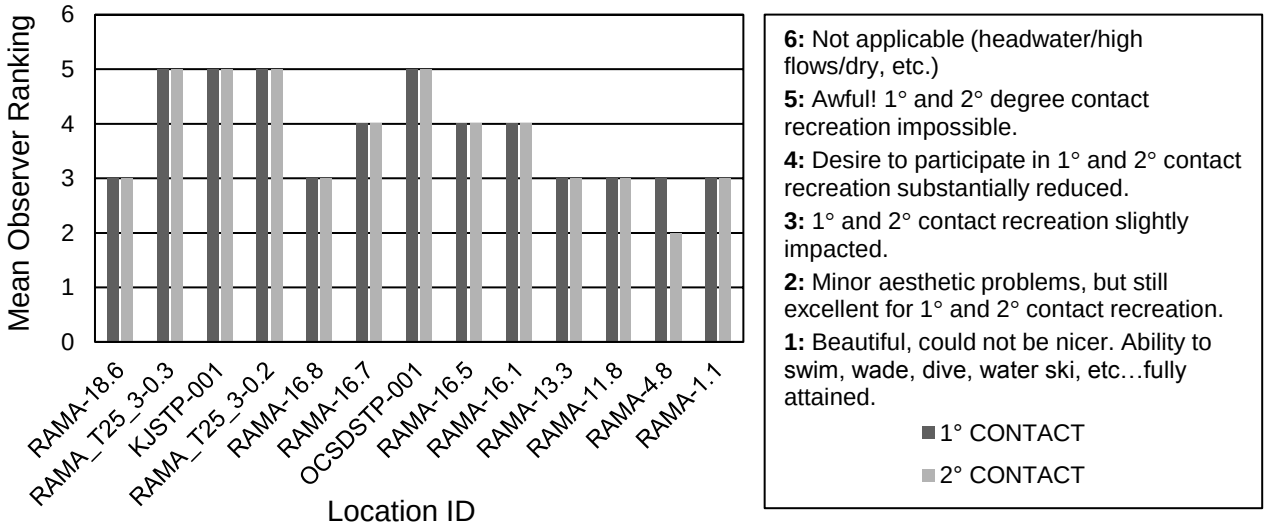
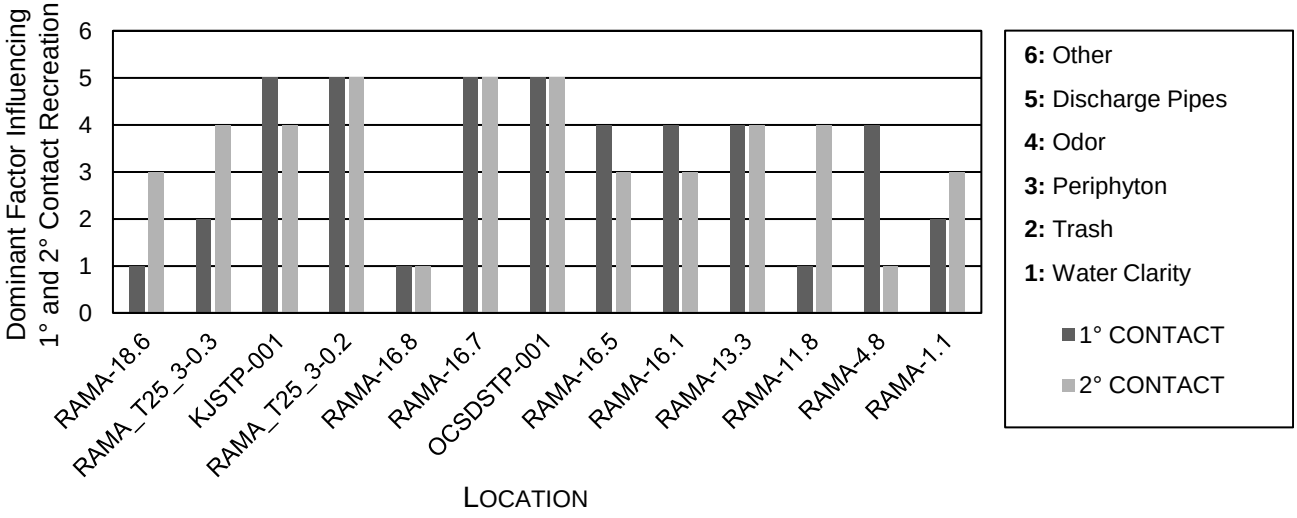


Table 4. Mean observer ranked value for factors influencing desire to participate in 1° and 2° contact recreation in the Ramapo River, 2018. Factors were ranked on a 10 scale (0 – Best/Natural; 10 Worst/Severe) according to perceived impact on a location. Ranking of recreation ability was performed for all locations during each site visit.

Location ID	Water Clarity	Suspended Phytoplankton	Periphyton	Macrophyte	Odor	Trash	Discharge Pipes
RAMA-18.6	3	0	1	1	0	1	0
RAMA_T25_3-0.3	5	0	5	0	7	10	1
KJSTP-001	3	0	6	3	6	9	10
RAMA_T25_3-0.2	4	0	5	2	5	8	7
RAMA-16.8	5	0	3	1	1	3	0
RAMA-16.7	5	3	6	3	7	2	10
OCSDSTP-001	3	1	5	0	9	2	10
RAMA-16.5	2	1	7	2	5	4	1
RAMA-16.1	3	0	5	1	6	1	0
RAMA-13.3	3	0	2	0	4	1	0
RAMA-11.8	2	0	4	0	3	4	0
RAMA-4.8	5	0	5	0	2	3	1
RAMA-1.1	2	0	4	1	4	3	3

Figure 24. Most frequently ranked factor influencing observer desire to participate in 1° and 2° contact recreation in the Ramapo River. Factors influencing desire to recreate were ranked and a primary factor influencing the desire to participate in 1° and 2° contact recreation was chosen during each site visit. Column values represent the factor selected most frequently at each site.



E) Sediment and Porewater Microtox® Analysis

Toxicity testing of surface waters, sediments, porewaters, and effluents are routinely performed as part of the RIBS program (https://www.dec.ny.gov/chemical/29854.html). Sediment toxicity was evaluated according to SOP #403-16 *Microtox® Acute Toxicity Test for Sediments, Porewaters and Effluents*. Testing procedures use a bioassay to assess potential acute toxicity in sediments and surface waters to aquatic life (SOP #403-16). Sediment and extracted sediment porewater samples are tested using a bioluminescent bacterium *Vibrio fischeri (V. fischeri)*. Tests are a measure of light reduction between collected samples and a control following a 15-minute exposure period and expressed as the median effect concentration (EC50) of a sample that causes a 50% reduction in light emission from the *V. fischeri*. Appendix VI (Fact Sheet: *Acute & Chronic Toxicity Assessments of NY Streams & Rivers*) describes toxicity testing procedures, Assessment criteria and results classifications.

Porewater toxicity was found to be non-toxic at all sampled locations while sediment toxicity ranged from non-toxic to severely toxic (Table 5). Sediment at the upstream reference sampling location (RAMA-18.6) was non-toxic. Sediment at the sampling location on Tributary 25 immediately downstream of the Kiryas-Joel WWTF (RAMA_T25-0.2) was severely toxic (Table 5). Sediment at the two Ramapo River sampling locations immediately downstream of the Orange County WWTF (RAMA-16.5, RAMA-16.1) was severely toxic (Table 5). Sediment at the most downstream Ramapo River sampling location (RAMA-1.1) was slightly toxic (Table 5).

Table 5. Ramapo River Microtox® sediment and porewater toxicity results for select locations in the Ramapo River Survey, 2018. Sediment samples were collected for toxicity testing in baseflow conditions during macroinvertebrate community collection at sampling locations.

Location ID	Sample Date	Test Date	Sediment Assessment	Porewater Assessment	Sediment EC50	Porewater EC50
RAMA-18.6	9/6/2018	10/11/2018	Non-toxic	Non-toxic	68.75	> 100
RAMA_T25_3-0.2	8/22/2018	10/11/2018	Severely Toxic	Non-toxic	6.842	> 100
RAMA-16.5	8/21/2018	10/11/2018	Severely Toxic	Non-toxic	13.78	> 100
RAMA-16.1	8/21/2018	10/11/2018	Severely Toxic	Non-toxic	19.64	> 100
RAMA-1.1	8/21/2018	10/11/2018	Slightly Toxic	Non-toxic	44.05	> 100

Section II: **SITE-SPECIFIC DATA SUMMARY**

Section II provides a summary of results from each sampling location. Data provided includes waterbody class and WI/PWL number along with a summary of metal, general chemistry, and *in situ* chemistry results, BAP scores and instantaneous discharge. Water chemistry results are summarized by number of records reported after quality assurance (Appendix III), exceedances of water quality standards and a statistical summary that includes mean, median, minimum, and maximum concentrations. Specific exceedances of water quality standards are also specified. Complete, quality assured raw chemistry data results accompanied by all applicable standards are available in Attachment I. BAP scores are provided and include a statistical summary of results for each site that includes mean, impairment threshold, minimum, maximum, standard deviation and standard error. Instantaneous stream discharge (cubic feet/second) is reported for dates when conditions allowed safe, wadeable access to streams (RAS QAPP 2018; SOP #210-18).

Ramapo River – River mile 18.6

Waterbody Class: B | WI/PWL: 1501-0037

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Aluminum	Dissolved	2	0	37.5	37.5	22	53	**µg/L**
Arsenic	Total	3	0	1.5	1.5	1.4	1.6	**µg/L**
Calcium	Total	6	N/A	45000	38000	28000	83000	**µg/L**
Copper	Dissolved	6	0	3.62	3	2	7.2	**µg/L**
Copper	Total	6	N/A	4.28	3.95	2.4	7.3	**µg/L**
Iron	Total	5	N/A	666	330	280	1300	**µg/L**
Lead	Dissolved	1	0	1	1	1	1	**µg/L**
Lead	Total	2	N/A	2.35	2.35	2.1	2.6	**µg/L**
Magnesium	Total	6	N/A	11300	9400	7200	20000	**µg/L**
Manganese	Total	6	N/A	426.33	190	88	1700	**µg/L**
Nickel	Dissolved	4	0	1.48	1.4	1.1	2	**µg/L**
Sodium	Total	6	N/A	106333	83000	66000	220000	**µg/L**
Zinc	Total	2	0	7.5	7.5	7	8	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	6	N/A	103.33	104.5	69	130	**mg/L**
Dissolved Organic Carbon	Dissolved	6	N/A	6.22	6	3.4	8.5	**mg/L**
Chloride	Total	6	N/A	148.17	135	99	240	**mg/L**
Fluoride	Total	2	0	0.1	0.1	0.1	0.1	**mg/L**
Hardness	Total	6	N/A	159.67	135	98	290	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	3	N/A	1.57	0.35	0.17	4.2	**mg/L**
Nitrogen, Total	Total	3	N/A	2.1	0.85	0.75	4.7	**mg/L**
Nitrogen, Ammonia	Total	3	0	0.06	0.03	0.025	0.12	**mg/L**
Total Kjeldahl Nitrogen	Total	2	N/A	0.54	0.54	0.44	0.64	**mg/L**
Nitrogen, Nitrate	Total	6	N/A	0.89	0.26	0.11	4.2	**mg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Nitrogen, Nitrite	Total	1	0	0.01	0.01	0.01	0.01	**mg/L**
Ortho-phosphate	Dissolved	4	N/A	0.03	0.02	0.02	0.04	**mg/L**
Total Phosphorus	Total	6	N/A	0.07	0.05	0.03	0.12	**mg/L**
Sulfate	Total	5	N/A	11.84	11	7.4	19	**mg/L**
Total Dissolved Solids	Total	5	0	342	350	280	410	**mg/L**
Turbidity	Total	2	N/A	8.8	8.8	3.6	14	**ntu**

In situ Water Quality Characteristics:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	6	N/A	765	710	510	1200	**µS/cm**
Dissolved Oxygen	Dissolved	6	1	5.92	6.15	3.4	7.8	**mg/L**
Percent Saturation	Total	6	N/A	68	73	38	81	**std unit**
pH	Total	6	0	7.38	7.45	7.1	7.5	**pH units**
Salinity	Total	6	N/A	0.38	0.35	0.25	0.6	**ppm**
Water Temperature	Total	6	N/A	21.67	22.5	17	25	**deg c**

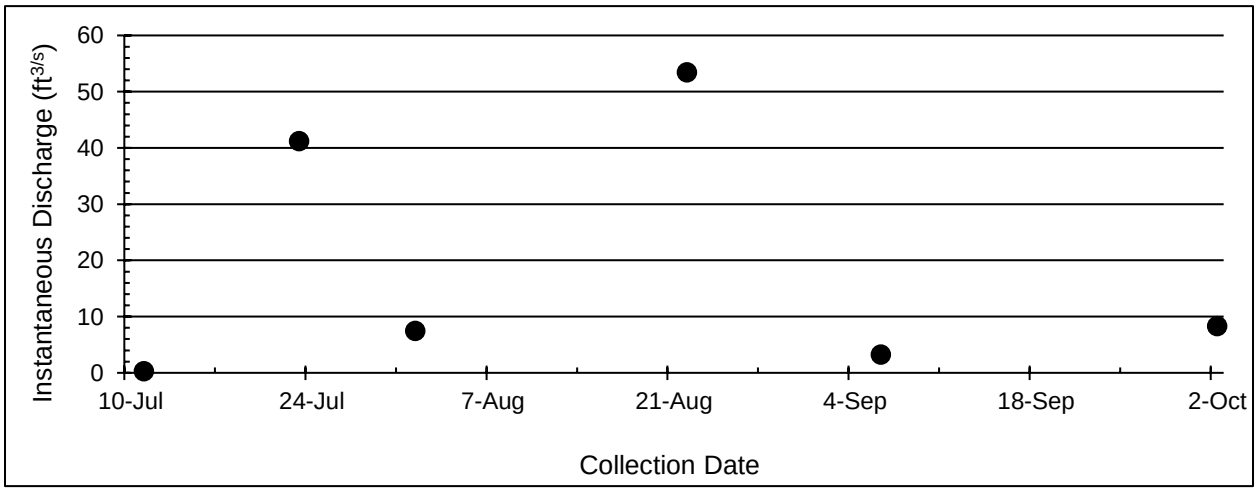
Water Quality Standard Exceedances:

Analyte	Fraction	Sample Date	Standard	Result Value	Units
Dissolved Oxygen	Dissolved	7/11/2018	< 4.0	3.4	**mg/L**

Biological Assessment Profile Score Summary:

n	Mean	Impairment Threshold	Min	Max	Std. Dev	Std. Err
4	4.85	5	4.39	5.2	0.34	0.17

Instantaneous Discharge ($ft^{3/s}$), Ramapo - 18.6. Points represent the calculated instantaneous stream discharge measured during each site visit when conditions permitted.



