



Data Quality Standards for Sonoran Desert and Southern Plains Stream Monitoring

Natural Resource Report NPS/SODN/NRR—2018/1786



ON THE COVER

West Fork Gila River, Gila Cliff Dwellings National Monument.

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Natural Resource Report NPS/SODN/NRR—2018/1786

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Abstract

In accordance with guidelines set forth by the National Park Service Inventory & Monitoring Division, a quality-assurance plan has been created for use by the Sonoran Desert and Southern Plains Networks and in the implementation of Streams Protocol (Gwilliam et al. 2018). This quality-assurance plan documents the standards, policies, and procedures used by the Sonoran Desert and Southern Plains Networks for activities related to the collection, processing, storage, analysis, and publication of monitoring data. The policies and procedures documented in this quality-assurance plan for activities complement the quality-assurance plans for other monitoring activities conducted by the Sonoran Desert and Southern Plains Networks and supplement the National Inventory & Monitoring Division Quality Management Plan.

List of Terms¹

Accepted Data: Data that have undergone all QA and QC procedures as defined in a published protocol and associated SOPs. Used in cases where a Quality Assurance Plan has not been developed and approved.

Accreditation: A formal recognition that an individual or organization (e.g., laboratory) is competent to carry out specific tasks or specific types of tests, and/or meets predetermined qualifications or standards. For labs, this is typically done on an analyte basis for a limited/specific period of time.

Accuracy: A measure of the degree of conformance of the values generated by a specific method or procedure with the true value. The concept of accuracy includes both bias (systematic error) and precision (random error). EPA recommends that this term not be used and that precision and bias be used to convey the information usually associated with accuracy. See Precision and Bias.

Bias: Systematic error that is manifested as a consistent positive or negative deviation from the known or true value. It differs from random error which shows no such deviation.

Calibration: Determination, by measurement or comparison with a standard, the correct value of each measure on a meter or other device, or the correct value for each setting of a control knob. The levels of the calibration standards should bracket the range of planned measurements.

Certified Data: Certified data are those data that a) have been through all QA/QC procedures as outlined in the QAP, b) meet expected quality standards, or are appropriately identified and annotated at the record level in cases where they do not meet those standards, c) have documented procedures for data collection, processing, and transformation in appropriate metadata formats, and d) are suitable for use.

Comparability: The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator.

Data Quality Objectives (DQOs): Qualitative and quantitative statements that clarify the objectives of observations, define the appropriate type of data, and specify levels of uncertainty that are acceptable to managers when using data. DQOs provide the statistical framework for planning data collection and management, and are used as the basis for establishing the quality and quantity of data needed to support decisions. Includes Qualitative Data Quality Values (DQVs), and informs development of Measurement Standards (or Measurement

¹ Definitions are based on a combination of USGS (1995) and EPA (1997).

Quality Objectives; MQOs), Performance Standards, Accreditation Standards, and Policy Standards.

Data Quality Values (DQVs): Desired qualitative characteristics of data and datasets related to intrinsic data quality (reasonability, accuracy, objectivity, credibility), contextual data quality (relevance, timeliness, completeness, comparability), representational data quality (interpretability, understandability, consistency), and data accessibility (security, discoverability, utility).

Data Validation: Quality Control tools or processes designed to evaluate legitimacy of data as they proceed through the data management lifecycle. Typically data that do not pass validation procedures are either corrected using prescribed methods or flagged/graded to inform data users as to their appropriate use.

Data Verification: Quality Assurance tools or processes where data are checked for accuracy and inconsistencies as they migrate through the data management lifecycle. Data Verification helps to ensure that data are complete, properly formatted so that they can be processed, and accurately translated when transferred from one source to another.

Data Flagging / Data Qualification: A code or annotation that signals that data do not meet specified data quality standards so as to inform appropriate use.

Minimum Detection Limit (MDL): The minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, qualitatively or quantitatively measured, and reported to be greater than zero.

Minimum Quantification Limit (MQL): The concentration of analyte in a specific matrix for which the probability of producing analytical values above the method detection limit is 99 percent.

Precision: The degree of similarity among independent measurements of the same quantity, without reference to the known or true value.

Provisional Data: Provisional data are those data that have undergone incomplete QA/QC procedures as defined in the QAP and are not suitable for general use. Provisional data may be used in some cases, however, depending on the amount of QA/QC completed, and the intended use.

