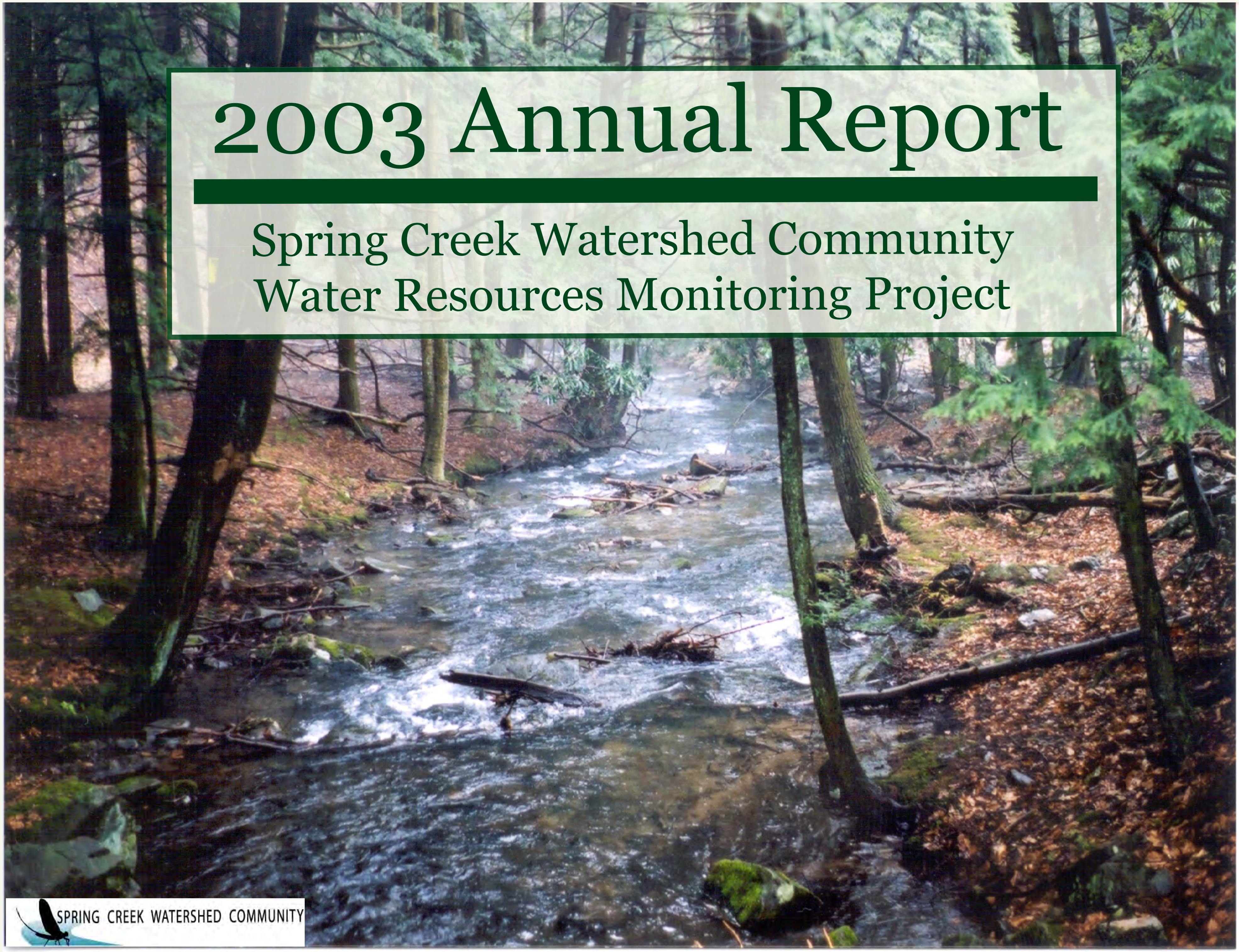
2003 Annual Report

Spring Creek Watershed Community Water Resources Monitoring Project



SPRING CREEK WATERSHED COMMUNITY

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A Sampling of Data Highlights from this 5-year Summary

- Among the 12 sampling stations in the watershed, water quality was highest in Lower Buffalo Run, Lower Logan Branch, and Upper Spring Creek.
- Water quality was poorest in Slab Cabin Run Upper, Spring Creek at Axemann, and Spring Creek at Milesburg.
- None of the 5-year mean values for nutrients or metals exceeded the Pennsylvania Department of Environmental Protection criteria for clean water.
- The warmest stream temperatures were recorded in Slab Cabin Run and Spring Creek at Houserville; the coolest stream temperatures were recorded in Logan Branch, Spring Creek at Oak Hall, and Spring Creek at Milesburg.
- Stream flow in urbanized sub-basins such as Slab Cabin Run was most severely influenced by drought conditions and by storm events.
- During storms stream flow increased most rapidly in streams draining urban areas.
- During the 1998 – 2003 period, rainfall ranged from about 26% below normal in 2000 to 41% above normal in 2003; these extremes were reflected in stream flows and groundwater supplies.
- Monitoring wells showed a gradual decline in the water table starting in late 1998 and continuing until 2002. Water-table levels rose significantly during 2003 in response to the record above-normal precipitation.

Copies of this report and data collected by the Water Resources Monitoring Project will be available at:
Spring Creek Watershed Community's Website www.springcreekwatershed.org
or
ClearWater Conservancy
2555 North Atherton Street
State College, PA 16803
(814) 237-0400

The Water Resources Monitoring Committee would like to extend a special thank you to Thomas Campitelli and Larry Fennessey for their contributions to this report. Front Cover: Galbraith Gap Run by Katie Ombalski

1.0 INTRODUCTION

The intent of the Water Resources Monitoring Project (WRMP) 2003 Annual Report is to document the data-gathering and interpretive work of the WRMP and to illustrate how the project has evolved to reflect the needs and concerns of the Watershed's residents. Rather than focus solely on data collected in 2003, this report summarizes five years of cumulated data and provides recommendations to promote overall Watershed health.

Also included in this document are WRMP project background information and methodology, as well as a list of agencies and authorities who have used WRMP data. An addendum provides a summary of the 2003 base-flow data and is available upon request. If you are interested in receiving a copy, contact the project manager at (814) 237-0400.

THE WATER RESOURCES MONITORING COMMITTEE

The 2003 – 2004 Water Resources Monitoring Committee is a volunteer group comprised of twelve professionals who oversee and guide the activities of the Water Resources Monitoring Project (Table 1).

PROJECT FUNDING

In 2003, financial support for the Water Resources Monitoring Project (WRMP) came from a variety of Watershed stakeholders including:

- State College Borough Water Authority
- University Area Joint Authority
- Penn State University Office of Physical Plant
- Benner Township
- Bellefonte Borough
- Halfmoon Township
- Harris Township
- Milesburg Borough
- Patton Township
- Spring Township
- State College Borough
- Spring Creek Chapter of Trout Unlimited
- Pennsylvania Department of Environmental Protection

Table 1. 2003-2004 Water Resources Monitoring Committee.

WRMP Committee Member	Affiliation
Robert Carline, Ph.D. Committee Chair, Adjunct Professor and Leader	Pennsylvania Cooperative Fish & Wildlife Research Unit, USGS
Bert Lavan Committee Vice-Chair, Senior Process Engineer	Corning Asahi Video Products
Chris Finton, P.G. * Hydrogeologist	Meiser & Earl, Inc.
Steve Foard, P.E. ** Environmental/Safety Manager	Murata Electronics North America, Inc.
Dennis Genito Physical Science Technician	U.S. Department of Agriculture
Todd Giddings, Ph.D., P.G. Hydrogeologist	Todd Giddings and Associates, Inc.
James Hamlett, Ph.D. Associate Professor of Agricultural Engineering	Department of Agricultural and Biological Engineering The Pennsylvania State University
Mark Ralston, P.G. Hydrogeologist	Converse Consultants
John Sengle Water Quality Specialist	PA Department of Environmental Protection
David Smith Assistant Executive Director	University Area Joint Authority
Rick Wardrop, P.G. Hydrogeologist and Industrial Contamination Specialist	USFilter Groundwater Services and Shaw Environmental & Infrastructure
Dave Yoxtheimer, P.G. Senior Hydrogeologist	USFilter Groundwater Services

* Professional Geologist
** Professional Engineer

SPRING CREEK WATERSHED FACTS

The Spring Creek Watershed is approximately 145 square miles (as delineated from surface topography). Due to hydrogeologic conditions, the ground-water boundary of the watershed is slightly larger at 175 square miles. The watershed is home to approximately 94,000 people, 14 municipalities, and the University Park Campus of the Pennsylvania State University. According to 34 years of historical data, an average of 148 million gallons of water leaves the Spring Creek Watershed daily at Milesburg. After the water leaves the Spring Creek Watershed, it flows into Bald Eagle Creek and eventually reaches the West Branch of the Susquehanna River and the Chesapeake Bay.

The citizens living in the watershed, local businesses, and industries rely almost entirely on ground water for drinking water and water supply. To meet the drinking water demand, approximately 25 Public Water Supply (PWS) systems pump about 16.8 million gallons of ground water daily from the limestone and dolomite aquifers located under the valley floor.

IN-KIND CONTRIBUTIONS

The Water Resources Monitoring Project received over $40,000 of in-kind contributions in 2003. These contributions included professional services, fundraising materials, ground-water monitoring wells, stilling well maintenance, technical assistance, chemical supplies, transportation, and laboratory facilities and analyses. In-kind contributors for 2003 include:

- Bryce Boyer
- Converse Consultants
- Corning Asahi Video Products
- Exygen Research
- Pennsylvania Cooperative Fish and Wildlife Research Unit, United States Geological Survey
- Pennsylvania Department of Conservation and Natural Resources Bureau of Forestry
- Pennsylvania Department of Environmental Protection
- Pennsylvania State University Office of Physical Plant
- Private well owners (2)
- Todd Giddings and Associates
- United States Geological Survey
- University Area Joint Authority
- USFilter Groundwater Services
- Volunteer field assistants and Penn State University students
- Water Resources Monitoring Committee

2.0 MONITORING STATIONS

The twelve base flow and storm water monitoring stations (Figure 1) were established so that Spring Creek's water could be monitored as it flowed from the upper part of the Watershed to its confluence with Bald Eagle Creek (in Milesburg).

The groundwater reservoir in the Spring Creek Watershed is monitored with a network of seven ground-water monitoring wells (Figure 2).

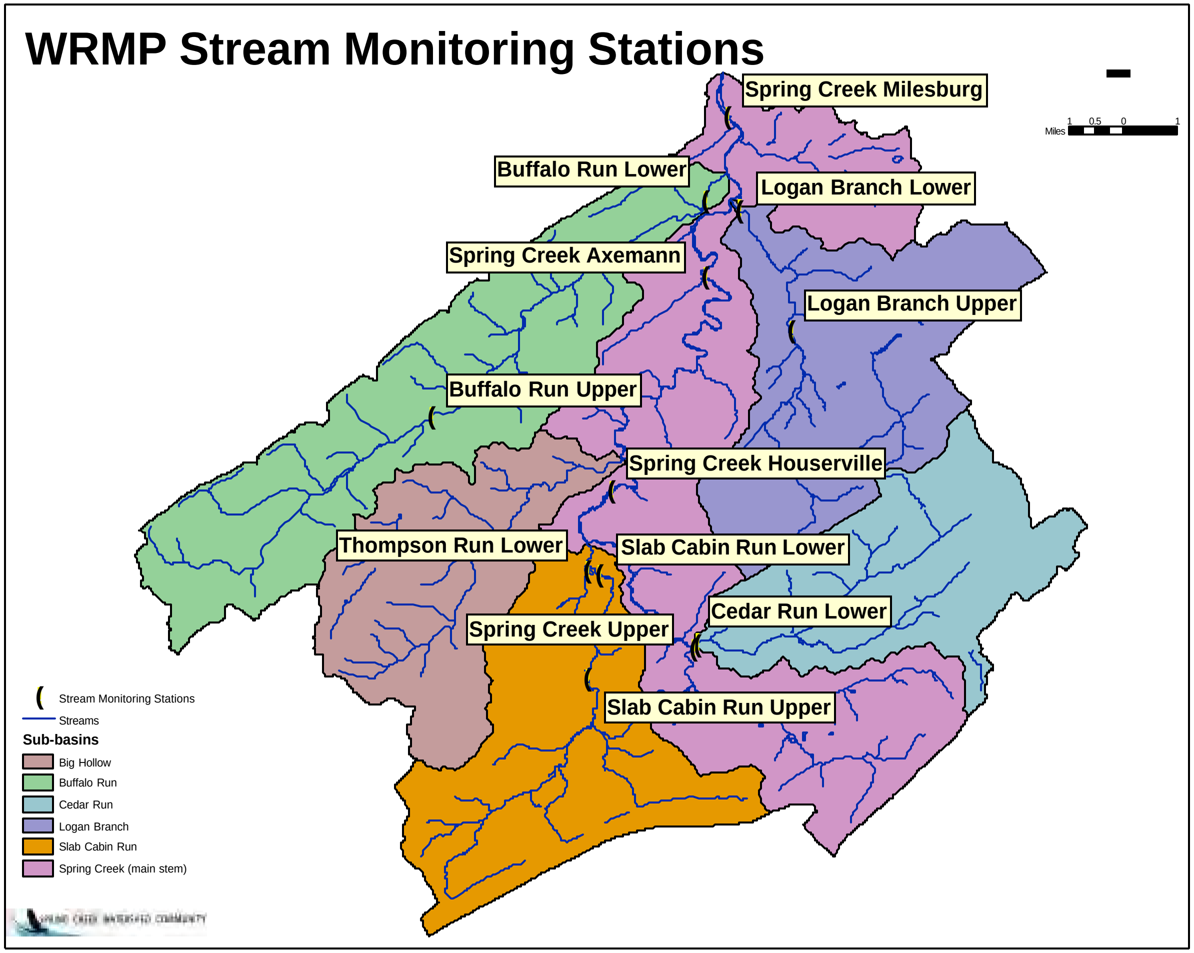


Figure 1. WRMP Stream Monitoring Stations.

3.0 METHODS

Data collection is carried out according to standardized methods that are documented in the Spring Creek Watershed Water Resources Monitoring Protocol and the Spring Creek Watershed Storm Water Monitoring Protocol. The following is a brief description of the methods used and parameters measured.

BASE FLOW MEASUREMENTS

Streamflow

Streamflow data are recorded every 30 minutes at nine of the 12 monitoring stations by the WRMP and every 15 minutes at the three U.S. Geological Survey stations.

Water Temperature

Water temperature monitoring instruments located at all 12 monitoring sites record temperature hourly.

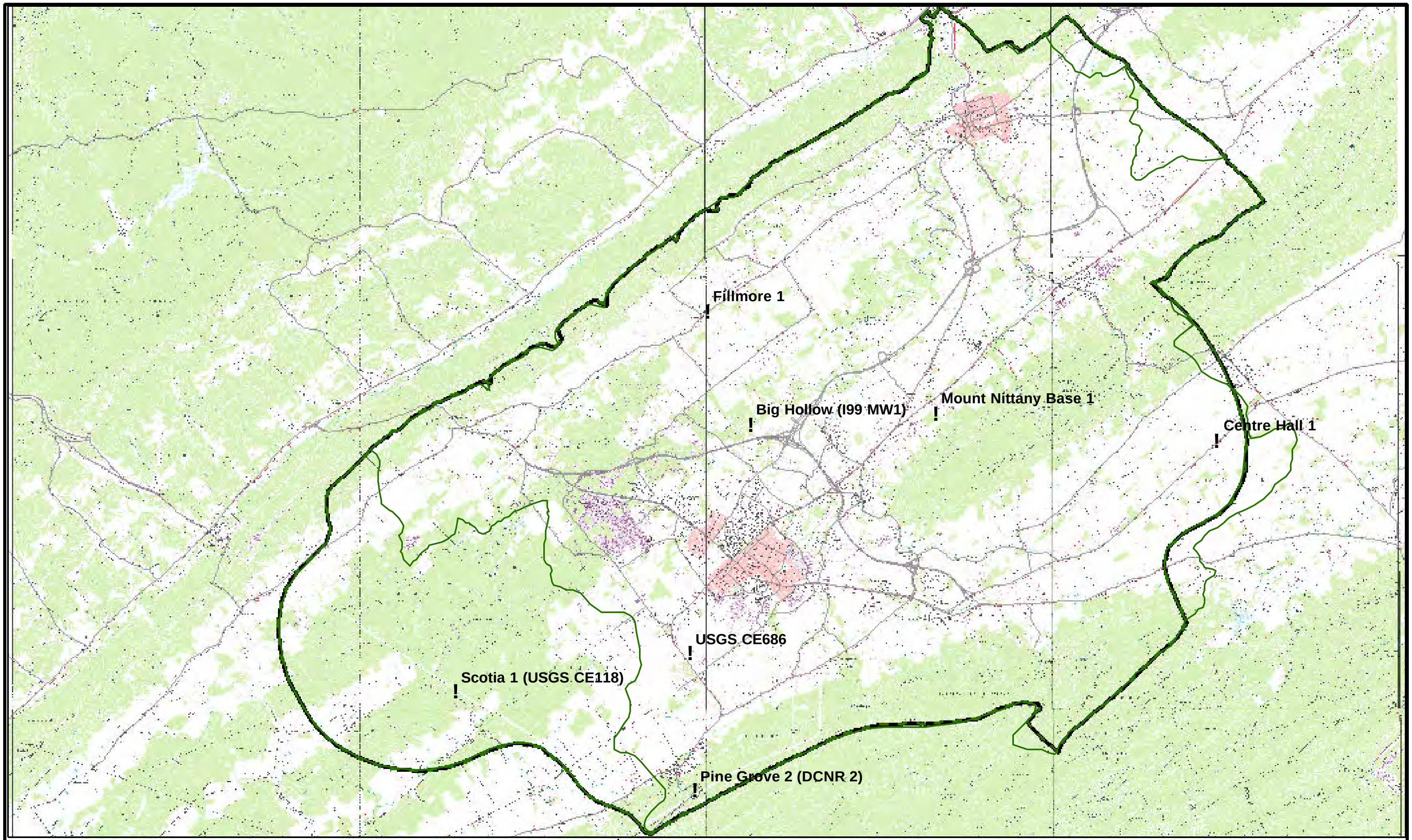
Monthly Measurements

Water samples are collected during base flow conditions. After collection, the samples are sent to a laboratory for analysis of the 10 constituents listed in Appendix 1. Additional measurements of dissolved oxygen and pH are completed in the field.

In 2003, samples could not be collected in June, August, September, and November due to frequent precipitation events.

STORM EVENT MEASUREMENTS

Storm water was monitored in 2001 and 2002 by rotating seven automatic samplers throughout the 12 monitoring stations to capture data from a minimum of one storm per season at each station. Storm-water samples were analyzed for ammonia as well as for the constituents listed in Appendix 1, excluding dissolved oxygen and petroleum hydrocarbons.



WRMP Ground-Water Monitoring Wells

Legend

- ! Ground-Water Monitoring Wells
- ― Spring Creek Surface-Water Boundary
- ― Roads

SPRING CREEK WATERSHED COMMUNITY

Well	Sub-basin	Hydrogeologic Environment
Centre Hall 1	Cedar Run	Valley Center Upland
1-99 MW-1 (Big Hollow)	Big Hollow	Valley Bottom
Pine Grove Mills 2 (DCNR2)	Slab Cabin Run	Mountain Foot
Mt. Nittany Base1 (Dale Summit)	Logan Branch	Mountain Foot
Filmore	Buffalo Run	Valley Bottom Floodplain
USGS CE 118 (Scotia 1)	Gatesburg Upland	Valley Center Ridge
USGS CE 686	Big Hollow	Valley Center Upland

Figure 2. WRMP Ground-water Monitoring Wells.

The storm-water monitoring study design is currently under development by the Water Resources Monitoring Committee.

GROUND-WATER LEVEL MEASUREMENTS

Ground water levels are measured every three hours at all seven ground-water wells. Five of the seven wells are operated by the Spring Creek Watershed Community and two (CE 118 and CE 686) are operated by the U.S. Geological Survey.

WRMP History

The Water Resources Monitoring Project was initiated in 1998 by the Spring Creek Watershed Community to establish baseline water quality and quantity data for Spring Creek and its tributaries. Some of WRMP's accomplishments include:

- **Storm-water monitoring grant** from PA Department of Environmental Protection Growing Greener Program
- **Ground-water monitoring grant** from PA Department of Environmental Protection Growing Greener Program
- **2001 Governor's Award for Watershed Stewardship** in the Assessment and Planning Category
- **Technical Assistants Grant** from PA Department of Environmental Protection
- **PA Department of Environmental Protection Watershed Snapshot** participant

4.0 RESULTS AND ANALYSES

4.1 WATER QUALITY

Geological features and human activities influence chemical water quality in the Spring Creek Watershed. Nutrients (nitrate and phosphate) and suspended solids originate from both agricultural and urban sources. There is little evidence that high concentrations of nutrients and solids are directly lethal to aquatic biota, but these pollutants can have undesirable effects. Nitrogen and phosphorus enrichment stimulates algal growth. Excess algae may depress aquatic insect populations and deplete dissolved oxygen. As the amount of degraded habitat increases, the abundance of aquatic insects (and fish, which feed on aquatic insects) may decrease. Chloride and metals (copper, lead, and zinc) originate from urban and industrial activities, and can be toxic to both humans and aquatic organisms.