Kiryas-Joel Tributary 25 to Ramapo – River mile 0.3

Waterbody Class: C | WI/PWL: 1501-0037

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Aluminum	Dissolved	2	1	72.5	72.5	15	130	**µg/L**
Arsenic	Total	1	0	1	1	1	1	**µg/L**
Calcium	Total	2	N/A	20000	20000	14000	26000	**µg/L**
Copper	Dissolved	2	0	2.75	2.75	2.4	3.1	**µg/L**
Copper	Total	2	N/A	3.2	3.2	2.9	3.5	**µg/L**
Iron	Total	2	N/A	390	390	120	660	**µg/L**
Lead	Dissolved	1	0	1.1	1.1	1.1	1.1	**µg/L**
Lead	Total	1	N/A	1.5	1.5	1.5	1.5	**µg/L**
Magnesium	Total	2	N/A	4400	4400	3300	5500	**µg/L**
Manganese	Total	2	N/A	55	55	47	63	**µg/L**
Nickel	Dissolved	2	0	2.15	2.15	1.5	2.8	**µg/L**
Potassium	Total	1	N/A	6200	6200	6200	6200	**µg/L**
Sodium	Total	2	N/A	41500	41500	28000	55000	**µg/L**
Zinc	Total	1	0	8.5	8.5	8.5	8.5	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	2	N/A	50	50	42	58	**mg/L**
Dissolved Organic Carbon	Dissolved	2	N/A	7.6	7.6	5.2	10	**mg/L**
Chloride	Total	2	N/A	61.5	61.5	35	88	**mg/L**
Hardness	Total	2	N/A	67.5	67.5	48	87	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	1	N/A	0.52	0.52	0.52	0.52	**mg/L**
Nitrogen, Total	Total	1	N/A	1.6	1.6	1.6	1.6	**mg/L**
Nitrogen, Ammonia	Total	1	0	0.02	0.02	0.02	0.02	**mg/L**
Nitrogen, Nitrate	Total	2	N/A	0.81	0.81	0.52	1.1	**mg/L**
Ortho-phosphate	Dissolved	1	N/A	0.05	0.05	0.05	0.05	**mg/L**
Total Phosphorus	Total	2	N/A	0.06	0.06	0.03	0.09	**mg/L**
Sulfate	Total	1	N/A	9.2	9.2	9.2	9.2	**mg/L**
Total Dissolved Solids	Total	2	0	215	215	150	280	**mg/L**

In situ Water Quality Characteristics:

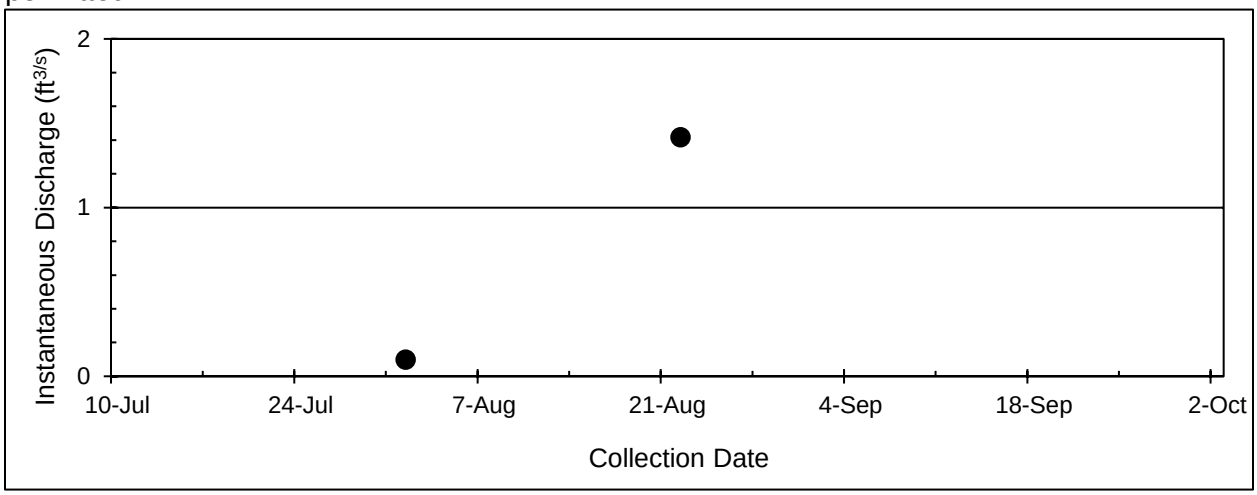
Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	2	N/A	335	335	220	450	**µS/cm**
Dissolved Oxygen	Dissolved	2	0	7.3	7.3	7.1	7.5	**mg/L**
Percent Saturation	Total	2	N/A	85	85	84	86	**std unit**
pH	Total	2	0	6.95	6.95	6.9	7	**pH units**
Salinity	Total	2	N/A	0.17	0.17	0.11	0.22	**ppm**
Water Temperature	Total	2	N/A	20.5	20.5	20	21	**deg c**

Water Quality Standard Exceedances:

Analyte	Fraction	Sample Date	Standard	Result Value	Units
Aluminum	Dissolved	8/22/2018	100	130	**µg/L**

Biological Assessment Profile Score Summary:
No benthic macroinvertebrates were collected at this location due to stream reach physical habitat.

Instantaneous Discharge ($ft^{3/s}$), Kiryas-Joel Tributary 25 to Ramapo – 0.3. Points represent the calculated instantaneous stream discharge measured during each site visit when conditions permitted.



Kiryas-Joel Tributary 25 to Ramapo – Kiryas-Joel WWTF 001

Waterbody Class: C | WI/PWL: 1501-0037

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Aluminum	Dissolved	5	N/A	40.4	26	16	110	**µg/L**
Arsenic	Total	1	N/A	1.1	1.1	1.1	1.1	**µg/L**
Calcium	Total	6	N/A	67666.7	66000	58000	81000	**µg/L**
Copper	Dissolved	6	N/A	17.4	14.5	4.3	40	**µg/L**
Copper	Total	6	N/A	17.95	14.5	4.6	40	**µg/L**
Iron	Total	2	N/A	130	130	130	130	**µg/L**
Magnesium	Total	6	N/A	20000	19500	19000	22000	**µg/L**
Manganese	Total	6	N/A	321.67	285	110	570	**µg/L**
Nickel	Dissolved	6	N/A	7.73	7.75	4.4	10	**µg/L**
Sodium	Total	6	N/A	658333	790000	110000	1200000	**µg/L**
Zinc	Dissolved	5	N/A	33.12	36	9.6	62	**µg/L**
Zinc	Total	5	N/A	34.2	38	11	61	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	6	N/A	14.2	8.2	5.6	46	**mg/L**
Dissolved Organic Carbon	Dissolved	6	N/A	4.11667	3.8	3	6.1	**mg/L**
Chloride	Total	6	N/A	1113.33	1300	220	2100	**mg/L**
Fluoride	Total	3	N/A	0.116667	0.1	0.1	0.15	**mg/L**
Hardness	Total	6	N/A	251.667	250	220	290	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	3	N/A	30.6667	34	24	34	**mg/L**
Nitrogen, Total	Total	6	N/A	31	32	24	36	**mg/L**
Nitrogen, Ammonia	Total	5	N/A	0.414	0.38	0.17	0.68	**mg/L**
Total Kjeldahl Nitrogen	Total	3	N/A	1.4	1.4	1.3	1.5	**mg/L**
Nitrogen, Nitrate	Total	6	N/A	30	31	24	34	**mg/L**
Nitrogen, Nitrite	Total	5	N/A	0.1186	0.099	0.041	0.25	**mg/L**
Ortho-phosphate	Dissolved	4	N/A	0.0899	0.022	0.0056	0.31	**mg/L**
Total Phosphorus	Total	6	N/A	0.1615	0.096	0.068	0.42	**mg/L**
Sulfate	Total	5	N/A	54	51	49	60	**mg/L**
Total Dissolved Solids	Total	6	N/A	2115	2350	630	3800	**mg/L**
Turbidity	Total	1	N/A	1.2	1.2	1.2	1.2	**ntu**

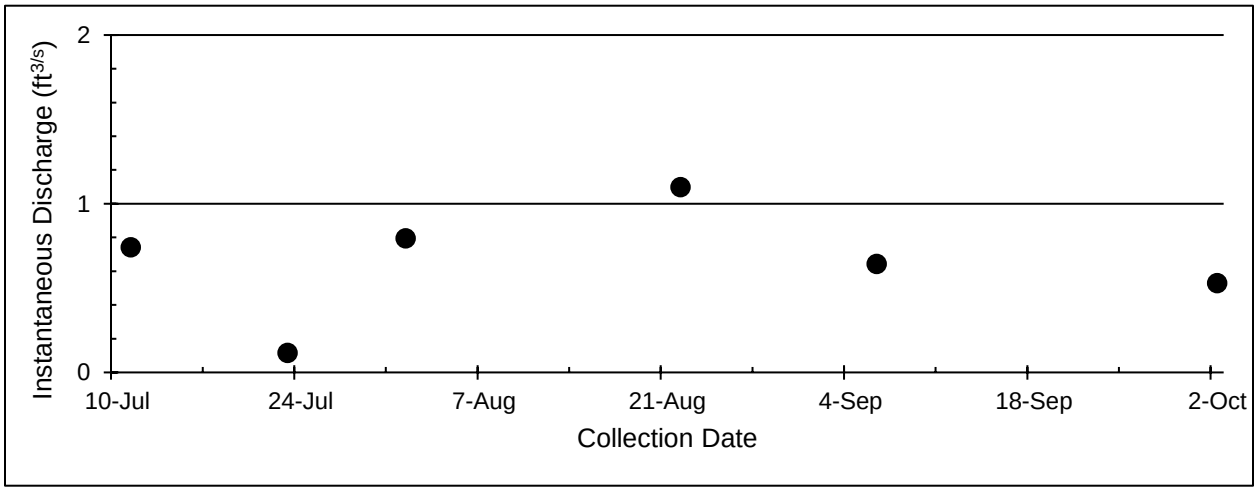
In situ Water Quality Characteristics:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	6	N/A	3733.33	4150	1100	6600	**µS/cm**
Dissolved Oxygen	Dissolved	6	N/A	7.6	7.65	6.9	8.2	**mg/L**
Percent Saturation	Total	6	N/A	91.5	92	82	100	**std unit**
pH	Total	6	N/A	6.93	6.95	6.6	7.2	**pH units**
Salinity	Total	6	N/A	2.00	2.2	0.56	3.6	**ppm**
Water temperature	Total	6	N/A	23.5	23.5	21	26	**deg c**

Water Quality Standard Exceedances:
Water quality standards are not applicable due to this sampling location occurring at the point at which a WWTF outfall discharges into the stream.

Biological Assessment Profile Score Summary:
No benthic macroinvertebrates were collected at this location due to stream reach physical habitat.

Instantaneous Discharge ($ft^{3/s}$), Kiryas-Joel Tributary 25 to Ramapo – Kiryas-Joel WWTF 001 (KJSTP-001). Points represent the calculated instantaneous stream discharge measured during each site visit when conditions permitted.



Kiryas-Joel Tributary 25 to Ramapo – River mile 0.2

Waterbody Class: C | WI/PWL: 1501-0037

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Aluminum	Dissolved	5	1	56.2	21	13	160	**µg/L**
Arsenic	Total	1	0	1.2	1.2	1.2	1.2	**µg/L**
Calcium	Total	6	N/A	56666.7	62500	31000	81000	**µg/L**
Copper	Dissolved	6	1	13.32	11.45	3.9	34	**µg/L**
Copper	Total	6	N/A	14.83	13	4.1	37	**µg/L**
Iron	Total	5	N/A	352	230	100	830	**µg/L**
Lead	Dissolved	1	0	1	1	1	1	**µg/L**
Lead	Total	1	N/A	1.6	1.6	1.6	1.6	**µg/L**
Magnesium	Total	6	N/A	16333.3	18000	9100	22000	**µg/L**
Manganese	Total	6	N/A	258.67	225	92	510	**µg/L**
Nickel	Dissolved	6	0	6.32	5.5	3.6	9.8	**µg/L**
Potassium	Total	1	N/A	32000	32000	32000	32000	**µg/L**
Sodium	Total	6	N/A	555000	575000	77000	1200000	**µg/L**
Zinc	Dissolved	5	0	23.42	21	6.1	42	**µg/L**
Zinc	Total	5	N/A	26.8	25	11	45	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	6	N/A	24.1	23	6.8	47	**mg/L**
Dissolved Organic Carbon	Dissolved	6	N/A	5.3	4.5	2.9	8.3	**mg/L**
Chloride	Total	6	N/A	898.33	880	140	2000	**mg/L**
Fluoride	Total	1	0	0.1	0.1	0.1	0.1	**mg/L**
Hardness	Total	6	N/A	210	235	120	290	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	3	N/A	22.63	26	7.9	34	**mg/L**
Nitrogen, Total	Total	6	N/A	22.83	27	9	35	**mg/L**
Nitrogen, Ammonia	Total	4	0	0.38	0.33	0.19	0.68	**mg/L**
Total Kjeldahl Nitrogen	Total	3	N/A	1.17	1.2	1	1.3	**mg/L**
Nitrogen, Nitrate	Total	6	N/A	21.72	26	7.9	34	**mg/L**
Nitrogen, Nitrite	Total	5	3	0.10	0.11	0.03	0.18	**mg/L**
Ortho-phosphate	Dissolved	3	N/A	0.07	0.04	0.02	0.16	**mg/L**
Total Phosphorus	Total	6	N/A	0.12	0.10	0.06	0.23	**mg/L**
Sulfate	Total	5	N/A	42.6	44	23	57	**mg/L**
Total Dissolved Solids	Total	6	5	1701.67	1700	360	3600	**mg/L**
Turbidity	Total	2	N/A	5.7	5.7	1.4	10	**ntu**

In situ Water Quality Characteristics:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	6	N/A	3091.67	2850	960	6300	**µS/cm**
Dissolved Oxygen	Dissolved	6	0	6.45	6.35	6.2	6.9	**mg/L**
Percent Saturation	Total	6	N/A	77	78	71	81	**std unit**
pH	Total	6	0	7.18	7.2	7	7.3	**pH units**
Salinity	Total	6	N/A	1.65	1.51	0.47	3.4	**ppm**
Water temperature	Total	6	N/A	22.5	22.5	20	25	**deg c**

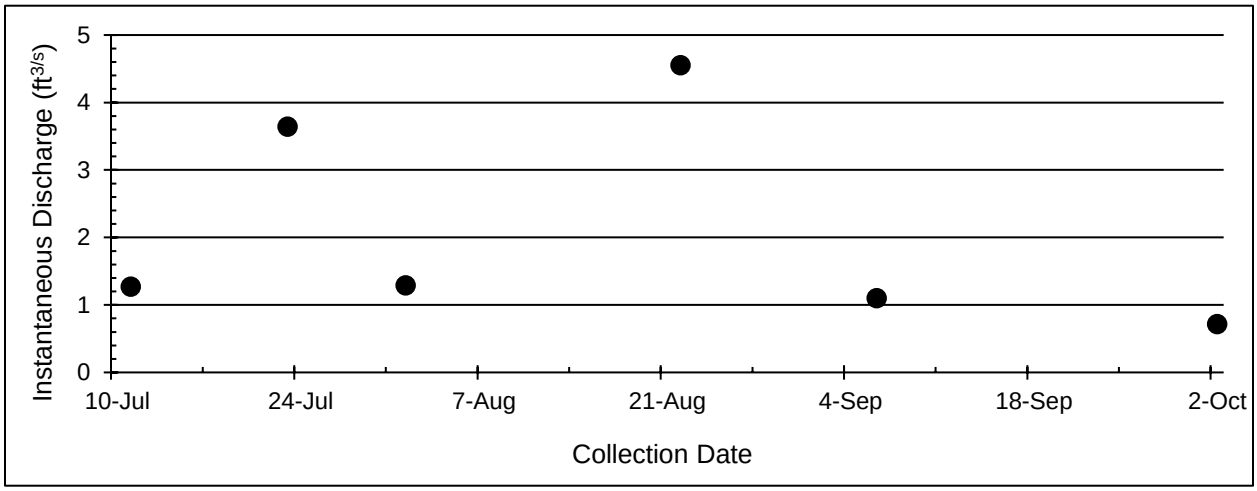
Water Quality Standard Exceedances:

Analyte	Fraction	Sample Date	Standard	Result Value	Units
Aluminum	Dissolved	8/22/2018	100	160	**µg/L**
Copper	Dissolved	9/6/2018	22.44	34	**µg/L**
Nitrogen, Nitrite	Total	7/11/2018	0.1	0.11	**mg/L**
Nitrogen, Nitrite	Total	9/6/2018	0.1	0.15	**mg/L**
Nitrogen, Nitrite	Total	10/2/2018	0.1	0.18	**mg/L**
Total Dissolved Solids	Total	7/11/2018	500	2300	**mg/L**
Total Dissolved Solids	Total	8/1/2018	500	2300	**mg/L**
Total Dissolved Solids	Total	8/22/2018	500	1100	**mg/L**
Total Dissolved Solids	Total	9/6/2018	500	3600	**mg/L**
Total Dissolved Solids	Total	10/2/2018	500	550	**mg/L**

Biological Assessment Profile Score Summary:

n	Mean	Impairment Threshold	Min	Max	Std. Dev	Std. Err
4	4.04	5	3.65	4.2	0.26	0.13

Instantaneous Discharge ($ft^{3/s}$), Kiryas-Joel Tributary 25 to Ramapo – 0.2. Points represent the calculated instantaneous stream discharge measured during each site visit when conditions permitted.