Quality Assurance (QA): The set of activities designed to ensure that data, products, or services meet defined standards of quality with a stated level of confidence. Quality Assurance focuses on ensuring that data are collected to and managed to the highest practicable quality, at or above stated data quality standards.

Quality Assurance Plan (QAP): Documentation of Quality Assurance and Quality Control procedures for a protocol, program (inventory and overall I&M), and national database application (i.e., Data Store).

Quality Control (QC): Operational techniques and activities that are used to ensure that data or products meet designated requirements for quality. Quality Control procedures focus on testing data for quality and can include both an evaluation of whether data quality meet data quality objectives and/or procedures to correct data.

Raw Data: Data in their state of original collection, either in the form of paper or electronic field forms, electronic sensor files, or digital media (photo, video, or audio). These data generally have been collected following some QA procedures, but have not undergone any QC procedures.

Sensitivity: The ability of a method or instrument to discriminate between minimally different levels of a variable of interest by producing a noticeably different measurement response.

Standards, Measurement (also Measurement Quality Objectives): Data quality requirements specifying the level of precision, bias, sensitivity, resolution, etc. that data must meet to be accepted for use in analysis.

Standards, Performance: Data quality requirements specifying the detection ability, sensitivity, variability, etc., of equipment, sensors, or observers to reliably measure characteristics within target populations.

Standards, Accreditation: Data quality requirements related to individuals or organizations involved with data collection, analysis or processing to ensure desired data credibility and defensibility. Examples include professional accreditation/certificates, required training, chain-of-custody requirements and others.

Standards, Policy: Data quality requirements related to ensuring appropriate management, use, dissemination, qualification, and documentation of data.

Introduction

The National Park Service (NPS) Inventory and Monitoring Program was established by an act of Congress in 1999 to provide more than 270 national park system units a core suite of baseline minimum scientific information (inventories) and to identify and implement long-term monitoring of high-priority measurements of resource condition in those units (Fancy et al. 2009). The overarching purpose of natural resource monitoring in parks is to develop scientifically sound information on the current status and long-term trends in the composition, structure, and function of park ecosystems, and determine how well current management practices are sustaining those ecosystems.

The purpose of this QAP is to document the standards, policies, and procedures used by the Sonoran Desert and Southern Plains Networks for activities related to the collection, processing, storage, analysis, and publication of monitoring data as described in the (Gwilliam et al. 2018). The policies and procedures documented or referenced in this quality-assurance plan complement the quality-assurance plans for other monitoring activities conducted by the Sonoran Desert and Southern Plains Networks and supplement the quality management plan for the NPS Inventory & Monitoring Program. The QAP also serves as a guide for all Sonoran Desert and Southern Plains Networks 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 monitoring plans for the Sonoran Desert Network (SODN) and Southern Plains Network (SOPN) identified vital signs representing a diverse range of natural resources, including air, water, climate, soils, plants, invertebrates, and vertebrates (NPS 2005; NPS 2008). Within each of these categories, a workgroup of between four and eight regional and national experts chose vital signs. Each workgroup evaluated high-priority resource issues and identified candidate vital signs on the basis of ecological significance, feasibility, and relevance to management (NPS 2005; NPS 2008).

At SODN and SOPN, workgroups for hydrology, vertebrates, invertebrates, plants, and soils all selected high-priority vital signs emphasizing the importance and feasibility of long-term monitoring of the condition of perennial streams and rivers from an integrated ecological perspective.

The SODN and SOPN Stream Monitoring Protocol (Gwilliam et al. 2018) identifies a structured method for monitoring selected metrics derived from these vital signs, following the framework found in Oakley and others (2003). The vital signs are grouped into relevant “modules,” making undertaking the similar monitoring activities efficacious for implementation and ecological interpretation. Monitoring methods were selected (mostly) from existing methods and techniques. The stream protocol is a strategy to collect useful, credible and scientifically rigorous data on the diverse streams in both SODN and SOPN networks and provide detailed instructions for the consistent and comparable collection of data in the present and the future (Hughes et al. 2018).

The goal of this protocol is to determine status and long-term trend on selected metrics from the identified vital signs grouped into the following modules: water quantity, channel morphology, riparian vegetation, water quality, benthic macroinvertebrates and fish and other wildlife.

