



Data Quality Standards for Stream Communities and Ecosystems in Alaska's Arctic Network

Natural Resource Report NPS/ARCN/NRR—2018/1709





ON THIS PAGE

Headwater tributary of the Agashashok River in Noatak National Preserve, Alaska.
NPS/Jon O'Donnell

ON THE COVER

The Itkillik River in Gates of the Arctic National Park and Preserve
NPS/Jon O'Donnell

Data Quality Standards for Stream Communities and Ecosystems in Alaska's Arctic Network

Natural Resource Report NPS/ARCN/NRR—2018/1709

Jonathan A. O'Donnell

National Park Service
Arctic Inventory and Monitoring Network
240 W. 5th Avenue
Anchorage, AK 99501

September 2018

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available in digital format from the [Arctic Network website](#) and the [Natural Resource Publications Management website](#). If you have difficulty accessing information in this publication, particularly if using assistive technology, please email irma@nps.gov.

Please cite this publication as:

O'Donnell, J. A. 2018. Data quality standards for stream communities and ecosystems monitoring in Alaska's Arctic Network. Natural Resource Report NPS/ARC/NRR—2018/1709. National Park Service, Fort Collins, Colorado.

Contents

	Page
Tables.....	iii
Abstract.....	iv
Introduction.....	1
Protocol Overview	1
Protocol Activities and Modules.....	3
Sampling Design.....	8
Data Quality Objectives.....	11
Change Detection.....	16
Literature Cited	17

Tables

	Page
Table 1. Protocol activity matrix for Stream Communities and Ecosystems monitoring in the Arctic Network Inventory & Monitoring program.	5
Table 2. Activity-level sample design matrix for Stream Communities and Ecosystems monitoring in the Arctic Network (O'Donnell and Miller 2016)	8
Table 3. Data Quality Values (DQVs) for continuous water quality monitoring in the Arctic Inventory & Monitoring Network.....	11
Table 4. Measurement Quality Objectives for Stream Communities and Ecosystems monitoring protocol in the Arctic Inventory & Monitoring Network (O'Donnell and Miller 2016)	13
Table 5. Data Protection standards for Stream Communities and Ecosystems monitoring in the Arctic Inventory & Monitoring Network (O'Donnell and Miller 2016)	15

Abstract

The Stream Communities and Ecosystems vital sign is one of 19 vital signs monitored by the National Park Service's (NPS) Arctic Inventory and Monitoring Network (ARCN). In accordance with guidelines set forth by the NPS Inventory and Monitoring Division, this report summarizes data quality standards associated with the monitoring of stream water quality in ARCN parks. This report documents the standards, policies, and procedures for activities related to the collection, processing, storage, analysis, and publication of monitoring data. Components of the report include monitoring activities, sampling design, data quality objectives, and change detection over space and time. The policies described here are consistent with and compliment data quality standards for water quality monitoring across the NPS Inventory and Monitoring Division.

Introduction

The purpose of this report is to document the standards, used by the Arctic Network (ARCN) Inventory and Monitoring Program for activities related to the collection, processing, storage, analysis, and publication of monitoring data as described in the ARCN Stream Communities and Ecosystems Monitoring Protocol. The policies and procedures documented in this quality-assurance plan for activities complement the quality-assurance plans for other monitoring activities conducted by the ARCN and supplement National Inventory & Monitoring Division Quality Management Plan. The plan also serves as a guide for all ARCN personnel who are involved in protocol/program activities and as a resource for identifying memoranda, publications, and other literature that describe associated techniques and requirements in more detail.

Protocol Overview

The ARCN Stream Communities and Ecosystems Monitoring Protocol describes the background, rationale, and sampling design for monitoring streams and rivers in five ARCN parks: Bering Land Bridge National Preserve (BELA), Cape Krusenstern National Monument (CAKR), Gates of the Arctic National Park and Preserve (GAAR), Kobuk Valley National Park (KOVA), and Noatak National Preserve (NOAT). The main goals of the protocol are to: (1) detect long-term trends in the magnitude and seasonality of stream and river discharge in watersheds draining or adjacent to ARCN park units, (2) detect long-term changes in the chemical composition of streams and rivers draining watersheds that vary with soil and permafrost properties, and (3) monitor and evaluate the implications of physical and chemical changes for stream and river biota.

