2004
State of the Water Resources

Spring Creek Watershed Community
Water Resources Monitoring Project


9/3/2002


7/31/2004


9/18/2004

A Comparison of Wet and Dry Years

SPRING CREEK WATERSHED COMMUNITY

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A Sampling of Data Highlights from this Report

- The Spring Creek Watershed received 53.69 inches of precipitation in 2004, which was 36% above normal, making it the third wettest year in 109 years of record.
- An increase of 43% in basin water yield occurred at Spring Creek Milesburg between the 2001 drought year and the wet year of 2004.
- Water-table levels rose during 2004 in response to the record above-normal precipitation.
- Ground-water wells CE686 and CE118 experienced the highest water levels recorded (since monitoring began in 2001) during 2004.
- During baseflow, water quality tended to be relatively consistent among dry and wet years.
- The Slab Cabin Run sub basin experienced water quality changes over time that were distinctly different than adjacent sub basins.
- Streams with relatively low percent of ground water input displayed more of a temperature fluctuation between both wet and dry years.

Copies of this report and data collected by the Water Resources Monitoring Project are available at:
Spring Creek Watershed Community's Website www.springcreekwatershed.org
or

ClearWater Conservancy
2555 North Atherton St
State College, PA 16803
(814) 237-0400

Photos on Front Cover: T. Giddings

1.0 INTRODUCTION

The intent of the Water Resources Monitoring Project (WRMP) 2004 *State of the Water Resources 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. This report compares water quality and quantity data collected in 2004, a relatively wet year, to data collected during the drought period of 2000 and 2001.

Also, this document includes background information on the WRMP project, as well as a list of agencies and authorities that have used WRMP data. An addendum provides a summary of the 2004 base-flow data and is available upon request. If you are interested in receiving a copy, contact the project manager at (814) 237-0400.

2004 FLOODING IN THE SPRING CREEK WATERSHED

The Spring Creek Watershed delivers approximately 148 million gallons of water daily to the West Branch of the Susquehanna River and eventually the Chesapeake Bay. According to the Susquehanna River Basin Commission (SRBC), American Indians told of serious floods along the Susquehanna River occurring approximately every 14 years. Since the early 1800s, the main stem of the Susquehanna has flooded on average once every 20 years. Large-scale floods have devastated portions of the basin in 1865, 1936, 1955, 1972, 1975, 1996, and 2004.

The Spring Creek Watershed received 53.69 inches of precipitation in 2004(as measured in State College), making it the 3rd wettest year in 109 years of record. The most notable rain events occurred in September and were associated with Hurricanes Frances and Ivan.

Hurricane Frances

The remnants of Hurricane Frances moving up the western slopes of the Appalachian Mountains on the 8th and 9th of September brought heavy rain to central Pennsylvania. Penn State University recorded 2.97 inches of rain at the Walker Building on September 9th and the United States Geological Survey recorded a peak average discharge of 1,060 cubic feet per second at Spring Creek at Milesburg.

Hurricane Ivan

A complex interaction between a strong, slow-moving cold front and the remnants of Hurricane Ivan produced heavy rainfall throughout the Spring Creek Watershed on the 17th and 18th of September. Many areas were still saturated from the rainfall associated with Hurricane Frances and the 5.05 inches of rain associated with Ivan produced significant widespread moderate-to-major flooding. Spring Creek discharge at Milesburg

Figure 1. Fishermans Paradise, Spring Township, after Hurricane Ivan. Photo: T. Giddings

Figure 2. Bush House Hotel, Bellefonte, inundated with flood waters from Hurricane Ivan. Photo: T. Giddings

was recorded at 6,701 cubic feet per second and stage was 12.41 feet. According to Pennsylvania's Weather Forcast Office (WFO), this storm event was likely the single most damaging weather event to strike central Pennsylvania since the WFO in State College (KCTP) commenced operations in the autumn of 1993.

In Centre County, overflowing streams flooded thousands of basements and destroyed 21 mobile homes. Approximately 100 people were evacuated. Interstate 80 and U.S. Routes 220 and 322 were closed and water rescues occurred in Milesburg.

A Look Back at Hurricane Agnes (1972)

In June 1972, Hurricane Agnes caused the worst recorded flood in the Susquehanna basin. Seventy two people were killed throughout the basin and damages were estimated at $2.8 billion. At the time, the Agnes flood was the nation's most destructive and costly natural disaster.

Rainfall levels of 3.02 inches and 4.71 inches were recorded on June 22nd and 23rd 1972 respectively, at the Walker building on the Penn State Main Campus. Discharge at Milesburg was recorded at 8,170 cubic feet per second and stage was 13.2 feet.

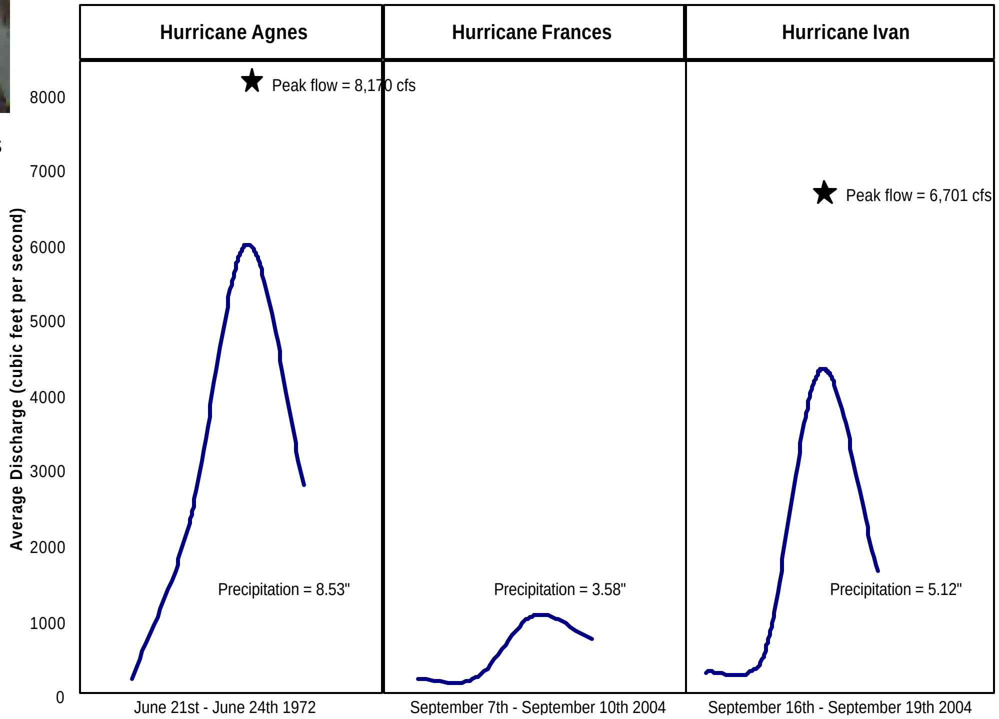


Figure 3. Discharge at Spring Creek Milesburg associated with Hurricane Agnes (1972) and Hurricanes Frances and Ivan (2004).

WRMP Equipment Damaged During Hurricane Ivan Flood.

Photos: R. Dunlap

Figure 4. Storm-Water Box

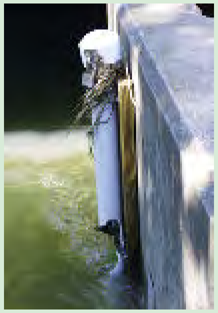


Figure 5. Stilling Well

Figure 6. Staff Gage

Figure 7. Storm-Water Box

Figure 8. Pressure Transducer

WRMP HISTORY

The Water Resources Monitoring Project (WRMP) was initiated in 1998 as part of the strategic planning of the Spring Creek Watershed Community. WRMP maintains a comprehensive monitoring network that produces data to be used for the long-term protection of Spring Creek and its tributaries. The project was designed by the Water Resources Monitoring Committee (Table 1), a volunteer group of environmental professionals, to:

1. Provide a description of the quantity and quality of surface waters,
2. Provide a description of the quality of storm-water runoff,
3. Monitor ground-water levels,
4. Provide the means to detect changes in quantity and/or quality of base flow, storm water, and ground water, and
5. Provide sufficient measurement sensitivity to permit assessment of these changes.

WRMP began monitoring base flow conditions in 1999 and with the award of two Pennsylvania Department of Environmental Protection Growing Greener Grants initiated storm-water monitoring in 2000 and ground-water monitoring in 2001. WRMP was awarded the 2001 Governor's Award for Watershed Stewardship in the Assessment and Planning Category. This award recognized the efforts of the Water Resources Monitoring Committee, the comprehensive nature of the study design, and most importantly, the need for baseline data collection to proactively protect the water quality and quantity of Spring Creek and its tributaries.

WRMP Data Users

Data collected by WRMP have been used by a wide variety of Watershed stakeholders including:

- PA Department of Environmental Protection
- PA Fish and Boat Commission
- Pennsylvania State University
- Spring Creek Watershed Commission
- Spring Creek Watershed Community
- Spring Township Water Authority
- State College Borough Water Authority
- Susquehanna River Basin Commission
- University Area Joint Authority
- Upper/Middle Susquehanna Regional Committee

Table 1. 2004/2005 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,** West Nile Virus Program Coordinator	Centre County Planning Office
Ann Donovan Watershed Specialist	Centre County Conservation District
Rebecca Dunlap (Staff) Water Monitoring Coordinator	ClearWater Conservancy
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
Katie Ombalski (Staff) Watershed Coordinator	ClearWater Conservancy
Mark Ralston, P.G.* Hydrogeologist	Converse Consultants
Kristen Saacke-Blunk	Penn State Cooperative Wetlands Center
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	Shaw Environmental & Infrastructure
Dave Yoxtheimer, P.G.* Senior Hydrogeologist	N.A. Water Systems

* Professional Geologist

PROJECT FUNDING

Since its inception, WMRP has raised close to $428,000. Local municipalities and organizations have embraced the importance of WRMP's efforts and donated approximately $43,000 in 2004 for the project's continuation. 2004 financial contributors include:

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

WRMP received over $25,000 of in-kind contributions in 2004 including professional services, laboratory analyses and supplies, technical assistance, and transportation. In-kind contributors for 2004 include:

- Exygen Research
- GeoDecisions
- Ground water well owners (Corning Asashi, Howard Dashem, PA Department of Conservation and Natural Resources, Todd Giddings, Penn State University – Office of Physical Plant, and United States Geological Survey)
- PA Department of Environmental Protection
- Pennsylvania Cooperative Fish and Wildlife Research Unit, United States Geological Survey

- Spring Owners (Bellefonte Borough, Centre Region Parks and Recreation, Continental Courts, Linden Hall Village Association, Rockview, and Spring Township)
- University Area Joint Authority
- Volunteer field assistants
- Water Resources Monitoring Committee

2.0 MONITORING STATIONS

STREAM MONITORING STATIONS

WRMP monitored base flow conditions at thirteen stream locations in 2004 (Figure 10). Twelve of the stations were established in 1998 with the premise of including at least one station in each of Spring Creek's sub-watersheds or sub-basins that would best represent land use patterns. The existence of three United States Geological Survey gaging stations on the main stem of Spring Creek and three gaging stations maintained by the Pennsylvania Cooperative Fish and Wildlife Research Unit were also taken into account.

A thirteenth station was added in early 2004 in response to the acid rock drainage issues raised by the uncovering of pyritic rock during I-99 roadway construction near the headwaters of Buffalo Run. The station is located on an unaffected tributary to Buffalo Run and serves as a control for comparison of the degraded waters in the upper portion of the sub-basin.

Visit us on the web at www.springcreekwatershed.org

GROUND-WATER MONITORING WELLS

The ground-water reservoir in the Spring Creek Watershed was monitored with a network of seven ground-water monitoring wells (Figure 11). The wells are established at locations where they are able to reasonably represent ground-water conditions over a large area and are not influenced by high-yield pumping wells or well fields, storm water, artificial ground-water recharge, or surface water discharges.

3.0 DATA COLLECTION

Standardized methods have been developed for data collection and sample processing to provide quality assurance for all data collected by WRMP. Detailed methods are documented in the Spring Creek Watershed Water Resources Monitoring Protocol which is available at www.springcreekwatershed.org or upon request at (814) 237-0400.