Water quantity data are collected by USGS stream gauge stations at or near park stream segments, or by SODN-SOPN or NPS staff at gauge stations at sample sites in park units where USGS gauges are not located. At these NPS gauge stations, the protocol follows USGS recommendations for establishment. This module includes discrete measurements of discharge, collected quarterly, and continuous measurements of stream stage, presence/absence of water and surveying of flood impact for indirect flow measurements.

Channel morphology is collected at an index stream segment every five years, and is contingent on 100-yr flood events, or other large disruptive events. This includes surveying of channel cross sections, a longitudinal profile of the stream segment, assessment of stream segment sinuosity and characterization of the substrate size composition.

Collection of *riparian vegetation* data are conducted at an index stream segment every five years, and is contingent on 100-yr flood events, or other large disruptive events. This includes collecting data on community composition, abundance and frequency of perennial aquatic and riparian taxa and measures of common riparian tree recruitment and vigor.

Water quality includes discrete (distinct “grab” sample) and continuous measurements (samples every 15 min for 2-3 weeks per quarter) of five water quality parameters (Temperature, specific conductivity, pH, dissolved oxygen and turbidity). Other water quality parameters are collected quarterly for up to 70 parameters. See Appendix A for a detailed list.

Benthic macroinvertebrates are collected annually at each index reach during the index period and using the methods of the state the sample index is located. The samples are identified by the Buglab at the University of Utah which provides metrics from these taxa.

Fish and other wildlife are sampled annually at individual reaches following applicable state and/or federal methods

Data and information are shared with parks, NPS staff, and the public through a variety of reports and products. At the end of each field season, network staff send a short field and data summary that summarize observations and highlight observations of interest or concern to each park. Annually, SODN summarizes springs data in Climate and Water Resources Reports that also incorporate data from climate, groundwater, and streams monitoring. Additional products will be derived from the published reports, including but not limited to two-page briefs and social media posts.

Protocol Activities and Modules

Data are collected or derived as a part of the Streams Protocol (Gwilliam et al. 2018) in six different modules. Within each module, as noted above, a variety of activities are undertaken (Table 1). All SOP referenced in Table 1 are from Gwilliam and others (2018). Other methods referenced are cited.

Table 1. Protocol activity matrix for modules used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	#	Activity	Description
Site Recon, Establishment, and Maintenance	1	Stream Segment Recon	Selection of an index stream segments in each network park unit with perennial water (see protocol Chapter 3.2; SOP 3); select landscape level stream segments (SOP 3)
	2	Stream Segment Establishment	Collect GPS point locations identifying upstream and downstream ends of each Stream Segment
	3	Stream Segment Cross-section recon	Initial selection of cross-section start point. See SOP_03 and Chapters 2.2, 3.3 and 4.2 of Gwilliam and others (2018)
	4	Stream Segment Cross-section Establishment	Selecting and establishing cross-sections perpendicular to the flow of the stream. See SOP 03 and SOP 08
	5	Stream Segment Cross-section Maintenance	Resurveying cross-section end pins, see SOP 08
	6	Selection of ripveg transects	Riparian vegetation transects and density are selected; see SOP14 and chapter 4.3 Gwilliam et al. 2018) on the stream segment cross-sections
	7	Assessment and establishment of riparian vegetation transects, and density plots	Field crews visit the selected locations on the stream segment cross-sections. Assess the validity of transect and density plots following SOP 14. Establish start and end points of transect and collect photopoint data (SOP 14)
	8	Reach Recon	Select reach location in stream segment (SOP 3) Investigate suitability of sites to be used as sampling location. Data collected and retained (descriptions, photos) for reference when being considered for future work or work to be conducted as a part of other monitoring efforts.
	9	Reach Establishment	Locate sample locations for sampling riffles, and for sampling across the index site including the cross sections where macroinvertebrate habitat metrics are collected (SOP 3 and SOP 25)
	10	Sample Site/Index site Recon	Investigate suitability of sites to be used as index sample sites. Includes possible locations in or near Index Stream Segment. Data collected and retained (descriptions, photos) for reference when being considered for future work or work to be conducted as a part of other monitoring efforts. The nearest USGS stream gauge either in, adjacent or near park unit will be identified and utilized for gauge record (SOP 3)
	11	Sample Site/Index site establishment	One Index Sample Site selected in or near each perennial stream in each park unit (SOP 3). Includes installing equipment, collecting GPS data on site and gathering information as described in Turnipseed and Sauer (2010)
	12	Sample Site/Index site maintenance	Where appropriate, log of damage and replacement, modification, and upgrade history to permanent sampling locations; see Turnipseed and Sauer (2010)

