National Park Service
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Northeast Region
Natural Resource Stewardship and Science

Level I Water Quality Inventory and Aquatic Biological Assessment of the Allegheny Portage Railroad National Historic Site and the Johnstown Flood National Memorial

Technical Report NPS/NER/NRTR-2006/060

ON THE COVER
Blair Gap Run headwaters at the Allegheny Portage Railroad National Historic Site.
Photograph by: Caleb Tzilkowski.

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October 2006

U.S. Department of the Interior
National Park Service
Northeast Region
Philadelphia, Pennsylvania

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This report was produced by the Enter author's affiliation here under Cooperative Agreement H4560030064, Task Agreement No. 002 with the Northeast Region of the National Park Service.

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Please cite this publication as:

Sheeder, S. A. and C. J. Tzilkowski. October 2006. Level I Water Quality Inventory and Aquatic Biological Assessment of The Allegheny Portage Railroad National Historic Site and The Johnstown Flood National Memorial. Technical Report NPS/NER/NRTR -2006/060. National Park Service, Northeast Region. Philadelphia, PA.

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Summary

This ‘Level 1’ water quality inventory was conducted for streams located within Allegheny Portage Railroad National Historic Site (ALPO) and Johnstown Flood National Memorial (JOFL), National Park Service (NPS) properties, from April 2004 to November 2004.

Eleven sites throughout these properties were sampled for a suite of 35 water quality parameters approximately every four weeks during this time period. Water quality parameters included core parameters (stream discharge, pH, dissolved oxygen, temperature, and specific conductivity), fecal coliform bacteria, an extensive suite of metals, nutrients, alkalinity, acidity, and turbidity. Metals analyzed were aluminum, antimony, arsenic, beryllium, cadmium, lead, thallium, selenium, barium, calcium, chromium, copper, iron, manganese, magnesium, nickel, potassium, sodium, strontium, zinc, cyanide, and mercury. Nutrient concentrations analyzed were nitrate-nitrogen, sulfate, and total phosphorus.

Aquatic macroinvertebrates (MI) and fishes were sampled from 100 m (328 ft) reaches centered on water quality sampling locations. Fish and MI samples were collected during November 2004 and January 2005, respectively.

Results of the water quality analysis indicated that: 1) Water chemistry of Blair Gap Run (BGR) and associated tributaries flowing through the ALPO property were typical of forested watersheds with similar geologic characteristics. However, elevated concentrations of some metals indicated some impairment of the BGR headwaters, potentially from acid mine drainage and atmospheric pollution. Lower reaches of BGR had high fecal coliform bacteria concentrations, likely from small-scale farming operations and malfunctioning septic systems in the watershed; and 2) The mainstem of the South Fork of the Little Conemaugh River (SF-LCR), flowing through the JOFL property, was severely impaired, likely due to acid mine drainage. Three tributaries to the SF-LCR that flow through park property had water chemistry signatures typical of similar-sized valley streams located throughout Pennsylvania; however, two of the three streams showed moderate signs of impairment. Elevated nutrient levels and high sodium concentrations in those two tributaries indicated that upstream agricultural operations, current and historical land use related disturbances, and the proximity to a divided four-lane highway were likely causes of impairment.

As expected, diversity of aquatic MI and fish communities was greatest at sampling locations that had the best water quality (i.e., low metals concentrations, high buffering capacity, and low sediment and nutrient levels). Results of the biological inventories generally agreed with the water quality analysis and indicated that: 1) Four of the six ALPO sampling locations had diverse MI communities typical of relatively undisturbed Pennsylvania stream ecosystems; however, MI communities located in the BGR headwaters and below the Hollidaysburg Reservoir on Blair Run were impaired. Both of these sites had few total MI taxa and few pollution-intolerant taxa relative to other sites in the BGR watershed. Impairment of these communities was directly related to water chemistry data collected at the respective sampling locations. The nine fish species found throughout BGR and its surveyed tributaries were typical of cool and coldwater fish communities of the Susquehanna River drainage; no state or federally endangered species were captured and brown trout (*Salmo trutta*) was the only nonnative species

captured from any location. Given the location of ALPO in the Susquehanna River drainage and the available habitat throughout the property, it is probable that additional fish species seasonally occur in the park. This survey did not investigate the productivity of BGR as a potential wild trout fishery, but the occurrence of brook and brown trout natural reproduction during these surveys suggested good water quality throughout the watershed. Moreover, additional sampling should be done to rectify findings of these surveys that were in contradiction with Pennsylvania Fish and Boat Commission trout management designations; and 2) Fishes and MI were not sampled in the SF-LCR within JOFL because it was found to be severely impaired during the water quality analysis. Although water quality was generally good at JOFL tributary sampling sites, based on chemical analyses all three sites had impaired MI and fish communities. MI taxa richness in one tributary (JOFL-2) was high (33 taxa) compared to the other two tributaries (17 taxa and 16 taxa), but was numerically dominated by relatively pollution-tolerant taxa (e.g., hydropsychid caddisflies). Fish communities at these sites followed a similar pattern; the tributary (JOFL-2) that supported the most abundant and diverse invertebrate community also supported the greatest abundance and diversity of fishes. No piscivorous (i.e., fish-eating) fishes were found at any of the stations, which may have partially explained the apparently high densities of "forage" fishes at JOFL-2. Five of the six fish species captured at JOFL-2 are considered tolerant to human-induced disturbance, which, in combination with the lack of piscivorous fishes, indicated impairment. The two streams with depauperate MI communities harbored only one fish species (creek chub [*Semotilus atromaculatus*]) represented by one and two individuals which indicated severe biological impairment. The depauperate fish and MI communities among the sampled JOFL tributaries was likely due to habitat degradation from historic land use in the watershed; furthermore, the severe impairment of the SF-LCR has likely impeded reestablishment of aquatic organisms to the sampled JOFL tributaries.

The greatest threats to ALPO aquatic resources identified during this inventory were proximity to State Route 3012, potential acid-mine drainage in the BGR headwaters, and acid precipitation/atmospheric deposition. We recommend that suspected seeps should be identified and assessed to quantify their potential effect on water quality. Additionally, quarterly long-term monitoring of nutrient species, a few metals (Al, Ba, Sr, Na, K, Mg, Mn), and acid-neutralizing capacity in the BGR headwaters (ALPO-1) is recommended to assess trends related to the atmospheric threats. Measurement of these same parameters at a downstream station (ALPO-2, ALPO-4, ALPO-6) should be made to determine whether acid precipitation/atmospheric deposition is affecting lower reaches of BGR. Several water quality samples at ALPO-6 contained relatively high concentrations of fecal coliform bacteria, likely from farm animal operations and leaking or short-circuiting septic systems. Due to these high readings, fecal coliform samples should be collected several times throughout the year. Annual sampling of MI communities at the upstream (ALPO-1) and downstream (ALPO-6) limits of ALPO property concurrent with chemical sampling during the winter quarter is recommended for long-term biomonitoring of BGR at ALPO. If perturbations are suggested by changes in the MI communities at these two sites, additional chemical and/or biological sampling could be done throughout the watershed to determine the source and extent of impairment. Discrepancies between published Pennsylvania Fish and Boat Commission (PAFBC) information and the results of this survey should be rectified by additional sampling of the BGR watershed. Results of further sampling could potentially justify alteration of current PAFBC fisheries-management regulations throughout ALPO and BGR.

Based on data collected during this project, additional sampling at JOFL sites 1 and 5 is not recommended. It is evident that the SF-LCR is severely impaired and will remain so, pending a major watershed reclamation project. If such a reclamation project is implemented in the future, chemical and biological monitoring should be initiated in the SF-LCR. Current conditions in the SF-LCR are so poor that there are very limited biological communities to monitor or protect. JOFL tributary sites 2, 3, and 4 currently have generally good water quality, although all are showing signs of stress, likely due to upstream land use and the proximity of the sites to U.S. Route 219. Therefore, monitoring of sodium (and/or specific conductivity), dissolved oxygen, and nutrient (i.e. nitrogen, phosphorus) concentrations at these sites would provide useful information for NPS staff. Nutrient measurements can be made less often than the other constituents if associated laboratory costs are prohibitive to more frequent analysis. Given the comparatively high taxa richness of MI and fishes found at JOFL-2 and its potential as a source for future colonization of the other currently impaired JOFL waterways, JOFL-2 should be monitored annually and protected from further perturbations. Reestablishment of biological communities in the other two tributaries (JOFL-1, JOFL-3) should be assessed at a minimum of once every five years.

Introduction

According to the 2001 National Park Service (NPS) Management Policies, "Natural systems in the national park system, and the human influences upon them, will be monitored to detect change. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions." To aid in the fulfillment of these objectives, a baseline of water-quality information for all key water bodies within each of the NPS units is currently being collected and assembled. Key water bodies are those that are essential to the cultural, historical, or natural resource management themes of the unit or that provide habitats for threatened or endangered plants and animals. Because limited information regarding aquatic resources within Allegheny Portage Railroad National Historic Site (ALPO) and Johnstown Flood National Memorial (JOFL) properties was available, a comprehensive chemical survey of streams within these properties (termed as "level 1" inventory) was conducted from April–November of 2004. Fishes and aquatic macroinvertebrates (MI) were inventoried once at water quality sampling locations to identify the biological condition of these streams. This document summarizes the methods, results, and significance of these surveys.

The ALPO and JOFL properties were obtained by the National Park Service primarily because of their historical significance, but both of these properties potentially contain significant aquatic natural resources. Prior to publication of this report, limited data regarding water quality and biological communities had been collected in the Blair Gap Run (BGR) watershed within the ALPO property; whereas aquatic systems within JOFL property had not been surveyed.

ALPO was created in 1964 to preserve remnants of the Allegheny Portage Railroad and is located in the Laurel Highlands of southwestern Pennsylvania near Gallitzin in Blair and Cambria Counties. The site is divided into two units: (1) the Main Unit, which includes the Visitor Center, the Lemon House, the summit of the Allegheny Portage Railroad, the Skew Arch Bridge and Incline Planes, and levels 6–10, and (2) the Staple Bend Tunnel Unit, which contains Incline Plane 1 and Level 2, located approximately 6.4 km (4 mi) east of Johnstown along the Little Conemaugh River. This study focuses on the main unit. The Main Unit is composed primarily of deciduous forest but there are also wetlands along BGR (a high-gradient, cold-water trout stream that runs through the park). Acid mine drainage (AMD) at the Staple Bend Unit has been a problem due to abandoned mines on the site. There are also potential threats to streams within the Main Unit of the park due to mine drainage.

JOFL was created in 1964 to commemorate events of the 1889 Johnstown Flood. The park contains remnants of the South Fork Dam and a portion of the historic Conemaugh Lakebed near Johnstown in Cambria County. The area is primarily forested, with areas of early successional habitat and wet meadows. The main water body on the property is the South Fork of the Little Conemaugh River (SF-LCR) which runs through remnants of the South Fork Dam. The SF-LCR has historically been, and continues to be (as the data presented in this report show), severely polluted with AMD and other contaminants that detract from the biological integrity and aesthetic value of the park. Cleanup of this section of the river will require a major collaborative effort among many partners. Additional aquatic resources include three small tributaries to the SF-LCR that flow through the JOFL property. The biological and chemical character of these tributaries was mostly unknown prior to this inventory.

Methods

Sampling Station Locations

Chemical and biological sampling locations were chosen to evaluate sub-basin effects on water quality and associated pollutant quantities flowing into and out of ALPO and JOFL properties (Figures 1 and 2, respectively). Locations were selected based upon the principal investigator's knowledge of aquatic systems, input regarding the properties from the natural resource specialist (Kathy Penrod) and the Eastern Rivers and Mountains Network coordinator (Matt Marshall), and available funding.

Six stations were selected for sampling within the ALPO property (Figure 1). ALPO-1 was selected to describe the headwater condition of BGR. ALPO-2 was located on BGR, upstream of the confluence with Blair Run. The Blair Run watershed, represented by ALPO-3 in the sampling design, contains a drinking water reservoir for the town of Hollidaysburg. ALPO-3 was located approximately 250 m (820 ft) downstream of the reservoir outlet. ALPO-4 was located approximately 50 m (164 ft) downstream of the confluence of Blair Run and BGR; this station was selected because it represented stream characteristics that result from the mixing of Blair Run and BGR. ALPO-5 was located on an unnamed tributary to BGR. ALPO-6 was located on BGR at the downstream boundary of the ALPO property and represented the watershed outlet of all streams flowing through the park.

There were five stations selected to describe aquatic conditions within the JOFL park property (Figure 2). JOFL-1 and JOFL-5 were located on the SF-LCR at the upstream and downstream park boundaries, respectively. As mentioned above, historical water quality data suggested that the SF-LCR is severely impaired by acid mine drainage. JOFL-1 and JOFL-5 were selected to refute or confirm this assertion, as well as to evaluate the water quality contributions of three tributaries to the SF-LCR that flow through park property. JOFL-2, JOFL-3, and JOFL-4 were located on these three tributaries.

Water Quality Inventory

Water Quality Parameters

Streams were analyzed for chemical and physical constituents including pH, conductivity, dissolved oxygen (DO), temperature, and instantaneous discharge rate, termed "core parameters" in the NPS Inventory and Monitoring (I & M) Program. In addition to these "core" water quality parameters, alkalinity, acidity, metallic and non-metallic elements, mineral compounds, nutrients, turbidity, and fecal coliform bacteria concentration were also analyzed (Table 1).

The extensive nature of this project satisfied several important objectives of the NPS Level 1 Inventory. This analysis provided an assessment of the current condition of surface water bodies located within the ALPO and JOFL properties. Additionally, this assessment provided a baseline for a variety of water quality constituents, that in the future could be reassessed to document improvements or perturbations in water quality. Land cover change, construction projects, deterioration of septic systems, and other changes occurring within a watershed can often be

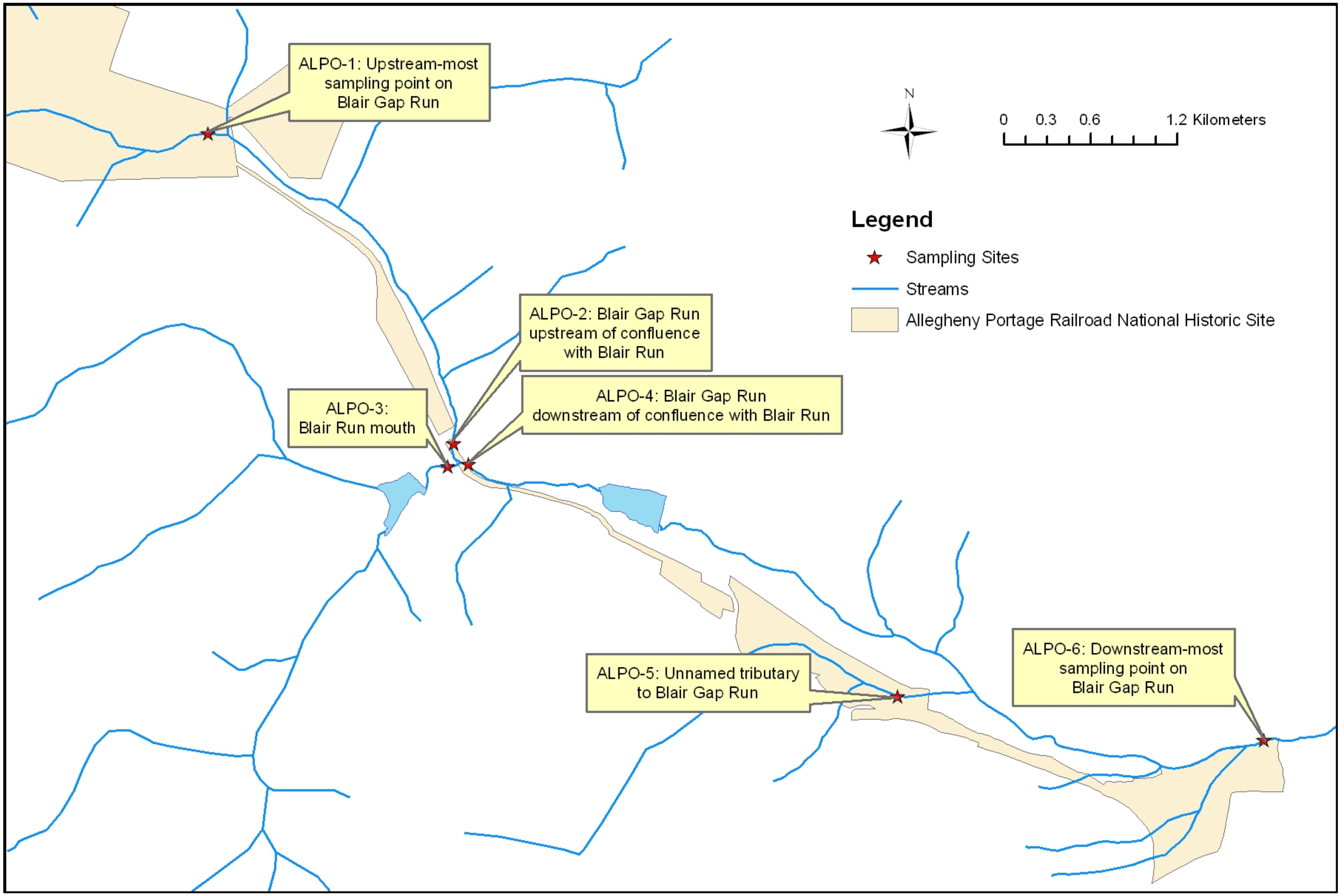

Figure 1. Chemical and biological sampling stations located at Allegheny Portage Railroad National Historic Site.

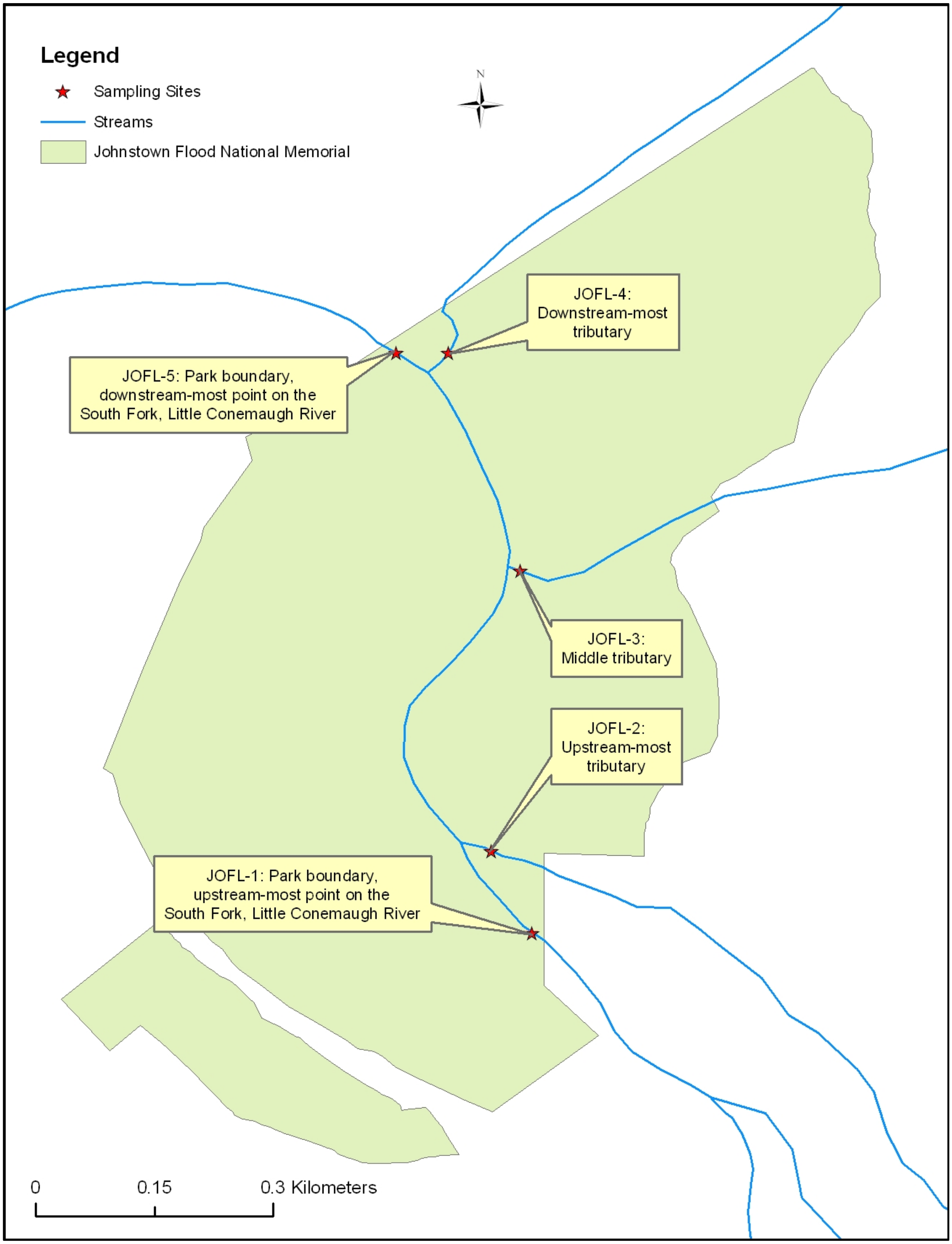

Figure 2. Chemical and biological sampling stations located at Johnstown Flood National Memorial.

Table 1. Water quality sampling parameters, detection limits, and analytical methods used throughout Allegheny Portage Railroad National Historic Site and Johnstown Flood National Memorial.

	Parameter Description	Detection Limit	Method
Parameters Requiring Laboratory Analysis	Alkalinity	0.2 mg/l	Titration method - 2320 B[1]
	Acidity	0.2 mg/l	Titration Method - 2310 B[1]
	Nitrate-Nitrogen	0.01 mg/l	Ion-Chromatogrphy with Chemical Suppression of Eluent Conductivity - 4110 B[1]
	Sulfate	0.03 mg/l	
	Total Phosphorus	0.001 mg/l	Ascorbic Acid Method 4500-P E & Persulfate Digestion Method[1]
	Turbidity	0.6 NTU	Nephelometric Method - 2130 B[1]
	Aluminum (fur)	0.002 mg/l	Atomic Absorption Spectrometric - 3113[1]
	Antimony (fur)	0.002 mg/l	
	Arsenic (fur)	0.002 mg/l	
	Beryllium (fur)	0.002 mg/l	
	Cadmium (fur)	0.002 mg/l	
	Lead (fur)	0.002 mg/l	
	Thallium (fur)	0.002 mg/l	
	Selenium (fur)	0.002 mg/l	
	Barium (fl)	0.01 mg/l	Atomic Absorption Spectrometric - 3111[1]
	Calcium (fl)	0.01 mg/l	
	Chromium (fl)	0.01 mg/l	
	Copper (fl)	0.01 mg/l	
	Iron (fl)	0.01 mg/l	
	Manganese (fl)	0.01 mg/l	
	Magnesium (fl)	0.01 mg/l	
	Nickel (fl)	0.01 mg/l	
	Potassium (fl)	0.01 mg/l	
	Sodium (fl)	0.01 mg/l	
	Strontium (fl)	0.01 mg/l	
	Zinc (fl)	0.01 mg/l	
	Cyanide	0.1 mg/L	EPA SW-846, Section 7.3.3.2 + 9010[2]
	Mercury	0.00004 mg/L	EPA 7470[2]
	Fecal Coliform	1/100 mL	Fecal Coliform Membrane Filter - 9222 D[1]
Field Analysis Parameters	Stream Discharge	0.1 fps	Swoffer Instruments, Inc. Model 2100 Series Current Velocity Meter
	pH	0.01	Hanna Instruments HI 8314 Membrane pH Meter
	Dissolved Oxygen Concentration	0.01 mg/L	YSI, Inc. Model 85 Handheld Oxygen, Conductivity, Salinity, and Temperature System.
	Dissolved Oxygen Saturation	0.1 % Air saturation	
	Conductivity	0.1 µs/cm	
	Specific Conductivity	0.1 µs/cm	
	Stream Water Temperature	0.1 ˚C	

[1]Standard Methods for the Examination of Water and Wastewater, 20th ed.
[2]USEPA 1986
fur: graphite furnace
fl: flame furnace
mg/L: milligrams per liter
mL: milliliter
fps: feet per second
µS: microsiemens
cm: centimeter
˚C: degrees celcius

detected by comparing water quality samples with historic data. This Level 1 Inventory provides necessary data for change detection analysis. Finally, results of this analysis could potentially be used by the NPS to provide support for changes in regulatory designations (PA Department of Environmental Protection designated use, USEPA 303-d listing, etc.). Lastly, results of this analysis may prove useful for directing future ALPO and JOFL water quality and aquatic ecosystem investigations and monitoring.

Selection of water quality constituents considered in this inventory was based on several factors. Specifically, selection was based on the parameters required for NPS water resources investigations (the "core" parameters), chemical pollutants related to current land use surrounding NPS property, historic violation of constituent-specific water quality criteria, the association of several of these pollutants with mining activity, discussion with NPS staff, and historic accounts of mining activities within the ALPO and JOFL contributing watersheds.

Each of the core water quality parameters is discussed in the following paragraphs, followed by discussion of why the expanded suite of metals, nutrients, and bacteria parameters were sampled during this inventory.

Core Water Quality Parameters:

Discharge: Stream discharge measurements are necessary for calculation of pollutant loads, dilution curves, sediment transport rates, and many other types of watershed/water quality analyses. Stream discharge measurements collected during this inventory provide a baseline of flow information for points at which discharge information was previously unavailable. Additionally, the degree of groundwater-stream connection, and classification of the stream as perennial, intermittent, or ephemeral can sometimes be determined using limited data.

pH: Water pH is the negative logarithm ($-\log_{10}$) of hydrogen-ion activity in moles per liter and can range from 0 to 14 on a continuous scale. Low values are acidic, whereas high values are basic. A pH of 7 is generally considered neutral, though slight variability in the neutral value occurs with changing temperature. Unpolluted river water typically has a pH range of 6.5–8.5, with values outside of this range occurring under certain circumstances (i.e. thermal spring waters can have a very low pH). Measurement of pH is a very important component of many water quality investigations because pH partly determines solubility of ionic species in solution. For example, different aluminum species predominate under different pH conditions. The cation Al^{3+} predominates when pH is less than 4. Gibbsite is commonly formed by aluminum when the pH is between 4.5–6.5. Above neutral pH, the anion $Al(OH)_4^-$ predominates (Hem 1989).

DO: Fish, MI, and other aquatic organisms require oxygen. Therefore, the DO concentration is a vital component of any aquatic resource investigation. Principal sources of DO include mechanical aeration of the water and photosynthetic output. DO is consumed through respiration, mechanical degassing, and biochemical reactions that occur in the substrate. In unimpaired aquatic ecosystems DO concentrations are typically sufficient to support aquatic life, but in polluted environments DO concentrations are often depleted to the extent that many organisms cannot survive.

Conductivity: Conductivity is the ability of a substance to conduct an electrical current. In water conductivity is related to the concentration of dissolved ionic species in solution, and is therefore useful as a general indicator of water quality. The conductance of natural waters has a very wide range depending on geology, soil type, and other sources of solutes. Therefore, conductivity is not a direct indicator of water quality or impairment of an aquatic system. Conductivity can be used to identify changes in water chemistry. Comparing conductivity at a particular location with upstream locations can often allow inferences regarding groundwater inputs, malfunctioning septic systems, acid mine drainage, and other inputs.

Temperature: Water temperature, in combination with the previously mentioned parameters, strongly influences the type of biological community that will be present. When the water temperature regime of a system is changed by land cover alterations, construction of reservoirs, addition of point source discharges, and other human activities, aquatic community composition will change to reflect the new conditions. Therefore, temperature measurement can provide information regarding current habitat and serve as an indicator for changes in the physical environment and biological communities.

Expanded Suite of Water Quality Parameters: According to Technical Report NPS/NRWRD/NRTR-99/205, a Storage and Retrieval (STORET) water quality data query for the JOFL and ALPO study areas yielded 30,932 observations for 498 separate parameters collected by federal and state agencies. These samples were collected between 1926 and 1997 at 381 monitoring stations located within the ALPO and JOFL contributing watersheds. In the report, water quality sample data were compared to USEPA water quality criteria to identify potential water quality concerns within the watersheds. Results of this comparison indicated that dissolved oxygen, cyanide, cadmium, copper, lead, and zinc exceeded limits set forth by the USEPA to protect freshwater aquatic life. Additionally, sulfate, nitrate, antimony, beryllium, cadmium, nickel, and thallium concentrations exceeded their respective drinking water criteria.

Because the majority of these chemical constituents do not naturally occur in surface waters, the violations listed above indicated anthropogenic disturbance. For example, antimony, present in high concentrations in at least one of the STORET database samples, has been shown to naturally occur in concentrations of a few hundred micrograms per liter in the hot springs of Yellowstone National Park (White et al. 1963); whereas concentrations of the element in mine drainage can reach 3–6 mg/L (Shvartsev et al. 1974). Based upon personal communication with NPS personnel and historical land use in the watersheds that contribute streamflow to ALPO and JOFL, the combination of surface mining and deep shaft mining is a possible explanation for the presence of antimony, copper (USGS 1970), and beryllium (Hem 1989) in park waters. Further review of the ALPO and JOFL STORET data indicated that many of the remaining chemical constituents of concern are often found in receiving waters of industrial factories, smelting operations, and similar practices. For example, cadmium, lead, zinc, and nickel are often byproducts of metal plating, pigments, plastics, metallurgy, and smelting practices (Hem 1989).

Although the historical presence of the chemical constituents discussed above may indicate severe watershed impairment at the time of sampling, it is important to note that aquatic ecosystem impairment may not currently exist. Therefore, to develop a baseline of water quality information, samples were collected at all ALPO and JOFL sites and analyzed for an extensive suite of metallic and nonmetallic elements, as well as for mineral compounds, nutrients, turbidity, and bacteria. The chemical analyses conducted for each sample were expanded from the constituents identified in the historic samples to encompass a broad range of elements that behave similarly (if present) to those found in the historic samples.

Water Quality Sampling Procedures

Instantaneous stream discharge (flow), pH, DO, conductivity, specific conductivity, and temperature were measured on-site using calibrated field meters (Table 1). Stream discharge was measured using a Swoffer Model 2100 hand-held current velocity meter. The pH of the samples was measured using a Hanna Instruments membrane pH meter; whereas, DO, conductivity, specific conductivity, and temperature measurements were made using a YSI Model 85 handheld probe. Measurements of both conductivity/specific conductivity and DO concentration/percent saturation were included because specific conductivity and percent DO saturation standardize measurements based on stream temperature. Standardization allows for direct comparison of conductivity and DO samples under different temperature conditions.

All samples requiring laboratory analyses were preserved and transported directly to the water quality labs that conducted the analyses. With the exceptions of fecal coliform, cyanide, and mercury, all samples collected as part of this inventory were analyzed at the Penn State Institutes of the Environment (PSIE) Water Quality Laboratory (Project Manager, Scott Atkinson, 814-865-4806), located at the University Park campus of The Pennsylvania State University (PSU). Fecal coliform bacteria samples were delivered to Fairway Labs (Project Manager, Susan Lowery, 814-946-4306) for analysis. Cyanide and mercury concentrations were analyzed at the Agricultural Analytical Services Laboratory (Director, Ann Wolf, 814-863-0841) at PSU.

Water samples were collected and field parameters (flow, DO, conductivity, pH, temperature) were measured seven times at each sampling location between April 13–November 18, 2004. ALPO water chemistry samples were collected on April 15, May 6, June 17, August 2, September 2, October 21, and November 16. Water chemistry samples were collected from JOFL sites on April 13, May 4, June 16, August 4, September 7, October 28, and November 18. These sampling events were chosen to represent a variety of hydrologic and seasonal conditions to describe potential variability of physical and chemical parameters throughout the study period. Specifically, samples were collected during pre-leafout, growing season, and post-leafout conditions, as well as during different flow regimes, including spring runoff, immediately following precipitation events, and following extended periods of low precipitation.

Water Quality Sample Analysis and Interpretation

Due to the limited duration of this inventory and the limited number of samples collected at each site it was not feasible to conduct an extensive statistical analysis of the data collected throughout this project. Despite these limitations, water quality data collected throughout this inventory were analyzed by constructing boxplots of each chemical parameter for ALPO and JOFL. These boxplots illustrate the median value, the 1st and 3rd quartiles of the data distribution, the minimum and maximum value within the lower and upper limits, and any outliers. Boxplots of alkalinity and the core water quality parameters, with the exception of temperature, are provided in sections 3.1.1 and 3.2.1 below. Temperature data are presented in table format to allow for direct comparison between measured values and the Pennsylvania

Department of Environmental Protection's (PADEP) temporally-variable temperature criteria (discussed in further detail below). Boxplots of the remaining chemical constituents, in addition to the raw water quality data, are provided in Appendixes A and B for ALPO and JOFL, respectively.