To characterize water quality at each monitoring station, we first computed 5-year means for nitrate, orthophosphate, total suspended solids, chloride, lead, zinc, and thermal suitability. Copper was not considered because all means were below detection limits. We then assigned a ranked category for each measurement at each station. If a constituent ranked in the lowest one third of all stations it was labeled "better", "intermediate" if it ranked in the middle one third, and "worst" if it fell within the highest one third (Table 2).

None of the 5-year means for nutrients and metals were above PA Department of Environmental Protection criteria for clean water, where such criteria are established. Hence, stations that ranked "worst" for several categories are not necessarily seriously polluted, rather, they show evidence of degraded water quality. In general, stations with the best water quality, Buffalo Run Lower, Spring Creek Upper, and Logan Branch Lower, have the least amount of urbanization upstream from them. Stations that ranked “intermediate” or “worst” often drained areas with moderate to high levels of urbanization. The effects of urbanization were also evident in stream temperatures and streamflow.

Table 2. Ranked Chemistry and Thermal Suitability.

	Total Nitrates	Total Orthophosphates	Total Suspended Solids	Total Chloride	Total Lead	Total Zinc	Thermal Suitability	**Total Rank**
Buffalo Run Lower	🟦	🟦	🟦	🟦	🟦	🟦	🟨	🟦
Spring Creek Upper	🟦	🟨	🟨	🟦	🟦	🟦	🟦	🟦
Logan Branch Lower	🟨	🟦	🟦	🟦	🟦	🟥	🟦	🟦
Spring Creek Houserville	🟨	🟦	🟦	🟨	🟦	🟦	🟥	🟦
Cedar Run Lower	🟥	🟦	🟥	🟦	🟦	🟦	🟨	🟨
Buffalo Run Upper	🟦	🟨	🟥	🟨	🟦	🟦	🟥	🟨
Thompson Run Lower	🟥	🟨	🟨	🟥	🟦	🟨	🟦	🟨
Slab Cabin Run Lower	🟦	🟨	🟨	🟥	🟦	🟨	🟥	🟨
Logan Branch Upper	🟨	🟥	🟨	🟨	🟨	🟥	🟦	🟥
Slab Cabin Run Upper	🟨	🟥	🟥	🟨	🟦	🟨	🟥	🟥
Spring Creek Axemann	🟥	🟥	🟥	🟥	🟦	🟦	🟨	🟥
Spring Creek Milesburg	🟥	🟥	🟦	🟥	🟨	🟥	🟦	🟥

🟦 0-33% "Better"
🟨 34-66% "Intermediate"
🟥 67-100% "Worst"

4.2 THERMAL SUITABILITY

Variations in seasonal temperatures in the tributaries and in the main stem of Spring Creek are strongly influenced by the amount of ground water entering the streams. Among the tributaries, temperatures during winter in Slab Cabin Run and Buffalo Run tend to be coldest, while winter temperatures are highest in Thompson Run and Logan Branch (Table 3). In summer we see the opposite trend. Temperatures are highest in Slab Cabin Run and Buffalo Run and lowest in Thompson Run and Logan Branch. Relative to their surface areas, Slab Cabin Run and Buffalo Run have low streamflows, while Thompson Run and Logan Branch have high streamflows. Thus, the larger the input of ground water, the greater the moderation in both streamflows and stream temperatures.

Temperature variations in the main stem of Spring Creek are driven by inputs from ground water and ambient air temperature . The upper station on Spring Creek has a large, nearby spring that results in relative warm temperatures in winter and cool temperatures in summer. As the water moves downstream it cools in winter and warms in summer. This general trend is evident from Boalsburg to Bellefonte. When stream water reaches Bellefonte, two significant inputs alter stream temperature - Big Spring and Logan Branch. These two sources tend to reduce stream temperatures in summer and increase them in winter.

These seasonal variations in stream temperature are of particular interest, because stream temperatures dictate the kinds of fishes a stream will support, and they strongly influence how fast these fishes will grow. In this Watershed, trout are a major focus because of their recreational value. One benchmark that is used to determine the thermal suitability of a stream reach is the number of days in summer that the maximum daily temperature exceeds 76^{o}F. At this temperature brown trout show obvious signs

Table 3. Average Seasonal Stream Temperatures.

	Buffalo Run Upper	Buffalo Run Lower	Cedar Run Lower	Logan Branch Upper	Logan Branch Lower	Slab Cabin Run Upper	Slab Cabin Run Lower	Thompson Run Lower	Spring Creek Upper	Spring Creek Houserville	Speing Creek Axemann	Spring Creek Milesburg
Dates	7/16/1999 - 12/31/2003	5/13/1999 - 12/31/2003	5/12/1999 - 12/31/2003	5/13/1999 - 11/24/2003	6/7/2000 - 11/24/2003	5/12/1999-- 12/3/2003	5/12/1999-- 12/31/2003	5/12/1999 - 12/31/2203	5/12/1999 - 12/31/2003	5/12/1999 - 12/9/2003	5/13/1999 - 10/22/2003	5/13/1999 - 12/31/2003
Jan	33.7	35.7	39.9	44.1	47.4	35.1	36.4	45.9	46.2	39.7	40.4	43.5
Apr	50.4	51.5	51.4	51.2	51.2	50.8	51.0	52.4	49.5	50.9	53.6	52.5
Jul	63.3	64.7	61.3	63.1	55.7	66.5	66.8	58.0	54.7	62.2	65.9	61.8
Oct	50.1	51.4	52.1	55.2	52.1	52.5	53.4	52.4	51.9	52.5	54.0	52.8

* Data for the period from 1999 to 2003 were combined.

of stress and some individuals will die. When stream temperatures reach levels that are stressful to trout, these fish begin to seek cooler water, which is usually associated with spring inputs. Thus, even though daily temperatures may reach 76^{o}F, no trout mortality may result, but weight loss is likely as is increased susceptibility to disease.

We ranked the thermal suitability of the 12 monitoring stations in the Watershed by computing the number of days that daily maximum stream temperature equaled or exceeded 76^{o}F during the period May 1 to September 30 for the years 1999 to 2003. The upper and lower stations on Slab Cabin Run had the highest percentage of days in which temperatures equaled or exceeded 76^{o}F (Table 4). Spring Creek at Houserville had the third worst thermal suitability, followed by Buffalo Run Upper and Spring Creek at Axemann. These warm temperatures in Slab Cabin Run and Upper Buffalo Run are related to low flows during summer and to some extent, lack of a forested riparian buffer. The warm temperatures in the main stem of Spring Creek are related to small inputs of ground water and solar heating. Increases in forested riparian buffers should be beneficial, but this reach of stream is vulnerable to inputs of warm, urban storm water during summer.

Table 4. Percent of Daily Maximum Temperature Equal to or Exceeding 76^{o} F.

Station	%of Daily Maximum Temperature Equal to or Exceeding 76°F.
Slab Cabin Run Upper	21.4%
Slab Cabin Run Lower	10.5%
Spring Creek Houserville	6.9%
Buffalo Run Upper	4.7%
Spring Creek Axemann	3.7%
Buffalo Run Lower	1.0%
Cedar Run Lower	0.9%
Thompson Run Lower	0.1%
Logan Branch Upper	0%
Spring Creek Milesburg	0%
Spring Creek Upper	0%
Logan Branch Lower	0%

Photo by: Mark Ralston

4.3 STREAMFLOW DATA

Background

The US Environmental Protection Agency (USEPA) defines hydrology as “the science of water relating to occurrence, properties, distribution, circulation and transport of water” . Hydrology therefore relates to all aspects of the hydrologic cycle: precipitation, storm-water runoff, streamflow, ground-water circulation, evaporation, etc.

Streamflow can be broken down into two components: groundwater base flow and surface-water runoff. In the absence of recent precipitation, ground-water base flow (as contributed by springs, seeps, and other hydrologic features) makes up *all* of the water in a stream. Overland flow of water during and immediately following a precipitation event (or snow melt) can boost the quantity of water in a stream by a significant amount, but for a limited period of time. The timing of storm-water runoff entering a stream is related to a complex array of factors, including the slope of the upland contributing area, land cover, overland flow paths, and other factors.

A hydrograph is a plot of streamflow over time at a particular point of analysis. An evaluation of streamflow (hydrographic) data can be used to assess many of the hydrologic aspects of a given Watershed, such as responsiveness to precipitation, ground-water base-flow contribution to streams, effects of land use (such as impervious cover), effects of ground water and surface water manipulation by man, and many other factors. Both the absolute streamflow data and also the differences in streamflow data between subbasins within a larger Watershed can be useful in such an assessment. Hydrologic data are also used to assess the assimilative capacity of streams to receive wastewater discharges and to assess flood peak flows and return period (e.g., for sizing of culverts and bridges).

In the remainder of this section, representative hydrographs for gaging stations in the Spring Creek Basin are presented, along with an informal evaluation of some of the noteworthy features of the hydrographs. Please note that the left axis (which indicates flow amounts in cubic feet per second, or cfs) of each hydrograph uses a logarithmic scale.

Each hydrograph presents flow data for the three USGS gaging stations on the main stem of Spring Creek (located at Houserville, Axemann, and Milesburg). The remaining nine gaging stations of the Water Resources Monitoring Project (WRMP) are categorized as follows:

- lower Spring Creek tributaries (upper and lower Logan Branch stations, upper and lower Buffalo Run stations),
- upper Spring Creek tributaries (Spring Creek at Oak Hall, lower Cedar Run), and
- urbanized tributaries (upper and lower Slab Cabin Run and Thompson Run).

Hydrographs for these stations are presented to illustrate how our local streams responded to drought conditions during the summer of 2001 and also to illustrate response to a storm event.

Comments on Streamflow Data Quality Control

The heart of a stream gaging station is a device that records stream “stage”, or the height of water in the stream. Using a flow meter, many individual streamflow measurements are made at the gaging station location under different stream stage conditions (i.e., under low-flow, moderate flow, high flow, etc.). The individual streamflow and stage measurements are compiled to develop a rating curve, which is a mathematical relationship between stream stage and streamflow at the gaging station location. The rating curve is then used to convert recorded stream stage data into streamflow values.

The relationship between stream stage and streamflow can be difficult to characterize when streamflow drops to zero, as has been the case recently in Slab Cabin Run and in Buffalo Run. In addition, it is difficult to conduct streamflow measurements when a stream is at very high flow rates, so rating curves may use extrapolation to assess stream flows under very high stage conditions (i.e., flood flows higher than any of the individual flow measurements). Consequently, the WRMP Committee wishes to qualify the streamflow data as being somewhat provisional: our streamflow data are probably most accurate at “mid-range” flow values. Absolute flow numbers may be somewhat less reliable at both the low and high end of the streamflow values. However, other aspects of the hydrographs, such as the timing of rise and fall of the streams and the inflection points in the hydrographs are probably reasonably reliable.

The WRMP continues to collect regular streamflow measurements and to build the reliability of our rating curves.

Stream Low-Flow Conditions; Summer of 2001

By December, 2001, 62 of 67 Pennsylvania counties were under declared drought conditions. During the summer of 2001, many of our local streams were under historic, low-flow conditions. Hydrographs are presented for the period June 1, 2001 through August 1, 2001 to illustrate how streams responded to drought conditions.

A. Spring Creek Main Stem and Lower Tributaries

Daily fluctuations in flow, which are attributable to differences in plant uptake of water and evaporation between daytime and nighttime, are apparent at all gaging stations (Figure 3.). Daily fluctuations are especially apparent at the Buffalo Run stations, due to the use of a logarithmic scale for flow (y-axis).

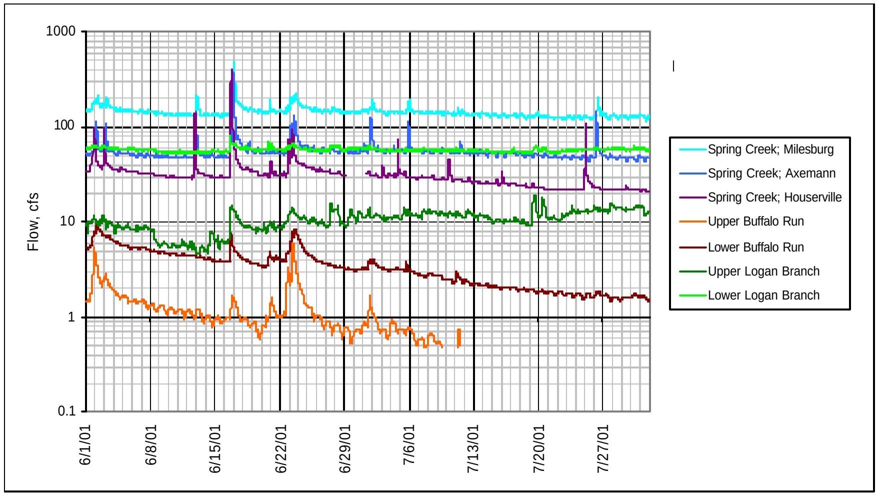


Figure 3. Low-Flow Conditions in Spring Creek and Lower Tributaries.

In spite of approximately eleven precipitation events, streamflow at most of the gaging stations gradually decreased throughout this period. Flow at the upper Buffalo Run station ceased during the second week of July 2001.

Streamflow at the lower Logan Branch station held fairly constant, and flow at upper Logan Branch increased somewhat during this time period. This apparent anomaly is likely due to man's influence, such as mine dewatering pumpage at the mining operations in Pleasant Gap and the delivery of water from Bellefonte Borough's Big Spring to the Corning Asahi Plant (which, during 2001, was eventually discharged within the upper Logan Branch Basin).

Streamflow decreased by approximately 35 percent at Houserville compared to less than 5 percent at Axemann. This suggests that ground-water inputs to Spring Creek between Houserville and Axemann buffered the decline in streamflow over this stream reach to a greater degree than in Spring Creek above Houserville. This may be due to differences in local hydrogeology (such as the effect of Benner Spring), and/or ground-water withdrawal in the upper Spring Creek Watershed. The University Area Joint Authority (UAJA) discharge, which occurs between the Houserville and Axemann stations, also contributed to the flow that was observed at Axemann.

B. Upper Spring Creek Tributaries

Flow at Spring Creek at Oak Hall (Figure 4) remained fairly constant throughout this time period, and flow at lower Cedar Run fell by approximately 50 percent (from 10 cfs to 5 cfs). Based upon hydrogeologic conditions in these two subbasins, the flow at Cedar Run might be expected to be more persistent and consistent than the flow at upper Spring Creek; no explanation for this apparent anomaly was immediately apparent from the data.

C. Urbanized Spring Creek Tributaries

Flow at upper Slab Cabin Run (Figure 5) ceased during the second week of July 2001, and flow at lower Slab Cabin Run decreased by approximately 95 percent (approximately from 3 cfs to 0.13 cfs). The urbanized tributaries responded much more intensely to the few precipitation events than the main stem of Spring Creek. Some of the peak flow values for Slab Cabin Run and Thompson Run seem anomalously high, as discussed above.

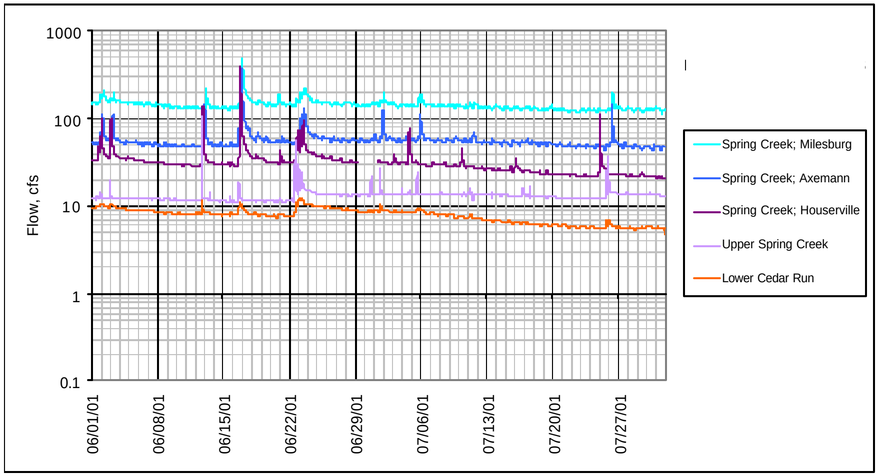


Figure 4. Low-Flow Conditions in Spring Creek and Upper Tributaries.

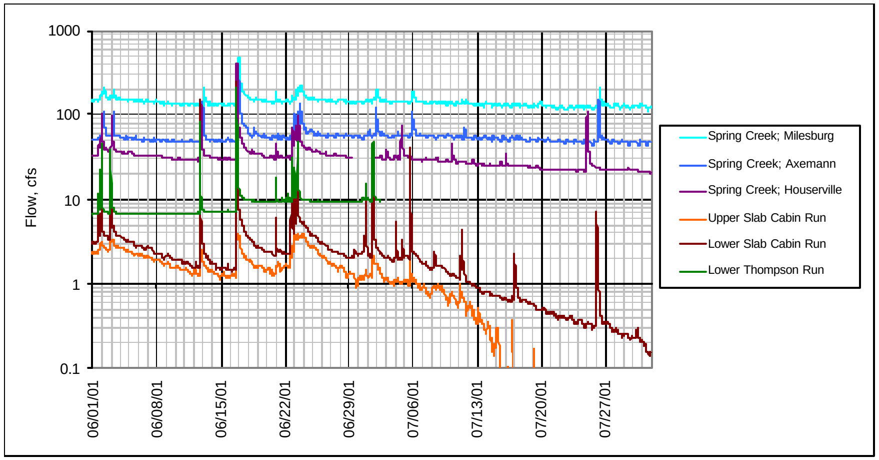


Figure 5. Low-Flow Conditions in Spring Creek and Urban Tributaries.

The flow record at Thompson Run was interrupted due to equipment malfunction during the first week of July. However, the data through the end of June indicate that flow did not decrease throughout this time period. The typical flow in this time period was approximately 7 to 9 cfs, or approximately 3,000 to 4,000 gallons per minute (gpm). The apparent, steady base flow at Thompson Run may be attributable, in part, to water that is leaked from water utilities in State College and Penn State University.

Stream Response to June 27, 2002 Storm Event

As reported by the Pennsylvania State Climatologist, 1.66 inches of rain fell during the evening of June 27, 2002. Only 0.26 inches of rain had fallen during the previous 300 hours (approximately 12.5 days), hence, most of the streamflow immediately prior to the June 27th precipitation event consisted of ground-water base flow.

A. *Spring Creek Main Stem and Lower Tributaries*

The flood peak of 460 cfs at Houserville was higher than the flood peak of 440 cfs at Axemann (Figure 6) . The flood peak moved from Houserville to Axemann in approximately three hours and from Axemann to Milesburg in approximately one hour.

A minor peak in flow is seen at the Milesburg station at the onset of the storm event. This minor flow peak is likely due to storm water runoff from impervious surfaces in Bellefonte Borough. Streamflow at Milesburg receded somewhat after this minor peak before the main flood peak arrived at Milesburg.

The two Logan Branch gaging stations showed little response to this storm event, so the rainfall in the Logan Branch subbasin may have been less than the rainfall in the rest of the Spring Creek Watershed.

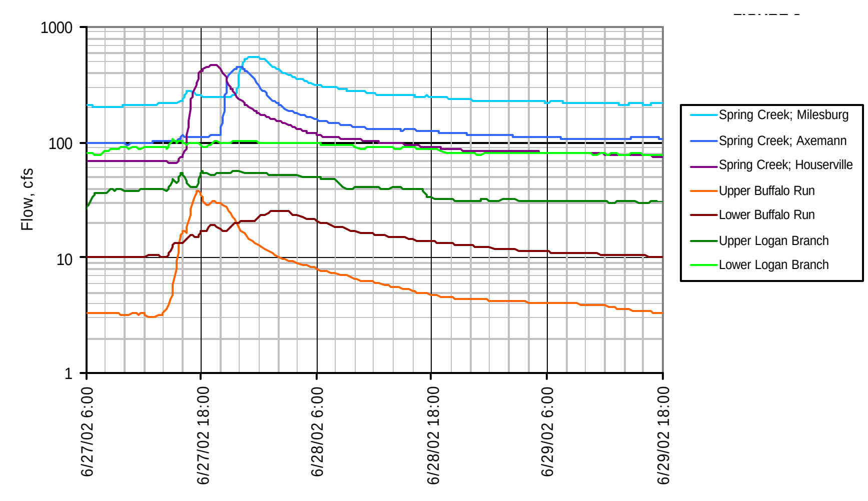


Figure 6. Storm Response in Spring Creek and Lower Tributaries.