Table 1 (continued). Protocol activity matrix for modules used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	#	Activity	Description
Field Data Collection	13	Discharge Measurements	Discharge measurements will be collected following SOP 07, following Turnipseed and Sauer (2010)
	14	Stream Stage Measurements	Recording stream stage before and after discharge measurement SOP 07 (from Turnipseed and Sauer 2010)
	15	Measure stream segment cross-sections	Measure the elevation of the surface across the cross-section (see SOP 08 and SOP 10)
	16	Measure stream segment longitudinal profile	Measure the elevation of the thalweg of the channel across the stream segment SOP08
	17	Measure stream bed particle size	Collect bed particle size data at each stream segment cross-section location (SOP 09)
	18	Measure stream bed particle size	Collect bed particle size data at each reach cross-section location (SOP 09)
	19	Measure stream bed particle size	Collect bed particle size data at each riffle (SOP 09)
	20	Assess habitat at cross-sections	Collect qualitative data on the status of the stream habitat at each stream segment cross-section. (SOP 11)
	21	Read riparian zone vegetation transect	Read riparian zone transects following SOP 14
	22	Read greenline vegetation transects	Read greenline riparian vegetation transects following SOP 14
	23	Read nested density plots	Read nested plots (pole count and DBH data) following SOP 14
	24	Read aquatic macrophyte plot	Read plot following SOP 14
	25	Locate and assess legacy trees	Locate/relocate legacy trees in riparian area of stream segment and conduct vigor assessment following SOP 14
	26	Collect core water quality parameters	Use a handheld multiparameter water quality meter to collect a discrete measurement of core water quality parameters (following SOP 19)
	27	Conduct qualitative assessment of sample site	Collect field observations on the status of the index site (site changes, air temp, water color) following SOP 17
	28	Conduct habitat assessment of reach	Collect data on habitat status in the reach in association with macroinvertebrate sampling (SOP 25)
Sensor data collection	29	Pressure transducer data	Collecting data with a logging pressure transducer about water depth every 15 min at sampling site (SOP 07)
	29	Multiparameter sonde	Collecting core water quality samples with a logging multiparameter instrument (SOP 18)
	29	Processing pressure transducer data	Data are downloaded from logger, along with data from a logger collecting contemporaneous atmospheric pressure data, and is corrected for with atmospheric pressure data. Stored in AQUARIUS software (SOP 07)

Table 1 (continued). Protocol activity matrix for modules used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	#	Activity	Description
Sensor data collection (continued)	29	Processing sonde data	Data are downloaded and corrected with corresponding discrete water quality measurements. Data are processed and stored in AQUARIUS software (SOP 18)
	29	Photopoint data	Collected at each riparian vegetation transect (SOP 14); also at each reach transect as part of macroinvertebrate sampling (SOP 26)
Field Sample Data	30	Collecting new or unknown plant taxa	If new or unknown plant taxa are collected during riparian vegetation sampling, follow: GOP Botanical_Curation Procedures_v2
	31	Staff collecting turbidity samples	Collection and processing of turbidity grab samples (SOP 21)
	32	Staff collecting E. coli samples	Collecting and processing of E. coli grab samples (SOP 22)
Lab Sample Data	33	Collection of water quality grab sample	Water column grab sample for the analysis of total and dissolved metals; nutrients; biological condition; suspended sediment and general water quality and inorganics (SOP 17 and 20). A list of parameters with associated methods is located in appendix A. This includes shipping (including COC forms) and receiving final data.
	34	Collection of benthic macroinvertebrate samples	Collection of macroinvertebrate samples to assess state IBI and reach-wide community. This includes shipping (including COC forms) and receiving final data.(SOP 25).
External Data	35	Stream Gage Data	Data from USGS stream gauges used to measure status and trend in annual and seasonal stream baseflow
	36	Stream Gage Data	Data from state managed stream gauges (CO and TX) used to measure status and trend in annual and seasonal stream baseflow
Derivative Data	37	Derived stream discharge metrics	Derived metrics and summary analysis of stream flow conducted by the USGS
	38	Macroinvertebrate metrics and indexes	The contract lab identifies and enumerates our benthic macroinvertebrate samples, providing us with derived metrics and indices.
Quality Control Data	39	Assuring quality of logging pressure transducers	Assessing if the pressure transducers can meet QAQC qualifications identified by the sensor vendor (SOP 07)
	40	Assuring the quality of the acoustic velocimeter data	Annually audit discharge measurement of each worker (SOP 07)
	41	Survey the elevation of any mounted equipment	Measure any movement of mounts or equipment (Turnipseed and Sauer 2010)
	42	Field audit	Each crew member will have work assessed by supervisor (SOP 14)