Figure 9. Bryce Boyer, WRMP volunteer, prepares a stream sample for analysis. Photo: ClearWater Staff

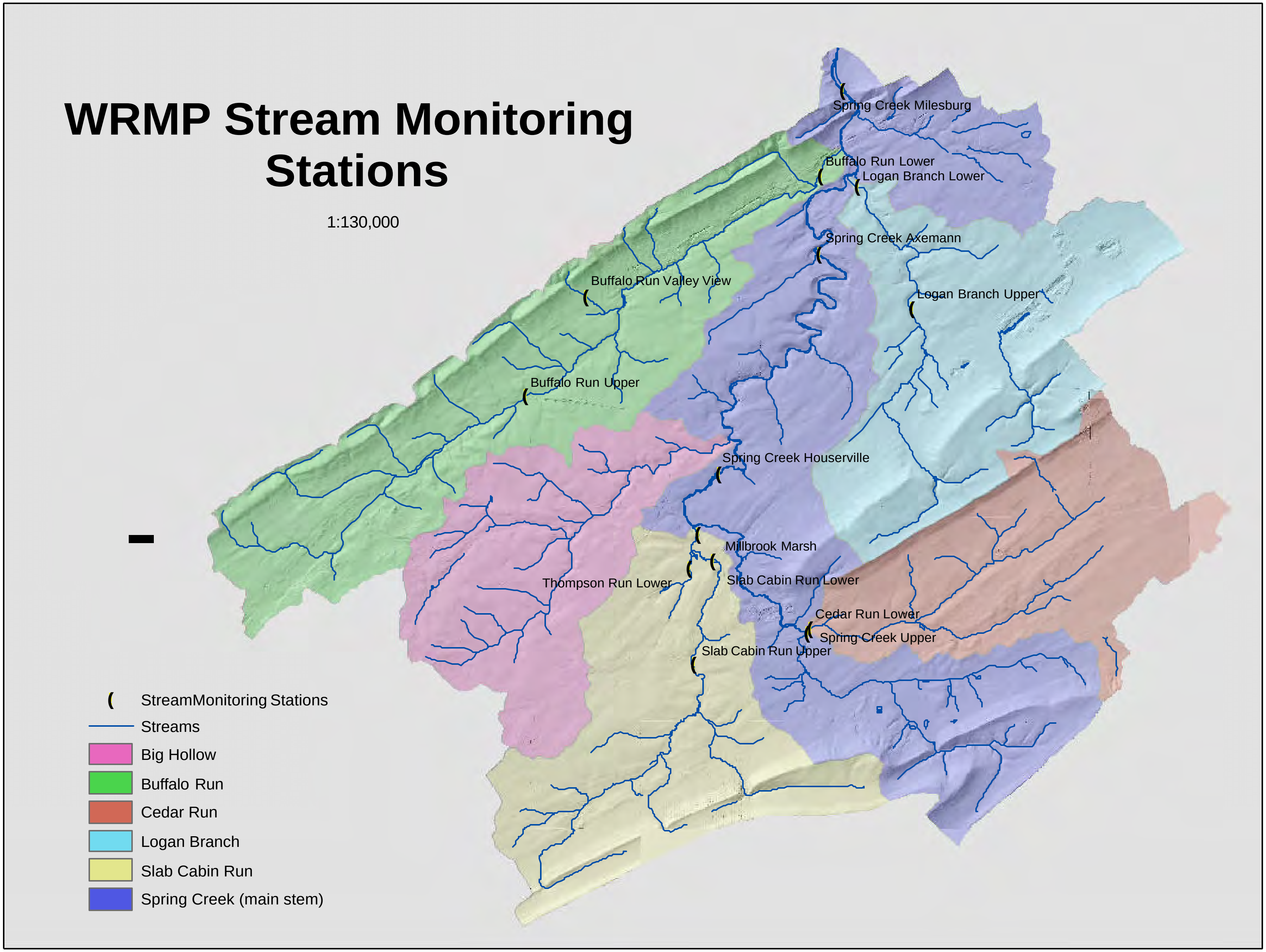
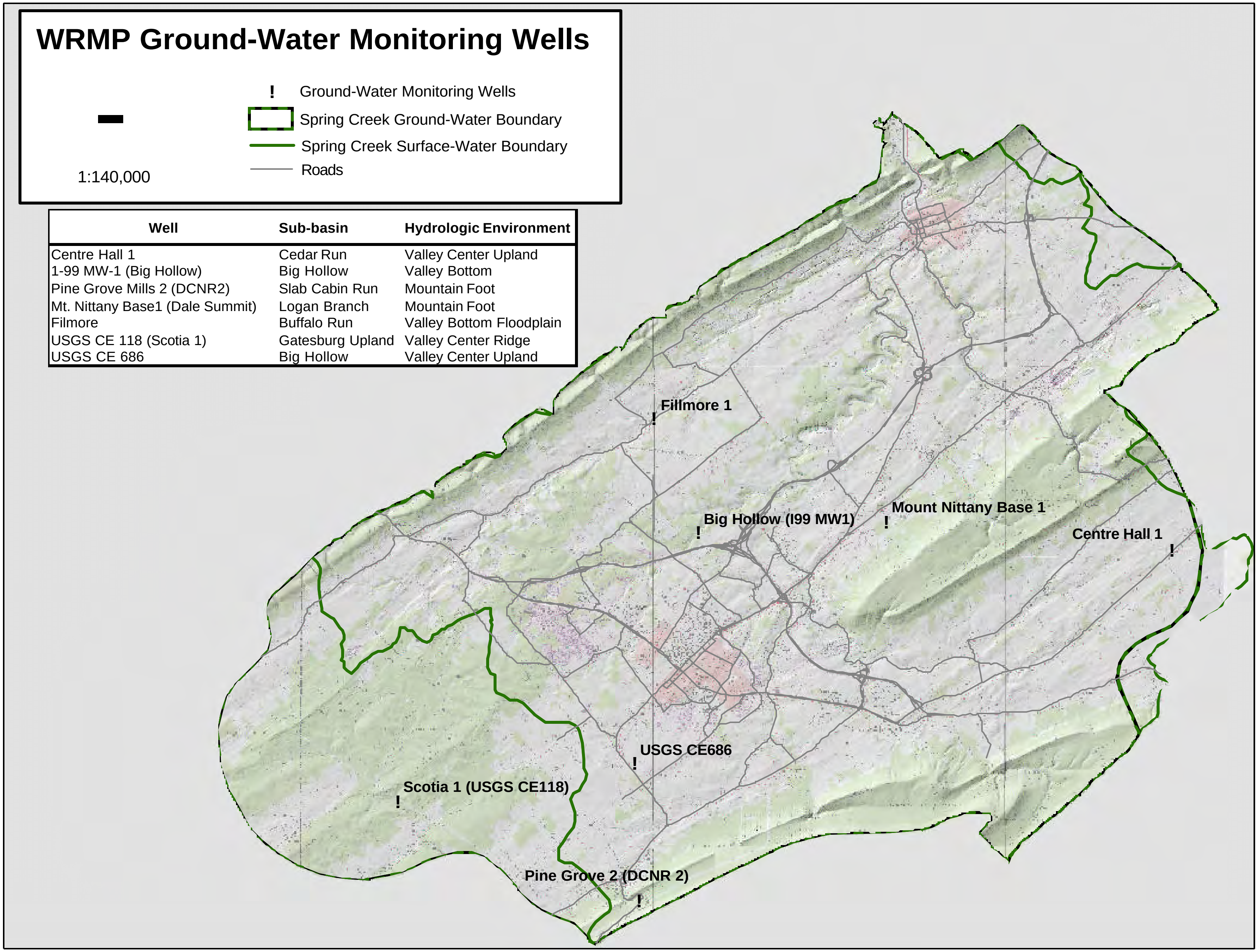


Figure 10. WRMP Stream Monitoring Stations



Well	Sub-basin	Hydrologic 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 11. WRMP Ground-Water Monitoring Stations

CONTINUOUS MEASUREMENTS

Stream stage was continuously measured at twelve of the stream monitoring stations in 2004. Nine stations are equipped with instruments that record water level every 30 minutes. Streamflow was recorded every 15 minutes by the United States Geological Survey at Spring Creek Houserville, Spring Creek Axemann, and Spring Creek Milesburg.

Water temperature was recorded hourly at twelve of the stream monitoring stations.

Ground-water levels at the 7 ground water wells were recorded at three-hour intervals. Five of the seven ground-water wells are operated by WRMP and two (CE 118 and CE 686) are operated by the U.S. Geological Survey.

MONTHLY MEASUREMENTS

Stage and discharge at twelve of the monitoring stations were measured monthly. These data were used to construct a rating curve which is subsequently used to convert the 30 minute stage measurements into discharge. The monthly stage and discharge measurements are also used to detect stream channel change resulting from erosion or sediment deposition.

QUARTERLY MEASUREMENTS

Water samples were collected during base-flow conditions at each of the stream monitoring stations and analyzed for a range of constituents (Appendix A). Base-flow sampling also included field measurements of dissolved oxygen, pH, and conductivity. Samples were collected monthly in the early part of 2004. The sampling frequency was reduced to quarterly mid way though the year in an effort to focus more comprehensively on the ground water and storm water components of the project.

Data User Testimonial

Tony Buda, School of Forest Resources (PSU) – “Dr. DeWalle and I have used the WRMP data for a variety of projects. We rely very heavily on the streamflow information collected from gages on the major tributaries of Spring Creek. We have also benefited from water chemistry data in the WRMP. Overall, the WRMP has been extremely beneficial for several reasons:

1. We use streamflow information to guide us on our sampling, especially on peakflow (event-based) sampling efforts. The staff gages are also very useful for grab sampling because we can use them as a guide to estimate when the different streams are peaking.
2. We also use the streamflow information in conjunction with chemical sampling to separate baseflow and stormflow components during storm events. We typically sample oxygen isotopes in water during baseflow and peakflow to make these calculations. We also have used conductivity measurements, nitrate, and chloride. The nitrate and chloride data have often been obtained from the WRMP storm database, so we have also benefited greatly from the chemistry data that is collected on Spring Creek.
3. Finally, we use WRMP data to help generate a clear picture of the condition of Spring Creek and its tributaries. This has been especially useful when writing grants that include Spring Creek and its tributaries. Every grant proposal that I have written for work within Spring Creek has included data from the WRMP.”

TMDLs in the Spring Creek Watershed

What is a TMDL?

A TMDL (Total Maximum Daily Load) is the maximum calculated amount of pollutant that a water body can safely handle and still meet its water quality standards. A TMDL must identify all point and non-point sources of pollution as well as background levels of the pollutant, seasonal variation, and all uncertainty associated with the calculation. TMDLs for point sources of pollution are often easily calculated because the amount of discharge can be measured directly. However, determining the loadings from non-point sources of pollution can be much more difficult, because a model is often used to make assumptions about specific loads based on stream monitoring above and below a source. Additionally, loadings from non-point sources depend upon a number of variables including rainfall, riparian buffer width, land use, and storm water management practices.

State agencies evaluate the water quality of many water bodies every two years and place impaired waters, or waters that are not meeting their designated use, on the Integrated List (formerly the 303(d) List of Impaired Waters). Any watershed that has impaired streams will eventually be subject to a TMDL.

TMDLs and Impaired Streams in the Spring Creek Watershed

A TMDL has not yet been developed for the Spring Creek Watershed. However, in 2003 the Pennsylvania Department of Environmental Protection (PA DEP) recommended that 16.2 miles of impaired stream be placed on the Integrated List because they are not meeting the water quality standards for their designated uses. The majority of streams in the Spring Creek Watershed are designated as either a High Quality Cold Water Fishery or a Cold Water Fishery (Fig 12). Approximately 80% of the impairments are caused by non-point sources of pollution including urban runoff, storm sewer outfalls, siltation, and agricultural related activities.

