National Park Service
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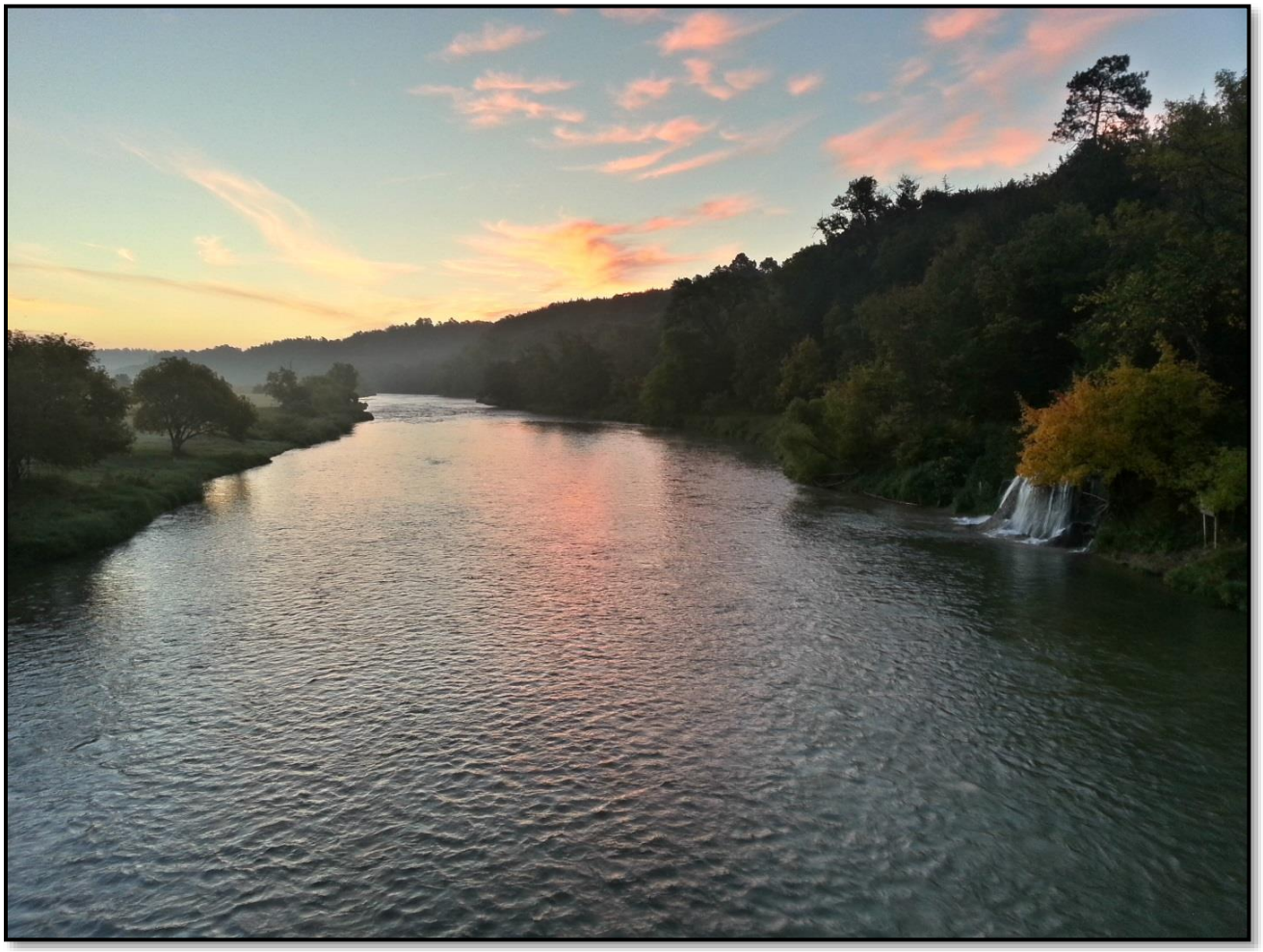
Natural Resource Stewardship and Science

# Protocol Implementation Plan for Stream Channel Monitoring in the Northern Great Plains Network

*Narrative Version 1.0*

Natural Resource Report NPS/NGPN/NRR—2019/1918



**ON THIS PAGE**
Little Missouri River, Theodore Roosevelt National Park.
Photograph courtesy of D. Licht

**ON THE COVER**
Niobrara River, Niobrara National Scenic River near Sparks, Nebraska.
Photograph courtesy of M. Moser, United States Geological Service, Nebraska Water Science Center

# Protocol Implementation Plan for Stream Channel Monitoring in the Northern Great Plains Network

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Natural Resource Report NPS/NGPN/NRR—2019/1918

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# Executive Summary

The Northern Great Plains Inventory and Monitoring Network includes thirteen park units located in five northern Great Plains states across six ecoregions. In collaboration with these parks, NGPN will monitor stream channel characteristics at nine park units. This stream channel monitoring effort includes fluvial resources at Agate Fossil Beds National Monument, Niobrara National Scenic River, Mount Rushmore National Memorial, Fort Laramie National Historical Site, Missouri National Recreational River, Wind Cave National Park, Devils Tower National Monument, Knife River Indian Villages National Historic Site, and Theodore Roosevelt National Park.

This Protocol Implementation Plan for Stream Channel Monitoring in the NGPN outlines how monitoring data will be collected, managed, and reported for NGPN Stream Channel Monitoring (SCM). This protocol implementation plan is developed from standard data collection, field sampling methods, and standard operating procedures currently in use by the NPS Southeast Coast Network from their *Monitoring wadeable stream habitat conditions in Southeast Coast Network parks: Protocol narrative*.

NGPN chose to follow the sampling design, sampling schedule, and geographic sampling reach locations from *Water Quality Monitoring Protocol for Wadeable Streams and Rivers in the Northern Great Plains Network: Narrative version 1.0*, to better integrate multiple vital signs (i.e. water quality monitoring and stream channel monitoring) and monitoring of water resources for NGPN parks. Coordinated field site locations, frequency, and sampling schedules following the NGPN water quality monitoring protocol may provide a more integrated assessment of ecological conditions of water resources in the NGPN. In some cases, this may provide insight into underlying causes that allow for interpretation of environmental changes in stream channel characteristics at the reach scale, and of core water quality parameters in the context of stream flow data.

The goal of the *Protocol Implementation Plan for Stream Channel Monitoring in the NGPN* is to provide information to park managers about baseline stream and river channel characteristics, and identify the long-term trends, variability, and potential environmental stressors for stream and river geomorphology in the network parks. Early identification of changes in baseline stream and river channel characteristics, along with an understanding of normal variability, is vital to recognizing potential ecological problems in parks' fluvial resources. Numerous factors can affect water resources at large scales as well as at the park scale. Changes in climate, watershed processes, groundwater withdrawals, and visitor use all have the potential to threaten stream geomorphology. Stream Channel Monitoring in the NGPN focuses on changes in geomorphology and channel characteristics that are particularly problematic for park managers because they can affect habitat, park infrastructure, and archaeological and paleontological resources.