Table 1 (continued). Protocol activity matrix for modules used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	#	Activity	Description
Quality Control Data (continued)	43	Pre- and post-calibration of temperature sensors	Calibration of temperature sensors before and after deployment to test for measurement drift (SOP 18)
	44	Annual oversample of 10% of grab laboratory samples	10% of samples collected for analysis at lab will be blanks and duplicate samples to assess the quality of the contract lab (SOP 20)

Sampling Design

The sampling design matrix for the SODN stream sampling protocol is shown in Table 2.

Table 2. Activity-level sample design matrix used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	#	Activity	Sample Design	Revisit Design
Field Data Collection	13	Discharge Measurements	Targeted	Revisit quarterly (four times annually)
	14	Stream Stage Measurements	Targeted	Revisit quarterly (four times annually)
	15	Measure stream segment cross-sections	Targeted	Resampled every five years
	16	Measure stream segment longitudinal Profile	Targeted	Resampled every five years
	17	Measure stream bed particle size (Segment)	Targeted	Resampled every five years
	18	Measure stream bed particle size (reach)	Targeted	Resampled annually
	19	Measure stream bed particle size (riffles)	Targeted	Resampled annually
	20	Assess habitat at cross-sections	Targeted	Resampled annually
	21	Read riparian zone vegetation transect	Targeted	Resampled every five years
	22	Read greenline vegetation transects	Targeted	Resampled every five years
	23	Read nested density plots	Targeted	Resampled every five years
	24	Read aquatic macrophyte plot	Targeted	Resampled every five years
	25	Locate and assess legacy trees	Targeted	Revisited every five years
	26	Collect core water quality parameters	Targeted	Revisited quarterly (four times annually)
	27	Conduct qualitative assessment of sample site	Targeted	Resampled annually
	28	Conduct habitat assessment of reach	Targeted	Resampled annually
Sensor Data Collection	29	Pressure transducer data	Targeted	Continuous
	30	Multiparameter sonde	Targeted	Revisit quarterly (four times annually)
	31	Processing pressure transducer data	Targeted	Revisit quarterly (four times annually)
	32	Processing sonde data	Targeted	Revisit quarterly (four times annually)

Table 2 (continued). Activity-level sample design matrix used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	#	Activity	Sample Design	Revisit Design
Sensor Data Collection (continued)	33	Photopoint data	Targeted	Revisit quarterly (four times annually)
Field Sample Data	34	Collecting new or unknown plant taxa	Targeted	Resampled every five years
	35	Staff collecting turbidity samples	Targeted	Revisit quarterly (four times annually)
	36	Staff collecting E. coli samples	Targeted	Revisit quarterly (four times annually)
Lab Sample Data	37	Collection of water quality grab sample	Targeted	Resampled quarterly (four times annually)
	38	Collection of benthic macroinvertebrate samples	Targeted	Resampled annually

Data Quality Objectives

The data quality values, objectives, and laboratory performance requirements, and taxonomic standards used for the SODN stream sampling protocol are shown in Tables 3–7.

Table 3. Data quality values (DQVs) used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Type	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.	Plans for protocols, programs, or projects specify accuracy requirements designed to ensure desired results, taking into account estimated or expected precision and bias. May be of heightened importance for protocols where data are known or expected to be used in legal, regulatory, or policy situations.
	Representativeness	Measurements represent conditions at the time of sampling. Combined with accuracy, leads to repeatable data collection.	At the first level of implementation, one targeted stream segment is located in each park unit. This segment is compared against itself for parameters that are considered for trend analysis. Results may be compared to regional results, such as macroinvertebrate indices, however it must be recognized that any results have statistical inference ONLY TO THE SITE, NOT ACROSS THE ENTIRE PARK At the second level of implementation in parks with more than 10km of stream length, one watershed unit will be randomly selected and stream segments will be chosen using the GRTS algorithm. Twenty segments will be sampled for appropriate monitoring modules in a (4-1) panel. This will give park wide inference about trends in parameters across the park
Contextual Data Quality	Comparability	The degree to which data can be compared among sample locations, data sources, or periods of time.	Stream segments monitored will only be compared to themselves over time. Standard operating procedures, equipment, and calibration procedures are identical among sites.
	Timeliness / Currency	How recent the data need to be to be considered valid for their intended use. Data represents conditions and/or is available and in a format for use at the appropriate time in the decision-making process.	Data processing occurs in a timely fashion based on certification requirements and intended use of data. 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.

