Protocol Development Summary (PDS)

ERMN Protocol Name: Water Quality and Quantity Monitoring (*last updated: August 17, 2007*)

Vital Signs Included in the Protocol: Water Chemistry – Core Parameters, Water Chemistry – Expanded Parameters; Surface Water Hydrology.

Related Vital Signs: Landscape Dynamics; Air Quality; Weather and Climate; Louisiana Waterthrush; Aquatic Macroinvertebrates; Riverscour Plant Communities; Soil Function and Dynamics.

ERMN Parks where protocol will be implemented: ALL: Delaware Water Gap National Recreation Area (DEWA), Upper Delaware National Scenic and Recreational River (UPDE), Allegheny Portage Railroad National Historic Site (ALPO), Johnstown Flood National Memorial (ALPO), Fort Necessity National Battlefield (FONE), Friendship Hill National Historic Site (FRHI), New River Gorge National River (NERI), Gauley River National Recreation Area (GARI), and Bluestone National Scenic River (BLUE).

Justification/Issue being addressed:

Surface water hydrology and chemical/physical water quality monitoring was recognized as a top priority at the network level during the vital signs prioritization process. The significance of water resources within ERMN (including roughly 211 miles of river and more than 425 miles of stream) is reflected in the network's ranking of river and stream hydrology and chemical/physical water quality as 2nd among all of the potential vital signs identified and prioritized by the ERMN. Flowing freshwater quality and quantity has *direct* impact on several other vital signs and park resources including fishes, crayfish, mussels, and salamander assemblages, several threatened and endangered (T&E) aquatic species, riparian and floodplain vegetation and bird communities, and aquatic macroinvertebrates (these last three are also top priorities for network monitoring). Freshwater quality and quantity has *indirect* impacts on all plant and animal life as well as human consumption, recreation, and enjoyment (i.e., the intrinsic value of water). Much of what is on the land is transferred to water via surface runoff, subsurface flow, and base flow (ground and soil water). Therefore, not only is water quality an indicator of the integrity of aquatic systems, but it is an important indicator of overall ecosystem integrity.

ERMN park watersheds consist of a complex of streams, riparian zones, wetlands, and rivers that are hydrologically supported by various combinations of precipitation, surface water, and groundwater. The physiographic origins, flow patterns, hydrodynamics, and water quality attributes determine the mosaic of aquatic habitats in these systems. Water quality in its broadest interpretation refers to all of the factors that influence the hydrology, biogeochemistry, and habitats of aquatic organisms. In a more typical interpretation, water quality of surface water relates to physical and chemical factors such as temperature, pH, conductivity, nutrient content, sediment load, and toxicant presence. Sources of degraded water quality can originate from point sources and non-point sources. Point sources are represented primarily by wastewater treatment systems from municipal and industrial sources, stormwater discharge pipes, as well as local,

residential sewage “straight pipes”; a significant issue at several ERMN parks. Non-point sources are more diffuse, typically driven by a variety of land uses and continues to be a chronic and difficult problem to resolve. Land use normally is the major factor affecting water quality. For example, rowcrop and livestock agriculture and various urban land uses have strong effects of water quality in addition to direct discharges from point sources. Moreover, it is rare that a particular watershed is contained completely within park boundaries making ERMN aquatic systems vulnerable to these upstream influences. Unless in-stream processes improve water quality, nutrients and other contaminants will be transferred downstream to higher order streams and rivers. Natural variation in aquatic substrate, water temperature, acidity, and dissolved oxygen are major controls over species composition of aquatic communities. These controls, however, may be easily overwhelmed by eutrophication, excessive sediments, and toxicants that stress, and potentially eliminate, aquatic species.

This protocol will describe how to best provide park managers with comprehensive long-term data about the status and trends in the flow and select chemical and physical aspects of park water including the effects of ecological and anthropogenic stressors. Additional components of this protocol will eventually include landscape-scale analyses (changes in landuse, cover types, patch size, fragmentation) and links to air quality, climate and weather, and soils monitoring.

Availability of these monitoring data will increase manager knowledge, improve their ability to steward park resources, and allow them to adjust to and/or mitigate threats to the park’s aquatic resources. The proposed monitoring strategy attempts to balance the immediate requirements of managers for current information (i.e., data on how current values compare to applicable standards and regulations) against the necessity for insight into the changes occurring in surface waters over time.

Management objectives:

Detect water quality threats to the park’s aquatic resources in time to prevent or mitigate damage to those resources.

Determine weather water quality standards are in compliance with the Delaware River Basin Special Protection Regulations (UPDE and DEWA).

Specific monitoring questions and objectives to be addressed by this protocol:

Objective 1. Document long-term trends in the concentration of the “core” water quality parameters (dissolved oxygen, pH, water temperature, and specific conductance) at selected sites.

Objective 2. Document long-term trends in the flow regime (e.g., annual hydrograph) at selected sites.

Objective 3. Document long-term trends in the concentration of several “expanded” water quality parameters [e.g., sediment (total suspended sediment, turbidity), acid neutralizing capacity, plant nutrients (total phosphorous, total nitrogen, nitrate + nitrogen), and human indicators (boron, chloride)] at selected sites.

Objective 4. Document long-term trends in chemical *loadings* at selected sites.

Objective 5. Document how park/network status and trends compare to regional and national trends.

Basic approach: It is proposed that the ERMN sampling design will consist of a fixed-site trends network for flow-related trends in water quality that are nested within a set of randomly selected sampling stations that are sampled periodically to define the state of the entire resource. The fixed-site network will include both within-park streams (i.e., the contributing area of the subwatershed is completely within the park boundary) that are protected from human disturbance of the watershed or channel, and stream and river reaches near the park boundary where the quality of water entering the park from private lands may be differentiated from within-park changes in water quality. New and existing sampling locations will be prioritized by USGS staff in collaboration with park staff.

The random design component will allow us to make inferences to a larger population of sites within or draining through the parks. Where parks in the ERMN have limited lotic aquatic resources, the random design may not provide useful additional information, in which case "index" sites will be selected deterministically to approximate the condition of the entire resource.

The protocol will summarize the overall network design for each park, including detailed maps and descriptions of where samples will be taken, and will describe the overall statistical sampling methodology used. The design will also include justifications for co-locating or not co-locating sampling for multiple vital signs (macroinvertebrates, flow, etc.) and recommendations for measurements within the watershed that will provide significant ancillary information for interpreting the status and trends of surface-water quality and quantity (weather and climate, soil chemistry, air quality and deposition, etc.). Sampling design details will include where and when to sample, desired levels of precision (i.e., how we define "meaningful change"), how large a sample size, and how often selected vital signs will be measured (frequency).

Principal investigators and NPS lead: Peter Murdoch, USGS Research Hydrologist, will be the lead PI for this project. Dr. Matt Marshall, ERMN Coordinator, will be the lead NPS contact. Alan Ellsworth, NPS NER Hydrologist, will be the primary technical contact for this project. In addition, Scott Sheeder, Penn State Institutes of the Environment, will collaborate on standard operating procedure (SOP) development and implementation. The USGS will write the network design and monitoring strategy, etc. (termed the "protocol"); the SOPs will be selected by the USGS, but written descriptions will be completed by Scott Sheeder and NPS personnel.

Key Citations:

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