The Protocol Implementation Plan for Stream Channel Monitoring in the NGPN will monitor fixed stream reaches at nine parks, with each reach sampled every three years for stream geomorphic dimensions and habitat features, and every nine years for watershed characteristics. The primary monitoring objectives are:

- Determine the status of upstream watershed characteristics such as watershed area, catchment slope, and drainage density, and changes to land cover that may affect stream habitat.
- Determine the status of and trends in the geomorphic dimensions (cross-sectional morphology) of selected wadeable stream reaches including channel widths, bank characteristics (e.g., heights, angles, and vegetative cover), and reach slope and sinuosity.
- Determine the status of and trends in physical measures of benthic and riparian habitat features present in selected wadeable stream reaches such as the size, type, and distribution of bed sediment and large woody debris, the distribution of geomorphic channel units, canopy cover, and discharge.

Data collected as part of this effort are archived locally on the NGPN Server and will be re-named following Network standards. NGPN will store data on the NGPN Server in an NGPN Geodatabase and in a relational Microsoft Access database. Certified data will also be uploaded to the Data Store annually, and to NPS Environmental Quality Information Systems (EQuIS) database when available. Reporting will consist of brief Natural Resource Data series reports every year that summarize watershed characteristics, reach level geomorphic dimensions, and habitat features for selected wadeable stream reaches. After four sampling cycles (or twelve years), and every three sampling cycles thereafter, NGPN will publish trend reports for each park unit sampled.

# Acknowledgments

Funding for part of the development of this protocol was provided through the National Park Service Northern Great Plains Inventory and Monitoring Network (NGPN) to U.S. Geological Survey Dakota Water Science Center. We would like to thank D. Bender with the Dakota Water Science Center for his help in reviewing potential protocols for the development of this Protocol Implementation Plan (PIP) and in reviewing additional protocols that would fit the need for accompanying SOPs for the development of the PIP Stream Channel Monitoring (SCM) in the NGPN.

We would also like to thank the Southeast Coast Network (SECN) for the development of their protocol “Monitoring wadeable stream habitat conditions in Southeast Coast Network parks: Protocol narrative”. This PIP has adopted and adapted major parts of the SECN protocol for sample frame, reach selection, permanent index site establishment, reach length layout and establishment, photo collection, reach scale field data collection, and watershed assessment to make this PIP fully functional and scientifically sound (McDonald et al. 2018a).

Several standard operating procedures and parts of this protocol were derived from methods developed by U.S. EPA (2013), and those written by NGPN other I&M Networks, especially, SECN and KLMN. We thank those networks who have gone before us and made our path easier. We thank the 2017 and 2018 NGPN staff, and seasonal crew for implementing some of the field methods from earlier versions of this PIP during pilot testing in 2017 and 2018 and providing feedback on the methods.

# Abbreviations and Acronyms

| | |
|---|---|
| °C: | degrees Celsius |
| EQuIS: | Environmental Quality Information Systems |
| ft: | feet |
| °F: | degrees Fahrenheit |
| GPS : | Global Positioning System |
| I&M : | Inventory & Monitoring |
| JHA: | job hazard analysis |
| m: | meter |
| $m^2$: | square meter |
| $mi^2$: | square miles |
| ND: | North Dakota |
| NE: | Nebraska |
| NGPN: | Northern Great Plains Network |
| NHS: | National Historic Site |
| NHD: | National Hydrography Dataset |
| NM: | National Monument |
| NMEM | National Memorial |
| NP: | National Park |
| NPS: | National Park Service |
| NRR: | National Recreational River |
| NRSA: | National Rivers and Streams Assessment (U.S. EPA) |
| NSR: | National Scenic River |
| PFD: | personal flotation device |
| PIP: | Protocol Implementation Plan |
| QA/QC: | quality assurance/quality control |
| SD: | South Dakota |
| SECN: | Southeast Coast Network |
| SOP: | standard operating procedure |
| SCM: | Stream Channel Monitoring |
| U.S.: | United States |
| U.S. EPA | U.S. Environmental Protection Agency |
| USGS: | U.S. Geological Survey |
| VAA: | Value Added Attributes |

# Section 1. Introduction

The National Park Service (NPS) established the Inventory & Monitoring Program to facilitate information sharing and natural resource monitoring in national parks. The goal of the program is to gather and analyze information on specific park resources to help parks make sound, science-based decisions.

The Northern Great Plains Inventory and Monitoring Network (NGPN), is made up of 13 NPS park units across Nebraska, Wyoming, North and South Dakota (Figure 1). Two of the units are large river parks (Missouri National Recreational River and Niobrara National Scenic River) but all 13 parks protect and preserve some type of surface-water resource including streams, springs; constructed irrigation ditches, ponds and cave lakes (Gitzen et al. 2010).

Winter precipitation accumulates as snow pack in much of the Great Plains and supplies the area with useable water. Stream hydrographs are dominated by peaks from snowmelt runoff in spring with much lower base flows occurring in late summer, fall, and winter. Dramatic weather extremes are considered normal events for the region (Wilken 1988) and droughts cycles generally range from 10 to 20 years (Clark et al. 2002).

Managers need to understand and track changes in water resources in the Northern Great Plains. Both anthropogenic and naturally occurring stressors to the aquatic systems can create changes in stream/river channel characteristics, sediment loads, water quality and water supply. The physical and chemical changes can affect the diversity of biota, and alter riparian areas and wetlands (Longo and Yoskowitz 2002). For example, withdrawal of water resources associated with anthropogenic land use within Nebraska, North Dakota, South Dakota, and Wyoming may result in withdrawal of water from aquifers faster than the aquifers are being recharged (Luckey et al. 1988, Johnson and Bouzaher 1995). Luckey et al. (1988) reported groundwater declines of 50–100 feet near NGPN park units in western Nebraska. These changes can have cascading impacts on other park resources.

Moreover, in this region extreme flow events threaten to change stream channels and geomorphology. Great Plains prairie streams are characterized by frequent drying and flooding, with upstream reaches having little canopy cover (Dodds et al. 2004). Prairie streams are often low elevation with meandering channels. Changes in channel geomorphology can contribute to a reduction in active floodplains, reducing or eliminating recruitment of cottonwood and suitable nesting habitat for Piping Plovers and Least Terns, and pallid sturgeons (Gitzen et al. 2010). River erosion from accelerated rates of meander bend migration is also threatening cultural resources and landscapes at Fort Laramie, and Fort Union Trading Post, and Knife River Indian Villages National Historic Sites (Gitzen et al. 2010).