The structure of the protocol follows the recommended framework and suggestions of Oakley et al. (2003). The Stream Communities and Ecosystems Monitoring Protocol also describes the sensitivity and vulnerability of aquatic resources within ARCN parks to climate change and disturbance (e.g. permafrost thaw) that are unique to Arctic parklands. Using existing datasets (O'Donnell et al. 2015) and peer-reviewed studies (O'Donnell et al. 2012, 2014, 2016), the protocol establishes that while most streams and rivers are pristine with respect to water quality, climate change and disturbance may alter the physical, chemical, and biological properties of surface waters.

The objective of this monitoring program is to determine annual status and long-term trends for a suite of chemical parameters at a range of intensive monitoring sites throughout the ARCN parks. Discrete water samples will be collected annually at 22 streams or rivers, and will be analyzed for a broad range of chemical constituents, including carbon, nutrients, and major ions. All samples will be collected during the period of maximum annual thaw depth, which can influence the chemical character of stream water (O'Donnell et al. 2014). Continuous water quality monitors (sondes) will be deployed during the ice-free season (June-September) at a subset of headwater stream locations to monitor seasonal dynamics of four core water quality parameters (temperature, specific conductivity, pH, and dissolved oxygen). These four water quality parameters are measured at one-hour intervals, allowing for eventual determination of trends at daily, monthly, seasonal and annual time scales.

Time-series data collected from continuous in situ monitoring of water-quality parameters using this protocol will be stored in the National Park Service's (NPS) Integrated Resource Management Applications (IRMA) and analyzed using Aquatic Informatics Aquarius software. Two primary emphases of the NPS Inventory and Monitoring Program are to ensure that results and knowledge obtained from monitoring are communicated in a timely manner and to maximize understanding in order to best meet park needs. Where appropriate, monitoring results will be shared as broadly as possible with park partners, NPS staff, and the public. Water quality status will be summarized in annual reports and resource briefs at the end of each calendar year. Longer term trends and/or synthesis reports will be written every three to seven years, depending on the needs of the parks. The synthesis reports will include information from a regional perspective in order to look at landscape-scale changes. Water quality data collected using this protocol will provide a scientific foundation for evaluating ARCN parks.

Protocol Activities and Modules

Under this protocol, discrete water samples for chemical characterization of stream water are collected at 15 watersheds underlain by different parent material types ($n = 3$ streams per type; O'Donnell and Miller 2017 (in review)). These parent material types include bedrock, glaciolacustrine deposits, loess, sand, and volcanic deposits, and have been documented to influence stream and river chemistry in ARCN parks (O'Donnell et al. 2016) and lake chemistry in ARCN and Central Alaskan Inventory and Monitoring Network (CAKN) parklands (Larsen et al. 2017). Discrete samples will also be collected annually from the seven National Wild and Scenic rivers located within GAAR, including the Alatna, John, Kobuk, Noatak, North Fork of the Koyukuk, Tinayguk, and Salmon Rivers.

Continuous water quality multi-parameter sondes will be deployed seasonally at a minimum of three locations that vary with parent material and ground ice content: the Agashashok River (NOAT; ice-poor bedrock), the Cutler River (NOAT; moderate ice, glaciolacustrine), and Nigruk Creek (KOVA; ice-rich loess) (O'Donnell et al. 2016). The deployment sites are in headwater streams upstream of the confluence with the main-stem of the major rivers. Continuous monitoring stations are co-located with established study sites associated with the United States Geological Survey's (USGS) Changing Arctic Ecosystems program (O'Donnell et al. 2017) and other ongoing research projects (e.g. Stottlemeyer 2001). Discrete water quality measurements and continuous water quality measurements are complemented by seasonal streamflow data collected by USGS at these sites.