Federal and/or state regulatory criteria exist for several of the chemical constituents analyzed as part of this inventory. In many cases, multiple thresholds have been established for the concentration of a given chemical in solution. These regulatory criteria or thresholds are typically assigned according to the protected use of the water body. In Pennsylvania (contributing watersheds for the ALPO and JOFL properties are contained entirely within Pennsylvania) protected uses of surface waters include aquatic life, water supply, recreation and fish consumption, navigation, and special protection (PADEP 2003). Protected uses of the surface waters at ALPO include aquatic life – cold water fishes (CWF) and aquatic life – trout stocking (TSF). ALPO sampling stations 1, 2, 3, and 4 are located within stream reaches that currently possess CWF designations. ALPO monitoring stations 5 and 6 are located within stream reaches currently possessing TSF designations. The protected use of the SF-LCR and the three unnamed tributaries flowing through JOFL property is CWF. Pennsylvania water quality standards for alkalinity, dissolved oxygen, pH, and temperature have been established for the CWF and TSF protected uses. Table 2 provides information regarding established standards for alkalinity, DO, and pH. Temperature criteria are provided in Table 3.

Specific conductivity is the only parameter included in the NPS list of core water quality parameters that does not have an established water quality standard. A water quality standard for conductivity is not warranted because conductivity is not directly correlated with aquatic health. Nonetheless, this measurement is important for water quality assessment because the conductivity of a water sample provides an indication of dissolved ionic concentration. Therefore, measuring conductivity at points within a watershed can provide information on water sources with associated conductivities that differ from background conditions. In many cases, the location of groundwater input, a malfunctioning septic system, mine discharge, etc., can be identified by comparing conductivity measurements at a particular site with upstream and downstream measurements.

In addition to Pennsylvania water quality standards outlined above, there are established federal aquatic life, water quality criteria for several metallic constituents considered in this inventory. These include criteria for arsenic (As), cadmium (Cd), lead (Pb), selenium (Se), chromium (Cr), copper (Cu), iron (Fe), nickel (Ni), zinc (Zn), cyanide (Cn), and mercury (Hg) and are provided in the USEPA publication "National Recommended Water Quality Criteria: 2002" available at www.epa.gov. Several different types of criteria are provided in this publication: criteria maximum concentration (CMC), criterion continuous concentration (CCC), and human health consumption. The CMC is defined as an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The CCC is defined as an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

Table 2. Pennsylvania alkalinity, dissolved oxygen (DO), and pH criteria for the protection of aquatic life (PADEP 2003). Water quality parameter, protected use, and criteria are presented. Aquatic life protected uses include cold water fishes (CWF), trout stocking (TSF), warm water fishes (WWF), and migratory fishes (MF).

Parameter	Protected Use	Criteria
Alkalinity	CWF, WWF, TSF, MF	Minimum 20 mg/L as $CaCO_3$, except where natural conditions are less
Dissolved Oxygen	TSF	For the period of February 15 to July 31, minimum 5.0 mg DO/L. Minimum of 4.0 mg DO/L remainder of the year
	CWF	Minimum of 5 mg DO/L
pH	CWF, WWF, TSF, MF	6.0 to 9.0

Table 3. Pennsylvania temperature criteria for the protection of aquatic life (PADEP 2003). Time period and maximum temperature criteria for aquatic life cold water fishes (CWF), trout stocking (TSF), and warm water fishes (WWF) are presented.

	Temperature (°C)		
Time period	CWF	TSF	WWF
January	3.3	4.4	4.4
February	3.3	4.4	4.4
March	5.6	7.8	7.8
April 1–15	8.9	11.1	11.1
April 16–30	11.1	14.4	14.4
May 1–15	12.2	17.8	17.8
May 16–31	14.4	20.0	22.2
June 1–15	15.6	21.1	26.7
June 16–30	17.8	22.2	28.9
July	18.9	23.3	30.6
August 1–15	18.9	26.7	28.9
August 16–30	18.9	30.6	30.6
September 1–15	17.8	28.9	28.9
September 16–30	15.6	25.6	25.6
October 1–15	12.2	22.2	22.2
October 16–31	10.0	18.9	18.9
November 1–15	7.8	14.4	14.4
November 16–31	5.6	10.0	10.0
December	4.4	5.6	5.6

For this inventory, measured pollutant concentrations were compared to both the CMC and CCC criteria when applicable (the majority of pollutants analyzed currently do not have regulatory water quality standards; Table 4). It is important to note that when grab sample concentrations are compared to these criteria, exceedence of the CMC constitutes impairment of the biological community, whereas exceedence of the CCC does not necessarily indicate biological impairment. Therefore, the provided CCC values are intended to provide a reference for potential impairment (i.e. risk) only.

There is no Pennsylvania or federal in-stream nutrient threshold criteria for protection of aquatic life. This is principally due to the many factors that determine whether a prescribed concentration of nutrients will impair an aquatic biological community. The phosphorus criteria provided was based upon a study conducted on Pennsylvania watersheds. In their report, Sheeder and Evans (2004) showed that streams can be at risk of biological impairment when median in-stream phosphorus concentrations exceed 0.07 mg P/L.

Aquatic Macroinvertebrate Inventory

Rationale for Using Benthic Macroinvertebrates for Water Quality Assessment

Aquatic macroinvertebrates (MI) are aquatic invertebrate animals larger than microscopic size. Freshwater forms used for water quality assessment include arthropods (insects, arachnids, crustaceans), worms, clams, and snails. The USEPA and state agency representatives formed, and commonly use, standardized Rapid Bioassessment Protocols (RBP) or similar methods to efficiently gain knowledge regarding the condition of the Nations' surface waters (Barbour et al. 1999). Macroinvertebrates are the most frequently used organisms in water quality assessment because: 1) they are relatively easy to collect; 2) many taxa can be identified to the family level in the field (Barbour et al. 1999); and 3) several MI life history traits make them uniquely advantageous for monitoring water quality (Table 5).

The ecosystem is the largest spatial and temporal scale for studying MI (Merritt and Cummins 1996), but studying MI at the ecosystem level is usually impractical with regard to both time and finances. The second largest scale of bioassessment is the community (Merritt and Cummins 1996), and because of its relatively large scale and practicality, the MI community is the most commonly used level for water quality assessment. Biological communities have several attributes (Table 6) that make biological monitoring the "most direct and effective measure of a water body" (Karr and Chu 1999).

Macroinvertebrate Sampling

Macroinvertebrate communities at all ALPO sites and three JOFL sites (JOFL-2, JOFL-3, and JOFL-4) were surveyed following protocols developed by USEPA (Barbour et al. 1999). Macroinvertebrate communities were not sampled at the two water quality stations on the SF-LCR (JOFL-1 and JOFL-5) because the SF-LCR was obviously impaired (i.e., extremely low pH, non-existent buffering capacity, elevated metals concentration) as described in the results of this report. Macroinvertebrates—notably mollusks, crustaceans, leeches, mayflies, some species of water striders, caddisflies, damselflies, dragonflies, and cladocerans—are sensitive to acidification and become scarce or disappear between pH 5.0–6.0 (Havas and Hutchinson 1982;

Table 4. Established USEPA criterion continuous concentration (CCC) and criteria maximum concentration (CMC) values for the analyzed water quality parameters. The values presented here are also available in the USEPA publication, "National Recommended Water Quality Criteria: 2002."

Water quality Parameter	Criterion Continuous Concentration (CCC), mg/L	Criteria Maximum Concentration (CMC), mg/L
Aluminum	0.087	0.750
Arsenic	0.150	0.340
Cadmium	0.00025	0.002
Lead	0.0025	0.065
Selenium	0.005	NA
Chromium	0.074 (Chromium III), 0.011 (Chromium IV)	0.570 (Chromium III), 0.016 (Chromium IV)
Copper	0.009	0.013
Iron	1.0	NA
Nickel	0.052	0.470
Zinc	0.120	0.120
Cyanide	0.0052	0.022
Mercury	0.00077	0.0014

Table 5. Advantageous traits of aquatic macroinvertebrates for water quality assessment (Merritt and Cummins 1996; Barbour et al. 1999).

Trait	Advantage for water quality assessment
Sedentary	Relatively limited migration of macroinvertebrates permits examination of spatial effects from environmental perturbations.
Ubiquitous	Macroinvertebrates are affected by stress in a variety of aquatic habitats. Small (1st and 2nd order) streams that may not support fish fauna usually support a diverse macroinvertebrate fauna.
Trophic level	Macroinvertebrates form the food base of at least a portion of the life cycle of fishes and other aquatic vertebrates.
Speciose	Macroinvertebrate assemblages constitute a wide range of trophic levels, providing information regarding cumulative effects of perturbations.
Complex life cycle	Most macroinvertebrate taxa have a complex life cycle of one year or more and sensitive life stages respond quickly to stress.

Table 6. Attributes of biological communities that have made them useful for monitoring integrity of surface waters (Barbour et al. 1999).

1) Biological communities reflect overall ecological integrity (*i.e.,* chemical, physical, and biological integrity) of aquatic ecosystems.
2) Biological communities integrate and reflect effects of multiple stressors, providing a broad measure of the aggregate impact.
3) Biological communities integrate stresses over time, providing an ecological measure of changing environmental conditions.
4) Monitoring biological communities is cheap compared to other types of testing (chemical, toxicity).
5) The status of biological communities provides a meaningful measure of pollution to the public.
6) Biological communities may better reflect the impacts of ambient impacts (*e.g.*, nonpoint-source discharges, acid deposition) than other means of evaluation.

Eilers et al. 1984; Bendell and McNicol 1987). Given the obviously polluted condition of the SF-LCR, it was unlikely that unique MI taxa occurred there that did not occur at the sampled locations.

Nine 20-second D-frame kick net (250 µm mesh) samples were taken on January 12, 2005 from 100 m (328 ft) reaches centered on water quality sampling locations. D-frame kick nets are the recommended sampling gear for RBP multihabitat bioassessments (Barbour et al. 1999) because they typically collect 95 % of the MI taxa present in a stream and can be used in pools, riffles, and runs (Frost et al. 1970). Samples were pooled then preserved in 70% ethyl alcohol. Biomonitoring programs often use subsampling to provide a "consistent unit of effort" and to reduce the amount of time, effort, and ultimately cost, necessary for characterizing MI communities; however, all organisms were identified during this study because the primary intent was to inventory as many taxa as possible within the park streams. MI were identified in the laboratory to the lowest practical taxonomic level (usually genus) using standard keys (Peckarsky et al. 1990; Merritt and Cummins 1996) and counted under 60X – magnification. At least one individual from every taxon was digitally photographed under magnification as a voucher.

Macroinvertebrate Community Data Analysis

Bioassessment protocols advocated by the USEPA include RBP (Barbour et al. 1999) and the Macroinvertebrate Biotic Integrity Index (MBII) (Klemm et al. 2003). These protocols consist of metrics that describe components of benthic MI community richness or composition using groups of organisms defined by phylogenetic, tolerance, habit, or feeding relationships. The rationale behind these indices is that a suite of metrics representing community structure, pollution tolerance, functional feeding groups and habitat occurrences, life history strategies, disease, and density provide insights regarding how biological communities respond to different natural and anthropogenic stressors (Klemm et al. 2003).

A common practice for stream bioassessments is to compare MI community composition and structure from candidate streams to those collected from reference streams by using metrics. Reference streams are relatively unperturbed, similarly-sized streams within similar geographic and geologic settings as candidate streams that provide an estimate of natural stream communities. The departure of the sampled MI community from expected MI community composition (i.e., reference streams) based on various metrics serves as a measure of stream impairment. The MBII is one such index that uses reference streams to assess stream impairment.

The MBII was used for this study because it was developed for upland and lowland streams dominated by riffle habitat in the Mid-Atlantic Highlands Region (MAHR), which contains Pennsylvania. Moreover, the MBII was based on a large data set of 574 wadeable stream reaches and was thoroughly tested. The MBII uses seven metrics selected from 100 that are used by governmental agencies throughout the MAHR. The seven that were chosen were those that performed best in terms of range, precision, responsiveness to various human-induced disturbances, relationship to catchment area, and redundancy (Table 7) (Klemm et al. 2003). Most MBII metrics are counts or proportions of taxa in the community that are generally tolerant or intolerant to human perturbations; however, the Macroinvertebrate Tolerance Index (MTI) is more complex because it incorporates ranks (0–10) for each taxon with respect to pollution tolerance, weighted by taxon abundance, and results in higher scores as the proportion of taxa tolerant to general pollution increases (Klemm et al. 2003). Pollution Tolerance Values (PTV) incorporated in the MTI were average organism tolerances to "… various types of stressors" (Klemm et al. 2002).

The MBII was calculated based on floor and ceiling values determined by Klemm et al. (2003) as follows:

"For positive metrics (i.e., those that increased with improving conditions), the upper expectation (ceiling) was the 75th percentile of the distribution of reference reaches, while the lower expectation (floor) was the 25th percentile of the distribution of impaired reaches. Metrics with a value above the ceiling received a score of 10, while those below the floor scored 0. All other values were linearly scaled along the range between the high and the low. In other words, a raw metric value that was half way between the floor and ceiling values would be scored as 5.

For negative metrics, those that decreased with improving condition, the ceiling was the 75th percentile of the distribution of impaired reaches, and the floor was the 25th percentile of the distribution of reference reaches. Negative metrics with a value above the ceiling scored a 0, while those below the floor scored 10. All other values were linearly scaled along the range between the low and high as for positive metrics."

Metric scores were calculated according to the floor and ceiling values reported by Klemm et al. (2003) (Table 7). To calculate the MBII value, metric scores were added together and the sum was scaled by (100/70) which resulted in a range of 0–100 for the MBII. Impairment is expected to decrease with increasing MBII score.

Fish Species Inventory

Fishes were captured from ≥ 100 m (328 ft) reaches centered on water quality sampling locations with a three-person team and a gas-powered backpack electrofishing unit. Fish communities at ALPO (all sites) and Johnstown Flood (JOFL-2, JOFL-3, and JOFL-4) stations were surveyed on November 16 and November 18, 2004, respectively. Similarly to the MI surveys, fish communities at the two water quality sampling locations on the SF-LCR (JOFL-1, JOFL-5) were not sampled, given the obvious severe impairment of the SF-LCR. All captured individuals were identified, counted, and released unharmed. Additionally, digital photograph vouchers of each species were taken at the time of inventory.

Table 7. Macroinvertebrate Biotic Integrity Index (MBII) metric: descriptions, directions of response to increasing human perturbation (Klemm et al. 2003), and calculation formulas.

Metric	Description	Response	Metric Calculation
Ephemeroptera richness	Number of Ephemeroptera (mayfly) taxa	Decrease	1.01 x - 4.25
Plecoptera richness	Number of Plecoptera (stonefly) taxa	Decrease	1.69 x -6.03
Trichoptera richness	Number of Trichoptera (stonefly) taxa	Decrease	1.67 x -1.67
Collector-filterer richness	Number of taxa with a collecting or filtering-feeding strategy	Decrease	1.54 x – 5.98
Percent non-insect individuals	Percent of individuals that are not insects	Increase	-0.56 x +10.0
Macroinvertebrate Tolerance Index (MTI)	∑i piti, where pi is the proportion of individuals in taxon i and ti is the pollution tolerance value (PTV) for general pollution	Increase	-5.85 + 31.34
Percent five dominant taxa	Percentage of individuals in the five numerically dominant taxa	Increase	-0.26 +21.21

Results and Discussion

It is important to consider while evaluating hydrologic and biological conditions at ALPO and JOFL that precipitation amounts were atypical in southcentral Pennsylvania during this study. The region surrounding ALPO and JOFL received approximately 163 cm (64 in) of precipitation during 2004; average annual precipitation for this region is approximately 104 cm (41 in) (Pennsylvania State University, Kevin Horner, Senior Research Technologist, pers. comm., June 2005). Given these conditions, it is probable that data in this report did not represent average conditions at the sampled locations. Specifically, water quality data collected during this inventory likely represented lower-than-average in-stream pollutant concentrations due to higher-than-average stream discharge. High streamflows can also locally affect aquatic habitats and organism distributions; however, because this study did not address variability in abundance or spatial distribution of organisms, it was unlikely that increased precipitation prior to these surveys biased results among sampling stations or taxa (i.e., MI genera, fish species).

To illustrate the effect that dilution can have on in-stream pollutant concentrations, ALPO and JOFL specific conductivity plots are provided (Figures 3 and 4). Specific conductivity is directly related to dissolved and particulate ion concentrations within the sample, and is therefore a good indicator of water purity. Specific conductivity generally decreased with increasing streamflow at ALPO and JOFL. Therefore, collection of water quality samples during high flow time periods can lead to artificially low estimation of pollutant concentrations during low stream discharge periods.

Ten of the 29 parameters analyzed from ALPO and JOFL were below their respective laboratory detection limits in all samples. Chemical parameters that were analyzed for, but not detected included: cyanide (Cn), mercury (Hg), chromium (Cr), copper (Cu), antimony (Sb), arsenic (As), cadmium (Cd), lead (Pb), thallium (Tl), and selenium (Se). Generally, most compounds containing these elements are toxic to biological organisms. Although some occur naturally (toxic amounts of Se occur naturally in some soils) in the environment, most detectable quantities of compounds containing these elements indicate a significant level of human-induced environmental disturbance. For example, detectable levels of methyl-mercury (Hg) are a by-product of fossil fuel combustion in power plants, whereas Cr and Cd compounds are often present in mine drainage. Absence of compounds containing these elements is encouraging from an environmental perspective, but as discussed in the following pages, other elements present at some water quality monitoring stations (particularly JOFL-1 and JOFL-5) indicated severe impairment at these stations. Additionally, it is important to note that trace concentrations of mercury can accumulate in biological organisms and can lead to biological impairment. Biological tissue samples could be collected and analyzed to detect the occurrence of this phenomenon.

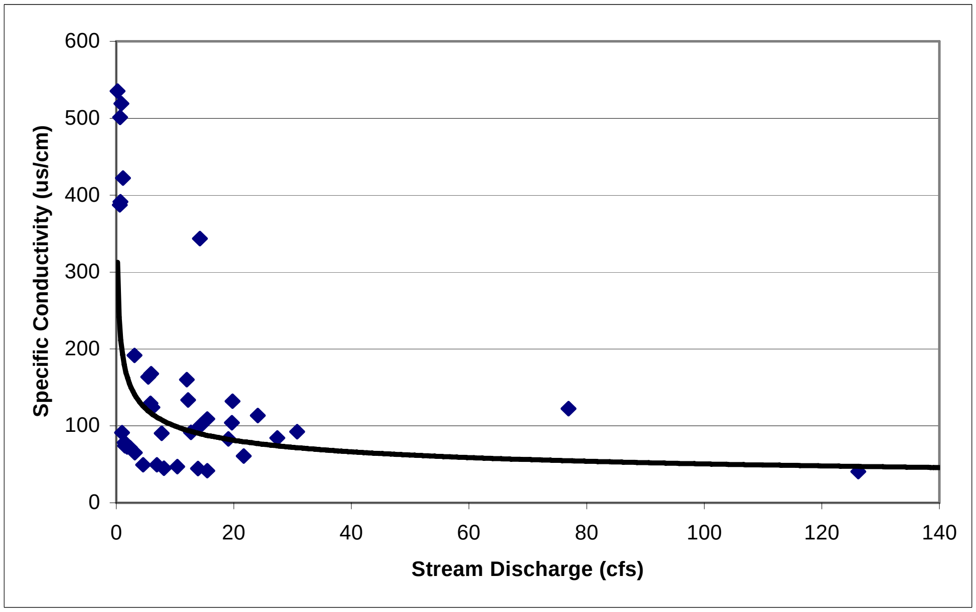

Figure 3. Relationship between stream discharge (cubic feet/sec; cfs) and specific conductivity of samples collected at Allegheny Portage Railroad National Historic Site sampling stations.

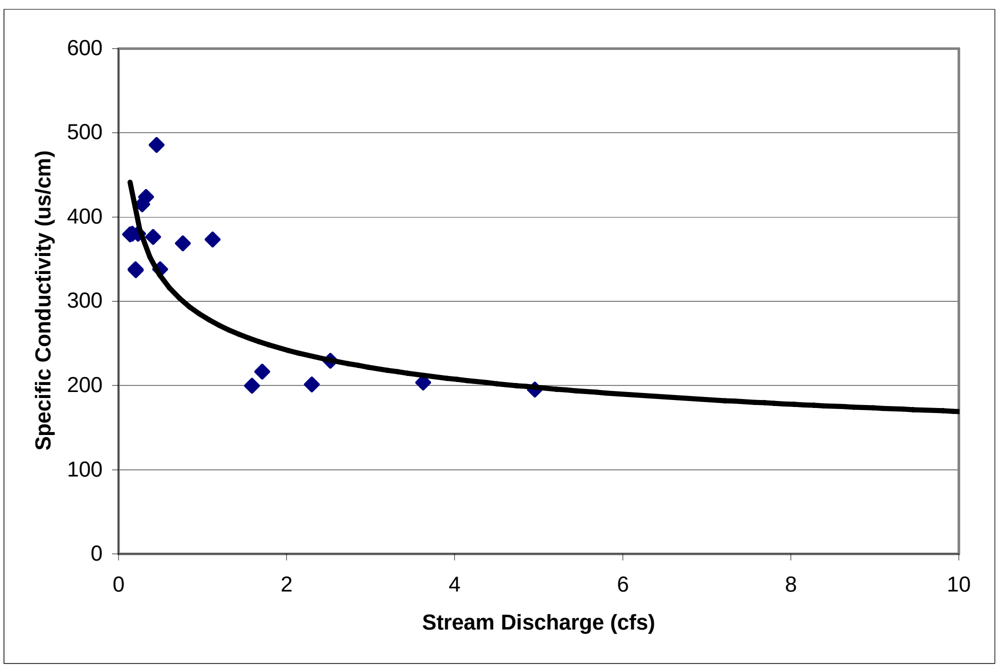

Figure 4. Relationship between stream discharge (cubic feet/sec; cfs) and specific conductivity of samples collected at Johnstown Flood National Memorial sampling stations 2, 3, 4 (stations 1 and 5 omitted because of weak relationship due to acid mine drainage in the South Fork, Little Conemaugh River).

Allegheny Portage Railroad National Historic Site (ALPO)

Water Quality

Figures 5 through 9 and Table 8 illustrate the statistical median, quartile, and range of values measured for alkalinity and each of the core water quality parameters measured at the ALPO sampling stations (n = 7 sampling occasions). The extended suite of water quality data collected at the ALPO sites are presented in tabular and graphical form in Appendix A.

In addition to providing an indication of the general condition of an aquatic system, the core water quality parameters collected at the ALPO sites can be used to assess the spatial and temporal variability in stream water chemistry within the Blair Gap Run (BGR) watershed. Variability in stream chemistry can be used to identify the location of pollution sources within a watershed, as well as to identify episodic deviations from baseline conditions.

Alkalinity data (Figure 5) collected at ALPO suggested that the ability of the BGR watershed to buffer low pH waters is limited. The PADEP alkalinity water quality criteria require a minimum of 20 mg/L as $CaCO_3$, except where natural conditions are less. Median alkalinity at the ALPO water quality monitoring sites ranged from approximately 10 mg $CaCO_3$/L at ALPO-3 to a median of 28 mg $CaCO_3$/L at ALPO-1 (Figure 5). Assessing the causes of this variation and determining what constitutes the natural alkalinity condition of the BGR watershed were beyond the scope of this inventory. However, it is reasonable to assume, based upon the geology of the watershed, that the natural buffering capacity is low relative to other streams in central Pennsylvania. It is also possible that the low alkalinity measurements were the result of anthropogenic disturbances within the watershed. For example, portions of the watershed were mined historically, and low pH waters emanating from abandoned mines may be reacting with $CaCO_3$ in solution. Additionally, the Appalachian Mountains are subjected to low pH precipitation under certain meteorological conditions (Lynch et al. 2005). Therefore, low pH precipitation may also be adversely affecting the alkalinity of BGR and its tributaries. While acid precipitation, acid mine drainage, and other potential sources of acidity may be affecting alkalinity in the BGR watershed, pH data collected at ALPO sites suggested that the existing buffering capacity of the watershed is sufficient to prevent acidification of the aquatic resources. Long-term monitoring of alkalinity and pH could provide useful information regarding trends in these water quality constituents.

The pH data (Figure 6) collected at the ALPO water quality sampling sites suggested that in-stream levels were within the acceptable range when compared to the PADEP's water quality criteria (Table 2). As mentioned in the previous paragraph, in-stream pH is the result of complex interactions between inputs of acidity such as acid precipitation and acid mine drainage, and buffering capacity (CaCO3 and other cation exchange molecules). Presently, in-stream pH values are circumneutral. However, as the buffering capacity of the watershed is depleted through reaction, the condition of BGR waters may change. Long-term monitoring of pH is necessary to detect changes in a watershed's ability to buffer pH.

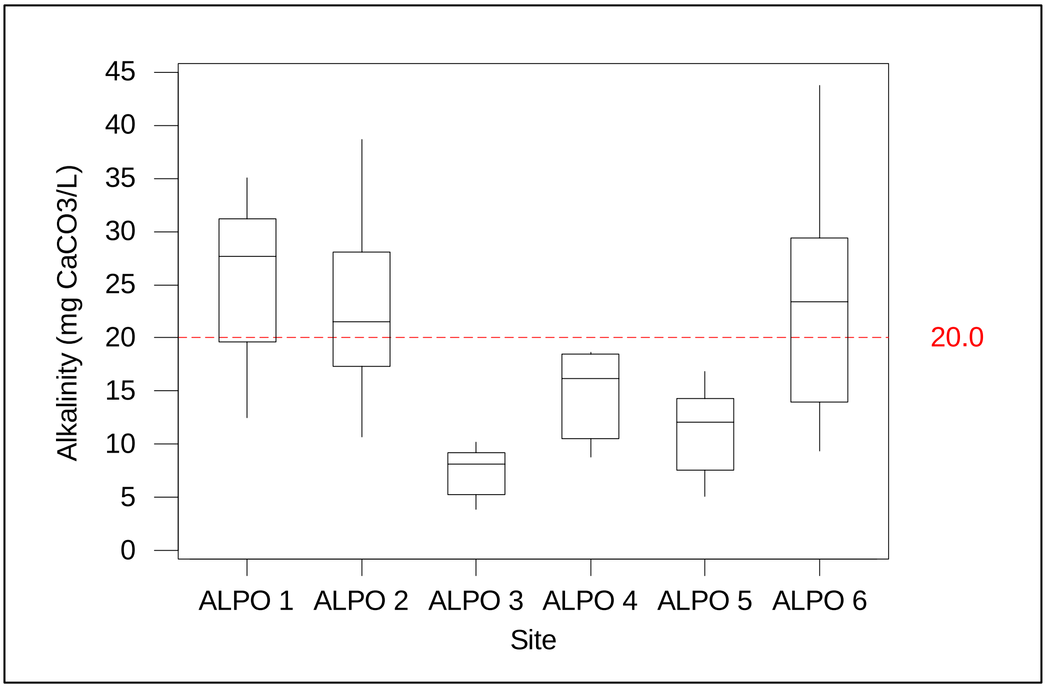

Figure 5. Alkalinity statistical boxplot for water quality samples collected at Allegheny Portage Railroad National Historic Site sampling stations during the Level 1 water quality inventory. The "box" represents median and 1st (Q1) and 3rd quartiles (Q3). The "whiskers" represent the highest and lowest value within the upper and lower limits respectively, calculated as upper limit = Q3 + 1.5(Q3-Q1) and lower limit = Q1-1.5(Q3-Q1). The red, dashed line at alkalinity = 20 mg/L represents the PA DEP's freshwater aquatic life standard (2003).

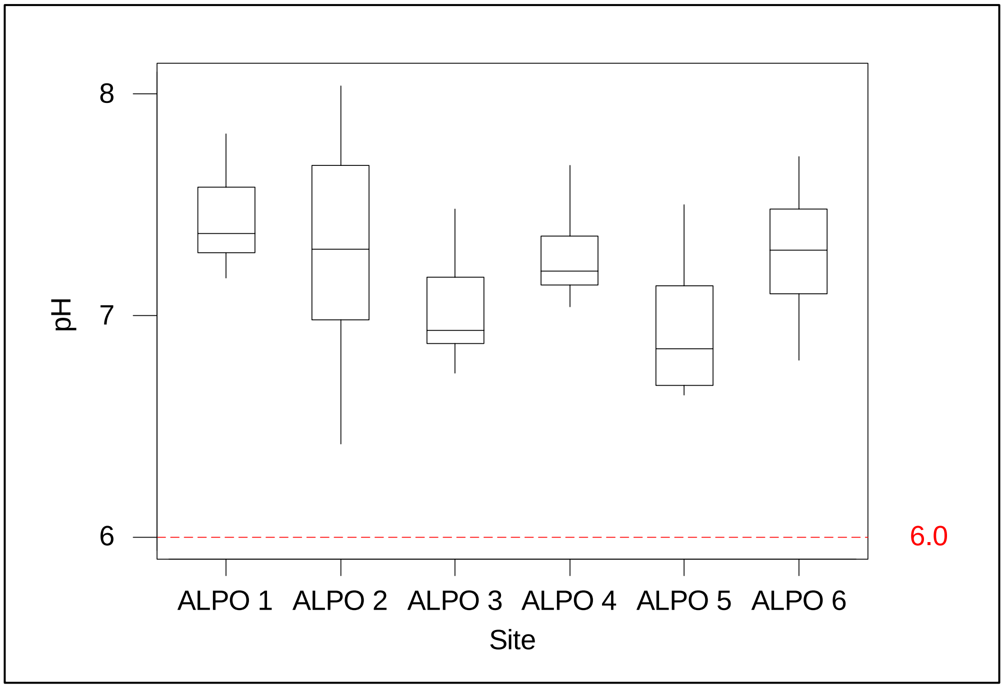

Figure 6. pH statistical boxplot for water quality samples collected at Allegheny Portage Railroad National Historic Site sampling stations during the Level 1 water quality inventory. The "box" represents median and 1st (Q1) and 3rd quartiles (Q3). The "whiskers" represent the highest and lowest value within the upper and lower limits respectively, calculated as upper limit = Q3 + 1.5(Q3-Q1) and lower limit = Q1-1.5(Q3-Q1). The red, dashed line at pH = 6.0 represents the PA DEP's lower limit freshwater aquatic life standard (2003).

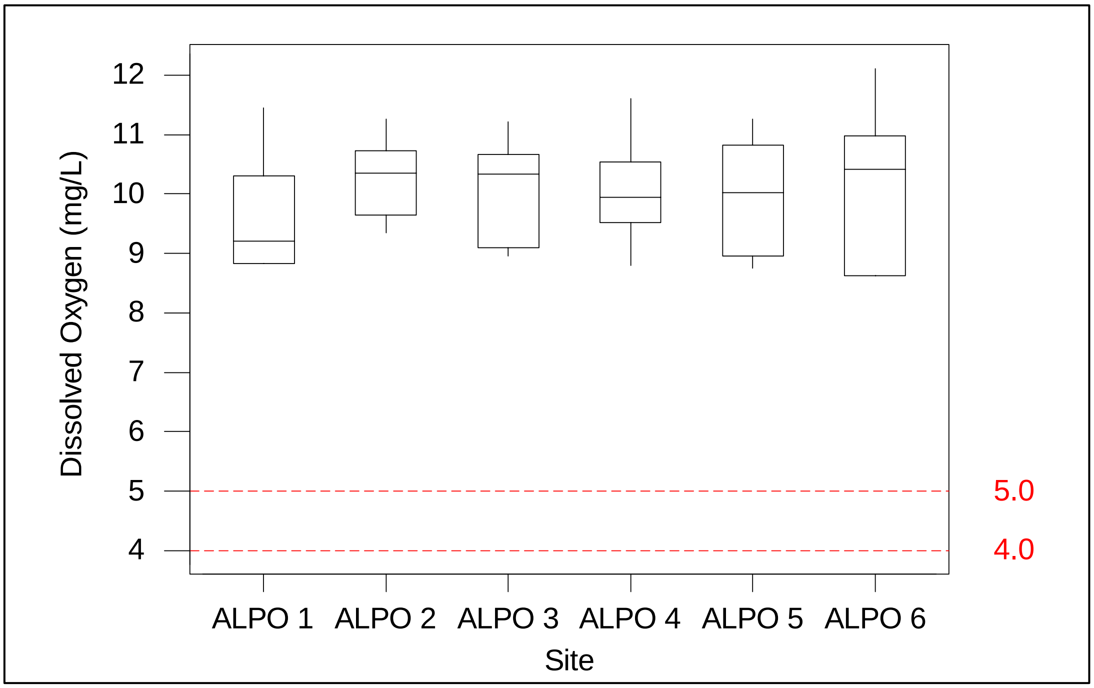

Figure 7. Dissolved oxygen concentration statistical boxplot for water quality samples collected at Allegheny Portage Railroad National Historic Site sampling stations during the Level 1 water quality inventory. The "box" represents median and 1st (Q1) and 3rd quartiles (Q3). The "whiskers" represent the highest and lowest value within the upper and lower limits respectively, calculated as upper limit = Q3 + 1.5(Q3-Q1) and lower limit = Q1-1.5(Q3-Q1). The red, dashed line at dissolved oxygen = 4.0 represents the PA DEP's aquatic life criteria for trout stocking (August 1 – February 14). The red, dashed line at dissolved oxygen = 5.0 represents the PA DEP's aquatic life criteria for cold water fishes and trout stocking (February 15 – July 31).