The upper Buffalo Run subbasin is fairly steeply sloped, which likely contributed to the rapidity of the increase in streamflow at the upper Buffalo Run station. The flood peak of 38 cfs at upper Buffalo Run was greater than the flood peak of 26 cfs at lower Buffalo Run. The flood peak moved from upper Buffalo Run to lower Buffalo Run in approximately 8 hours.

A more detailed assessment of these hydrographs might examine a) whether the reductions in peak flows from Houserville to Axemann and from upper to lower Buffalo Run are attributable to channel storage, streambed leakage, land cover, or some other factor, and b) changes in flood volume along these stream reaches.

B. *Upper Spring Creek Tributaries*

The rising limb of the hydrograph for the upper Spring Creek station is much steeper than the rising limb of the hydrograph for the lower Cedar Run station (Figure 7). Flow at the upper Spring Creek station increased from 17 cfs to 97 cfs (470 percent increase), while flow at the lower Cedar Run station increased from 18 cfs to 45 cfs (150 percent increase). The upper Spring Creek and lower Cedar Run subbasins are adjacent to each other, so it is not especially likely that precipitation amounts were significantly different in the two subbasins.

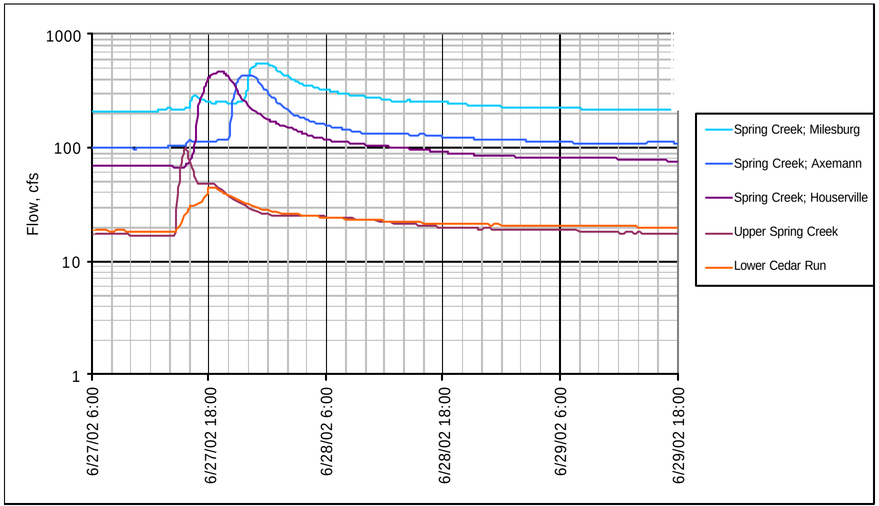


Figure 7. Storm Response in Spring Creek and Upper Tributaries.

The upper Spring Creek subbasin is 75 percent of the size of the lower Cedar Run subbasin, so the absolute increase in streamflow for the upper Spring Creek subbasin should have been somewhat less than the absolute increase in streamflow for the lower Cedar Run subbasin. The deviation in expected streamflow response is likely attributable to differences in land use and cover (i.e., impervious or developed land) in the two subbasins.

C. *Urbanized Spring Creek Tributaries*

Figure 8 is probably the most noteworthy of the six streamflow hydrographs presented in this Report. The greatest percent increases in streamflow in response to the 6/27/02 storm event were seen at the urbanized tributaries: upper Slab Cabin Run, lower Slab Cabin Run, and lower Thompson Run. In addition, flood peaks receded most quickly at the Slab Cabin, Thompson Run, and upper Spring Creek stations.

The upper Slab Cabin Run station might have been expected to show a slightly more subdued response to precipitation than the upper Buffalo Run station, due to the upper Slab Cabin Run station being located farther out in the valley floor than the upper Buffalo Run Station. However, either due to differences in local precipitation or due to differences in land cover and other hydrographic features, the response to precipitation was much more pronounced at the upper Slab Cabin Run station than at the upper Buffalo Run station.

Development and land cover are likely responsible for the "flashy" response of the urbanized tributaries to storm events.

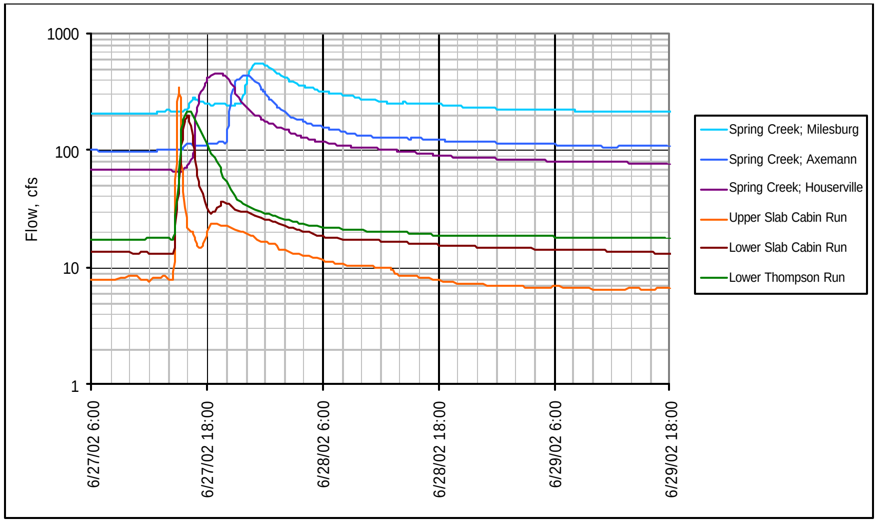


Figure 8. Storm Response in Spring Creek and Urban Tributaries.

Conclusions

This cursory review of the streamflow hydrographs for drought conditions and for storm response provides empirical evidence to support some widely-held beliefs regarding the hydrology of the Spring Creek Watershed:

- The amount of development and impervious cover in the Slab Cabin, Thompson Run, and upper Spring Creek subbasins strongly influences the streamflow regimes in these stream reaches. Urbanization results in a) a more "flashy" response to storm events and b) higher peak flood flows than might otherwise be expected for equivalent, undeveloped Watershed areas.
- Water utilization activities impact stream hydrology. Withdrawal of ground water from the upper Spring Creek Watershed diminishes streamflow, most noticeably under drought conditions.

In order to limit adverse impacts upon streamflow during storm events, it would be beneficial to carefully manage the creation of impervious surfaces and of impairment of storm water infiltration. This can be accomplished through the use of "low impact development" and other means.

Activities such as the UAJA's Beneficial Reuse project should provide some level of mitigation for the apparent diminution of streamflow in the upper portions of the Spring Creek Watershed. Future land use management should include measures to limit the loss of ground-water recharge in the Spring Creek Watershed.

4.4 GROUND-WATER STORAGE WAS REPLENISHED IN 2003

The Spring Creek Watershed received 54.78 inches (at the Walker Building weather station) of precipitation in 2003, which was 41% above normal. This made it the second wettest year in 108 years of record. Average annual precipitation is 39.51 inches, and the 16.27 inches of surplus contributed significantly to ground-water recharge in the Watershed. Water-table monitoring well CE 686, located two miles southwest of downtown State College, experienced a 62 foot net rise in its water-table level during 2003 as shown by the blue hydrograph line in Figure 9. Remember that some of the hydrograph rises are due to the melting of snow packs. This well represents the Spring Creek Watershed headwater areas that saw significant increases in net ground-water storage during 2003.

A unique characteristic of the Spring Creek Watershed is that 86% of the total annual flow of Spring Creek at the Watershed mouth at Milesburg is ground water. Only 14% of the total annual streamflow is surface water that flowed overland directly into the stream channels. The very high quality and the cold summer temperature of the ground water are principal reasons why Spring Creek and its tributaries are such renowned trout streams. During the ground-water drought period from 1999 through early 2002, ground-water discharges sustained the flow of Spring Creek. This ground water came from storage and the declines in water-table levels in well CE 686 show that the discharge of ground water from storage into the streams exceeded ground-water recharge during this period.

The red hydrograph line in Figure 9 is well CE 118, located in the Scotia Barrens area on State Game Lands 176 near the shooting range. While the historic, habitat, climate, mineral, wildlife, and recreational qualities of the Scotia Barrens are enjoyed and appreciated by many people, the critical role of this area in the water resources of the Spring Creek Watershed is not widely known or appreciated. The unique hydrogeologic characteristics of this area consist of a deep, sandy soil with a very high infiltration capacity, underlying carbonate bedrock with solution openings that provide a very high capacity to store ground water, and a regional fault zone that is the location of water-filled solution caverns. These unique hydrogeologic characteristics are the reason why the Scotia Barrens area is the headwaters of Big Spring in Bellefonte. Rainfall and snowmelt water that infiltrates into the Scotia Barrens soil percolates slowly down to the water table, and then flows northeast for a distance of 13 miles to discharge from Big Spring at a rate of 19 million gallons per day. This high discharge rate makes Big Spring the second largest spring in Pennsylvania.

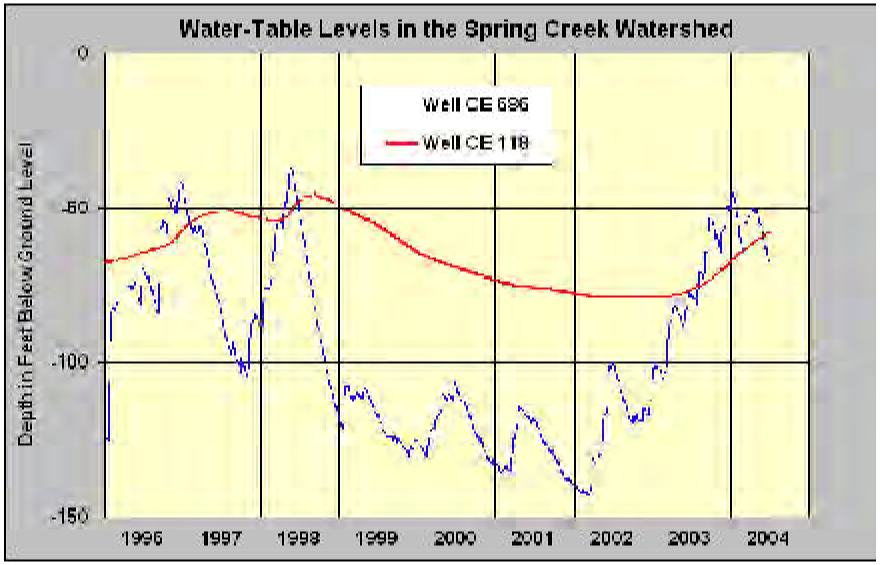


Figure 9. Water-Table Levels in the Spring Creek Watershed.

The high porosity of the bedrock underlying the Scotia Barrens makes this area the largest and most important ground-water reservoir in the Spring Creek Watershed. The subdued and delayed hydrograph of CE 118 in Figure 9 illustrates the high storage capacity of this Scotia Barrens area ground-water reservoir. Notice the lag in the CE 118 response to both major winter recharge events and to the ground-water drought during the four years from 1999 through 2002. This Scotia Barrens ground-water reservoir also drains much more slowly than the ground-water reservoir monitored by well CE 686. Remember, ground water beneath the Scotia Barrens has to flow 13 miles before it can discharge from Big Spring and enter Spring Creek. The other ground-water reservoirs in the Spring Creek Watershed have much shorter flow paths to their discharge points on Spring Creek and its tributaries, and they drain more quickly during drought periods. Several municipal well fields tap the Scotia Barrens ground-water reservoir and Bellefonte gets its drinking water directly from Big Spring. The natural forest covering the Scotia Barrens enhances its recharge capacity, and managing this critical ground-water resource area is a worthwile the goal of many people.

The amount of water-table rise seen in a monitoring well in response to a given precipitation event depends on the soil type and thickness, the rock type, the topographic location of the monitoring well, and the proximity of the monitoring well to streams and sinkholes. Together these factors are described as the hydrogeologic setting of the monitoring well. Using funds from a Growing Greener grant, water-level sensors and data loggers were purchased, and then installed in available wells located in a variety of hydrogeologic settings throughout the Spring Creek Watershed. Five wells were instrumented in early 2003, and water-table levels are monitored by the WRMP in those wells on a continuous basis by the WRMP. Unlike the US Geological Survey monitoring wells (CE 118 and CE 686), whose water-table level data are available live on the Internet, the five additional monitoring wells must have their water-table level data downloaded to a laptop computer on a periodic basis.

The Pine Grove Mills monitoring well is located approximately halfway up Tussey Mountain above the village of Pine Grove Mills and the Centre Hall monitoring well is located on the floor of Penns Valley along Route 45 approximately one mile west of Old Fort. The Dale Summit monitoring well is located at the foot of Nittany Mountain south of (behind) the Centre Daily Times office building and the Big Hollow monitoring well is located in Big Hollow just down this dry valley from where the State College bypass highway crosses Fox Hollow Road. The Filmore monitoring well is located on the right bank of Buffalo Run approximately one-tenth of a mile downstream from the bridge on Purdue Mountain Road (See Figure 2).

The 2003 hydrographs of the seven monitoring wells are shown in Figure 10 and contrasts the very different hydrogeologic environments of these wells are apparent in the shapes of their hydrographs. Some of the variability is due to variations in precipitation amounts throughout the Watershed for individual storms. Water-table fluctuations are generally greatest in wells farthest from ground-water discharge points, with the exception of well CE 118 where intergranular and solution conduit porosity cause its subdued and delayed response. The Filmore well has little fluctuation due to its position on the bank of Buffalo Run, which is the discharge point of ground water in the vicinity of this well.

Four miles upstream on Spring Creek from the Milesburg stream gage at the mouth of the Watershed is a stream gage called the Spring Creek at Axemann gage. It is located at the bridge where Fish Hatchery Road crosses Spring Creek by the intersection with Barnes Lane. The Watershed area above the Axemann gage is 87 square miles, which is one-half of the area of the 175 square mile Spring Creek Watershed area above the Milesburg gage. Therefore one would expect the mean annual discharge at the Milesburg gage to be twice the mean annual discharge at the Axemann gage because it drains twice the area. The stream flows are recorded every 15 minutes at each gage, so the mean annual discharge is the average of 2,102,400 measurements in each year. This mean annual flow is expressed in cubic feet per second (cfs), where one cfs equals 449 gallons per minute.

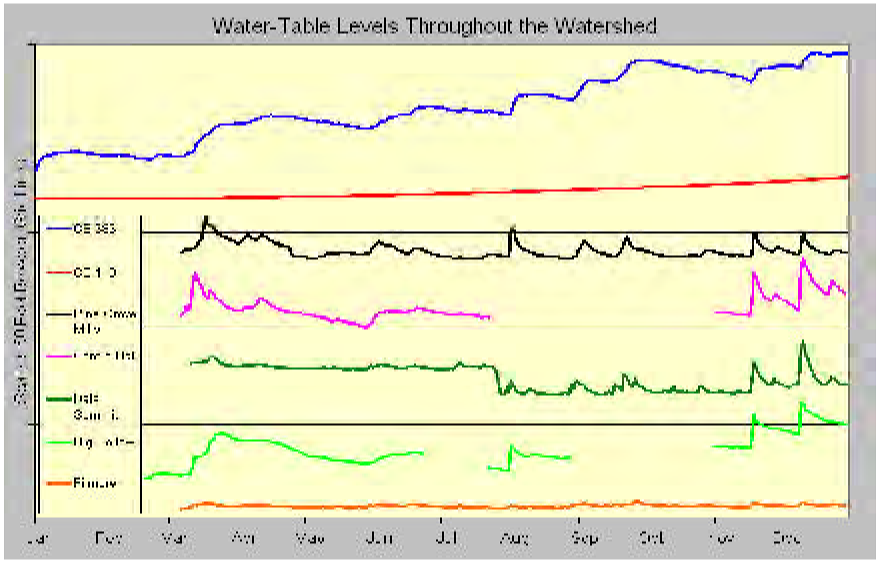


Figure 10. Water-Table Levels Througout the Watershed.

So the question is why, on Figure 11, is the Axemann gage mean annual flow equal to one-half of the Milesburg gage only in 1996 and 2003 of the past eight years? The answer is that the discharges of the several very large springs located downstream of the Axemann gage raised the mean annual discharge at the Milesburg gage from 1997 through 2002. During those six years ground-water recharge was significantly less than normal and thus the large spring discharges were a more significant portion of the Milesburg mean annual flow. The wettest year on record was

1996, the second wettest year was 2003, and during these two years the large spring discharges below the Axemann gage were a smaller component of the mean annual flow at the Milesburg gage and thus the mean annual flow at the Axemann gage was one-half of the mean annual flow at the Milesburg gage. Figure 11 illustrates the significant role the very large flow springs in the lower part of the Watershed in sustaining the flow of Spring Creek during periods of below-normal precipitation.

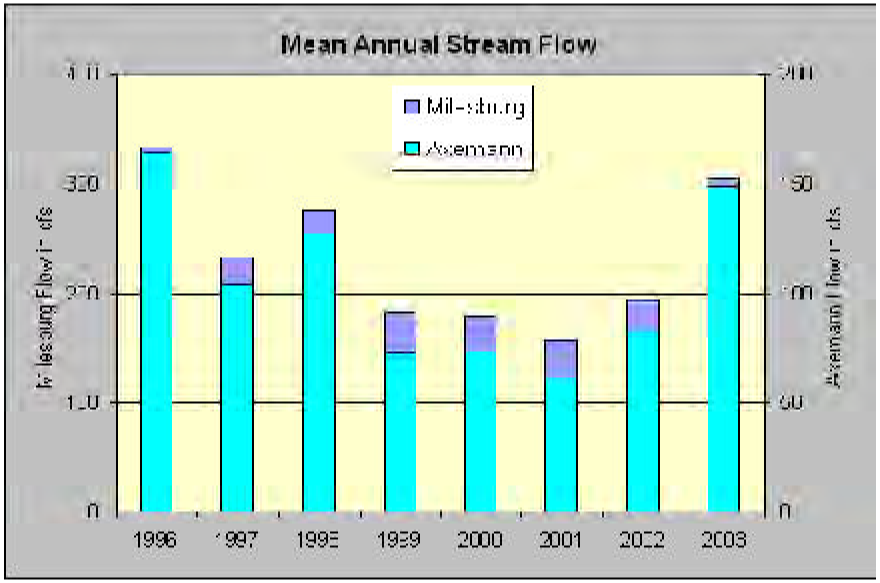


Figure 11. Mean Annual Stream Flow.

We currently pump approximately 16 million gallons per day of ground water from the aquifers in the Spring Creek Watershed. The renowned trout fishing at Fisherman's Paradise and at many other locations on Spring Creek and its tributaries can be attributed to the 86% ground-water component of the total annual streamflow. Because ground water has a predominant and vital role in the hydrology of the Spring Creek Watershed, we need to identify and protect the critical ground-water recharge areas in our Watershed to sustain both the high quality of our streams and our quality of life, and to ensure we will be able to meet our future needs for this renewable resource.

4.5 LAND USE AND WATER QUALITY

Approximately 21% of the Spring Creek Watershed is developed with the largest amount of developed land and impervious surfaces located in the Big Hollow and Slab Cabin Run subbasins (Figure 12). During the past five years, the highest mean concentrations of orthophosphates, chloride, suspended solids, and turbidity levels were observed in the Slab Cabin Run subbasin which is approximately 32% developed. High concentrations of these substances are detrimental to aquatic life. Suspended materials in turbid waters clog fish gills, damage stream habitats, and absorb sunlight which inhibits submerged aquatic plant growth and warms stream temperatures. High chloride levels are toxic to stream insects, and an increase in orthophosphates can lead to eutrophication (excessive plant growth).

The Cedar Run subbasin is the least developed subbasin (approximately 9%), and this area had either the lowest or second lowest 5-year mean levels of chloride, and orthophosphates. Although Cedar Run is not highly developed, slightly over 64% of its land use is considered agricultural (Figure 13). Water-quality data from the past five years show that the highest mean levels of dissolved and total nitrates were found in this subbasin. Like orthophosphates, high nitrate concentrations can lead to excessive plant growth.