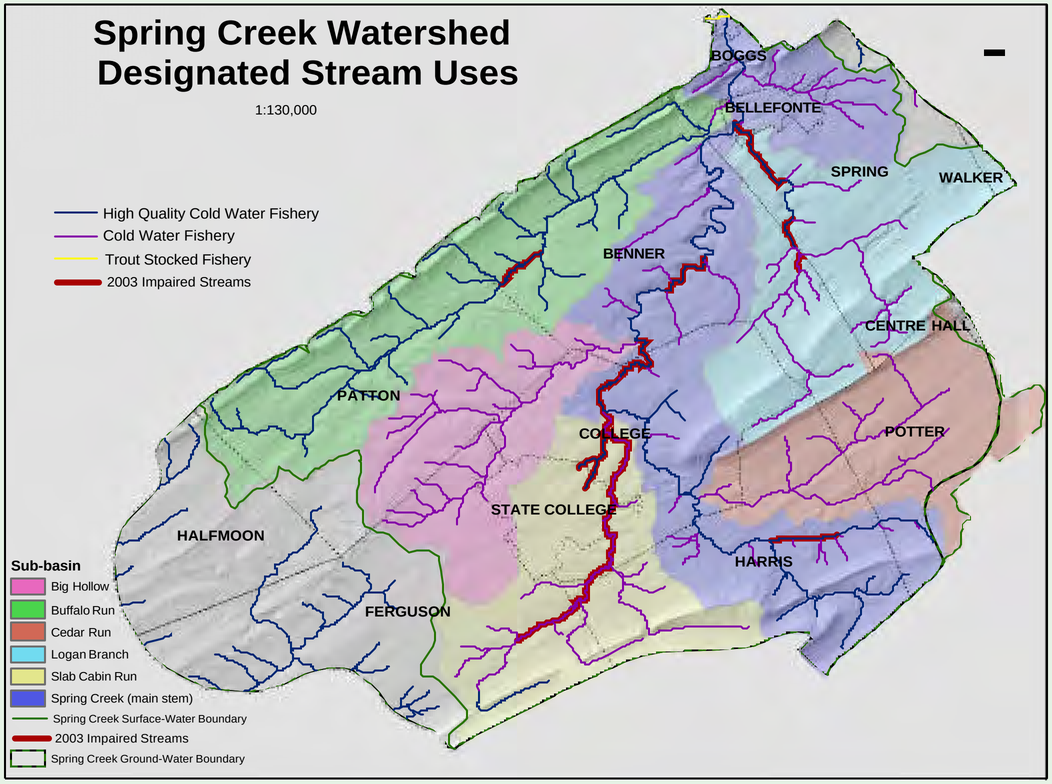


Figure 12. Spring Creek Watershed Designated Stream Uses.

4.0 RESULTS AND ANALYSES – WET VS. DRY YEARS

SURFACE WATER

A stream is a wonderfully complex, natural system. In the absence of recent precipitation, streamflow consists entirely of ground-water runoff (or base flow). Streams evolve naturally to convey storm-water runoff excess. The intricate, natural regime of high flows, low flows, seasonal average flows, water chemistry, temperature, stream gradient, geologic setting, stream substrate, and other factors establish a physical setting for the development of an aquatic ecosystem.

2001 was a year of historic low flows in Central Pennsylvania streams; 2004 was a year of significantly above-average flows. In general, how can streamflow data be used to tell us about the state of water resources in an area? Perhaps the most powerful and revealing way to assess water resources is through examination of numerical streamflow data.

Low Flow

A benchmark value that is used by many regulatory, resource management and scientific agencies to assess low-flow conditions in streams is the average 7-day low flow that is statistically likely to reoccur every 10 years (also called $Q_{7\text{-}10}$ flow). Many regulatory programs are tied to $Q_{7\text{-}10}$ flow conditions, including permissible wastewater discharges (i.e., what is the assimilative or dilution capacity of the stream under low flow conditions?) and conservation of stream habitat (i.e., to what extent is habitat lost or degraded under low flow conditions?).

$Q_{7\text{-}10}$ flow conditions have been calculated for the three USGS gaging stations on Spring Creek[1]: http://pa.water.usgs.gov/pc38/flowstats/

Table 2. $Q_{7\text{-}10}$ Flows in the Spring Creek Watershed

Station	Q7-10	Period of Record
Spring Creek, Houserville	15.0 cfs	1985 - 1995
Spring Creek, Axemann	28.7 cfs	1942 - 1994
Spring Creek, Milesburg	104 cfs	1969 - 1995

The plot below shows streamflow at the three USGS gaging stations in 2001:

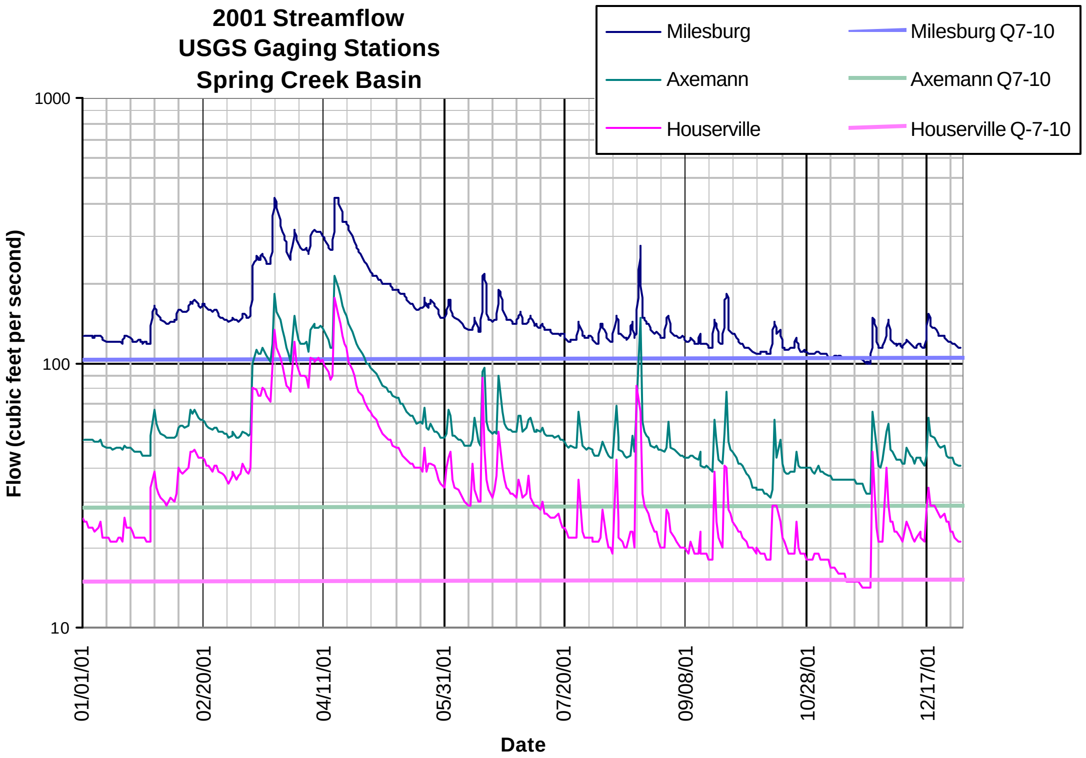


Figure 13. 2001 Stream Flow at USGS Gaging Stations in the Spring Creek Basin.

These hydrographs, or plots of streamflow versus time, show that the $Q_{7\text{-}10}$ flow condition was approached in November, 2001. Similar recession in streamflow was seen at all of the WRMP gaging station locations in the third and fourth quarters of 2001. The following stream segments were dry at some time during 2001: Upper Buffalo Run, Lower Slab Cabin Run, Upper Slab Cabin Run, and Spring Creek in the vicinity of the Military Museum.

It's also revealing to note that, during the summer of 2001, streamflow generally trended downward. Streamflow increased rapidly in response to precipitation and then rapidly fell to the rate that prevailed prior to the precipitation event. This tells us that the streams conveyed storm-water runoff for a short period of time, but the ground-water contribution to streams (i.e., ground-water recharge) was not significant, likely due to soil moisture deficit and uptake by plants. Meaningful ground-water recharge was not seen (as a function of the streamflow after the storm peak subsided) until well into December, 2001.

Basin yield under low flow conditions tells us how bedrock yields ground-water base flow to streams, and is used by agencies such as the Susquehanna River Basin Commission in assessing the "safe yield" of a land area (i.e., how much ground water is available under drought conditions). Basin yield under high flow conditions tells us how a given land area handles precipitation as runoff or ground-water recharge.

The table below lists land areas tributary to selected gaging stations and basin yield on November 22, 2001 (lowest flow during the drought year of 2001), August 20, 2001 (minor precipitation event of 2.28" during the drought summer of 2001), and September 18, 2004 (Hurricane Ivan high flow).

It is useful to compare the individual gaging station data with the data for the three mainstem Spring Creek stations (Houserville, Axemann, and Milesburg), since these mainstem stations have the largest contributing land areas of all of the gaging stations.

Basin Yield

Another useful way to look at streamflow data is to assess the quantity of water that is yielded by a given land area under low flow and high flow conditions. For example, if the flow in a stream is 20 cfs on a given day at a point on the stream that has 30 mi^2 of tributary watershed area, then the basin yield at that point is 20 cfs/30 mi^2, or 0.67 cfs/mi^2 on the date of observation.

Table 3. Land Areas Tributary to Select Gaging Stations and Basin Yield.

STATION	AREA, mi^2	Basin Yield 11/22/2001 cfs/mi^2 (Drought)	Basin Yield 8/20/2001 cfs/mi^2 (Precipitation During Drought)	Basin Yield 9/18/2004 cfs/mi^2 (Hurricane Ivan)
Lower Thompson Run	3.94	1.50	5.1	(no data)*
Upper Spring Creek	13.1	0.52	1.7	96.9
Lower Slab Cabin Run	16.7	0.0 (dry)	0.3	(no data)*
Lower Cedar Run	17.5	0.20	0.6	23.8
Lower Logan Branch	22.5	2.10	3.0	27.4
Lower Buffalo Run	26.8	0.03	0.1	56.6
Spring Creek, Houserville	58.1	0.24	1.1	28.2
Spring Creek, Axemann	85.8	0.37	1.7	30.8
Spring Creek, Milesburg	145	0.69	1.9	29.9

*due to equipment damage

For the November 22nd, 2001 observation (drought), the Lower Logan Branch station showed the highest basin yield. This may be due to the effects of natural subsurface geologic conditions or non-natural discharges by mines and the Corning Asahi facility. Interestingly, Lower Thompson Run also showed a high basin yield compared to the other stations. This is the smallest of all of the Spring Creek basins, and includes State College Borough and Penn State. It is possible that the elevated basin yield during the drought was due, in part, to either leakage of ground water from the Slab Cabin Run basin or leakage of water from public water system distribution pipe systems.

Lower Thompson Run again stands out for the 8/20/01 date of observation (precipitation event during drought). The high basin yield for this station is likely due to the high percentage of impervious cover in this small basin, which results in a greater percentage of runoff per unit land area than the other basins. Lower Logan Branch is also noteworthy for this date of observation in that the basin yield is approximately twice the yield of the mainstem Spring Creek stations. The increase in basin yield (as a percentage of flow on 11/22/2001) in response to the 8/20/2001 precipitation event is only 44% for Logan Branch, as compared to an average increase in basin yield of 280% for the other listed gaging stations. Again, subsurface geology in this basin likely contributes to this basin yield.

For the 9/18/04 date of observation (Hurricane Ivan), the three mainstem stations showed basin yields that were very similar at approximately 30 cfs/mi^2. The Buffalo Run and Upper Spring Creek stations showed basin yields that were significantly higher than the mainstem stations, likely due to the runoff characteristics of the steeply-sloped mountain lands that predominate in these basins.


Figure 14. WRMP Awards and Publications.

Photo: R. Dunlap

Data User Testimonial

Andrew Dehoff, Susquehanna River Basin Commission (SRBC) – “The streamflow data provided by WRMP were essential to SRBC’s efforts to coordinate the review and impact mitigation associated with the mining operations in the Pleasant Gap area.

SRBC, PA DEP and the PFBC, working cooperatively with the mining companies, developed operating requirements and a mitigation plan to ensure that the mining operations would have minimal impact on the habitat in Logan’s Branch of Spring Creek and also allow continued operation of the Pleasant Gap fish hatchery.

WRMP’s streamflow data were used in developing a simulation model of the Logan Branch system for use in evaluating potential impacts and flow augmentation plans during times of lower flow in the watershed.”