Discrete water samples are analyzed for a broad suite of chemical constituents at Oregon State University's Cooperative Chemical Analytical Laboratory (CCAL). Lab managers at CCAL provide NPS personnel with data reports and results of internal quality control/quality assurance (QA/QC) measures. Multi-parameter sondes deployed for continuous monitoring are used to record data for four core water-quality parameters so that status and trends can be determined. Measurements of dissolved oxygen, pH, temperature, conductivity, and turbidity are taken at one-hour intervals and are retrieved prior to river freeze-up during autumn. Data collection and data handling procedures are carried out by ARCN personnel.

Data are collected as part of five separate activities or modules. These data collection activities are summarized in Table 1 below for the following activities:

1. Field Measurements and Site Reconnaissance: Data generated from *in situ* measurements conducted during site visits.
2. Collecting Discrete Water Samples: Describes different types of water samples collected for laboratory analyses.
3. Laboratory Analyses: Describes different types of laboratory analyses conducted on water samples collected from monitoring locations.
4. Continuous Monitoring of Core Water Quality Parameters: Includes any data collected by the sensor, information associated with sensor deployment and retrieval, or post-processing.

5. External data: Data collected and managed by cooperators (e.g. USGS).
6. QA/QC data. Data collected and managed as a part of the protocol when it is to be used as a part of a QC process.

Table 1. Protocol activity matrix for Stream Communities and Ecosystems monitoring in the Arctic Network Inventory & Monitoring program.

Category	Activity #	Activity	Description
Field Measurements and Site Reconnaissance	1	Core Water Quality Parameters	Discrete measurement of four core water quality parameters are conducted at all monitoring sites.
	2	Qualitative Discharge Assessment	There are no USGS gauges within ARCN parks. Discharge is assessed qualitatively following NPS Water Resource Division guidelines, as described in SOP: <i>Discharge Analysis</i> of the Stream Communities and Ecosystems Monitoring Protocol.
	3	Benthic Algae Biomass and Composition	Measurements are conducted at all wade-able monitoring sites using a BenthosTorch, as described in SOP: <i>Field Measurements</i> of the Stream Communities and Ecosystems Monitoring Protocol.
	4	Habitat Characterization	NPS personnel describe habitat characteristics by filling out field sheet SOP: <i>Field Measurements</i> of the Stream Communities and Ecosystems Monitoring Protocol.
Collecting Discrete Water Samples	5	Filtered sample	This sample is collected using a Geotech Peristaltic Pump and 0.45-micron high-capacity capsule filter and is stored in a 500-mL HDPE Nalgene bottle. The sample can be frozen until shipped to CCAL, where it will be analyzed for dissolved nitrogen and phosphorus species, base cations, and anions.
	6	Dissolved organic carbon (DOC)	This sample is collected using a Geotech Peristaltic Pump and 0.45-micron high-capacity capsule filter and stored in a 125-mL amber glass bottle. The sample is refrigerated and shipped as soon as possible to the USGS for analysis of DOC concentration.
	7	Unfiltered sample	This unfiltered sample is collected using a Geotech Peristaltic Pump (without filter attached) and is stored in a 250-mL HDPE Nalgene bottle. The sample can be frozen until shipped to CCAL, where it will be analyzed for total nitrogen, phosphorus, and alkalinity.
	8	Dissolved inorganic carbon (DIC)	This sample is collected (unfiltered) in a 60-mL syringe with luer-lock tip fitted to a three-way stopcock. The sample is kept refrigerated and shipped immediately to CCAL for analysis of DIC concentration.
	9	Chlorophyll a	This sample is collected by filtering 500 mL of stream water through a GF/F filter in the field. The filter is then shipped to CCAL for analysis of chlorophyll- <u>a</u> concentration.

Table 1 (continued). Protocol activity matrix for Stream Communities and Ecosystems monitoring in the Arctic Network Inventory & Monitoring program.