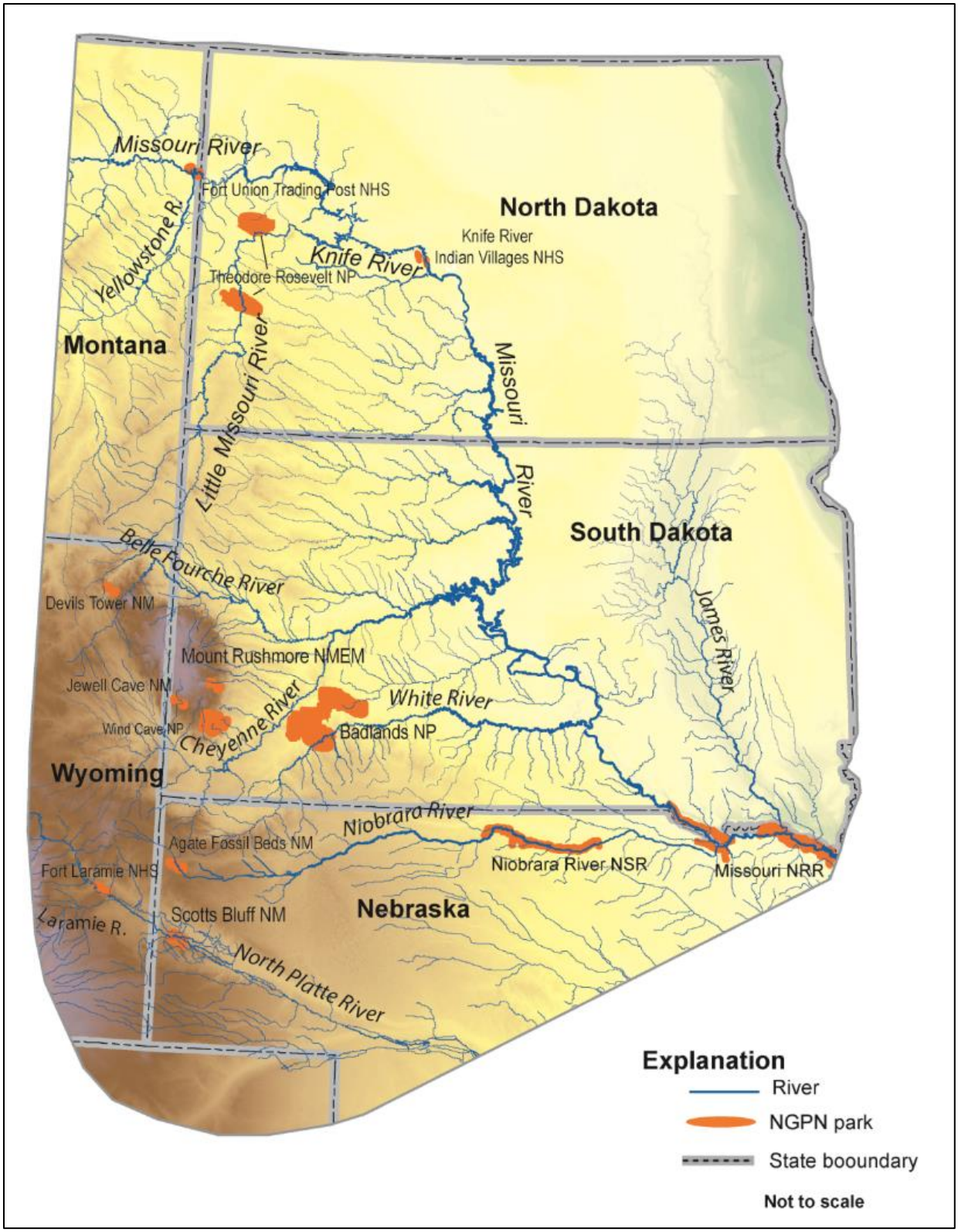


**Figure 1**. National park units and the major rivers and tributaries in Northern Great Plains Network.

Successful monitoring of changes to water resources requires consistent application of repeatable procedures for collecting and processing data. These repeatable procedures ensure detected changes are real and not a result of measurements taken by different people or different ways (Oakley et al. 2003). To better understand and monitor water resources, the NGPN has published two monitoring protocols. One focuses on continuous monitoring of water flow and chemistry at one location in each park with substantial water resources, in collaboration with the U. S. Geological Survey (Wilson et al. 2014). The other is a single-park protocol monitoring aquatic macroinvertebrate assemblages at Agate Fossil Beds National Monument (Peterson et al. 1999).

Here, we present methods to monitor stream channel characteristics in nine national park units. Stream and rivers are an important resource. Understanding stream channel geomorphology is a critical vital sign, and a key part of the NGPN monitoring program for understanding water resources. Prioritization efforts by the NGPN and parks since publication of the Vital Signs Monitoring Plan have reduced the scope of the stream channel monitoring efforts due to logistical and budgetary constraints.

NGPN has chosen to expedite protocol development by completing a Protocol Implementation Plan (PIP) to adopt an existing stream channel monitoring protocol. A PIP provides information about the published source document and then describes and justifies any differences between the implemented methods and the published source (NPS 2015). This streamlines the publication process and encourages consistency of methods across parks and partners.

## Protocol Implementation Plan

The methods described in this PIP are based on those used by other I&M networks, and other federal and state agencies. They have been implemented in monitoring programs across a wide range of physical settings and stream types, and allow comparisons to be made across a large area.

This PIP outlines how monitoring data will be collected, managed, and reported for Stream Channel Monitoring (SCM). This PIP is developed from the Southeast Coast I&M Network's wadeable stream habitat conditions protocol, as described in McDonald et al. (2018a-g).

This PIP has adopted the sampling design and sampling schedule from *Water Quality Monitoring Protocol for Wadeable Streams and Rivers in the Northern Great Plains Network: Narrative version 1.0* (Wilson et al. 2014). We have chosen to follow the sampling design and sampling schedule from Wilson et al. (2014) to better integrate multiple vital signs (i.e. water quality monitoring and stream channel monitoring) and monitoring of water resources for NGPN parks. Probabilistic approaches to reach selection could not be used due to the limited number of potential reaches within NGPN park units.

Sampling sites will be close to stream reaches with NGPN water quality monitoring at park units. The sample schedule for this PIP will coordinate field visits so the reach level sampling of stream channel characteristics is sampled in the same year that water quality is being monitored on the stream system (Wilson et al. 2014). The sampling frequency for this PIP, (evaluated in Wilson et al. 2014 for efficiency of network resources), follows a three-year rotation. Coordinated field site

locations, frequency and sampling schedule may provide a more integrated assessment of ecological conditions of water resources in the NGPN and in some cases, insight into underlying causes or allow for interpretation of environmental changes in stream channel characteristics at the reach scale and of core water quality parameters in the context of stream flow data.

For this PIP, the NGPN will adopt or adapt methods from *Monitoring wadeable stream habitat conditions in Southeast Coast Network parks: Protocol narrative* and accompanying SOPs (McDonald et al. 2018a-g). These include methods for: reach selection, index site establishment, reach length layout and establishment, photo collection, reach scale field data collection, watershed assessment, and Job Hazard Analysis (JHAs).

Primary differences:

- We will only sample one reach for each park unit, and will locate sampling reaches close to NGPN water quality monitoring sites (Wilson et al. 2014).
- Field site locations, sampling frequency, and sampling schedule will be coordinated with NGPN water quality monitoring sites.

Additional SOPs including discharge measurement, data management, operations, safety, and equipment will be adopted from U.S. EPA (2013), NGPN or other NPS I&M Network protocols (see Section 9. Standard Operating Procedures and Deviations from Source Protocols).

## Section 2. Conceptual Framework for Monitoring

The primary goal of Stream Channel Monitoring in the NGPN is to provide information to park managers about baseline stream and river channel characteristics, and identify the long-term trends, variability and potential environmental stressors for stream and river geomorphology in the network parks. Numerous factors can affect water resources at large scales and at the park scale (Figure 2). Changes in climate, watershed processes, groundwater withdrawals, and visitor use all have the potential to threaten stream geomorphology. Stream Channel Monitoring in the NGPN focuses on changes in geomorphology and channel characteristics that are particularly problematic for park managers because they can affect habitat, park infrastructure, and archaeological and paleontological resources (Table 1).

During the review of current NPS protocols and others, there was no protocol available to adopt that fit all the needs of NGPN parks and the NGPN Vital Signs Monitoring Plan (Gitzen et al. 2010). Prioritization efforts by the Network and parks since the Vital Signs Monitoring Plan was published have reduced the scope of the stream channel monitoring efforts due to logistical and budgetary constraints. Monitoring will be limited to watershed characteristics, geomorphic dimensions, and habitat features of select streams and rivers.