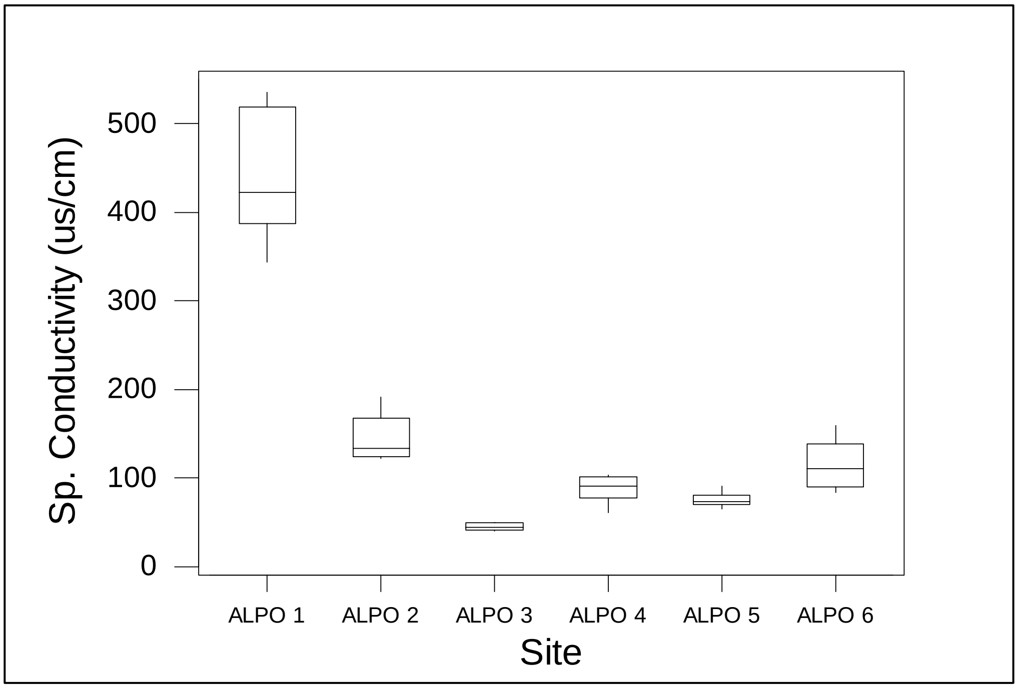

Figure 8. Specific conductivity statistical boxplot for water quality samples collected at Allegheny Portage Railroad National Historic Site sampling stations during the Level 1 water quality inventory. The "box" represents median and 1st (Q1) and 3rd quartiles (Q3). The "whiskers" represent the highest and lowest value within the upper and lower limits respectively, calculated as upper limit = Q3 + 1.5(Q3-Q1) and lower limit = Q1-1.5(Q3-Q1).

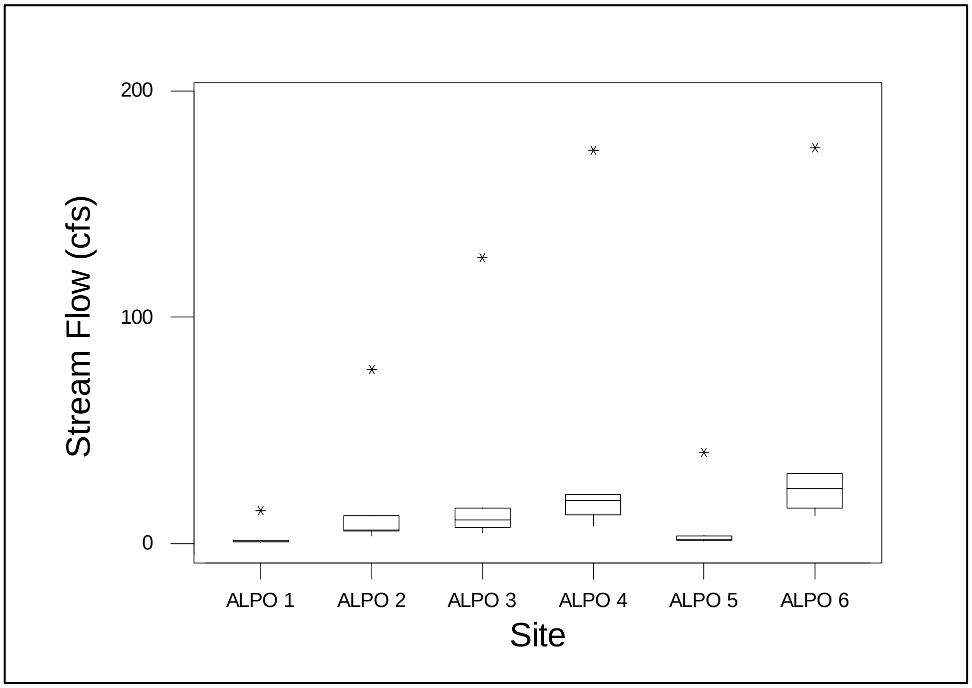

Figure 9. Streamflow boxplot for water quality samples collected at Allegheny Portage Railroad National Historic Site sampling stations. The "box" represents median and 1st (Q1) and 3rd quartiles (Q3). The "whiskers" represent the highest and lowest value within the upper and lower limits respectively, calculated as upper limit = Q3 + 1.5(Q3-Q1) and lower limit = Q1-1.5(Q3-Q1). Outliers are represented by an asterisk (*).

Table 8. Temperature data collected at Allegheny Portage Railroad National Historic Site sampling stations during the Level 1 water quality inventory. The temperature data are presented with the PA DEP's corresponding aquatic life criteria. Samples violating their respective criteria are in bold.

Sample Date	Sample Station	Sample Value	Corresponding Criteria
04/15/2004	ALPO 1	7.7	8.9
	ALPO 2	7.7	8.9
	ALPO 3	6.4	8.9
	ALPO 4	7.6	8.9
	ALPO 5	7.6	11.1
	ALPO 6	6.5	11.1
05/06/2004	**ALPO 1**	**12.5**	**12.2**
	ALPO 2	11.6	12.2
	ALPO 3	**12.6**	**12.2**
	ALPO 4	11.6	12.2
	ALPO 5	10.2	17.8
	ALPO 6	10.3	17.8
06/17/2004	ALPO 1	16.9	17.8
	ALPO 2	13.9	17.8
	ALPO 3	**18.4**	**17.8**
	ALPO 4	16.5	17.8
	ALPO 5	15.6	22.2
	ALPO 6	19.2	22.2
08/02/2004	ALPO 1	17.4	18.9
	ALPO 2	15.7	18.9
	ALPO 3	**19.1**	**18.9**
	ALPO 4	17.2	18.9
	ALPO 5	16.3	26.7
	ALPO 6	19.6	26.7
09/02/2004	ALPO 1	15.6	17.8
	ALPO 2	14.6	17.8
	ALPO 3	**18.1**	**17.8**
	ALPO 4	16.9	17.8
	ALPO 5	15.6	28.9
	ALPO 6	17.4	28.9
10/21/2004	ALPO 1	9.3	10.0
	ALPO 2	9.6	10.0
	ALPO 3	9.8	10.0
	ALPO 4	9.7	10.0
	ALPO 5	10.0	18.9
	ALPO 6	10.6	18.9
11/16/2004	**ALPO 1**	**6.1**	**5.6**
	ALPO 2	**7.9**	**5.6**
	ALPO 3	**6.6**	**5.6**
	ALPO 4	**7.3**	**5.6**
	ALPO 5	7.2	10.0
	ALPO 6	5.8	10.0

DO concentrations (Figure 7) in the BGR watershed were found to be well above the PADEP water quality criteria for CWF and TSF. BGR and its tributaries can generally be described as high gradient, forested streams. In watersheds of this type, mechanical reaeration rates and oxygen saturation concentrations are optimal for aquatic health. Therefore, DO levels are likely to remain well above the established thresholds for CWF and TSF streams, assuming that land use patterns remain constant. Changes in land use (principally, conversion of forest to agricultural land, or development) and/or addition of municipal point source discharges commonly lead to increased nutrient fluxes. Excess nutrient flux, or eutrophication, is the leading cause of DO depletion in aquatic systems.

Specific conductivity (Figure 8) was generally low at ALPO stations 2–6, while measurements at ALPO-1 were high in comparison to levels detected at the other ALPO sites. Potential causes of these high conductivity measurements included the station's proximity to the road (road salt application will elevate conductivity levels), potential headwater acid mine drainage seeps, and soil mineral and metals leaching caused by acidic precipitation.

With respect to stream discharge measurement at the ALPO sites (Figure 9), several points deserve mention. Flow measured at ALPO-1 reached a minimum of 0.21 cfs on September 2. As mentioned in the discussion above, precipitation was approximately 60% greater than normal during the period of data collection. Given this information, it is possible that BGR at ALPO-1 is typically an intermittent stream that dries for portions of the year. Secondly, the discharge measurements support the assertion that BGR is a gradually gaining stream (i.e. gradually gaining discharge from groundwater and tributaries as the streamflows from the headwaters to the mouth). While this information does not play a significant role for interpretation of water quality data collected at ALPO, large increases or decreases in streamflow can indicate the presence of springs or sinks, which can substantially alter stream chemistry.

With the exception of ALPO-3, stream temperatures (Table 8) were generally acceptable for the designated uses of the streams in the BGR watershed. Violations in PADEP temperature criteria occurred at ALPO sites 1, 2, 3, and 4, with violations at ALPO-3 being the most frequent and severe. Water temperature at ALPO-3 exceeded CWF criteria during five of the seven sampling events. It is likely that the elevated temperatures at this site were due to the site's location, immediately downstream of the Hollidaysburg drinking water reservoir. The reservoir discharges water warmed by solar radiation to Blair Run via surface spillway. Potential solutions to the problem include installation of a subsurface reservoir discharge system, or by promoting/permitting shoreline canopy growth, thereby decreasing solar radiation input. The violations in CWF temperature criteria witnessed at ALPO-1 were within 0.5°C (32.9°F) of the established criteria, and should not be considered significant without the collection of additional data. ALPO stations 2 and 4 violated CWF temperature criteria on November 16. These violations may have been caused by a variety of climatic factors including solar radiation intensity on the day of measurement, time of day that measurements were made, etc. Additional temperature data collection and analysis would be required to determine whether the temperature of BGR headwaters is a threat to aquatic biological communities.

In addition to the required core water quality parameters discussed above, detectable levels of the following water quality parameters were identified at ALPO water quality sampling locations: nitrate-nitrogen (NO_3-N), sulfate (SO_4), total phosphorus (TP), aluminum (Al), barium (Ba), calcium (Ca), iron (Fe), magnesium (Mg), manganese (Mn), potassium (K), sodium (Na), strontium (Sr), zinc (Zn), fecal coliform bacteria, and turbidity. The figures presented in Appendix A illustrate the statistical median, quartile, and range of values measured for each of these parameters measured at the ALPO water quality sampling stations. A review of the figures presented in Appendix A indicates that water quality is generally good at stations sampled within the ALPO property. However, there are a few trends illustrated in this series of plots that deserve mention.

With respect to in-stream nutrients, Pennsylvania streams with median phosphorus concentrations exceeding 0.07 mg/L are at risk of biological impairment due to eutrophication (Sheeder and Evans 2004). Median concentrations of phosphorus at all ALPO stations were below their respective thresholds. There is no established sulfate water quality criterion for protection of aquatic life (250 mg/L is the sulfate criteria for public water supplies). Therefore, sulfate levels detected at ALPO sites cannot be used to identify risk or impairment in the aquatic biological communities. However, the sulfate data collected indicated that concentrations at ALPO-1 were approximately twice that of the other stations. High headwater sulfate concentrations may indicate that atmospheric deposition of sulfur compounds and other chemicals may be adversely affecting portions of the BGR watershed. Alternatively, the high sulfate concentrations may indicate presence of headwater acid mine drainage. Additional data collection and a detailed headwater survey is required if identification of the source(s) of sulfates is a priority for the NPS.

A trend similar to sulfate concentrations is apparent when Al, Ba, Ca, Mg, Mn, K, Na, Sr, and Zn statistical plots are examined (Appendix A). With each of these chemical constituents, median concentrations were greatest at ALPO-1. With respect to Al, in-stream concentrations present in several ALPO-1 water samples were in excess of the established CCC threshold, though none of the samples contained Al concentrations exceeding the CMC (USEPA 2002). The elevated concentrations of these nine constituents at ALPO-1 indicated that the upper reaches of BGR are being adversely affected by several potential pollution sources.

The ridgetop location of ALPO-1 places this site at greater risk of acid precipitation and atmospheric deposition, relative to the other sampling locations. The Appalachian Plateau receives some of the highest levels of acidic precipitation and atmospheric deposition in the continental United States (Lynch et al. 2005). The low pH and high sulfate and nitrogen concentration rainwater of this region stems primarily from fossil fuel combustion power plants located in western Pennsylvania and mid-western states. The adverse effects of acidic precipitation may be compounded in this particular watershed by the lack of a buffering geologic substrate. The BGR watershed is underlain by formations of sandstone, shale, and interbedded sedimentary rock, all of which exhibit low acid buffering capacity (Shultz 1999). Therefore, precipitation and stream discharge waters are buffered by calcium and other ions in the soil. Based upon the calcium plot of the ALPO data, it appears that calcium, and by extension, buffering capacity, is being leached from the surrounding soils. If acid precipitation is reducing the buffering capacity of this watershed, the stream will eventually lose its ability to buffer acidic inputs and may become chronically acidified. Acid neutralizing capacity (ANC) of this site was not analyzed during this study. While calculations based upon ion concentrations can provide a rough estimate of ANC, the calculations are unreliable in the presence of certain metals detected at this site. Therefore, although ANC was not calculated as part of this study, measurement of this constituent in the future could provide useful information regarding the effect acid precipitation and/or acid mine drainage is having on BGR.

Historical land use in the vicinity of the BGR headwaters included surface and subsurface mining activities. Personal communication with the ALPO and JOFL natural resource specialist (Kathy Penrod) suggested that there are multiple, undocumented acidic seeps in the headwater region of this watershed. Though these seeps are not introducing quantities of mine drainage pollutants severe enough to create an inhospitable environment for brook trout and other organisms (as discussed in the following section), the extent to which mine drainage is affecting the BGR headwaters is unclear at this time. Additional research regarding sources of acidity and metals at the headwaters of BGR is warranted by these data.

Finally, the proximity of ALPO-1 to a divided, well-traveled road (State Route 3012) located approximately 100 m (328 ft) up-slope from the sampling location may be having adverse effects on water quality. This road is very well traveled and is heavily salted in the winter; thus, it may be the source of a variety of automobile-related pollutants including sulfate, zinc, and sodium, among others.

Fecal coliform bacteria levels at the ALPO stations exhibited a trend opposite to those of the other laboratory-tested chemicals discussed above. Although concentrations at all stations were relatively low, the concentrations were greatest at downstream stations. This was not surprising, given that the majority of development in the watershed has occurred downstream of ALPO-4. The elevated fecal coliform concentrations measured at ALPO stations 5 and 6 were likely the result of agricultural operations and septic systems present in the downstream portions of the watershed.

Aquatic Macroinvertebrate Inventory

Fifty-nine benthic taxa were found throughout ALPO property. All but one taxa (two-lined salamander [*Eurycea bislineata*]) collected from the BGR watershed were MI (Table 9). Taxa richness of MI communities generally increased from upstream to downstream sampling locations, but the downstream-most site (ALPO-6) had fewer MI taxa than the next site upstream on the BGR mainstem (ALPO-4). Blair Run (ALPO-3) and the unnamed tributary to BGR (ALPO-5) both had more MI taxa, 32 and 33 respectively, than any sites on the BGR mainstem. These data are in agreement with the River Continuum Concept (RCC) proposed by Vannote et al. (1980).

Relatively few organisms inhabit headwaters according to the RCC. But progressing downstream, increasing habitat variability typically provides additional niche spaces for other taxa to occupy; therefore, taxa richness is often greatest at intermediate zones along the stream course (e.g., ALPO-4 and -5). Progressing farther downstream, habitat variability decreases and interspecific competition often leads to a reduction of taxa richness (e.g., ALPO-6). Following that logic, the Hollidaysburg Reservoir on Blair Run likely alters abiotic conditions (e.g., alkalinity) to the extent that relatively few taxa (18) exist just downstream of the reservoir (ALPO-3). Blair Run and Adams Run historically joined to make a third-order stream where the reservoir is now situated. If the reservoir were not there, it is likely that the structure and

Table 9. Summary of macroinvertebrate taxa by sampling location inventoried at Allegheny Portage Railroad National Historic Site on January 12, 2005.

			ALPO Station					
			1	2	3	4	5	6
		Total taxa	15	27	18	32	33	28
		Total individuals	65	309	276	322	777	249
Order	Family	Genus						
Anisoptera	Aeshnidae	*Boyeria*			1			
Coleoptera	Elmidae	*Microcylloepus*						1
	Psehenidae	*Ectopria*					2	
Decapoda	Cambaridae	*Cambarus bartonii,b.*					1	
Diptera	Athericidae	*Atherix*						1
	Chironomidae	*Chironomidae*	11	30	50	32	55	30
	Simulidae	*Prosimulium*		5		6	10	2
	Tabanidae	*Chrysops*					3	
	Tipulidae	*Brachypremna*					2	
		Dicranota					3	
		Hexatoma		7	1	2	2	1
		Limnophila	1			1		
		Molophilus	2					
		Tipula	1			1		1
Ephemeroptera	Baetidae	*Baetis*						2
		Centroptilium		23	7	8	28	
	Ephemerellidae	*Ephemerella*		7	15	8	31	18
		Eurylophella				1	2	
	Ephemeridae	*Ephemera*					1	
	Heptageniidae	*Epeorus*	1	114	34	119	255	6
		Stenonema		10	92	27	35	14
	Isonychiidae	*Isonychia*		1		1		7
	Leptophlebiidae	*Leptophlebiidae*						1
		Paraleptophlebia		25	9	8	43	
	Siphlonuridae	*Ameletus*	9	6		5	26	1
Megaloptera	Corydalidae	*Nigronia*			1		2	
Oligochaeta	Lumbricina	*Oligochaeta*	2			9		4
Plecoptera	Capniidae	*Allocapnia*	15	1				10
		Paracapnia		10		6	22	
	Chloroperlidae	*Shipsa*		7		9		
		Suwallia						1
		Sweltsa	1	7		10	2	
	Leuctridae	*Leuctra*		6		3	11	
	Nemouridae	*Nemoura*					2	19
		Soyedina	4					
		Strophopteryx			5			22
	Peltoperlidae	*Peltoperla*		1		4		
	Perlidae	*Acroneuria*		1	25	7	7	1
		Beloneuria				2		
	Perlodidae	*Clioperla*					2	
		Diura				1		
		Isoperla		1			22	
	Pteronarcyidae	*Pteronarcys*		11		7		
	Taeniopterygidae	*Taeniopteryx*		4	1	1	2	71
Trichoptera	Glossosomatidae	*Glossosoma*						1
	Hydropsychidae	*Cheumatopsyche*					5	1
		Diplectrona	6	4	15	15	148	12
		Hydropsyche	8	15	12	12	10	16
	Lepidostomatidae	*Lepidostoma*		1		1		
	Limnephilidae	*Hydatophylax*	1	1				
		Pseudostenophylax					2	
		Pycnopsyche	2			6	1	

Table 9. Summary of macroinvertebrate taxa by sampling location inventoried at Allegheny Portage Railroad National Historic Site on January 12, 2005 (continued).

			ALPO Station					
			1	2	3	4	5	6
Order	Family	Genus						
Trichoptera (cont)	Philopotamidae	*Chimarra*				1		1
		Dolophiloides		1	2	3	13	1
	Polycentropidae	*Polycentropus*			1			
	Rhyachphilidae	*Rhya cophila*	1	3	1	5	8	3
	Uenoidae	*Neophylax*		7	4	1	19	1
Amphibia	Plethodontidae	*Eurycea bislineata*					1	

composition of the MI community present at ALPO-3 would be more similar to that of a third-order (e.g., ALPO-4) than a first-order stream (e.g., ALPO-1).

Impaired and reference streams for the MBII were identified by Klemm et al. (2003) using water chemistry, qualitative habitat, and minimum organism count criteria. Impaired reaches were defined by meeting any one of the following criteria: pH < 5, chloride > 1000 µeq/L, sulfate > 1000 µg/L, total phosphorous > 100 µg/L, total nitrogen > 5000 µg/L, or a mean qualitative habitat score < 10. Reference reaches met all of the following criteria (Klemm et al. 2003): sulfate < 400 µg/L, acid neutralizing capacity (ANC) > 50 µeq/L, chloride < 100 µeq/L, total phosphorous < 20 µg/L, total nitrogen < 750 µg/L, mean qualitative habitat score > 15 (of a possible 20), and at least 150 organisms. Two stations surveyed (ALPO-1, ALPO-3) were classified as impaired based on MBII values (Figure 10). In contrast to the impaired sites (ALPO-1, -3) that had few individuals and/or few taxa, the remaining sites were diverse and well-represented by pollution-intolerant taxa; thus, those sites did not appear to be impaired according to the MBII.

Only 65 individuals were collected at ALPO-1 disqualifying it as a reference site according to the standards of Klemm et al. (2003), which in combination with the low observed MBII score (39.9) suggested impairment at that site (Tables 9 and 10). More individuals were collected at ALPO-3 (276) than at ALPO-1, but taxa richness was only slightly greater (18) at that site. Only five mayfly genera and three stonefly genera were found at ALPO-3. Communities dominated by relatively few taxa are indicative of relatively homogenous, often impaired environments where organisms well suited to those conditions have competitive advantages. Two taxa (Chironomidae, [*Stenonema* sp.]) comprised 51% of the individuals captured at ALPO-3; moreover, 78.5% of all organisms were from five dominant taxa. Although ALPO-2 (which was not identified as impaired) and ALPO-3 were similar in size and very close to each other in the watershed, the Hollidaysburg Reservoir just upstream of ALPO-3 probably caused the observed specific conductivity (µs/cm) difference between ALPO-3 (45.3 $\pm$ 3.4; mean $\pm$ SD) and ALPO-2 (147.5 $\pm$ 26.9). Low specific conductivity is generally indicative of low productivity habitats typical of headwater streams; thus, the reservoir just upstream of ALPO-3 has likely caused downstream habitat to be similar to a low-conductivity, first-order stream with relatively few MI taxa. Blair Run is a third-order stream, but the MI community exhibited characteristics of a first-order stream due to the upstream reservoir; consequently, although not "polluted" per say, the MI community at ALPO-3 is nonetheless impaired because it is likely different than it would be in absence of the upstream reservoir.

Metrics typically used by the Pennsylvania Department of Environmental Protection (PADEP) (Table 11) to assess stream condition are similar to those used for the MBII and provided similar results as the MBII. All three richness metrics (taxa, modified EPT, modified % Ephemeroptera), that were expected to decrease with increasing perturbation, were lower at ALPO-1 and -3 which suggested impairment. According to the Hilsenhoff Family-Level Biotic Index (HBI) (Hilsenhoff 1987), all sites were characterized as having excellent water quality (i.e., HBI score $\leq$ 3.75) with regard to organic pollution; however, both ALPO-1 and -3 had greater HBI scores than the remaining sites, which again, suggested potential impairment relative to the other ALPO sites.

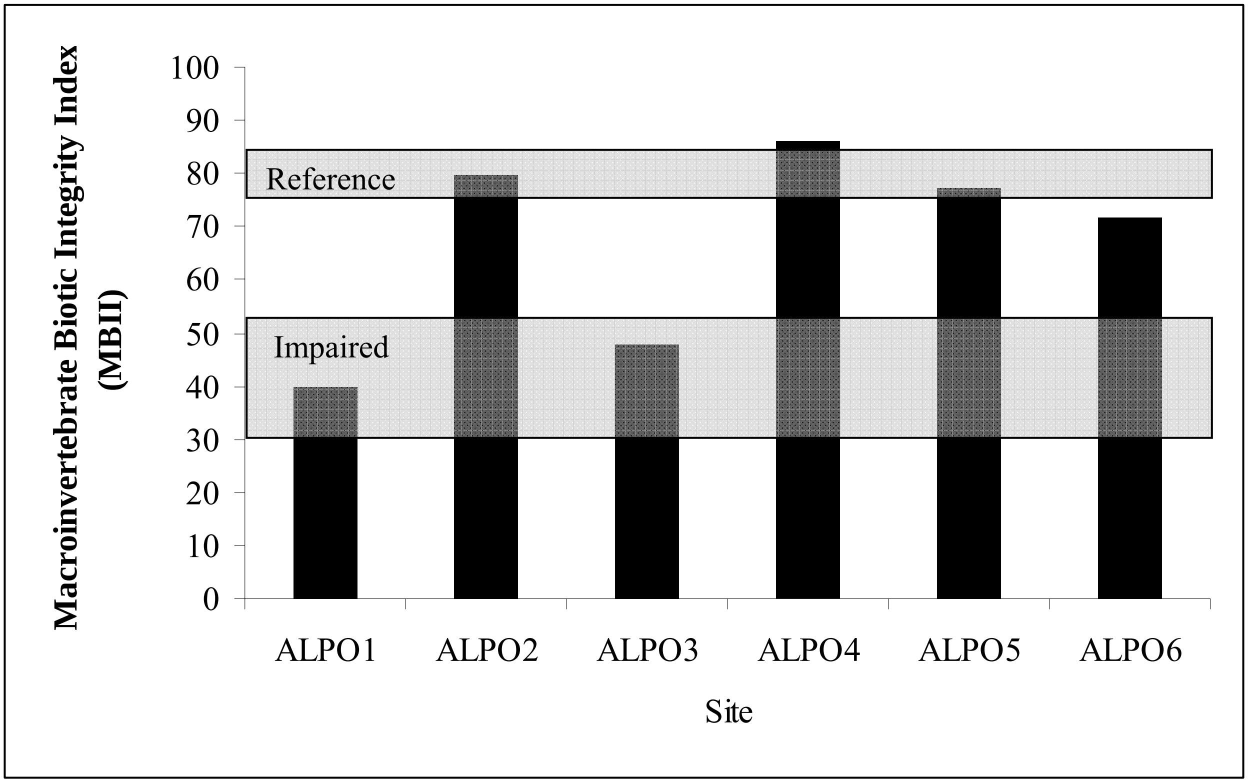

Figure 10. Macroinvertebrate Biotic Integrity Index (MBII) scores for stations surveyed in Allegheny Portage Railroad National Historic Site on January 12, 2005. Shaded areas represent middle interquartile range (25–75 %) of MBII values reported for reference and impaired streams in uplands of the Mid-Atlantic Highlands Region.

Table 10. Summary of Macroinvertebrate Biotic Integrity Index (MBII) scores and individual metrics used to calculate the MBII for samples collected on January 12, 2005 throughout Allegheny Portage Railroad National Historic Site.

Index or Metric	ALPO1	ALPO2	ALPO3	ALPO4	ALPO5	ALPO6
MBII Score	39.92	79.63	47.70	86.04	77.39	71.81
Epehemeroptera Richness	2	7	5	8	8	7
Plecoptera Richness	3	10	3	10	8	6
Trichoptera Richness	5	7	6	8	8	8
Collector/filterer Richness	5	10	7	13	12	14
% noninsect Taxa	3.1	0.0	0.0	2.8	0.3	1.6
Macroinvertebrate Tolerance Index (MTI)	3.57	3.50	3.83	3.73	3.57	3.49
% 5 dominant Taxa	75.4	67.0	78.3	63.7	69.0	64.3

Table 11. Aquatic macroinvertebrate metrics typically used for stream assessments by the Pennsylvania Department of Environmental Protection (PADEP) and metric scores for samples collected on January 12, 2005 throughout Allegheny Portage Railroad National Historic Site.

Metric	ALPO1	ALPO2	ALPO3	ALPO4	ALPO5	ALPO6
Taxa Richness	15	27	18	32	33	28
Modified (Pollution Tolerance Value < 4) Ephemeroptera, Plecoptera, and Trichoptera (EPT) Richness	8	21	11	21	20	15
Modified % Ephemeroptera (Pollution Tolerance Value < 4)	13	26	28	25	24	21
% Dominant Taxon	23	37	18	37	33	29
Hilsenhoff Family-Level Biotic Index (HBI)	3.65	3.13	3.48	3.19	3.35	2.90

Fish Species Inventory

The nine fish species found throughout BGR and its surveyed tributaries (Table 12) were typical of cool- and coldwater fish communities of the Susquehanna River drainage: no state or federally endangered species were captured and brown trout (*Salmo trutta*) was the only nonnative species captured from any location. The greatest number of species (7) was captured at ALPO-4 and formed a typical coolwater community, whereas, only brook trout (*Salvelinus fontinalis*) were found at ALPO-1 (Table 13). This pattern was expected because stream fish communities usually have few species in headwaters with additional species entering the community progressing downstream. The downstream-most station (ALPO-6) likely supports all of the species (except possibly brook trout) captured in upstream sections, but some species were not captured there. Likelihood of capture varies among fishes and habitat types; consequently, the relatively large size of BGR at ALPO-6 made capturing fishes difficult compared to upstream, smaller sampling reaches. Additional sampling at ALPO-6 with a larger crew would likely result in capture of all fishes captured upstream with the likely exception of brook trout.

Given the location of ALPO in the Susquehanna River drainage, and available habitat throughout the property, it is probable that additional fish species seasonally occur in the park. For example, smallmouth bass (*Micropterus dolomieui*), rock bass (*Ambloplites rupestris*), and redbreast sunfish (*Lepomis auritus*) are warmwater fishes that may move upstream to ALPO reaches of BGR during the summer months when water temperatures are relatively warm.

Benthic fishes are less susceptible to capture with electrofishing gear than those that inhabit upper portions of the water column. Benthic fishes that possibly occur in ALPO that were not captured include margined madtom (*Noturus insignis*), shield darter (*Percina peltata*), and tessellated darter (*Etheostoma olmstedi*). Other fishes that may inhabit ALPO waters that were not captured include river chub (*Nocomis micropogon*), common shiner (*Luxilus cornutus*), rosyface shiner (*Notropis rubellus*), bluntnose minnow (*Pimephales notatus*), fallfish (*Semotilus corporalis*), and creek chub (*Semotilus atromaculatus*).

Brown trout and brook trout are similarly susceptible to electrofishing gear (Reynolds 1996); consequently, considering available habitat and that brown trout were captured at ALPO-6 and brook trout were not, brown trout was likely the only salmonid species in the downstream-most reaches of ALPO waters. Conversely, brook trout and not brown trout were found in BGR headwaters. The scope of this survey did not address the upstream and downstream limits of these two trout species, but brown trout was probably limited in upstream distribution by stocking location, barriers to upstream movement, and potentially intolerable conditions. Brook trout downstream distribution was likely dictated by a synergy of water quality characteristics (e.g., temperature, pH) and possible competition with brown trout (Fausch and White 1981). At some point in BGR chemical and physical characteristics likely favor brown trout to the extent that brook trout are out-competed for necessary resources (e.g., feeding locations).

Adams Run and Blair Run are tributaries to BGR upstream of the Hollidaysburg Reservoir and are both classified by the Pennsylvania Fish and Boat Commission (PAFBC) as “Stream Sections that Support Natural Reproduction of Trout” (PAFBC 2005a). Trout smaller than 17.8 cm (7”) can be presumed wild-spawned in most Pennsylvania streams, and although no fishes were measured during this survey, obviously wild-spawned brown trout were found at all

Table 12. Fish species captured at Allegheny Portage Railroad National Historic Site on November 16, 2004.

Common name	Family	Species
White sucker	Catostomidae	*Catostomus commersonii*
Northern hog sucker	Catostomidae	*Hypentelium nigricans*
Mottled sculpin	Cottidae	*Cottus bairdii*
Blacknose dace	Cyprinidae	*Rhinichthys atratulus*
Central stoneroller	Cyprinidae	*Campostoma anomalum*
Cutlips minnow	Cyprinidae	*Exoglossum maxillingua*
Longnose dace	Cyprinidae	*Rhinichthys cataractae*
Brook trout	Salmonidae	*Salvelinus fontinalis*
Brown trout	Salmonidae	*Salmo trutta*

Table 13. Summary of sampling location, common name, and number of fishes captured at Allegheny Portage Railroad National Historic Site on November 16, 2004.