Category	Activity #	Activity	Description
Laboratory Analyses	10	Organic carbon	DOC concentration is determined by oxidative combustion and infrared analysis on a Shimadzu TOC-VCSH at CCAL.
	11	Dissolved inorganic carbon	DIC concentration is determined by acidification, sparging, and infrared analysis on a Shimadzu TOC-VCSH at CCAL.
	12	Nitrogen species	All N species are measured at CCAL. Total nitrogen (TN) and total dissolved nitrogen (TDN) are determined by persulfate digestion followed by colorimetric analysis on a Technicon Auto-Analyzer II. Nitrate + nitrite are determined by the cadmium reduction method. Unionized ammonia is determined following the phenate method.
	13	Phosphorus species	All P species are measured at CCAL. Total P (TP) and total dissolved P (TDP) are determined using the persulfate digestion method followed by colorimetric analysis on a Technicon Auto-Analyzer II. Soluble reactive phosphorus (SRP) concentration is determined using the ascorbic acid method.
	14	Base cations	All cations are measured at CCAL. Calcium, magnesium, potassium, sodium and total iron concentrations are all measured using flame atomic absorbance spectroscopy.
	15	Anions	All anions are measured at CCAL. Chloride and sulfate are analyzed using ion chromatography on a Dionex 1500.
	16	Alkalinity	Alkalinity is determined at CCAL by titrating to a pH of .5 on a ManTech PC-Titrate Auto Titrator System.
	17	Chlorophyll-a (seston)	Chlorophyll-a is determined using spectrophotometric methods.
Continuous Monitoring of Core Water Quality Parameters	18	pH	Sensor calibrated in laboratory prior to initial deployment Sensors replaced when measurements do to conform with criteria as described in Wagner et al. (2006).
	19	Temperature	Annual checks using a NIST-calibrated thermistor.
	20	Dissolved Oxygen (DO)	Sensor calibrated in laboratory prior to initial deployment.
	21	Conductivity	Sensor calibrated in laboratory prior to initial deployment.

Table 1 (continued). Protocol activity matrix for Stream Communities and Ecosystems monitoring in the Arctic Network Inventory & Monitoring program.

Category	Activity #	Activity	Description
External Data	22	Stream Discharge at ARCN Continuous Water Quality Monitoring Sites	Data collected seasonally at sites where sondes are deployed (Agashashok, Cutler, and Nigeruk). Data are available from USGS (Joshua Koch, personal communication).
	23	Stream Discharge at USGS gauged sites	Data archived by USGS National Water Information System (NWIS) and available for use as described in SOP: <i>Discharge Analysis</i> .
QA/QC Data	24	Quantifying bias and variability of water samples	Field blanks are collected across a range of conditions to assess bias due to possible contamination of water samples. Replicate samples are collected from a subset of monitoring sites to quantify variability in sample collection and analysis.
	25	Analytical Sensitivity of Laboratory Methods	For each chemical analysis, CCAL has provided data for method detection limits (MDL), minimum level of quantification (ML), and precision (http://ccal.oregonstate.edu/detection). MDL is three times the standard deviation of a low level standard. ML is 3.18 times the MDL.
	26	Data Sonde Calibration	Conductance, pH, dissolved oxygen, and turbidity sensors calibrated prior to deployment. Calibration drift of deployed monitors evaluated as part of monthly O&M site visits.
	27	Data editing	Data outliers and uncorrectable fouling conditions manually removed from record using USGS ADAPS system or Aquarius system. Data shifts made in accordance with procedures described in Wagner et al. (2006).
	28	Data Quality Assessment	Data verification is conducted to ensure that data are free of transcription or coding errors, and that all documentation is correct. Data review is conducted to ensure that lab results are reasonable. Data validation is conducted by CCAL to determine the specific quality of a data set.
	29	Site representativeness	Repeat cross-section survey of field parameters on an annual basis to verify that location of field measurements and water sample collection remains representative of water quality at the monitoring site.

Sampling Design

Information regarding the sampling design is provided in **Error! Reference source not found..**

Table 2. Activity-level sample design matrix for Stream Communities and Ecosystems monitoring in the Arctic Network (O'Donnell and Miller 2016). Numbers (left column) match those in the Protocol Activity Matrix (Table 1).