Ramapo River – River mile 16.8

Waterbody Class: B | WI/PWL: 1501-0037

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Aluminum	Dissolved	2	0	64	64	40	88	**µg/L**
Arsenic	Total	2	0	1.5	1.5	1.5	1.5	**µg/L**
Calcium	Total	6	N/A	45666.7	41500	29000	81000	**µg/L**
Copper	Dissolved	6	0	4.07	3.55	3	7.4	**µg/L**
Copper	Total	6	N/A	5.08	4.75	3.2	8.2	**µg/L**
Iron	Total	5	N/A	932	470	290	1900	**µg/L**
Lead	Total	2	N/A	2.4	2.4	2.4	2.4	**µg/L**
Magnesium	Total	6	N/A	12016.7	10500	7100	23000	**µg/L**
Manganese	Total	6	N/A	179.83	170	69	330	**µg/L**
Nickel	Dissolved	5	0	1.8	1.4	1	3.9	**µg/L**
Potassium	Total	1	N/A	4600	4600	4600	4600	**µg/L**
Sodium	Total	6	N/A	148333	86500	64000	420000	**µg/L**
Zinc	Dissolved	1	0	5.9	5.9	5.9	5.9	**µg/L**
Zinc	Total	3	N/A	11.3	11	6.9	16	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	6	N/A	100.83	104	76	120	**mg/L**
Dissolved Organic Carbon	Dissolved	6	N/A	5.78	5.35	4.7	7.3	**mg/L**
Chloride	Total	6	N/A	289.5	205	97	740	**mg/L**
Fluoride	Total	1	0	0.11	0.11	0.11	0.11	**mg/L**
Hardness	Total	6	N/A	165	150	100	300	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	3	N/A	0.79	0.49	0.17	1.7	**mg/L**
Nitrogen, Total	Total	4	N/A	5.5	2.85	1.3	15	**mg/L**
Nitrogen, Ammonia	Total	3	0	0.04	0.02	0.02	0.06	**mg/L**
Total Kjeldahl Nitrogen	Total	2	N/A	0.67	0.67	0.64	0.69	**mg/L**
Nitrogen, Nitrate	Total	6	N/A	3.47	1.18	0.16	15	**mg/L**
Nitrogen, Nitrite	Total	2	0	0.02	0.02	0.01	0.04	**mg/L**
Ortho-phosphate	Dissolved	4	N/A	0.03	0.03	0.03	0.04	**mg/L**
Total Phosphorus	Total	6	N/A	0.07	0.05	0.03	0.13	**mg/L**
Sulfate	Total	5	N/A	19.1	15	9.5	40	**mg/L**
Total Dissolved Solids	Total	5	2	480	390	260	810	**mg/L**
Turbidity	Total	2	N/A	15.45	15.45	2.9	28	**ntu**

In situ Water Quality Characteristics:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	6	N/A	1201.67	945	540	2700	**µS/cm**
Dissolved Oxygen	Dissolved	6	0	7.68	7.7	6.6	8.6	**mg/L**
Percent Saturation	Total	6	N/A	87.17	88	79	94	**std unit**
pH	Total	6	0	7.65	7.75	7.2	7.8	**pH units**
Salinity	Total	6	N/A	0.61	0.46	0.26	1.4	**ppm**
Water temperature	Total	6	N/A	21.5	22	16	24	**deg c**

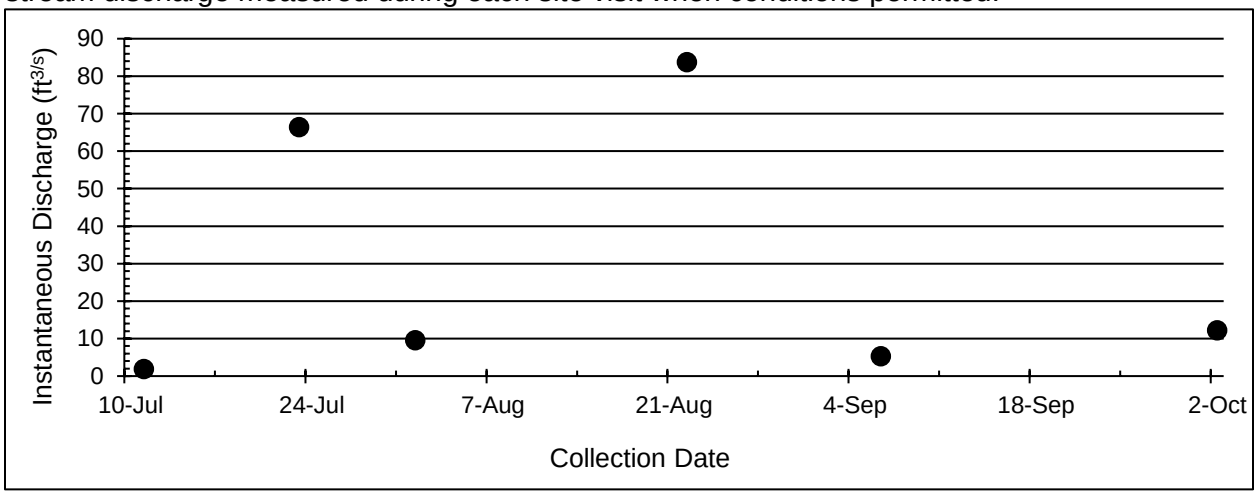
Water Quality Standard Exceedances:

Analyte	Fraction	Sample Date	Standard	Result Value	Units
Total Dissolved Solids	Total	8/1/2018	500	620	**mg/L**
Total Dissolved Solids	Total	9/6/2018	500	810	**mg/L**

Biological Assessment Profile Score Summary:

n	Mean	Impairment Threshold	Min	Max	Std. Dev	Std. Err
4	5.6	5	5.55	5.69	0.06	0.03

Instantaneous Discharge ($ft^{3/s}$), Ramapo – 16.8. Points represent the calculated instantaneous stream discharge measured during each site visit when conditions permitted.



Ramapo River – River mile 16.7

Waterbody Class: B | WI/PWL: 1501-0037

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Aluminum	Dissolved	3	0	16.67	12	12	26	**µg/L**
Arsenic	Total	3	0	1.73	1.9	1.4	1.9	**µg/L**
Calcium	Total	5	N/A	46800	46000	41000	55000	**µg/L**
Copper	Dissolved	5	0	4.36	4	2.9	6.9	**µg/L**
Copper	Total	5	N/A	5.42	4.8	3.3	10	**µg/L**
Iron	Total	4	N/A	892.5	580	410	2000	**µg/L**
Lead	Total	2	N/A	2.5	2.5	1.6	3.4	**µg/L**
Magnesium	Total	5	N/A	13000	12000	10000	16000	**µg/L**
Manganese	Total	5	N/A	178	180	110	250	**µg/L**
Nickel	Dissolved	5	0	1.82	1.7	1.4	2.4	**µg/L**
Sodium	Total	5	N/A	157600	130000	78000	240000	**µg/L**
Zinc	Dissolved	1	0	7.4	7.4	7.4	7.4	**µg/L**
Zinc	Total	3	N/A	10.43	5.8	5.5	20	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	5	N/A	113.2	120	96	120	**mg/L**
Dissolved Organic Carbon	Dissolved	5	N/A	5.7	5.8	5	6.2	**mg/L**
Chloride	Total	5	N/A	268	220	130	430	**mg/L**
Fluoride	Total	4	0	0.11	0.11	0.1	0.12	**mg/L**
Hardness	Total	5	N/A	168	160	140	200	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	3	N/A	2.4	2.2	1.4	3.6	**mg/L**
Nitrogen, Total	Total	5	N/A	3.32	2.8	2	4.7	**mg/L**
Nitrogen, Ammonia	Total	2	0	0.06	0.06	0.05	0.06	**mg/L**
Total Kjeldahl Nitrogen	Total	1	N/A	1.2	1.2	1.2	1.2	**mg/L**
Nitrogen, Nitrate	Total	5	N/A	2.46	2.2	1.4	3.6	**mg/L**
Nitrogen, Nitrite	Total	3	0	0.04	0.03	0.02	0.09	**mg/L**
Ortho-phosphate	Dissolved	1	N/A	0.02	0.02	0.02	0.02	**mg/L**
Total Phosphorus	Total	5	N/A	0.06	0.06	0.04	0.07	**mg/L**
Sulfate	Total	5	N/A	18.4	17	13	28	**mg/L**
Total Dissolved Solids	Total	5	4	612	540	390	840	**mg/L**
Turbidity	Total	2	N/A	4.1	4.1	3.5	4.7	**ntu**

In situ Water Quality Characteristics:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	5	N/A	1114	940	650	1700	**µS/cm**
Dissolved Oxygen	Dissolved	5	0	9.32	9	7.6	12	**mg/L**
Percent Saturation	Total	5	N/A	113.8	110	94	150	**std unit**
pH	Total	5	2	8.36	7.9	7.9	9.3	**pH units**
Salinity	Total	5	N/A	0.55	0.46	0.32	0.84	**ppm**
Water temperature	Total	5	N/A	25.2	25	17	30	**deg c**

Water Quality Standard Exceedances:

Analyte	Fraction	Sample Date	Standard	Result Value	Units
PH	Total	7/10/2018	8.5-6.5	9.3	**pH units**
PH	Total	9/5/2018	8.5-6.5	8.8	**pH units**
Total Dissolved Solids	Total	7/10/2018	500	840	**mg/L**
Total Dissolved Solids	Total	7/31/2018	500	540	**mg/L**
Total Dissolved Solids	Total	8/21/2018	500	500	**mg/L**
Total Dissolved Solids	Total	9/5/2018	500	790	**mg/L**

Biological Assessment Profile Score Summary:
No benthic macroinvertebrates were collected at this location due to stream reach physical habitat.

Instantaneous Discharge ($ft^{3/s}$), Ramapo – 16.7.
No flow data acquired at this sampling location due to influence of dam weir and stream braiding.

Ramapo River – Orange County STP 001

Waterbody Class: C | WI/PWL: 1501-0037

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Calcium	Total	5	N/A	62400	62000	58000	67000	**µg/L**
Copper	Dissolved	5	N/A	15.4	15	14	17	**µg/L**
Copper	Total	5	N/A	16.2	16	15	18	**µg/L**
Magnesium	Total	5	N/A	16200	16000	14000	20000	**µg/L**
Manganese	Total	5	N/A	23.4	23	14	40	**µg/L**
Nickel	Dissolved	5	N/A	2.82	2.8	2.5	3.1	**µg/L**
Sodium	Total	5	N/A	148000	150000	140000	160000	**µg/L**
Zinc	Dissolved	4	N/A	34.5	32	25	49	**µg/L**
Zinc	Total	4	N/A	35.25	33	26	49	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	5	N/A	107.8	110	99	110	**mg/L**
Dissolved Organic Carbon	Dissolved	5	N/A	7.2	6.8	6.6	8.2	**mg/L**
Chloride	Total	5	N/A	252	250	240	270	**mg/L**
Fluoride	Total	5	N/A	0.12	0.12	0.12	0.13	**mg/L**
Hardness	Total	5	N/A	222	220	200	250	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	3	N/A	17	17	16	18	**mg/L**
Nitrogen, Total	Total	5	N/A	18.2	19	16	20	**mg/L**
Nitrogen, Ammonia	Total	3	N/A	0.14	0.08	0.06	0.3	**mg/L**
Total Kjeldahl Nitrogen	Total	2	N/A	1.2	1.2	1.2	1.2	**mg/L**
Nitrogen, Nitrate	Total	5	N/A	16.6	17	15	18	**mg/L**
Nitrogen, Nitrite	Total	4	N/A	0.06	0.04	0.01	0.14	**mg/L**
Ortho-phosphate	Dissolved	2	N/A	2.75	2.75	2.3	3.2	**mg/L**
Total Phosphorus	Total	5	N/A	2.86	3.2	2.1	3.4	**mg/L**
Sulfate	Total	4	N/A	39.25	38	36	45	**mg/L**
Total Dissolved Solids	Total	5	N/A	700	710	650	740	**mg/L**
Turbidity	Total	1	N/A	1.3	1.3	1.3	1.3	**ntu**

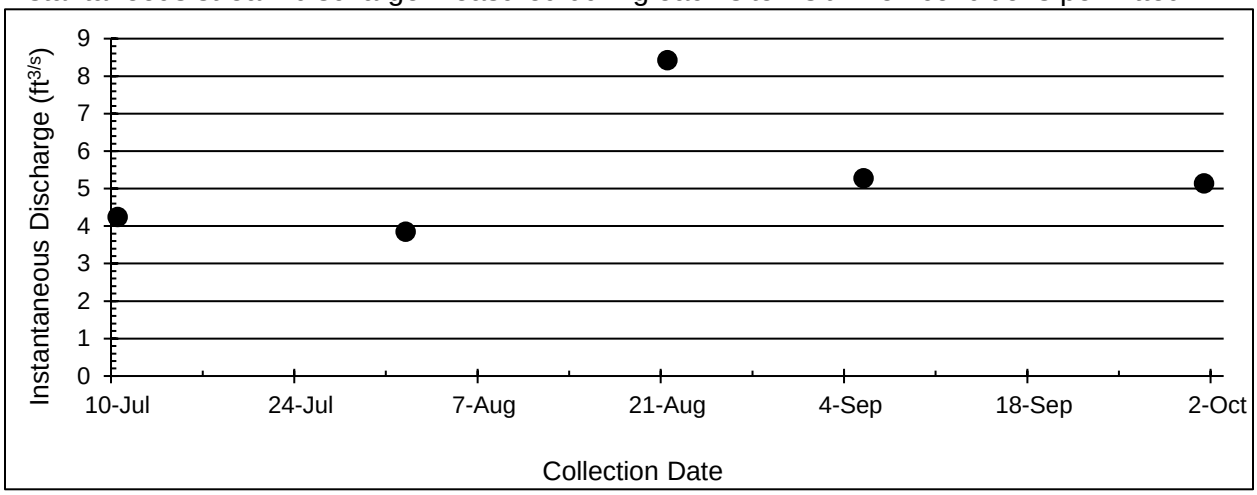
In situ Water Quality Characteristics:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	5	N/A	1200	1200	1100	1400	**µS/cm**
Dissolved Oxygen	Dissolved	5	N/A	8.32	8.4	7.8	8.5	**mg/L**
Percent Saturation	Total	5	N/A	97.8	100	92	100	**std unit**
pH	Total	5	N/A	7.4	7.4	7.2	7.6	**pH units**
Salinity	Total	5	N/A	0.60	0.61	0.54	0.7	**ppm**
Water temperature	Total	5	N/A	22.6	23	21	24	**deg c**

Water Quality Standard Exceedances:
Water quality standards are not applicable due to this sampling location occurring at the point at which a WWTF outfall discharges into the stream.

Biological Assessment Profile Score Summary:
No benthic macroinvertebrates were collected at this location due to stream reach physical habitat.

Instantaneous Discharge ($ft^{3/s}$), Orange County STP 001. Points represent the calculated instantaneous stream discharge measured during each site visit when conditions permitted.