Station	Common name	Number Captured
ALPO-1	Brook trout	7
ALPO-2	Mottled sculpin	36
	Blacknose dace	7
	Brown trout	7
	Brook trout	13
ALPO-3	White sucker	1
	Mottled sculpin	3
	Blacknose dace	1
	Brown trout	3
	Brook trout	12
ALPO-4	White sucker	4
	Mottled sculpin	8
	Cutlips minnow	3
	Blacknose dace	4
	Longnose dace	1
	Brown trout	21
	Brook trout	4
ALPO-5	Blacknose dace	12
	Brown trout	15
	Brook trout	16
ALPO-6	Northern hog sucker	1
	Central stoneroller	3
	Cutlips minnow	1
	Blacknose dace	25
	Longnose dace	4
	Brown trout	7

stations except for the upstream-most station (ALPO-1); conversely, wild-spawned brook trout were found at all but the downstream-most station (ALPO-6). The PAFBC manages BGR as an "Approved Trout Water;" consequently, PAFBC annually stocks legally harvestable (≥ 17.8 cm; 7") brown and/or brook trout in BGR to provide recreational fishing opportunity (PAFBC 2005b). Trout stocking in BGR occurs in the downstream reaches of the watershed below the reservoirs (NPS, Kathy Penrod, Natural Resource Specialist, pers. comm., June 2005). It is very unlikely that juvenile trout made it past the reservoirs within the watershed and migrated throughout BGR; therefore, BGR appears to support natural trout reproduction from ALPO-1 to ALPO-6, which is in contradiction to PAFBC published information (i.e., BGR is not listed as a "Stream Section that Supports Natural Reproduction of Trout" [PAFBCa 2005]). Similarly, both wild brook trout and wild brown trout were captured from the unnamed tributary to BGR (ALPO-5), although it does not have any PAFBC-management designation. Naturally reproducing trout populations, particularly brook trout, are indicative of relatively cold, "clean" streams in Pennsylvania. Although this survey did not investigate the productivity of BGR as a potential wild trout fishery, the apparent occurrence of trout natural reproduction suggests good water quality in BGR.

The brook trout is the Pennsylvania state fish and is native to the Commonwealth and much of northeastern North America (Behnke 2002). Although abundant in Pennsylvania compared to southern populations, the brook trout has declined throughout much of its native range due to human land uses (e.g., mining, deforestation), pollution (e.g., acid mine drainage), susceptibility to fishing pressure, and introduction of rainbow trout (*Oncorhynchus mykiss*) and brown trout (Behnke 2002). The brown trout is a European native and thought to be a superior competitor to brook trout in conditions suitable to both (Fausch and White 1981); consequently, brook trout are typically restricted to cold and relatively acidic Pennsylvania headwater streams where conditions do not favor brown trout (e.g., ALPO-1 to ALPO-5).

Some national parks (e.g., Great Smokey Mountains National Park) are eradicating nonnative salmonids to reclaim streams for native species (Kulp and Moore 2000), but such an effort would be improbable if not impossible in ALPO waters. Potential options for removing fishes from streams include physical removal (e.g., electrofishing) or use of piscicides (e.g., rotenone, antimycin). Due to the size of BGR, limited ownership by the NPS, connectivity of stream systems, and the current lack of public support, physically removing brown trout from the watershed is probably impossible. Using piscicides in the watershed is an unrealistic strategy given the water-supply reservoirs present. Other, more passive strategies to ensure brook trout preservation in BGR include ending trout stocking in the watershed and implementing regulations that limit trout harvest (e.g., catch and release of brook trout) and/or useable gear types that limit brook trout mortality (e.g., artificial lures only). Such regulation changes would likely require extensive communication and cooperation with the public and PAFBC; however, given the relative abundance of small (< 7") trout found throughout BGR during this survey, it appears that the watershed could provide a valuable wild trout fishery.

Johnstown Flood National Memorial (JOFL)

Water Quality

Figures 11 through 15 and Table 14 illustrate the statistical median, quartile, and range of values measured for alkalinity and each of the core water quality parameters measured at the JOFL sampling stations (n = 7 sampling occasions). The expanded suite of water quality data collected at the JOFL sites are presented in tabular and graphical form in Appendix B.

DO concentrations (Figure 11) were high at all JOFL sites, in many cases approaching the temperature compensated saturation levels. In all samples analyzed, DO concentrations were well above the PADEP's 5.0 mg/L water quality standard for CWF-designated streams.

Stream discharge measurements recorded at JOFL sites (Figure 12) suggested that the SF-LCR is neither significantly gaining nor losing baseflow as the river winds through park property. The slight increase in SF-LCR discharge between JOFL-1 and JOFL-5 is generated via input from the three tributaries represented by JOFL sites 2, 3, and 4. There are several important points to consider when examining the JOFL discharge data. First, the April 13, 2004 discharge was not measured at JOFL-1 and JOFL-5 sites due to dangerous, high water conditions. Therefore, median, quartile, and limit values calculated for these sites are artificially low relative to sites 2, 3, and 4, at which discharge was recorded during all sampling events. Secondly, JOFL-3 is located on the smallest of the three tributaries flowing through park property. During the study period minimum flows at this site reached 0.14 cfs. As mentioned previously, precipitation during the study period was approximately 60% above normal. Based on this information, it is possible that this tributary may dry up during prolonged periods of drought.

Violations in the PADEP CWF temperature criteria (Table 14) were recorded at every JOFL water quality monitoring site. In-stream temperature violated the CWF standard once at stations 2 and 3, twice at station 2 and 4, and four times at station 5. While exact causes of these violations are unknown, thermal pollution of surface waters is often caused by lack of a shading tree canopy, upstream impoundments (there are several lakes/ponds upstream of the JOFL on SF-LCR), and impervious surfaces within the watershed (pavement warms precipitation, and promotes runoff). Alternatively, the CWF designation of streams flowing through JOFL, particularly SF-LCR, may be inappropriate. Without significant groundwater input it is unlikely that a stream the size of the SF-LCR would be able to sustain cold water conditions throughout the summer months. A detailed survey of thermal conditions, invertebrate communities, sources of groundwater, reservoir retention time, etcetera, in the watershed upstream of JOFL would help determine whether the CWF designation is appropriate for the SF-LCR. However, given the other SF-LCR impairments discussed in the following paragraphs, this type of investigation should not be considered a priority.

When the plots of alkalinity (Figure 13), pH (Figure 14), specific conductivity (Figure 15), and many of the expanded suite of water quality parameters (Appendix 2) are examined, a clear dichotomy in water quality condition between the SF-LCR sites (JOFL-1, JOFL-5) and the tributary sites (JOFL-2, JOFL-3, JOFL-4) becomes evident. Therefore, results from and discussion of JOFL sites 1 and 5 (i.e., sampling points on SF-LCR) are addressed separately from JOFL sites 2, 3, and 4 in the following paragraphs.

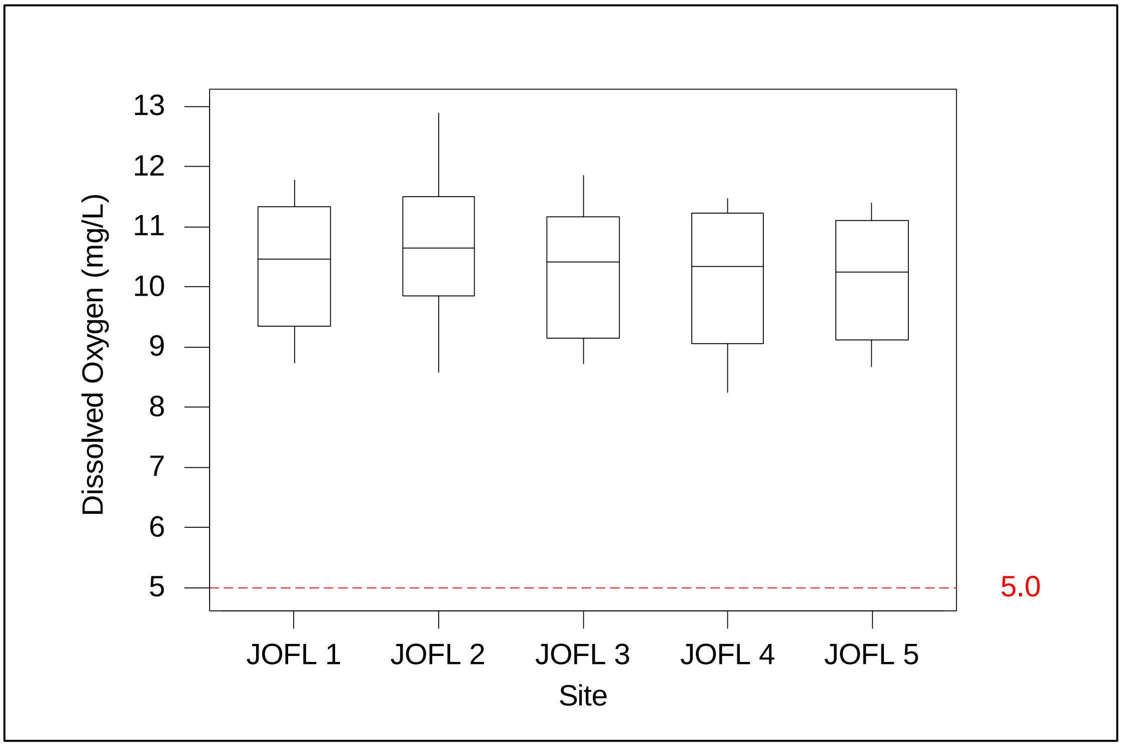

Figure 11. Dissolved oxygen concentration statistical boxplot for water quality samples collected at Johnstown Flood National Memorial sampling stations during the Level 1 water quality inventory. The "box" represents median and 1st (Q1) and 3rd quartiles (Q3). The "whiskers" represent the highest and lowest value within the upper and lower limits respectively, calculated as upper limit = Q3 + 1.5(Q3-Q1) and lower limit = Q1-1.5(Q3-Q1). The red, dashed line at dissolved oxygen = 5.0 represents the PA DEP's aquatic life criteria for cold water fishes.

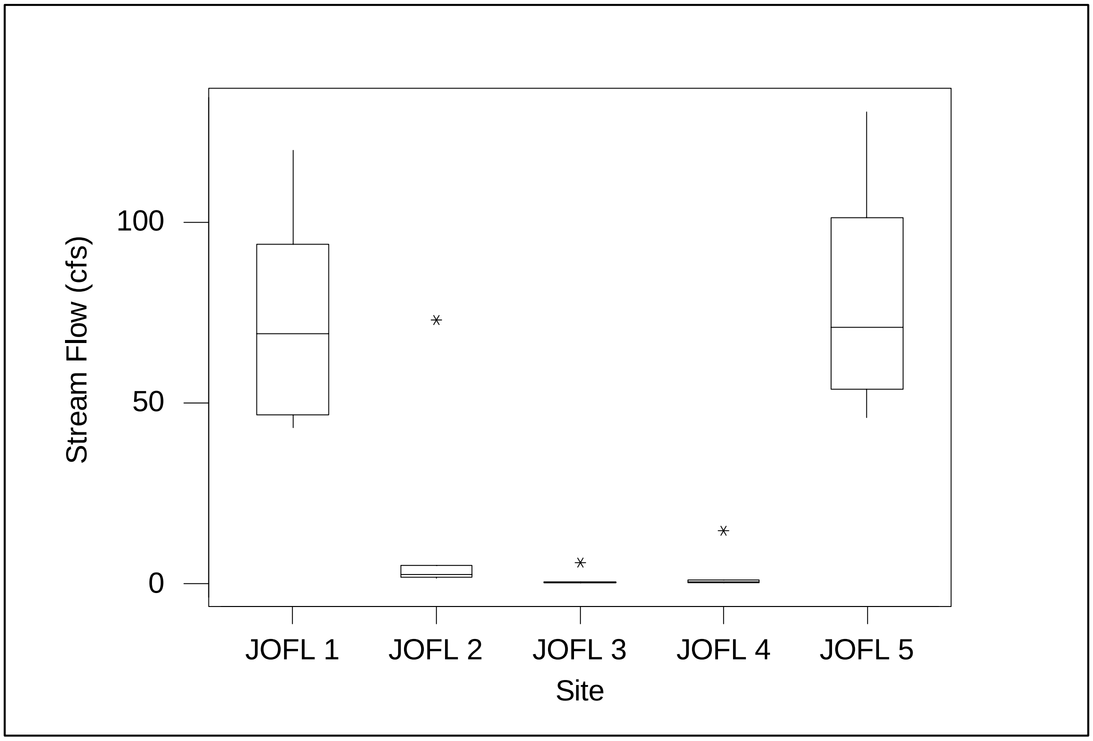

Figure 12. Streamflow boxplot for water quality samples collected at Johnstown Flood National Memorial sampling stations. The "box" represents median and 1st (Q1) and 3rd quartiles (Q3). The "whiskers" represent the highest and lowest value within the upper and lower limits respectively, calculated as upper limit = Q3 + 1.5(Q3-Q1) and lower limit = Q1-1.5(Q3-Q1). Outliers are represented by an asterisk (*).

Table 14. Temperature data collected at Johnstown Flood National Memorial sampling stations during the Level 1 water quality inventory. The temperature data are presented with the PADEP's corresponding aquatic life criteria. Samples violating their respective criteria are in bold.

Sample Date	Sample Station	Sample Value	Corresponding CWF Criteria
04/13/2004	JOFL 1	5.4	8.9
	JOFL 2	5.2	8.9
	JOFL 3	6.1	8.9
	JOFL 4	6.4	8.9
	JOFL 5	5.6	8.9
05/04/2004	JOFL 1	9.8	12.2
	JOFL 2	7.5	12.2
	JOFL 3	9.7	12.2
	JOFL 4	11.4	12.2
	JOFL 5	**13.2**	**12.2**
06/16/2004	JOFL 1	16.5	17.8
	JOFL 2	17.1	17.8
	JOFL 3	15.2	17.8
	JOFL 4	17.1	17.8
	JOFL 5	17.1	17.8
08/04/2004	JOFL 1	18.0	18.9
	JOFL 2	18.0	18.9
	JOFL 3	17.7	18.9
	JOFL 4	18.8	18.9
	JOFL 5	**20.3**	**18.9**
09/07/2004	JOFL 1	16.2	17.8
	JOFL 2	16.9	17.8
	JOFL 3	15.9	17.8
	JOFL 4	17.2	17.8
	JOFL 5	16.9	17.8
10/28/2004	**JOFL 1**	**10.4**	**10.0**
	JOFL 2	8.1	10.0
	JOFL 3	9.1	10.0
	JOFL 4	**10.6**	**10.0**
	JOFL 5	**11.5**	**10.0**
11/18/2004	**JOFL 1**	**10.3**	**5.6**
	JOFL 2	**9.0**	**5.6**
	JOFL 3	**9.9**	**5.6**
	JOFL 4	**9.2**	**5.6**
	JOFL 5	**9.8**	**5.6**

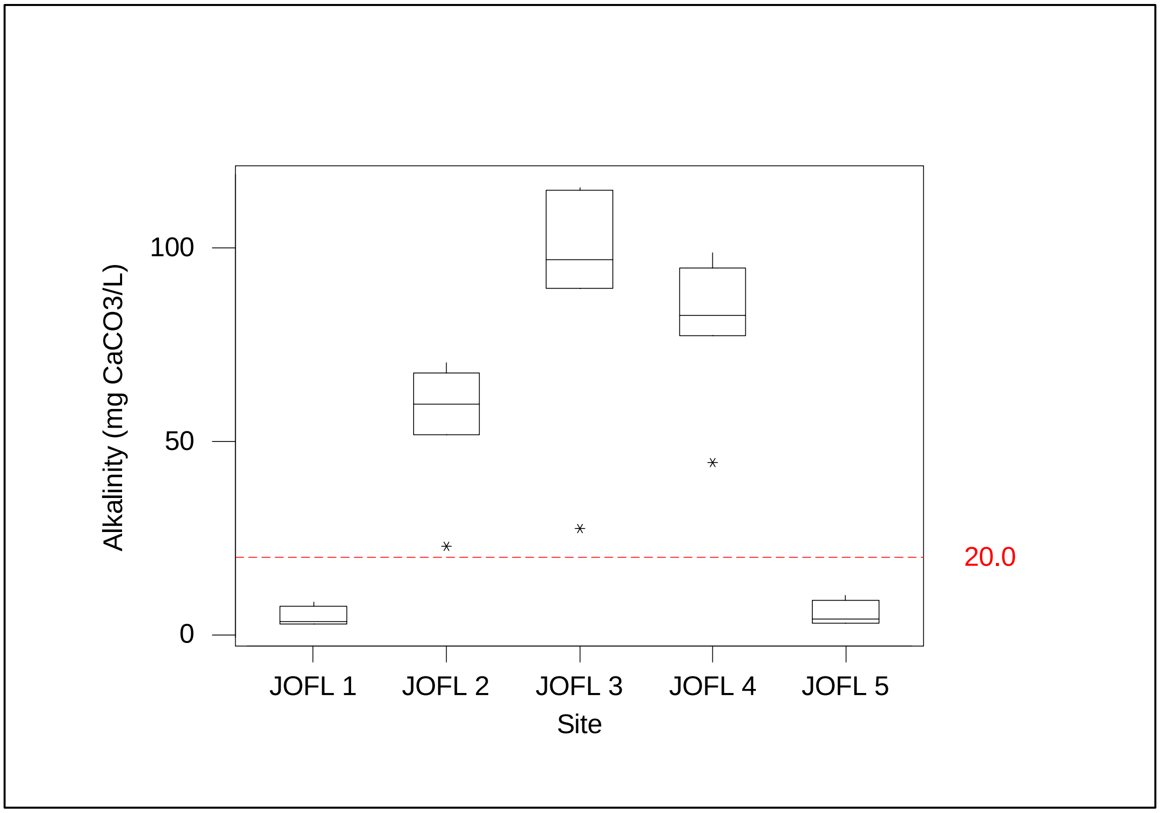

Figure 13. Alkalinity statistical boxplot for water quality samples collected at Johnstown Flood National Memorial sampling stations during the Level 1 water quality inventory. The “box” represents median and 1st (Q1) and 3rd quartiles (Q3). The “whiskers” represent the highest and lowest value within the upper and lower limits respectively, calculated as upper limit = Q3 + 1.5(Q3-Q1) and lower limit = Q1-1.5(Q3-Q1). Outliers are represented by an asterisk (*). The red, dashed line at alkalinity = 20 mg/L represents the PA DEP’s freshwater aquatic life standard (2003).

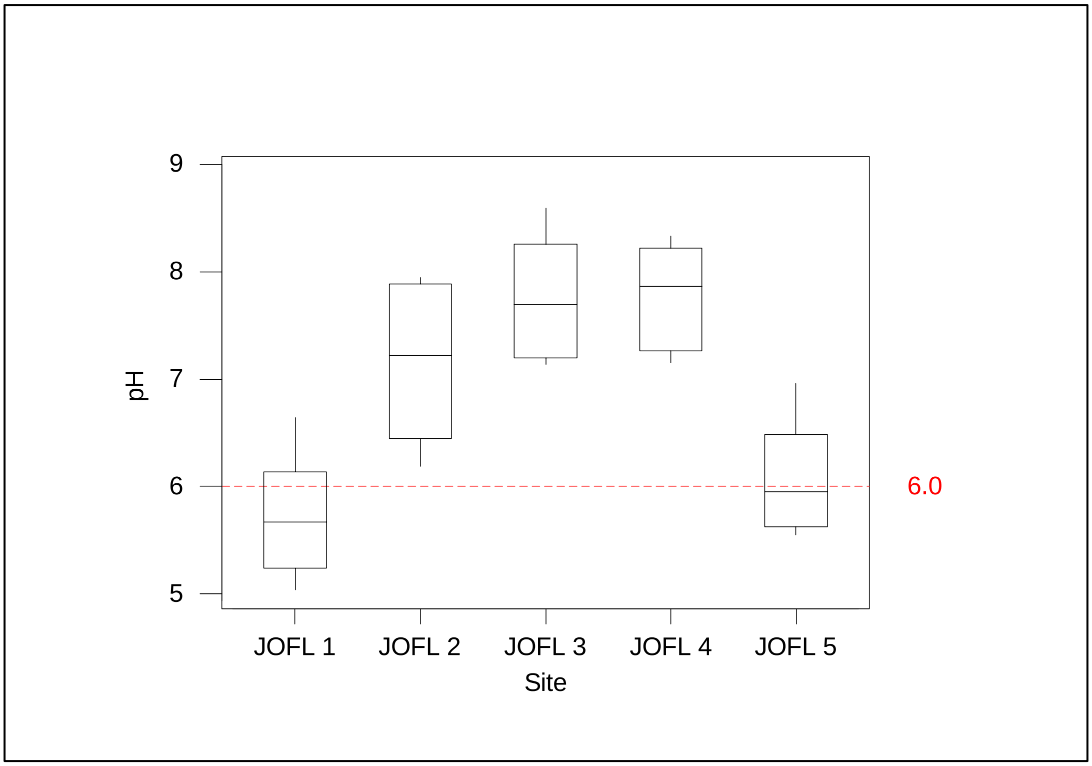

Figure 14. pH statistical boxplot for water quality samples collected at Johnstown Flood National Memorial sampling stations during the Level 1 water quality inventory. The "box" represents median and 1st (Q1) and 3rd quartiles (Q3). The "whiskers" represent the highest and lowest value within the upper and lower limits respectively, calculated as upper limit = Q3 + 1.5(Q3-Q1) and lower limit = Q1-1.5(Q3-Q1). The red, dashed line at pH = 6.0 represents the PA DEP's lower limit freshwater aquatic life standard (2003).

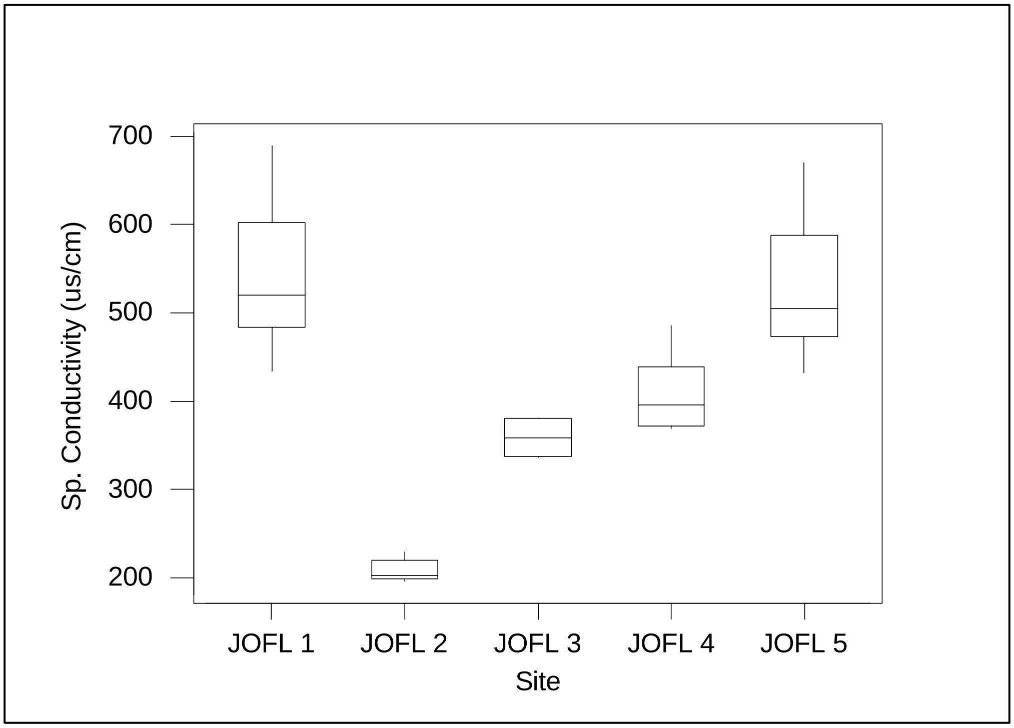

Figure 15. Specific conductivity statistical boxplot for water quality samples collected at Johnstown Flood National Memorial sampling stations during the Level 1 water quality inventory. The “box” represents median and 1st (Q1) and 3rd quartiles (Q3). The “whiskers” represent the highest and lowest value within the upper and lower limits respectively, calculated as upper limit = Q3 + 1.5(Q3-Q1) and lower limit = Q1-1.5(Q3-Q1).

South Fork, Little Conemaugh River Water Quality (JOFL-1 and JOFL-5): The alkalinity (Figure 13), pH (Figure 14), and specific conductivity (Figure 15) data collected at JOFL sites 1 and 5 indicated that conditions in the SF-LCR have been degraded. There was no detectable concentration of alkalinity present in three of the samples collected at either the JOFL-1 or JOFL-5 sites. The remaining four samples collected at these sites each contained minimal alkalinity concentrations (<10 mg $CaCO_3$/L). The PADEP alkalinity standard is 20 mg/L $CaCO_3$ except where natural conditions are less. Given the relatively high alkalinity concentrations present in tributary samples, it is likely that higher than current alkalinity concentrations would be present in the SF-LCR under natural conditions. Therefore, it is probable that the majority, and under certain conditions, all of the naturally occurring alkalinity is being consumed in acid-base reactions in the water column.

The plot of pH strengthens this hypothesis. The pH boxplot (Figure 14) indicates that the SF-LCR is acidic under most hydrologic conditions. When compared to the PADEP water quality standard of 6.0, the pH of SF-LCR is often below the threshold for aquatic life impairment.

Specific conductivity (Figure 15) levels measured at the SF-LCR sites were the highest detected at any site throughout the course of this inventory. Conductivity was elevated due to the high dissolved metals concentrations discussed below.

The low or non-existent alkalinity concentrations, low pH, and high conductivity measurements were consistent with acid mine drainage effects. Within the SF-LCR watershed there is an extensive network of abandoned coal mines that are likely the source of low pH, high dissolved metals concentrations, and depleted buffering capacity seen in the data collected at JOFL-1 and JOFL-5.

In addition to the 'Level 1' water quality parameters, the following water quality parameters were identified at the JOFL-1 and JOFL-5 water quality sampling locations: acidity, turbidity, nitrate-nitrogen (NO_3-N), total phosphorus (TP), sulfate (SO_4), aluminum (Al), arsenic (As), beryllium (Be), barium (Ba), calcium (Ca), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), magnesium (Mg), nickel (Ni), potassium (K), sodium (Na), strontium (Sr), zinc (Zn), and fecal coliform bacteria. All of the data collected at JOFL sampling sites are provided in tabular and graphical (where applicable) format in Appendix B.

A review of the figures presented in Appendix B indicates that water quality in the SF-LCR (represented in this inventory by JOFL-1 and JOFL-5) in the region surrounding the JOFL property is impaired to the extent that no semblance of a healthy biological community is possible at this time. Fe, Ni, and Zn concentrations exceeded their respective CCC and/or CMC standards in many of the samples collected. Water quality standards have not been established for most of the chemical constituents analyzed in this inventory; thus, prevented the direct comparison of chemical constituents with an impairment threshold. However, the general trend of the data suggested that the metals concentrations were greatest in samples collected from the SF-LCR sites. While this trend does not necessarily constitute impairment, the presence of non-naturally occurring constituents such as Al, As, Ba, Be, Ca, Cr, Cu, Fe, Mg, Mn, K, Na, and Sr supports the assertion that the SF-LCR is severely impaired.

Tributary Water Quality (JOFL-2, JOFL-3, and JOFL-4): In contrast to the data collected at JOFL-1 and JOFL-5, median alkalinity concentrations in the three tributaries to the SF-LCR ranged from 60 to 95 mg $CaCO_3$/L (Figure 13). In all samples collected at JOFL sites 2, 3, and 4, alkalinity concentrations were in excess of the PADEP's alkalinity water quality standard of 20 mg $CaCO_3$/L. Interestingly, the alkalinity measurements made at JOFL sites 2, 3, and 4 on April 14, 2004 were substantially lower than their respective median values. While the specific cause of these low values cannot be determined using the data collected, it appeared possible that alkalinity in the tributaries can be consumed under certain hydrologic conditions. Therefore, episodic acidification of the tributaries to the SF-LCR may be possible under certain conditions. Alternatively, it is possible that alkalinity concentration in these three tributaries is diluted during periods of increased runoff due to precipitation, snowmelt, etc.

The pH measurements (Figure 14) recorded at JOFL sites 2, 3, and 4 are neutral to slightly basic, ranging from a median value of 7.2 at JOFL-2 to 7.9 at JOFL-4. All measured values were greater than the PADEP's pH standard of 6.0.

Median specific conductivity readings (Figure 15) were 200 µs/cm at JOFL-2, 350 µs/cm at JOFL-3, and 400 µs/cm at JOFL-4. Although a freshwater water quality standard for specific conductivity does not exist, levels measured in the JOFL-3 and -4 sites were high relative to the specific conductance of waters flowing through relatively pristine forested watersheds (i.e., ALPO-2, -4, -5, and -6). The elevated specific conductivity measurements at JOFL-3 and -4 were potentially due to upstream agricultural practices and the sampling stations' proximity to a four-lane divided highway (U.S. Route 219) that crosses the SF-LCR at the downstream boundary of the JOFL property. With the exception of the tributary mouths, the majority of these tributaries are located outside of the JOFL boundary. Many of the contributing watersheds are comprised of agricultural land, with pollutants associated with agricultural practices all contributing to increased in-stream conductivity. Road salt and automobile emissions are additional sources of pollution that may be contributing to high in-stream conductivity.

In addition to the required 'level 1' water quality parameters discussed above, the following chemical constituents were detected at JOFL stations 2, 3, and 4: nitrate-nitrogen (NO_3-N), sulfate (SO_4), total phosphorus (TP), aluminum (Al), barium (Ba), calcium (Ca), iron (Fe), magnesium (Mg), manganese (Mn), potassium (K), sodium (Na), strontium (Sr), zinc (Zn), fecal coliform bacteria, and turbidity. Federal regulatory water quality standards exist for Al, Fe, and Zn. In contrast to concentrations of these constituents present in samples collected from the SF-LCR (JOFL-1 and JOFL-5), concentrations of Al, Fe, and Zn were generally below their respective CCC and CMC values at sites JOFL-2, -3, and -4. Al concentration exceeded the CCC in one sample from JOFL-2. It is again important to note that the CCC is a chronic criterion. Because the remaining six JOFL-2 Al concentration measurements were below the CCC, it is unlikely that stream communities are impaired due to excessive Al concentration. All Fe and Zn samples collected at JOFL-2, -3, and -4 sites were below the CCC and CMC thresholds. Based upon the concentrations of these and other chemical parameters included in the extended suite (Appendix B), water quality is generally good at the tributary stations sampled within the JOFL property. However, several trends illustrated by the Appendix B plots deserve mention.

First, the plots of SO_4, TP, and Na show higher concentrations of these constituents at JOFL stations 4 and 3 than at JOFL-2. NO_3-N concentrations were much higher at JOFL-4 than at either JOFL-3 or JOFL-2. Generally, elevated levels of SO_4, TP, and NO_3-N can often be attributed to non-point source pollution from agricultural practices located upstream of the sampling point. Elevated levels of Na at JOFL-4 and JOFL-3 were likely the result of road salt (NaCl, sodium chloride) application.

Lastly, a general comparison between chemical concentrations detected at JOFL sites 2, 3, and 4 and ALPO can be made. When comparing JOFL and ALPO results for any of the chemical parameters analyzed concentrations are generally greater at JOFL stations. While documentation of specific reasons for these discrepancies was beyond the scope of this inventory, it is likely that prior large-scale disturbance and current differences in land cover/land use can explain these results. The BGR watershed (ALPO) is almost entirely forested, with atmospheric deposition potentially affecting water quality at ALPO-1, and sparse development-related impairments in the downstream reaches being the only apparent sources of pollution. In contrast, land use surrounding the JOFL property is mostly disturbed, with pollution sources ranging from agricultural practices, acid mine drainage, and interstate highways to development/construction sites, high-density residential and commercial space, and point sources of pollution. These landscape-scale differences likely explain the differences in water chemistry at the two parks.

Aquatic Macroinvertebrate Inventory

Forty-two benthic taxa were found throughout JOFL stations 2, 3, and 4 (Table 15); all but one taxa (two-lined salamander [*Scientific name*]) were MI. Although JOFL-2 had approximately twice as many taxa as the other two streams, all stations were classified as impaired (Table 16, Figure 16 using the same MBII criteria described in the previous section. Despite relatively good water quality at JOFL stations 2–4, it was not surprising that JOFL tributaries were characterized as impaired using PADEP metrics (Table 17) and the MBII, given past land uses surrounding JOFL and the poor water quality in SF-LCR.