GROUND WATER

Monitoring Well Observations

USGS Well 686

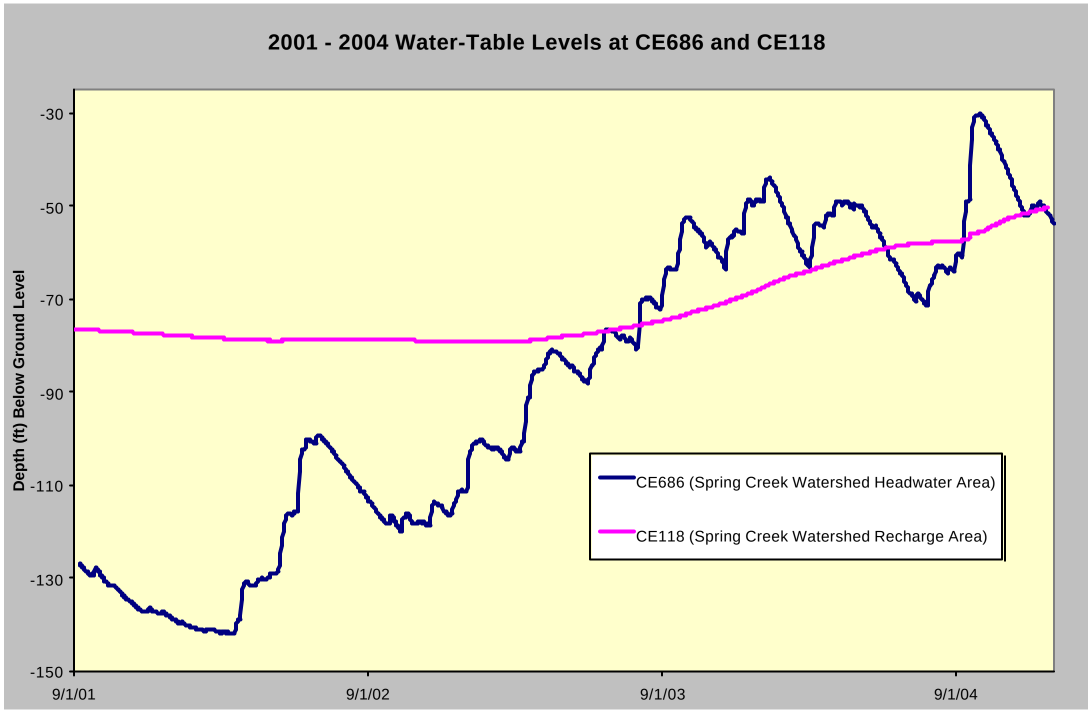


Figure 15. Water-Table Levels in the Spring Creek Watershed.

The Spring Creek Watershed received 53.69 inches of precipitation in 2004 (as measured in State College), which was 35% above normal, making it the third wettest year in 109 years of record. Average annual precipitation for the Centre Region is 39.84 inches, and the additional 3.85 inches of precipitation over the average precipitation in 2004 continued the trend of rising ground-water levels that occured during the preceding two years. Water-table monitoring well CE 686, located two miles southwest of downtown State College in the Nittany Dolomite geologic unit, experienced a 25 foot net rise in water level during 2004. This well represents the Spring Creek Watershed headwater areas that saw continued significant increases in net ground-water storage during 2004. Figure 15 shows that 2004 had the highest water level recorded in this well since monitoring began in 2001. In addition, note the decrease in the water level during the summer months when ground-water recharge typically decreases due to evapotranspiration by plants and increased runoff from more intense rainfall events.

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 base flow from ground water discharge, while only 14% of the total annual streamflow is surface water runoff that flowed overland directly into the stream channels. The very high quality and the relatively 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 majority of Spring Creek's flow. This ground water came from storage in interconnected void space in the carbonate rocks that underlie Nittany Valley. The void space consists of fractures, bedding plane partings, and solutionally-enlarged openings. The decline 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.

USGS Well CE 118

The pink hydrograph line in Figure 15 represents the water level for well CE 118, located in the Scotia Barrens area on Game Lands 176 near the shooting range. The Scotia Barrens area is not only historically significant and an area to be enjoyed by both mankind and the many types of animals that call it home, but it is also a critical ground water recharge area for the Spring Creek Watershed. The unique hydrogeologic characteristics of this area consist of a deep, sandy soil with a very high infiltration capacity, underlain by carbonate bedrock with solution openings that provide a very high capacity to store and transmit ground water, and a deep water table (>250 feet below the ground surface). The Scotia Barrens area serves as the headwaters of Big Spring in Bellefonte. Rainfall and snowmelt water that infiltrates into the Scotia Barrens soil percolates slowly down to the deep 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, making Big Spring the second largest spring in Pennsylvania.

The high porosity of the Gatesburg Dolomite bedrock underlying the Scotia Barrens makes this area the largest and most important ground-water reservoir in the Spring Creek Watershed. The natural forest covering of the Scotia Barrens enhances its recharge capacity. The subdued and delayed hydrograph of CE 118 in Figure 15 illustrates the high storage capacity of the ground-water reservoir in this area. The 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 so 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. Thus, preserving this critical ground-water recharge area (for both quality and quantity) is critical to ensuring the protection of the ground-water supply in the Spring Creek Watershed.

Five New Ground-Water Monitoring Points

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 and amount of fracturing, 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 PA Department of Environmental Protection Growing Greener grant, water-level sensors and data loggers were purchased, and then installed in five available wells located in a variety of representative hydrogeologic settings throughout the Spring Creek Watershed. The locations of the new monitoring points were carefully selected by hydrogeologists and hydrologists who are members

Figure 16. Bryce Boyer, WRMP volunteer, and Mark Ralston, WRMP committee member, install ground-water monitoring equipment at Fillmore.
Photo: K. Ombalski

of the Water Resources Monitoring Committee. To a large extent the success of the expanded ground-water monitoring program is attributed to the well owners without whose cooperation the expanded program would not be possible. Five wells were instrumented in early 2003, and water-table levels are monitored in those wells on a continuous basis. 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 by Spring Creek Water Monitoring Committee staff to a laptop computer on a periodic basis.

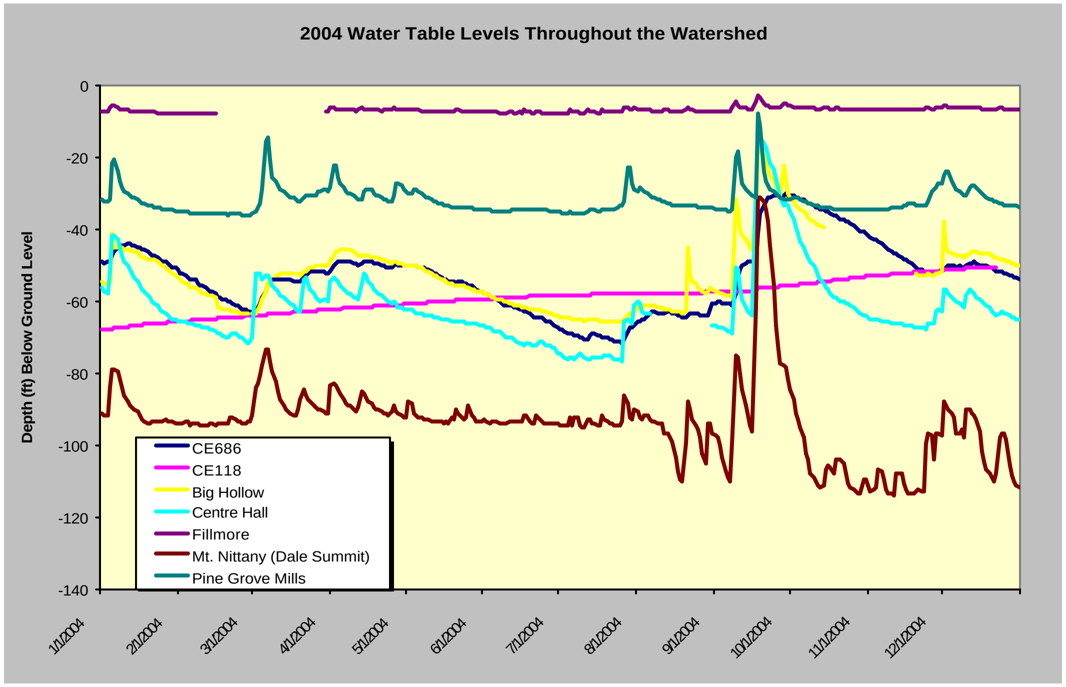


Figure 17. Water-Table Levels Throughout the Watershed.

The Pine Grove Mills monitoring well is located in a mountain flank setting approximately half way up Tussey Mountain in the Reedsville Shale above the village of Pine Grove Mills. The Centre Hall monitoring well is located in the Benner, Snyder, Hatter Limestone 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 in the Reedsville Shale. The Big Hollow monitoring well is located in Big Hollow just down gradient of this underdrained valley of Gatesburg Dolomite from where the State College bypass crosses Fox Hollow Road. The Fillmore 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 in the Nittany Dolomite. The locations of the seven monitoring wells (two USGS wells and five recently instrumented wells) in the Spring Creek Watershed are shown on the map in Figure 11.

The 2004 water table levels of the seven monitoring wells are shown in Figure 17, and the contrasts due to the very different hydrogeologic environments of these wells are apparent in the shapes of their water table plots. Some of the variability is due to variations in precipitation amounts throughout the watershed for individual storms. Note the impact that the tropical storms of September had on the well water levels, especially the water level rise in the valley settings wells. 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 Fillmore 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.

Stream Gage Observations

Figure 18 illustrates the significant role of the large springs in the lower part of the watershed in sustaining the flow of Spring Creek during periods of below-normal precipitation. Four miles upstream on Spring Creek from the Milesburg stream gage at the mouth of the watershed is a second stream gage called the 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 streamflows 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.

So the question is why, on Figure 18, is the Axemann gage mean annual flow equal to one-half of the Milesburg gage only in three (1996, 2003, and 2004) of the past nine 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 relative to Axemann during 1997 - 2002 period. 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 first, second and third wettest years on record were 1996, 2003, and 2004; respectively, and during these years the large spring discharges below the Axemann gage were a smaller component of the mean annual flow at the Milesburg gage. Thus the mean annual flow at the Axemann gage was one-half of the mean annual flow at the Milesburg gage.

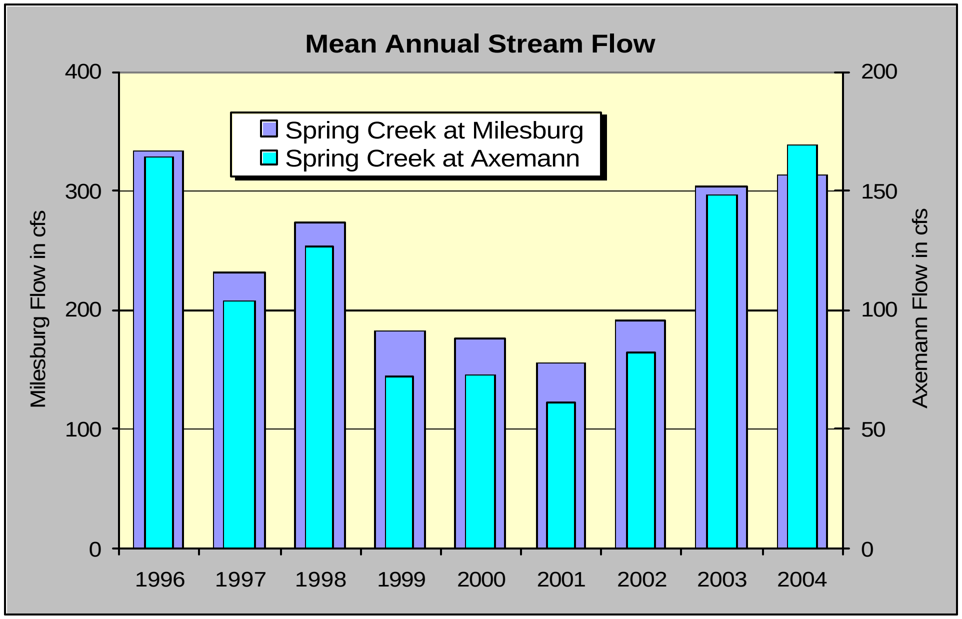


Figure 18. Mean Annual Stream Flow.