None of the water quality parameters discussed above have been found at concentrations above the PA Department of Environmental Protection in-stream criteria. Despite this, data collected by the Water Resources Monitoring Project demonstrate that an increase in developed, impervious, and agricultural land coincide with an increased pollutant load in the streams. This is why we

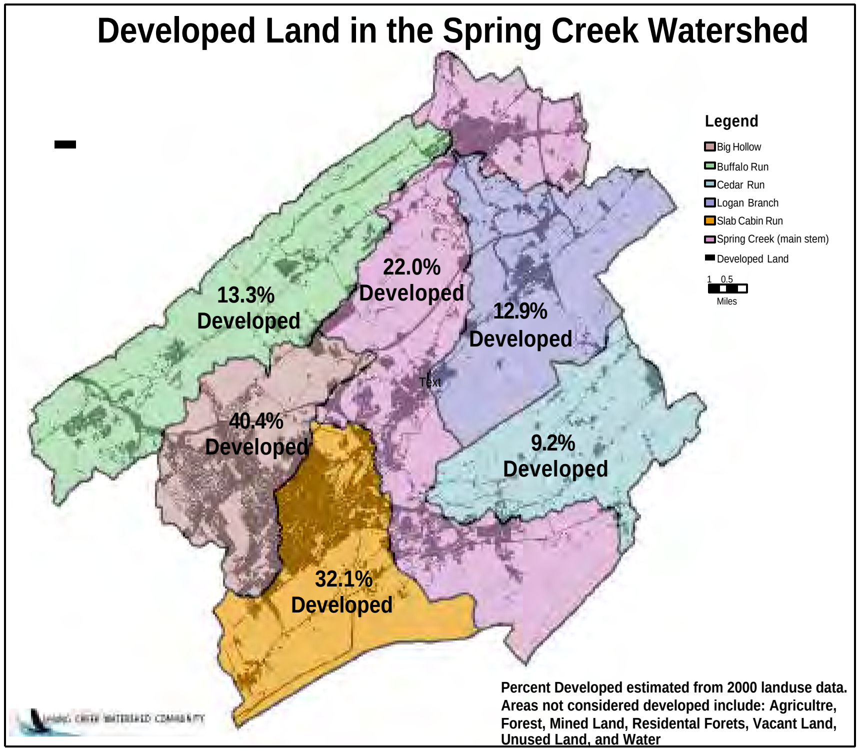


Figure 12. Developed Land in the Spring Creek Watershed.

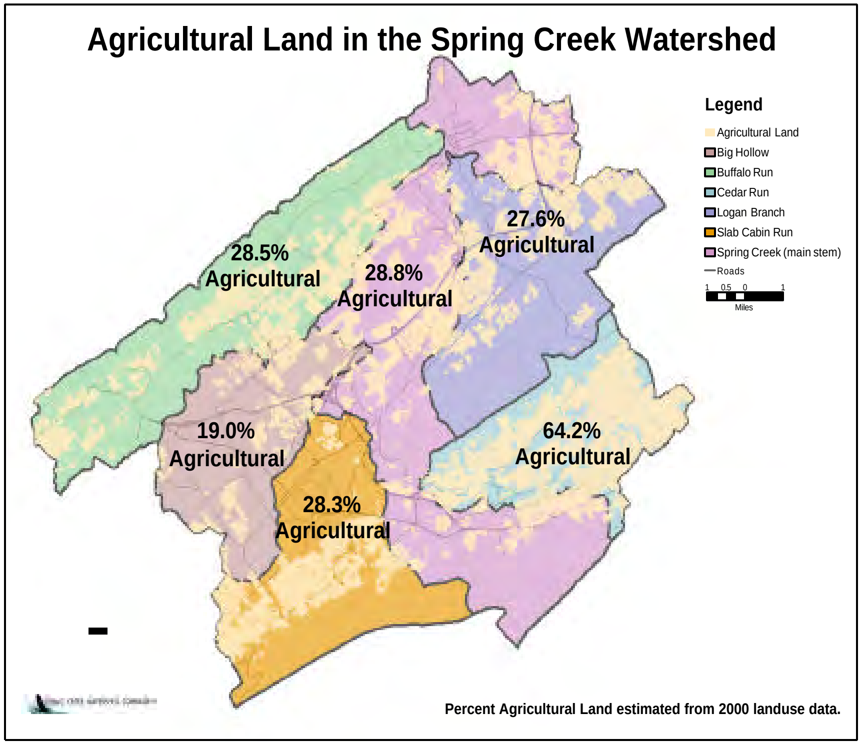


Figure 13. Agricultural Land in the Spring Creek Watershed

must better manage our growth, protect our recharge areas, and develop riparian buffers on the streams in the Spring Creek Watershed.

4.6 IMPAIRED WATERS

According to the Pennsylvania Department of Environmental Protection, almost 20% of Spring Creek Watershed's approximate 80 miles of stream are considered impaired because they do not meet water quality standards for their designated uses.

In late 2002, the Pennsylvania Department of Environmental Protection identified seven reaches of stream totaling 15.6 miles, in the Spring Creek Watershed for possible inclusion on the 303(d) List of Impaired Waterbodies. These stream sections include portions of Thompson Run, Slab Cabin Run, Logan Branch, and parts of Spring Creek itself. In early 2003, a portion of Buffalo Run was added to the list, bringing the total stream length involved to 16.2 miles (Table 5, Figure 14).

Three of the eight impairments are caused by point source pollution and are located immediately below Pennsylvania Fish and Boat Commission (PFBC) hatcheries. The remaining five impairments are caused by nonpoint source pollution, including sedimentation and storm water runoff from both urban and agricultural land, and removal of riparian vegetation. Nonpoint source pollution problems are widespread and often difficult to address.

WHAT'S BEING DONE?

- The PA DEP and PFBC and working together to address the impairments created by point source pollution.
- Penn State University Office of Physical Plant (PSU-OPP), University Area Joint Authority (UAJA), and ClearWater Conservancy, all stakeholders of the Spring Creek Watershed Community, have partnered together to create the Plan For Recovery Project. The intent of this project is to create a "plan for recovery" for each municipality and Penn State University (i.e., define doable and reasonable actions for each entity that will help reduce the stream impairments). Before these actions can be identified, total maximum daily loads (TMDL's) must be estimated. UAJA and PSU-OPP have partnered together to model TMDL's for the Spring Creek Watershed to help the plan for recovery effort.

Table 5. Impaired Streams in the Spring Creek Watershed.

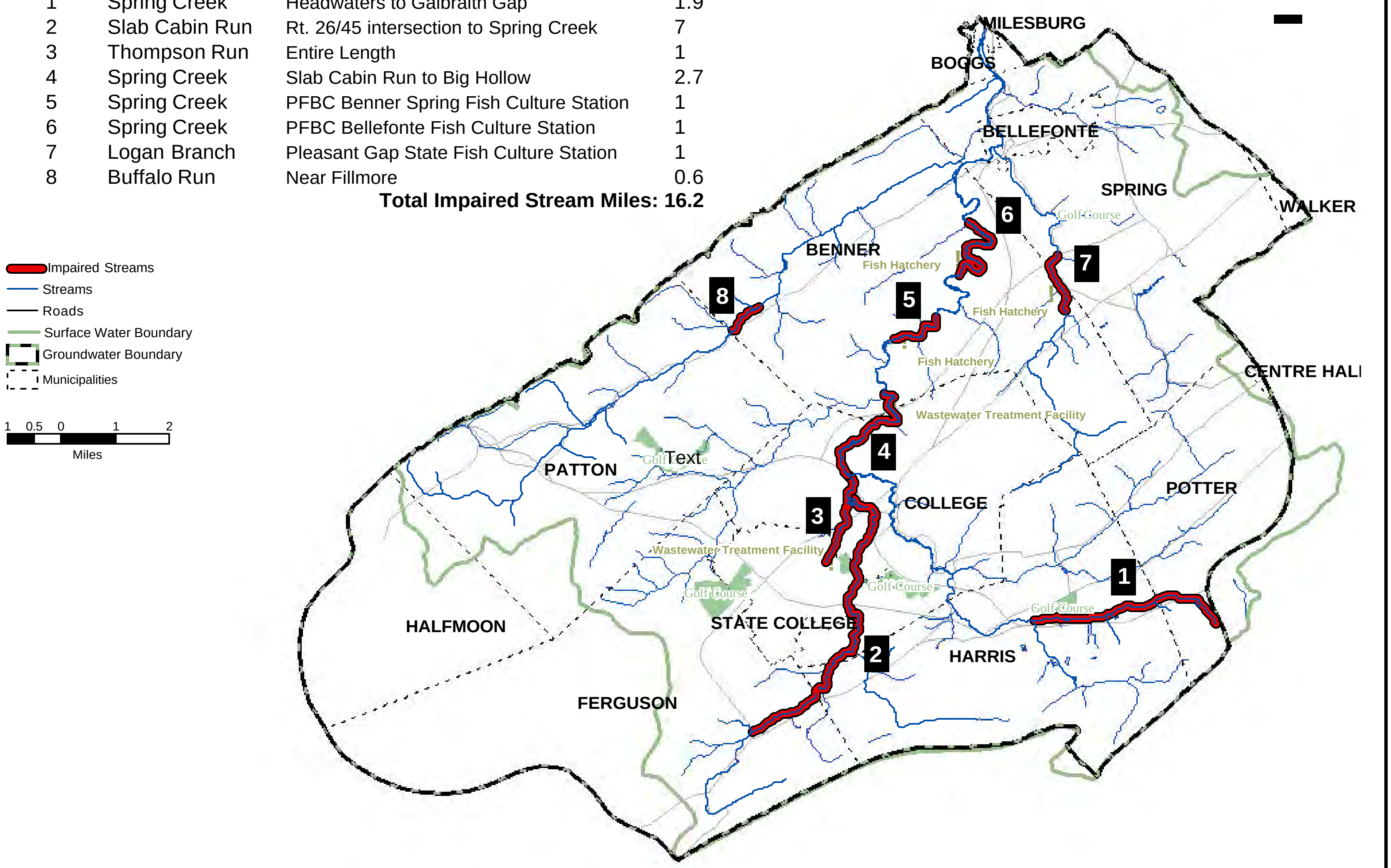
PADEP-ASSESSED [1] SOURCE OF IMPAIRMENT	Spring Creek upstream from Boalsburg	Slab Cabin Run	Thompson Run	Spring Creek PAFBC Benner Spring Facility	Spring Creek – Bellefonte Facility	Logan Branch – PAFBC [2] Pleasant Gap Facility	Spring Creek- Slab Cabin to Big Hollow	Buffalo Run
Golf Course	✓	✓						
Residential Runoff	✓							
Agriculture	✓							✓
Removal of Riparian Vegetation	✓							
Grazing		✓						
Flow Modification		✓						
Urban Runoff		✓	✓				✓	
Storm Sewers							✓	
Industrial Point Source				✓	✓	✓		
ENVIRONMENTAL EFFECT								
Flow Variability		✓						
Organic Enrichment				✓	✓	✓		
Silt	✓	✓	✓				✓	✓
Thermal Modification	✓	✓						

[1] PADEP Report

[2] PAFBC = Pennsylvania Fish and Boat Commission

- ClearWater Conservancy and the Spring Creek Chapter of Trout Unlimited partnered together to initiate a "Riparian Conservation Program" in 2003 to educate the public on the importance of riparian vegetation, help landowners establish or restore buffers on their property, and offer permanent protection options (e.g., conservation easements) for riparian properties. This program is funded by PA DEP Growing Greener Program, Chesapeake Bay Small Watershed Grants Program, and the Western Pennsylvania Protection Program.
- Penn State Office of Physical Plant applied for and was awarded a PA Department of Environmental Protection Growing Greener grant in 2003 to identify, design and permit a wetland treatment system to improve the water quality of Slab Cabin Run before its confluence with Spring Creek.
- Through the National Pollutant Discharge Elimination System (NPDES) Phase II storm water regulations, PA DEP requires municipalities in "urbanized areas" to obtain NPDES permit coverage for municipal separate storm sewer systems (MS4s) and implement a program of best management practices for improving and maintaining the quality of storm water discharges. In 2003, MS4 permits

Map ID	Stream Name	Section	Length (MI)
1	Spring Creek	Headwaters to Galbraith Gap	1.9
2	Slab Cabin Run	Rt. 26/45 intersection to Spring Creek	7
3	Thompson Run	Entire Length	1
4	Spring Creek	Slab Cabin Run to Big Hollow	2.7
5	Spring Creek	PFBC Benner Spring Fish Culture Station	1
6	Spring Creek	PFBC Bellefonte Fish Culture Station	1
7	Logan Branch	Pleasant Gap State Fish Culture Station	1
8	Buffalo Run	Near Fillmore	0.6
		Total Impaired Stream Miles:	**16.2**



Impaired Streams in the Spring Creek Watershed

SPRING CREEK WATERSHED COMMUNITY

Map layout adapted from Dwight Landis
(Spring Creek Impairment Map, 2002 WRMP Annual Report).

Figure 14. Impaired Streams in the Spring Creek Watershed.

A SAMPLING OF WATER RESOURCES MONITORING PROJECT DATA USERS

- **Confidential Engineering User** - Streamflow and ground-water level data to assess impacts of I-99 acid rock drainage.
- **Confidential Industrial User** – Streamflow data used to assess impacts of uncontrolled release of industrial material.
- **Confidential Industrial User** - Streamflow data used to support SRBC permit application for ground water withdrawal.
- **PA Department of Environmental Protection** - Water quality data used to support Section 303d assessment.
- **PSU Graduate Students** – Streamflow and water quality data used for M.S. and P.H.D. research work.
- **Spring Creek Watershed Community** – Streamflow, water-table level, and water quality data used for the WRMP 2003 Annual Report.
- **Spring Creek Watershed Plan; USGS, Spring Creek Watershed Municipalities** – Streamflow data used for assessment of watershed hydrologic conditions.
- **Spring Township Water Authority** – Streamflow data used to assess water resources impacts of development of a new public water supply source well.
- **State College Borough Water Authority** – Streamflow and water quality data to be used for source water protection study.
- **Susquehanna River Basin Commission** – WRMP project data and project reports added to SRBC files.
- **Spring Creek Watershed Commission** – Water-table level data presented at each meeting in a 'Recharge Report'.
- **Upper/Middle Susquehanna Regional Committee** – Water-table level data presented to illustrate Critical Water Planning Area criteria.

were issued to five Spring Creek Watershed municipalities (College, Harris, Ferguson, and Patton Townships and the Borough of State College), Penn State University, and Rockview Correctional Institute. Among other things, these permits require illicit discharge detection and elimination, construction site runoff control, post-construction storm water management in new development and redevelopment and, pollution prevention and good housekeeping for municipal operations and maintenance, which will all help reduce the impairments caused by nonpoint source pollution in the Spring Creek Watershed.

5.0 WATERSHED RECOMMENDATIONS

Industrial point sources of pollution are presently being addressed by PA DEP under its National Pollutant Discharge Elimination System (NPDES) program. Most of the remaining identified potential sources of impairment fall under the broad heading of "nonpoint" sources (NPS). Most state and federal environmental management agencies would agree that the management of nonpoint source pollution is one of the most significant challenges for the future. In fact, PA DEP's Growing Greener Program was initiated, in part, to allocate resources to local stakeholder groups and other entities specifically to address nonpoint source pollution issues.

WATERSHED-WIDE RECOMMENDATIONS

The following recommendations apply to the entire Spring Creek Watershed with particular relevance to sections impaired by nonpoint sources. These recommendations may apply to a variety of entities and individuals: municipalities, sewer and water authorities, the Centre County Conservation District, Penn State University, environmental organizations, and private land owners.

- Survey subbasins to assess the listed 303(d) impairments. Confirm the Pennsylvania Department of Environmental Protection assessment of sources of impairment and identify possible additional causes of impairment.
- Identify current storm-water problem areas caused by existing urban development and prioritize actions to correct them.
- Implement the Spring Creek Watershed Act 167 Stormwater Management Plan to help address future adverse effects of urbanization upon the natural hydrologic function of the Watershed.
- Implement NPDES Phase II Stormwater Management to help address adverse effects of urban runoff.
- Protect, preserve, and enhance riparian vegetation.
- Implement streambank protection practices such as fencing, stream bank and bed stabilization, and riparian buffers.
- Implement best management practices to reduce runoff, erosion and nutrient/chemical losses from agricultural land areas.
- Implement macroinvertebrate monitoring to assess effectiveness of remediation.
- Identify and protect critical ground-water recharge areas to ensure the future availability of ground-water resources and base flow.

SUBBASIN RECOMMENDATIONS

Spring Creek Upstream from Boalsburg

- The Centre County Conservation District and environmental groups should continue working with private landowners to implement Best Management Practices on agricultural lands to improve riparian conditions.
- Municipalities should carefully examine proposed developments in this subbasin to minimize runoff and nonpoint source pollution transport to streams.

Slab Cabin Run

- This subbasin will probably come under severe development pressure in the near future. To ensure that water quality is not further degraded, municipalities should closely scrutinize proposed developments, insist on application of Best Management Practices, promote preservation of open space, and seek to minimize installation of impervious surfaces.
- Water and sewer authorities should seek to reduce flow modification, such as through the UAJA Beneficial Reuse Project.
- The Centre County Conservation District and environmental groups should work with private landowners to implement Best Management Practices on agricultural lands and to improve riparian conditions.

Thompson Run

- Making progressive implementation of NPDES Phase II storm water management is a high priority.
- This is the most extensively developed subbasin in the Watershed and may be the most challenging to address existing problems. Municipalities and Penn State University should seek to improve storm water management where feasible, preserve existing open space, and avoid increasing impervious surfaces.

Spring Creek; Slab Cabin Run to Big Hollow

- Making progressive implementation of NPDES Phase II storm water management is a high priority.

Table 6. Summary Recommendations for Impaired Sub basins.

RECOMMENDED ACTION	Spring Creek upstream from Boalsburg	Slab Cabin Run	Thompson Run	Spring Creek- Slab Cabin to Big Hollow	Buffalo Run
Survey Sub-basins	✓	✓	✓	✓	✓
Act 167 Implementation	✓	✓	✓	✓	✓
Low-impact development BMP's	✓	✓			✓
NPDES Phase II Implementation		✓	✓	✓	
Mitigate existing residential runoff problems	✓	✓			
Mitigate existing urban runoff problems			✓	✓	
Streambank fencing and riparian buffers	✓	✓		✓	✓

Buffalo Run

- The Centre County Conservation District and environmental groups should work with private landowners to implement Best Management Practices on riparian lands and on adjacent agricultural areas.

WRMP Technician downloading stream stage data at Thompson Run.
Photo by: Todd Giddings

APPENDIX

Monthly data for 2003 are compiled in an addendum to this report. If you would like to receive a copy of the addendum, please contact the Water Resources Monitoring Project Manager at (814) 237-0400.

PARAMETER	DESCRIPTION	SOURCES	ENVIRONMENTAL EFFECTS	PA DEP CRITERIA*
pH	A measure of the acidity of water on a logarithmic scale of 1 to 14. A pH below 7 is acidic, above 7 is basic or alkaline, and a pH of 7 is neutral.	The pH of Spring Creek is slightly alkaline because of the carbonate bedrock. pH can be lowered by acid mine drainage or acid rain.	Extreme pH can inhibit growth and reproduction.in aquatic organisms. Acidic waters also release metals from the sediment, creating toxic conditions.	6-9
Dissolved Oxygen (DO)	Oxygen gas dissolved in the water is crucial to aquatic life. The amount of oxygen dissolved at saturation is inversely related to temperature.	DO is depleted by respiration and the microbial breakdown of organic wastes. It is restored by photosynthesis and physical aeration.	Low levels of dissolved oxygen are harmful to aquatic animals. This is usually the result of organic pollution or elevated temperatures.	> 7 mg/L (HQCWF**) >5.0 mg/L (CWF**)
Turbidity	A measure of water clarity expressed as the amount of light penetrating the water. It is relative to the amount of suspended material in the water.	While some clean rivers are naturally turbid, turbidity can be increased by earth-moving activities, urban runoff, and erosion from agricultural fields.	High turbidity blocks light from the water column and inhibits submerged aquatic plants. By absorbing sunlight, the particles also increase water temperature.	No criteria established.
Total Suspended Solids (TSS)	Any particles carried by the water and include silt, plankton, organic stream litter, industrial waste and sewage.	Sources include urban runoff, wastewater treatment plants, soil erosion, and decaying plant and animal material.	Suspended solids clog fish gills and alter stream-bed habitat when settled. Particles may carry bound toxic compounds or metals.	No criteria established.
Chloride	The concentration of chloride salt ions dissolved in the water.	Washes off of roads where it is applied as a deicing agent.	Very high chloride concentrations can be toxic to macroinvertebrates.	< 150 mg/L HQ-CWF**
Ortho-phosphate	Orthophosphate is the form of inorganic phosphorous required by plants. Its availability is often the limiting factor in plant growth.	Rocks and minerals provide a low natural level. Human sources include commercial cleaning products, water treatment plants, and fertilized lawns and farmland.	A small increase in orthophosphate can cause eutrophication, the loss of dissolved oxygen through the stimulation and decay of excessive plant growth.	No criteria established.
Nitrate (NO3)	One of three forms of nitrogen found in water bodies, nitrate is the form used by aquatic plants. Organic nitrogen (N) is converted to nitrate (NO3) by bacteria.	Any nitrogen-containing organic waste, including sewage from water treatment plants and septic systems, and runoff from fertilized lawns, farms and livestock areas.	High nitrate levels promote excessive plant growth and eutrophication. Excess nitrate in drinking water can cause illness of death in infants.	< 10 mg/L for Nitrate and Nitrite Combined
Total Petroleum Hydrocarbons	Molecules found in petroleum fuels. Indicates oil pollution and road runoff.	Runoff from roads, careless disposal, accidental spills, and natural deposits.	Varying degrees of toxicity to aquatic organisms and birds.	No criteria established.
Total Organic Carbon	A measure of the amount of carbon-containing compounds and thus the amount of organic material present.	Animal wastes, human wastes, plant material, agricultural chemicals, and petroleum compounds.	High carbon content in streams increases the growth of microorganisms, which depletes dissolved oxygen.	No criteria established.
Copper	A heavy metal less common than lead and zinc in nature.	Used in wiring, plumbing, and electronics, and to control algae, bacteria, and fungi.	Toxic to humans and aquatic life. Toxicity is affected by water hardness.	<12.7 ug/L***
Lead	A heavy metal that occurs naturally as lead sulfide but may exist in other forms.	Urban & industrial uses include gasoline, batteries, solder, pigments, and paint.	Toxic to humans and aquatic life. Toxicity is affected by water hardness.	<3.90 ug/L***
Zinc	A heavy metal commonly found in rock-forming minerals.	Urban runoff, industrial discharges and natural sources. Used in many alloys.	Somewhat toxic to humans and aquatic life. Toxicity is affected by water hardness.	<167 ug/L***

*From Pennsylvania Code Title 25, Chapters 16 and 93
**HQ-CWF = High Quality Cold Water Fishery, CWF = Cold Water Fishery
***Assuming a water herdness of 150 mg/L.