Fish Species Inventory

Despite their PADEP designation as coldwater fisheries, the tributaries to the SF-LCR did not contain fish communities warranting that designation. The upstream-most tributary (JOFL-2) to the SF-LCR contained six fish species typical of Pennsylvania warmwater stream fish communities (Table 18), whereas the two downstream tributaries (JOFL-3 and JOFL-4) contained only one and two creek chubs (*Semotilus atromaculatus*), respectively (Table 19). One northern red salamander (*Pseudotriton ruber ruber*) was captured at JOFL-4.

No piscivorous (i.e., fish-eating) fishes (e.g., smallmouth bass [*Micropterus dolomieui*]) were found at any of the stations, which may have partially explained the apparently high densities of "forage" fishes at JOFL-2. Indices of biotic integrity (IBI) for fish communities (Karr 1981; McCormick et al. 2001) include the proportion of carnivores in the community as a metric that estimates the ability of the food chain to support fish that prey largely on other fish, vertebrates, or large macrobenthos. Carnivores are expected to decline with increased habitat degradation. Although creek chub, darters (*Etheostoma spp.*), and sculpin are insectivores and were all found at JOFL-2, no fishes that are primarily piscivorous were found. Given the size of the stream

Table 15. Macroinvertebrate taxa found at Johnstown Flood National Memorial on January 12, 2005.

			Station		
			JOFL-2	JOFL-3	JOFL-4
		Total taxa	33	17	16
		Total individuals	589	403	202
ORDER	FAMILY	GENUS			
Bivalvia	Sphaeridae	*Pisidium*	4		
Coleoptera	Elmidae	*Microcylloepus*	6		
		Optioservus	59	1	1
		Promoresia	1		
	Psehenidae	*Psephenus*	4		
Decapoda	Cambaridae	*Cambarus.bartonii,b.*	3	2	
Diptera	Chironomidae	*Chironomidae*	107	21	40
	Simulidae	*Prosimulium*	14		
	Tipulidae	*Antocha*	20		1
		Dicranota	11	2	1
		Hexatoma		11	1
		Psuedolimnophila	1		
		Tipula	4	7	1
Ephemeroptera	Baetidae	*Baetis*			98
		Centroptilium	94	55	
	Ephemerellidae	*Ephemerella*	1	191	14
	Ephemeridae	*Ephemera*	1		
	Leptophlebiidae	*Paraleptophlebia*	1		
	Siphlonuridae	*Ameletus*	3	22	3
Gastropoda	Planorbidae	*Gyraulus deflectus*	1		
	Lymnaeidae	*Pseudosuccinea collumella*	1		
	Physidae	*Unidentifiable*	1		
Megaloptera	Corydalidae	*Nigronia*	1	2	
	Sialidae	*Sialis*	2		
Oligochaeta	Lumbricina	*Oligochaeta*	5	2	8
Plecoptera	Capniidae	*Capnia*			2
	Chloroperlidae	*Sweltsa*	1		
	Leuctridae	*Paraleuctra*	1		
	Perlidae	*Agnetina*	1		
	Perlodidae	*Clioperla*	1		
		Malerikus		12	
	Taeniopterygidae	*Taeniopteryx*	1		
Trichoptera	Hydropsychidae	*Cheumatopsyche*	191		
		Diplectrona		55	10
		Hydropsyche	35	7	8
	Limnephilidae	*Hydatophylax*	1		
		Pycnopsyche		2	
	Philopotamidae	*Chimarra*	8		1
		Wormaldia		3	
	Rhyachphilidae	*Rhyacophila*		8	2
	Uenoidae	*Neophylax*	4		11
Amphibia	Plethodontidae	*Eurycea bislineata*		4	

Table 16. Summary of Macroinvertebrate Biotic Integrity Index (MBII) scores and individual metrics used to calculate the MBII for samples collected on January 12, 2005 throughout Johnstown Flood National Memorial.

Index or Metric	JOFL2	JOFL3	JOFL4
Macroinvertebrate Biotic Integrity Index (MBII) Score	47.95	47.78	46.20
Epehemeroptera Richness	5	3	3
Plecoptera Richness	5	1	1
Trichoptera Richness	5	5	5
Collector/filterer Richness	16	9	9
% noninsect Taxa	3	2	4
Macroinvertebrate Tolerance Index (MTI)	4.49	3.20	3.55
% 5 dominant Taxa	83	85	86

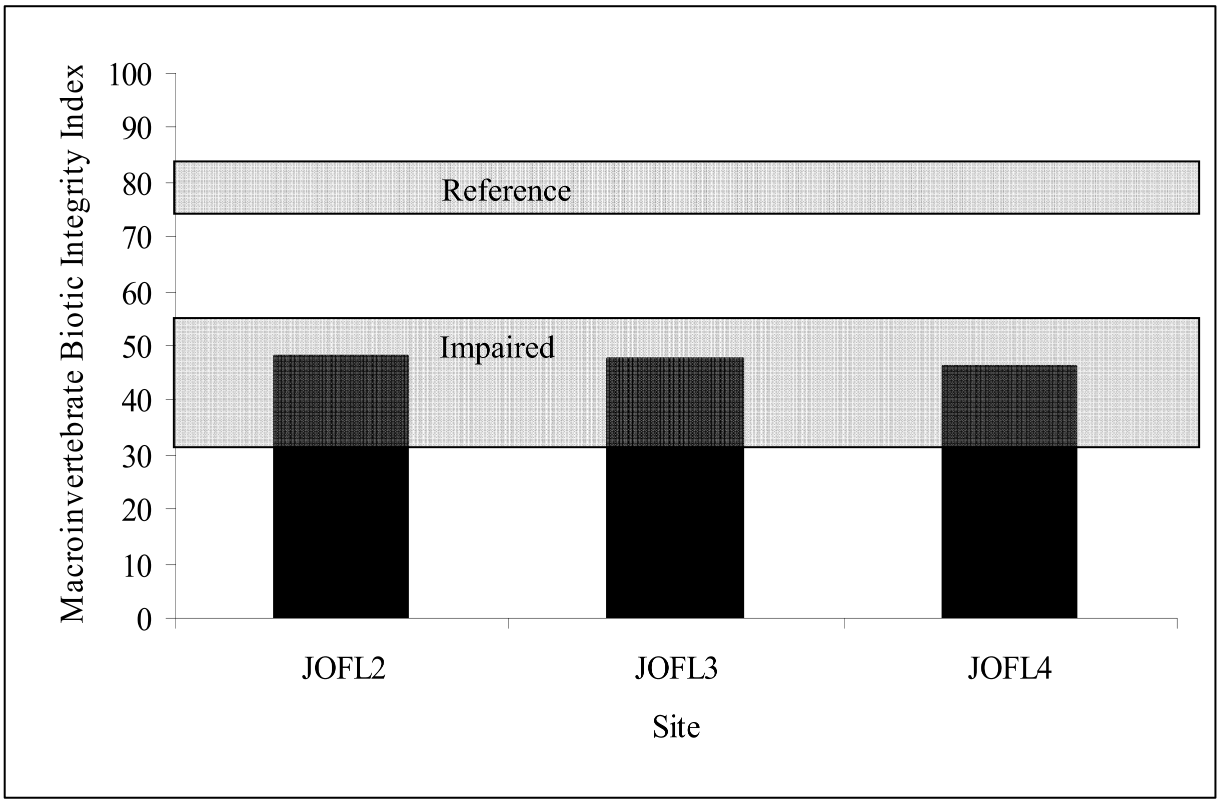

Figure 16. Macroinvertebrate Biotic Integrity Index scores for stations surveyed in Johnstown Flood National Memorial on January 12, 2005. Shaded areas represent middle interquartile range (25 – 75 %) of MBII values reported for reference and impaired streams in uplands of the Mid-Atlantic Highlands Region.

Table 17. Aquatic macroinvertebrate metrics typically used for stream assessments by the Pennsylvania Department of Environmental Protection (PADEP) and metric scores for samples collected on January 12, 2005 throughout Johnstown Flood National Memorial.

PADEP Metrics	JOFL2	JOFL3	JOFL4
Taxa Richness	33	17	16
Modified (Pollution Tolerance Value < 4) Ephemeroptera, Plecoptera, and Trichoptera (EPT) Richness	11	7	7
Modified % Ephemeroptera (Pollution Tolerance Value < 4)	15	18	19
% Dominant Taxon	32	47	49
Hilsenhoff Biotic Index (HBI)	4.53	2.67	4.70

Table 18. Fish species inventoried at Johnstown Flood National Memorial on November 18, 2004 and their reported tolerance to human-induced disturbance (Tolerance) (McCormick et al. 2001).

Common name	Family	Species	Tolerance
White sucker	Catostomidae	*Catostomus commersonii*	Tolerant
Mottled sculpin	Cottidae	*Cottus bairdii*	-
Blacknose dace	Cyprinidae	*Rhinichthys atratulus*	Tolerant
Creek chub	Cyprinidae	*Semotilus atromaculatus*	Tolerant
Fantail darter	Percidae	*Etheostoma flabellare*	Tolerant
Johnny darter	Percidae	*Etheostoma nigrum*	Tolerant

Table 19. Sampling location, common name, and number of fishes captured at Johnstown Flood National Memorial on November 18, 2004.

Sampling Station	Common name	Number Captured
JOFL-2	White sucker	10
	Mottled sculpin	3
	Blacknose dace	12
	Creek chub	59
	Fantail darter	42
	Johnny darter	41
JOFL-3	Creek chub	1
JOFL-4	Creek chub	2

where JOFL-2 was located, it could have been expected that large piscivores (such as black bass [*Micropterus* spp.] and pickerel [*Esox* spp.]) would be collected.

Five of the six fish species captured at JOFL-2 are considered tolerant to human-induced disturbance (McCormick et al. 2001). The proportion of tolerant individuals in the community is expected to increase with decreasing water quality, channel habitat, and watershed condition. McCormick et al. (2001) reported that the proportion of tolerant fishes was positively correlated with increased acid mine drainage (sulfate), increased turbidity, increased nutrients (ammonium, total phosphorus), and general human activity (chloride). Tolerant individuals generally decline with increased fish cover and with various indices of channel, riparian, and watershed quality (McCormick et al. 2001). Although no fish IBI's were calculated for this inventory, as this was not the primary intent of these surveys, the abundance of tolerant fishes at JOFL-2 suggested stream impairment with regard to a combination of habitat, watershed, and/or water quality.

The fact that only one and two fish were found at JOFL-3 and JOFL-4, respectively, suggested that these streams are degraded to the extent that they likely do not support reproducing fish populations. It is possible that creek chub, which is considered a pollution-tolerant species (McCormick et al. 2001), found at these two stations migrated from the tributary upstream (JOFL-2) and moved downstream in the SF-LCR during high flows (when water quality was at least marginally tolerable) and moved into JOFL-3 and JOFL-4 to where conditions were more tolerable than the SF-LCR mainstem. Although unlikely given the small size of these streams, it is also possible that creek chub populations existed upstream of areas sampled at JOFL-3 and JOFL-4.

Conclusions and Overall Aquatic Assessment

Allegheny Portage Railroad National Historic Site (ALPO)

The chemical quality of water at ALPO was the result of precipitation chemistry, possible acid mine drainage in the BGR headwaters, and chemical reactions occurring in the stream and within the soil and groundwater. There appeared to be minimal impact from local disturbance. Two reservoirs in the BGR watershed appeared to have an effect on aquatic resources in the following ways. ALPO-3 was located directly downstream of the Hollidaysburg Reservoir and had a different chemical signature than ALPO-2 which was located on the mainstem of BGR. Water samples collected at ALPO-3 indicate that the reservoir was retaining nutrients and other chemical species.

Water quality samples collected at ALPO-1 indicated a greater level of disturbance relative to the other ALPO sites. Elevated metals and sulfate concentrations at this site could have been due to acid precipitation and the resultant soil and bedrock chemical reactions, acid mine drainage or acidic seeps in the headwaters, and proximity to state route 3012. ALPO-6 sampling revealed higher concentrations of fecal coliform bacteria relative to the other ALPO sites (which were likely the result of small-scale farming operations and septic systems located in the downstream portion of the watershed).

Macroinvertebrate communities at two sampling locations (ALPO-1 and ALPO-3) were classified as impaired using the MBII. Metrics used by the PADEP supported the MBII results. At both impaired sites there were fewer total MI taxa than at unimpaired ALPO sites. Additionally, MI taxa (e.g., mayflies, stoneflies, caddisflies) considered to be intolerant to pollution were underrepresented at ALPO-1 and ALPO-3. BGR headwaters (ALPO-1) were classified as impaired using the MBII due to a combination of lower than recommended sample size (65 instead of 270 individuals) and potential impairment as suggested by chemistry data. Only 15 MI taxa and eight “pollution intolerant” EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa were found at ALPO-1. In comparison, the next sampling site downstream (ALPO-2) had 27 total MI taxa and 21 “pollution intolerant” EPT taxa.

As evidenced by the water chemistry data collected during this study, the nutrient-poor environment downstream of the reservoir (ALPO-3) apparently yielded a relatively scarce, “impaired” MI community. Only 18 MI taxa and 11 intolerant EPT taxa were found at ALPO-3. Whereas ALPO-4, which was within 100 m (328 ft) but on the BGR mainstem, had 32 MI taxa and 21 intolerant EPT taxa. Although ALPO-3 water quality was not poor, the reservoir yielded a relatively sterile environment atypical of comparably-sized Pennsylvania streams.

Distribution of fishes in BGR and its tributaries was typical of comparably sized Pennsylvania streams in the Susquehanna River drainage, but brook trout was the only fish species found in BGR headwaters (ALPO-1), and, in general, increasingly more species were captured moving downstream. Brown trout may be partially limiting the abundance and downstream distribution of brook trout in BGR, but juveniles of both species were found in the mainstem downstream to ALPO-4 and at the downstream tributary at ALPO-5. Additionally, juvenile brown trout were found downstream to ALPO-6. Given these findings, BGR supports natural reproduction of either brook trout or brown trout from ALPO-1 to ALPO-6, which is in contradiction to PAFBC published information that BGR is not a “Stream Section that Supports Natural Reproduction of Trout” (http://www.fish.state.pa.us/). Wild brook trout and brown trout were also found at one locality (ALPO-5) that currently does not have a PAFBC management designation.

Johnstown Flood National Memorial (JOFL)

The chemical quality of streams at JOFL ranged from generally good to severely impaired. JOFL sites 1 and 5 have been affected by acid mine drainage to such a severe extent that the SF-LCR probably does not likely support either MI or fish species. Low pH and exceedingly high metals concentrations both contribute to this condition.

JOFL sites 2, 3, and 4 are currently supporting biological communities. Although water quality at all of these sites appeared to be generally good, the core parameters, metals, and nutrients figures previously provided and in Appendix B illustrate differences in water quality among the sites. Pollutant levels were generally lowest at JOFL-2, with greater concentrations at JOFL-3, and highest concentrations at JOFL-4. This trend was likely due to land use/land cover differences and relative proximity of the sites to U.S. Route 219 (JOFL-4 was the closest site to U.S. Route 219). The nutrient and sodium concentration in water samples collected from JOFL sites 2, 3, and 4 supported this assertion.

Although water quality at JOFL sites 2, 3, and 4 was generally good, all three sites had impaired MI and fish communities. MI taxa richness at JOFL-2 was relatively high (33 taxa), but numerically dominated by relatively pollution-tolerant taxa (e.g., hydropsychid caddisflies). Approximately half the number of taxa found at JOFL-2 were found at JOFL sites 3 (17 taxa) and 4 (16 taxa). Many of these taxa were redundant among the three sites. Given the limited distance that aquatic insects and other MI can travel over land during their adult stages, and the taxa present among the three tributaries, it seems likely that JOFL-2 historically harbored source populations of MI to the other tributaries.

The fish community at JOFL-2 was characterized by abundant, relatively disturbance-tolerant fishes, but lacked any top-level warm-water predators that would likely be present in less disturbed areas. JOFL sites 3 and 4 harbored only one and two individuals of one species (creek chub), respectively, which indicated that these tributaries support, at best, minimal reproduction of fishes. It is more likely that these creek chub migrated from JOFL-2 into the SF-LCR during high flows, moved downstream, and then found refuge from the rivers’ toxic conditions in JOFL-3 and JOFL-4.

Given the history of the watershed where JOFL is situated, it is likely that parts, or all of these localities were once severely impaired. Over time, MI and fishes that found tolerable refuge in the watershed (likely some portion of JOFL-2) have colonized these tributaries to varying degrees. Although the MI and fish communities appeared to be recovering from historical perturbations, they are still isolated (due to severe impairment of SF-LCR) and, hence, particularly vulnerable to further human disturbance. As water quality hopefully improves over time in the SF-LCR, JOFL tributaries (particularly JOFL-2) may provide source populations of fishes, amphibians, and MI to colonize the river and other tributaries.

Recommendations for Future Aquatic Resource Monitoring

Allegheny Portage Railroad National Historic Site (ALPO)

The BGR watershed is primarily forested. With drinking water reservoirs in the watershed that serve Hollidaysburg and Altoona, land use in the watershed will be carefully monitored and regulated to protect these drinking water supplies. The greatest threats to ALPO aquatic resources identified throughout this inventory were state route 3012, potential acid mine drainage in the BGR headwaters, and acid precipitation/atmospheric deposition.

Evidence (i.e., low pH, high Al concentrations) suggested that acid mine drainage or seeps may be adversely affecting water quality in the BGR headwaters, represented by ALPO-1. These suspected seeps are undocumented and should be identified and assessed to quantify the potential effect these sites are having on water quality. Identification of these sites, and analysis of water quality and MI samples at these sites would provide useful information to NPS staff regarding potential remediation strategies. Because of the small sample size of MI at ALPO-1 during this survey, it was unclear if biological communities are definitively being adversely affected by impaired water quality in BGR headwaters. The headwaters currently support a wild brook trout population that constitutes a significant natural resource deserving protection. Mitigation of headwater acid mine drainage sites would improve water quality and aquatic habitat in this region of the watershed.

Major threats related to acid precipitation/atmospheric deposition include sulfate and nitrogen inputs, soil ion depletion resulting from low pH rainwater, and the associated loss of soil buffering capacity. These harmful effects of atmospheric pollution are likely to manifest themselves as water quality problems in the BGR headwaters in the future. Therefore, quarterly, long-term monitoring of nutrient species, a few metals (Al, Ba, Sr, Na, K, Mg, Mn), and acid neutralizing capacity at ALPO-1 is recommended to assess trends related to the atmospheric threats mentioned above. Measurement of these same parameters at a downstream station (ALPO-2, ALPO-4, ALPO-6) also should be made to determine whether acid precipitation/atmospheric deposition is affecting lower reaches of BGR in the future.

The only development in the BGR watershed that may affect ALPO is located in the downstream reaches of the watershed. At ALPO-6, several water quality samples contained relatively high concentrations of fecal coliform bacteria. Major sources of bacterial pollution include farm animal operations and leaking or short-circuiting septic systems. Due to these high readings, fecal coliform samples should be collected at several times throughout the year. To identify high fecal coliform inputs, samples should be collected to capture the ‘first flush’ of the hydrologic system. The ‘first flush’ occurs as stream discharge begins to increase as the result of a precipitation event. Additionally, spikes in specific conductivity can indicate pollution from septic systems (as well as many other sources). Conductivity measurements in the lower reaches of the watershed can be made to identify both temporal and spatial variation in ionic concentrations.

Annual sampling of MI communities at the upstream (ALPO-1) and downstream (ALPO-6) limits of ALPO property, concurrent with chemical sampling during the winter quarter is recommended for long-term biomonitoring of BGR at ALPO. If perturbations are suggested by changes in the MI communities at these two sites, additional chemical and/or biological sampling could be done throughout the watershed to determine the source and extent of impairment.

Wild trout and other fish species indicative of relatively unimpaired conditions were found throughout the BGR watershed. Many trout captured were nonnative brown trout, which is known to limit the distribution and abundance of native brook trout. Although some national parks are preserving native species by removing nonnative species with physical or chemical applications, these methods do not seem feasible at ALPO. Other, more passive strategies to ensure long-term brook trout preservation as a native species in BGR include ending trout stocking in the watershed and implementing regulations that limit 1) brook trout harvest (e.g., catch and release), but allow brown trout harvest; and 2) useable gear types that limit brook trout mortality (e.g., artificial lures only). Such regulation changes would likely require extensive communication and cooperation with the public and PAFBC; however, given the relative abundance of small (< 7") trout found during this survey, it appears that BGR could provide a valuable and attractive wild trout fishery. Implementing these changes is further complicated by not knowing the genetic origin of ALPO brook trout (i.e., hatchery-reared trout may have been the source of the resident populations), which could only be quantified by genetic analysis.

Discrepancies between published PAFBC information and the results of this survey should be rectified by additional sampling of the BGR watershed. Results of further sampling could potentially justify alteration of current PAFBC fisheries management regulations throughout ALPO and BGR.

Johnstown Flood National Memorial (JOFL)

Based upon data collected during this project, additional sampling at JOFL sites 1 and 5 is not recommended. It is evident that the SF-LCR is severely impaired and will remain so pending a major watershed reclamation project. If such a reclamation project is implemented in the future, chemical and biological monitoring should be initiated in the SF-LCR. Current conditions in the SF-LCR are so poor that there are very limited biological communities to monitor or protect.

JOFL sites 2, 3, and 4 currently have generally good water quality, although all are showing signs of stress, likely due to upstream land use and the proximity of the sites to U.S. Route 219. Therefore, monitoring of sodium (and/or specific conductivity), dissolved oxygen, and nutrient (i.e. nitrogen, phosphorus) concentrations at these sites would provide useful information for NPS staff. Nutrient measurements can be made less often than the other constituents if associated laboratory costs are prohibitive to more frequent analysis.

Given the comparatively high taxa richness of MI and fishes found at JOFL-2 and its potential as a source for future colonization of currently impaired waterways, JOFL-2 should be monitored annually and protected from further perturbations to the extent possible.

Information Storage

All water quality data collected over the course of this project have been provided to the Eastern Rivers and Mountains Network data manager (Nathan Piekielek) for upload to the U.S. Environmental Protection Agency's STORET water quality database.

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Appendix A. Data collected at the Allegheny Portage Railroad National Historic Site (ALPO) water quality sampling sites and statistical boxplots of expanded water quality parameters.

Water Quality Data

All water quality data collected at the Level 1 Allegheny Portage Railroad National Historic Site (ALPO) water quality sampling sites are provided in table A1. Chemical constituent concentrations that were below laboratory detection limits are indicated as “<” followed by the detection limit.

Table A1. Level 1 water quality data, Allegheny Portage Railroad National Historic Site.

Site	Date	Temp (°C)	Conductivity (µs/cm)	Sp. Conductivity (µs/cm)	pH	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	Stream Flow (ft^3/sec)
ALPO 1	04/15/2004	7.7	229.8	343.6	7.36	9.20		14.24
ALPO 1	05/06/2004	12.5	321.4	422.0	7.50	10.02	93.9	1.16
ALPO 1	06/17/2004	16.9	438.7	519.0	7.32	8.83	91.2	0.88
ALPO 1	08/02/2004	17.4	429.5	501.0		8.97	94.2	0.63
ALPO 1	09/02/2004	15.6	438.5	535.0	7.82	8.83	88.7	0.21
ALPO 1	10/21/2004	9.3	273.6	391.2	7.17	10.30	89.5	0.69
ALPO 1	11/16/2004	6.1	246.0	387.3	7.38	11.45	94.0	0.59
ALPO 2	04/15/2004	7.7	81.6	122.2	7.17	9.64		76.91
ALPO 2	05/06/2004	11.6	96.4	129.4	7.56	10.47	96.2	5.81
ALPO 2	06/17/2004	13.9	105.5	133.7	7.33	10.73	103.7	12.20
ALPO 2	08/02/2004	15.7	137.9	167.7		10.04	101.1	5.94
ALPO 2	09/02/2004	14.6	157.9	191.7	8.04	9.35	92.0	3.11
ALPO 2	10/21/2004	9.6	115.5	163.7	7.27	10.36	90.8	5.44
ALPO 2	11/16/2004	7.9	83.4	124.1	6.42	11.26	95.0	6.16
ALPO 3	04/15/2004	6.4	26.3	40.7	6.94	10.67		126.21
ALPO 3	05/06/2004	12.6	31.7	41.6	7.07	10.34	97.4	15.49
ALPO 3	06/17/2004	18.4	40.9	46.8	6.93	9.38	100.1	10.37
ALPO 3	08/02/2004	19.1	43.7	49.3		9.09	98.3	6.91
ALPO 3	09/02/2004	18.1	42.8	49.3	7.48	8.95	95.0	4.55
ALPO 3	10/21/2004	9.8	31.8	44.9	6.92	10.44	92.1	8.08
ALPO 3	11/16/2004	6.6	28.8	44.6	6.74	11.22	92.5	13.90
ALPO 4	04/15/2004	7.6	123.8		7.18	9.93		173.89
ALPO 4	05/06/2004	11.6	45.2	60.7	7.22	10.54	97.1	21.66
ALPO 4	06/17/2004	16.5	86.3	104.0	7.25	9.95	101.6	19.65
ALPO 4	08/02/2004	17.2	83.1	100.0		9.52	99.5	14.28
ALPO 4	09/02/2004	16.9	78.1	90.5	7.68	8.80	91.0	7.72
ALPO 4	10/21/2004	9.7	61.8	91.5	7.17	10.43	92.0	12.72
ALPO 4	11/16/2004	7.3	52.2	83.2	7.04	11.61	96.3	19.08
ALPO 5	04/15/2004	7.6	42.6		6.70	10.22		40.23
ALPO 5	05/06/2004	10.2	47.3	65.3	7.01	10.83	96.6	3.17
ALPO 5	06/17/2004	15.6	58.8	72.5	6.85	9.82	98.5	1.82
ALPO 5	08/02/2004	16.3	62.4	74.2		8.95	91.5	1.46
ALPO 5	09/02/2004	15.6	74.5	91.0	7.50	8.75	88.1	0.99
ALPO 5	10/21/2004	10.0	56.0	78.0	6.85	10.03	89.0	1.42
ALPO 5	11/16/2004	7.2	46.7	71.6	6.64	11.27	93.6	2.36
ALPO 6	04/15/2004	6.5	88.8		7.26	10.81		174.83
ALPO 6	05/06/2004	10.3	60.6	84.2	7.40	10.98	98.9	27.39
ALPO 6	06/17/2004	19.2	101.0	113.5	7.33	9.52	103.2	24.05
ALPO 6	08/02/2004	19.6	118.3	132.0		8.63	94.7	19.80
ALPO 6	09/02/2004	17.4	136.6	159.9	7.72	8.62	89.9	12.03
ALPO 6	10/21/2004	10.6	79.0	109.0	7.20	10.42	93.6	15.49
ALPO 6	11/16/2004	5.8	58.5	92.4	6.80	12.12	96.9	30.78

Table A1. Level 1 water quality data, Allegheny Portage Railroad National Historic Site (continued).

Site	Date	Acidity (mg $CaCO_3$/l)	Alkalinity (mg $CaCO_3$/l)	Turbidity NTU	NO_3-N Mg N/l	TP (mg P/l)	SO_4 (mg/l)	Al (mg/L)
ALPO 1	04/15/2004	<.200	12.5	1.97	0.006	0.937	37.6	0.074
ALPO 1	05/06/2004	<.200	19.6	1.59	0.005	0.433	55.6	0.145
ALPO 1	06/17/2004	<.2	30.0	3.54	0.405	0.004	45.9	0.095
ALPO 1	08/02/2004	-20.9	31.2	1.72	0.366	0.003	47.9	0.081
ALPO 1	09/02/2004	<.200	35.1	4.75	0.202	0.011	74.7	0.140
ALPO 1	10/21/2004	<.200	27.7	2.35	0.231	0.002	53.5	0.48
ALPO 1	11/16/2004	<.012	22.5	2.86	0.339	0.007	45.6	0.057
ALPO 2	04/15/2004	<.200	10.7	2.90	0.012	1.19	16.7	0.031
ALPO 2	05/06/2004	<.200	17.3	1.25	0.005	0.868	17.5	0.021
ALPO 2	06/17/2004	24.5	21.2	4.82	0.702	0.016	17.4	0.016
ALPO 2	08/02/2004	-20.3	27.2	15.0	0.716	0.030	19.5	0.025
ALPO 2	09/02/2004	<.200	38.7	3.83	0.729	0.016	25.0	0.023
ALPO 2	10/21/2004	<.200	28.1	3.48	0.599	0.008	22.3	0.135
ALPO 2	11/16/2004	<.012	21.5	2.45	0.664	0.008	17.1	0.025
ALPO 3	04/15/2004	3.63	3.89	1.06	0.009	0.792	8.74	0.041
ALPO 3	05/06/2004	4.66	5.28	0.539	0.002	0.611	8.52	0.012
ALPO 3	06/17/2004	9.43	7.91	1.28	0.618	0.024	8.36	0.005
ALPO 3	08/02/2004	-3.5	9.21	1.15	0.601	0.004	8.27	0.013
ALPO 3	09/02/2004	<.200	10.2	1.54	0.535	0.008	8.90	0.008
ALPO 3	10/21/2004	<.200	8.4	1.45	0.406	0.007	7.77	0.016
ALPO 3	11/16/2004	<.012	8.10	1.36	0.527	0.005	7.96	0.020
ALPO 4	04/15/2004	<.200	10.5	3.28	0.012	1.20	16.1	0.026
ALPO 4	05/06/2004	<.200	8.76	0.659	0.002	0.711	11.2	0.013
ALPO 4	06/17/2004	<.2	15.2	2.73	0.674	0.020	12.9	0.007
ALPO 4	08/02/2004	-10.5	16.5	4.49	0.658	0.014	12.6	0.015
ALPO 4	09/02/2004	<.200	18.5	2.12	0.563	0.012	12.8	0.015
ALPO 4	10/21/2004	<.200	18.6	1.81	0.477	0.004	14.8	0.013
ALPO 4	11/16/2004	<.012	16.2	1.38	0.601	0.007	14.0	0.058
ALPO 5	04/15/2004	3.56	5.10	4.18	0.018	1.74	11.8	0.015
ALPO 5	05/06/2004	0.237	7.58	5.35	0.017	1.47	12.1	0.014
ALPO 5	06/17/2004	<.2	11.7	18	1.331	0.073	11.5	0.007
ALPO 5	08/02/2004	-4.9	12.1	4.30	1.24	0.027	11.3	0.009
ALPO 5	09/02/2004	<.200	16.8	7.54	1.34	0.030	13.2	0.045
ALPO 5	10/21/2004	<.200	14.3	2.01	1.15	0.011	12.4	0.018
ALPO 5	11/16/2004	<.012	13.7	3.14	1.13	0.009	13.6	0.021
ALPO 6	04/15/2004	<.200	9.40	2.49	0.013	1.09	13.1	0.017
ALPO 6	05/06/2004	<.200	14.0	3.72	0.008	0.862	13.2	0.011
ALPO 6	06/17/2004	<.2	23.4	4.89	0.724	0.024	13.2	0.005
ALPO 6	08/02/2004	-25.3	29.4	4.13	0.672	0.012	14.0	0.013
ALPO 6	09/02/2004	<.200	43.8	3.13	0.758	0.020	16.6	0.014
ALPO 6	10/21/2004	<.200	26.4	0.401	0.540	0.006	13.8	0.020
ALPO 6	11/16/2004	<.012	20.9	2.00	0.587	0.006	12.5	0.022

Table A1. Level 1 water quality data, Allegheny Portage Railroad National Historic Site (continued).

Site	Date	Sb (mg/L)	As (mg/L)	Be (mg/L)	Cd (mg/L)	Pb (mg/L)	Ti (mg/L)	Se (mg/L)
ALPO 1	04/15/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
ALPO 1	05/06/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
ALPO 1	06/17/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 1	08/02/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 1	09/02/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 1	10/21/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 1	11/16/2004	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 2	04/15/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
ALPO 2	05/06/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
ALPO 2	06/17/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 2	08/02/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 2	09/02/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 2	10/21/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 2	11/16/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 3	04/15/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
ALPO 3	05/06/2004	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002
ALPO 3	06/17/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 3	08/02/2004	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 3	09/02/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 3	10/21/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 3	11/16/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 4	04/15/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
ALPO 4	05/06/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
ALPO 4	06/17/2004	<0.001	0.001	<0.001	<0.001	0.004	<0.001	<0.001
ALPO 4	08/02/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 4	09/02/2004	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 4	10/21/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 4	11/16/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 5	04/15/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
ALPO 5	05/06/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
ALPO 5	06/17/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 5	08/02/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 5	09/02/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 5	10/21/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 5	11/16/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 6	04/15/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
ALPO 6	05/06/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
ALPO 6	06/17/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 6	08/02/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 6	09/02/2004	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
ALPO 6	10/21/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALPO 6	11/16/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table A1. Level 1 water quality data, Allegheny Portage Railroad National Historic Site (Continued).