Table 3 (continued). Data quality values (DQVs) used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Type	Data Quality Value	Definition	Protocol Considerations
Contextual Data Quality (continued)	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. However, instrument loss or failures, logistical issues, and safety issues may result in an incomplete record.
Representational Data Quality	Consistent Representation	Use of standard definitions when describing data quality or resource quality based on data	Data definitions are internally consistent, and are consistent with definitions common to the field. Any obscure terms are defined so the layman can understand.
Data Accessibility	Secure	Access to data, products, and systems limited to appropriate audiences.	Protected data may be released in limited cases only with park Superintendent or Chief of Resources approval following park procedures. Networks also are developing sensitive information plans.

Table 4. Measurement quality objectives used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	#	Module/Quality Indicator	Quality Objective
Site Recon, Establishment, and Maintenance	–	Location of all sampling sites	± 3m (horizontal)
	–	Sample Site/Index site	Description provided with enough detail to relocate without use of GPS equipment
Field Data Collection	13	Discharge Measurements	75% of stream velocity measurements are of "fair" quality or better (SOP 07)
	14	Stream Stage Measurements	+/- 0.01m
	15	Measure stream segment cross-sections	+/- 10cm
	16	Measure stream segment longitudinal profile	+/- 10cm
	17	Measure stream bed particle size	5mm accuracy with 1m resolution
	21	Read riparian vegetation transect	95% accuracy, taxonomic resolution to species; 90% completeness
	22	Read greenline vegetation transects	95% accuracy, taxonomic resolution to species; 90% completeness
	23	Read nested density plots	95% accuracy, taxonomic resolution to species; 95% completeness

Table 4 (continued). Measurement quality objectives used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	#	Module/Quality Indicator	Quality Objective
Field Data Collection (continued)	24	Read aquatic macrophyte plot	95% accuracy, taxonomic resolution to species; 95% completeness
	25	Locate and assess legacy trees	95% accuracy, taxonomic resolution to species; 95% completeness
	26	Collect core water quality parameters	Accuracy/Resolution
	26	Temperature	± 0.2°C/0.1°C
	26	SpCond	± 3% >200 µS/cm; 5% ≤200 µS/cm/0.001 mS/cm to 0.1 mS/cm (range dependent)
	26	pH	± 0.2 units/0.01 units
	26	DO	± 2% of reading or air saturation (max) 0-200%; ± 6% of reading 200-500%/± 2% of reading or ± 0.2 mg/L (max) 0-20 mg/L; ± 6% of reading 20-50 mg
	27	Conduct qualitative assessment of sample site	Description contains enough detail to characterize the critical aspects of the site
Sensor Data Collection	29	Pressure transducer data	+/- 10mbar/1mb resolution
	30	Multiparameter sonde	Accuracy/Resolution
	30	Temperature	± 0.2°C/0.1°C
	30	SpCond	± 3% >200 µS/cm; 5% ≤200 µS/cm/0.001 mS/cm to 0.1 mS/cm (range dependent)
	30	pH	± 0.2 units/0.01 units
	30	DO	± 2% of reading or air saturation (max) 0-200%; ± 6% of reading 200-500%/± 2% of reading or ± 0.2 mg/L (max) 0-20 mg/L; ± 6% of reading 20-50 mg
	33	Photopoint data	10MP resolution; format JPEG w/embedded metadata
Field Sample Data	35	Staff collecting turbidity samples	accuracy ± 0.01 NTU/resolution 0.01 NTU
	36	Staff collecting E. coli samples	accuracy ± 10 NPN /resolution of 1 MPN
Lab Sample Data	37	Collection of water quality grab sample	–
	38	Collection of benthic macroinvertebrate samples	–
	38	Taxonomic resolution	Identifications made to the family level or better

Table 4 (continued). Measurement quality objectives used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	#	Module/Quality Indicator	Quality Objective
Lab Sample Data (continued)	38	Identification Accuracy	100% accurate in 10% random subsample.
	38	Identification Completeness	95% of observations made to designated taxonomic resolution