Ramapo River – River mile 16.5

Waterbody Class: C | WI/PWL: 1501-0037

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Aluminum	Dissolved	1	0	11	11	11	11	**µg/L**
Arsenic	Total	2	0	1.1	1.1	1	1.2	**µg/L**
Calcium	Total	5	N/A	56200	53000	47000	66000	**µg/L**
Copper	Dissolved	5	0	10.5	8.6	7.6	14	**µg/L**
Copper	Total	5	N/A	11.58	9.7	8.1	16	**µg/L**
Iron	Total	4	N/A	282.5	290	190	360	**µg/L**
Lead	Total	1	N/A	1.2	1.2	1.2	1.2	**µg/L**
Magnesium	Total	5	N/A	14800	14000	11000	20000	**µg/L**
Manganese	Total	5	N/A	75.6	66	35	120	**µg/L**
Nickel	Dissolved	5	0	2.32	2	1.8	3	**µg/L**
Sodium	Total	5	N/A	140000	140000	100000	170000	**µg/L**
Zinc	Dissolved	4	0	24.25	25.5	11	35	**µg/L**
Zinc	Total	4	N/A	26.75	27	13	40	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	5	N/A	114	110	110	120	**mg/L**
Dissolved Organic Carbon	Dissolved	5	N/A	6.68	6.3	6	7.9	**mg/L**
Chloride	Total	5	N/A	244	240	170	300	**mg/L**
Fluoride	Total	5	0	0.12	0.11	0.11	0.13	**mg/L**
Hardness	Total	5	N/A	202	190	160	250	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	3	N/A	9.6	8.1	7.7	13	**mg/L**
Nitrogen, Total	Total	5	N/A	11.86	10	8.5	18	**mg/L**
Nitrogen, Ammonia	Total	2	0	0.08	0.08	0.07	0.10	**mg/L**
Total Kjeldahl Nitrogen	Total	1	N/A	1.2	1.2	1.2	1.2	**mg/L**
Nitrogen, Nitrate	Total	5	N/A	11	9.2	7.7	17	**mg/L**
Nitrogen, Nitrite	Total	4	0	0.03	0.04	0.01	0.05	**mg/L**
Ortho-phosphate	Dissolved	3	N/A	1.43	1.2	0.98	2.1	**mg/L**
Total Phosphorus	Total	5	N/A	1.72	1.3	0.92	2.9	**mg/L**
Sulfate	Total	5	N/A	31.4	33	23	44	**mg/L**
Total Dissolved Solids	Total	5	4	634	620	480	750	**mg/L**

In situ Water Quality Characteristics:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	5	N/A	1200	1200	1100	1400	**µS/cm**
Dissolved Oxygen	Dissolved	5	0	8.32	8.4	7.8	8.5	**mg/L**
Percent Saturation	Total	5	N/A	97.8	100	92	100	**std unit**
pH	Total	5	0	7.4	7.4	7.2	7.6	**pH units**
Salinity	Total	5	N/A	0.60	0.61	0.54	0.7	**ppm**
Water temperature	Total	5	N/A	22.6	23	21	24	**deg c**

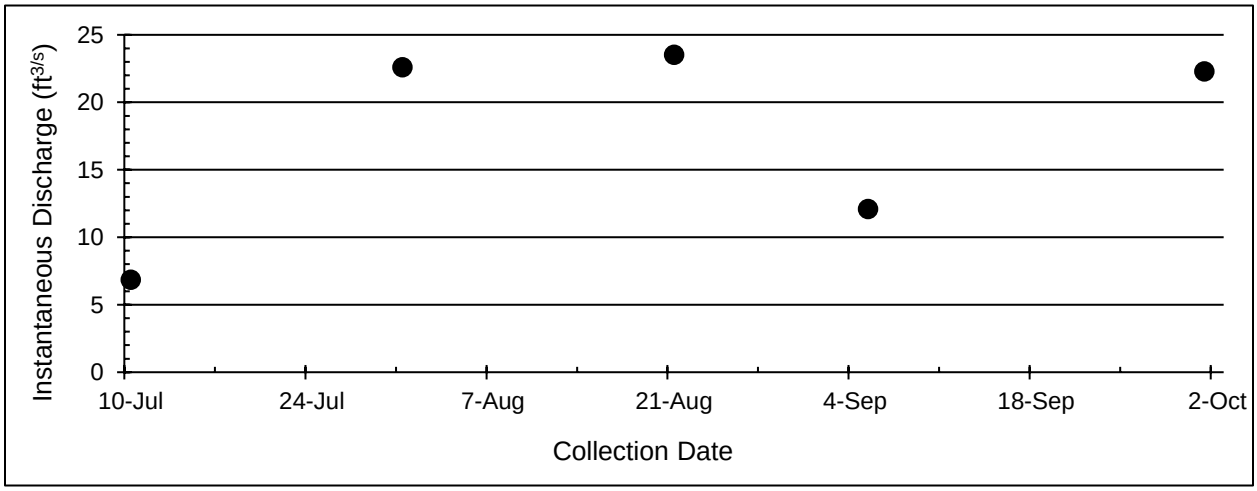
Water Quality Standard Exceedances:

Analyte	Fraction	Sample Date	Standard	Result Value	Units
Total Dissolved Solids	Total	7/10/2018	500	740	**mg/L**
Total Dissolved Solids	Total	7/31/2018	500	620	**mg/L**
Total Dissolved Solids	Total	8/21/2018	500	580	**mg/L**
Total Dissolved Solids	Total	9/5/2018	500	750	**mg/L**

Biological Assessment Profile Score Summary:

n	Mean	Impairment Threshold	Min	Max	Std. Dev	Std. Err
4	3.6	5	3.4	3.84	0.19	0.09

Instantaneous Discharge ($ft^{3/s}$), Ramapo – 16.5. Points represent the calculated instantaneous stream discharge measured during each site visit when conditions permitted.



Ramapo River – River mile 16.1

Waterbody Class: C | WI/PWL: 1501-0037

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Aluminum	Dissolved	1	0	10	10	10	10	**µg/L**
Arsenic	Total	2	0	1.1	1.1	1.1	1.1	**µg/L**
Calcium	Total	5	N/A	55400	54000	45000	65000	**µg/L**
Copper	Dissolved	5	0	9.34	8	6.1	13	**µg/L**
Copper	Total	5	N/A	10.2	9.2	6.7	14	**µg/L**
Iron	Total	4	N/A	255	275	120	350	**µg/L**
Lead	Total	1	N/A	1.1	1.1	1.1	1.1	**µg/L**
Magnesium	Total	5	N/A	14800	14000	11000	20000	**µg/L**
Manganese	Total	5	N/A	87.2	80	58	130	**µg/L**
Nickel	Dissolved	5	0	2.24	2.1	1.7	3	**µg/L**
Sodium	Total	5	N/A	141000	140000	95000	170000	**µg/L**
Zinc	Dissolved	4	0	21.3	21	9.2	34	**µg/L**
Zinc	Total	4	N/A	23	23	11	35	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	5	N/A	114	110	110	120	**mg/L**
Dissolved Organic Carbon	Dissolved	5	N/A	6.72	6.5	5.9	8.3	**mg/L**
Chloride	Total	5	N/A	240	240	160	300	**mg/L**
Fluoride	Total	5	0	0.11	0.11	0.1	0.13	**mg/L**
Hardness	Total	5	N/A	200	190	160	240	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	3	N/A	8.47	7.1	6.3	12	**mg/L**
Nitrogen, Total	Total	5	N/A	10.76	8.8	7	17	**mg/L**
Nitrogen, Ammonia	Total	2	0	0.10	0.10	0.09	0.12	**mg/L**
Total Kjeldahl Nitrogen	Total	1	N/A	1.1	1.1	1.1	1.1	**mg/L**
Nitrogen, Nitrate	Total	5	N/A	9.8	7.8	6.2	16	**mg/L**
Nitrogen, Nitrite	Total	4	0	0.03	0.03	0.02	0.06	**mg/L**
Ortho-phosphate	Dissolved	3	N/A	1.24	1	0.91	1.8	**mg/L**
Total Phosphorus	Total	5	N/A	1.47	1.1	0.63	2.6	**mg/L**
Sulfate	Total	5	N/A	31	29	24	45	**mg/L**
Total Dissolved Solids	Total	5	4	624	620	450	740	**mg/L**
Turbidity	Total	1	N/A	1.2	1.2	1.2	1.2	**ntu**

In situ Water Quality Characteristics:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	5	N/A	1114	1100	790	1400	**µS/cm**
Dissolved Oxygen	Dissolved	5	0	7.78	8	6.6	8.7	**mg/L**
Percent Saturation	Total	5	N/A	93.4	94	80	110	**std unit**
pH	Total	5	0	7.54	7.5	7.4	7.7	**pH units**
Salinity	Total	5	N/A	0.55	0.53	0.39	0.7	**ppm**
Water temperature	Total	5	N/A	23.2	23	19	26	**deg c**

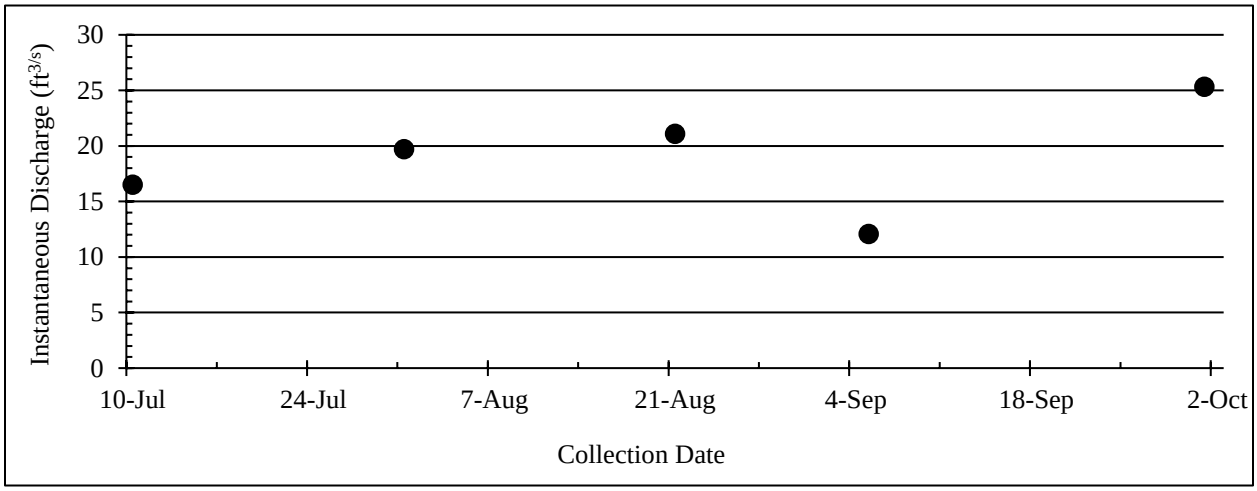
Water Quality Standard Exceedances:

Analyte	Fraction	Sample Date	Standard	Result Value	Units
Total Dissolved Solids	Total	7/10/2018	500	740	**mg/L**
Total Dissolved Solids	Total	7/31/2018	500	620	**mg/L**
Total Dissolved Solids	Total	8/21/2018	500	570	**mg/L**
Total Dissolved Solids	Total	9/5/2018	500	740	**mg/L**

Biological Assessment Profile Score Summary:

n	Mean	Impairment Threshold	Min	Max	Std. Dev	Std. Err
2	3.8	5	3.78	3.83	0.04	0.03

Instantaneous Discharge ($ft^{3/s}$), Ramapo – 16.1. Points represent the calculated instantaneous stream discharge measured during each site visit when conditions permitted.



Ramapo River – River mile 13.3

Waterbody Class: A(T) | WI/PWL: 1501-0036

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Arsenic	Total	2	0	1.3	1.3	1.3	1.3	**µg/L**
Calcium	Total	5	N/A	52400	51000	44000	61000	**µg/L**
Copper	Dissolved	5	0	6.32	5.4	3.9	9.2	**µg/L**
Copper	Total	5	0	6.96	6	4.8	10	**µg/L**
Iron	Total	4	2	330	325	200	470	**µg/L**
Lead	Total	1	0	1	1	1	1	**µg/L**
Magnesium	Total	5	0	14200	13000	11000	18000	**µg/L**
Manganese	Total	5	0	97.6	75	41	170	**µg/L**
Nickel	Dissolved	5	0	1.84	1.8	1.3	2.5	**µg/L**
Sodium	Total	5	N/A	120800	120000	84000	140000	**µg/L**
Zinc	Dissolved	4	0	14.98	14.1	5.7	26	**µg/L**
Zinc	Total	4	N/A	18.08	17.9	7.5	29	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	5	N/A	120	120	110	130	**mg/L**
Dissolved Organic Carbon	Dissolved	5	N/A	5.84	5.7	5.1	6.8	**mg/L**
Chloride	Total	5	2	206	200	130	270	**mg/L**
Fluoride	Total	5	0	0.12	0.12	0.11	0.13	**mg/L**
Hardness	Total	5	N/A	188	180	150	230	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	3	0	5.4	4.1	3.8	8.3	**mg/L**
Nitrogen, Total	Total	5	N/A	7.34	4.8	4.4	14	**mg/L**
Nitrogen, Ammonia	Total	2	0	0.06	0.06	0.06	0.06	**mg/L**
Total Kjeldahl Nitrogen	Total	1	N/A	0.96	0.96	0.96	0.96	**mg/L**
Nitrogen, Nitrate	Total	5	1	6.54	4	3.6	13	**mg/L**
Nitrogen, Nitrite	Total	5	3	0.04	0.04	0.02	0.05	**mg/L**
Ortho-phosphate	Dissolved	3	N/A	0.73	0.47	0.41	1.3	**mg/L**
Total Phosphorus	Total	5	N/A	0.98	0.64	0.37	2	**mg/L**
Sulfate	Total	5	0	26	23	19	39	**mg/L**
Total Dissolved Solids	Total	5	4	550	520	410	670	**mg/L**

In situ Water Quality Characteristics:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	5	N/A	956	920	700	1200	**µS/cm**
Dissolved Oxygen	Dissolved	5	0	8.9	9.1	7.2	9.8	**mg/L**
Percent Saturation	Total	5	N/A	100.6	110	81	110	**std unit**
pH	Total	5	0	7.54	7.5	7.3	7.8	**pH units**
Salinity	Total	5	N/A	0.48	0.45	0.34	0.62	**ppm**
Water temperature	Total	5	N/A	21	21	17	24	**deg c**

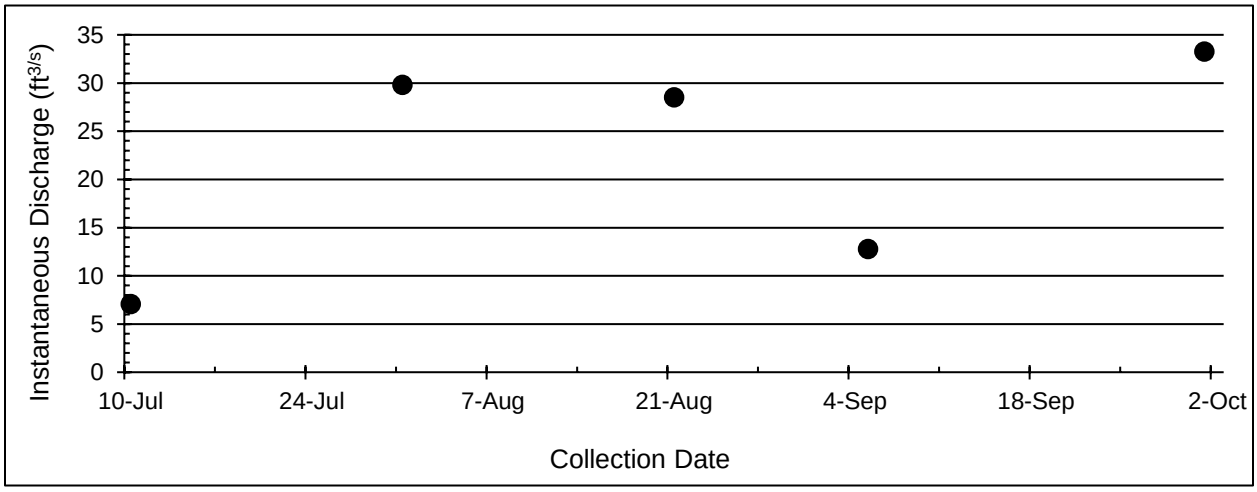
Water Quality Standard Exceedances:

Analyte	Fraction	Sample Date	Standard	Result Value	Units
Chloride	Total	7/10/2018	250	270	**mg/L**
Chloride	Total	9/5/2018	250	250	**mg/L**
Iron	Total	7/31/2018	300	430	**µg/L**
Iron	Total	8/21/2018	300	470	**µg/L**
Nitrogen, Nitrate	Total	7/10/2018	10	13	**mg/L**
Nitrogen, Nitrite	Total	7/10/2018	0.02	0.054	**mg/L**
Nitrogen, Nitrite	Total	7/31/2018	0.02	0.04	**mg/L**
Nitrogen, Nitrite	Total	9/5/2018	0.02	0.045	**mg/L**
Total Dissolved Solids	Total	7/10/2018	500	670	**mg/L**
Total Dissolved Solids	Total	7/31/2018	500	520	**mg/L**
Total Dissolved Solids	Total	8/21/2018	500	500	**mg/L**
Total Dissolved Solids	Total	9/5/2018	500	650	**mg/L**

Biological Assessment Profile Score Summary:

n	Mean	Impairment Threshold	Min	Max	Std. Dev	Std. Err
4	4.94	5	4.59	5.25	0.28	0.14

Instantaneous Discharge ($ft^{3/s}$), Ramapo – 13.3. Points represent the calculated instantaneous stream discharge measured during each site visit when conditions permitted.