Site	Date	Ba (mg/L)	Ca (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Mn (mg/L)	Mg (mg/L)	Ni (mg/L)
ALPO 1	04/15/2004	0.059	17.6	<0.005	<0.005	0.04	0.09	5.21	0.01
ALPO 1	05/06/2004	0.105	25.6	0.02	0.01	0.08	0.11	5.93	0.01
ALPO 1	06/17/2004	0.066	26.0	<0.001	<0.001	0.03	0.09	7.9	0.002
ALPO 1	08/02/2004	0.070	24.2	<0.001	0.001	0.02	0.11	8.8	0.003
ALPO 1	09/02/2004	0.080	33	<0.001	<0.001	0.03	0.17	10.7	0.003
ALPO 1	10/21/2004	0.042	23.7	<0.001	0.001	0.14	0.17	7.4	0.006
ALPO 1	11/16/2004	0.029	21.2	<0.001	0.001	0.02	0.16	6.7	0.003
ALPO 2	04/15/2004	0.049	7.2	<0.005	<0.005	0.03	0.02	2.10	0.01
ALPO 2	05/06/2004	0.052	10.8	0.01	0.01	<0.005	<0.005	2.75	0.02
ALPO 2	06/17/2004	0.062	11.2	<0.001	<0.001	0.03	0.01	2.78	<0.001
ALPO 2	08/02/2004	0.060	12.9	<0.001	<0.001	0.06	0.02	3.15	<0.001
ALPO 2	09/02/2004	0.070	12.2	<0.001	<0.001	0.02	0.01	2.99	<0.001
ALPO 2	10/21/2004	0.040	8.5	<0.001	0.012	0.26	0.01	3.28	0.011
ALPO 2	11/16/2004	0.029	9.9	<0.001	<0.001	0.02	0.01	2.37	<0.001
ALPO 3	04/15/2004	0.043	3.25	<0.005	<0.005	0.01	0.01	0.89	0.01
ALPO 3	05/06/2004	0.039	4.25	0.01	0.01	0.01	0.001	1.09	0.01
ALPO 3	06/17/2004	0.054	5.03	<0.001	<0.001	0.02	0.02	1.16	<0.001
ALPO 3	08/02/2004	0.080	5.3	<0.001	0.002	0.07	0.04	1.00	<0.001
ALPO 3	09/02/2004	0.049	4.54	<0.001	<0.001	0.03	0.02	1.14	<0.001
ALPO 3	10/21/2004	0.044	4.61	<0.001	<0.001	0.03	0.12	1.22	<0.001
ALPO 3	11/16/2004	0.022	4.99	<0.001	<0.001	0.02	0.07	1.33	<0.001
ALPO 4	04/15/2004	0.053	7.0	<0.005	0.01	0.01	0.02	1.91	0.01
ALPO 4	05/06/2004	0.044	5.99	0.01	0.01	0.01	0.001	1.51	0.01
ALPO 4	06/17/2004	0.065	8.6	<0.001	<0.001	0.03	0.01	2.08	<0.001
ALPO 4	08/02/2004	0.080	8.1	<0.001	0.003	0.06	0.02	1.72	<0.001
ALPO 4	09/02/2004	0.051	7.2	<0.001	<0.001	0.03	0.01	1.76	<0.001
ALPO 4	10/21/2004	0.038	8.8	<0.001	<0.001	1.02	0.06	2.39	<0.001
ALPO 4	11/16/2004	0.023	8.1	<0.001	<0.001	0.02	0.03	2.00	<0.001
ALPO 5	04/15/2004	0.056	4.13	<0.005	0.01	0.01	0.01	1.91	<0.005
ALPO 5	05/06/2004	0.050	5.07	<0.005	<0.005	0.01	0.001	2.55	<0.005
ALPO 5	06/17/2004	0.063	6.0	<0.001	<0.001	0.02	0.01	2.78	<0.001
ALPO 5	08/02/2004	0.080	5.6	<0.001	0.002	0.06	0.01	2.21	<0.001
ALPO 5	09/02/2004	0.033	5.4	<0.001	<0.001	0.05	0.01	2.49	<0.001
ALPO 5	10/21/2004	0.035	6.0	<0.001	<0.001	0.04	0.02	2.89	<0.001
ALPO 5	11/16/2004	0.027	5.28	<0.001	<0.001	0.02	0.01	2.35	<0.001
ALPO 6	04/15/2004	0.051	5.65	<0.005	0.01	0.01	0.01	1.71	<0.005
ALPO 6	05/06/2004	0.048	7.2	0.01	<0.005	0.01	0.001	2.38	<0.005
ALPO 6	06/17/2004	0.061	10.4	<0.001	<0.001	0.02	<0.005	2.86	<0.001
ALPO 6	08/02/2004	0.100	11.1	<0.001	<0.001	0.05	0.01	2.55	<0.001
ALPO 6	09/02/2004	0.059	12.1	<0.001	0.001	0.03	0.01	3.15	<0.001
ALPO 6	10/21/2004	0.033	9.9	<0.001	<0.001	0.03	0.01	2.95	<0.001
ALPO 6	11/16/2004	0.024	8.4	<0.001	<0.001	0.02	0.01	2.18	<0.001

Table A1. Level 1 water quality data, Allegheny Portage Railroad National Historic Site (Continued).

Site	Date	K (mg/L)	Na (mg/L)	Sr (mg/L)	Zn (mg/L)	CN (mg/L)	Hg (mg/L)	F.Coliform (FC/100mL)
ALPO 1	04/15/2004	1.59	28.5	0.095	0.02	<0.1	<0.0004	1
ALPO 1	05/06/2004	1.76	32	0.150	<0.005	<0.1	<0.0004	5
ALPO 1	06/17/2004	2.09	47	0.135	0.03	<0.1	<0.0004	22
ALPO 1	08/02/2004	2.28	44	0.100	0.004	<0.1	<0.0004	48
ALPO 1	09/02/2004	2.27	45	0.105	0.004	<0.1	<0.0004	6
ALPO 1	10/21/2004	2.08	29.5	0.086	0.015	<0.1	<0.0004	<2
ALPO 1	11/16/2004	1.63	29.2	0.110	0.007	<0.1	<0.0004	<2
ALPO 2	04/15/2004	1.02	8.7	0.037	<0.005	<0.1	<0.0004	1
ALPO 2	05/06/2004	1.11	8.1	0.037	<0.005	<0.1	<0.0004	1
ALPO 2	06/17/2004	1.01	7.8	0.044	0.03	<0.1	<0.0004	16
ALPO 2	08/02/2004	1.19	9.9	0.050	0.002	<0.1	<0.0004	26
ALPO 2	09/02/2004	1.33	12.0	0.055	0.001	<0.1	<0.0004	22
ALPO 2	10/21/2004	1.31	8.7	0.058	0.011	<0.1	<0.0004	<2
ALPO 2	11/16/2004	1.07	5.8	0.040	0.001	<0.1	<0.0004	<2
ALPO 3	04/15/2004	0.72	0.42	0.019	<0.005	<0.1	<0.0004	<1
ALPO 3	05/06/2004	0.69	0.47	0.022	<0.005	<0.1	<0.0004	<1
ALPO 3	06/17/2004	0.70	0.59	0.022	0.02	<0.1	<0.0004	2
ALPO 3	08/02/2004	0.75	0.61	0.022	0.004	<0.1	<0.0004	2
ALPO 3	09/02/2004	0.73	0.76	0.019	0.002	<0.1	<0.0004	10
ALPO 3	10/21/2004	0.77	0.58	0.022	0.007	<0.1	<0.0004	6
ALPO 3	11/16/2004	0.81	2.17	0.024	0.002	<0.1	<0.0004	2
ALPO 4	04/15/2004	0.98	8.3	0.034	<0.005	<0.1	<0.0004	1
ALPO 4	05/06/2004	0.79	2.47	0.027	<0.005	<0.1	<0.0004	<1
ALPO 4	06/17/2004	0.94	5.05	0.035	0.04	<0.1	<0.0004	50
ALPO 4	08/02/2004	0.93	4.28	0.031	0.003	<0.1	<0.0004	182
ALPO 4	09/02/2004	0.9	3.68	0.027	0.002	<0.1	<0.0004	8
ALPO 4	10/21/2004	1.06	4.89	0.040	0.009	<0.1	<0.0004	4
ALPO 4	11/16/2004	1.01	4.95	0.030	0.001	<0.1	<0.0004	<2
ALPO 5	04/15/2004	0.94	1.30	0.020	<0.005	<0.1	<0.0004	5
ALPO 5	05/06/2004	0.92	1.97	0.026	<0.005	<0.1	<0.0004	30
ALPO 5	06/17/2004	1.03	2.19	0.027	0.03	<0.1	<0.0004	42
ALPO 5	08/02/2004	1.11	2.00	0.024	0.002	<0.1	<0.0004	122
ALPO 5	09/02/2004	1.29	3.21	0.023	0.002	<0.1	<0.0004	178
ALPO 5	10/21/2004	1.36	2.56	0.030	0.003	<0.1	<0.0004	38
ALPO 5	11/16/2004	1.13	2.44	0.024	0.002	<0.1	<0.0004	52
ALPO 6	04/15/2004	0.89	4.48	0.032	<0.005	<0.1	<0.0004	14
ALPO 6	05/06/2004	0.88	3.48	0.036	<0.005	<0.1	<0.0004	34
ALPO 6	06/17/2004	1.07	4.88	0.042	0.03	<0.1	<0.0004	2
ALPO 6	08/02/2004	1.25	6.2	0.040	0.003	<0.1	<0.0004	124
ALPO 6	09/02/2004	1.47	6.6	0.060	0.003	<0.1	<0.0004	250
ALPO 6	10/21/2004	1.23	3.83	0.048	0.002	<0.1	<0.0004	18
ALPO 6	11/16/2004	1.01	3.11	0.038	0.001	<0.1	<0.0004	136

The following figures illustrate median, quartile, and outlier data for water quality parameters measured at ALPO sampling sites. In each figure, the "box" represents median and 1st (Q1) and 3rd quartiles (Q3). The "whiskers" represent the highest and lowest value within the upper and lower limits, respectively, calculated as upper limit = Q3 + 1.5(Q3-Q1) and lower limit = Q1-1.5(Q3-Q1). Statistical outliers, if present, are represented by an asterisk (*). Statistical boxplots were generated for all chemical constituents that were present in concentrations above the laboratory detection limits.

The figures are grouped into the following subsets: nutrients, metals, and general watershed health indicators. Figures contained within the nutrient subset include; nitrate-nitrogen (NO_3-N), sulfates (SO_4), and total phosphorus (TP). Figures contained within the metals subset include aluminum (Al), barium (Ba), calcium (Ca), iron (Fe), magnesium (Mg), manganese (Mn), potassium (K), sodium (Na), strontium (Sr), and zinc (Zn). Figures contained within the general watershed health subset include fecal coliform bacteria and turbidity.

Many of the chemical parameters analyzed have established water quality criteria. These criteria are provided in the USEPA publication, "National Recommended Water Quality Criteria: 2002", available at www.epa.gov. Several different types of criteria are provided in this publication; criteria maximum concentration (CMC), criterion continuous concentration (CCC), and human health consumption. The CMC is defined as an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The CCC is defined as an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

For this inventory, measured pollutant concentrations were compared to both the CMC and CCC criteria when applicable (the majority of pollutants analyzed currently do not have regulatory water quality standards). It is important to note that when grab sample concentrations are compared to these criteria, exceedence of the CMC constitutes impairment of the biological community; whereas, exceedence of the CCC does not necessarily indicate biological impairment. Therefore, the provided CCC values are intended to provide a reference for potential impairment (i.e. risk) only.

There is no Pennsylvania or federal in-stream nutrient threshold criteria for protection of aquatic life. This is principally due to the many factors that determine whether a prescribed concentration of nutrients will impair an aquatic biological community. The phosphorus criteria provided was based upon a study conducted on Pennsylvania watersheds. In their report, Sheeder and Evans (2004) showed that streams can be at risk of biological impairment when median in-stream phosphorus concentrations exceed 0.07 mg P/L.

Nutrient Subset

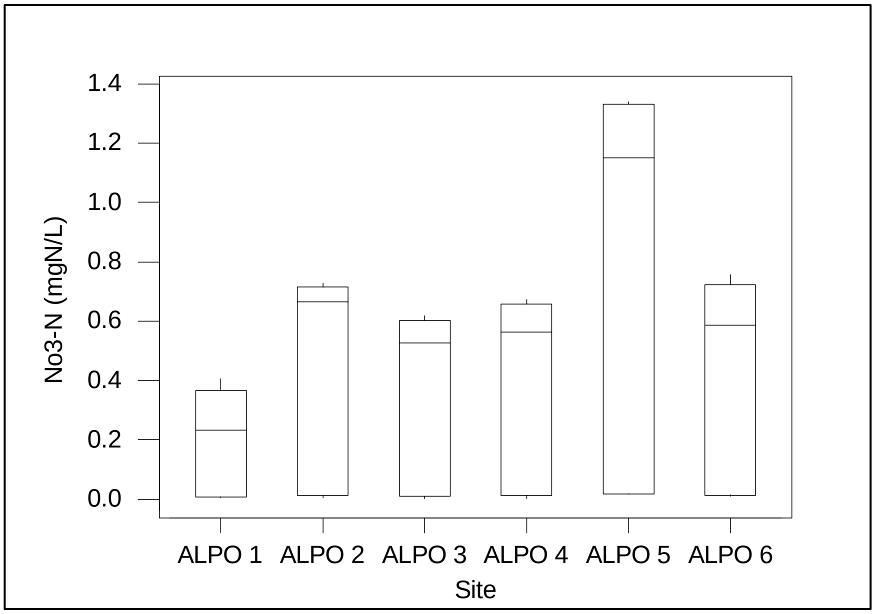

Figure A1. Nitrate-nitrogen (NO_3-N) concentration boxplot for water quality samples collected at ALPO sampling sites.

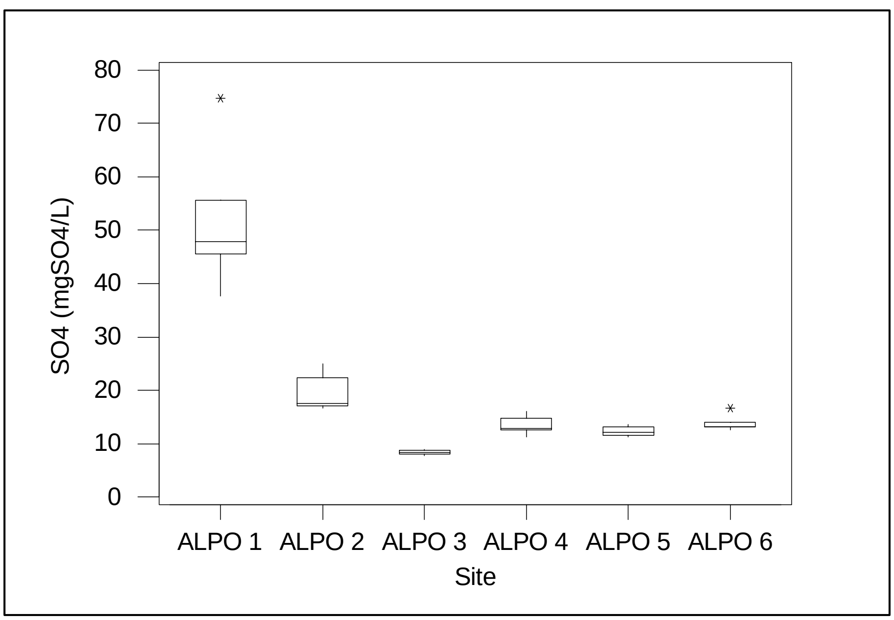

Figure A2. Sulfate (SO_4) concentration boxplot for water quality samples collected at ALPO sampling sites.

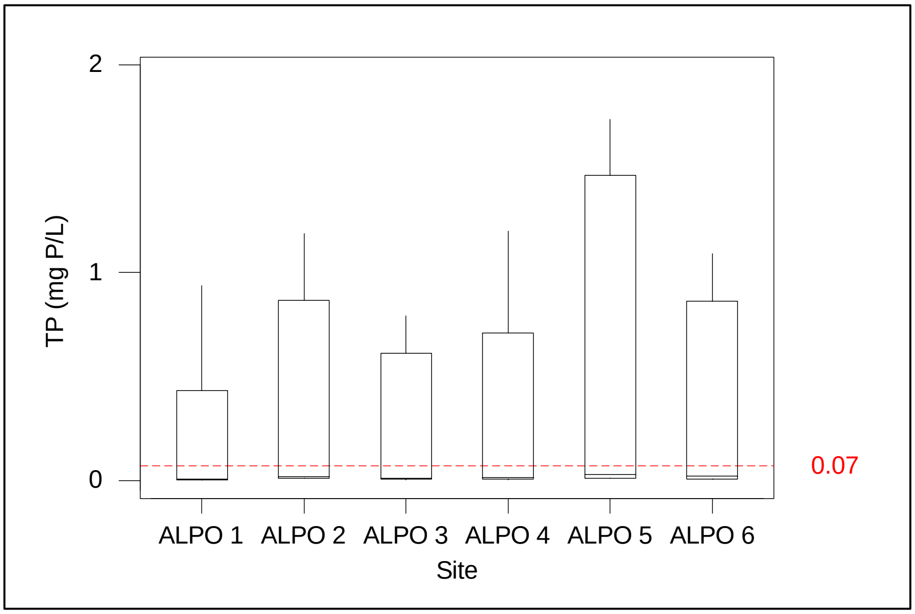

Figure A3. Total phosphorus (TP) concentration boxplot for water quality samples collected at ALPO sampling sites. The red, dashed line at TP = 0.07 represents an approximate median in-stream concentration impairment threshold, derived for Pennsylvania watersheds by Sheeder and Evans (2004).

Metals Subset

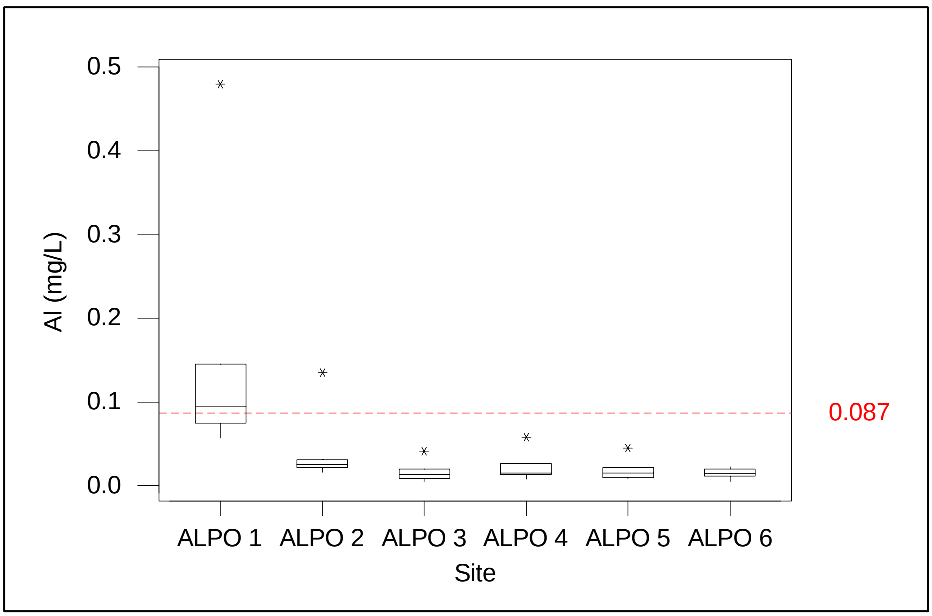

Figure A4. Aluminum (Al) concentration boxplot for water quality samples collected at ALPO sampling sites. The red, dashed line at Al = 0.087 represents the USEPA (2002) CCC for aluminum.

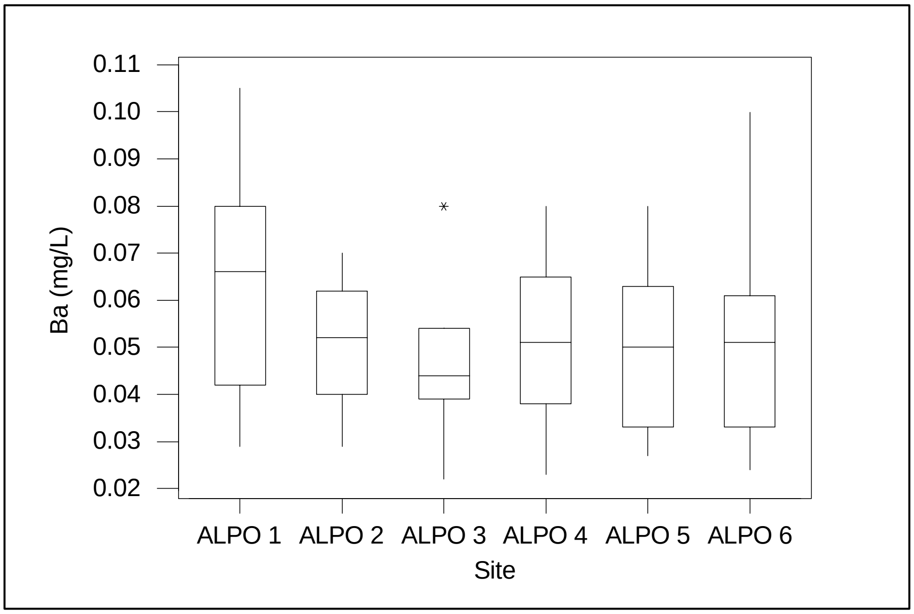

Figure A5. Barium (Ba) concentration boxplot for water quality samples collected at ALPO sampling sites.

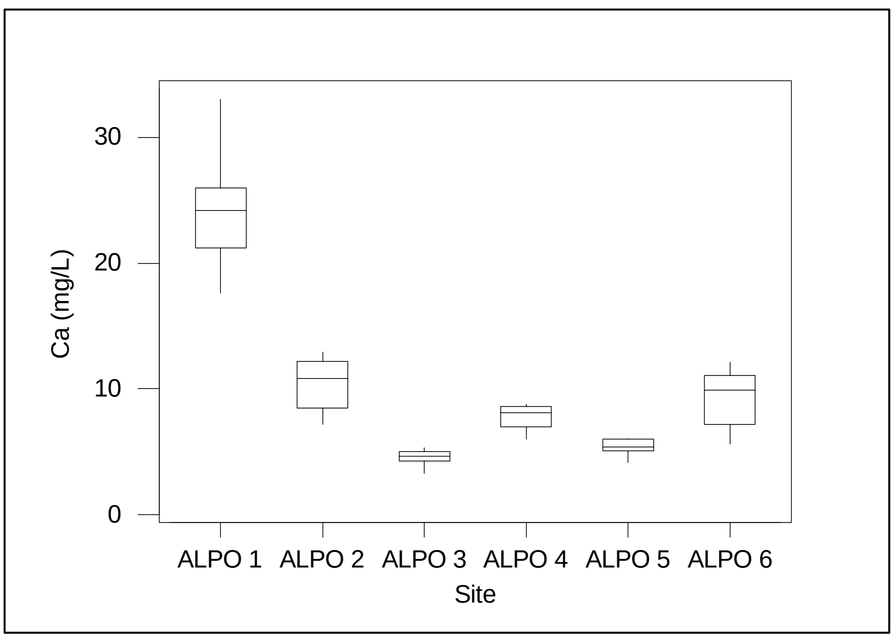

Figure A6. Calcium (Ca) concentration boxplot for water quality samples collected at ALPO sampling sites.

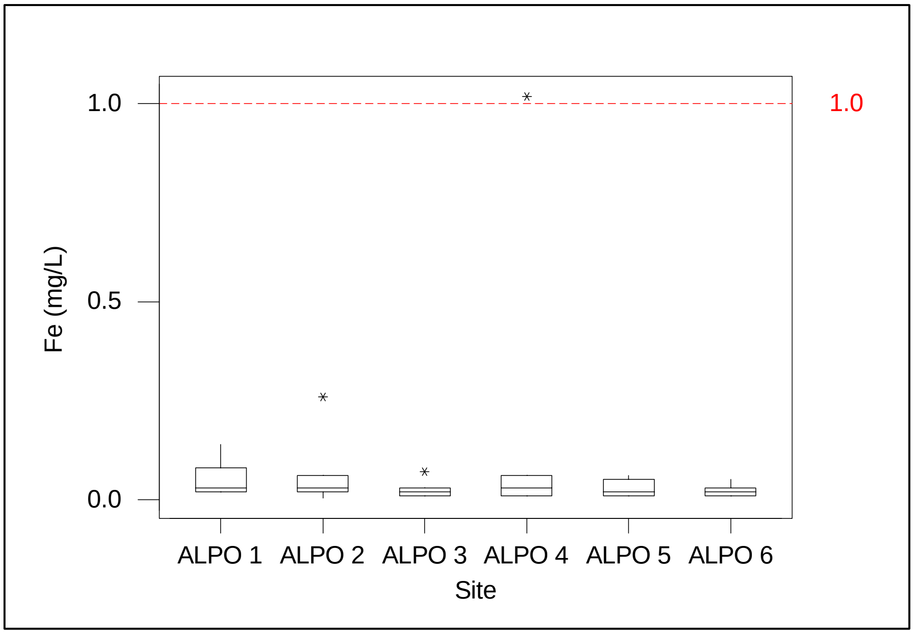

Figure A7. Iron (Fe) concentration boxplot for water quality samples collected at ALPO sampling sites. The red, dashed line at Fe = 1.0 represents the USEPA (2002) CCC for iron.

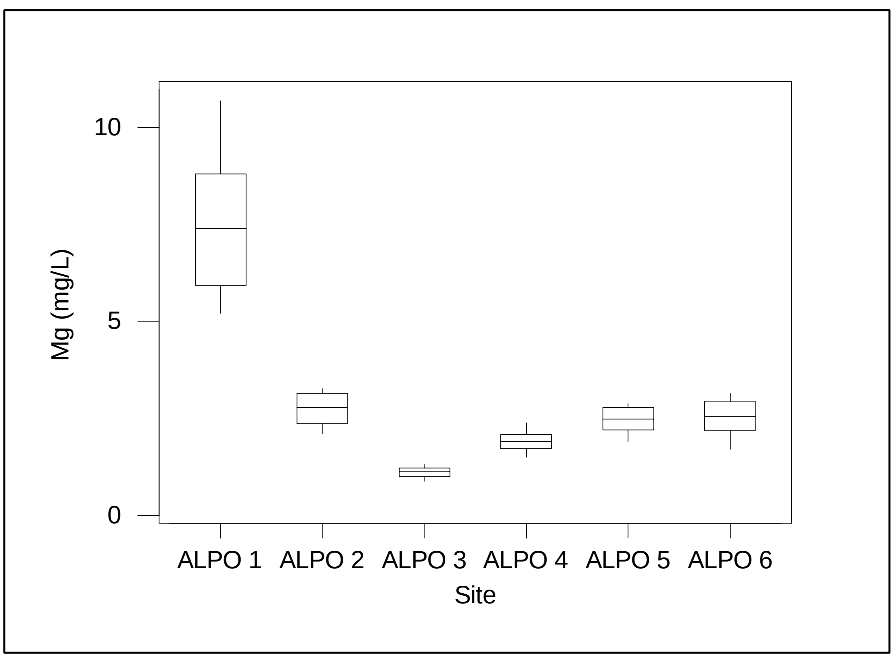

Figure A8. Magnesium (Mg) concentration boxplot for water quality samples collected at ALPO sampling sites.

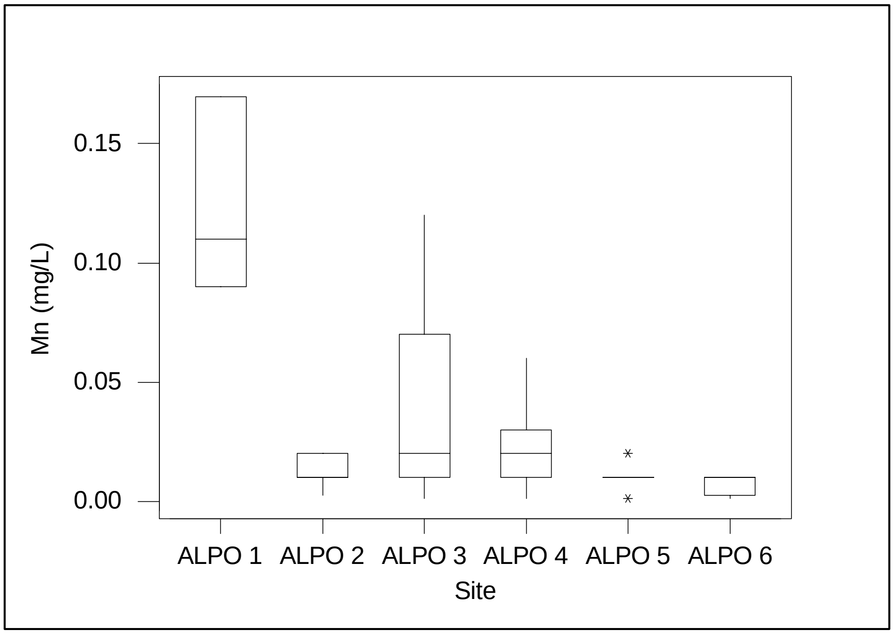

Figure A9. Manganese (Mn) concentration boxplot for water quality samples collected at ALPO sampling sites.

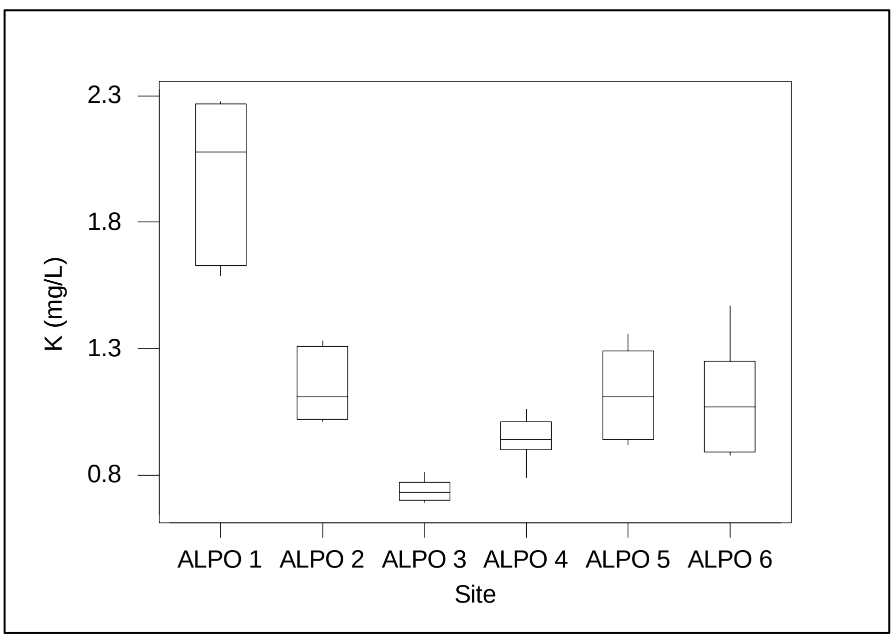

Figure A10. Potassium (K) concentration boxplot for water quality samples collected at ALPO sampling sites.

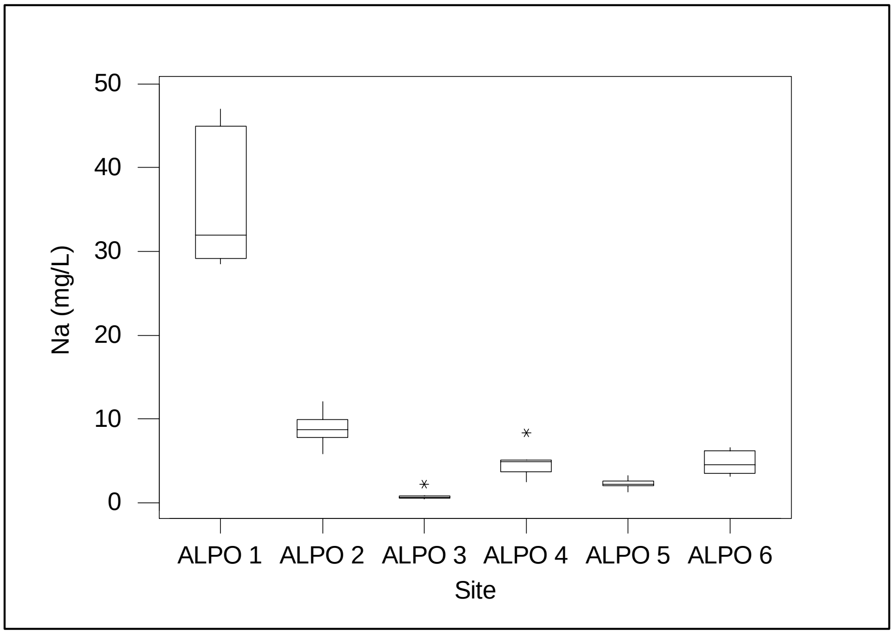

Figure A11. Sodium (Na) concentration boxplot for water quality samples collected at ALPO sampling sites.