Table 5. Laboratory method performance requirements used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	Analyte	Method	MDL
General	Acidity	SM 2310B	2.0mg/L
	Alkalinity as CaCO ₃	SM 2320B	2.0mg/L
	Bicarbonate as CaCO ₃ -included in alkalinity	SM 2320B	2.0mg/L
	Biological Oxygen Demand (BOD)	SM 5210B	5.0mg/L
	Carbon, Total Organic	SM5310C	0.080mg/L
	Carbonate as CaCO ₃	SM 2320B	1.2mg/L
	Cation-Anion Balance	–	–
	Chloride	300.0	0.25mg/L
	Conductance, Specific @25C	SM 2510B	1 umhos/cm @ 25°C
	Total cyanide	SM 4500 CN-C, E	0.017mg/L
	Fluoride	SM 4500 F,C	0.020mg/L
	Hardness as CaCO ₃	SM 2340C	4.0mg/L
	Mercury, dissolved	245.1	0.00010mg/L
	Nitrate as N, dissolved	300.0	0.0151mg/L
	Nitrite as N, dissolved	300.0	0.038mg/L
	Nitrogen, ammonia as N	SM4500-NH ₃ D	0.50mg/L
	Nitrogen, total Kjeldahl	SM4500 Norg C	1.0mg/L
	Nitrogen, total	Calculation	1.7mg/L
	pH	SM 4500 H B	1.68 pH Units
	Sulfate	300.0	0.20mg/L
	Residue, Non-Filterable (TSS)	SM 2540D	0.010mg/L
	TDS Residue on evap. @ 180°C, water, filtered	SM 2540C	1.0mg/L
	TDS calculated	–	–
	TDS (ratio - measured/calculated)	–	–

Table 5 (continued). Laboratory method performance requirements used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	Analyte	Method	MDL
ICP Metals with digestion Dissolved Metals Method 200.7	Boron	200.7	0.020 / 0.050 MDL/RL mg/L
	Cadmium	200.7	0.0020 / 0.0050 MDL/RL mg/L
	Iron	200.7	0.015 / 0.040 MDL/RL mg/L
	Magnesium	200.7	0.012 / 0.020 MDL/RL mg/L
	Phosphorus	200.7	0.020 / 0.040 MDL/RL mg/L
	Potassium	200.7	0.37 / 0.50 MDL/RL mg/L
	Silica SiO ₂	200.7	0.028 / 0.11 MDL/RL mg/L
	Sodium	200.7	0.19 / 0.50 MDL/RL mg/L
ICP Metals with digestion Total Metals Method 200.7	Boron	200.7	0.020 / 0.050 MDL/RL mg/L
	Calcium	200.7	0.050 / 0.10 MDL/RL mg/L
	Iron	200.7	0.015 / 0.040 MDL/RL mg/L
	Magnesium	200.7	0.012 / 0.020 MDL/RL mg/L
	Phosphorus	200.7	0.020 / 0.040 MDL/RL mg/L
	Potassium	200.7	0.37 / 0.50 MDL/RL mg/L
	Silica SiO ₂	200.7	0.028 / 0.11 MDL/RL mg/L
	Sodium	200.7	0.19 / 0.50 MDL/RL mg/L
ICPMS Metals with digestion Dissolved Metals Method 200.8	Aluminum	200.8	8.5 / 10.0 MDL/RL mg/L
	Antimony	200.8	0.30 / 2.0 MDL/RL mg/L
	Arsenic	200.8	0.90 / 1.0 MDL/RL mg/L
	Barium	200.8	0.30 / 1.0 MDL/RL mg/L

Table 5 (continued). Laboratory method performance requirements used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	Analyte	Method	MDL
ICPMS Metals with digestion Dissolved Metals Method 200.8 (continued)	Beryllium	200.8	0.10 / 0.50 MDL/RL mg/L
	Cadmium	200.8	0.10 / 1.0 MDL/RL mg/L
	Chromium	200.8	0.90 / 2.0 MDL/RL mg/L
	Copper	200.8	0.50 / 1.0 MDL/RL mg/L
	Lead	200.8	0.20 / 1.0 MDL/RL mg/L
	Manganese	200.8	0.70 / 1.0 MDL/RL mg/L
	Molybdenum	200.8	0.20 / 2.0 MDL/RL mg/L
	Nickel	200.8	0.50 / 2.0 MDL/RL mg/L
	Selenium	200.8	0.50 / 1.0 MDL/RL mg/L
	Silver	200.8	0.10 / 1.0 MDL/RL mg/L
	Thallium	200.8	0.20 / 1.0 MDL/RL mg/L
	Uranium	200.8	0.20 / 1.0 MDL/RL mg/L
	Zinc	200.8	4.0 / 5.0 MDL/RL mg/L