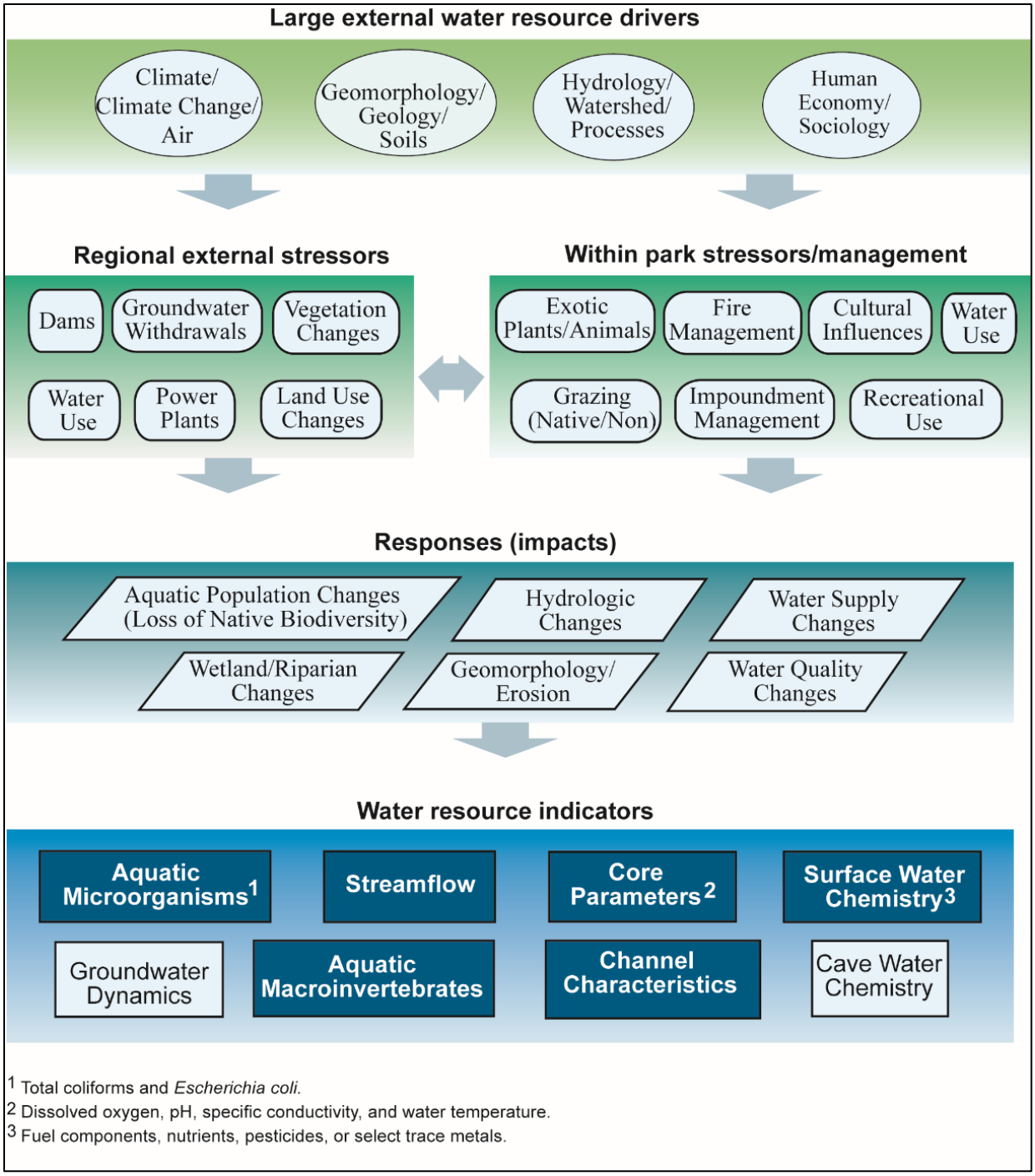


**Figure 2.** Conceptual diagram showing driver and stressors that influence water resources within Northern Great Plains park units.

**Table 1.** Factors affecting water resources within the Northern Great Plains and potential measures for vital sign monitoring.

| Category | Management relevance informed by monitoring | Potential measures |
|---|---|---|
| Stream Channel Characteristics | **Understanding Geomorphic Processes**. In an undisturbed state, streams are naturally dynamic systems controlled by local and upstream geology, soils, groundwater, and surficial hydrology. The combination of local and watershed conditions can drive erosive potential, rates of channel migration, stream type classification, habitat-type and availability, and suitability of those habitats to support ecological functions. | • **Bank geometry**[1]<br>• **Channel morphology**[1]<br>• **Grain size distribution**[1]<br>• **Slope, bank erosion/stability**[1]<br>• **Large woody debris distribution**[1]<br>• **Discharge/velocity**[1]<br>• **Distribution/area of geomorphic channel units (runs, riffles, pools)**[1] |
| | **Watershed Landscape Dynamics**. The type, distribution, and proximity of land use and land cover types to stream systems affect the rate and pathways for delivery of water and sediment to and through stream systems. | • **Land use type and distribution**[1]<br>• Soil type<br>• **Watershed shape, relief, and complexity**[1]<br>• Changes in channel location via aerial imagery |
| | **Visitor Experience**. Visitors have an expectation of aesthetics, particularly natural sights and sounds, when using park riverine systems for recreation (including streams and adjacent riparian zones). | • Type and volume of sounds present,<br>• Riparian zone vegetation cover / structure<br>• Turbidity<br>• Water odor<br>• **Canopy cover**[1]<br>• Visitor use |
| | **Recreational Potential**. In-stream habitats provide boating, hiking and fishing experiences to visitors, but access points also serve as potential areas of localized habitat disturbance. | • **Distribution / area of geomorphic channel units (runs, riffles, pools)**[1]<br>• **Woody debris distribution**[1]<br>• **Bank erosion/stability**[1]<br>• Fisheries population demographics<br>• Human disturbance type/extent |
| Water Quality Wadeable Streams | **Water Supply.** Changes in stream discharge, levels, and velocity are indicators of changes in water use, water management, and short- and long-term climatic changes. Changes also may be related to other effects, such as declines in stream riparian cover or effects from invasive plant species | • *Streamflow*[2]<br>• *Discharge*[2]<br>• *Stage*[2] |
| | **Water quality core parameters**. Ongoing monitoring of these parameters are important indicators of the ability of a waterbody to sustain life and can be used to track changes in riverine system measure response to changes in the environment. | • *Water temperature*[2]<br>• *Dissolved oxygen (DO)*[2]<br>• *pH*[2]<br>• *Specific conductivity*[2] |

[1] Measures (also in bold) are included in the NGPN Stream Channel Monitoring protocol (also in bold font).

[2] Measures (also in italics) are included in other NGPN protocols.