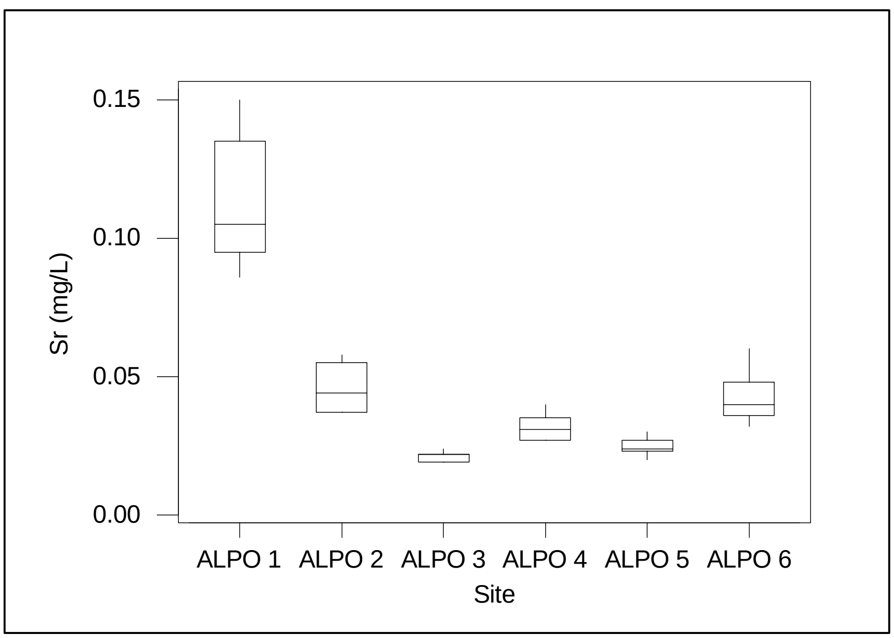

Figure A12. Strontium (Sr) concentration boxplot for water quality samples collected at ALPO sampling sites.

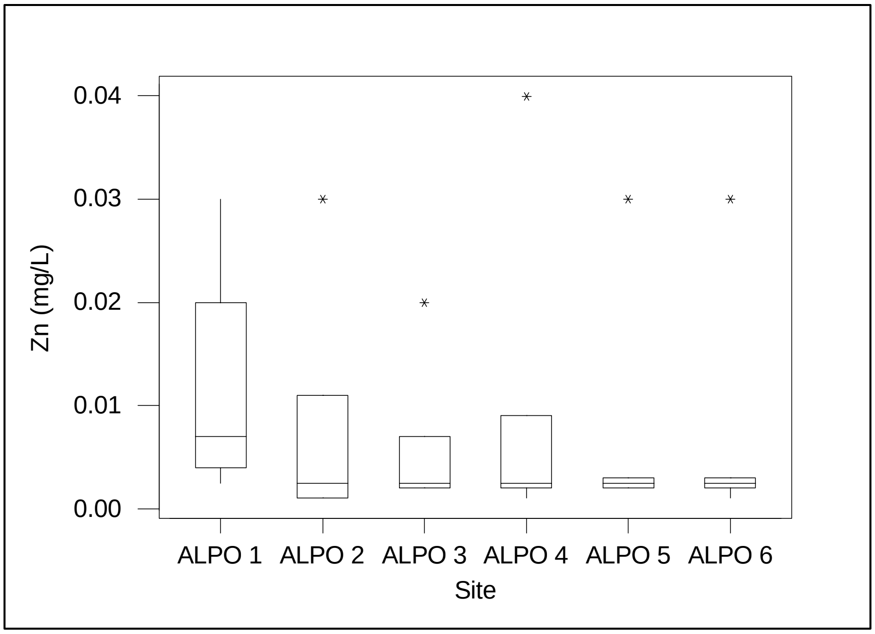

Figure A13. Zinc (Zn) concentration boxplot for water quality samples collected at ALPO sampling sites.

General Watershed Health Subset

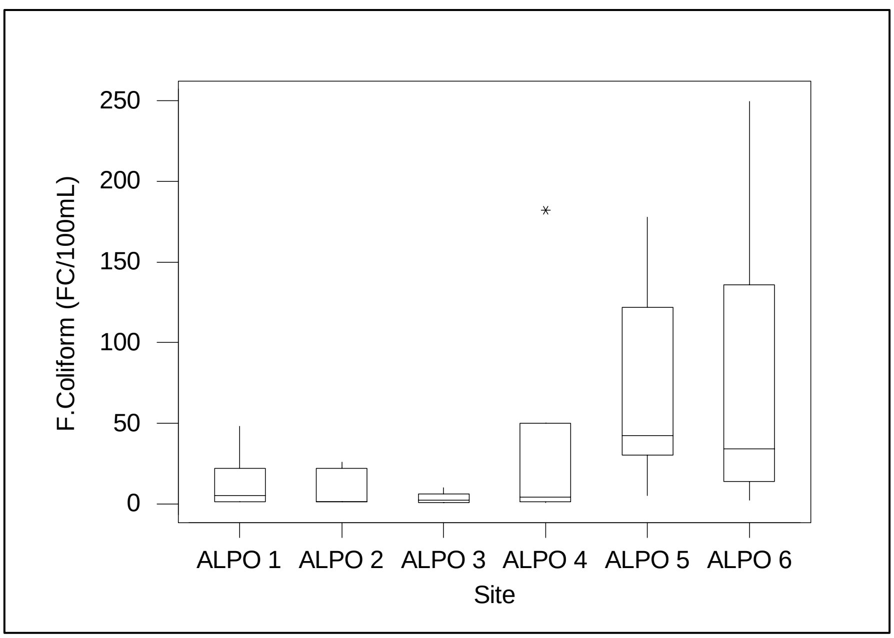

Figure A14. Fecal Coliform bacteria concentration boxplot for water quality samples collected at ALPO sampling sites.

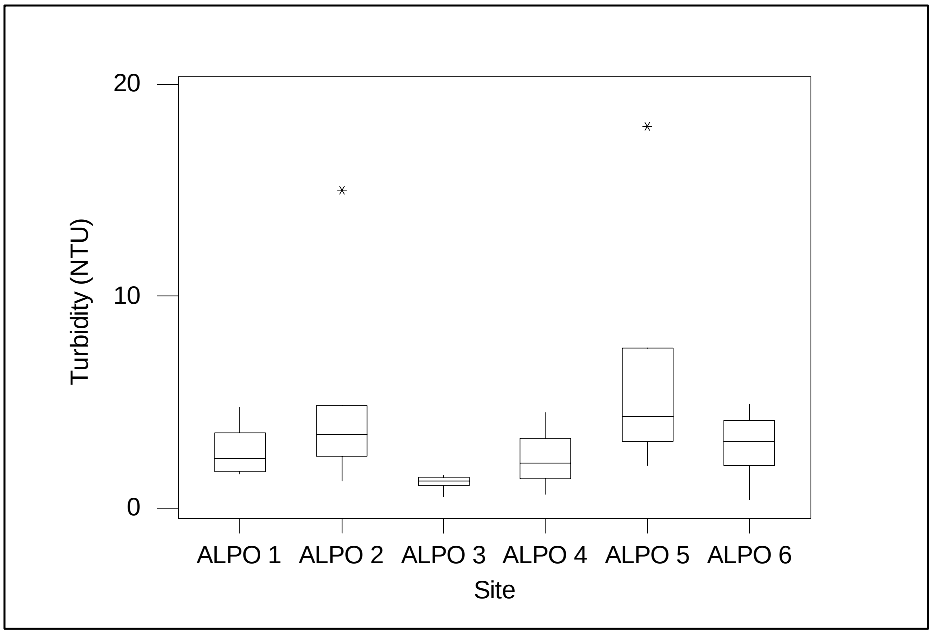

Figure A15. Turbidity (NTU) boxplot for water quality samples collected at ALPO sampling sites.

Appendix B. Data collected at the Johnstown Flood National Memorial (JOFL) water quality sampling sites and statistical boxplots of expanded water quality parameters.

Water Quality Data

All water quality data collected at the Level 1 Johnstown Flood National Memorial (JOFL) water quality sampling sites are provided in table A2.1. Chemical constituent concentrations that were below laboratory detection limits are indicated as "<", followed by the detection limit.

Table B1. Level 1 water quality data, Johnstown Flood National Memorial.

Site	Date	Temp (°C)	Conductivity (µs/cm)	Sp. Conductivity (µs/cm)	pH	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	Stream Flow (ft^3/sec)
JOFL 1	04/13/2004	5.4	170.0		6.64	10.46		
JOFL 1	05/04/2004	9.8	308.2	434.0	5.43	11.77	105.5	119.74
JOFL 1	06/16/2004	16.5	434.0	518.0	5.30	9.37	96.2	85.24
JOFL 1	08/04/2004	18.0	453.2	522.0		9.35	99.2	72.80
JOFL 1	09/07/2004	16.2	573.0	690.0	5.97	8.74	89.4	43.11
JOFL 1	10/28/2004	10.4	413.5	573.0	5.04	10.81	96.9	47.88
JOFL 1	11/18/2004	10.3	360.2	501.0	5.91	11.33	101.2	65.65
JOFL 2	04/13/2004	5.2	100.3		7.38	10.65		73.05
JOFL 2	05/04/2004	7.5	133.3	199.7	7.87	12.90	108.2	1.59
JOFL 2	06/16/2004	17.1	166.1	195.3	6.53	9.85	102.0	4.96
JOFL 2	08/04/2004	18.0	176.6	203.7		9.93	105.4	3.63
JOFL 2	09/07/2004	16.9	194.0	229.5	7.95	8.59	88.7	2.52
JOFL 2	10/28/2004	8.1	146.5	216.6	6.19	11.33	95.7	1.71
JOFL 2	11/18/2004	9.0	139.7	201.3	7.06	11.50	100.1	2.30
JOFL 3	04/13/2004	6.1	140.2		7.36	10.65		5.70
JOFL 3	05/04/2004	9.7	268.9	380.0	8.03	11.85	104.3	0.23
JOFL 3	06/16/2004	15.2	274.0	338.0	7.14	10.02	100.0	0.49
JOFL 3	08/04/2004	17.7	289.9	336.7		9.15	97.0	0.21
JOFL 3	09/07/2004	15.9	313.0	379.4	8.15	8.72	88.2	0.14
JOFL 3	10/28/2004	9.1	265.0	380.1	7.22	11.17	97.9	0.16
JOFL 3	11/18/2004	9.9	241.0	338.0	8.59	10.42	92.6	0.20
JOFL 4	04/13/2004	6.4	181.0		7.81	10.34		14.68
JOFL 4	05/04/2004	11.4	359.6	485.7	8.33	11.47	104.9	0.45
JOFL 4	06/16/2004	17.1	316.4	373.2	7.30	9.06	94.0	1.12
JOFL 4	08/04/2004	18.8	325.4	368.8		9.24	99.6	0.76
JOFL 4	09/07/2004	17.2	360.9	423.7	8.18	8.25	86.4	0.33
JOFL 4	10/28/2004	10.6	301.4	415.0	7.15	11.20	100.8	0.28
JOFL 4	11/18/2004	9.2	262.8	376.4	7.92	11.22	97.6	0.41
JOFL 5	04/13/2004	5.6	102.5		6.96	10.25		
JOFL 5	05/04/2004	13.2	333.7	431.9	5.65	11.11	105.9	130.57
JOFL 5	06/16/2004	17.1	427.1	503.0	6.01	9.50	99.0	91.43
JOFL 5	08/04/2004	20.3	462.0	507.0		9.12	101.9	76.04
JOFL 5	09/07/2004	16.9	567.0	670.0	6.33	8.68	90.0	45.89
JOFL 5	10/28/2004	11.5	416.7	561.0	5.55	10.83	99.2	56.25
JOFL 5	11/18/2004	9.8	346.2	487.6	5.89	11.40	101.0	65.84

Table B1. Level 1 water quality data, Johnstown Flood National Memorial (continued).

Site	Date	Acidity (mg $CaCO_3$/l)	Alkalinity (mg $CaCO_3$/l)	Turbidity NTU	NO_3-N Mg N/l	TP (mg P/l)	SO_4 (mg/l)	Al (mg/L)
JOFL 1	04/13/2004	60.5	8.51	317	0.58	0.652	61.0	0.043
JOFL 1	05/04/2004	243	<.200	23.2	0.010	0.453	185	0.69
JOFL 1	06/16/2004	60.8	2.65	67.5	0.441	0.025	246	0.033
JOFL 1	08/04/2004	39.8	3.03	61.9	0.509	0.007	249	0.048
JOFL 1	09/07/2004	67.7	<.200	39.2	0.273	0.014	369	0.40
JOFL 1	10/28/2004	65.2	<.200	108	0.307	0.020	281	0.26
JOFL 1	11/18/2004	56.2	4.00	65.2	0.355	0.008	227	0.061
JOFL 2	04/13/2004	2.60	23.0	298	0.94	0.952	12.8	0.060
JOFL 2	05/04/2004	<.200	59.7	2.62	0.011	1.10	24.8	0.185
JOFL 2	06/16/2004	<.2	51.7	31.3	1.446	0.073	21.7	0.012
JOFL 2	08/04/2004	-50.2	53.3	5.13	1.57	0.013	24.7	0.009
JOFL 2	09/07/2004	<.200	70.4	8.86	1.26	0.033	25.6	0.026
JOFL 2	10/28/2004	<.200	67.8	2.31	0.607	0.018	23.0	0.015
JOFL 2	11/18/2004	<.012	61.3	2.60	1.06	0.015	21.5	0.037
JOFL 3	04/13/2004	<.200	27.4	94	0.18	1.612	14.3	0.064
JOFL 3	05/04/2004	<.200	94.6	7.21	0.018	1.05	28	0.054
JOFL 3	06/16/2004	<.2	89.7	34.6	1.304	0.108	28.1	0.011
JOFL 3	08/04/2004	-93.2	97.1	7.49	0.820	0.022	30.6	0.015
JOFL 3	09/07/2004	<.200	115.8	6.27	0.481	0.023	28.3	0.026
JOFL 3	10/28/2004	<.200	115	3.56	0.488	0.019	28.6	0.035
JOFL 3	11/18/2004	<.012	105	2.67	0.764	0.010	28.0	0.048
JOFL 4	04/13/2004	<.200	44.6	161	0.34	3.138	25.4	0.068
JOFL 4	05/04/2004	<.200	82.1	6.44	0.021	2.86	38.2	0.028
JOFL 4	06/16/2004	<.2	77.3	36.4	3.797	0.122	31.5	0.090
JOFL 4	08/04/2004	-78.7	82.6	23.1	3.49	0.026	35.6	0.014
JOFL 4	09/07/2004	<.200	98.9	4.3	2.52	0.032	38.2	0.033
JOFL 4	10/28/2004	<.200	95	0.803	1.80	0.017	35.9	0.022
JOFL 4	11/18/2004	<.012	91.1	3.32	2.00	0.012	35.0	0.025
JOFL 5	04/13/2004	6.67	10.3	238	0.39	0.923	37.9	0.079
JOFL 5	05/04/2004	59.8	<.200	18.9	0.011	0.456	183	0.41
JOFL 5	06/16/2004	49.0	2.97	75.5	0.474	0.035	222	0.18
JOFL 5	08/04/2004	33.8	3.24	53.8	0.555	0.010	232	0.034
JOFL 5	09/07/2004	57.7	<.200	40.9	0.338	0.031	344	0.190
JOFL 5	10/28/2004	64.7	<.200	97	0.307	0.030	265	0.110
JOFL 5	11/18/2004	48.6	5.00	61.8	0.377	0.012	217	0.032

Table B1. Level 1 water quality data, Johnstown Flood National Memorial (Continued).

Site	Date	Sb (mg/L)	As (mg/L)	Be (mg/L)	Cd (mg/L)	Pb (mg/L)	Ti (mg/L)	Se (mg/L)
JOFL 1	04/13/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
JOFL 1	05/04/2004	<0.002	<0.002	0.001	<0.002	<0.002	<0.002	<0.002
JOFL 1	06/16/2004	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 1	08/04/2004	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
JOFL 1	09/07/2004	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
JOFL 1	10/28/2004	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001
JOFL 1	11/18/2004	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
JOFL 2	04/13/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
JOFL 2	05/04/2004	<0.002	<0.002	<0.001	<0.002	0.004	<0.002	<0.002
JOFL 2	06/16/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 2	08/04/2004	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 2	09/07/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 2	10/28/2004	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 2	11/18/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 3	04/13/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
JOFL 3	05/04/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
JOFL 3	06/16/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 3	08/04/2004	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 3	09/07/2004	<0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001
JOFL 3	10/28/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 3	11/18/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 4	04/13/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
JOFL 4	05/04/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
JOFL 4	06/16/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 4	08/04/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 4	09/07/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 4	10/28/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 4	11/18/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 5	04/13/2004	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002
JOFL 5	05/04/2004	<0.002	<0.002	0.001	<0.002	<0.002	<0.002	<0.002
JOFL 5	06/16/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 5	08/04/2004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
JOFL 5	09/07/2004	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
JOFL 5	10/28/2004	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
JOFL 5	11/18/2004	<0.001	0.002	0.001	<0.001	<0.001	<0.001	<0.001

Table B1. Level 1 water quality data, Johnstown Flood National Memorial (Continued).

Site	Date	Ba (mg/L)	Ca (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Mn (mg/L)	Mg (mg/L)	Ni (mg/L)
JOFL 1	04/13/2004	0.033	13.6	0.01	<0.005	0.33	0.63	4.97	0.02
JOFL 1	05/04/2004	0.086	39	0.02	0.01	11.9	1.86	7.1	0.13
JOFL 1	06/16/2004	0.060	43	<0.001	<0.001	15.0	1.87	19.0	0.096
JOFL 1	080/4/2004	0.115	42	<0.001	0.001	15.1	1.88	20.0	0.090
JOFL 1	09/07/2004	0.100	56	<0.001	<0.001	22.6	2.31	24.6	0.125
JOFL 1	10/28/2004	0.060	54	<0.001	0.001	18.7	2.20	23.3	0.115
JOFL 1	11/18/2004	0.050	46	<0.001	<0.001	16.0	1.76	18.6	0.077
JOFL 2	04/13/2004	0.028	9.8	<0.005	<0.005	0.07	0.03	2.60	<0.005
JOFL 2	05/04/2004	0.075	22.9	<0.005	<0.005	0.08	0.09	4.98	0.01
JOFL 2	06/16/2004	0.067	20.4	<0.001	<0.001	0.09	0.06	5.2	<0.001
JOFL 2	080/4/2004	0.115	19.9	<0.001	0.002	0.18	0.03	5.6	0.002
JOFL 2	09/07/2004	0.085	30	<0.001	0.001	0.19	0.08	9.0	0.001
JOFL 2	10/28/2004	0.055	22.9	<0.001	<0.001	0.20	0.13	5.7	0.001
JOFL 2	11/18/2004	0.045	22.3	<0.001	<0.001	0.13	0.11	5.3	<0.001
JOFL 3	04/13/2004	0.023	12.3	<0.005	<0.005	0.04	0.01	2.74	<0.005
JOFL 3	05/04/2004	0.140	38	0.01	<0.005	0.02	0.01	5.83	0.01
JOFL 3	06/16/2004	0.078	34	<0.001	<0.001	0.05	0.01	6.7	<0.001
JOFL 3	08/04/2004	0.27	35	<0.001	<0.001	0.08	0.02	8.0	<0.001
JOFL 3	09/07/2004	0.24	45	<0.001	<0.001	0.06	0.02	10.2	<0.001
JOFL 3	10/28/2004	0.087	42	<0.001	<0.001	0.04	0.02	9.0	<0.001
JOFL 3	11/18/2004	0.090	38	<0.001	<0.001	0.03	0.01	7.7	<0.001
JOFL 4	04/13/2004	0.040	19.0	<0.005	0.01	0.07	0.02	4.60	<0.005
JOFL 4	05/04/2004	0.095	36	0.01	<0.005	0.02	0.01	6.2	0.01
JOFL 4	06/16/2004	0.074	32	<0.001	<0.001	0.03	0.01	7.7	<0.001
JOFL 4	08/04/2004	0.185	32	<0.001	<0.001	0.02	0.01	9.1	<0.001
JOFL 4	09/07/2004	0.175	40	<0.001	<0.001	0.02	0.01	10.3	<0.001
JOFL 4	10/28/2004	0.086	39	<0.001	<0.001	0.02	0.01	9.5	<0.001
JOFL 4	11/18/2004	0.095	36	<0.001	<0.001	0.01	0.01	8.5	<0.001
JOFL 5	04/13/2004	0.038	12.3	<0.005	<0.005	0.14	0.46	4.45	0.03
JOFL 5	05/04/2004	0.085	38	0.03	0.01	11.3	1.78	7.2	0.12
JOFL 5	06/16/2004	0.071	42	<0.001	<0.001	13.6	1.86	18.0	0.090
JOFL 5	08/04/2004	0.190	42	<0.001	<0.001	14.0	1.76	19.6	0.085
JOFL 5	09/07/2004	0.185	55	<0.001	<0.001	22.2	2.20	24.4	0.120
JOFL 5	10/28/2004	0.074	50	<0.001	<0.001	17.6	2.09	21.7	0.095
JOFL 5	11/18/2004	0.090	42	<0.001	<0.001	14.6	1.65	17.3	0.060

Table B1. Level 1 water quality data, Johnstown Flood National Memorial (Continued).

Site	Date	K (mg/L)	Na (mg/L)	Sr (mg/L)	Zn (mg/L)	CN (mg/L)	Hg (mg/L)	F.Coliform (FC/100mL)
JOFL 1	04/13/2004	1.39	4.52	0.055	0.05	<0.1	<0.0004	<100
JOFL 1	05/04/2004	1.86	5.51	0.165	0.26	<0.1	<0.0004	<1
JOFL 1	06/16/2004	2.29	7.4	0.175	0.26	<0.1	<0.0004	10
JOFL 1	08/04/2004	2.47	6.8	0.085	0.015	<0.1	<0.0004	1
JOFL 1	09/07/2004	3.03	7.0	0.155	0.014	<0.1	<0.0004	2
JOFL 1	10/28/2004	2.58	6.3	0.165	0.165	<0.1	<0.0004	<2
JOFL 1	11/18/2004	2.22	5.8	0.095	0.175	<0.1	<0.0004	<2
JOFL 2	04/13/2004	1.45	3.30	0.072	0.03	<0.1	<0.0004	2200
JOFL 2	05/04/2004	1.21	7.0	0.175	<0.005	<0.1	<0.0004	54
JOFL 2	06/16/2004	1.55	6.3	0.130	0.05	<0.1	<0.0004	664
JOFL 2	08/04/2004	1.76	7.2	0.065	0.004	<0.1	<0.0004	228
JOFL 2	09/07/2004	1.82	7.1	0.130	0.002	<0.1	<0.0004	120
JOFL 2	10/28/2004	1.87	7.4	0.165	0.002	<0.1	<0.0004	30
JOFL 2	11/18/2004	1.65	6.5	0.120	0.002	<0.1	<0.0004	<2
JOFL 3	04/13/2004	1.26	5.61	0.073	0.01	<0.1	<0.0004	500
JOFL 3	05/04/2004	1.31	17.2	0.30	<0.005	<0.1	<0.0004	54
JOFL 3	06/16/2004	1.43	16.8	0.29	0.03	<0.1	<0.0004	288
JOFL 3	08/04/2004	1.54	13.7	0.135	0.002	<0.1	<0.0004	90
JOFL 3	09/07/2004	1.63	14.8	0.21	0.002	<0.1	<0.0004	90
JOFL 3	10/28/2004	1.69	14.1	0.26	0.002	<0.1	<0.0004	2
JOFL 3	11/18/2004	1.60	11.9	0.21	0.001	<0.1	<0.0004	<2
JOFL 4	04/13/2004	2.47	19.7	0.165	0.02	<0.1	<0.0004	100
JOFL 4	05/04/2004	2.45	33	0.32	<0.005	<0.1	<0.0004	28
JOFL 4	06/16/2004	2.57	22.3	0.20	0.03	<0.1	<0.0004	694
JOFL 4	08/04/2004	2.79	30	0.120	0.002	<0.1	<0.0004	742
JOFL 4	09/07/2004	3.08	24.8	0.21	0.005	<0.1	<0.0004	162
JOFL 4	10/28/2004	2.99	22.6	0.25	0.001	<0.1	<0.0004	48
JOFL 4	11/18/2004	2.62	19.2	0.195	0.001	<0.1	<0.0004	16
JOFL 5	04/13/2004	1.44	6.4	0.075	0.03	<0.1	<0.0004	800
JOFL 5	05/04/2004	1.83	5.34	0.20	0.25	<0.1	<0.0004	<1
JOFL 5	06/16/2004	2.48	7.9	0.185	0.28	<0.1	<0.0004	6
JOFL 5	08/04/2004	2.42	6.8	0.100	0.016	<0.1	<0.0004	4
JOFL 5	09/07/2004	3.00	7.7	0.20	0.017	<0.1	<0.0004	2
JOFL 5	10/28/2004	2.58	6.5	0.165	0.175	<0.1	<0.0004	<2
JOFL 5	11/18/2004	2.22	5.9	0.160	0.175	<0.1	<0.0004	<2

The following figures illustrate median, quartile, and outlier data for water quality parameters measured at the JOFL water quality sampling sites. In each figure, the “box” represents median and 1st (Q1) and 3rd quartiles (Q3). The “whiskers” represent the highest and lowest value within the upper and lower limits, respectively, calculated as upper limit = Q3 + 1.5(Q3-Q1) and lower limit = Q1-1.5(Q3-Q1). Statistical outliers, if present, are represented by an asterisk (*). Statistical boxplots were generated for all chemical constituents that were present in concentrations above the laboratory detection limits.

The figures are grouped into the following subsets: nutrients, metals, and general watershed health indicators. Figures contained within the nutrient subset include; nitrate-nitrogen (NO_3-N), sulfates (SO_4), and total phosphorus (TP). Figures contained within the metals subset include; aluminum (Al), barium (Ba), beryllium (Be), calcium (Ca), iron (Fe), magnesium (Mg), manganese (Mn), nickel (Ni), potassium (K), sodium (Na), strontium (Sr), and zinc (Zn). Figures contained within the general watershed health subset include acidity, fecal coliform bacteria and turbidity.

Many of the chemical parameters analyzed have established water quality criteria. These criteria are provided in the USEPA publication, “National Recommended Water Quality Criteria: 2002” available at www.epa.gov. Several different types of criteria are provided in this publication; criteria maximum concentration (CMC), criterion continuous concentration (CCC), and human health consumption. The CMC is defined as an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The CCC is defined as an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

For this inventory, measured pollutant concentrations were compared to both the CMC and CCC criteria when applicable (the majority of pollutants analyzed currently do not have regulatory water quality standards). It is important to note that when grab sample concentrations are compared to these criteria, exceedence of the CMC constitutes impairment of the biological community; whereas, exceedence of the CCC does not necessarily indicate biological impairment. Therefore, the provided CCC values are intended to provide a reference for potential impairment (i.e. risk) only.

There is no Pennsylvania or federal in-stream nutrient threshold criteria for protection of aquatic life. This is principally due to the many factors that determine whether a prescribed concentration of nutrients will impair an aquatic biological community. The phosphorus criteria provided was based upon a study conducted on Pennsylvania watersheds. In their report, Sheeder and Evans (2004) showed that streams can be at risk of biological impairment when median in-stream phosphorus concentrations exceed 0.07 mg P/L.

Nutrient Subset

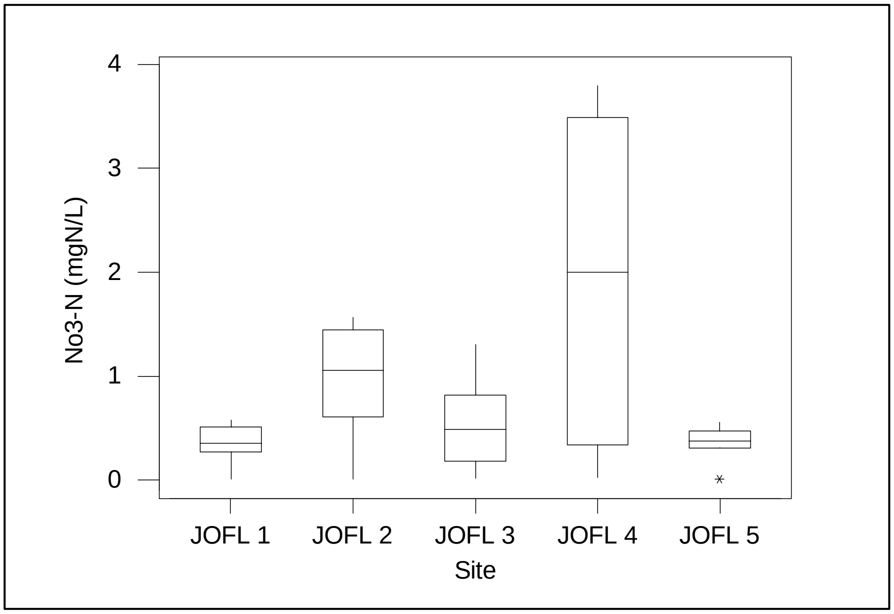

Figure B1. Nitrate-nitrogen (NO_3-N) concentration boxplot for water quality samples collected at JOFL sampling sites.

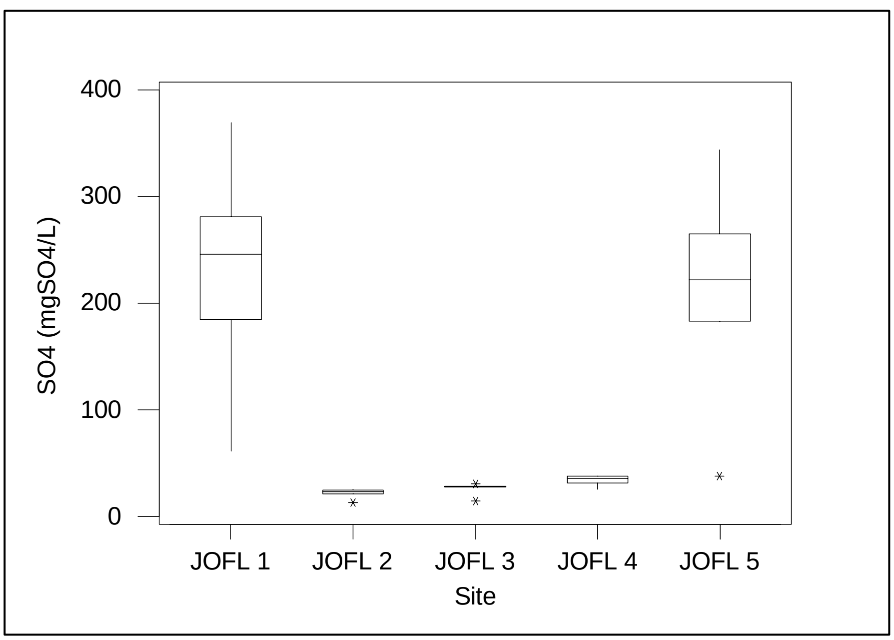

Figure B2. Sulfate (SO_4) concentration boxplot for water quality samples collected at JOFL sampling sites.