2003 Annual Report Addendum

Spring Creek Watershed Community
Water Resources Monitoring Project

Water Resources Monitoring Project 2003 Monthly Surface Water Data

* Base flow water quality samples were not collected in June, August, September, and Novemeber 2003 due to frequent precipitation events.

Table 1. 2003 Mean Monthly Stream Flows (cfs).

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Median
Buffalo Run Upper	18.8	10.5	26.3	17.4	13.9	20.6	11.6	13.8	29.2	19.6	26.2	33.3	20.1	19.2
Buffalo Run Lower	20.1	5.2	31.5	18.9	12.4	28.5	9.0	11.8	30.3	18.4	29.0	36.2	21.0	19.5
Cedar Run Lower	23.6	13.5	20.1	No Data	14.7	24.8	14.0	16.1	24.6	18.1	24.9	37.9	21.1	20.1
Logan Branch Upper	40.9	19.7	64.1	66.3	31.2	56.3	25.7	29.5	51.3	39.5	57.9	71.2	46.1	46.1
Logan Branch Lower	97.0	72.5	124.2	121.1	86.0	109.5	81.6	93.3	118.3	116.8	119.5	137.7	106.5	113.2
Slab Cabin Run Upper	17.5	5.3	32.0	29.3	12.1	28.3	13.6	35.3	48.3	29.5	34.5	45.4	27.6	29.4
Slab Cabin Run Lower	20.9	8.6	34.2	26.0	13.5	29.1	14.2	32.8	44.9	26.7	32.2	42.4	27.1	27.9
Thompson Run Lower	10.8	7.9	16.6	11.9	10.9	17.6	15.6	No Data	No Data	19.1	23.5	25.3	15.9	16.1
Spring Creek Upper	38.0	17.4	57.4	52.0	35.8	64.8	41.5	58.3	81.4	45.9	63.5	67.2	51.9	54.7
Spring Creek Houserville*	102.0	54.9	145.4	117.1	73.9	126.6	67.1	111.6	160.4	94.2	130.5	169.7	112.8	114.4
Spring Creek Axemann*	135.0	81.8	191.1	153.2	96.1	151.7	97.1	144.9	192.8	132.0	170.2	232.9	148.2	148.3
Spring Creek Milesburg*	268.5	175.9	385.4	327.3	208.5	319.3	201.3	270.2	368.9	300.6	382.0	432.4	303.3	310.0

* USGS Data is provisional and subject to change.

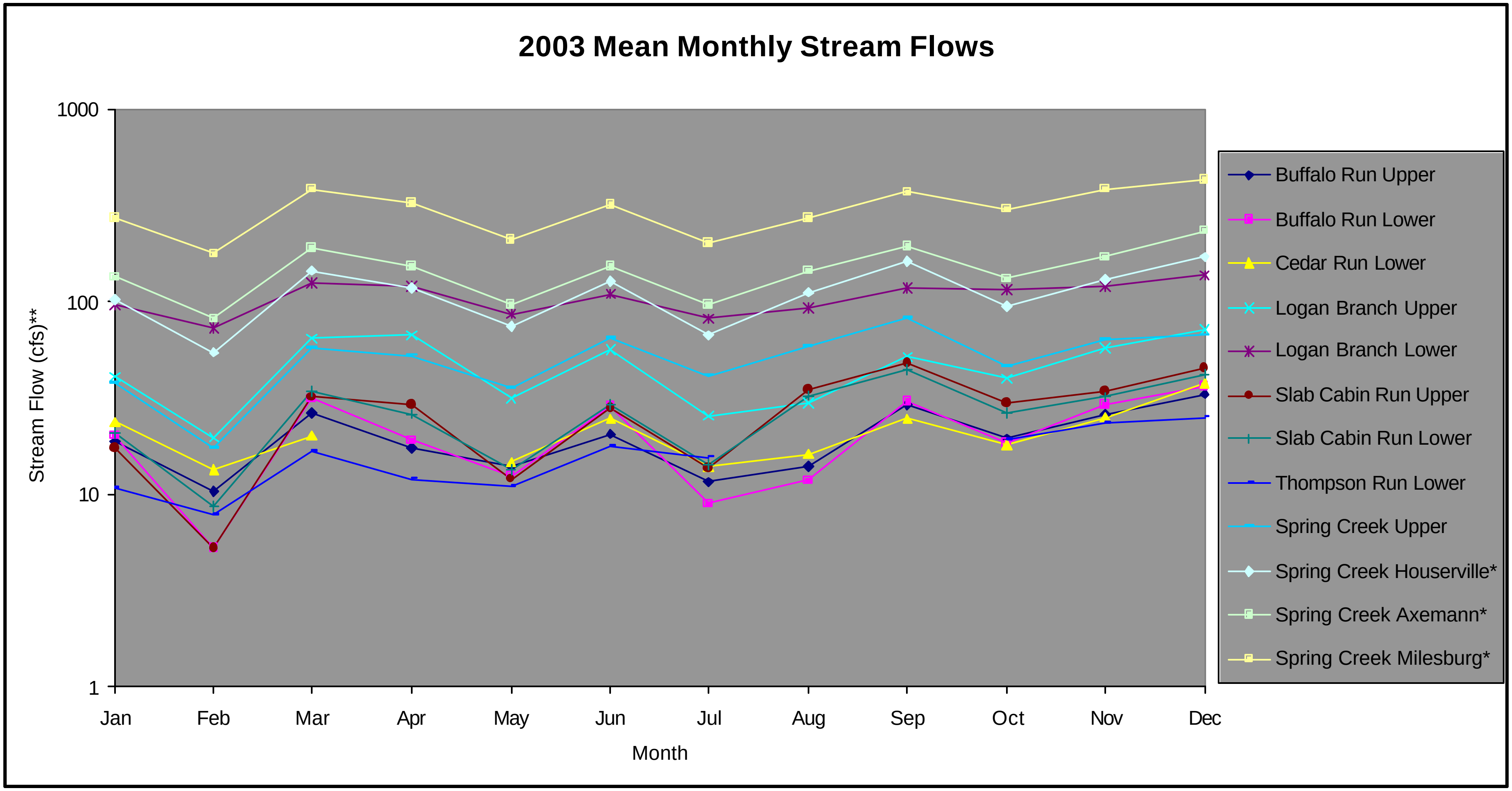


Figure 1. 2003 Mean Monthly Stream Flows.

* USGS Data are provisional and subject to change.

** Stream flow is displayed logarithmically. Each major gradation on the y-axis is 10 times greater than the previous major gradation.

Table 2. 2003 Mean Monthly Stream Temperatures (°F).

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Median
Buffalo Run Upper	35.3	33.3	36.0	53.6	54.1	57.0	62.3	63.5	58.1	51.1	No Data	38.9	49.4	53.6
Buffalo Run Lower	37.0	36.2	38.8	55.0	55.4	57.4	62.5	62.9	58.8	49.5	48.9	39.9	50.2	52.2
Cedar Run Lower	41.0	40.9	45.5	50.8	54.0	55.8	58.7	58.3	55.5	51.6	46.5	43.4	50.2	51.2
Logan Branch Upper	43.5	43.5	44.9	53.1	53.9	56.1	59.8	59.5	57.1	53.0	50.8	No Data	52.3	53.1
Logan Branch Lower	46.4	47.4	48.4	51.1	53.2	54.9	55.9	55.8	54.8	52.6	49.0	46.9	51.4	51.9
Slab Cabin Run Upper	39.0	38.3	43.4	50.1	54.3	55.7	59.8	58.9	55.9	51.7	48.8	41.4	49.8	50.9
Slab Cabin Run Lower	38.2	37.7	43.8	50.5	55.5	57.0	62.4	61.8	57.8	52.7	46.2	42.3	50.5	51.6
Thompson Run Lower	44.9	45.4	49.2	52.5	54.6	56.3	58.8	59.1	56.4	52.8	49.6	46.9	52.2	52.7
Spring Creek Upper	44.5	45.8	45.1	49.0	52.0	54.2	54.8	57.2	56.0	52.0	46.3	43.1	50.0	50.5
Spring Creek Houserville	40.2	40.5	45.1	49.9	55.4	57.0	60.7	61.3	57.7	52.9	No Data	No Data	52.1	54.1
Spring Creek Axemann	40.0	39.8	41.3	55.8	56.4	58.5	63.6	62.9	58.7	52.8	No Data	32.0	51.1	55.8
Spring Creek Milesburg	44.1	41.7	43.3	54.6	54.9	57.2	60.8	60.9	57.5	51.7	49.3	43.8	51.6	53.1

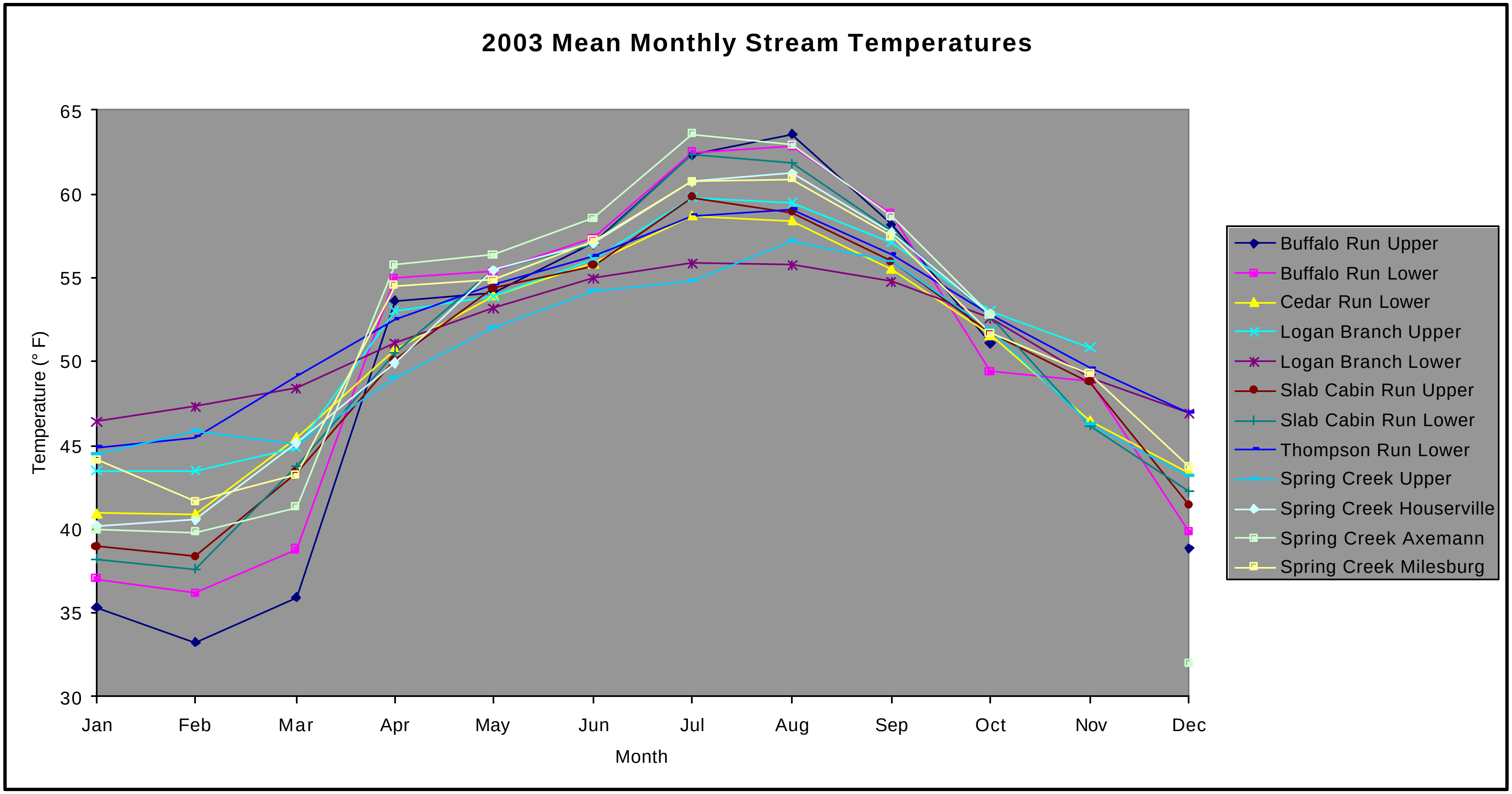


Figure 2. 2003 Mean Monthly Stream Temperatures.

Table 3. 2003 Total Suspended Solids Concentrations (mg/L).

Station Name	Jan	Feb	Mar	Apr	May	Jul	Oct	Dec	Mean*	Median*
Buffalo Run Upper	<2	No Data	<2	6	16	8	<2	6	5.6	6.0
Buffalo Run Lower	<2	12	<2	4	<2	4	<2	2	3.3	1.5
Cedar Run Lower	48	4	22	16	12	4	2	18	15.8	14.0
Logan Branch Upper	6	6	4	8	<2	2	<2	12	5.0	5.0
Logan Branch Lower	2	6	<2	<2	<2	4	<2	12	3.5	1.5
Slab Cabin Run Upper	6	8	18	6	12	8	4	20	10.3	8.0
Slab Cabin Run Lower	22	<2	2	12	<2	6	4	<2	6.1	3.0
Thompson Run Lower	8	12	2	2	<2	8	<2	18	6.5	5.0
Spring Creek Upper	<2	20	2	6	4	6	<2	14	6.8	5.0
Spring Creek Houserville	2	6	8	10	8	4	<2	30	8.6	7.0
Spring Creek Axemann	10	12	2	<2	10	8	<2	<2	5.6	5.0
Spring Creek Milesburg	<2	2	<2	14	6	4	<2	8	4.6	3.0

* Mean and median values were calculated using 1/2 the detection limit for non-detected values. Detection limit = 2 mg/L.

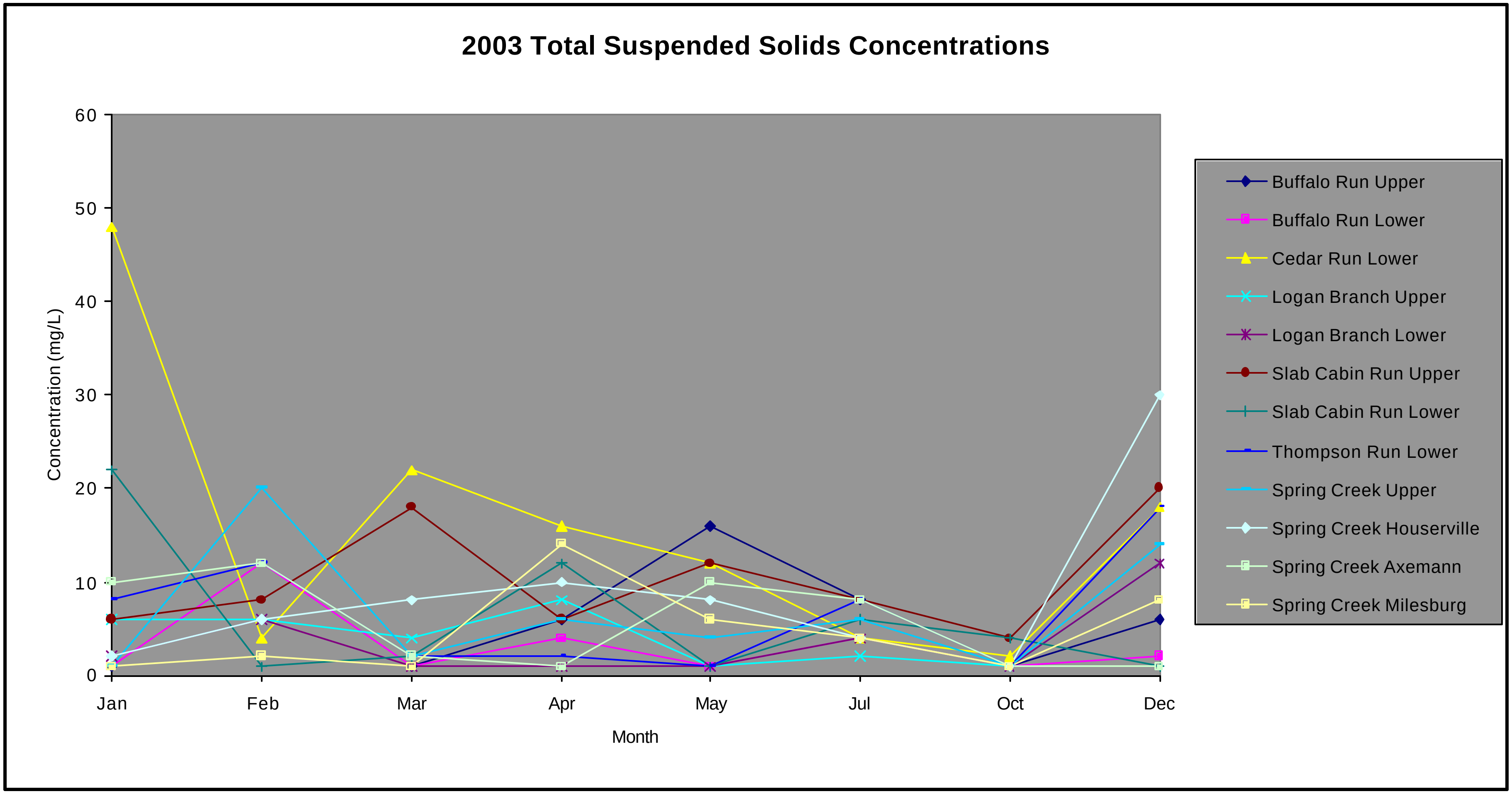


Figure 3. 2003 Total Suspended Solids Concentrations.

* Non-detected values shown at one-half detection limit.

Table 4. 2003 Turbidity Levels.

Station Name	Jan	Feb	Mar	Apr	May	Jul	Oct	Dec	Mean*	Median*
Buffalo Run Upper	5.2	No Data	10.5	5.7	13.3	4.7	3.0	4.5	6.7	5.2
Buffalo Run Lower	3.5	1.5	1.4	2.5	3.7	3.1	1.4	3.2	2.6	2.8
Cedar Run Lower	10.2	5.3	6.6	2.9	7.4	3.6	2.2	5.5	5.5	5.4
Logan Branch Upper	6.5	2.1	6.2	3.3	2.6	2.2	2.0	12.3	4.7	3.0
Logan Branch Lower	3.2	<1	1.4	1.8	2.0	1.3	1.4	5.4	2.1	1.6
Slab Cabin Run Upper	5.7	4.3	5.2	1.3	2.3	3.2	3.2	6.9	4.0	3.7
Slab Cabin Run Lower	4.2	<1	1.8	2.9	1.1	1.8	1.7	4.9	2.4	1.8
Thompson Run Lower	2.4	1.6	2.3	1.6	2.3	1.7	<1	1.2	1.7	1.6
Spring Creek Upper	2.0	<1	1.7	<1	2.4	1.0	<1	1.3	1.2	1.2
Spring Creek Houserville	3.4	1.2	2.9	1.6	3.9	2.2	1.1	2.5	2.3	2.4
Spring Creek Axemann	3.1	1.3	3.5	3.0	5.1	3.6	1.8	3.0	3.0	3.1
Spring Creek Milesburg	3.3	<1	2.4	3.3	3.4	2.6	1.8	4.5	2.7	2.9

* Mean and median values were calculated using 1/2 the detection limit for non-detected values. Detection limit = 1 NTU.