Ramapo River – River mile 11.8

Waterbody Class: A(T) | WI/PWL: 1501-0036

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Aluminum	Dissolved	1	0	14	14	14	14	**µg/L**
Calcium	Total	5	N/A	40200	40000	27000	54000	**µg/L**
Copper	Dissolved	5	0	5.22	4.4	2.8	8.7	**µg/L**
Copper	Total	5	0	5.5	4.9	3	9.1	**µg/L**
Iron	Total	4	2	262.5	280	110	380	**µg/L**
Magnesium	Total	5	0	10880	10000	7000	16000	**µg/L**
Manganese	Total	5	0	48.6	36	32	74	**µg/L**
Nickel	Dissolved	4	0	1.65	1.5	1.3	2.3	**µg/L**
Sodium	Total	5	N/A	92200	90000	52000	130000	**µg/L**
Zinc	Dissolved	2	0	16.5	16.5	14	19	**µg/L**
Zinc	Total	3	N/A	13.83	14	7.5	20	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	5	N/A	95	100	73	110	**mg/L**
Dissolved Organic Carbon	Dissolved	5	N/A	4.92	4.9	4.7	5.1	**mg/L**
Chloride	Total	5	0	156.8	140	84	240	**mg/L**
Fluoride	Total	5	0	0.11	0.12	0.1	0.13	**mg/L**
Hardness	Total	5	N/A	145.2	140	96	200	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	3	0	4.2	3.4	2.3	6.9	**mg/L**
Nitrogen, Total	Total	5	N/A	5.98	4	2.8	12	**mg/L**
Nitrogen, Ammonia	Total	1	0	0.05	0.05	0.05	0.05	**mg/L**
Total Kjeldahl Nitrogen	Total	1	N/A	0.86	0.86	0.86	0.86	**mg/L**
Nitrogen, Nitrate	Total	5	1	5.34	3.4	2.3	11	**mg/L**
Nitrogen, Nitrite	Total	3	1	0.02	0.02	0.01	0.022	**mg/L**
Ortho-phosphate	Dissolved	3	N/A	0.50	0.43	0.21	0.87	**mg/L**
Total Phosphorus	Total	5	N/A	0.75	0.43	0.22	1.7	**mg/L**
Sulfate	Total	5	0	20.6	17	13	34	**mg/L**
Total Dissolved Solids	Total	5	2	420	390	260	590	**mg/L**
Turbidity	Total	1	N/A	2.1	2.1	2.1	2.1	**ntu**

In situ Water Quality Characteristics:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	5	N/A	758	690	470	1100	**µS/cm**
Dissolved Oxygen	Dissolved	5	0	9.82	10	8.4	12	**mg/L**
Percent Saturation	Total	5	N/A	112.8	110	89	150	**std unit**
pH	Total	5	0	7.8	7.7	7.4	8.3	**pH units**
Salinity	Total	5	N/A	0.38	0.34	0.23	0.56	**ppm**
Water temperature	Total	5	N/A	20.6	21	16	23	**deg c**

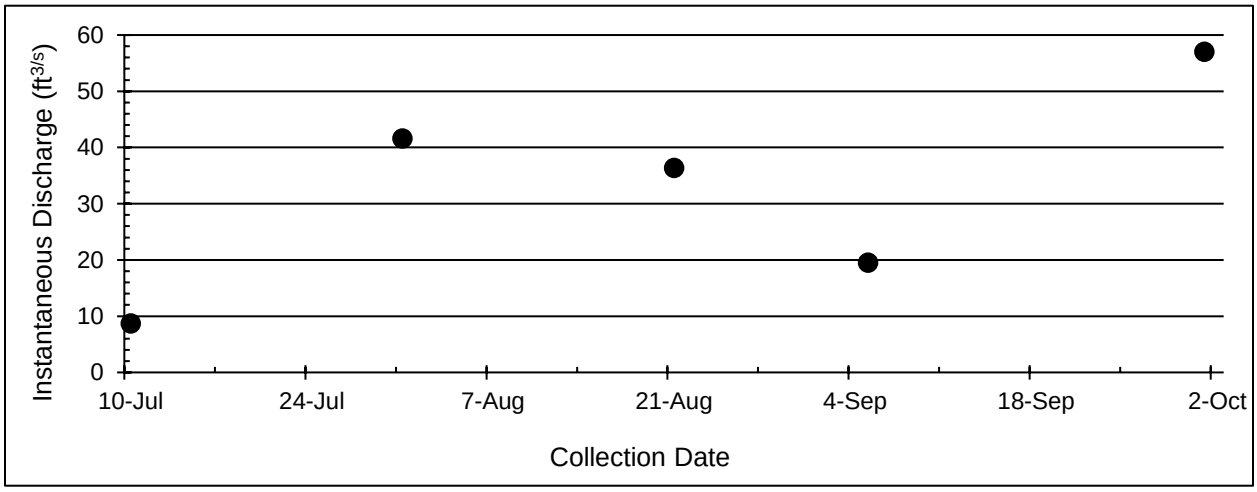
Water Quality Standard Exceedances:

Analyte	Fraction	Sample Date	Standard	Result Value	Units
Iron	Total	7/31/2018	300	320	**µg/L**
Iron	Total	8/21/2018	300	380	**µg/L**
Nitrogen, Nitrate	Total	7/10/2018	10	11	**mg/L**
Nitrogen, Nitrite	Total	7/31/2018	0.02	0.022	**mg/L**
Total Dissolved Solids	Total	7/10/2018	500	590	**mg/L**
Total Dissolved Solids	Total	9/5/2018	500	500	**mg/L**

Biological Assessment Profile Score Summary:

n	Mean	Impairment Threshold	Min	Max	Std. Dev	Std. Err
4	5.87	5	5.44	6.12	0.3	0.15

Instantaneous Discharge ($ft^{3/s}$), Ramapo – 11.8. Points represent the calculated instantaneous stream discharge measured during each site visit when conditions permitted.



Ramapo River – River mile 4.8

Waterbody Class: A(T) | WI/PWL: 1501-0012

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Aluminum	Dissolved	2	0	14	14	12	16	**µg/L**
Calcium	Total	5	N/A	28600	28000	20000	39000	**µg/L**
Copper	Dissolved	5	0	3.56	3.1	2.4	5	**µg/L**
Copper	Total	5	0	3.9	3.7	2.7	5.7	**µg/L**
Iron	Total	4	3	370	380	280	440	**µg/L**
Lead	Total	1	0	1.4	1.4	1.4	1.4	**µg/L**
Magnesium	Total	5	0	7660	7300	5000	11000	**µg/L**
Manganese	Total	5	0	72	76	43	88	**µg/L**
Nickel	Dissolved	2	0	1.35	1.35	1	1.7	**µg/L**
Sodium	Total	5	N/A	67400	61000	42000	100000	**µg/L**
Zinc	Dissolved	2	0	11.85	11.85	7.7	16	**µg/L**
Zinc	Total	4	0	8.3	7	5.2	14	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	5	N/A	70	72	53	89	**mg/L**
Dissolved Organic Carbon	Dissolved	5	N/A	4.98	5.1	4.4	5.5	**mg/L**
Chloride	Total	5	0	116.2	94	67	190	**mg/L**
Fluoride	Total	5	0	0.12	0.12	0.11	0.13	**mg/L**
Hardness	Total	5	N/A	102.8	100	69	140	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	3	0	2.1	1.6	1.3	3.4	**mg/L**
Nitrogen, Total	Total	5	N/A	2.82	2.1	1.6	4.8	**mg/L**
Nitrogen, Ammonia	Total	2	0	0.07	0.07	0.05	0.1	**mg/L**
Total Kjeldahl Nitrogen	Total	1	N/A	1.1	1.1	1.1	1.1	**mg/L**
Nitrogen, Nitrate	Total	5	0	2.19	1.6	0.95	3.7	**mg/L**
Nitrogen, Nitrite	Total	2	1	0.03	0.03	0.01	0.04	**mg/L**
Ortho-phosphate	Dissolved	4	N/A	0.32	0.29	0.12	0.58	**mg/L**
Total Phosphorus	Total	5	N/A	0.31	0.22	0.14	0.58	**mg/L**
Sulfate	Total	5	0	13.26	11	9.3	21	**mg/L**
Total Dissolved Solids	Total	5	0	308	280	200	450	**mg/L**
Turbidity	Total	1	N/A	2.5	2.5	2.5	2.5	**ntu**

In situ Water Quality Characteristics:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	5	N/A	556	470	360	870	**µS/cm**
Dissolved Oxygen	Dissolved	5	0	8.2	8	7.6	9	**mg/L**
Percent Saturation	Total	5	N/A	92.2	91	87	98	**std unit**
pH	Total	5	0	7.76	7.7	7.4	8.2	**pH units**
Salinity	Total	5	N/A	0.27	0.23	0.18	0.43	**ppm**
Water temperature	Total	5	N/A	21	22	16	23	**deg c**

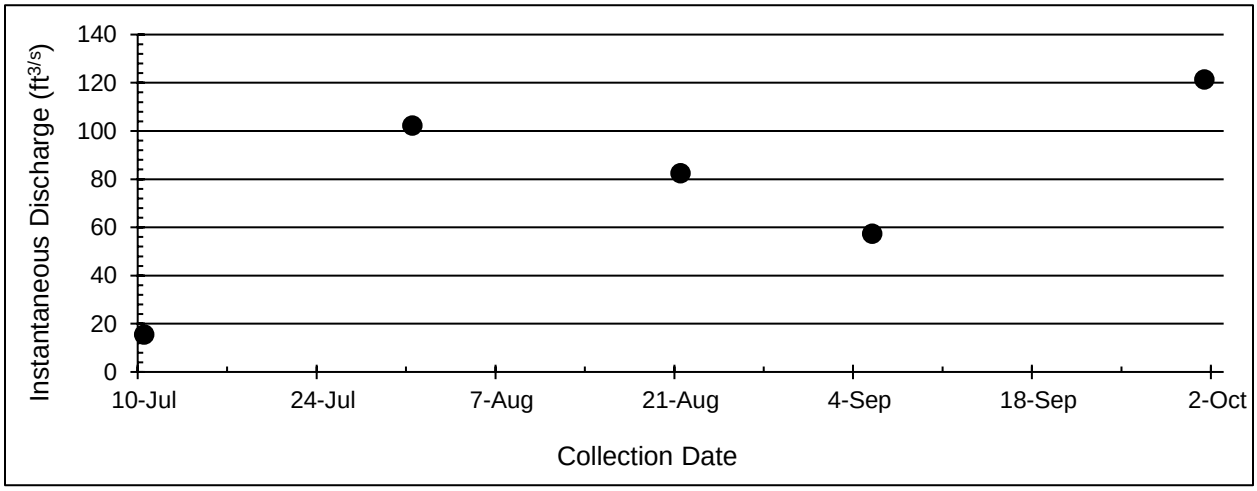
Water Quality Standard Exceedances:

Analyte	Fraction	Sample Date	Standard	Result Value	Units
Iron	Total	7/31/2018	300	440	**µg/L**
Iron	Total	8/21/2018	300	420	**µg/L**
Iron	Total	10/1/2018	300	340	**µg/L**
Nitrogen, Nitrite	Total	10/1/2018	0.02	0.042	**mg/L**

Biological Assessment Profile Score Summary:

n	Mean	Impairment Threshold	Min	Max	Std. Dev	Std. Err
4	7.23	5	6.76	7.68	0.46	0.23

Instantaneous Discharge ($ft^{3/s}$), Ramapo – 4.8. Points represent the calculated instantaneous stream discharge measured during each site visit when conditions permitted.



Ramapo River – River mile 1.1

Waterbody Class: A | WI/PWL: 1501-0012

Metals:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Aluminum	Dissolved	2	0	14	14	12	16	**µg/L**
Calcium	Total	5	N/A	25600	24000	15000	35000	**µg/L**
Copper	Dissolved	5	0	3.24	2.8	2.1	5.2	**µg/L**
Copper	Total	5	0	3.44	3.2	2.2	5.2	**µg/L**
Iron	Total	4	2	290	315	180	350	**µg/L**
Lead	Total	1	0	1.3	1.3	1.3	1.3	**µg/L**
Magnesium	Total	5	0	6900	6200	3800	10000	**µg/L**
Manganese	Total	5	0	41.4	40	27	54	**µg/L**
Nickel	Dissolved	2	0	1.3	1.3	1.2	1.4	**µg/L**
Sodium	Total	5	N/A	62000	53000	32000	91000	**µg/L**
Zinc	Dissolved	3	0	11.7	12	6.1	17	**µg/L**
Zinc	Total	3	0	8.97	6.8	5.1	15	**µg/L**

General Chemistry:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Total Alkalinity	Total	5	N/A	61.8	60	41	80	**mg/L**
Dissolved Organic Carbon	Dissolved	5	N/A	4.22	4.3	3.3	5	**mg/L**
Chloride	Total	5	0	109.2	89	53	180	**mg/L**
Fluoride	Total	5	0	0.12	0.12	0.11	0.12	**mg/L**
Hardness	Total	5	N/A	91.6	85	52	130	**mg/L**
Nitrate+Nitrite as Nitrogen	Total	3	0	1.78	1.3	0.83	3.2	**mg/L**
Nitrogen, Total	Total	3	N/A	2.8	3	1.8	3.6	**mg/L**
Nitrogen, Ammonia	Total	2	0	0.04	0.04	0.03	0.05	**mg/L**
Total Kjeldahl Nitrogen	Total	1	N/A	0.45	0.45	0.45	0.45	**mg/L**
Nitrogen, Nitrate	Total	5	0	1.76	1.3	0.83	3.2	**mg/L**
Nitrogen, Nitrite	Total	1	0	0.02	0.02	0.02	0.02	**mg/L**
Ortho-phosphate	Dissolved	3	N/A	0.17	0.15	0.08	0.28	**mg/L**
Total Phosphorus	Total	5	N/A	0.21	0.17	0.10	0.31	**mg/L**
Sulfate	Total	5	0	12.4	11	8.3	18	**mg/L**
Total Dissolved Solids	Total	5	0	276	240	150	390	**mg/L**
Turbidity	Total	1	N/A	1.5	1.5	1.5	1.5	**ntu**

In situ Water Quality Characteristics:

Analyte	Fraction	Record Count	Exceedances	Mean	Median	Min	Max	Units
Specific Conductance	Total	5	N/A	508	420	290	780	**µS/cm**
Dissolved Oxygen	Dissolved	5	0	8.7	8.3	7.7	11	**mg/L**
Percent Saturation	Total	5	N/A	95.8	96	88	110	**std unit**
pH	Total	5	0	7.5	7.6	7.3	7.7	**pH units**
Salinity	Total	5	N/A	0.25	0.2	0.14	0.38	**ppm**
Water temperature	Total	5	N/A	20.4	21	16	23	**deg c**