**Table 1 (continued).** Factors affecting water resources within the Northern Great Plains and potential measures for vital sign monitoring.

| Category | Management relevance informed by monitoring | Potential measures |
|---|---|---|
| Aquatic Invertebrate | **Aquatic invertebrates**. Maintaining long term data on aquatic invertebrates is an important tool for understanding natural variation, water quality, habitat conditions and assessing the impacts of disturbances on the ecosystem. | • *Aquatic invertebrate abundance*[2]<br>• *Diversity measures*[2]<br>• *Community structure*[2] |
| Cave Water Quality | **Runoff**. Storm water runoff or spills from parking areas, roads, and holding tanks can change water quality in caves. | • *Concentrations of chloride, dissolved salts, specific conductance, and other physical constituents in cave water*[2]<br>• Concentrations of hydrocarbons, such as toluene and benzene in cave water. |
| | **Infrastructure**. Sewer lines from developments in the park (e.g. housing, visitor center) or surroundings can corrode and leach contaminants into the underlying cave. | • *Concentrations of nutrients, metals and other organics in cave water*[2]<br>• Presence and concentration of *E.coli*[2]. |
| | **Climate**. Changes in climate or above ground features (fire regime) can change timing and amount of surface water. | • Change in rate of infiltration and water levels. *Potential for increased concentrations of nutrients, metals, and contaminants over time*[2] |
| | **Chemical application**. Integrated pest and exotic plant management activities, including pesticide and herbicide use, can pollute cave water. | • Concentrations of pesticides, such as glyphosate, in cave water. |

[1] Measures (also in bold) are included in the NGPN Stream Channel Monitoring protocol.

[2] Measures (also in italics) are included in other NGPN protocols.

# Section 3. Measurable Objectives

The NGPN Stream Channel Monitoring Protocol will monitor fixed stream reaches at nine parks, with each reach sampled every three years for stream geomorphic dimensions and habitat features, and every nine years for watershed characteristics. The primary monitoring objectives are:

1. Determine the status of upstream **watershed characteristics** such as watershed area, catchment slope, and drainage density, and changes to land cover that may affect stream habitat.

   Justification: Watershed characteristics are important for interpreting stream and river channel conditions and include both natural (geomorphic and climatic) and anthropogenic (land use/land cover) influences to stream and sediment flows (Fitzpatrick et al. 1998). Understanding the entire watershed (not just within the park) aids the interpretation of any observed changes in reach-scale habitats.

2. Determine the status of and trends in the **geomorphic dimensions** (cross-sectional morphology) of selected wadeable stream reaches including channel widths, bank characteristics (e.g., heights, angles, and vegetative cover), and reach slope and sinuosity.

   Justification: These data allow managers to better understand the normal and potential range of variability in channel morphology, help predict the types (and magnitude) of changes that may occur at each reach, and provide an understanding of the stability of each reach.

3. Determine the status of and trends in physical measures of benthic and riparian **habitat features** present in selected wadeable stream reaches such as the size, type, and distribution of bed sediment and large woody debris, the distribution of geomorphic channel units, canopy cover, and discharge.

Justification: The quality and suitability of physical habitat for organisms is ultimately dictated by the overall physical integrity of the stream system (Asmus et al. 2009). Streams with diverse and complex habitats often foster greater biodiversity than those that are more homogenous. Physical integrity and habitat diversity may be compromised when an imbalance occurs between the sediment supply and the transport capacity of a stream. This imbalance may lead to aggradation or degradation of the stream bed which can cause habitat homogenization and a resultant decrease in biodiversity.

# Section 4. What's being Measured and How

NGPN will monitor channel characteristics using methods developed by the NPS Southeast Coast Network McDonald et al. (2018a). Detailed methods are found in the Stream Channel Monitoring in the NGPN: Standard Operating Procedures. In brief, the steps include:

- Watershed and segment scale analysis is conducted with a GIS using data sets that are readily available. Watershed and segment measures will be done infrequently compared to reach scale assessment (Table 2).
- A permanently marked stream reach will be established in each park. Many of these will be collocated with USGS gauges and monitoring locations from the NGPN Water Quality Monitoring Protocol (Wilson et al. 2014).
- In the fall of every third year, field crews will measure geomorphic dimensions and habitat features of the permanently marked stream reach. Measures will be taken along 11 transects (Figure 3). Geomorphic dimension measures include detailed channel cross-sections, stream widths, and bank heights (Table 2). Habitat features measures include geomorphic channel units, large woody debris, bed sediment, and substrate (Table 2).
    - Reach discharge will be measured at sites being sampled without concurrent USGS or NGPN discharge monitoring.
    - Derived habitat measures will be calculated from geomorphic dimension and habitat feature measures (Thornbrugh and Mills 2019a).
- Three sites (one per park) will be visited per year (Table 3).
- NGPN will enter data into a relational database where it will be stored, analyzed, and reported on following all IMD data and reporting guidelines. Data will also be uploaded to NPS Environmental Quality Information Systems (EQuIS).

**Table 2**. Monitoring objective, sampling methods and variables measured as part of Stream Channel Monitoring Program.

| Objective | Sampling Method | Data Collected | Sampling interval |
|---|---|---|---|
| Watershed Characteristics | GIS Analysis | **Watershed**: Drainage area, total stream length, drainage density, basin length, watershed shape, average slope, standard deviation of slope, basin relief, basin relief ratio, standard deviation of elevation, entire stream gradient, and bifurcation ratio | 9 years |
| | GIS Analysis | Land use/land cover | 9 years |
| | GIS Analysis | **Segment**: gradient and Strahler stream order | 9 years |
| Geomorphic Dimensions | Field sampling at low flow or wadeable conditions | **Reach**: Longitudinal profile (reach slope), reach sinuosity, bearing sinuosity, thalweg sinuosity | 3 years |

**Table 2 (continued)**. Monitoring objective, sampling methods and variables measured as part of Stream Channel Monitoring Program.

| Objective | Sampling Method | Data Collected | Sampling interval |
|---|---|---|---|
| Geomorphic Dimensions (continued) | Field sampling at low flow or wadeable conditions | **Transects**: Wetted width, active channel width, bankfull width, channel full width, floodplain width, thalweg position, thalweg depth, in-channel features, bankfull height, channel full height, bank undercut depth, bank undercut height, bank angle, bank sediment, bank erosion (presence and type), bank stability index | 3 years |
| | Field sampling at low flow or wadeable conditions | **Detail transects**: Bankfull area, bankfull perimeter, bankfull hydraulic radius, bankfull width, bankfull depth, bankfull width to depth ratio, channel-full area, channel-full perimeter, channel-full hydraulic radius, channel-full width, channel-full depth, channel-full width to depth ratio | 3 years |
| Habitat Features | Field sampling at low flow or wadeable conditions | **Reach**: Large woody debris amount, volume, position and function, bed material (pebble count), distribution of geomorphic channel units, reach discharge | 3 years |
| | Field sampling at low flow or wadeable conditions | **Transects**: Canopy closure, dominant particle size, dominant habitat, vegetative cover, ground cover | 3 years |