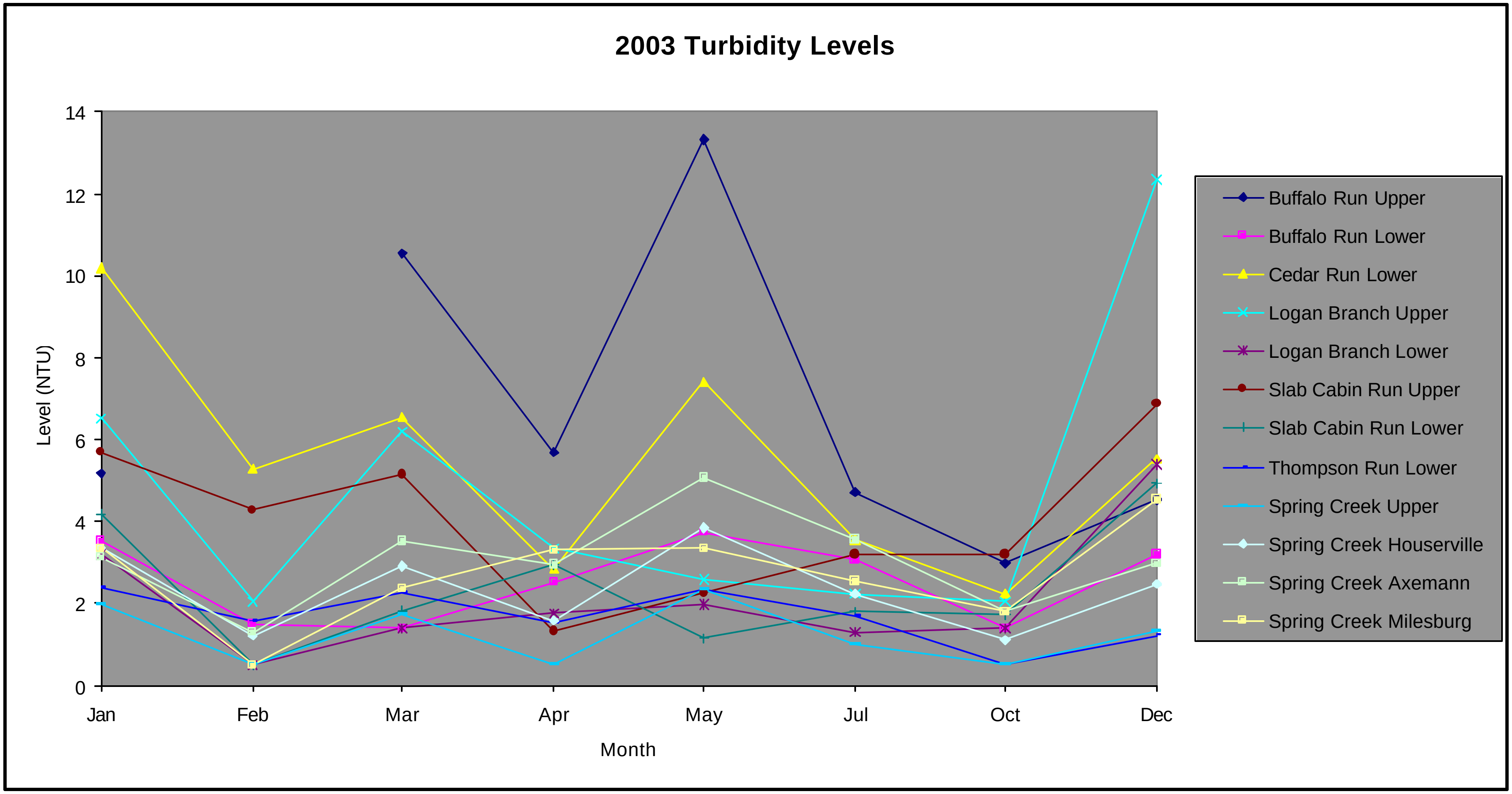


Figure 4. 2003 Turbidity Levels.

* Non-detected values shown at one-half detection limit.

Table 5. 2003 Dissolved Oxygen Concentrations (mg/L).

Station Name	Jan	Feb	Mar	Apr	May	Jul	Oct	Dec	Mean	Median
Buffalo Run Upper	12.5	No Data	16.9	12.9	12.2	9.1	10.5	13.0	12.4	12.5
Buffalo Run Lower	12.4	No Data	15.6	12.0	11.5	11.6	10.8	12.8	12.4	12.0
Cedar Run Lower	12.2	12.7	13.2	12.6	10.1	11.1	11.2	12.3	11.9	12.3
Logan Branch Upper	11.2	No Data	14.4	13.4	12.4	10.3	10.6	11.2	11.9	11.2
Logan Branch Lower	10.9	No Data	13.4	12.8	11.6	10.9	10.4	11.0	11.6	11.0
Slab Cabin Run Upper	12.4	11.9	13.3	13.0	9.4	8.2	11.4	12.3	11.5	12.1
Slab Cabin Run Lower	13.0	13.5	14.0	13.9	10.8	10.4	10.8	12.5	12.4	12.7
Thompson Run Lower	11.7	12.1	13.9	11.9	11.1	10.4	10.9	11.0	11.6	11.4
Spring Creek Upper	11.8	10.9	12.1	11.2	10.2	9.6	9.9	11.4	10.9	11.1
Spring Creek Houserville	13.7	14.7	15.1	13.6	11.4	11.1	11.7	12.7	13.0	13.1
Spring Creek Axemann	11.7	No Data	15.8	13.7	12.3	10.1	9.8	12.2	12.2	12.2
Spring Creek Milesburg	11.7	No Data	14.3	11.7	11.5	11.7	11.3	11.8	12.0	11.7

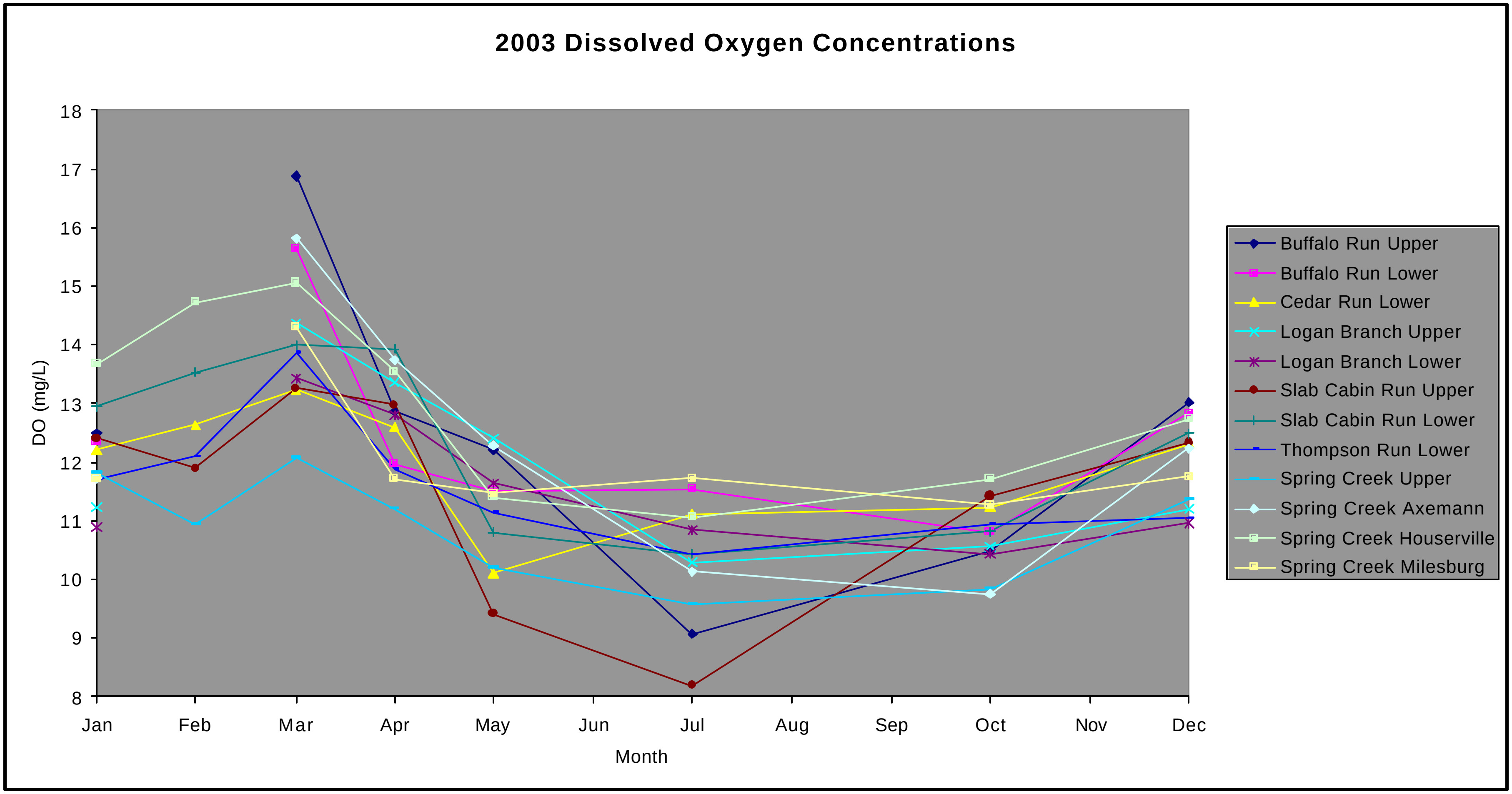


Figure 5. 2003 Dissolved Oxygen Concentrations.

Table 6. 2003 pH Values (Standard Units).

Station Name	Jan	Feb	Mar	Apr	May	Jul	Oct	Dec	Mean	Median
Buffalo Run Upper	8.1	No Data	8.3	8.3	8.4	8.2	8.4	8.1	8.3	8.3
Buffalo Run Lower	8.1	8.1	8.1	8.3	8.4	8.3	8.2	8.3	8.2	8.3
Cedar Run Lower	8.1	8.2	8.1	8.3	8.2	8.2	8.4	8.3	8.2	8.2
Logan Branch Upper	7.7	7.9	7.8	8.2	8.2	8.0	8.0	7.8	8.0	8.0
Logan Branch Lower	7.8	7.8	7.9	8.1	8.1	8.1	8.4	7.9	8.0	8.0
Slab Cabin Run Upper	7.7	7.8	7.7	8.0	7.8	7.7	7.9	8.1	7.8	7.8
Slab Cabin Run Lower	8.1	8.1	7.9	8.6	8.1	8.1	8.3	8.0	8.2	8.1
Thompson Run Lower	8.0	8.1	8.2	8.2	8.1	8.0	8.2	8.0	8.1	8.1
Spring Creek Upper	7.7	7.5	7.6	7.7	7.7	7.6	7.8	7.9	7.7	7.7
Spring Creek Houserville	8.3	8.3	8.3	8.5	8.2	8.3	8.4	8.2	8.3	8.3
Spring Creek Axemann	8.0	8.1	8.1	8.3	8.3	8.1	8.2	8.1	8.2	8.1
Spring Creek Milesburg	8.1	8.3	8.3	8.5	8.4	8.4	8.3	8.3	8.3	8.3

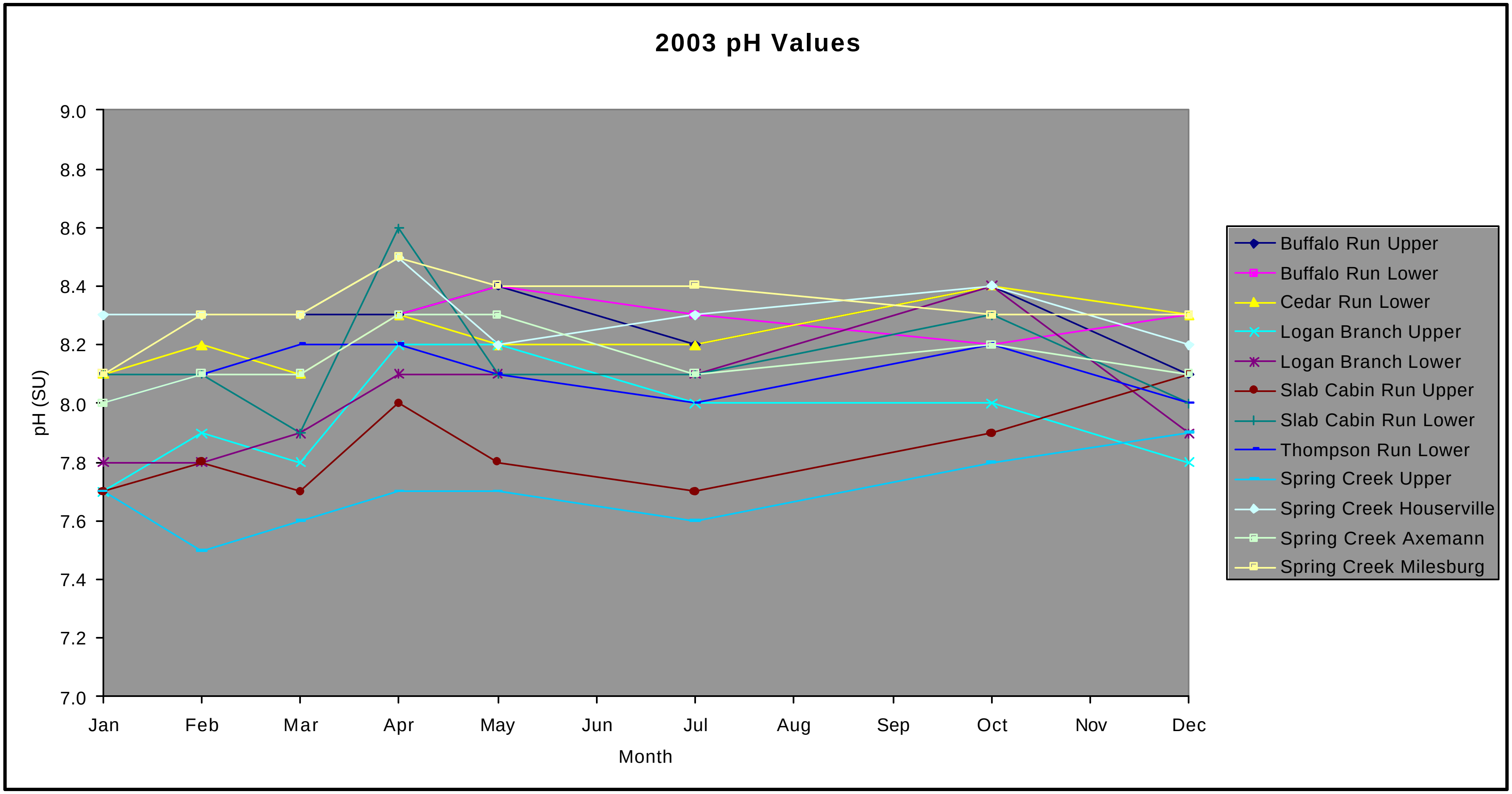


Figure 6. 2003 pH Values.

Table 7. 2003 Total Chloride Concentrations (mg/L).

Station Name	Jan	Feb	Mar	Apr	May	Jul	Oct	Dec	Mean	Median
Buffalo Run Upper	27.1	No Data	35.0	26.9	20.5	27.7	23.3	15.7	25.2	26.9
Buffalo Run Lower	20.3	18.9	28.5	19.3	18.1	17.4	18.9	14.6	19.5	18.9
Cedar Run Lower	15.9	15.0	20.8	16.1	16.0	15.3	13.0	12.1	15.5	15.6
Logan Branch Upper	23.8	29.6	35.8	23.1	18.9	19.4	17.8	11.7	22.5	21.3
Logan Branch Lower	22.0	22.9	27.0	21.7	20.8	19.9	19.8	15.7	21.2	21.3
Slab Cabin Run Upper	25.5	30.7	37.0	26.7	24.4	28.6	19.0	16.2	26.0	26.1
Slab Cabin Run Lower	41.8	54.6	65.7	39.9	40.7	45.7	31.1	25.2	43.1	41.3
Thompson Run Lower	230.0	95.9	88.5	73.2	62.3	62.9	65.3	71.4	93.7	72.3
Spring Creek Upper	17.6	19.9	24.1	15.8	13.8	19.9	14.9	11.0	17.1	16.7
Spring Creek Houserville	53.6	47.9	51.0	33.9	32.3	36.4	32.0	26.4	39.2	35.2
Spring Creek Axemann	53.1	65.6	59.3	43.6	45.2	47.9	41.2	31.4	48.4	46.6
Spring Creek Milesburg	41.4	44.8	42.5	34.8	34.5	34.0	33.5	26.8	36.5	34.7

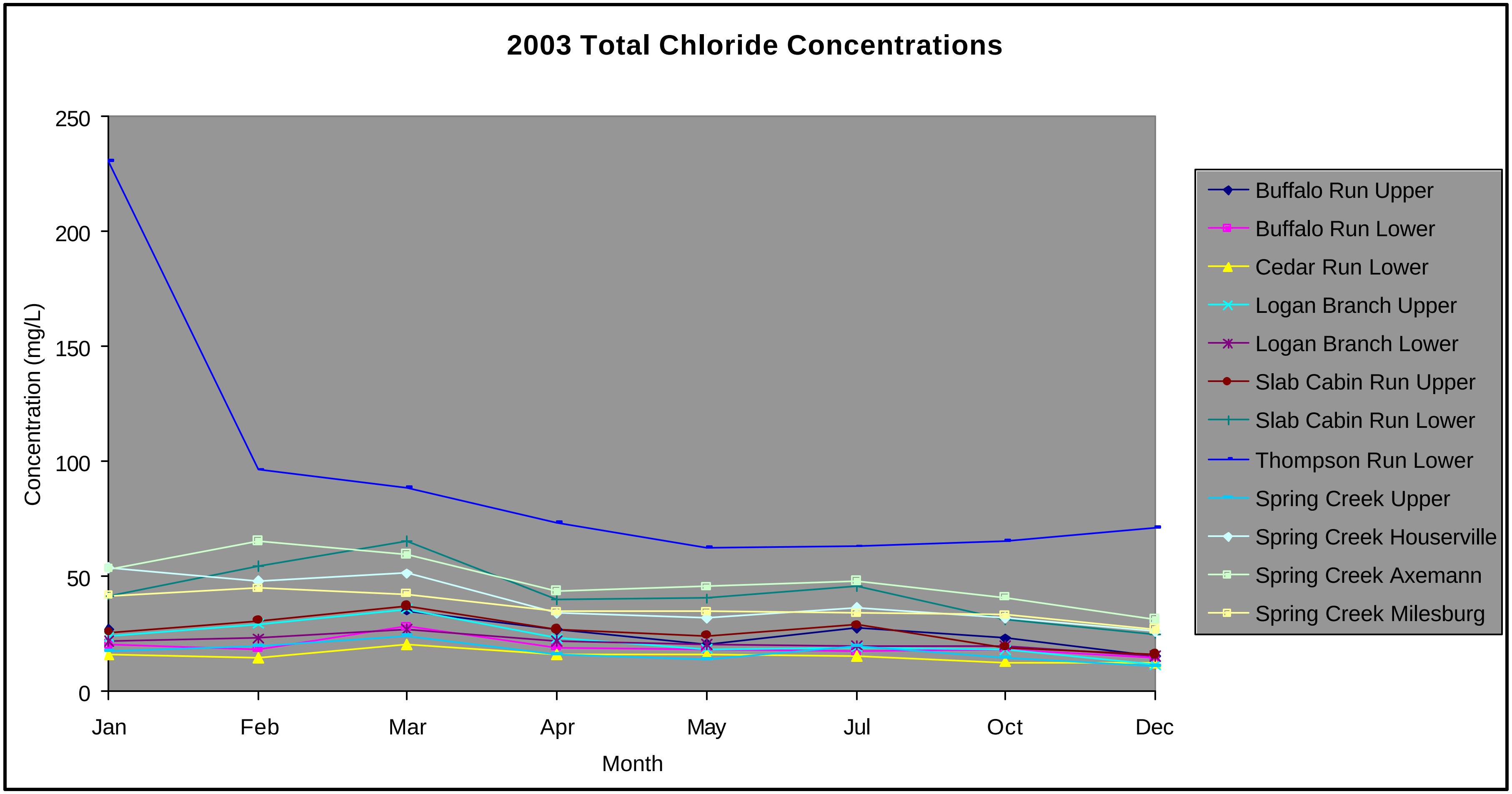


Figure 7. 2003 Total Chloride Concentrations.

Table 8. 2003 Total Lead Concentrations (ug/L).

