

Protocol Development Summary

7 December 2007

Protocol: Flowing Waters

Parks Where Protocol Will be Implemented: BELA, GAAR, KOVA, NOAT,

Vital Signs Addressed: Stream Communities and Ecosystems

Justification/Issues being Addressed:

A network of greater than 25,000 miles of perennial and intermittent mountain headwater streams; turbid, glacial-fed streams; meandering clear-water tundra streams; thermally stable spring-fed streams; and large rivers flow across the ARCN landscape (National Hydrography Dataset). This complex network of stream and river ecosystems represents a great range of depths, flows and trophic states and is underlain by continuous or discontinuous permafrost. Thermokarst action and solifluction have a substantial and ongoing influence on the structure and function of aquatic ecosystems across the ARCN landscape. The net result of these processes is a dynamic system of lakes, streams and water tracks that appear and disappear by draining, drying, slumping and infilling. From a monitoring perspective it will be important to quantify the variability of these processes to better understand the cumulative nature of their impacts on aquatic systems, particularly since these processes are demonstrably sensitive to changes in climate (see PDS for Permafrost Dynamics).

There are seven National Wild and Scenic Rivers in ARCN, including the Noatak, Salmon, Kobuk, Alatna, John, Tinayguk and North Fork of the Koyokuk Rivers. The Kobuk and Noatak rivers are the largest rivers in northwest Alaska and together drain an area of 63,654 km². More than two hundred turbid headwater streams originate from glaciers in the Brooks Range; however, the majority of streams in ARCN run clear. Due to the stabilizing effect of permafrost on soils, relatively low topographic relief, and low levels of precipitation, average sediment loads in many ARCN streams and rivers are low compared to sediment loads in other Alaskan rivers. There are several spring streams, including tributaries of the Reed River, Kugrak River, and Alatna River. Traditional knowledge indicates these springs do not freeze solid during winter and are an important habitat for overwintering resident and anadromous fish species. The Noatak River, which originates in GAAR, flows into NOAT, where the river and its surrounding watershed have been designated as an internationally recognized Biosphere Reserve (UNESCO).

All of the streams in ARCN are free of man-made impoundments. Currently, there are no waters in ARCN listed as impaired under Section 303(d) of the Clean Water Act; however, no adequate assessment of water quality in the ARCN parks has been conducted.

Potential local impacts on flowing waters in ARCN include consumptive use of stream and river resources and impending development. Subsistence users and recreational users fish in ARCN units. Habitat quality and fish populations are important to local communities and must be managed, protected, and preserved under provisions of ANILCA. Other local stressors to flowing water ecosystems may include road construction, industrial development, mining, and nonpoint source petrochemical pollution from snowmobiles and motor boats.

Potential global stressors on flowing waters in ARCN include wet and dry deposition of contaminants and climate change. Climate change models predict that the magnitude of climate warming in the northern polar regions will be substantially greater than the global average. At the watershed scale, the cumulative effects of warming may lead to a wide range of cascading effects. For example, increased air and water temperatures may lead to degradation of permafrost and increasing soil permeability may cause ground water tables to fluctuate. In some areas small streams and large rivers may cease to flow aboveground and increased rates of solifluction and erosion may occur. Changes in the timing and extent of glacial and snowmelt water contributions and precipitation regimes are also likely to occur, according to climate projections. Fire is likely to increase in frequency and magnitude, which would significantly alter riparian habitat, active layer depth, thermokarsting, hydrological patterns, and nutrient cycling in both terrestrial and aquatic systems. These ecosystem-level changes are likely to affect water quantity and quality and species diversity within these systems.

Specific Monitoring Questions and Monitoring Objectives to be Addressed by the Protocol:

1. Is water quantity and/or temperature of flowing waters changing in wadeable streams within ARCN watersheds and do these changes influence water quantity and/or temperature of large receiving rivers?

Estimate discharge and temperature regime of water in Tier 1 (high-priority) rivers and streams. Determine hydrologic permanence and seasonal temperatures of headwater streams and tributaries in secondary (medium priority -- rotating) watersheds.

Justification: Water quantity and temperature have extremely important effects on aquatic communities and are likely to change in response to global warming.

2. Is the chemical water quality of flowing waters changing in ARCN watersheds?

Measure status and trends in chemical water quality parameters, including dissolved oxygen, pH, specific conductivity, nutrients, anions, cations and selected contaminants. **Justification:** Water quality affects the integrity of aquatic ecosystems, thus its monitoring is required by WRD.

3. What are the trends in diatom and macroinvertebrate assemblages in streams and how do the status and trends of these communities relate to trends in hydrology, temperature and water quality?