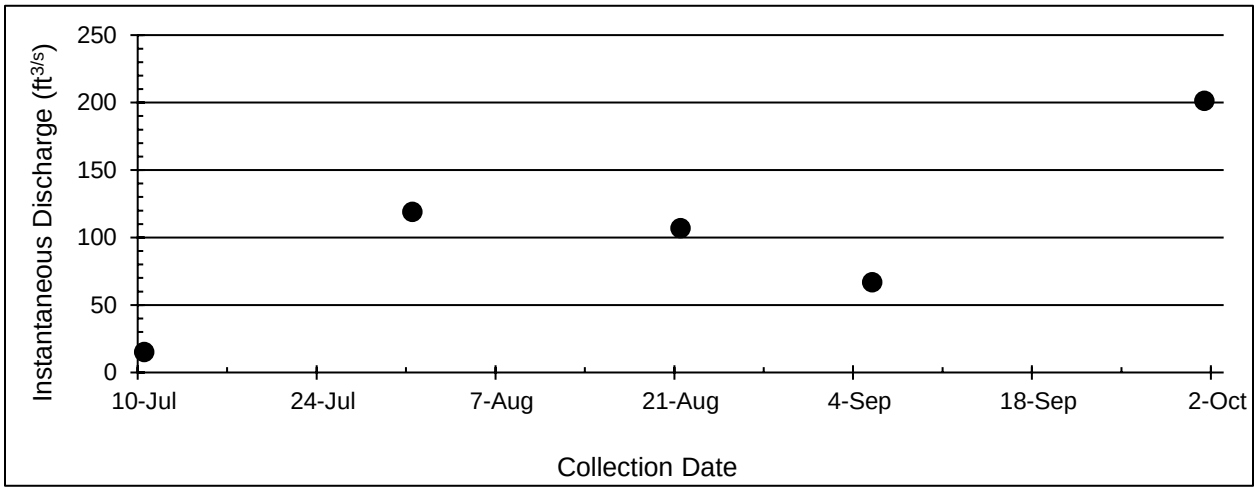
Water Quality Standard Exceedances:

Analyte	Fraction	Sample Date	Standard	Result Value	Units
Iron	Total	7/31/2018	300	339	**µg/L**
Iron	Total	8/21/2018	300	350	**µg/L**

Biological Assessment Profile Score Summary:

n	Mean	Impairment Threshold	Min	Max	Std. Dev	Std. Err
4	6.15	5	5.47	6.6	0.49	0.24

Instantaneous Discharge ($ft^{3/s}$), Ramapo – 1.1. Points represent the calculated instantaneous stream discharge measured during each site visit when conditions permitted.



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Section IV: **APPENDIX**

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

$$Q = \sum_{i=1}^{n} a_i v_i, \tag{1}$$

where Q total discharge, in cubic feet per second,
a_i cross-section area, in square feet, for the ith 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 ith 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

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

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

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

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

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,

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

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

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

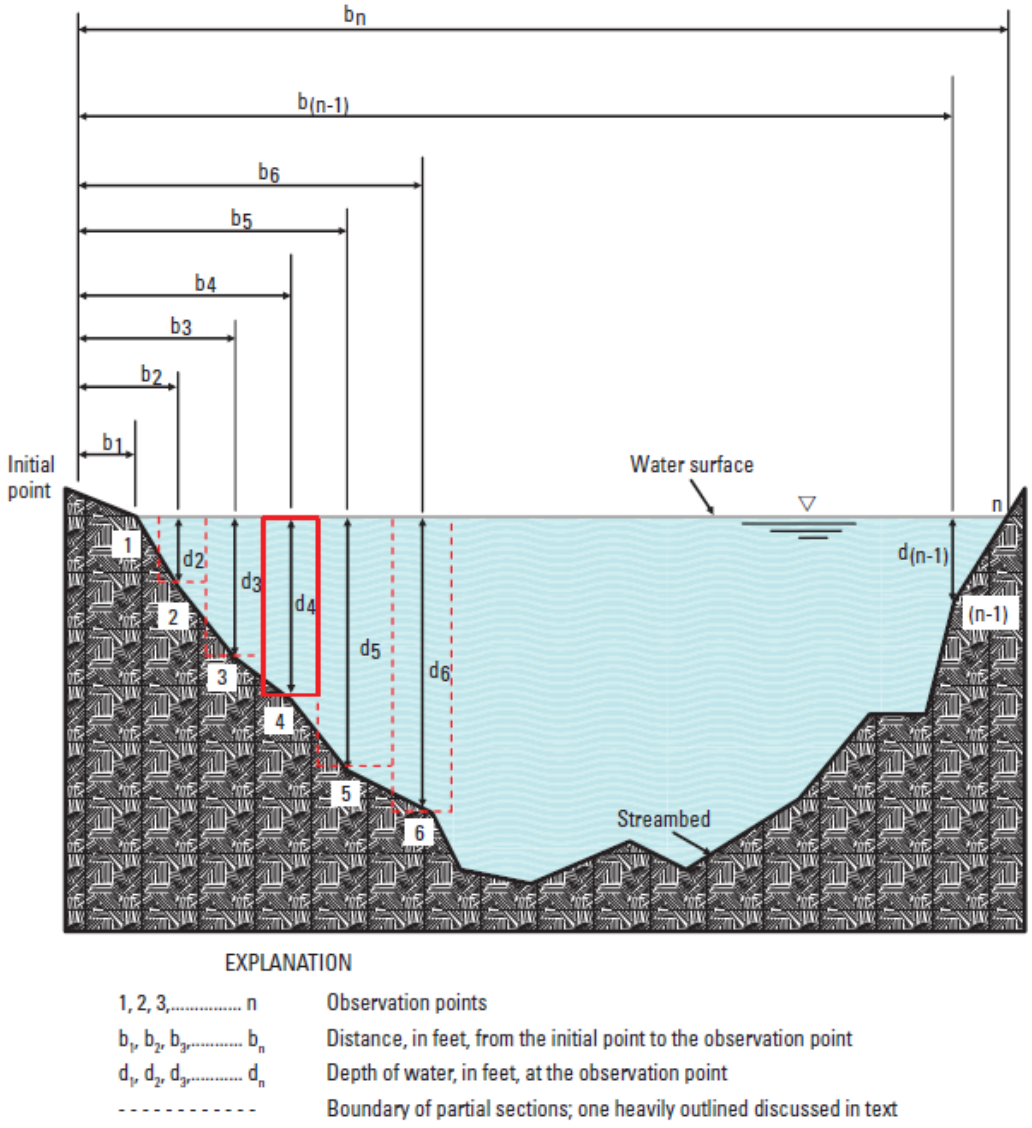

Figure 1. Definition sketch of the current-meter *midsection* method of computing cross-section area for discharge measurements.

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. 2*D*). 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. 2*C*).

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

Paper note sheets, as shown in figure 2*A*, 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)

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 field sheet 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			
	10			
	11 (water edge)			
Additional Notes:				

Appendix III: QA/QC Summary Report

A. QA/QC Analysis and Flagging of Non-Organic Water Chemistry Data

A.1. For non-organic water chemistry data sets, the designated staff performs quality assurance quality control review using the BWAM QAQC R script. This script is maintained on GitHub to preserve the revision history (https://github.com/BWAM/QAQC.git) and a locked version is stored on the NYSDEC server in the BWAM folder on the L:Drive. The components of the quality review are described below.

A.2. Laboratory QAQC. The BWAM QAQC R script checks that the laboratory analyses met all internal QAQC checks by examining the laboratory applied qualifiers (see Fig.1). The QAQC script assigns validator qualifiers to the data records if these criteria are met:

- Data accepted based on QAQC review ("A")
- Rejected validator qualifier ("R") is applied to all data with laboratory qualifiers B, N, *, D, or W
- Estimated validator qualifier ("J") is applied to all data with laboratory qualifiers E or J
- Non-Detect validator qualifier ("U") is applied to all data with laboratory qualifier U

REPORT QUALIFIERS AND DEFINITIONS

U	Analyte was analyzed for but not detected. The sample quantitation limit has been corrected for dilution and for percent moisture, unless otherwise noted in the case narrative.
J	Estimated value due to either being a Tentatively Identified Compound (TIC) or that the concentration is between the MRL and the MDL. Concentrations are not verified within the linear range of the calibration. For DoD: concentration >40% difference between two GC columns (pesticides/Arclors).
B	Analyte was also detected in the associated method blank at a concentration that may have contributed to the sample result.
E	Inorganics- Concentration is estimated due to the serial dilution was outside control limits.
E	Organics- Concentration has exceeded the calibration range for that specific analysis.
D	Concentration is a result of a dilution, typically a secondary analysis of the sample due to exceeding the calibration range or that a surrogate has been diluted out of the sample and cannot be assessed.
*	Indicates that a quality control parameter has exceeded laboratory limits. Under the "Notes" column of the Form I, this qualifier denotes analysis was performed out of Holding Time.
H	Analysis was performed out of hold time for tests that have an "immediate" hold time criteria.
#	Spike was diluted out.
+	Correlation coefficient for MSA is <0.995.
N	Inorganics- Matrix spike recovery was outside laboratory limits.
N	Organics- Presumptive evidence of a compound (reported as a TIC) based on the MS library search.
S	Concentration has been determined using Method of Standard Additions (MSA).
W	Post-Digestion Spike recovery is outside control limits and the sample absorbance is <50% of the spike absorbance.
P	Concentration >40% difference between the two GC columns.
C	Confirmed by GC/MS
Q	DoD reports: indicates a pesticide/Aroclor is not confirmed (≥100% Difference between two GC columns).
X	See Case Narrative for discussion.
MRL LOQ	Method Reporting Limit. Also known as: Limit of Quantitation (LOQ) The lowest concentration at which the method analyte may be reliably quantified under the method conditions.
MDL	Method Detection Limit. A statistical value derived from a study designed to provide the lowest concentration that will be detected 99% of the time. Values between the MDL and MRL are estimated (see J qualifier).
LOD	Limit of Detection. A value at or above the MDL which has been verified to be detectable.
ND	Non-Detect. Analyte was not detected at the concentration listed. Same as U qualifier.

A.3. Accuracy Analysis. The BWAM QAQC R script checks that the spiked QA samples met acceptable percent recovery criteria.

A.3.1. The sample matrix spike samples are used to document the bias of a method in a given sample matrix. Matrix Spike Samples are collected at a percentage of sampling locations specified in the QAPP 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. Spike samples are acceptable if the percent recovery is 100% +/- the accuracy criteria specified in the QAPP. Otherwise, the spike and its associated samples are flagged as rejected. Furthermore, if the sample is >4x the spiked amount, the spike assessment is irrelevant and flagged NA.

A.3.2. The accuracy assessments are performed on a subset of samples. The errors discovered with these QC assessments are applied to all regular ambient samples. This is done by associating ambient samples to those QC samples closest in date/time to each sample.

A.3.3. The matrix spike duplicate samples are only analyzed when measuring organics.

A.4. Precision Analysis. The BWAM QAQC R script checks that the duplicate samples met acceptable precision criteria.

A.4.1. Duplicate samples are analyzed from the same date/location to assess the method precision. The relative % difference (%RPD) between these samples must satisfy precision criteria as used by Ohio EPA (2018). Duplicate samples are rejected where

%RPD > (0.9465x^-0.344)100 +5

Where: x = sample / detection limit %RPD = [diff(duplicate pair)/av(duplicate pair)]*100

The precision assessments are performed on a subset of samples. The errors discovered with these QC assessments are applied to all regular ambient samples. This is done by associating normal samples to those QC samples closest in date/time to each sample. NOTE: the quantitation limit is NOT the method detection limit. Both are set by the lab and can vary week to week. The quantitation limit is the practical limit the lab was able to achieve and has confidence in on that date.

The complete Ohio EPA method can be found in Ohio EPA, 2018. Surface Water Field Sampling Manual. Appendix IV. https://epa.ohio.gov/Portals/35/documents/SW-Sampling-Manual-2018-AppIV.pdf.

A.5. Equipment Blank Analysis. The BWAM QAQC R script checks for contaminated equipment blanks and based on the relative concentration of the ambient sample, determines whether the level of contamination render the associated ambient sample results invalid.

A.5.1 An equipment blank is considered contaminated if the result value exceeds the quantitation limit.

A.5.2 If the equipment blank is contaminated, the results may still be useable depending on the concentration in the ambient sample vs. the concentration in the equipment blank. Acceptable thresholds are laid out in table 1 below. According to the Ohio EPA Surface Water Field Sampling Manual (Ohio EPA 2018), the logic for these thresholds is as follows:

"Laboratories often use a factor of three to differentiate a detected compound from background "noise" present in the system (analytical instrument, etc.). When a result exceeds three times the background noise, it is considered to be positively identified in the sample. We can consider blank contamination as extra "noise" in the system, since we don't know the source of the contamination, and use this factor of three to help us assess our data. To do so, the sample concentration must be at least three times the blank concentration for us to be confident that analyte is truly present in the sample"

A.5.3 Table 1: Acceptable thresholds for equipment blank (EB) contamination

Sample Result	**Interpretation**	**Validator Qualifier**
Sample ≤ 3x EB	Reject sample results in this range as insufficiently different from blank results	R
3x EB < Sample ≤ 5x EB	Likely indication that the analyte is present but poor confidence in the numerical result - generally limit data use to data "trend" applications	T
5x EB < Sample ≤ 10x EB	Consider the sample result to be an estimated concentration (qualified "J") but still suitable for most data uses	J
< 10x EB	Do not qualify data (blank contamination does not significantly change the result within the uncertainty of the value reported)	

A.5.4 The equipment blanks are collected at a percentage of locations specified in the QAPP. Contaminated equipment blank samples are applied to project sample results that are nearest in date/time.

A.6. Parameter Pair Analysis. The BWAM QAQC R script flags data where component parameters exceed total amounts.

A.6.1. The following component parameters should not exceed total parameters. Those that do are rejected and the R validator qualifier is applied.

Component Parameter	**Should not exceed total**
Nitrogen, Nitrate (as N)	Nitrate+Nitrite as Nitrogen
Nitrogen, Nitrite	Nitrate+Nitrite as Nitrogen
Nitrate+Nitrite as Nitrogen	Total Nitrogen
Nitrogen, ammonia (As N)	Total Nitrogen
Nitrogen, Kjeldahl, Total	Total Nitrogen
Orthophosphate as Phosphorus, Dissolved	Total Phosphorus

A.7. Holding Time Analysis. The BWAM QAQC R script calculates the holding time for each sample and flags those samples that exceed established holding times.

A.7.1. The holding time thresholds are published in Standard Methods for the Examination of Water and Wastewater (2017). Data are rejected and an “R” validator qualifier is applied if the holding time threshold +12 hour buffer is exceeded.

A.7.2. The holding times for Nitrate samples are ignored because this parameter is not calculated from TKN and Ammonia samples and is not measured directly.