Station Name	Jan	Feb	Mar	Apr	May	Jul	Oct	Dec	Mean*	Median*
Buffalo Run Upper	<1	No Data	<1	<1	<1	<1	<1	<1	<1	<1
Buffalo Run Lower	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cedar Run Lower	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Logan Branch Upper	4.0	3.3	3.2	1.5	1.9	2.2	<1	2.8	2.4	2.5
Logan Branch Lower	2.2	<1	<1	1.6	<1	1.8	<1	1.8	1.2	1.1
Slab Cabin Run Upper	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Slab Cabin Run Lower	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Thompson Run Lower	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Spring Creek Upper	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Spring Creek Houserville	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Spring Creek Axemann	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Spring Creek Milesburg	<1	47.1	<1	<1	<1	<1	<1	<1	6.3	<1

* Mean and median values were calculated using 1/2 the detection limit for non-detected values. Mean and median values less than the detectable limit are reported as < detection limit. Detection limit = 1 ug/L.

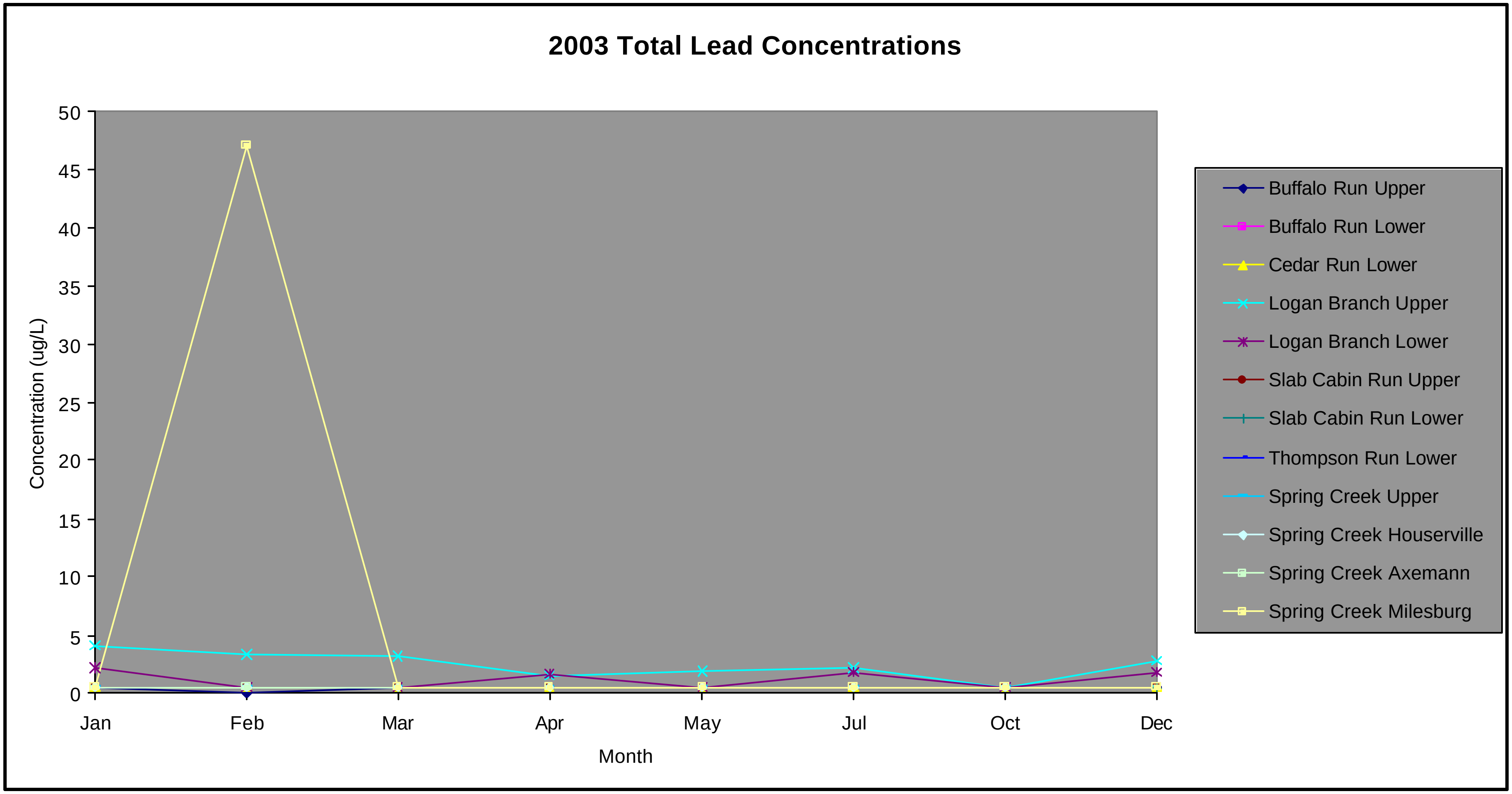


Figure 8. 2003 Total Lead Concentrations.

* Non-detected values shown at one-half detection limit.

Table 9. 2003 Total Zinc Concentrations (ug/L).

Station Name	Jan	Feb	Mar	Apr	May	Jul	Oct	Dec	Mean*	Median*
Buffalo Run Upper	<10	No Data	<10	<10	<10	<10	<10	49	11.3	<10
Buffalo Run Lower	<10	<10	10	<10	17	228	<10	<10	35.0	<10
Cedar Run Lower	<10	<10	96	<10	22	10	17	383	67.9	13.5
Logan Branch Upper	<10	14	<10	<10	26	278	<10	<10	42.9	<10
Logan Branch Lower	23	16	25	17	45	34	32	18	26.3	24.0
Slab Cabin Run Upper	<10	<10	72	<10	18	<10	<10	262	47.1	<10
Slab Cabin Run Lower	<10	<10	<10	112	22	11	162	251	71.6	16.5
Thompson Run Lower	<10	<10	89	143	51	<10	200	<10	62.9	28.0
Spring Creek Upper	<10	<10	76	91	16	<10	20	<10	27.9	10.5
Spring Creek Houserville	<10	<10	93	123	19	10	200	<10	57.5	14.5
Spring Creek Axemann	<10	<10	14	<10	23	15	<10	<10	<10	<10
Spring Creek Milesburg	10	17	17	10	20	234	<10	10	40.4	13.5

* Mean and median values were calculated using 1/2 the detection limit for non-detected values. Mean and median values less than the detectable limit are reported as < detection limit. Detection limit = 10 ug/L.

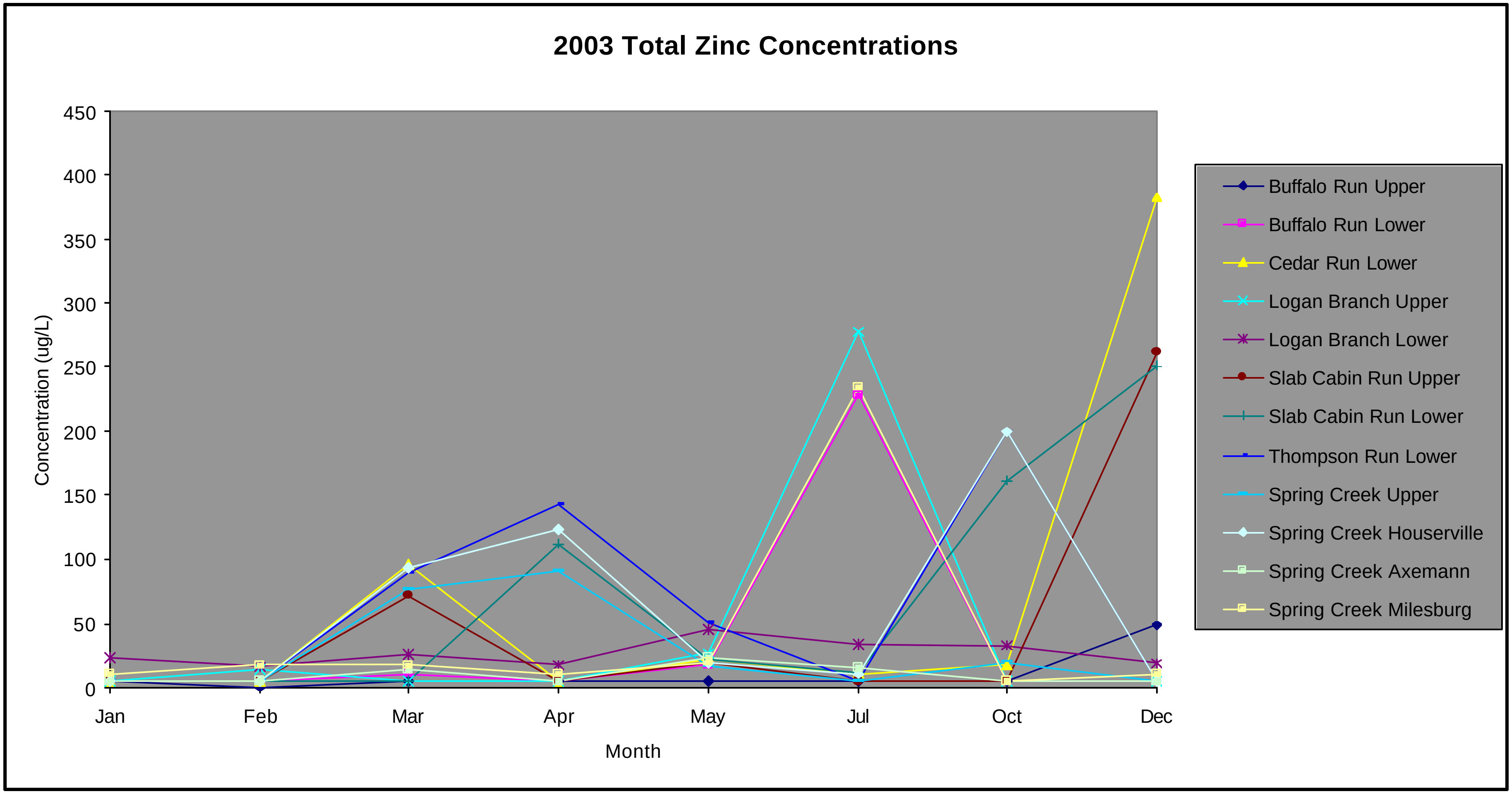


Figure 9. 2003 Total Zinc Concentrations.

* Non-detected values shown at one-half detection limit.

Table 10. 2003 Total Nitrate Concentrations (mg/L).

Station Name	Jan	Feb	Mar	Apr	May	Jul	Oct	Dec	Mean	Median
Buffalo Run Upper	1.58	No Data	1.28	1.53	1.13	1.70	1.77	1.63	1.52	1.58
Buffalo Run Lower	1.96	2.25	1.64	1.79	1.45	2.11	1.81	1.57	1.82	1.80
Cedar Run Lower	4.74	4.94	4.63	4.54	4.22	4.45	4.68	4.84	4.63	4.66
Logan Branch Upper	2.86	3.31	3.26	2.14	2.31	3.80	3.98	2.58	3.03	3.06
Logan Branch Lower	3.48	3.33	3.33	2.76	2.90	3.60	3.93	3.08	3.30	3.33
Slab Cabin Run Upper	2.59	4.53	3.76	3.32	2.88	3.44	3.96	3.43	3.49	3.44
Slab Cabin Run Lower	2.68	4.00	3.56	3.15	2.72	3.09	3.73	3.43	3.30	3.29
Thompson Run Lower	4.04	4.35	4.13	4.08	3.79	3.82	4.02	4.08	4.04	4.06
Spring Creek Upper	1.82	2.63	2.32	1.84	1.44	2.42	2.21	1.78	2.06	2.03
Spring Creek Houserville	3.20	3.84	3.46	3.01	2.64	3.26	3.36	3.17	3.24	3.23
Spring Creek Axemann	4.29	4.69	3.87	4.10	3.96	4.36	4.80	3.67	4.22	4.20
Spring Creek Milesburg	3.73	3.78	3.20	3.34	3.06	3.70	4.19	3.24	3.53	3.52

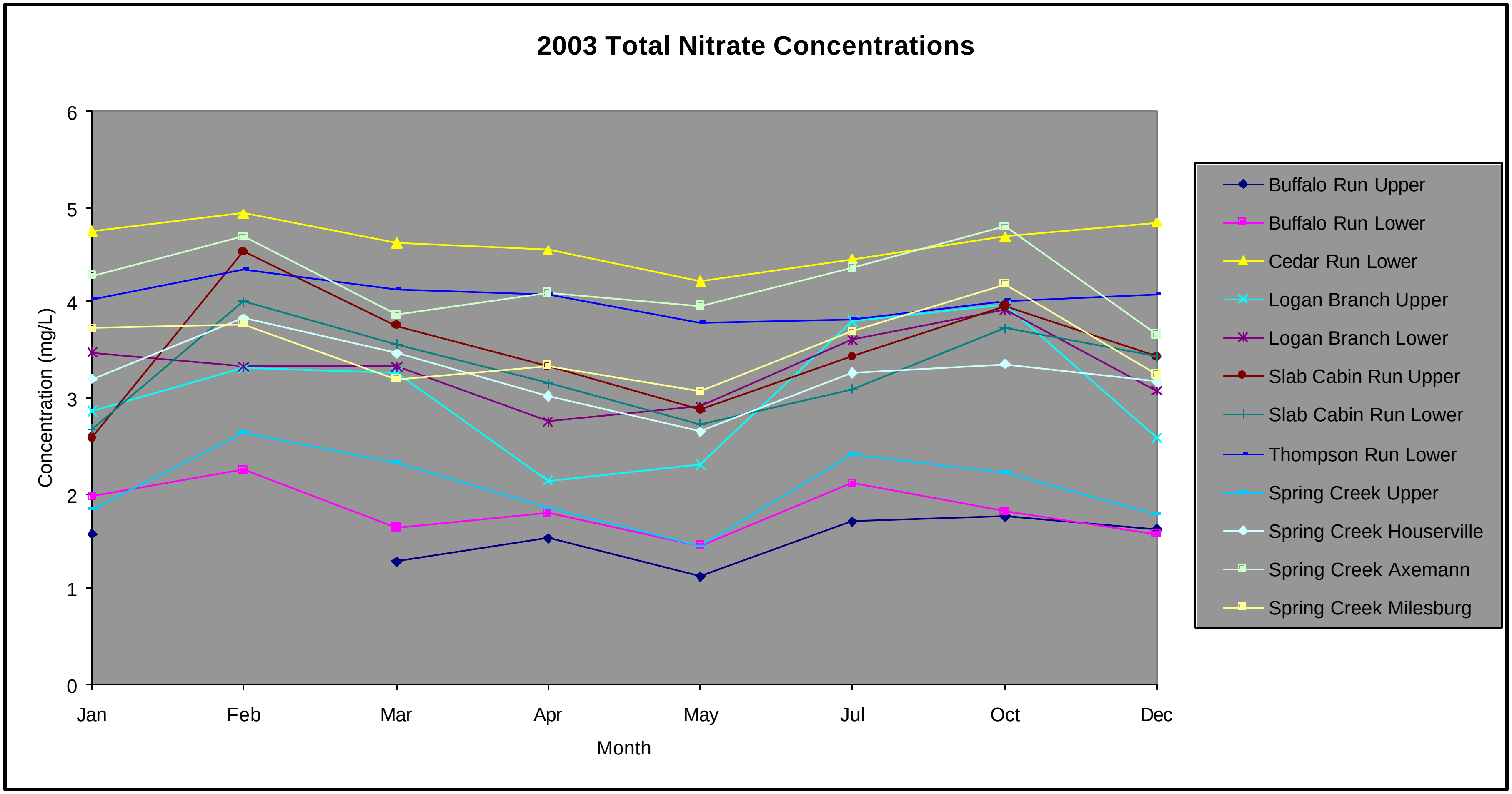


Figure 10. 2003 Nitrate Concentrations.

Table 11. 2003 Total Orthophosphate Concentrations (mg/L).

Station Name	Jan	Feb	Mar	Apr	May	Jul	Oct	Dec	Mean*	Median*
Buffalo Run Upper	0.016	No Data	0.028	0.020	0.027	0.024	0.013	0.017	0.021	0.020
Buffalo Run Lower	0.011	<0.01	<0.01	0.011	0.013	0.013	0.011	0.014	0.010	0.011
Cedar Run Lower	0.014	0.011	0.024	0.016	0.025	0.015	0.014	0.019	0.017	0.016
Logan Branch Upper	0.025	0.026	0.044	0.019	0.019	0.016	0.024	0.031	0.026	0.025
Logan Branch Lower	0.015	<0.01	0.016	0.012	0.014	0.012	0.014	0.019	0.013	0.014
Slab Cabin Run Upper	0.016	0.018	0.031	0.019	0.020	0.022	0.023	0.021	0.021	0.021
Slab Cabin Run Lower	0.015	<0.01	0.017	0.014	0.016	0.022	0.014	0.021	0.016	0.016
Thompson Run Lower	<0.01	0.015	0.015	0.020	0.027	0.033	0.019	0.013	0.018	0.017
Spring Creek Upper	<0.01	<0.01	0.013	0.011	0.013	0.010	0.012	<0.01	<0.01	0.011
Spring Creek Houserville	0.013	<0.01	0.017	0.014	0.016	0.018	0.013	0.013	0.014	0.014
Spring Creek Axemann	0.016	0.012	0.017	0.019	0.024	0.025	0.024	0.020	0.020	0.020
Spring Creek Milesburg	0.022	0.010	0.016	0.021	0.023	0.025	0.026	0.020	0.020	0.022

* Mean and median values were calculated using 1/2 the detection limit for non-detected values. Detection limit = 0.01 mg/L.

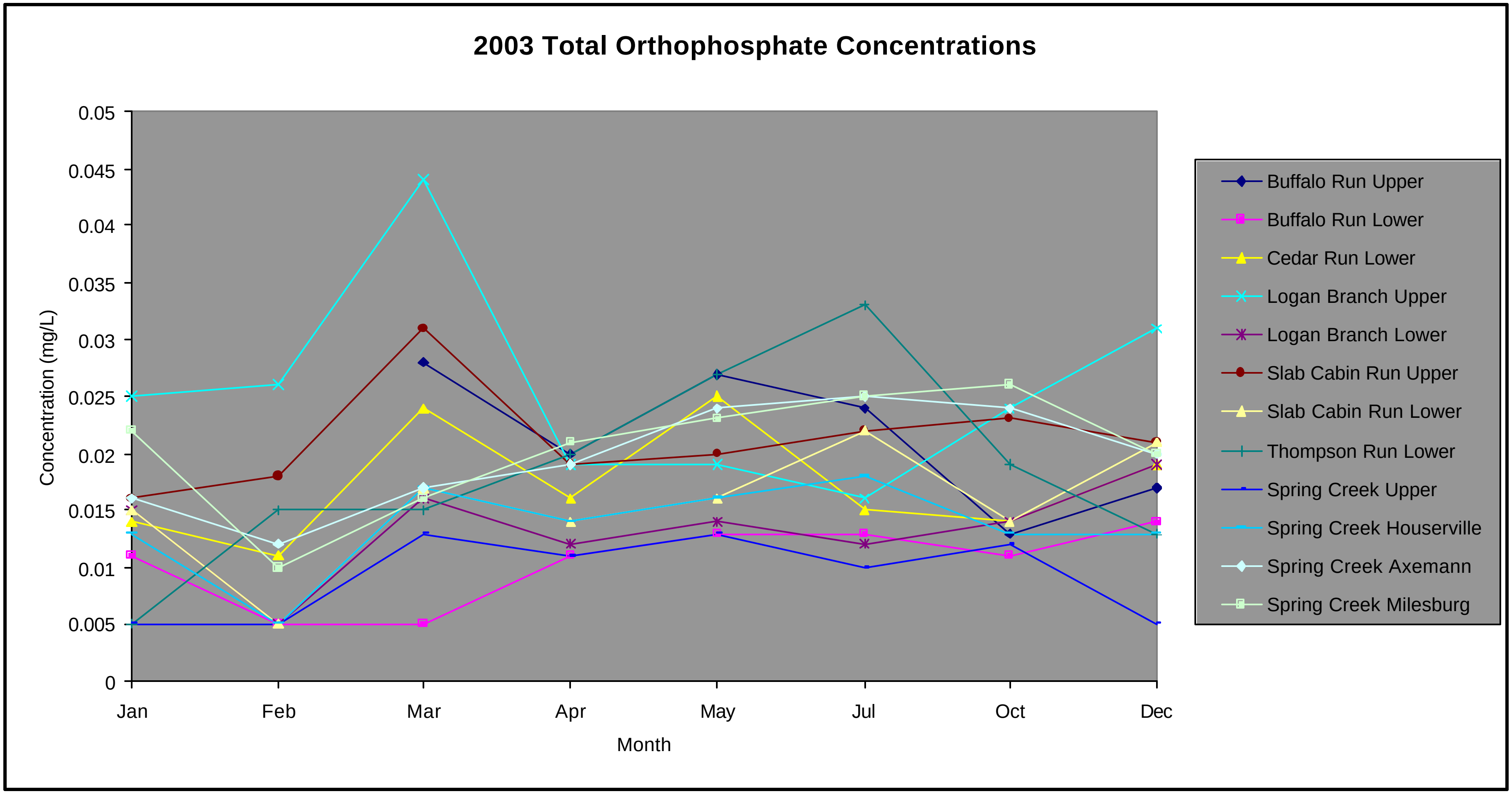


Figure 11. 2003 Total Orthophosphate Concentrations.