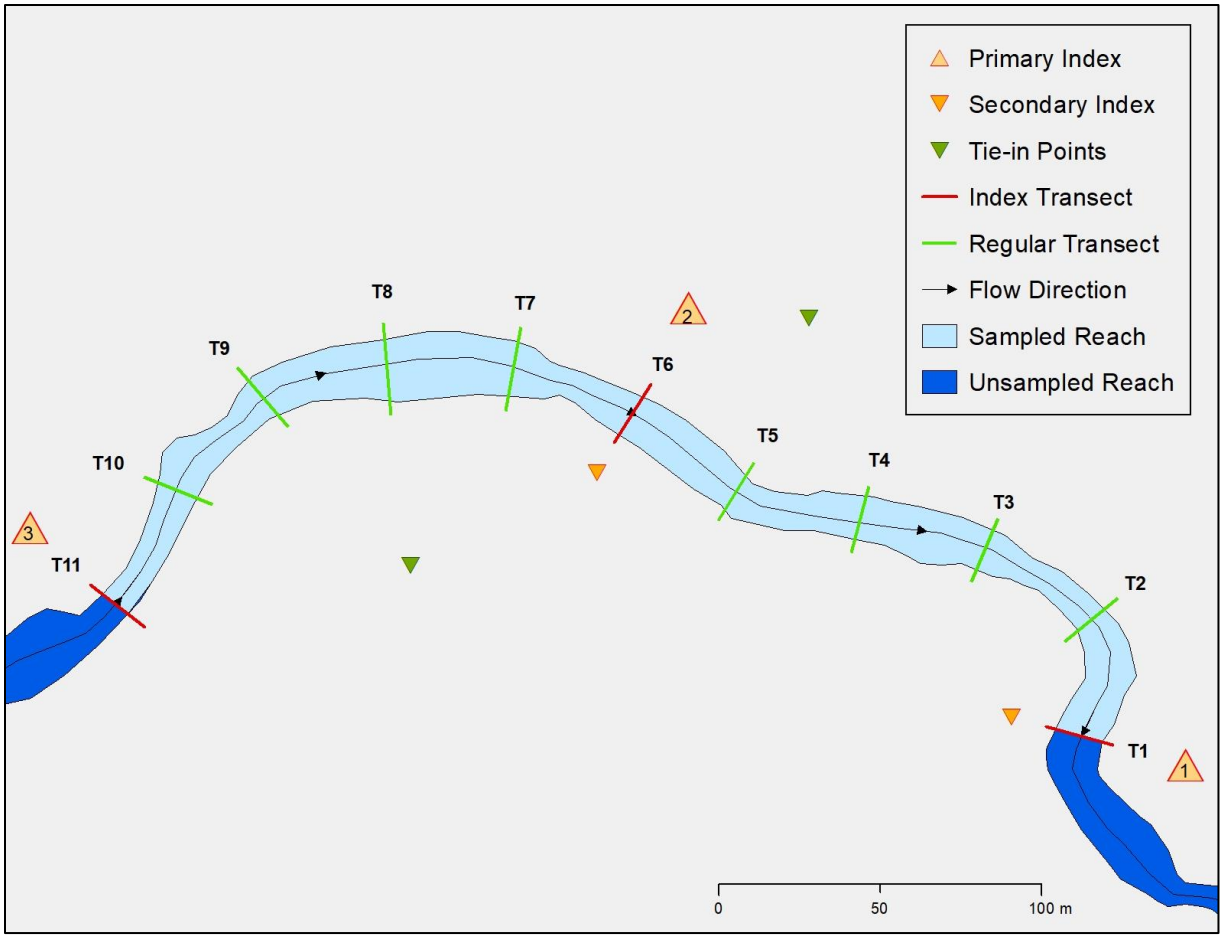


**Figure 3**. Example layout of stream reach with index locations, and transects. The distance between each transect is equal to two times mean wetted width. Total reach length is equal to twenty times mean wetted width, established on initial site visit.

**Table 3**. Monitoring schedule for proposed sample sites in the Northern Great Plains Network. Stream Channel Monitoring will be completed every three years. An "X" denotes that sampling will occur for that combination of park unit, water body, and year.

| Park Unit | Water Body | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| Agate Fossil Beds NM | Niobrara River | X | – | – | X | – | – |
| Niobrara NSR | Niobrara River | X | – | – | X | – | – |
| Mount Rushmore NMEM | Grizzly Creek | X | – | – | X | – | – |
| Fort Laramie NHS | Laramie River | – | X | – | – | X | – |
| Missouri NRR | Bow Creek | – | X | – | – | X | – |
| Wind Cave NP | Highland Creek | – | X | – | – | X | – |
| Devils Tower NM | Belle Fourche River | – | – | X | – | – | X |
| Knife River Indian Villages NHS | Knife River | – | – | X | – | – | X |
| Theodore Roosevelt NP | Little Missouri River | – | – | X | – | – | X |

## Operational Implementation Notes

Water flows vary substantially with the extreme climate cycles that are typical in the Northern Great Plains. The NGPN Stream Channel Monitoring Protocol aims to monitor wadeable streams during low-flow conditions, which are usually in September or October. Flood conditions may delay sampling by a month or more, or prevent sampling entirely. Moreover, following drought conditions, some streams may run dry.

If transect six (T6) of the stream reach is dry and more that 50 percent of the stream permanent reach is dry on a sampling visit, one additional attempt will be made to sample the site that year. If the site remains dry on the second attempt, the site will not be sampled and will instead be classified as “Dry-visited”. The sampling site will then be further evaluated for future viability as a monitoring location.

Due to large sediment movement on the streams and rivers in this region, permanent markers will be placed in upland areas, sometimes more than 10 meters from bankfull height, but still have line of sight for detailed transects across the channel.

# Section 5. Sampling Design and Monitoring Schedule

Stream Channel Monitoring in the NGPN monitors wadeable stream reaches. These are small to medium sized waterbodies with perennial flow within defined channel banks that can be accessed and traversed during base flow conditions without the use of watercraft. The sampling frame includes wadeable, perennial stream segments connected to NGPN water quality monitoring sites that are within the boundaries of parks having major water resources (Wilson et al. 2014). Other stream like features such as ephemeral stream channels or geomorphic features (paleochannels and flood chutes) typical of large river flood plains are not included in the sampling frame.

The Inventory & Monitoring Division advocates the use of randomized sampling to best understand park resources (Fancy et al. 2009), but this approach to sampling stream and river channel characteristics exceeds NGPN's resources. This PIP instead focuses on repeated measures from a few fixed index sites (Table 3). The number of sites is constrained by the small sampling frame at most parks (many NGPN parks have less than two miles of wadeable streams) and limited budget. Sites were collocated with the sites of the larger NGPN Water Quality Monitoring Protocol (Wilson et al. 2014), instead of being randomly distributed.

The timing of reach scale sampling is coincident with the NGPN Water Quality Monitoring Protocol. Sites will be visited every three years at low flow during the same season that continuous stream flow and water quality measurements are monitored at park units (Table 3). Monitoring multiple vital signs with similar sampling intervals and geographic locations for stream channel characteristics, hydrology, and water quality can provide integrated assessment of ecological condition and insight into underlying causes of change in park fluvial resources.

Watershed scale characterization is infrequent compared to the reach scale assessments (Table 2). Measures at the watershed scale will be assessed through a variety of GIS base data layers like the National Hydrography Dataset (NHD) and the National Land Cover Dataset (NLCD) (USGS 2017, Homer et al. 2015). NLCD is updated every five years. Watershed scale assessments are determined for all reaches during the first year of protocol implementation for park units, then updated once every nine years thereafter (Table 2).

Index sites will be permanently marked, with special attention to concerns with NEPA/NHPA compliance (e.g. many archeological resources are focused along the riparian corridor), frost heave, and the high rates of lateral channel migration from large sediment movement associated with river and streams in this region.

Potential stream segments and sampling locations will be identified in GIS, then reviewed by park staff and visited by park and network staff before selection. Index sites will be selected using the following criteria and prioritization: management relevance, proximity to stream gauges and NGPN water quality monitoring sites, evaluation for field suitability.