Table 6. Taxonomic standards used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	#	Activity	Standard to be used	Reference/Authority
Field Data Collection	21	Read riparian zone vegetation transect	Scientific publication or resource	See Appendix A
	22	Read Greenline vegetation transects	Scientific publication or resource	See Appendix A
	23	Read nested density plots	Scientific publication or resource	See Appendix A
	24	Read aquatic macrophyte plot	Scientific publication or resource	See Appendix A
	25	Locate and assess legacy trees	Scientific publication or resource	See Appendix A

Table 6 (continued). Taxonomic standards used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	#	Activity	Standard to be used	Reference/Authority
Field Sample Data	34	Collecting new or unknown plant taxa	Scientific publication or resource	See Appendix A
Lab Sample Data	38	Collection of benthic macroinvertebrate samples	Scientific publication or resource	This link provides access to resources used for taxonomic ID by the lab https://www.usu.edu/buglab/SampleProcessing/LaboratoryProcedures/#item=74

Accreditation Standards

The professional and laboratory accreditation standards used for the stream monitoring protocol are shown in Tables 7 and 8.

Table 7. Professional and laboratory accreditation used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018).

Category	Activity	Parameter	Accreditation Requirement	Location of Certification Documentation
Lab Accreditations	#37 Grab sample collected for analysis by contract lab	All	State departments of environmental quality NELAP	Copy of certification on file in Network office

Table 8. Data Protection standards used for the Sonoran Desert and Southern Plains networks stream monitoring protocol (Gwilliam et al. 2018). 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
Resource Data and Information	Federal and State T&E species locations	Legally Protected	Locations of observations reported at park centroid or park extent (boundary polygon).
Resource Data and Information	Species of concern and/or commercially valuable	Operationally protected	Redacted or dissemination to non-NPS staff must be approved by park Chief of Resources (depending on park and species).
Resource Data and Information	Archeological and paleontological	Legally Protected	Redacted
Location Data and Information	Spring locations and permanent sampling locations	Legally protected	Redacted
Location Data and Information	Spring access descriptions and any other relevant notes	Legally protected	Redacted
Personally Identifiable Information	Non-NPS staff information	Legally Protected	All but first name and last initial redacted from public release

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Appendix A. References and Authorities for Taxonomic Standards

Herbaria Consortium

Southwest Environmental Information Network (SEINet)

<http://swbiodiversity.org/seinet/>

Resources: Plant image library, descriptions, regional species list, herbaria search engine, dynamic keys

Taxonomic Keys

eFloras

<http://efloras.org/>

Resources: Flora of North America

Canotia

<http://canotia.org/>

Resources: Vascular Plants of Arizona, botanical journal articles published by Arizona State University

Phytoneuron: Digital Publications of Plant Biology

<http://www.phytoneuron.net/>

Resources: Ajo Peak to Tinajas Altas: A flora in southwestern Arizona (Felger, R.S. et al.), journal articles

Image Libraries

New Mexico Flora

<http://www.polyplod.net/swplants/index.html>

Resources: Plant image library

Vascular Plants of the Gila Wilderness

<http://www.wnmu.edu/academic/nspages/gilaflora/index.html>

Resource: Image Library

Northern Arizona Flora

<http://www.nazflora.org/>

Resource: Image Library

Plant Distribution and Nativity

USDA Plants

<http://plants.usda.gov/java/>

Resource: Nativity, distribution by state, images, taxonomy and nomenclature

Taxonomy Taxonomic Name Resolution Service (TNRS)

<http://tnrs.iplantcollaborative.org/index.html>

Resources: taxonomic and nomenclature

Tropicos

<http://www.tropicos.org/>

Resources: taxonomy, nomenclature, image library

Integrated Taxonomic Information System (ITIS)

<http://www.itis.gov/>

Resources: taxonomy, nomenclature

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.

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National Park Service
U.S. Department of the Interior



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