A.8. Summary of Internal Data Flags. Depending on application of the data and data quality objectives of a survey, increasingly stringent requirements may be placed on the data. The following validator qualifiers are applied to the data records according to the procedures described above. [2]

Flag	description
A	Accepted data
J	Consider the sample result to be an estimated concentration but still suitable for most data uses
T	Likely indication that the analyte is present but poor confidence in the numerical result - generally limit data use to data trend applications
U	Analyte was analyzed for but not detected
R	Rejected samples

For the purpose of data reporting for the Ramapo survey, only data meeting the highest quality assurance standard are reported. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

[2] A HIGH RATE OF REJECTED TURBIDITY SAMPLES RESULT FROM LOW AMBIENT SAMPLE RESULT VALUES COUPLED WITH SENSITIVE DETECTION LIMITS

B. Laboratory and Internal QA/QC Results

B.1. Laboratory QC Results

Conclusions from the lab reports

SDG	Errors
lab_sdg R1806960	Method 180.1 (turbidity), R1806960-002,003: The analysis was performed slightly outside the 48 hour holding time due to a laboratory error
lab_sdg R1806960	Method 200.7 (analyzes Calcium, Iron, Magnesium, Potassium, and Sodium) R1806960-001, 002: The Relative Percent Difference (RPD) for the serial dilution test of one or more analytes was above the method control limits which indicates the presence of physical or chemical interference for analysis of these analytes in this sample matrix. Exceedances have been flagged.
lab_sdg R1806960	Method 353.2 (analyzes Nitrite and Nitrite + Nitrate),R1806960-004:The analysis was initially performed within the recommended holding time but due to a spiking error the sample could not be reported. The reanalysis was performed past the recommended holding time.
lab_sdg R1806961	Method 180.1 (turbidity), R1806961-001,002: The analysis was analyzed slightly outside the 48 hour holding time of the method due to a laboratory error.
lab_sdg R1806961	Method 353.2 (analyzes Nitrite and Nitrite + Nitrate),R1806961-012:The analysis was initially performed within the recommended holding time. Reanalysis at a dilution was required. The reanalysis was performed past the recommended holding time
lab_sdg R1807763	Method 180.1 (turbidity): One or more samples were received with sufficient hold time remaining to complete the analysis within the recommended limit. Due to Lab error the analysis was performed as soon as possible after receipt by the laboratory. The data is flagged to indicate the holding time violation.
lab_sdg R1808566	Method 200.7 (analyzes Calcium, Iron, Magnesium, Potassium, and Sodium), R1808566-014: The Relative Percent Difference (RPD) for the serial dilution test of one or more analytes was above the method control limits which indicates the presence of physical or chemical interference for analysis of these analytes in this sample matrix. Exceedances have been flagged.
lab_sdg R1808568	Method 180.1 (turbidity): Due to analyst error one sample was analyzed out of hold time. The data is flagged to indicate the holding time violation.
lab_sdg R1808568	Method 180.1 (turbidity): One or more samples were received with insufficient hold time remaining to complete the analysis within the recommended limit. The analysis was performed as soon as possible after receipt by the laboratory. The data is flagged to indicate the holding time violation.
lab_sdg R1808568	Method 353.2 (analyzes Nitrite and Nitrite + Nitrate): One or more samples were received with insufficient hold time remaining to complete the analysis within the recommended limit. The analysis was performed as soon as possible after receipt by the laboratory. The data is flagged to indicate the holding time violation.
lab_sdg R1809619	Method 180.1 (turbidity): One or more samples were received with insufficient hold time remaining to complete the analysis within the recommended limit. The analysis was performed as soon as possible after receipt by the laboratory. The data is flagged to indicate the holding time violation.
lab_sdg R1809619	Method 353.2 (analyzes Nitrite and Nitrite + Nitrate): One or more samples were received with insufficient hold time remaining to complete the analysis within the recommended limit. The analysis was performed as soon as possible after receipt by the laboratory. The data is flagged to indicate the holding time violation.
lab_sdg R1809619	Method 353.2 (analyzes Nitrite and Nitrite + Nitrate): One or more samples were received with insufficient hold time remaining to complete the analysis within the recommended limit. The analysis was performed as soon as possible after receipt by the laboratory. The data is flagged to indicate the holding time violation.

B.2. Lab and Internal QA/QC Validation

RAMA-18.6 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Aluminum (dissolved)	6	N/A	N/A	4	N/A	N/A	N/A	N/A	3	1	N/A	N/A	**2**
Nitrogen, Ammonia	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	**3**
Arsenic	6	N/A	N/A	1	N/A	N/A	N/A	N/A	1	2	N/A	N/A	**3**
Cadmium (dissolved)	6	N/A	N/A	2	N/A	N/A	4	N/A	2	N/A	N/A	4	**N/A**
Calcium	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Chloride	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Copper (dissolved)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Copper (total)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Dissolved Organic Carbon	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Fluoride	6	N/A	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	N/A	4	**2**
Hardness	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Iron (total)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**5**
Lead (dissolved)	6	N/A	N/A	4	N/A	N/A	1	N/A	4	N/A	N/A	1	**1**
Lead (total)	6	N/A	N/A	4	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	**2**
Magnesium	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Manganese (total)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Nickel (dissolved)	6	N/A	N/A	2	N/A	N/A	N/A	N/A	2	N/A	N/A	N/A	**4**
Nitrate+Nitrite as Nitrogen	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	**3**
Nitrogen, Nitrate	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Nitrogen, Nitrite	6	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	5	**1**
Nitrogen, Total	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	2	N/A	**3**
Ortho-phosphate	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**4**
Potassium	6	3	2	1	N/A	N/A	N/A	N/A	6	N/A	N/A	N/A	**N/A**
Silver (total)	6	N/A	N/A	N/A	N/A	N/A	6	N/A	N/A	N/A	N/A	6	**N/A**
Sodium	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Sulfate	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**5**
Total Dissolved Solids	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**5**
Total Kjeldahl Nitrogen	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	2	N/A	**2**
Total Phosphorus	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Turbidity	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	1	N/A	**2**
Zinc (dissolved)	6	N/A	N/A	4	N/A	N/A	2	N/A	4	1	N/A	1	**N/A**
Zinc (total)	6	N/A	N/A	3	N/A	N/A	1	N/A	3	1	N/A	N/A	**2**
Totals	**198**	**3**	**2**	**25**	**N/A**	**N/A**	**23**	**N/A**	**31**	**20**	**5**	**21**	**121**

RAMA_T25_3-0.3 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Aluminum (dissolved)	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Nitrogen, Ammonia	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**1**
Arsenic	2	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**1**
Cadmium (dissolved)	2	N/A	N/A	1	N/A	N/A	1	N/A	1	N/A	N/A	1	**N/A**
Calcium	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Chloride	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Copper (dissolved)	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Copper (total)	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Dissolved Organic Carbon	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Fluoride	2	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	N/A	N/A	2	**N/A**
Hardness	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Iron (total)	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Lead (dissolved)	2	N/A	N/A	1	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	**1**
Lead (total)	2	N/A	N/A	1	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	**1**
Magnesium	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Manganese (total)	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Nickel (dissolved)	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Nitrate+Nitrite as Nitrogen	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**1**
Nitrogen, Nitrate	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Nitrogen, Nitrite	2	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	N/A	N/A	2	**N/A**
Nitrogen, Total	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	**1**
Ortho-phosphate	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**1**
Potassium	2	1	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	**1**
Silver (total)	2	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	N/A	N/A	2	**N/A**
Sodium	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Sulfate	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**1**
Total Dissolved Solids	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Total Kjeldahl Nitrogen	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	N/A	N/A	**N/A**
Total Phosphorus	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2**
Turbidity	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**N/A**
Zinc (dissolved)	2	N/A	N/A	2	N/A	N/A	N/A	N/A	1	1	N/A	N/A	**N/A**
Zinc (total)	2	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**1**
Totals	**66**	**1**	**N/A**	**7**	**N/A**	**N/A**	**7**	**N/A**	**7**	**10**	**N/A**	**7**	**42**

KJSTP-001 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Aluminum (dissolved)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	5
Nitrogen, Ammonia	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	5
Arsenic	6	N/A	N/A	3	N/A	N/A	2	N/A	2	2	N/A	1	1
Cadmium (dissolved)	6	N/A	N/A	2	N/A	N/A	4	N/A	2	N/A	N/A	4	N/A
Calcium	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Chloride	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Copper (dissolved)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Copper (total)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Dissolved Organic Carbon	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Fluoride	6	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	N/A	N/A	3	3
Hardness	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Iron (total)	6	N/A	N/A	4	N/A	N/A	N/A	N/A	3	1	N/A	N/A	2
Lead (dissolved)	6	N/A	N/A	4	N/A	N/A	2	N/A	4	N/A	N/A	2	N/A
Lead (total)	6	N/A	N/A	4	N/A	N/A	2	N/A	4	N/A	N/A	2	N/A
Magnesium	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Manganese (total)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Nickel (dissolved)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Nitrate+Nitrite as Nitrogen	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	3
Nitrogen, Nitrate	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Nitrogen, Nitrite	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	5
Nitrogen, Total	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Ortho-phosphate	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	N/A	N/A	4
Potassium	6	6	N/A	N/A	N/A	N/A	N/A	N/A	6	N/A	N/A	N/A	N/A
Silver (total)	6	N/A	N/A	N/A	N/A	N/A	6	N/A	N/A	N/A	N/A	6	N/A
Sodium	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Sulfate	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	5
Total Dissolved Solids	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Total Kjeldahl Nitrogen	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	N/A	3
Total Phosphorus	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Turbidity	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	4	N/A	N/A	1
Zinc (dissolved)	6	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	1	N/A	N/A	5
Zinc (total)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	5
Totals	198	6	N/A	17	1	N/A	19	N/A	26	17	N/A	18	137

RAMA_T25_3-0.2 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Aluminum (dissolved)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	5
Nitrogen, Ammonia	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	N/A	N/A	4
Arsenic	6	N/A	N/A	4	N/A	N/A	1	N/A	2	2	N/A	1	1
Cadmium (dissolved)	6	N/A	N/A	2	N/A	N/A	4	N/A	2	N/A	N/A	4	N/A
Calcium	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Chloride	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Copper (dissolved)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Copper (total)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Dissolved Organic Carbon	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Fluoride	6	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	5	1
Hardness	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Iron (total)	6	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	5
Lead (dissolved)	6	N/A	N/A	3	N/A	N/A	2	N/A	3	N/A	N/A	2	1
Lead (total)	6	N/A	N/A	5	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	1
Magnesium	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Manganese (total)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Nickel (dissolved)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Nitrate+Nitrite as Nitrogen	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	3
Nitrogen, Nitrate	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Nitrogen, Nitrite	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	5
Nitrogen, Total	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Ortho-phosphate	6	N/A	N/A	N/A	N/A	N/A	1	N/A	1	1	N/A	1	3
Potassium	6	5	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	1
Silver (total)	6	N/A	N/A	N/A	N/A	N/A	6	N/A	N/A	N/A	N/A	6	N/A
Sodium	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Sulfate	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	5
Total Dissolved Solids	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Total Kjeldahl Nitrogen	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	N/A	3
Total Phosphorus	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
Turbidity	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	1	N/A	2
Zinc (dissolved)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	5
Zinc (total)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	5
Totals	198	5	N/A	15	N/A	N/A	19	N/A	22	16	1	19	140

RAMA-16.8 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Aluminum (dissolved)	6	N/A	N/A	4	N/A	N/A	N/A	N/A	3	1	N/A	N/A	**2**
Nitrogen, Ammonia	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	**3**
Arsenic	6	N/A	N/A	2	N/A	N/A	N/A	N/A	2	2	N/A	N/A	**2**
Cadmium (dissolved)	6	N/A	N/A	2	N/A	N/A	4	N/A	2	N/A	N/A	4	**N/A**
Calcium	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Chloride	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Copper (dissolved)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Copper (total)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Dissolved Organic Carbon	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Fluoride	6	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	5	**1**
Hardness	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Iron (total)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**5**
Lead (dissolved)	6	N/A	N/A	6	N/A	N/A	N/A	N/A	6	N/A	N/A	N/A	**N/A**
Lead (total)	6	N/A	N/A	4	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	**2**
Magnesium	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Manganese (total)	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Nickel (dissolved)	6	N/A	N/A	1	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	**5**
Nitrate+Nitrite as Nitrogen	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	**3**
Nitrogen, Nitrate	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Nitrogen, Nitrite	6	N/A	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	N/A	4	**2**
Nitrogen, Total	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	N/A	**4**
Ortho-phosphate	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**4**
Potassium	6	5	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**1**
Silver (total)	6	N/A	N/A	N/A	N/A	N/A	6	N/A	N/A	N/A	N/A	6	**N/A**
Sodium	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Sulfate	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**5**
Total Dissolved Solids	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**5**
Total Kjeldahl Nitrogen	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	3	N/A	**2**
Total Phosphorus	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**6**
Turbidity	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	3	N/A	N/A	**2**
Zinc (dissolved)	6	N/A	N/A	1	N/A	N/A	4	N/A	1	1	N/A	3	**1**
Zinc (total)	6	N/A	N/A	3	N/A	N/A	N/A	N/A	2	1	N/A	N/A	**3**
Totals	**198**	**5**	**N/A**	**23**	**N/A**	**N/A**	**23**	**N/A**	**30**	**19**	**3**	**22**	**124**

RAMA-16.7 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Aluminum (dissolved)	5	N/A	N/A	1	N/A	N/A	N/A	N/A	1	1	N/A	N/A	**3**
Nitrogen, Ammonia	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	1	N/A	**2**
Arsenic	5	N/A	N/A	2	N/A	N/A	N/A	N/A	1	1	N/A	N/A	**3**
Cadmium (dissolved)	5	N/A	N/A	2	N/A	N/A	3	N/A	2	N/A	N/A	3	**N/A**
Calcium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Chloride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Dissolved Organic Carbon	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Fluoride	5	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	1	**4**
Hardness	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Iron (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Lead (dissolved)	5	N/A	N/A	5	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Lead (total)	5	N/A	N/A	3	N/A	N/A	N/A	N/A	3	N/A	N/A	N/A	**2**
Magnesium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Manganese (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nickel (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrate+Nitrite as Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**3**
Nitrogen, Nitrate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrogen, Nitrite	5	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	1	N/A	1	**3**
Nitrogen, Total	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Ortho-phosphate	5	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	3	N/A	1	**1**
Potassium	5	5	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Silver (total)	5	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	5	**N/A**
Sodium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Sulfate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Dissolved Solids	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Kjeldahl Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	1	N/A	**1**
Total Phosphorus	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Turbidity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	1	N/A	N/A	**2**
Zinc (dissolved)	5	N/A	N/A	N/A	N/A	N/A	3	1	N/A	1	N/A	3	**1**
Zinc (total)	5	N/A	N/A	1	N/A	N/A	N/A	N/A	1	1	N/A	N/A	**3**
Totals	**165**	**5**	**N/A**	**14**	**N/A**	**N/A**	**14**	**1**	**23**	**14**	**2**	**14**	**112**

OCSDSTP-001 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Aluminum (dissolved)	5	N/A	N/A	5	N/A	N/A	N/A	N/A	4	1	N/A	N/A	**N/A**
Nitrogen, Ammonia	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	N/A	**3**
Arsenic	5	N/A	N/A	5	N/A	N/A	N/A	N/A	4	1	N/A	N/A	**N/A**
Cadmium (dissolved)	5	N/A	N/A	2	N/A	N/A	3	N/A	2	N/A	N/A	3	**N/A**
Calcium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Chloride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Dissolved Organic Carbon	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Fluoride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Hardness	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Iron (total)	5	N/A	N/A	5	N/A	N/A	N/A	N/A	4	1	N/A	N/A	**N/A**
Lead (dissolved)	5	N/A	N/A	5	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Lead (total)	5	N/A	N/A	5	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Magnesium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Manganese (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nickel (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrate+Nitrite as Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**3**
Nitrogen, Nitrate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrogen, Nitrite	5	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	1	N/A	N/A	**4**
Nitrogen, Total	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Ortho-phosphate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	**2**
Potassium	5	5	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Silver (total)	5	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	5	**N/A**
Sodium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Sulfate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Total Dissolved Solids	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Kjeldahl Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	N/A	**2**
Total Phosphorus	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Turbidity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	2	N/A	**1**
Zinc (dissolved)	5	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Zinc (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Totals	**165**	**5**	**N/A**	**27**	**1**	**N/A**	**9**	**N/A**	**32**	**15**	**3**	**8**	**107**