Category	Activity #	Activity	Sampling Design	Revisit Design
Field Observations	1	Core Water Quality Parameters	Stratified; with three replicate streams sampled across five watershed types underlain by different parent materials (following methods of O'Donnell et al. 2016). Targeted; seven National Wild and Scenic Rivers are all sampled.	Revisit annually; Take every fourth year off for data analyses and writing.
	2	Qualitative Discharge Assessment	Stratified; with three replicate streams sampled across five watershed types underlain by different parent materials (following methods of O'Donnell et al. 2016). Targeted; seven National Wild and Scenic Rivers are all sampled.	Revisit annually; Take every fourth year off for data analyses and writing.
	3	Benthic Algae Biomass and Composition	Stratified; with three replicate streams sampled across five watershed types underlain by different parent materials (following methods of O'Donnell et al. 2016). Targeted; seven National Wild and Scenic Rivers are all sampled.	Revisit annually; Take every fourth year off for data analyses and writing.
	4	Habitat Characterization	Stratified; with three replicate streams sampled across five watershed types underlain by different parent materials (following methods of O'Donnell et al. 2016). Targeted; seven National Wild and Scenic Rivers are all sampled.	Revisit annually; Take every fourth year off for data analyses and writing.
Collecting Discrete Water Samples and Laboratory Analysis	5	Filtered sample	Stratified; with three replicate streams sampled across five watershed types underlain by different parent materials (following methods of O'Donnell et al. 2016). Targeted; seven National Wild and Scenic Rivers are all sampled.	Revisit annually; Take every fourth year off for data analyses and writing.

Table 2 (continued). Activity-level sample design matrix for Stream Communities and Ecosystems monitoring in the Arctic Network (O'Donnell and Miller 2016). Numbers (left column) match those in the Protocol Activity Matrix (Table 1).

Category	Activity #	Activity	Sampling Design	Revisit Design
Collecting Discrete Water Samples and Laboratory Analysis (continued)	6	Dissolved organic carbon (DOC)	Stratified; with three replicate streams sampled across five watershed types underlain by different parent materials (following methods of O'Donnell et al. 2016). Targeted; seven National Wild and Scenic Rivers are all sampled.	Revisit annually; Take every fourth year off for data analyses and writing.
	7	Unfiltered sample	Stratified; with three replicate streams sampled across five watershed types underlain by different parent materials (following methods of O'Donnell et al. 2016). Targeted; seven National Wild and Scenic Rivers are all sampled.	Revisit annually; Take every fourth year off for data analyses and writing.
	8	Dissolved inorganic carbon (DIC)	Stratified; with three replicate streams sampled across five watershed types underlain by different parent materials (following methods of O'Donnell et al. 2016). Targeted; seven National Wild and Scenic Rivers are all sampled.	Revisit annually; Take every fourth year off for data analyses and writing.
	9	Chlorophyll a	Stratified; with three replicate streams sampled across five watershed types underlain by different parent materials (following methods of O'Donnell et al. 2016). Targeted; seven National Wild and Scenic Rivers are all sampled.	Revisit annually; Take every fourth year off for data analyses and writing.
Continuous Monitoring of Core Water Quality Parameters	10	pH	Targeted/Stratified: Deploying sondes at three headwater streams draining watersheds underlain by differing parent material and ground ice configurations (following O'Donnell et al. 2016). Sites coincide with USGS Changing Arctic Ecosystems project where stream discharge is being monitored.	Continuous during open-water, ice-free season.

Table 2 (continued). Activity-level sample design matrix for Stream Communities and Ecosystems monitoring in the Arctic Network (O'Donnell and Miller 2016). Numbers (left column) match those in the Protocol Activity Matrix (Table 1).

Category	Activity #	Activity	Sampling Design	Revisit Design
Continuous Monitoring of Core Water Quality Parameters (continued)	11	Temperature	Targeted/Stratified: Deploying sondes at three headwater streams draining watersheds underlain by differing parent material and ground ice configurations (following O'Donnell et al. 2016). Sites coincide with USGS Changing Arctic Ecosystems project where stream discharge is being monitored.	Continuous during open-water, ice-free season.
	12	Dissolved Oxygen (DO)	Targeted/Stratified: Deploying sondes at three headwater streams draining watersheds underlain by differing parent material and ground ice configurations (following O'Donnell et al. 2016). Sites coincide with USGS Changing Arctic Ecosystems project where stream discharge is being monitored.	Continuous during open-water, ice-free season.
	13	Conductivity	Targeted/Stratified: Deploying sondes at three headwater streams draining watersheds underlain by differing parent material and ground ice configurations (following O'Donnell et al. 2016). Sites coincide with USGS Changing Arctic Ecosystems project where stream discharge is being monitored.	Continuous during open-water, ice-free season.