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 that we will be able to meet our future needs for this renewable resource.

BASE-FLOW HYDROLOGIC YIELD

Hydrologic yield is computed by converting the mean daily flow at baseflow to an equivalent depth of water over the contributing watershed. This metric allows us to conduct a meaningful comparison of mean streamflow between basins of dramatically different sizes.

Data from 2000-2001 showed a roughly seven-fold difference in streamflow per unit watershed area (hydrologic yield), from a low of 0.0130 inches/day for Slab Cabin Run to a high of 0.101 inches/day for Logan Branch. This rather dramatic variation across basins that are relatively similar in their geologic setting was not expected, and was attributed primarily to hydrogeologic features and/or processes that may be diverting or "exporting" ground water across surface sub basin boundaries. Karst conduit flow common to the Spring Creek basin makes this scenario highly likely. Data for 2004 showed significantly higher hydrologic yields for all basins as compared to 2000-2001. This was expected given the much higher rainfall (31.56" vs. 53.69") for the 2004 sampling period. 2004 hydrologic yields ranged from a low of 0.026 inches/day for Buffalo Run, and a high of 0.160 inches/day for Logan Branch, nearly double the yields of 2000-2001. The relative ranks of each sub basin are similar to the 2000-2001 data, and the significant differences in hydrologic yield are still nearly seven-fold among the nine sub basins. These hydrologic yield similarities during both record rainfall and record drought years suggest that the differences in hydrologic yield across the Spring Creek sub basins are indeed rooted in geologic features and hydrogeologic flow patterns unique to the bedrock geology of the of the Spring Creek Watershed, and these features are equally important over the full range of drought and wet weather conditions.

Figure 19. Bert Lavan, WRMP Committee member, measures Slab Cabin Run streamflow. Photo: R. Dunlap

Base-Flow Water Quality in Dry and Wet Years

In this section we examine average values during base flow for several water quality variables in 2001, a relatively dry year, and in 2004, a rather wet year. We are interested in determining how water quality during baseflow might change with streamflow yield.

Chloride

At most sampling stations, chloride concentrations were not substantially different in 2001 and 2004 (Table 4). The two exceptions were at lower Slab Cabin Run and Thompson Run, the most urbanized sub-basins. At lower Slab Cabin Run chlorides declined from 2001 to 2004, while the opposite occurred in Thompson Run. Reasons for this anomaly are not apparent.

Nitrate-N

Nitrate concentrations were generally greater in 2004 than in 2001, though differences tended to be small. Here again, lower Slab Cabin Run was the exception in that nitrate concentrations more than doubled. The data from all other stations suggest that the source pool of ground-water nitrates is providing a

Table 4.

Concentrations of several water quality variables measured during baseflow at nine monitoring stations in 2001 and 2004. Twelve samples were collected in 2001 and four in 2004. When a constituent concentration was below detection limits it is labeled as ND, or not detected. Single values represent the median value for twelve or four samples. Highlighted values are regarded as significant changes between years.

	Chloride (mg/L)	Nitrate - Nitrogen (mg/L)	Orthophosphate (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	TSS (mg/L)
Slab Cabin Run Lower							
2001	71	1.7	0.016	11 of 12 NDs	10 of 12 NDs	10 of 12 NDs	2.6
2004	38	3.8	0.014	4 of 4 NDs	4 of 4 NDs	65	7
Thompson Run Lower							
2001	56	4.0	0.022	12 of 12 NDs	12 of 12 NDs	10 of 12 NDs	8
2004	74	4.0	0.019	4 of 4 NDs	4 of 4 NDs	12.5	3
Cedar Run							
2001	15	4.4	0.018	12 of 12 NDs	12 of 12 NDs	10 of 12 NDs	10
2004	14	4.7	0.014	4 of 4 NDs	4 of 4 NDs	4 of 4 NDs	14
Spring Creek Upper							
2001	17	2.5	0.012	12 of 12 NDs	12 of 12 NDs	5	7
2004	18	2.7	0.011	4 of 4 NDs	4 of 4 NDs	11	3
Spring Creek Houserville							
2001	34	3.1	0.015	12 of 12 NDs	11 of 12 NDs	11 of 12 NDs	5.5
2004	38	3.6	0.013	4 of 4 NDs	4 of 4 NDs	4 of 4 NDs	2
Spring Creek Axemann							
2001	49	4.7	0.028	12 of 12 NDs	10 of 12 NDs	8 of 12 NDs	18
2004	43	4.4	0.018	4 of 4 NDs	4 of 4 NDs	4 of 4 NDs	5.5
Spring Creek Milesburg							
2001	35	3.3	0.030	12 of 12 NDs	9 of 12 NDs	10	2.5
2004	35	3.7	0.016	4 of 4 NDs	4 of 4 NDs	17	2
Logan Branch Upper							
2001	34	2.6	0.049	12 of 12 NDs	3.6	11 of 12 NDs	3
2004	21	3.8	0.026	4 of 4 NDs	4 of 4 NDs	3 of 4 NDs	6
Logan Branch Lower							
2001	22	2.9	0.013	2.6	1.3	20	3
2004	21	3.6	0.014	4 of 4 NDs	4 of 4 NDs	26.5	4
Buffalo Run Lower							
2001	16	1.7	0.018	12 of 12 NDs	12 of 12 NDs	11 of 12 NDs	13
2004	20	1.9	0.016	4 of 4 NDs	4 of 4 NDs	4 of 4 NDs	6

relatively constant contribution to stream baseflow. Except for Slab Cabin Run, in-stream nitrate concentrations at base flow do not appear to be influenced by streamflow volume. Nitrate concentrations in 2004 were very similar to nitrate concentrations in 2000-2001, even though base flow was much higher.

Ortho-Phosphate

Concentrations of orthophosphate decreased among stations from 2001 to 2004. The most notable decreases occurred at upper Logan Branch and Spring Creek at Milesburg. These data indicate that strong retention and uptake of available orthophosphate, presumably by plant life in the streams, is occurring at both drought and wet weather conditions.

Copper

Copper was not detected in most samples from 2001 except those from lower Logan Branch, where one-half of the samples were above detection limits. Because copper was not detected at the Upper Logan Branch station, it had to be entering the stream between the upper and lower stations. In 2004, when streamflow was substantially higher than in 2001, copper was not detected at the lower station. We cannot determine if this decrease was due to a reduction in inputs or to higher flows that diluted the concentrations.

Lead

Like copper, lead was not frequently detected at any station in 2001, except those in Logan Branch. Concentrations were highest at the upper station and declined by one-third at the lower station. By 2004, no lead was detected in Logan Branch, presumably owing to the cessation of discharge from the Corning Asahi Plant.

Zinc

Among the three heavy metals, zinc was most frequently detected in 2001. Highest concentrations occurred in lower Logan Branch, though it was rarely detected at the upstream station. Zinc concentrations increased from 2001 to 2004 at five of nine stations. In the upper part of the watershed, these increases occurred at stations downstream of urbanized areas, mainly State College and Boalsburg. A modest increase in zinc was noted in Spring Creek at Milesburg, which was presumably due to the high concentrations of zinc from lower Logan Branch, though Bellefonte could have also contributed to this increase. Among the three metals, zinc showed the most response to increased streamflow.

Total Suspended Solids (TSS)

There was no trend in changes in TSS between 2001 and 2004. In general, changes at a given station were relatively small. TSS decreased at about one-half of the stations and increased at the other stations.

Slab Cabin Run

It is worth noting that for both chloride and nitrate-N concentrations, Slab Cabin Run showed notably different trends than other Spring Creek sub-basins. Slab Cabin Run was significantly lower in chloride concentration, and higher in nitrate-N concentration in 2004 vs. 2000-2001, which ran counter to temporal changes shown in most other basins. Data from 2000-2001 showed Slab Cabin Run to be more variable with respect to flow, chloride, and nitrate concentrations than all other sub-basins. Data from 2004 seem to confirm 2000-2001 data, and suggest that the Slab Cabin Run basin experiences water quality changes over time that are distinctly different than adjacent sub-basins. Whether these water quality differences are related to hydrogeologic or anthropogenic influences, remains an unanswered question.

Conclusions

The large increases in streamflow in 2004 as contrasted to 2000-2001 were accompanied by generally modest changes in water quality variables. Although a few variables exhibited significant changes between 2001 and 2004, there were no consistent changes at any given sampling station. Thus, during baseflow water quality tends to be relatively consistent among dry and wet years.

Data User Testimonial

Robert Wilberding, PA Fish and Boat Commission – “I used WRMP data from the monitoring station on Upper Logan Branch to determine recent high and low water flow levels of Logan Branch. As a State Fish Hatchery manager, water flow is very important to me in raising trout. I hope to continue to use the Watershed data, especially during periods of low flow, to assist me with water management and keeping Pleasant Gap State Fish Hatchery’s fish in good health”

TEMPERATURE

In the 2003 Annual Report, the impact of ground-water input to Spring Creek and its tributaries was illustrated. Ground water remains at nearly constant year-round temperature (approximately 10 degrees C, or 50 degrees F) and emerges through springs and seeps, as opposed to surface runoff from precipitation events which varies with above-ground temperatures. Specifically, the data showed that streams such as Slab Cabin Run and Buffalo Run, which have relatively low ground-water input, tended to have the coldest winter temperatures and warmest summer temperatures in the watershed, while the opposite was true for Thompson Run and Logan Branch, which are influenced to a greater extent by ground-water input from springs. As the water in the main stem of Spring Creek flows downstream, the temperature is increasingly influenced by surface runoff and ambient air temperature until the stream reaches Bellefonte, where large ground-water inputs from Logan Branch and Big Spring cool the stream in summer and warm it in winter.

Following three consecutive years of below normal precipitation, the watershed in 2003 and 2004 received significantly above-normal precipitation, which facilitated the recharge of ground-water resources and subsequently increased streamflows. Since 86% of the annual flow that exits the watershed at Milesburg is from ground-water inputs, it would be expected that this increased contribution from water of constant temperature would have more of a moderating effect on stream temperatures than in a year of lower than average precipitation.

Table 5. Comparison of Dry Year/Wet Year Winter Stream Temperatures (ºF)

	Low Ground-Water Input			High Ground-Water Input		
	Buffalo Run Upper	**Slab Cabin Run Upper**	**Spring Creek Axemann**	**Thompson Run Lower**	**Logan Branch Lower**	**Spring Creek Milesburg**
Mar-01	39.0	39.9	43.7	47.5	48.2	45.0
Mar-04	42.3	48.7	46.2	48.9	47.7	46.4
Difference between 2001 and 2004	+3.3	+8.8	+2.5	+1.4	-0.5	+1.4

Table 5 contains dry year (2001) versus wet year (2004) average winter (March) stream temperature differences for selected monitoring sites in the watershed.

The table shows that the sites with low ground-water input experienced a 2.5º - 8.8º difference between winter temperatures in 2001 and 2004 while the sites with high ground-water input experienced only a 0.5º - 1.4º difference.

Table 6 compares the average summer (August) stream temperatures in 2001 and 2004 at the same selected sites. Again, the sites with low ground-water input experienced a larger difference in summer temperatures (6.1º - 12.4º) than the sites with high ground-water input (0.9º - 2.9º).

Another look at Table 6 shows that in 2001 the tributaries to Spring Creek had summer water temperatures in excess of 68º F, which is approaching the point at which brown trout begin to show signs of stress. In contrast, the cooler water temperatures of summer 2004 were optimal for brown trout survival. Thus, the abundant precipitation and ground-water recharge of 2003 and 2004 benefited both the human population that depends on the watershed for sustenance and the creatures who share the watershed with us.

Table 6. Comparison of Dry Year/Wet Year Summer Stream Temperatures (ºF)

	Low Ground Water Input			High Ground Water Input		
	Buffalo Run Upper	**Slab Cabin Run Upper**	**Spring Creek Axemann**	**Thompson Run Lower**	**Logan Branch Lower**	**Spring Creek Milesburg**
2001	70.2	72.1	67.8	58.3	55.2	62.6
2004	60.3	59.7	61.7	57.4	54.3	59.7
Difference in 2004	-9.9	-12.4	-6.1	-0.9	-0.9	-2.9

Buffalo Run in Dry (2002) and Wet Years (2004)

Photos: T. GIddings

Figure 20. Buffalo Run 9/3/2002.