# Section 6. Data Management and Reporting

The primary data collected in this protocol are geomorphic dimensions and habitat feature measures from select wadeable streams and rivers. Watershed characteristic will also be calculated. Staff and crew members should follow the collection methods, reporting requirements, and quality assurance procedures summarized in SOPs and DQS (Thornbrugh 2019). This approach will provide field measurement data that meet data quality values (DQVs) and measurement quality objectives for stream channel monitoring, listed in Tables 4 and 5 of the DQS. NGPN will manage the data according to the NGPN Data Management Plan (Brumm 2009) and current Inventory & Monitoring Standards. Data quality standards are listed in the companion Data Quality Standards document (Thornbrugh 2019). Data will be entered into a relational database modified from the one used by the NPS Klamath Network (Dinger et al. 2013) and uploaded to Data Store and / or EQuIS, a database and software solution, using the NPS Water Resource Division processing tools. After each sampling season, NGPN will publish data reports or resource briefs summarizing field activities and results. More detail is provided in the Data Management SOP and the Data Analysis and Reporting SOP.

In brief, the data management and reporting workflow is:

1. All data, including digital copies of supplementary data sheets and digital photographs, will be archived locally on the NGPN Server and will be re-named following Network standards.
2. NGPN will store data on the NGPN Server, Geodatabase, in a relational Microsoft Access database, and upload the certified data to Data Store and to EQuIS using an electronic data deliverable (EDD) following guidance from NPS Water Resources Division (Table 4, NPS 2018).
3. Data summary reports or resource briefs will be produced for each park within a year of completion of data collection. A trend report will occur less frequently, the first being after four sampling events, or twelve years, and every three sampling events thereafter.

**Table 4**. Stream channel monitoring datasets that will be created as part of PIP and where data will be stored. Official repository for datasets are listed in data stored column and denoted with an asterisk (*).

| Major datasets | Data stored | Data Collected | Sampling interval |
|---|---|---|---|
| Watershed characteristics (Geodatabase) | • Data Store*<br>• NGPN Server | **Watershed**: Drainage area, total stream length, drainage density, basin length, watershed shape, average slope, standard deviation of slope, basin relief, basin relief ratio, standard deviation of elevation, entire stream gradient, and bifurcation ratio | 9 years |
| | • Data Store*<br>• NGPN Server | Land use/land cover | 9 years |
| | • Data Store*<br>• NGPN Server | **Segment**: gradient and Strahler stream order | 9 years |

**Table 4 (continued)**. Stream channel monitoring datasets that will be created as part of PIP and where data will be stored. Official repository for datasets are listed in data stored column and denoted with an asterisk (*).

| Major datasets | Data stored | Data Collected | Sampling interval |
|---|---|---|---|
| Transect-level data (Microsoft Access) | • NPS-EQuIS*<br>• Data Store*<br>• NGPN Server | **Reach**: Longitudinal profile (reach slope), reach sinuosity, bearing sinuosity, thalweg sinuosity | 3 years |
| | • NPS-EQuIS*<br>• Data Store*<br>• NGPN Server | **Transects**: Wetted width, active channel width, bankfull width, channel full width, floodplain width, thalweg position, thalweg depth, in-channel features, bankfull height, channel full height, bank undercut depth, bank undercut height, bank angle, bank sediment, bank erosion (presence and type), bank stability index | 3 years |
| | • NPS-EQuIS*<br>• Data Store*<br>• NGPN Server | **Detail transects**: Bankfull area, bankfull perimeter, bankfull hydraulic radius, bankfull width, bankfull depth, bankfull width to depth ratio, channel-full area, channel-full perimeter, channel-full hydraulic radius, channel-full width, channel-full depth, channel-full width to depth ratio | 3 years |
| Reach-level data (Microsoft Access) | • NPS-EQuIS*<br>• Data Store*<br>• NGPN Server | **Reach**: Large woody debris amount, volume, position and function, bed material (pebble count), distribution of geomorphic channel units, reach discharge | 3 years |
| | • NPS-EQuIS*<br>• Data Store*<br>• NGPN Server | **Transects**: Canopy closure, dominant particle size, dominant habitat, vegetative cover, ground cover | 3 years |
| Event-level data (jpg, pdf) | • NGPN Server | Field notes, photographs, and documentation | 3 years |

# Section 7. Budget

The cost for the NGPN Stream Channel Monitoring is approximately $38,000 annually. These funds will be primarily used to cover the salary of the Aquatic Ecologist. Table 5 shows the approximate breakdown of funds.

**Table 5**. Estimated operating costs (based on fiscal year 2018 dollars) for implementation of the NGPN Stream Channel Monitoring.

| Category | Item | Notes | Costs |
|---|---|---|---|
| Personnel | NGPN Aquatic Ecologist | 0.25 FTE GS-11 | $17,200 |
| | NGPN Data Manager | 0.10 FTE GS-11 | $6,100 |
| | NGPN Technician | 0.08 FTE GS-06 | $3,000 |
| | NGPN Technician | 0.08 FTE GS-05 | $2,700 |
| **Total Personnel Costs** | – | – | **$29,000** |
| Equipment & Supplies | Annual Equipment Maintenance/Replacement | – | $1,000 |
| | Total station rental | 3 weeks @ $1,000/week | $3,000 |
| | Field Supplies | – | $1,000 |
| **Total Equipment Costs** | – | – | **$5,000** |
| Travel | Lodging | – | $1,700 |
| | MI&E | – | $1,800 |
| **Total Travel Costs** | – | – | **$3,500** |
| Training | Survey training | Time for refresher training on field methods is included above. | $400 |
| **Total Annual Cost** | – | – | **$37,900** |

# Section 8. Safety

Fieldwork involves significant risks to personal safety and health. Field crews will be working in remote areas and around potentially fast flowing water. Crews must stay aware of their safety and prepare for emergencies. Field crew safety training is part of routine protocol training, as listed in Training Field Personnel SOP. Additional protocol specific safety practices are also in Training Field Personnel SOP. The Job Hazard Analysis (JHA) for SCM that lists potential hazards, and procedures for safely working in streams and rivers (Thornbrugh and Mills 2019b).

The Equipment and Supply List for SCM includes required and recommended safety and personal protective equipment (Thornbrugh and Mills 2019c). NGPN will ensure these items are available and used throughout fieldwork, and replace them as needed.

NGPN is committed to safe fieldwork and the practice of Operational Leadership. Every crew member has the right to refuse to participate in any operation that he or she feels is unsafe. Everyone is encouraged to identify potential hazards or unsafe actions, and to work with crew and protocol leads to find safe ways to proceed. This includes stopping work in progress to make changes, or canceling work altogether.

During fieldwork, crews will follow NGPN's standard field safety and communications practices, which include:

- Checking in / out of the field with a pre-arranged park Point of Contact.
- Carrying multiple methods of communication to contact park or NGPN staff, or local emergency responders.
- Two crew members must be present during all sample collection activities, and no one should be left alone while in the field.
- Field crews will wear suitable PFDs and other PPE during sampling, and will not attempt to collect measurements or samples from vertical or near vertical banks.
- Crew safety will be the top priority during sampling.

# Section 9. Standard Operating Procedures and Deviations from Source Protocols

Table 6 lists Standard Operating Procedures (SOPs) that have been identified or developed to ensure consistent implementation of NGPN Stream Channel Monitoring. To the greatest extent practicable, SOPs are adopted from published, approved procedures implemented through other monitoring efforts. The latest published versions of operational SOPs are available for download at the NPS Data Store at https://irma.nps.gov/DataStore/.