Data Quality Objectives

Data quality values and standards for implementation are provided in Table 3.

Table 3. Data Quality Values (DQVs) for continuous water quality monitoring in the Arctic Inventory & Monitoring Network.

Category	Data Quality Value	Definition	Protocol Considerations
Intrinsic Data Quality	Accuracy	Measurements reflect the true value of the parameter being observed. This applies to measures (length, width, position) or classes (species, types, or categories). Includes components of precision and bias.	All chemical analyses are determined using standards prepared using high-quality reagents. Labs use methods following EPA standards. Sondes sensors are calibrated in a laboratory environment in accordance with methods described in <i>SOP: Instrument Calibration</i> . Continuous monitoring is conducted following methods of Wagner et al. (2006).
	Representativeness	Measurements represent conditions at the time of sampling. Combined with accuracy, leads to repeatable data collection.	Water samples are collected at representative locations of a stream or river based on cross-section surveys of core water quality parameters. Discrete field measurements and continuous water quality monitoring is also conducted at representative locations based on cross-section surveys and habitat characterization (<i>SOP: Field Measurements</i>).
Contextual Data Quality	Comparability	At all monitoring sites, data are collected using identical water sampling and field monitoring equipment. All sites are monitored on a consistent schedule using standardized procedures.	Instrumentation, standard operating procedures, calibration procedures, and routine maintenance schedule are identical for all continuous monitoring stations. Data management and editing is conducted in accordance with standard operating procedures that are consistent between stations.

Table 3 (continued). Data Quality Values (DQVs) for continuous water quality monitoring in the Arctic Inventory & Monitoring Network.

Category	Data Quality Value	Definition	Protocol Considerations
Contextual Data Quality (continued)	Timeliness / Currency	Discrete field measurements and water samples for chemical analyses are collected annually during the period of maximum thaw depth (following O'Donnell et al. 2014). While field measurements are available right away, lab results are typically not available for up to six months following sample submission. Continuous monitoring data are collected at hourly intervals during the open-water, ice-free season (June – September). Data are available upon retrieval of sondes prior to river freeze-up.	Data verification, review, and validation of field measurements and water chemistry are conducted in the fall/winter. Chemistry data reports from USGS or CCAL typically take six months to receive from the time of sample submission. Data certification will be completed annually. Continuous data are not available in real time, but only after sonde retrieval. All continuous data importing, management, and editing is conducted in the fall following retrieval. Data certification will be conducted on an annual basis for all three monitoring stations. Where certified data cannot be provided for resource management decisions in a timely manner, requirements for provisional use of data are defined and documented prior to data dissemination and use.
	Completeness	All data/ measures required to evaluate accuracy representativeness are present; incomplete data sets (either at a location, across sampling locations, or over time) lose utility or relevance. Data records contain values as planned across the period of record.	Methods, sampling plans, and analyses are designed and implemented such that they result in a complete dataset across space and the planned period of record. Note that this value is for a collection of data records; how many measures are deemed valid and suitable for use at the completion of all QA/QC procedures.
Representational Data Quality	Consistent Representation	Use of standard definitions when describing data quality or resource quality based on data	Standard definitions of data quality are provided. Provisional data indicate data that have been reviewed but not certified. Provided data is defined (by USGS) as data provided by cooperating agency (i.e., NPS). Certified data are defined as those data that have been reviewed, QA/QC checked, and edited in accordance with procedures described in SOPs. Data are reported and flagged in comparison to established management, ecological, or regulatory thresholds in accordance with procedures described in O'Donnell and Miller (2017 (in review)).

Table 3 (continued). Data Quality Values (DQVs) for continuous water quality monitoring in the Arctic Inventory & Monitoring Network.