Figure 21. Buffalo Run 5/31/2004.

Figure 22. Buffalo Run 7/31/2004.

Figure 23. Buffalo Run 9/9/2004.

Figure 24. Buffalo Run 9/18/2004.

5.0 SPRING CREEK WATERSHED'S WETLANDS: A SOURCE OF NATURAL FLOOD CONTROL

The Spring Creek Watershed is riddled with wetlands – throughout the stream valleys where we most expect to find them, but also on the mountain slopes and even forested pockets found far from stream sources. Wetland scientists at the Penn State Cooperative Wetlands Center estimate that the wetlands within the Spring Creek Watershed comprise nearly 1,200 acres, about 1.3% of the watershed's total land base. This is an impressively small area relative to the magnitude of the services that wetlands provide society and nature.

Wetlands are defined as "waters of the U.S." and are afforded similar protection to rivers, streams, and lakes under the Clean Water Act. However, wetlands, in some cases are trickier to identify when there is not a pond or cattail in sight. The features that determine the existence of a wetland include a water source (spring, stream, ground water), hydric soils (soils that are classified as typically being wet), and hydrophytic plants (plants that depend upon wet conditions to survive).

As development continues in the watershed, hydrologic modifications, typically earth moving activities and pavement, are among the greatest threats to wetlands because these modifications both increase the quick flow of storm waters to wetlands and increase the volume of water that the wetlands must accommodate. Wetlands, particularly those in the floodplains adjacent to streams, absorb a high volume of the floodwaters that spill over the streambanks during storms. This ecological service results in slowing down excess waters, retaining floodwaters over time allowing filtration back into the ground-water source, and in many cases, saves considerable damage to more vulnerable human structures and ecosystems that are downstream of the wetland and less adaptable to flood conditions. Ever increasing volumes of water exacerbated by the runoff coming from developed areas can strip the wetland's ability to accommodate the water.

Scientists believe that 94% of wetlands in the Spring Creek Watershed are associated with stream systems. The remaining 6% are considered isolated depressions.

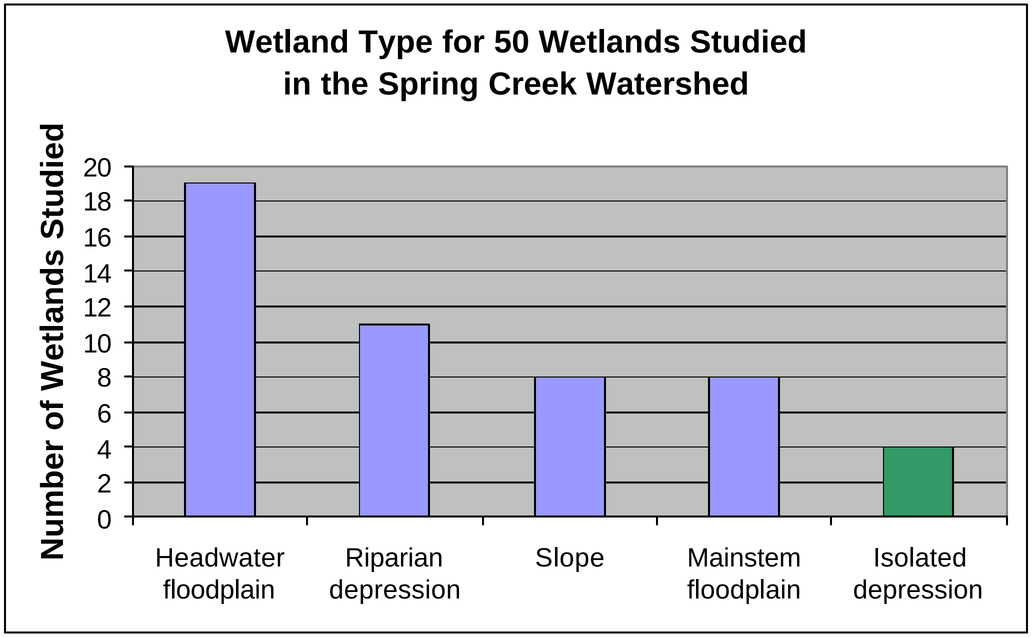
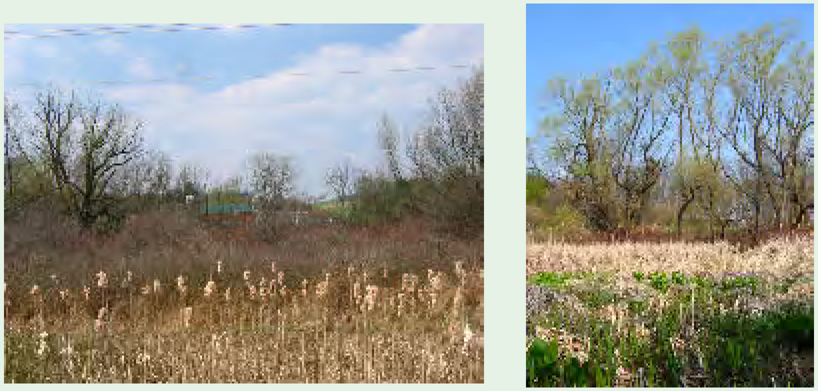


Figure 25. Only 4 of the 50 wetlands studied in the Spring Creek Watershed are considered isolated depressions are not within a 50 m radius of a stream.

The Scotia Barrens vernal pools are good examples of isolated depressions as are the ponds found in the Toftrees vicinity. Since the isolated depression is not dependent upon surface waters, like streams, for its water source, it may or may not be near the stream system. Instead, an isolated depression's source of water is from precipitation or ground water.

A "slope" wetland is fed by ground water, but instead of being a depression, they are typically situated on a hillside, and in some cases, the ground water can be seen coming to the surface and moving by gravitational pull across the slope wetland. Slope wetlands within the Spring Creek Watershed exist on the sides of Tussey, Nittany, and Bald Eagle mountains. There's also one in Walnut Springs Park and within the Millbrook Marsh.

In the Millbrook Marsh alone, four different hydrogeomorphic wetland classifications are present – slope, riparian depression, headwater floodplain, and mainstem floodplain. Each of these wetlands have unique characteristics relative to the types of plants that reside within them, the habitat opportunities provided, their water sources, and the ecological services they provide.



Figures 26 & 27. Millbrook Marsh Photos: ClearWater Staff

Some of the services Spring Creek's wetlands provide include short-term storm water detention, long-term storm water discharge, and removal and/or retention of inorganic particulates. Wetland services are more easily understood when we look at wildlife; nearly 80% of the animals native to the Spring Creek Watershed depend upon wetlands for habitat, food, or shelter (particularly for the young). In other words, protection of our area's biodiversity is greatly enhanced through protection of the wetlands.

Flood-control: The floodplain wetlands particularly are essential to providing buffer from heavy storms. As floodplains are encroached upon with buildings and roadways, the capacity of headwater and mainstem floodplains wetlands to accommodate the high volumes of water that accompany storm and flood events is greatly diminished. Since colonial times, Pennsylvania has lost over 50% of its wetlands. This figure leads us to wonder if the floodplain wetlands had been left intact, whether the devastation to property that historic floods like Agnes and Ivan caused may have been minimized.

Increasingly, as development encroaches more on the land space available for wetlands, people wonder whether the 'value' of wetlands is clearly understood. Wetlands have been valued from $15,000 to $48,000 per acre. These figures would suggest a total value between $10 million and $32 million for the wetland acreage in the Spring Creek Watershed.

Human caused changes to the land constitute the most common threats to the health and well-being and even very existence of wetlands in the Spring Creek Watershed. These stressors are generally categorized as hydrologic modifications (i.e., channelization, impoundment, water withdrawal), vegetative alterations (i.e., aquatic weed control, mowing, grazing), or sedimentation/erosion (i.e., channel incision, storm water inputs).

For the 50 wetlands studied in the Spring Creek Watershed, sedimentation/erosion related stressors were the most commonly found in both the urban and the agricultural areas. Hydrologic modifications, a close second to the sedimentation category, are confined primarily to urban areas.

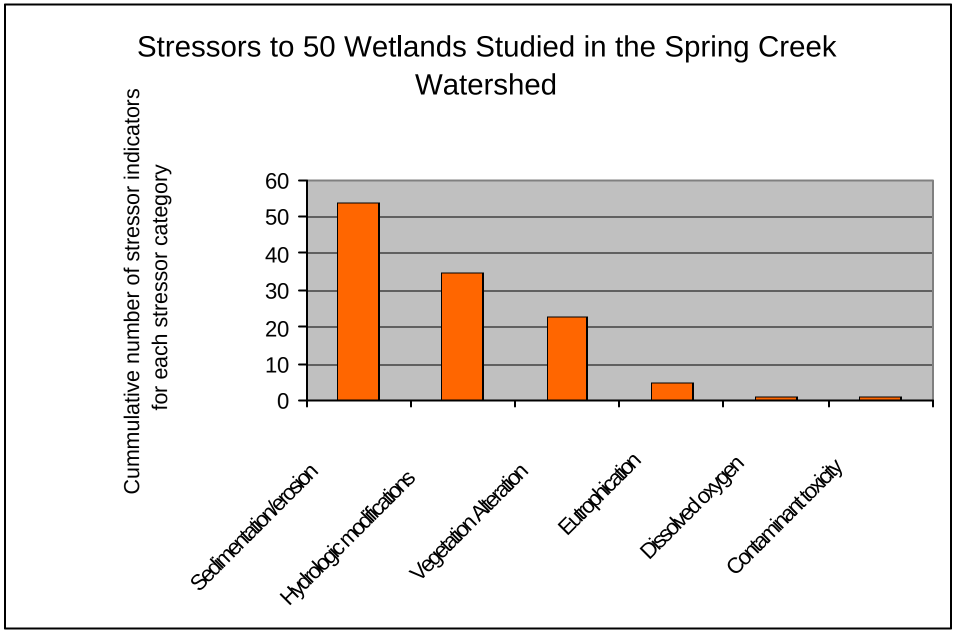


Figure 28. Stressors to the 50 Wetlands Studied in the Spring Creek Watershed.

6.0 WHAT'S NEW IN 2005

STORM-WATER MONITORING

WRMP has resumed storm-water monitoring. Two sites on Slab Cabin Run and a site on Thompson Run (Fig. 32) were selected by the Water Resources Monitoring Committee so that WRMP could (1) measure the effects of the Slab Cabin Run Stormwater Bio-retention project and (2) provide data to validate and test the GIS-based model AVGWLF (ArcView Generalized Watershed Loading Function).

The Slab Cabin Run Stormwater Bio-retention project was initiated by the Penn State Office of Physical Plant with a 2003 Growing Greener Grant from the PA DEP. The proposed project will reconnect the stream with its 1- to 2-year flood plain and promote flooding over adjacent wetlands during storm-water events. The project will optimize the natural function and value of the wetland soils and plants for storm-water retention and bioremediation. WRMP is collecting baseline storm-water data before project construction begins and will continue monitoring during and after the stream is reconnected to the floodplain.

The GIS-based model AVGWLF is used by the PA DEP to assess impaired stream segments. In anticipation of PA DEP using this model to assess the streams recommended for the Integrated List (formerly the 303(d) impaired streams list), several groups have funded a Spring Creek nonpoint source pollution assessment study which utilized AVGWLF. The results of the study showed high levels of sediment associated with storm-water runoff events both inside and outside of the Watershed's urban areas. WRMP's storm-water data will be used as background information to validate the AVGWLF model and the effectiveness of best management practices implemented in the Watershed.

WRMP Storm-Water Monitoring Equipment

Photos: ClearWater Staff

Figure 30.

Figure 29.

Figure 31.

SPRING MONITORING

Spring monitoring has been added to WRMP's base flow sampling regime so that the project can better characterize the quality and quantity of water in the Spring Creek Watershed. The Water Resources Monitoring Committee strategically selected seven springs to include in WRMP's quarterly sampling efforts (Fig. 33). The springs include Axemann Spring, Benner Spring, Blue Spring, Big Spring, Continental Courts Spring, Linden Hall Spring, and Windy Hill Farms Spring. Samples collected from these locations are analyzed for the constituents listed in Appendix A.