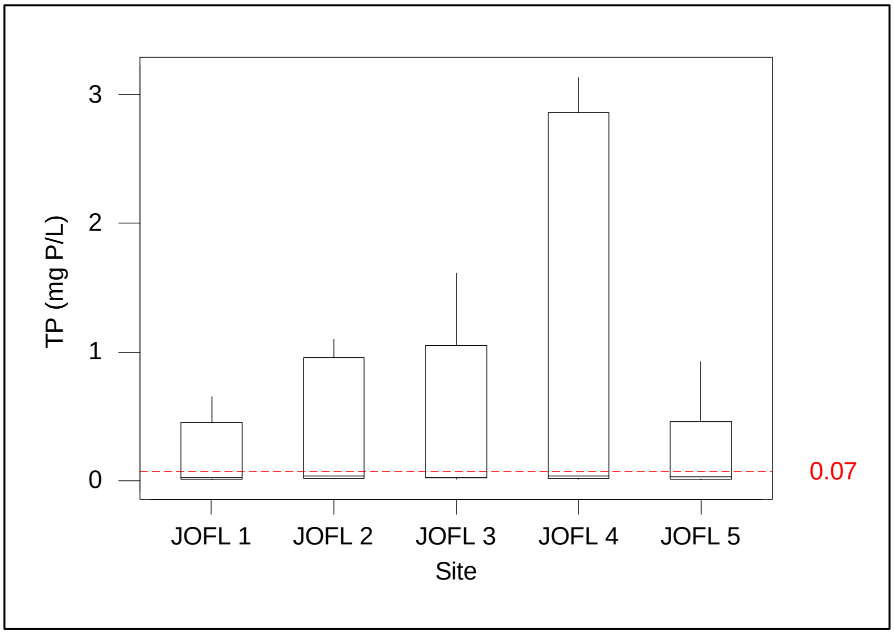

Figure B3. Total phosphorus (TP) concentration boxplot for water quality samples collected at ALPO sampling sites. The red, dashed line at TP = 0.07 represents an approximate median in-stream concentration impairment threshold, derived for Pennsylvania watersheds by Sheeder and Evans (2004).

Metals Subset

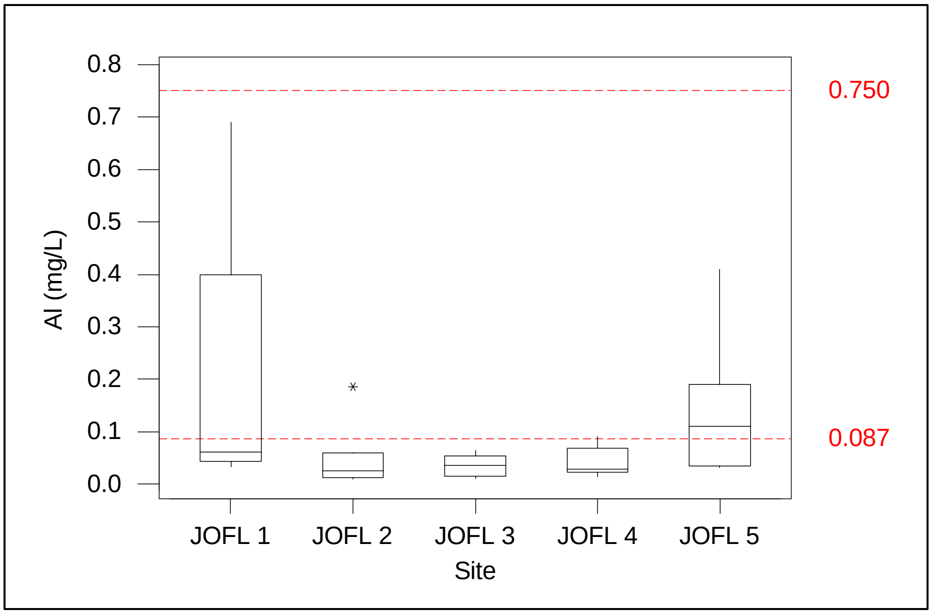

Figure B4. Aluminum (Al) concentration boxplot for water quality samples collected at JOFL sampling sites. The red, dashed lines at Al = 0.087 mg/L and Al = 0.750 mg/L represent the USEPA's CCC and CMC for the protection of aquatic life.

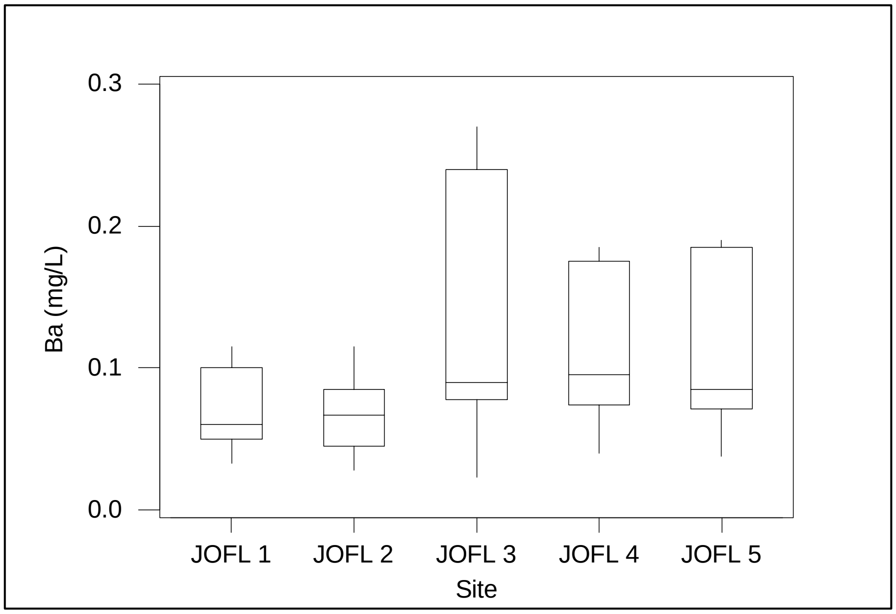

Figure B5. Barium (Ba) concentration boxplot for water quality samples collected at JOFL sampling sites.

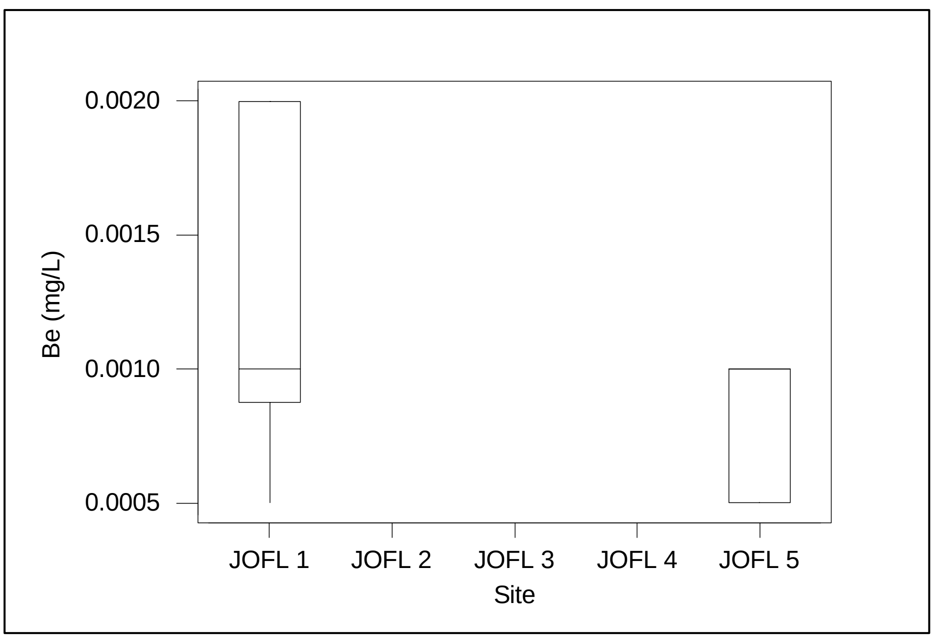

Figure B6. Beryllium (Be) concentration boxplot for water quality samples collected at JOFL sampling sites. Beryllium concentrations at JOFL sites 2, 3, and 4 were below the detection limit in all samples.

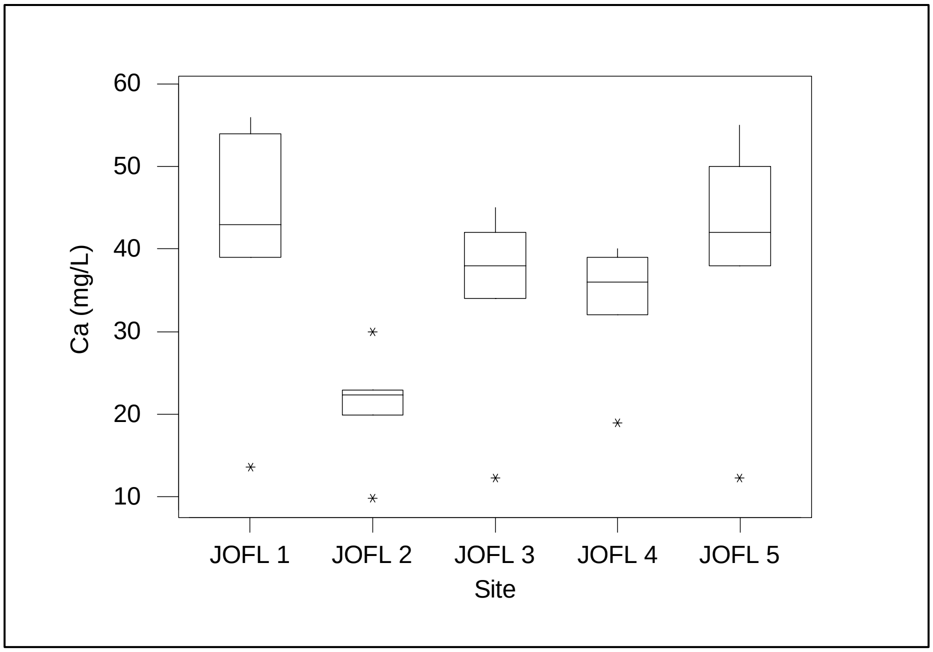

Figure B7. Calcium (Ca) concentration boxplot for water quality samples collected at JOFL sampling sites.

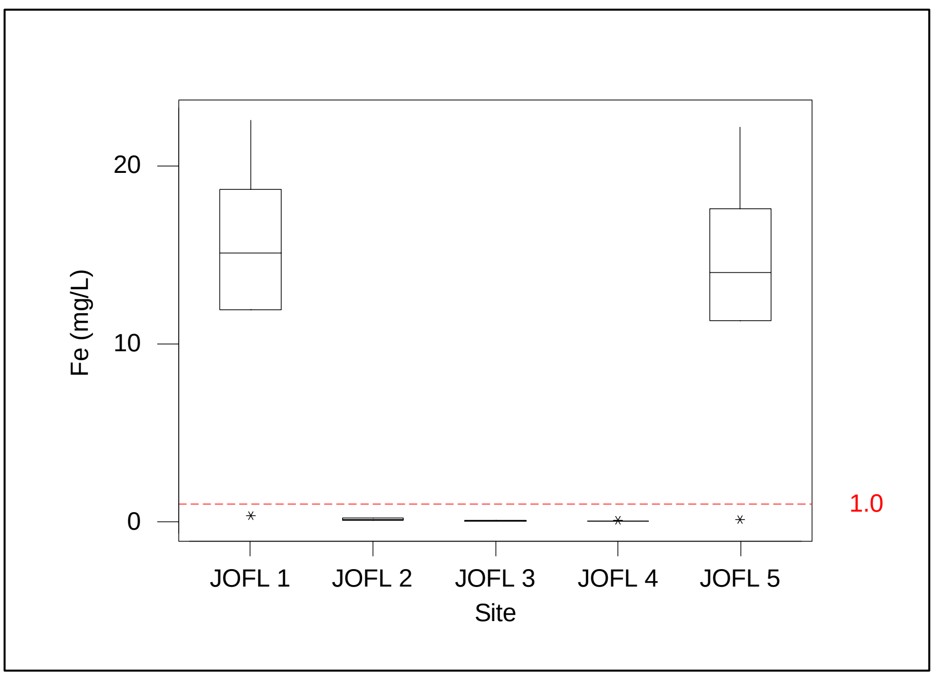

Figure B8. Iron (Fe) concentration boxplot for water quality samples collected at JOFL sampling sites. The red, dashed line at Fe = 1.0 represents the USEPA (2002) CCC for iron.

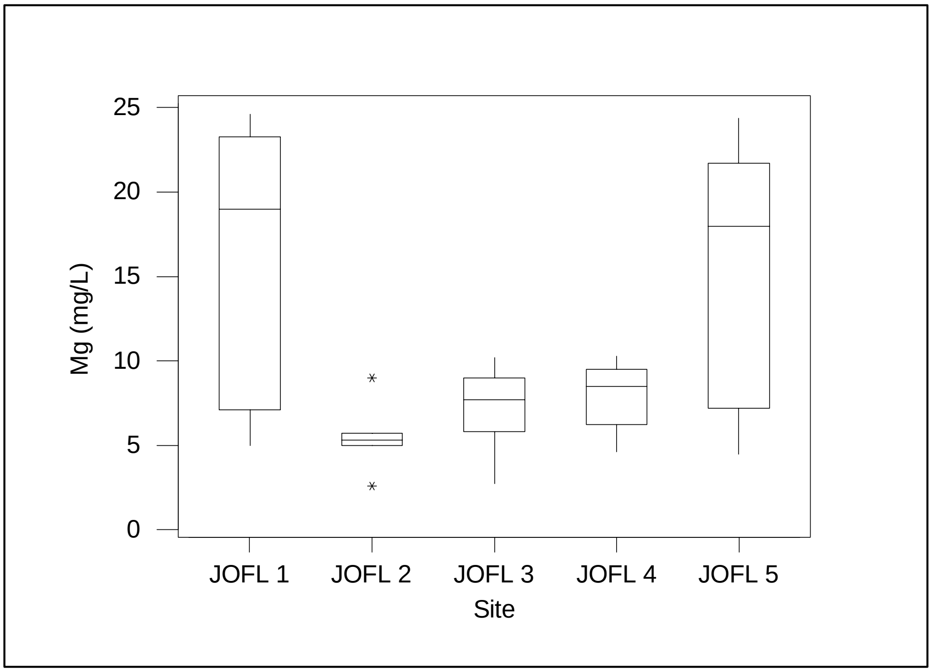

Figure B9. Magnesium (Mg) concentration boxplot for water quality samples collected at JOFL sampling sites.

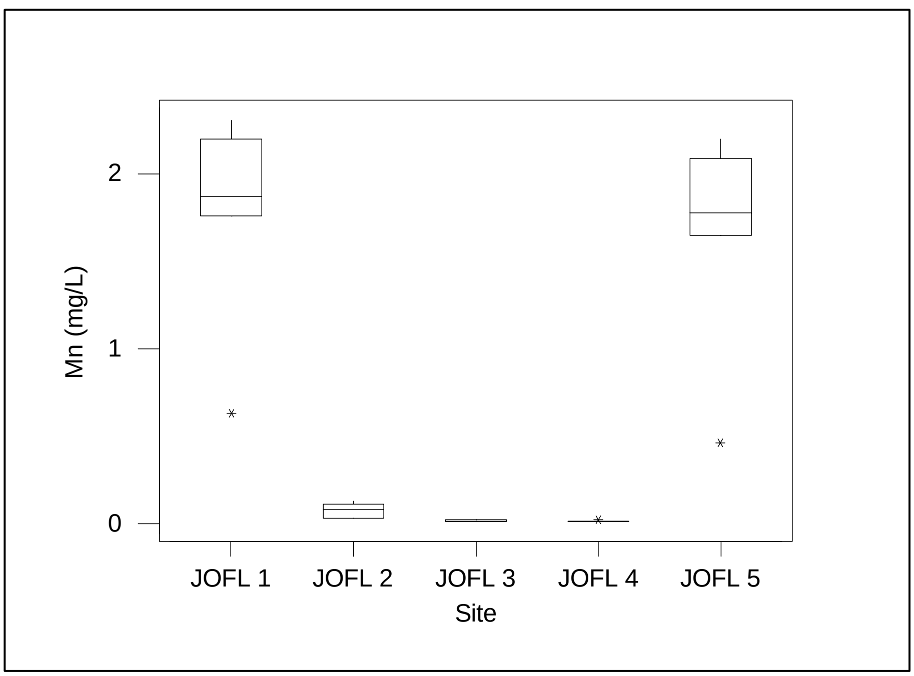

Figure B10. Manganese (Mn) concentration boxplot for water quality samples collected at JOFL sampling sites.

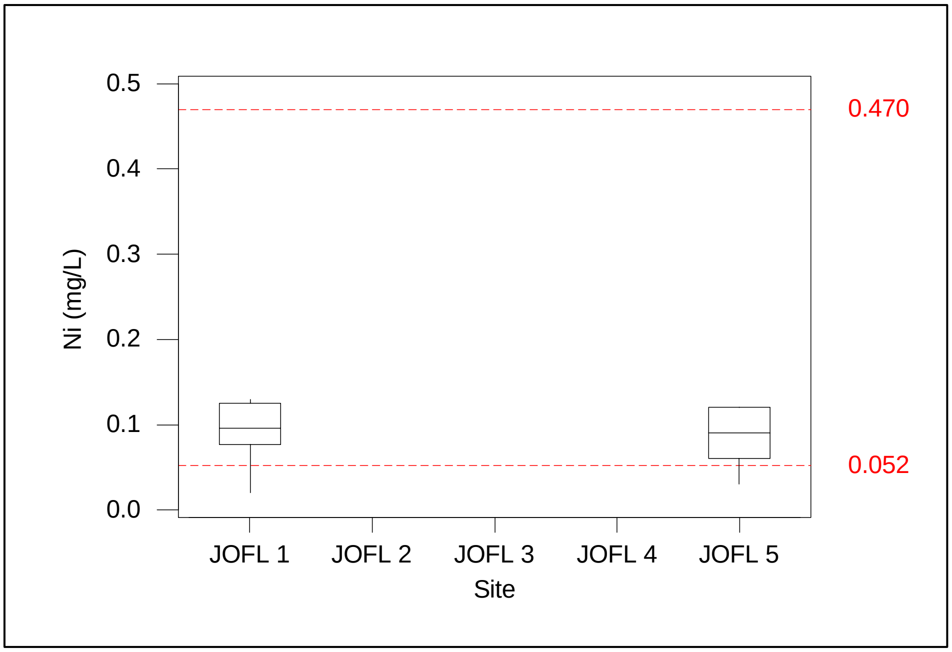

Figure B11. Nickel (Ni) concentration boxplot for water quality samples collected at JOFL sampling sites. The red, dashed lines at Ni = 0.052 mg/L and Ni = 0.470 mg/L represent the USEPA's CCC and CMC for the protection of aquatic life.

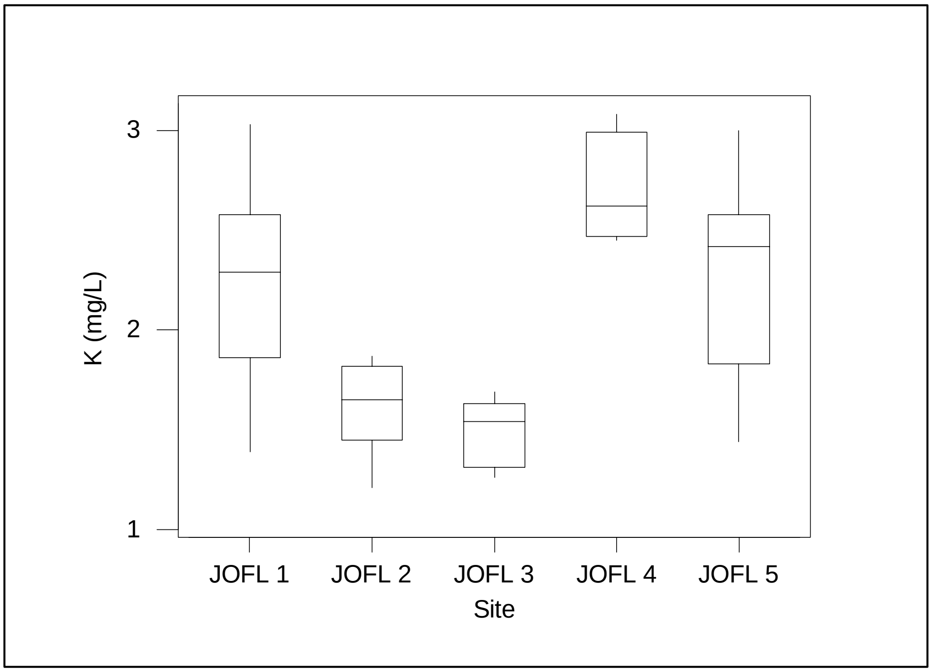

Figure B12. Potassium (K) concentration boxplot for water quality samples collected at JOFL sampling sites.

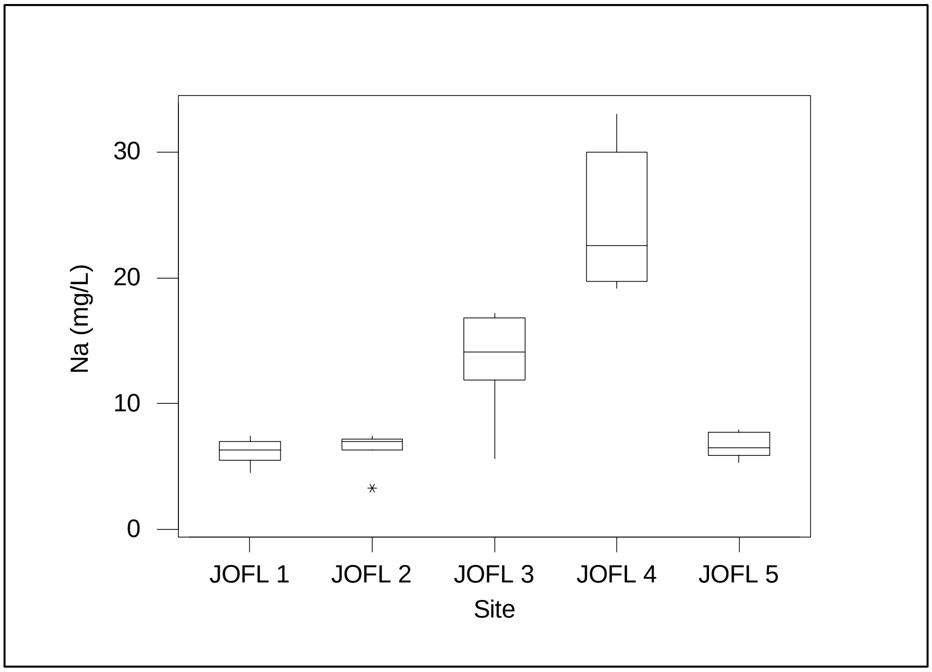

Figure B13. Sodium (Na) concentration boxplot for water quality samples collected at JOFL sampling sites.

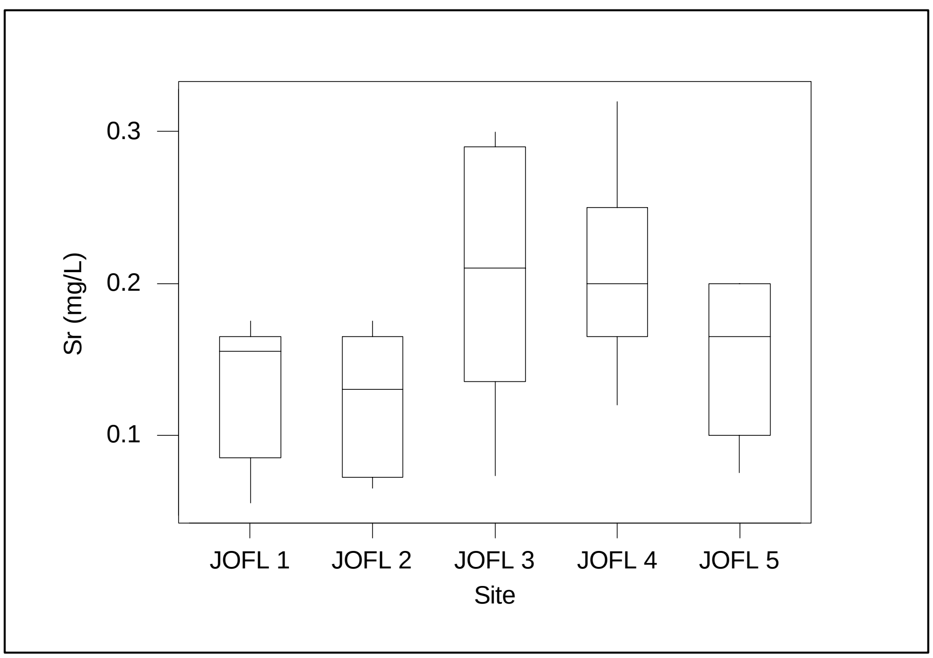

Figure B14. Strontium (Sr) concentration boxplot for water quality samples collected at JOFL sampling sites.

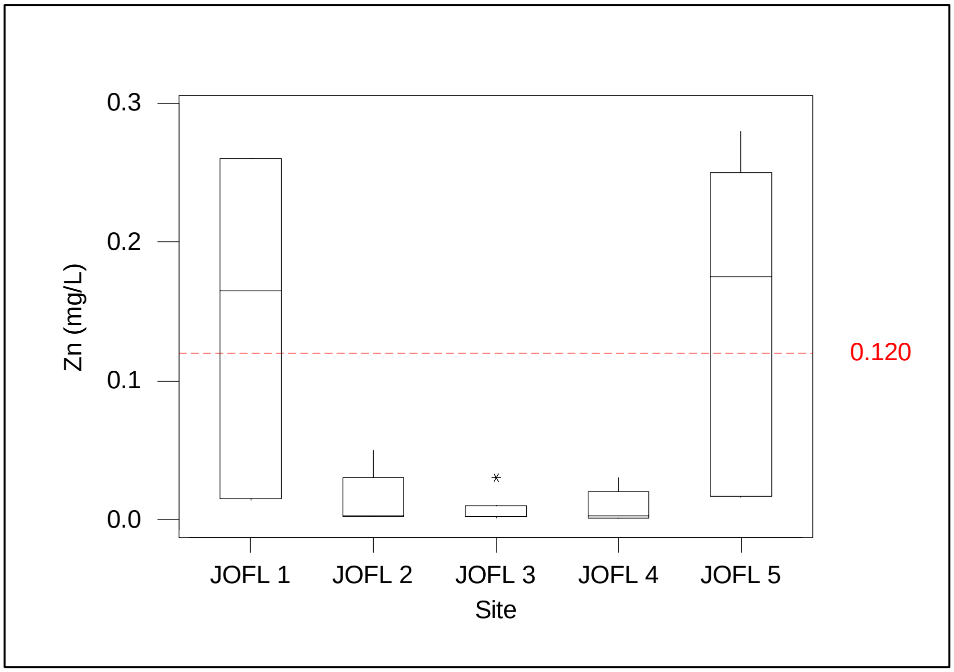

Figure B15. Zinc (Zn) concentration boxplot for water quality samples collected at JOFL sampling sites. The red, dashed line at Zn = 0.120 mg/L represents the USEPA's CCC and CMC for the protection of aquatic life.

General Watershed Health Subset

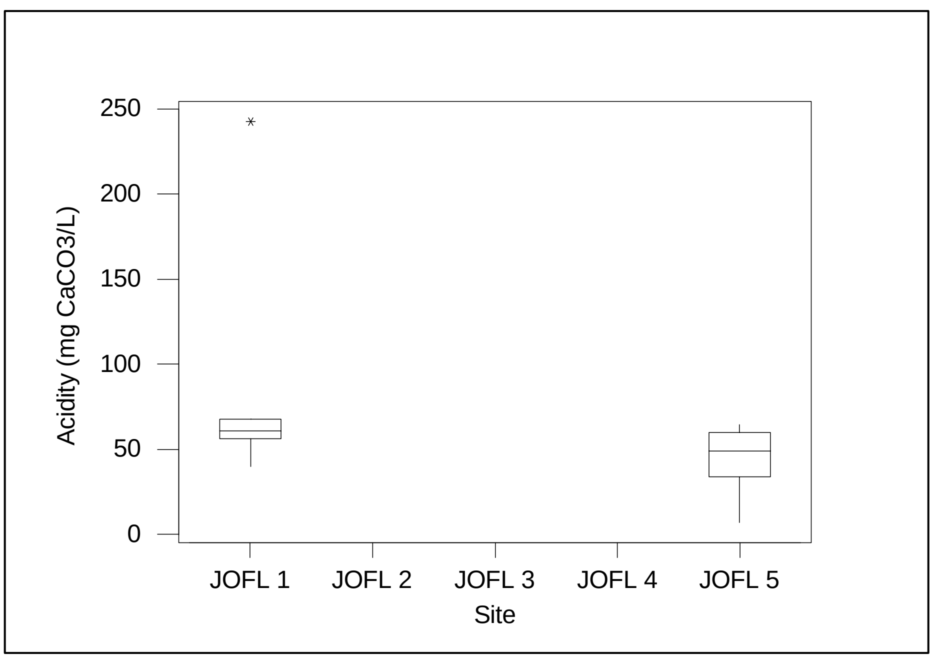

Figure B16. Acidity concentration boxplot for water quality samples collected at JOFL sampling sites.

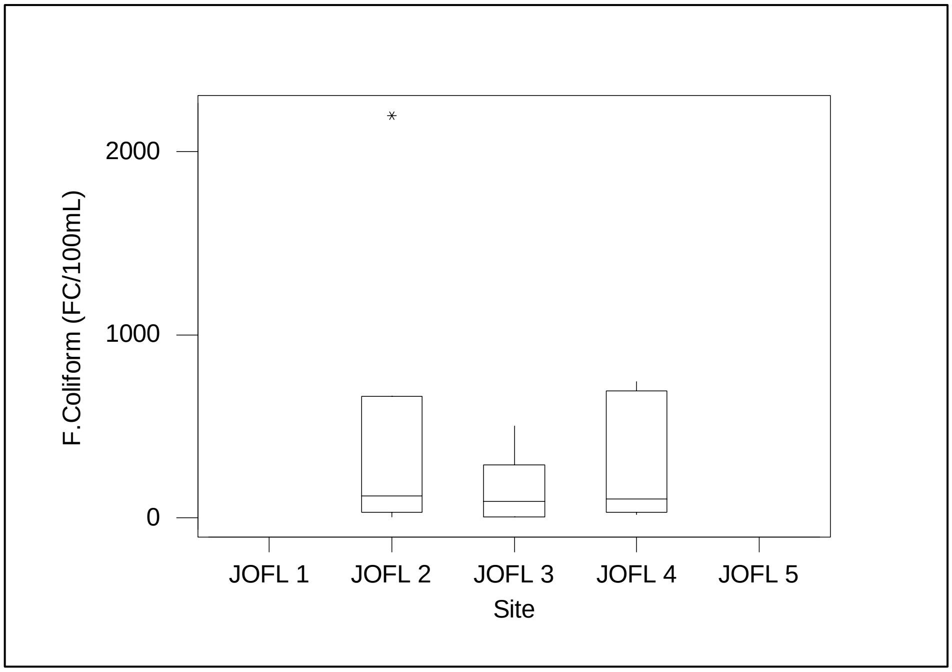

Figure B17. Fecal Coliform bacteria concentration boxplot for water quality samples collected at JOFL sampling sites.

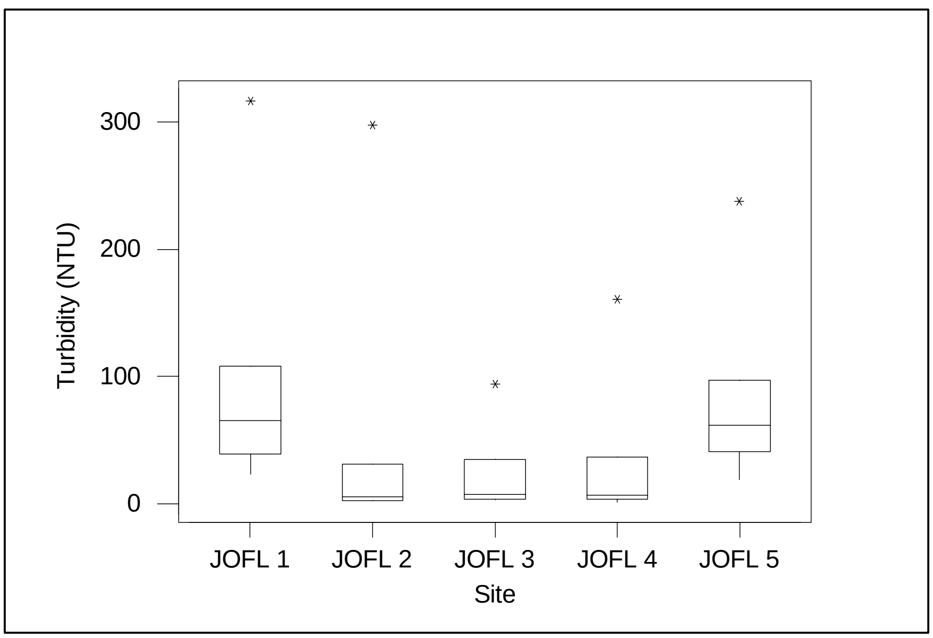

Figure B18. Turbidity (NTU) boxplot for water quality samples collected at JOFL sampling sites.

As the nation's primary conservation agency, the Department of the Interior has responsibility for most of our nationally owned public land and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-103 October 2006

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