Category	Data Quality Value	Definition	Protocol Considerations
Data Accessibility	Secure	Access to data, products, and systems limited to appropriate audiences.	Field observations, discrete water chemistry, and continuous water quality data are all stored and managed in the NPS IRMA (https://irma.nps.gov/Portal) No protected data will be generated as part of the ARCN Streams Communities and Ecosystems Monitoring Protocol.

Table 4. Measurement Quality Objectives for Stream Communities and Ecosystems monitoring protocol in the Arctic Inventory & Monitoring Network (O'Donnell and Miller 2016). Accuracy, range, and resolution standards from YSI, Inc. (2009).

Category	Measure / Quality Indicator	Quality Objective
Site Establishment	Location Accuracy	Monitoring sites have been established following pilot studies (O'Donnell et al. 2015) and a peer-reviewed article (O'Donnell et al. 2016). GPS coordinates and ARCN park unit maps are available for all monitoring sites.
	Location Description Detail	Maps, narrative directions, and site access descriptions are included in field folders for each continuous sampling location.
pH (cross-sectional and continuous measurements)	Units	standard pH units
	Accuracy	+/- 0.2 units
	Resolution	0.01 units
	Range	0 to 14 units
	Reporting	Report to one decimal place.
	Calibration/Data Correction Criteria	+ 0.2
	Maximum allowable discrepancy from field meter	± 2

Table 4 (continued). Measurement Quality Objectives for Stream Communities and Ecosystems monitoring protocol in the Arctic Inventory & Monitoring Network (O'Donnell and Miller 2016). Accuracy, range, and resolution standards from YSI, Inc. (2009).

Category	Measure / Quality Indicator	Quality Objective
Temperature (cross-sectional and continuous measurements)	Units	degrees Celsius (°C)
	Accuracy	+/- 0.15°C
	Resolution	0.01°C
	Range	- 5 to 50 °C
	Reporting	Report to one decimal place
	Calibration/Data Correction Criteria	+ 0.2
	Maximum allowable discrepancy from field meter	± 2.0
Dissolved Oxygen (cross-sectional and continuous measurements)	Units	milligrams per liter (mg/l)
	Accuracy	+/- 1%
	Resolution	+/- 1%
	Range	0 to 50 mg/l
	Reporting	Report to one decimal place
	Calibration/Data Correction Criteria	+ 0.3
	Maximum allowable discrepancy from field meter	± 2.0 or 20%, whichever is greater
Specific Conductivity (cross-sectional and continuous measurements)	Units	microsiemens per centimeter [µS/cm])
	Accuracy	0.5% within calibrated range
	Resolution	1 µS/cm

Table 4 (continued). Measurement Quality Objectives for Stream Communities and Ecosystems monitoring protocol in the Arctic Inventory & Monitoring Network (O'Donnell and Miller 2016). Accuracy, range, and resolution standards from YSI, Inc. (2009).

Category	Measure / Quality Indicator	Quality Objective
Specific Conductivity (cross-sectional and continuous measurements) (continued)	Range	0 to 100,000 $\mu\text{S/cm}$
	Reporting	Report to whole number
	Calibration/Data Correction Criteria	+ 5 or + 3% of the measured value, which-ever is greater
	Maximum allowable discrepancy from field meter	$\pm 30\%$

Table 5. Data Protection standards for Stream Communities and Ecosystems monitoring in the Arctic Inventory & Monitoring Network (O'Donnell and Miller 2016). With the exceptions noted, all data collected are to be made publicly available in a timely fashion.