Figure 32.WRMP Storm-Water Monitoring Sites

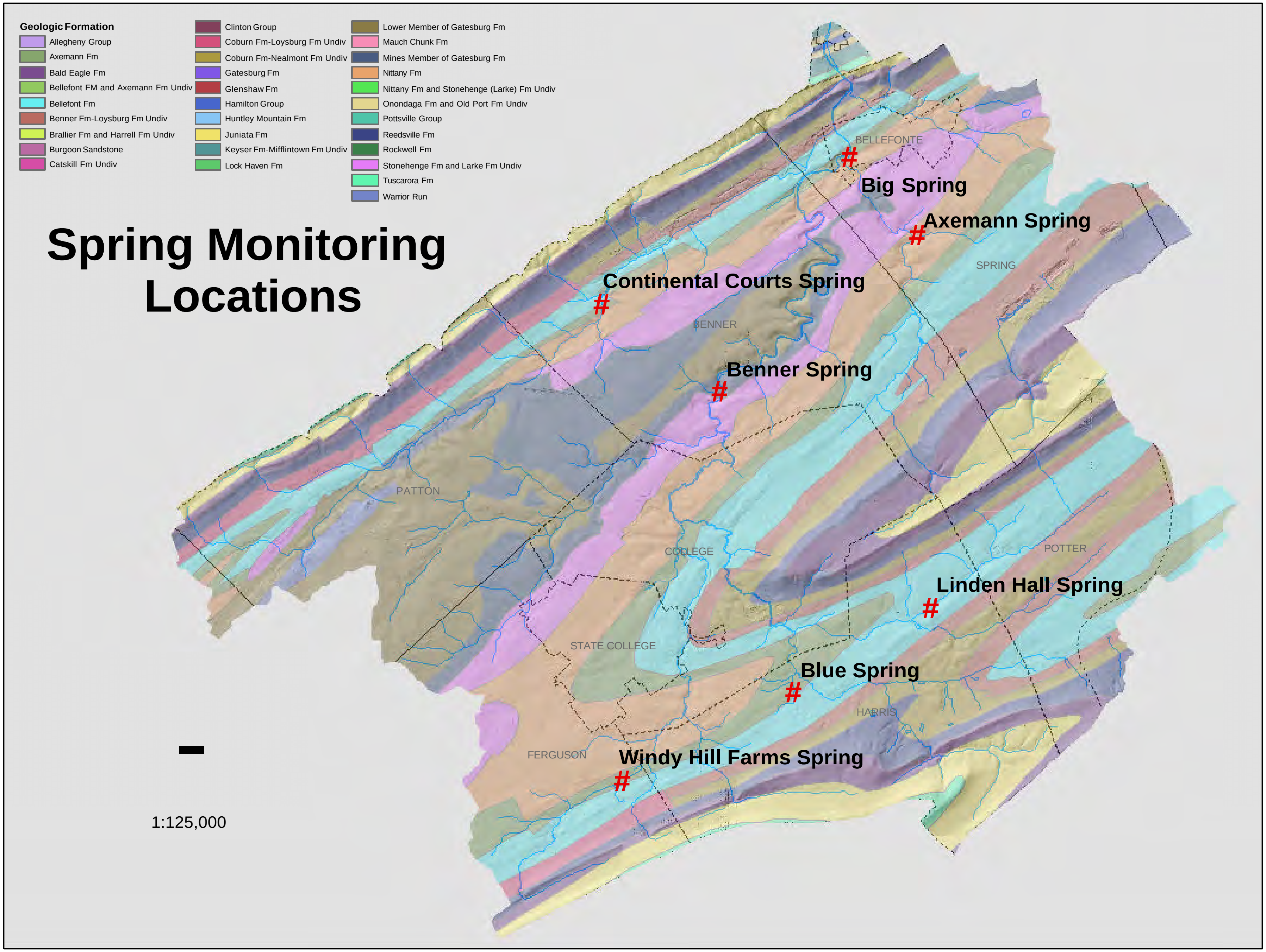


Figure 33. Spring Monitoring Locations

APPENDIX

Data collected in 2004 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	Base-Flow Monitoring	Storm-Water Monitoring (2005)
Aluminum	The most abundant metal on Earth.	Urban runoff, industrial discharges and natural sources.	May adversely affect the nervous system in humans and animals.	✓	✓
Cadmium	Natural element found in the earth's crust.	Industrial sources and urban sources including fertilizers, non-ferrous metals production, and the iron and steel industry.	Toxic to humans and aquatic life.	✓	
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.	✓	✓
Chromium	A Trace element essential for animals in small quanities.	Found in natural deposits as ores containing other elements.	Toxic to humans and aquatic life if present in excess.	✓	
Conductivity	Conductivity measures the ability of water to conduct an electrical current. A stream's conductivity is directly proportional to the concentrations and types of positively and negatively charged ions present.	Sources of ions are both naturally occurring and anthropogenic in origin, and include soil, bedrock, human and animal waste, fertilizers, pesticides, herbicides, and road salt.	Suspended solids clog fish gills and alter stream-bed habitat when settled. Particles may carry bound toxic compounds or metals.	✓	
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.	✓	✓
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.	✓	
Coliform Bacteria	Bacteria that are common in the intestines and feces of warm and cold blooded animals.	Animal wastes and sewage contamination.	Pathogenic to humans.		✓
Iron	Common element found in the earth's crust.	Urban runoff, industrial discharges and natural sources.	Toxic to humans and aqutic life.	✓	✓
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.	✓	✓
Manganese	Common element found in the earth's crust.	Urban runoff, industrial discharges and natural sources.	Toxic to humans and aquatic life.	✓	
Nickel	A Trace element essential for animals in small quanities.	Industrial wastewaters.	Toxic to humans and aquatic life if present in excess.	✓	

Parameter	Description	Sources	Environmental Effects	Base-Flow Monitoring	Storm-Water Monitoring (2005)
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.	✓	✓
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.	✓	✓
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.	✓	
Sodium	Soft metal commonly found in nature.	Various salts of sodium occur in considerable concentrations in the earth's crust.	There is some evidence to suggest that these high levels of sodicity are toxic to some plants.	✓	
Sulfate	Element commonly found in nature.	Urban runoff, industrial discharges and natural sources.	Toxic to humans and aquatic life.	✓	
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.	✓	✓
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.	✓	✓
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.	✓	✓
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.	✓	✓

2004
State of the Water Resources Addendum

Spring Creek Watershed Community
Water Resources Monitoring Project

9/3/2002 7/31/2004 9/18/2004

SPRING CREEK WATERSHED COMMUNITY

2004 State of the Water Resources Addendum

Table 1. 2004 Mean Monthly Stream Flows (cfs).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Median
Buffalo Run Lower	30.0	12.3	44.9	39.3	22.6	12.7	19.5	22.3	112.7	24.1	18.0	30.4	32.4	23.4
Buffalo Run Upper	34.7	17.3	45.1	33.2	17.4	13.3	22.2	25.1	43.8	16.2	15.5	26.8	25.9	23.7
Cedar Run Lower	31.1	14.9	35.3	31.4	20.9	13.8	13.7	20.6	62.2	24.5	19.9	32.5	26.7	22.7
Logan Branch Lower	122.6	82.7	133.4	136.8	111.3	94.2	76.6	80.1	151.7	103.7	87.8	113.8	107.9	107.5
Logan Branch Upper	114.5	59.9	125.4	122.9	87.4	56.0	48.0	64.2	149.3	84.8	54.7	98.6	88.8	86.1
Slab Cabin Run Lower	31.9	11.5	40.2	37.8	22.7	14.6					13.8	24.8	24.7	23.7
Slab Cabin Run Upper	16.5	12.5	18.4		13.6	14.1	11.8	13.3	19.2	15.0	13.6	16.1	14.9	14.1
Thompson Run Lower	19.9	11.4	18.7	18.0	12.8	6.0	3.3						12.9	12.8
Spring Creek Upper	39.5	10.2	53.3	49.6	27.3	10.9	10.7	21.7	126.4	20.9	15.6	34.7	35.1	24.5
Spring Creek Houserville*	136.6	60.7	165.4	157.8	103.4	60.7	61.6	90.5	270.2	88.6	74.7	122.5	116.1	97.0
Spring Creek Axemann*	196.5	100.9	221.9	214.5	144.0	95.7	103.0	140.1	359.1	152.1	122.0	186.6	169.7	148.0
Spring Creek Milesburg*	356.3	192.8	407.6	386.6	269.4	195.9	204.1	263.9	621.4	284.8	234.8	329.4	312.2	277.1

* USGS Data are provisional and subject to change.

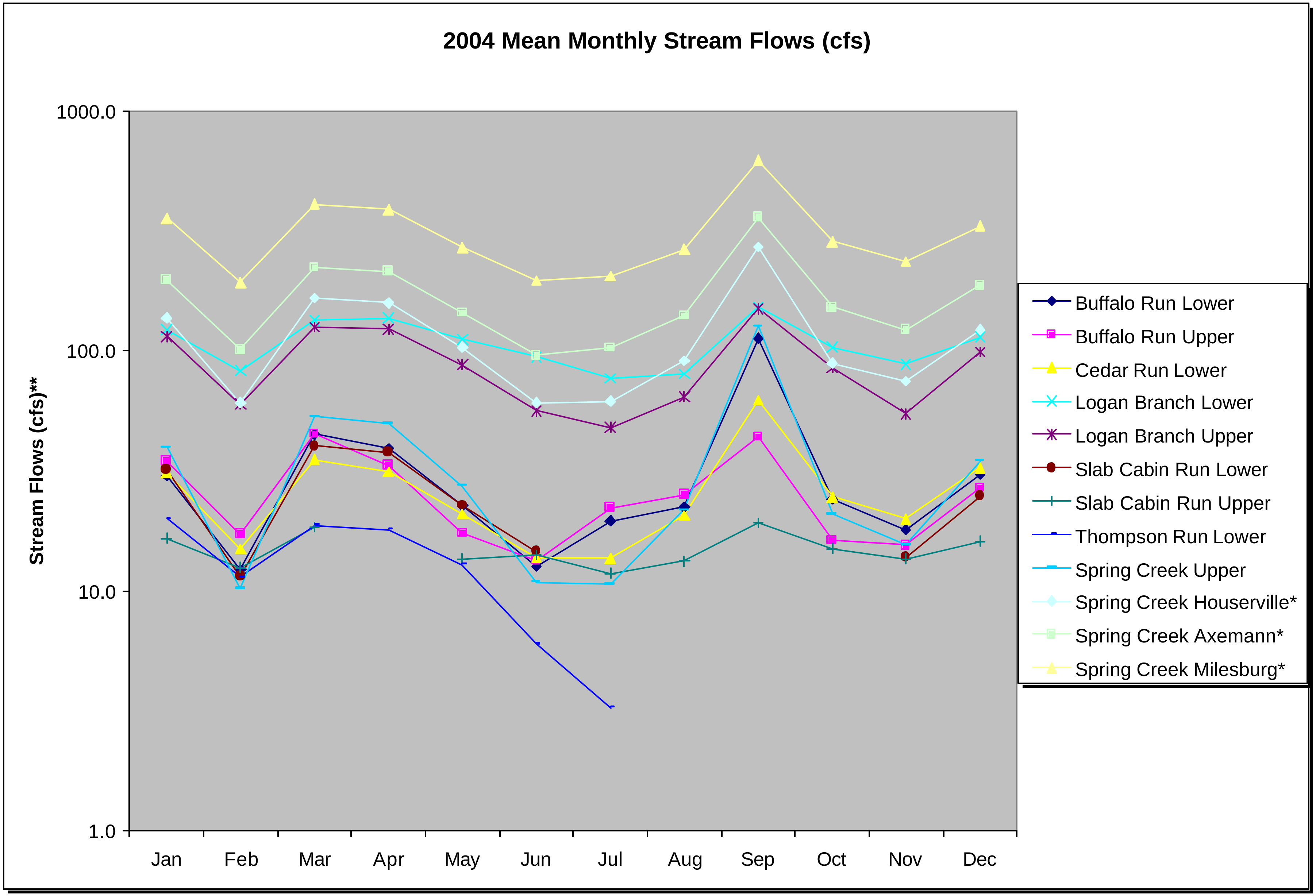


Figure 1. 2004 Mean Monthly Stream Flows (cfs).