Collect species composition data on macroinvertebrate and diatom communities in ARCN streams and rivers. **Justification:** Macroinvertebrate and diatom community composition data are universally accepted indicators of ecological condition in stream ecosystems. They are robust and sensitive integrators of change in both aquatic and proximate terrestrial ecosystems.

4. Can status and trends of water quantity and quality and biological community composition in flowing water be predicted from remote sensing tools (see PDS for surface water dynamics and distribution)?

Relate current status and future trends in water quantity, quality and biological community composition to timing and extent of ice-cover and timing and magnitude of peak discharge from aerial imagery. **Justification:** Relating remotely sensed data to data collected from more intensive ground-based sampling efforts, may allow us to minimize future field efforts and/or extend our findings to other watersheds where remote sensing studies are being conducted.

5. How do changes detected in watershed characteristics measured by other inventory and monitoring initiatives in ARCN relate to the current status of streams and large rivers?

Relate current status and future trends in water quantity, quality and biological community composition to physical, chemical and biological drivers quantified in other vital signs. **Justification:** Relating status and trends in aquatic ecosystems to variables measured by other ARCN initiatives may allow us to efficiently minimize future field efforts and/or extend our findings to broader spatial scales.

Basic Approach:

Because watersheds act as integrators of the atmosphere and surrounding landscape, our objective is to use watershed monitoring as a tool for understanding the natural variability and cumulative effects of local, regional and global stressors on aquatic ecosystems. A watershed monitoring approach will provide a better understanding of the synergistic nature of regional and global stressors on arctic ecosystems, and their potential to exert wide-scale, cascading ecosystem effects. A watershed approach will provide ARCN with a logistically feasible means of integrating sampling and interpretation of water quantity, quality and biological community structure with other ARCN vital signs.

Data collected during Phase 1 will be used to determine general status and trends of chemical, physical and biological characteristics of aquatic resources in relation to the

surrounding environment. During Phase 1 of our watershed approach, we will intensively sample stream ecosystems and surface water dynamics and distribution in six primary watersheds. Several extensive watersheds will be sampled less intensively on a rotating basis. These sites will provide additional data for model input and verification. Watersheds will be selected to represent extreme ends of physiographic covariates and by relevance and interconnectedness with other vital signs, in particular climate and weather, permafrost dynamics, snow and ice and terrestrial vegetation. Ground-based sampling will be conducted twice during every four year period. Between ground-based sampling efforts, data-loggers will continuously record temperature and discharge. Aerial photography and/or SAR imagery during hydrologically significant periods will be used to estimate the distribution of surface water, soil moisture, snow cover and other important hydrologic variables (see surface water distribution and dynamics and snow and ice vital sign descriptions) on an annual basis.

During Phase 1 we hope to make efficient use of existing data to refine an existing thermal-hydrologic model for arctic systems (Zhang et al 2000). Meteorological data will be used for model input. Physical data will be used for model verification and refinement of the hydrologic model. Additional chemical and biological data will be used in combination with NRCS soils data and ARCN vegetation data to create and validate biogeochemical and biological aspects of this processed based model. This model will allow us to assess the efficiency of our ground-based water quality sampling efforts and may ultimately allow us to decrease ground-based sampling efforts in favor of remotely sensed data, meteorological data and computer simulation modeling during Phase 2.

When logistically feasible, we will use methods developed by the National Ecological Monitoring and Assessment Plan. Many of these methods will be modified to deal with specific needs of working in remote arctic locations. NPS leads will collaboratively devise protocols with university cooperators and solicit advice from others as needed.

Principal Investigators and NPS Lead:

NPS Leads will be Dr. Greta Burkart, aquatic ecologist, ARCN Inventory and Monitoring Program, NPS (907-455-0669), Trey Simmons, aquatic ecologist, Central Alaska Network Aquatic Ecologist (907-455-0666). We will collaboratively develop protocols through a cooperative agreement with Michael Flinn and Breck Bowden (University of Vermont), Andrew Balser (University of Alaska Fairbanks) and Bruce Peterson (Woods Hole Marine Biological Laboratory).

Development Schedule, Budget, and Expected Interim Products:

FY 2008

- NPS leads will develop a study plan for sampling nonwadeable streams and large rivers by March 2008. Study plan implementation and testing will begin during summer 2008.
- NPS leads will continue to develop standard operating procedures with assistance from collaborators. In FY2007, \$147,000 was budgeted for cooperators assistance in SOP development.

FY2009

- NPS leads will use results from 2008 sampling to inform further development of standard operating procedures, which will be ready for peer review during winter 2009.
- We plan to implement protocol during spring and summer 2009.