Category	Type of Data	Level of Protection	Rules for Dissemination
Water Quality Data and Information	Water Quality Data	Unprotected	Data available on-line as public information.
	Water Quality Data	Operationally protected	Data provided without reference to sensitive species proximity.
Location Data and Information	Permanent Sampling Locations	Operationally protected	Provided upon request only. Shown in reports
Personally Identifiable Information	Non-NPS Staff Information	Legally Protected	All but first name and last initial redacted from public release

Change Detection

Our sampling approach was designed to maximize our chances of detecting change in stream water quality over space and time. Following O'Donnell et al. (2016), we have proposed using a stratified sampling approach to account for spatial variability in watershed properties (e.g., permafrost ground ice content, and underlying parent material). Through this approach, we will be able to detect long-term changes in streams across space, and to identify watersheds that convey resilience versus those that are vulnerable to climate change and disturbance. Further, we have focused the majority of our sample collection timing to occur during summer baseflow conditions. For many stream chemical constituents, there is considerably variability in concentration across seasons. By focusing on a single season under consistent flow conditions, we increase our capacity to detect change over time.

We have already shown that this sampling design can yield statistically significant patterns in stream chemistry across space in watersheds of the ARCN parks. O'Donnell et al. (2016) used two-way analysis of variance (ANOVA) techniques with Tukey's Honest Significant Difference post hoc test to compare differences in DOC concentration across different watershed types. They observed statistically significant differences in DOC concentration as a function of both watershed parent material and ground ice class (with P -values < 0.0001). A similar landscape and statistical analysis was conducted by Larsen et al. (2017), who documented significant differences in nitrogen and phosphorus species across shallow lakes of the ARCN parks.

We have also shown that statistical analysis of stream discharge trends can yield significant results, Tape et al. (2016) reported statistically significant trends in the timing of peak discharge during spring snowmelt using regression techniques. We have proposed a more robust statistical approach for discharge analysis following standard methods that have worked for similarly gauged USGS sites (e.g., Brabets and Walvoord 2009).

Literature Cited

- Larsen, A. S., J. A. O'Donnell, J. H. Schmidt, H. J. Kristenson, and D. K. Swanson. 2017. Physical and chemical characteristics of lakes across heterogeneous landscapes in arctic and subarctic Alaska. *Journal of Geophysical Research Biogeosciences* doi:10.1002/2016JG003729.
- O'Donnell, J. A., G. R. Aiken, M. A. Walvoord, and K. D. Butler. 2012. Dissolved organic matter composition of winter flow in the Yukon River basin: implications of permafrost thaw and increased groundwater discharge. *Global Biogeochemical Cycles* 26, doi:10.1029/2012GB004341.
- O'Donnell, J. A., G. R. Aiken, M. A. Walvoord, P. A. Raymond, K. D. Butler, M. M. Dornblaser, and K. Heckman. 2014. Using dissolved organic matter age and composition to detect permafrost thaw in boreal watersheds of interior Alaska. *Journal of Geophysical Research* 119, doi:10.1002/2014JG002695.
- O'Donnell, J. A., G. R. Aiken, T. P. Trainor, and K. D. Butler. 2015. Chemical composition of rivers in Alaska's Arctic Network, 2013-2014. Natural Resource Data Series NPS/ARC/NRDS-2015/809. National Park Service, Fort Collins, Colorado.
- O'Donnell, J. A., G. R. Aiken, D. K. Swanson, S. Panda, K. D. Butler, and A. P. Baltensperger. 2016. Dissolved organic matter composition of Arctic rivers: linking permafrost and parent material to riverine carbon. *Global Biogeochemical Cycles* 30:1811-1826, doi:10.1002/2016GB005482.
- O'Donnell, J. A., C. E. Zimmerman, M. P. Carey, and J. C. Koch. 2017. Potential effects of permafrost thaw on Arctic river ecosystems. *Alaska Park Science* 16:47-50.
- Stottlemeyer R. 2001. Biogeochemistry of a treeline watershed, northwestern Alaska. *Journal of Environmental Quality* 30:1990-1998, doi:10.2134/jeq2001.1990.
- Wagner, R. J., R. W. Boulger Jr., C. J. Oblinger, and B. A. Smith. 2006. Guidelines and standard procedures for continuous water-quality monitors – Station operation, record computation, and data reporting: U. S. Geological Survey Techniques and Methods 1-D3, 51 p. + 8 attachments; accessed April 26, 2017 at <http://pubs.water.usgs.gov/tm1d3>.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 953/147866, September 2018

National Park Service
U.S. Department of the Interior



[Natural Resource Stewardship and Science](#)

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525