* Non-detected values shown at one-half detection limit.

Table 12. 2003 Total Organic Carbon Concentrations (mg/L).

Station Name	Jan	Feb	Mar	Apr	May	Jul	Oct	Dec	Mean	Median
Buffalo Run Upper	1.2	No Data	1.9	1.5	1.5	1.8	1.6	1.4	1.6	1.5
Buffalo Run Lower	1.3	1.3	1.4	1.5	1.4	1.5	1.4	1.4	1.4	1.4
Cedar Run Lower	1.3	1.1	1.5	1.2	1.0	1.1	1.2	1.2	1.2	1.2
Logan Branch Upper	1.4	1.8	2.5	1.5	2.7	1.5	1.6	1.4	1.8	1.6
Logan Branch Lower	0.9	0.8	1.2	1.0	0.9	0.9	0.8	1.0	0.9	0.9
Slab Cabin Run Upper	1.3	1.9	2.4	1.4	1.5	1.5	1.3	1.3	1.6	1.5
Slab Cabin Run Lower	1.4	1.3	1.6	1.5	1.5	1.6	1.6	1.2	1.5	1.5
Thompson Run Lower	0.9	1.0	1.1	1.3	1.3	1.3	1.3	0.9	1.1	1.2
Spring Creek Upper	1.0	1.0	1.3	1.0	0.9	0.9	0.9	0.9	1.0	1.0
Spring Creek Houserville	1.2	1.1	1.6	1.3	1.3	1.3	1.4	1.1	1.3	1.3
Spring Creek Axemann	1.2	2.0	2.7	1.8	1.7	1.7	1.7	1.3	1.8	1.7
Spring Creek Milesburg	1.2	1.4	1.8	1.7	1.5	1.4	1.3	1.2	1.4	1.4

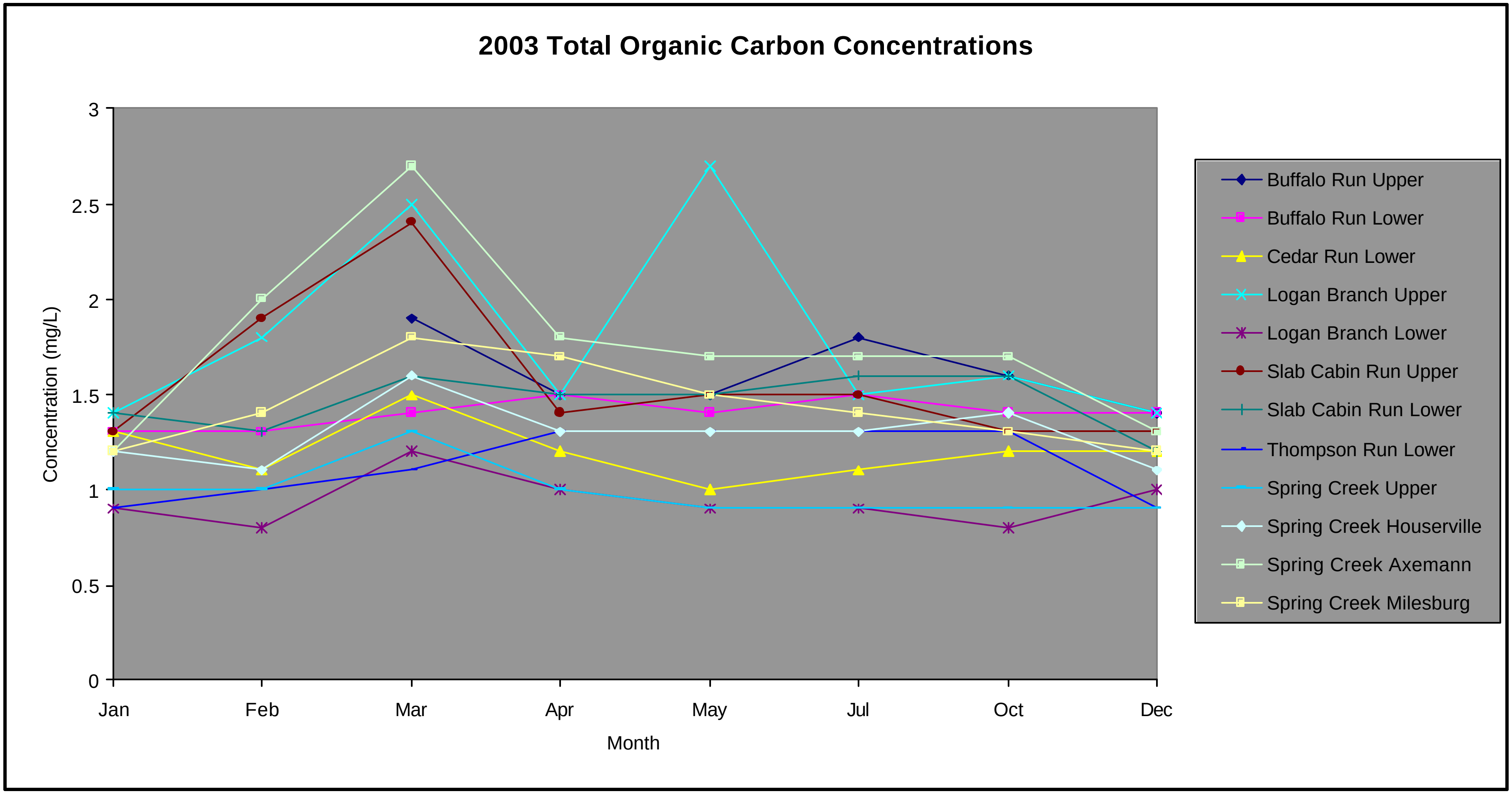


Figure 12. 2003 Total Organic Carbon Concentrations.

Table 13. 2003 Total Petroleum Hydrocarbons Concentrations (mg/L).

Station Name	Jan	Feb	Mar	Apr	May	Jul	Oct	Dec	Mean*	Median*
Buffalo Run Upper	<5	No Data	<5	<5	<5	<5	<5	<5	<5	<5
Buffalo Run Lower	<5	<5	12.4	<5	<5	403.3	<5	<5	53.8	<5
Cedar Run Lower	<5	<5	<5	<5	<5	<5	<5	9.1	<5	<5
Logan Branch Upper	<5	<5	6.1	<5	<5	186.6	<5	18.1	27.9	<5
Logan Branch Lower	<5	<5	5.5	<5	<5	190.1	<5	<5	26.3	<5
Slab Cabin Run Upper	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Slab Cabin Run Lower	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Thompson Run Lower	<5	<5	5.3	<5	<5	39.8	<5	10.0	8.5	<5
Spring Creek Upper	<5	<5	5.8	12.2	<5	6.7	<5	<5	<5	<5
Spring Creek Houserville	<5	<5	<5	<5	14.8	61.3	<5	<5	11.4	<5
Spring Creek Axemann	<5	<5	<5	<5	5.0	10.3	<5	<5	<5	<5
Spring Creek Milesburg	<5	<5	<5	<5	<5	500.4	<5	8.6	65.5	<5

* Mean and median values were calculated using 1/2 the detection limit for non-detected values. Mean and median values less than the detectable limit are reported as < detection limit. Detection limit = 5 mg/L.

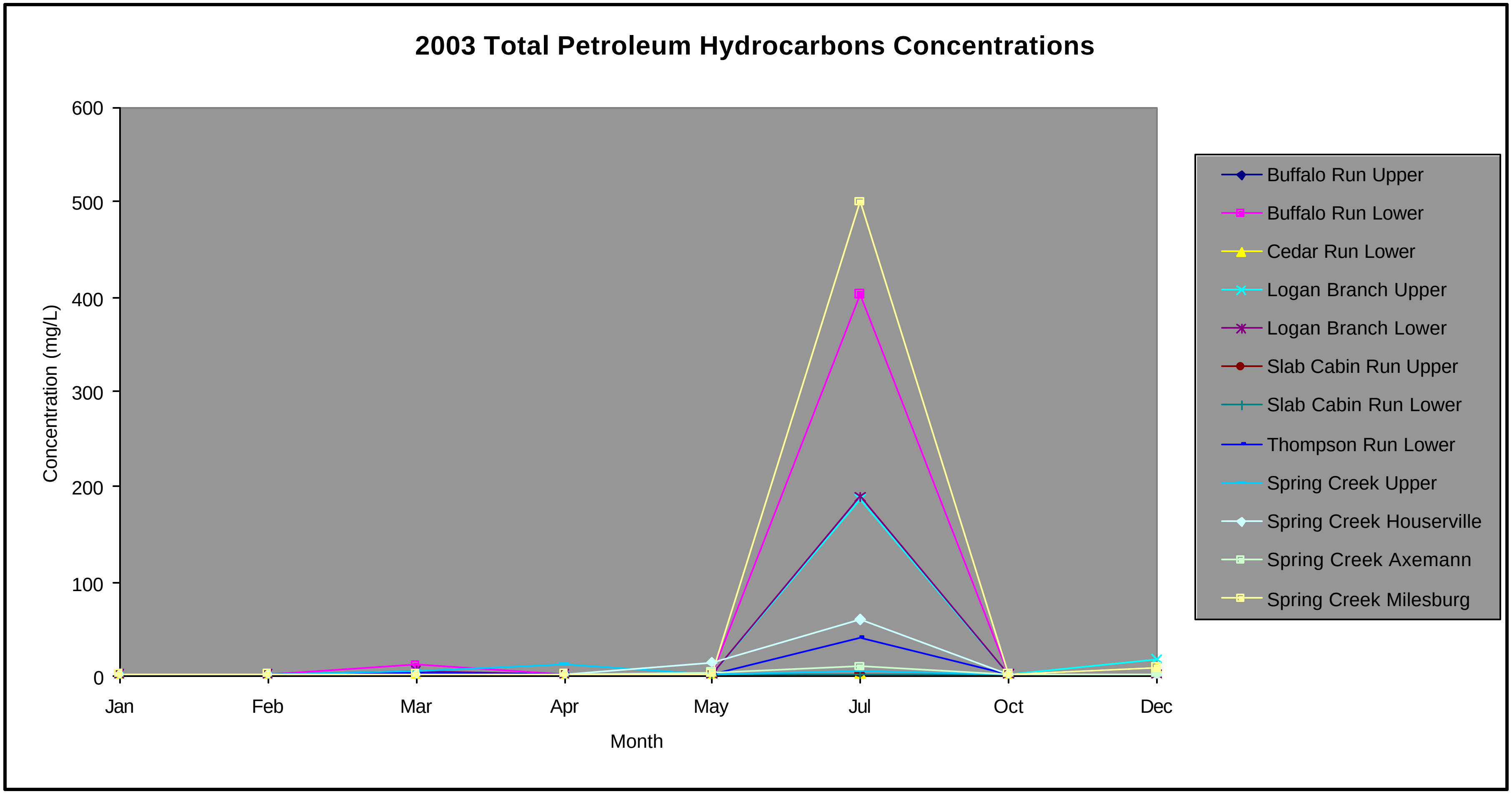


Figure 13. 2003 Total Petroleum Hydrocarbon Concentrations.

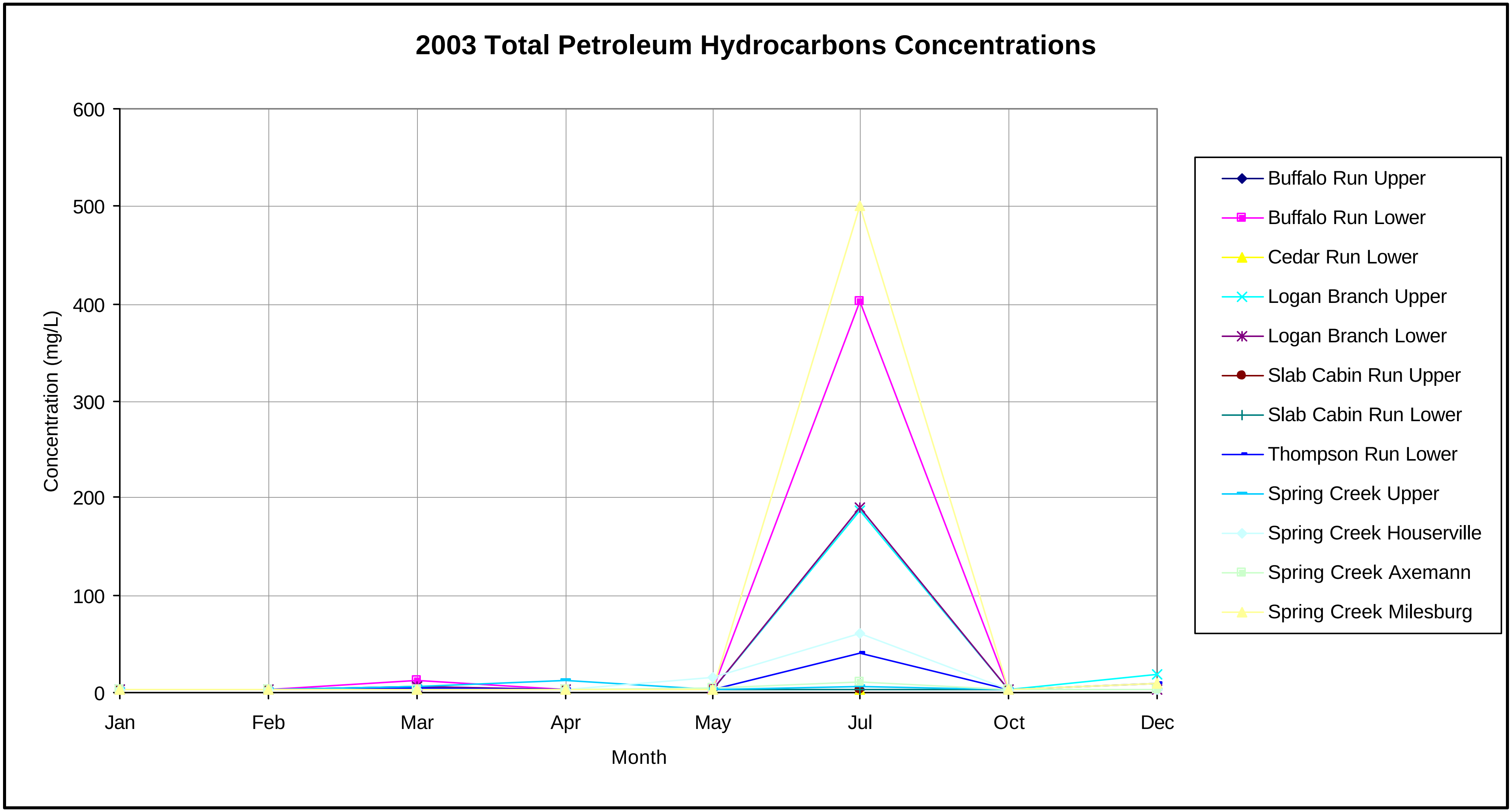
* Non-detected values shown at one-half detection limit.

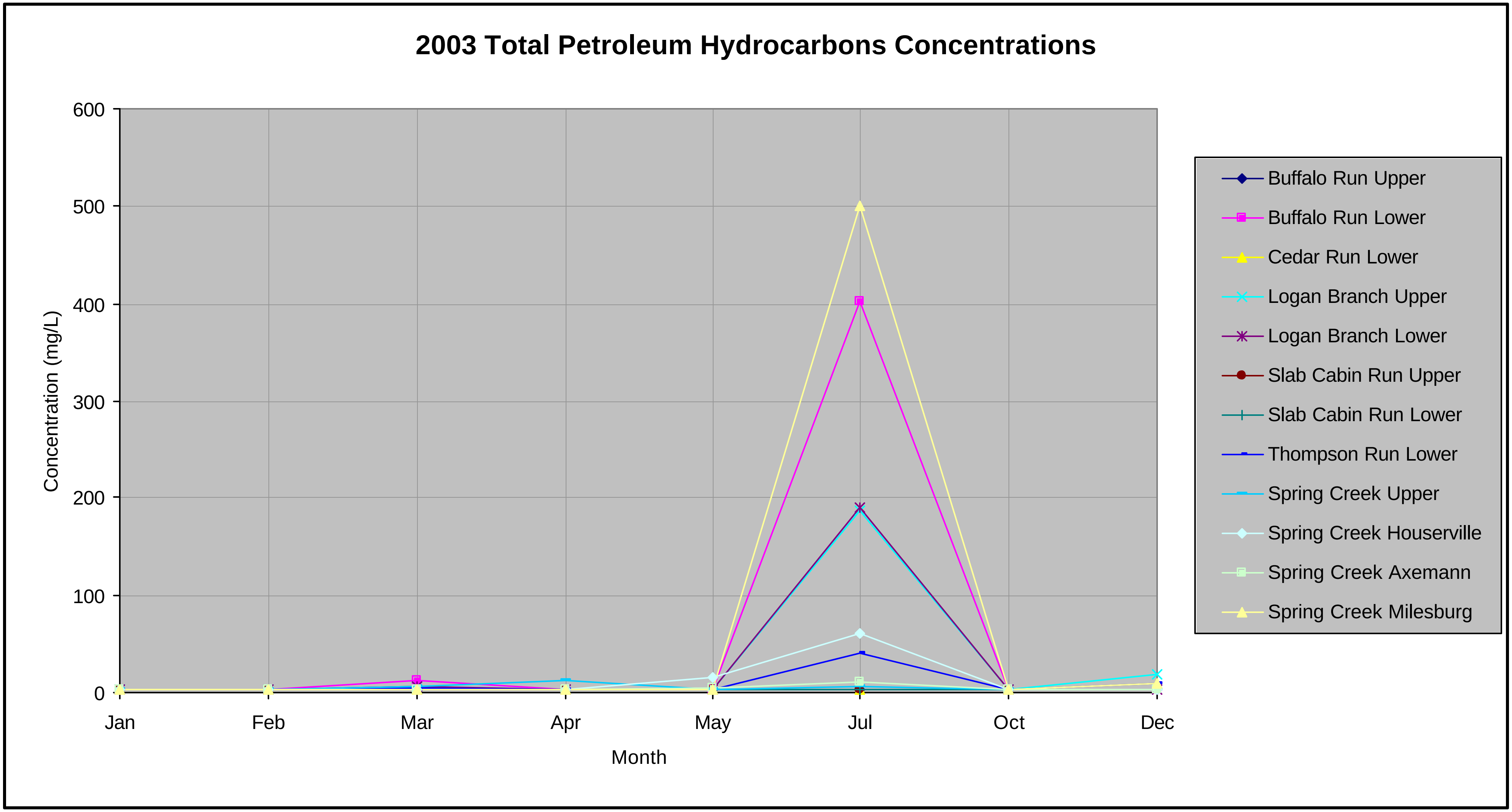
Table 14. 2003 Total Copper Concentrations (ug/L).

Station Name	Jan	Feb	Mar	Apr	May	Jul	Oct	Dec	Mean*	Median*
Buffalo Run Upper	<4	No Data	<4	<4	<4	<4	<4	<4	<4	<4
Buffalo Run Lower	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Cedar Run Lower	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Logan Branch Upper	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Logan Branch Lower	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Slab Cabin Run Upper	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Slab Cabin Run Lower	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Thompson Run Lower	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Spring Creek Upper	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Spring Creek Houserville	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Spring Creek Axemann	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Spring Creek Milesburg	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4

* Mean and median values were calculated using 1/2 the detection limit for non-detected values. Mean and median values less than the detectable limit are reported as < detection limit. Detection limit = 2 ug/L.

No accompanying figure is provided because copper did not exceed the detection limit at any station during 2003.


2003 Total Petroleum Hydrocarbons Concentrations
Concentration (mg/L)
600
500
400
300
200
100
0
Jan
Feb
Mar
Apr
May
Jul
Oct
Dec
Month
Buffalo Run Upper
Buffalo Run Lower
Cedar Run Lower
Logan Branch Upper
Logan Branch Lower
Slab Cabin Run Upper
Slab Cabin Run Lower
Thompson Run Lower
Spring Creek Upper
Spring Creek Houserville
Spring Creek Axemann
Spring Creek Milesburg


2003 Total Petroleum Hydrocarbons Concentrations
Concentration (mg/L)
600
500
400
300
200
100
0
Jan
Feb
Mar
Apr
May
Jul
Oct
Dec
Month
Buffalo Run Upper
Buffalo Run Lower
Cedar Run Lower
Logan Branch Upper
Logan Branch Lower
Slab Cabin Run Upper
Slab Cabin Run Lower
Thompson Run Lower
Spring Creek Upper
Spring Creek Houserville
Spring Creek Axemann
Spring Creek Milesburg