Some SOPs, such as data management, operations, safety, and equipment, will be adopted from NGPN or other NPS I&M Networks (Table 6). Many SOPs in the NGPN's implementation have had editorial revisions for clarity and ease of use that do not substantially change the procedures or methods.

**Table 6**. Standard Operating Procedures for Stream Channel Monitoring in the NGPN. Table lists SOPs by task category.

| SOP | Source Protocol / SOP | Explanation of Primary Differences | Link to Source Document | IRMA record |
|---|---|---|---|---|
| **1.** Preparations Prior to Field Season | Plant community composition and structure monitoring protocol for the Northern Great Plains I&M Network-Standard Operating Procedures: Version 1.01. (Symstad et al. 2012) | This version incorporates protocol-specific equipment and procedures for wadeable stream sampling, and includes updated policies and procedures. | https://irma.nps.gov/DataStore/Reference/Profile/2182546 | https://irma.nps.gov/DataStore/Reference/Profile/2259859 |
| **2.** Training Field Personnel | 62s Garmin GPS User Guide. Northern Great Plains I&M Network. (Wilson and Jarding 2016) | This version incorporates protocol-specific training standards, as well as updated network, region, and NPS-wide training and human resource management practices. | https://irma.nps.gov/DataStore/Reference/Profile/2259590 | https://irma.nps.gov/DataStore/Reference/Profile/2259860 |
| **3.** Using the Global Positioning System | 62s Garmin GPS User Guide. Northern Great Plains I&M Network. (Wilson and Jarding 2016) | This version incorporates new satellite technology and updated hardware and software. Procedures are revised for clarity and ease of use. | https://irma.nps.gov/DataStore/Reference/Profile/2259590 | https://irma.nps.gov/DataStore/Reference/Profile/2259861 |

**Table 6 (continued)**. Standard Operating Procedures for Stream Channel Monitoring in the NGPN. Table lists SOPs by task category.

| SOP | Source Protocol / SOP | Explanation of Primary Differences | Link to Source Document | IRMA record |
|---|---|---|---|---|
| **4.** Reach Selection and Establishing Index Sites | Wadeable stream reach selection and location of sampling points—Version 1.0. (McDonald et al. 2018b) | NGPN will sample only one site per park, near NGPN water quality monitoring sites. Permanent site marking methods and locations are adapted for NGPN parks. | https://irma.nps.gov/DataStore/Reference/Profile/2253887 | https://irma.nps.gov/DataStore/Reference/Profile/2259862 |
| **5.** Setting Up and Configuring a Total Station | Setting up and configuring a total station—Version 1.0. (McDonald et al. 2018d) | No differences; adopted as published. | https://irma.nps.gov/DataStore/Reference/Profile/2254014 | https://irma.nps.gov/DataStore/Reference/Profile/2259863 |
| **6.** Using a Total Station to Conduct a Stream Survey | Using a total station to conduct a stream survey—Version 1.0. (McDonald et al. 2018e) | No differences; adopted as published. | https://irma.nps.gov/DataStore/Reference/Profile/2254016 | https://irma.nps.gov/DataStore/Reference/Profile/2259865 |
| **7.** Wadeable Stream Reach Scale Field Data Collection | Wadeable stream reach-scale field data collection—Version 1.0. (McDonald et al. 2018f) | No substantial differences; minor changes adapted for NGPN parks, clarity of data specific to Network and data management. | https://irma.nps.gov/DataStore/Reference/Profile/2254013 | https://irma.nps.gov/DataStore/Reference/Profile/2259864 |
| **8.** Discharge Measurements | National Rivers and Streams Assessment 2013-2014: Field Operations Manual – Wadeable. Chapter 8, section 8.1-4. (U.S. EPA 2013) | No substantial differences; minor edits for clarity. | https://www.epa.gov/national-aquatic-resource-surveys/manuals-used-national-aquatic-resource-surveys | https://irma.nps.gov/DataStore/Reference/Profile/2259866 |
| **9.** Post Field Season Activities | Water quality monitoring protocol for wadeable streams and rivers in the Northern Great Plains Network: Standard operating procedures version 1.0. (Wilson and Wilson 2014) | Updated with protocol-specific policies and procedures, and incorporated operational reviews per IMD Protocol Review Guidance (Mitchell et al. 2018). | https://irma.nps.gov/DataStore/Reference/Profile/2216800 | https://irma.nps.gov/DataStore/Reference/Profile/2259867 |

**Table 6 (continued)**. Standard Operating Procedures for Stream Channel Monitoring in the NGPN. Table lists SOPs by task category.

| SOP | Source Protocol / SOP | Explanation of Primary Differences | Link to Source Document | IRMA record |
|---|---|---|---|---|
| **10.** Watershed and Segment Scale Assessment | Wadeable stream basin- and segment-scale data summary—Version 1.0. (McDonald et al. 2018c) | File structures, software, and map datums are NGPN-specific. | https://irma.nps.gov/DataStore/Reference/Profile/2254012 | https://irma.nps.gov/DataStore/Reference/Profile/2259868 |
| **11.** Data Management | Plant community composition and structure monitoring protocol for the Northern Great Plains I&M Network-Standard Operating Procedures: Version 1.01. (Symstad et al. 2012) | Protocol and NGPN specific staff roles, file layout, and naming conventions. Simplified data management processes reflecting smaller data collection effort. | https://irma.nps.gov/DataStore/Reference/Profile/2182546 | https://irma.nps.gov/DataStore/Reference/Profile/2259869 |
| | Integrated aquatic community and water quality monitoring of wadeable streams in the Klamath Network: Narrative and standard operating procedures. (Dinger et al. 2013) | NGPN uses a Microsoft Access database developed by the Klamath Network that was adopted and modified to address our initial data storage, QA/QC, and reporting requirements. NGPN includes consideration for future move to EQuIS data storage. | https://irma.nps.gov/DataStore/Reference/Profile/2195825 | https://irma.nps.gov/DataStore/Reference/Profile/2259869 |
| **12.** Data Analysis and Reporting | Wadeable stream data processing and analysis—Version 1.0. (McDonald et al. 2018g) | Additional non-parametric analysis methods have been added, along with techniques and considerations specific to fixed-site sampling. | https://irma.nps.gov/DataStore/Reference/Profile/2254019 | https://irma.nps.gov/DataStore/Reference/Profile/2259870 |

**Table 6 (continued)**. Standard Operating Procedures for Stream Channel Monitoring in the NGPN. Table lists SOPs by task category.

| SOP | Source Protocol / SOP | Explanation of Primary Differences | Link to Source Document | IRMA record |
|---|---|---|---|---|
| **12.** Data Analysis and Reporting (continued) | Water quality monitoring protocol for wadeable streams and rivers in the Northern Great Plains Network: Standard operating procedures version 1.0. SOP 6 Data Analysis and Reporting. (Wilson and Wilson 2014) | Reporting plan is based on 2018 IMD data analysis and reporting requirements. Annual reporting may be limited to resource briefs. Trend reports will be published after every third sampling visit, but interim reports will be published as needed. | https://irma.nps.gov/DataStore/Reference/Profile/2216800 | https://irma.nps.gov/DataStore/Reference/Profile/2259870 |
| **13.** Protocol Revision | IMD Protocol Review Guidance (Mitchell et al. 2018) | No substantial differences; SOP is a summary of procedures in IMD Protocol Review Guidance. | https://irma.nps.gov/DataStore/Reference/Profile/2253227 | https://irma.nps.gov/DataStore/Reference/Profile/2259871 |

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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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