RAMA-16.5 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Aluminum (dissolved)	5	N/A	N/A	4	N/A	N/A	N/A	N/A	3	1	N/A	N/A	**1**
Nitrogen, Ammonia	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	1	N/A	**2**
Arsenic	5	N/A	N/A	3	N/A	N/A	N/A	N/A	2	1	N/A	N/A	**2**
Cadmium (dissolved)	5	N/A	N/A	2	N/A	N/A	3	N/A	2	N/A	N/A	3	**N/A**
Calcium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Chloride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Dissolved Organic Carbon	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Fluoride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Hardness	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Iron (total)	5	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Lead (dissolved)	5	N/A	N/A	5	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Lead (total)	5	N/A	N/A	4	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	**1**
Magnesium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Manganese (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nickel (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrate+Nitrite as Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**3**
Nitrogen, Nitrate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrogen, Nitrite	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Nitrogen, Total	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Ortho-phosphate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**3**
Potassium	5	5	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Silver (total)	5	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	5	**N/A**
Sodium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Sulfate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Dissolved Solids	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Kjeldahl Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	1	N/A	**1**
Total Phosphorus	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Turbidity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	1	1	N/A	**N/A**
Zinc (dissolved)	5	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Zinc (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Totals	**165**	**5**	**N/A**	**19**	**1**	**N/A**	**8**	**N/A**	**28**	**12**	**3**	**8**	**114**

RAMA-16.1 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Aluminum (dissolved)	5	N/A	N/A	4	N/A	N/A	N/A	N/A	3	1	N/A	N/A	**1**
Nitrogen, Ammonia	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	1	N/A	N/A	**2**
Arsenic	5	N/A	N/A	3	N/A	N/A	N/A	N/A	2	1	N/A	N/A	**2**
Cadmium (dissolved)	5	N/A	N/A	1	N/A	N/A	4	N/A	1	N/A	N/A	4	**N/A**
Calcium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Chloride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Dissolved Organic Carbon	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Fluoride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Hardness	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Iron (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Lead (dissolved)	5	N/A	N/A	5	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Lead (total)	5	N/A	N/A	4	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	**1**
Magnesium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Manganese (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nickel (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrate+Nitrite as Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**3**
Nitrogen, Nitrate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrogen, Nitrite	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Nitrogen, Total	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Ortho-phosphate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**3**
Potassium	5	5	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Silver (total)	5	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	5	**N/A**
Sodium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Sulfate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Dissolved Solids	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Kjeldahl Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	1	N/A	**1**
Total Phosphorus	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Turbidity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	2	N/A	**1**
Zinc (dissolved)	5	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Zinc (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Totals	**165**	**5**	**N/A**	**17**	**1**	**N/A**	**9**	**N/A**	**26**	**12**	**3**	**9**	**115**

RAMA-13.3 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Aluminum (dissolved)	5	N/A	N/A	5	N/A	N/A	N/A	N/A	4	1	N/A	N/A	**N/A**
Nitrogen, Ammonia	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	**2**
Arsenic	5	N/A	N/A	2	N/A	N/A	N/A	N/A	2	1	N/A	N/A	**2**
Cadmium (dissolved)	5	N/A	N/A	1	N/A	N/A	4	N/A	1	N/A	N/A	4	**N/A**
Calcium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Chloride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Dissolved Organic Carbon	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Fluoride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Hardness	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Iron (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Lead (dissolved)	5	N/A	N/A	4	N/A	N/A	1	N/A	4	N/A	N/A	1	**N/A**
Lead (total)	5	N/A	N/A	4	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	**1**
Magnesium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Manganese (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nickel (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrate+Nitrite as Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**3**
Nitrogen, Nitrate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrogen, Nitrite	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrogen, Total	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Ortho-phosphate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**3**
Potassium	5	5	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Silver (total)	5	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	5	**N/A**
Sodium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Sulfate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Dissolved Solids	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Kjeldahl Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	2	N/A	**1**
Total Phosphorus	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Turbidity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	3	N/A	N/A	**N/A**
Zinc (dissolved)	5	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Zinc (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Totals	**165**	**5**	**N/A**	**16**	**1**	**N/A**	**10**	**N/A**	**24**	**15**	**2**	**10**	**114**

RAMA-11.8 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Aluminum (dissolved)	5	N/A	N/A	4	N/A	N/A	N/A	N/A	3	1	N/A	N/A	**1**
Nitrogen, Ammonia	5	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	3	N/A	1	**1**
Arsenic	5	N/A	N/A	5	N/A	N/A	N/A	N/A	4	1	N/A	N/A	**N/A**
Cadmium (dissolved)	5	N/A	N/A	2	N/A	N/A	3	N/A	2	N/A	N/A	3	**N/A**
Calcium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Chloride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Dissolved Organic Carbon	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Fluoride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Hardness	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Iron (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Lead (dissolved)	5	N/A	N/A	5	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Lead (total)	5	N/A	N/A	5	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Magnesium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Manganese (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nickel (dissolved)	5	N/A	N/A	1	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	**4**
Nitrate+Nitrite as Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**3**
Nitrogen, Nitrate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrogen, Nitrite	5	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	N/A	N/A	2	**3**
Nitrogen, Total	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Ortho-phosphate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**3**
Potassium	5	5	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Silver (total)	5	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	5	**N/A**
Sodium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Sulfate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Dissolved Solids	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Kjeldahl Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	3	N/A	**1**
Total Phosphorus	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Turbidity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	2	N/A	**1**
Zinc (dissolved)	5	N/A	N/A	2	1	N/A	N/A	N/A	2	1	N/A	N/A	**2**
Zinc (total)	5	N/A	N/A	1	N/A	N/A	N/A	N/A	1	1	N/A	N/A	**3**
Totals	**165**	**5**	**N/A**	**25**	**1**	**N/A**	**11**	**N/A**	**28**	**15**	**5**	**11**	**106**

RAMA-4.8 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Aluminum (dissolved)	5	N/A	N/A	3	N/A	N/A	N/A	N/A	2	1	N/A	N/A	**2**
Nitrogen, Ammonia	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	**2**
Arsenic	5	N/A	N/A	5	N/A	N/A	N/A	N/A	4	1	N/A	N/A	**N/A**
Cadmium (dissolved)	5	N/A	N/A	2	N/A	N/A	3	N/A	2	N/A	N/A	3	**N/A**
Calcium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Chloride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Dissolved Organic Carbon	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Fluoride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Hardness	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Iron (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Lead (dissolved)	5	N/A	N/A	5	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Lead (total)	5	N/A	N/A	4	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	**1**
Magnesium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Manganese (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nickel (dissolved)	5	N/A	N/A	3	N/A	N/A	N/A	N/A	3	N/A	N/A	N/A	**2**
Nitrate+Nitrite as Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**3**
Nitrogen, Nitrate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrogen, Nitrite	5	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	N/A	N/A	3	**2**
Nitrogen, Total	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Ortho-phosphate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	**4**
Potassium	5	3	2	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Silver (total)	5	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	5	**N/A**
Sodium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Sulfate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Dissolved Solids	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Kjeldahl Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	3	N/A	**1**
Total Phosphorus	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Turbidity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	1	1	N/A	**1**
Zinc (dissolved)	5	N/A	N/A	2	N/A	1	N/A	N/A	2	1	N/A	N/A	**2**
Zinc (total)	5	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Totals	**165**	**3**	**2**	**25**	**N/A**	**1**	**11**	**N/A**	**30**	**12**	**4**	**11**	**108**

RAMA-1.1 totals for applied QA/QC flags. Table describes the total number of each lab QA/QC flag and internal validation QA/QC flag applied to every analyte analyzed. All records with a lab flag were removed from the analysis provided for this report. Only records flagged as accepted for all uses (A) through internal validation QA/QC were used in the analysis provided for this report.

		Lab Flags							QA/QC Flags				
Analyte	**Total Records**	**E**	**EJ**	**J**	**N**	**NJ**	**U**	**UN**	**J**	**R**	**T**	**U**	**A**
Alkalinity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Aluminum (dissolved)	5	N/A	N/A	3	N/A	N/A	N/A	N/A	2	1	N/A	N/A	**2**
Nitrogen, Ammonia	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	**2**
Arsenic	5	N/A	N/A	5	N/A	N/A	N/A	N/A	4	1	N/A	N/A	**N/A**
Cadmium (dissolved)	5	N/A	N/A	2	N/A	N/A	3	N/A	2	N/A	N/A	3	**N/A**
Calcium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Chloride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (dissolved)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Copper (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Dissolved Organic Carbon	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Fluoride	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Hardness	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Iron (total)	5	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	**4**
Lead (dissolved)	5	N/A	N/A	5	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Lead (total)	5	N/A	N/A	4	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	**1**
Magnesium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Manganese (total)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nickel (dissolved)	5	N/A	N/A	3	N/A	N/A	N/A	N/A	3	N/A	N/A	N/A	**2**
Nitrate+Nitrite as Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	**3**
Nitrogen, Nitrate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Nitrogen, Nitrite	5	N/A	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	N/A	4	**1**
Nitrogen, Total	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	N/A	**3**
Ortho-phosphate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	N/A	N/A	**3**
Potassium	5	2	3	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	**N/A**
Silver (total)	5	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	5	**N/A**
Sodium	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Sulfate	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Dissolved Solids	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Total Kjeldahl Nitrogen	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	3	N/A	**1**
Total Phosphorus	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**5**
Turbidity	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	3	N/A	**1**
Zinc (dissolved)	5	N/A	N/A	1	1	N/A	N/A	N/A	1	1	N/A	N/A	**3**
Zinc (total)	5	N/A	N/A	2	N/A	N/A	N/A	N/A	1	1	N/A	N/A	**3**
Totals	**165**	**2**	**3**	**26**	**1**	**N/A**	**12**	**N/A**	**30**	**13**	**6**	**12**	**104**

Appendix IV: Assessment of Stream Reach Physical Habitat Field Sheet

New York State Department of Environmental Conservation
Field Sheet for Rapid Assessment of Habitat Condition (High Gradient)

Stream Name:_____
4-letter Identifier/Station Number:_____
Collectors:_____
Biological Sample: Y N
Site Type: Screening Intensive Multi-Site

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover, mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient)	40 – 70% mix of stable habitat; well-suited for full colonization potential, adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonization (may rate at high end of scale).	20 – 40 % mix of stable habitat; habitat availability less than desirable, substrate frequently disturbed or removed.	Less than 20 % stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble and boulder particles are 0-25 % surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble and boulder particles are 25-50 % surrounded by fine sediment.	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble and boulder particles are more than 75 % surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderated deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constructions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable, infrequent, small areas of erosion; mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion potential during floods.	Unstable, many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9.Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation very high vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Note: determine left or right side by facing downstream.

Appendix V: Observer Ranking of Recreational Ability Field Sheet

NYSDEC - Assessment of Recreational Use Perception

Circle the one answer which best describes your ability to participate in 1^0 contact recreation:

a. Beautiful, could not be nicer. Ability to swim, wade, dive, water ski etc…fully attained.
b. Minor aesthetic problems, but still excellent for 1^0 contact recreation.
c. 1^0 contact recreation slightly impacted.
d. Desire to participate in 1^0 contact recreation substantially reduced.
e. Awful! 1^0 contact recreation impossible.
f. Not applicable (headwater/high flows/dry, etc.)

Circle the one answer which best describes your ability to participate in 2^0 contact recreation:

a. Beautiful, could not be nicer. Ability to fish and boat fully attained.
b. Minor aesthetic problems, but still excellent for 2^0 contact recreation.
c. 2^0 contact recreation slightly impacted.
d. Desire to participate in 2^0 contact recreation substantially reduced.
e. Awful! 2^0 contact recreation impossible.
f. Not applicable (headwater/high flows/dry, etc.)

Weather conditions (Current):	Sun	Rain	Clouds
Weather conditions (Past 24hrs):	Sun	Rain	Clouds

Water Clarity:	0	1	2	3	4	5	6	7	8	9	10
	Clear				Intermediate						Turbid
Phytoplankton: (suspended)	0	1	2	3	4	5	6	7	8	9	10
	Natural				Intermediate						Severe
Periphyton Cover:	0	1	2	3	4	5	6	7	8	9	10
	Natural				Intermediate						Severe
Macrophyte Cover:	0	1	2	3	4	5	6	7	8	9	10
	Natural				Intermediate						Severe
Odor:	0	1	2	3	4	5	6	7	8	9	10
	Natural				Intermediate						Noxious
Trash:	0	1	2	3	4	5	6	7	8	9	10
	None				Intermediate						Landfill
Discharges/Pipes:	0	1	2	3	4	5	6	7	8	9	10
	None				Intermediate						Dominant

Circle all the variables that negatively affect your opinion of recreational use of the waterbody today.

Water Clarity Phytoplankton Periphyton Macrophytes Odor Trash Discharges/Pipes

Other (Please list):

Appendix VI: Toxicity Fact Sheet

Fact Sheet: Acute & Chronic Toxicity Assessments of NY Streams & Rivers

A. Microtox®

1) **Bottom Sediments:** This bioassay method uses bioluminescent bacteria to assess the toxicity of aquatic bottom sediments. In a method developed by the NYSDEC's Toxicity Testing Unit, sediment samples are first centrifuged to remove the porewater, and then extracted with methanol. A reduction in light levels compared to a control sample following a 15-minute exposure is a measure of the acute toxicity of the sample, and expressed as an EC50. Results are categorized according to a four-tiered system (non, slight, moderate or severe) per Tables 1-3 below (note that changes in methanol quality over time have necessitated revisions to the rating system). Specific screening test methods follow NYSDEC Standard Operating Procedure: Microtox® Acute Toxicity Test for Sediments, Porewaters and Effluents (SOP#403-16), which is available for download from the agency.

Table 1: Rating system applied to Microtox® analyzed bottom sediments from 2001-12.

15-minute EC50 (%)	Toxicity Category
< 1.00	Severely Toxic
≥ 1.00 to < 20.00	Moderately Toxic
≥ 20.00 to < 40.00	Slightly Toxic
≥ 40.00	Non-Toxic

Table 2: Rating system applied to Microtox® analyzed bottom sediments from 2013-14.

15-minute EC50 (%)	Toxicity Category
< 40.00	Severely Toxic
≥ 40.00 to < 60.00	Moderately Toxic
≥ 60.00 to < 80.00	Slightly Toxic
≥ 80.00	Non-Toxic

Table 3: Rating system applied to Microtox® analyzed bottom sediments from 2015-present.

15-minute EC50 (%)	Toxicity Category
< 20.00	Severely Toxic
≥ 20.00 to < 40.00	Moderately Toxic
≥ 40.00 to < 60.00	Slightly Toxic
≥ 60.00	Non-Toxic

2) **Porewaters:** Microtox® is also used to assess the toxicity of the resulting porewaters. The EC50 results are categorized according to a two-tiered system (non-toxic or toxic) per Table 4 below. Specific screening test methods follow NYSDEC Standard Operating Procedure: Microtox® Acute Toxicity Test for Sediments, Porewaters and Effluents (SOP#403-16), which is available for download from the agency.

Table 4: Rating system applied to Microtox® analyzed porewater samples.

15-minute EC50 (%)	Toxicity Category
< 100	Toxic
≥ 100	Non-Toxic

B. *Water Fleas (Ceriodaphnia)*

This bioassay method uses water fleas, a freshwater invertebrate, to assess the toxicity of stream and river samples. Reductions in survival and/or reproductive rate compared to a control sample following a 7-day exposure is a measure of the chronic toxicity of the sample. Results are statistically categorized according to a four-tiered system (non, slight, moderate or severe) per Table 5 below. Specific test methods and conditions follow US EPA's Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, 4th ed., October 2002 (EPA-821-R-02-013), as well as NYSDEC Standard Operating Procedure: *Ceriodaphnia dubia* (*C. dubia*) 7-day Chronic Screening Test for Toxicity of Ambient Water Samples or Effluents (SOP#402-16), both documents which are available for download from each respective agency.

Table 5: Rating system applied to *Ceriodaphnia*.

Toxicity Category	7-day Statistical Test Definition
Severely Toxic	Statistically significant mortality **AND** reproductive effects
Moderately Toxic	Statistically significant mortality effect
Slightly Toxic	Statistically significant reproductive effect
Non-Toxic	No statistically significant mortality **OR** reproductive effects