* USGS Data are provisional and subject to change; ** Stream flow data are displayed lograthmically.

Table 2. 2004 Mean Monthly Stream Temperatures (ºF).

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Mean	Median
Buffalo Run Lower	36.8	37.3	43.3	49.6	57.5	59.3					46.5	41.4	46.5	44.9
Buffalo Run Upper	35.4	34.6	42.2	49.1	57.7	59.1	61.4	60.3	59.0	51.0	45.6	40.2	49.6	50.0
Cedar Run Lower	40.2	41.8	46.3	50.4	56.6	57.7	58.7	57.4	56.2	51.0	47.6	45.4	50.8	50.7
Logan Branch Lower	45.4	46.7	47.7	50.0	53.3	53.9	54.0	54.3	54.4	52.0	49.7	47.3	50.7	51.0
Logan Branch Upper		44.7	45.8	49.4	55.5	58.1	58.8	58.6	57.1	54.5	49.7	45.7	52.5	54.5
Slab Cabin Run Lower	39.2	39.7	44.9	50.1	58.6	61.7	64.7	61.2	58.6	52.0	47.5	42.5	51.7	51.1
Slab Cabin Run Upper			48.7	49.5	57.2	60.3	62.8	59.7	57.3	51.6	47.8	42.9	53.8	54.4
Thompson Run Lower	45.0	46.4	48.8	50.8	56.1	56.4	57.8	57.4	56.0	52.0	50.1	48.2	52.1	51.4
Spring Creek Upper	42.1	45.0	44.4	48.8	54.0	53.6	55.1	56.3	55.9	51.6	49.1	44.1	50.0	50.4
Spring Creek Axemann		42.8	46.2	51.2	59.4	61.5	63.1	61.7	59.0	52.5	48.1	43.0	53.5	52.5
Spring Creek Houserville			45.5	50.3	57.8	59.3	61.4	59.9	57.9	51.8	47.8	43.2	53.5	54.8
Spring Creek Milesburg	41.1	43.0	46.5	50.9	57.5	58.9	60.2	59.6	57.9	52.3	48.6	44.3	51.7	51.6

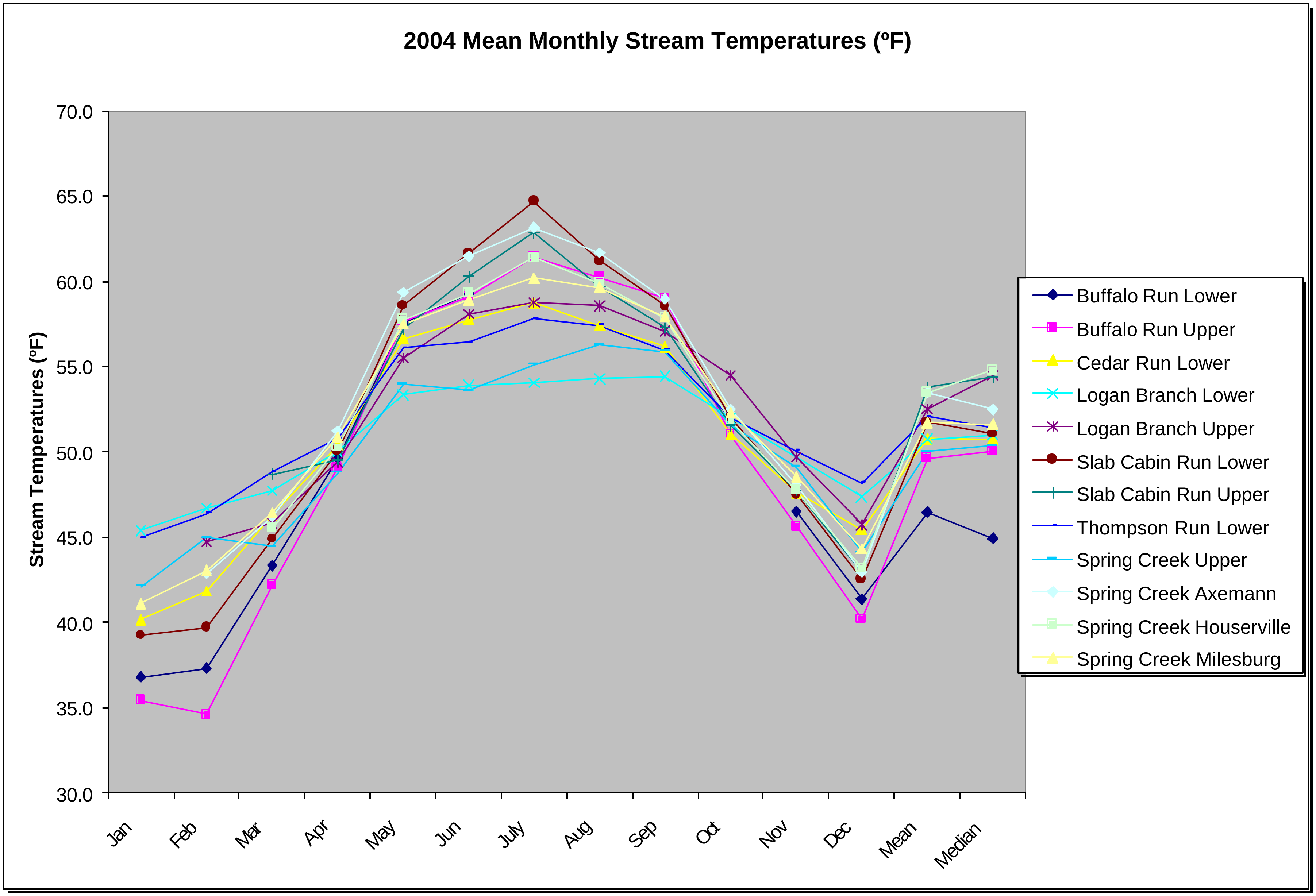


Figure 2. 2004 Mean Monthly Stream Temperatures (ºF).

Table 3. 2004 Range of Total Aluminum Concentrations (ug/L).

Station Name	March	June	October	Min	Med	Max
Buffalo Run Upper	429	131	55	55	131	429
Buffalo Run Lower	345	89	42	42	89	345
Buffalo Run Valley View	225	68	37	37	68	225
Cedar Run Lower	227	76	78	76	78	227
Logan Branch Upper	No Data	56	79	56		79
Logan Branch Lower	No Data	32	48	32		48
Slab Cabin Run Upper	No Data	100	252	100		252
Slab Cabin Run Lower	No Data	71	71	71		71
Thompson Run Lower	ND	46	32	32		46
Spring Creek Upper	No Data	44	48	44		48
Spring Creek Houserville	No Data	54	46	46		54
Spring Creek Axemann	No Data	61	35	35		61
Spring Creek Milesburg	No Data	42	42	42		42

ND = Not Detected

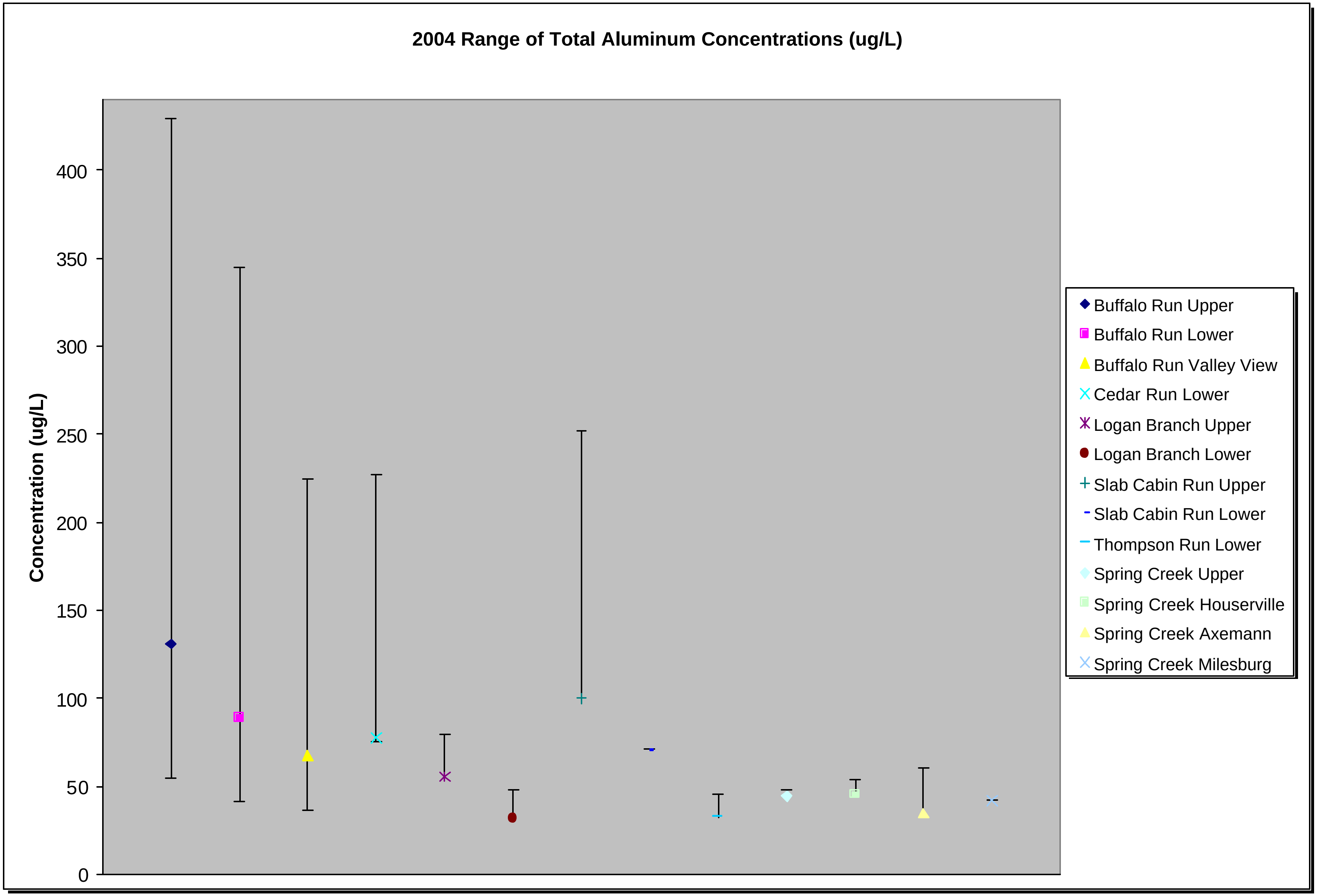


Figure 3. 2004 Range of Total Aluminum Concentrations (ug/L).

Table 4. 2004 Range of Total Chloride Concentrations (mg/L).

Station Name	Feburary	March	June	October	Min	Med	Max
Buffalo Run Upper	47.2	24.4	26.9	21.2	21.2	25.65	47.2
Buffalo Run Lower	30.1	21.6	18.2	17.5	17.5	19.9	30.1
Buffalo Run Valley View		22.1	13.2	6.3	6.3	13.2	22.1
Cedar Run Lower	15.3	26.1	13.7	12.3	12.3	14.5	26.1
Logan Branch Upper	30.3	22.4	20	14.5	14.5	21.2	30.3
Logan Branch Lower	24.8	22	19.9	18.2	18.2	20.95	24.8
Slab Cabin Run Upper	36	23.7	25.8	19.7	19.7	24.75	36
Slab Cabin Run Lower	63.7	39.1	36.7	27.5	27.5	37.9	63.7
Thompson Run Lower	95.4	85.8	59.5	61.8	59.5	73.8	95.4
Spring Creek Upper	28.2	16.2	20.4	15.8	15.8	18.3	28.2
Spring Creek Houserville	61.1	39.9	36.4	29.1	29.1	38.15	61.1
Spring Creek Axemann	74.3		48.4	37.3	37.3	48.4	74.3
Spring Creek Milesburg	50.6	33.2	36.3	29.4	29.4	34.75	50.6

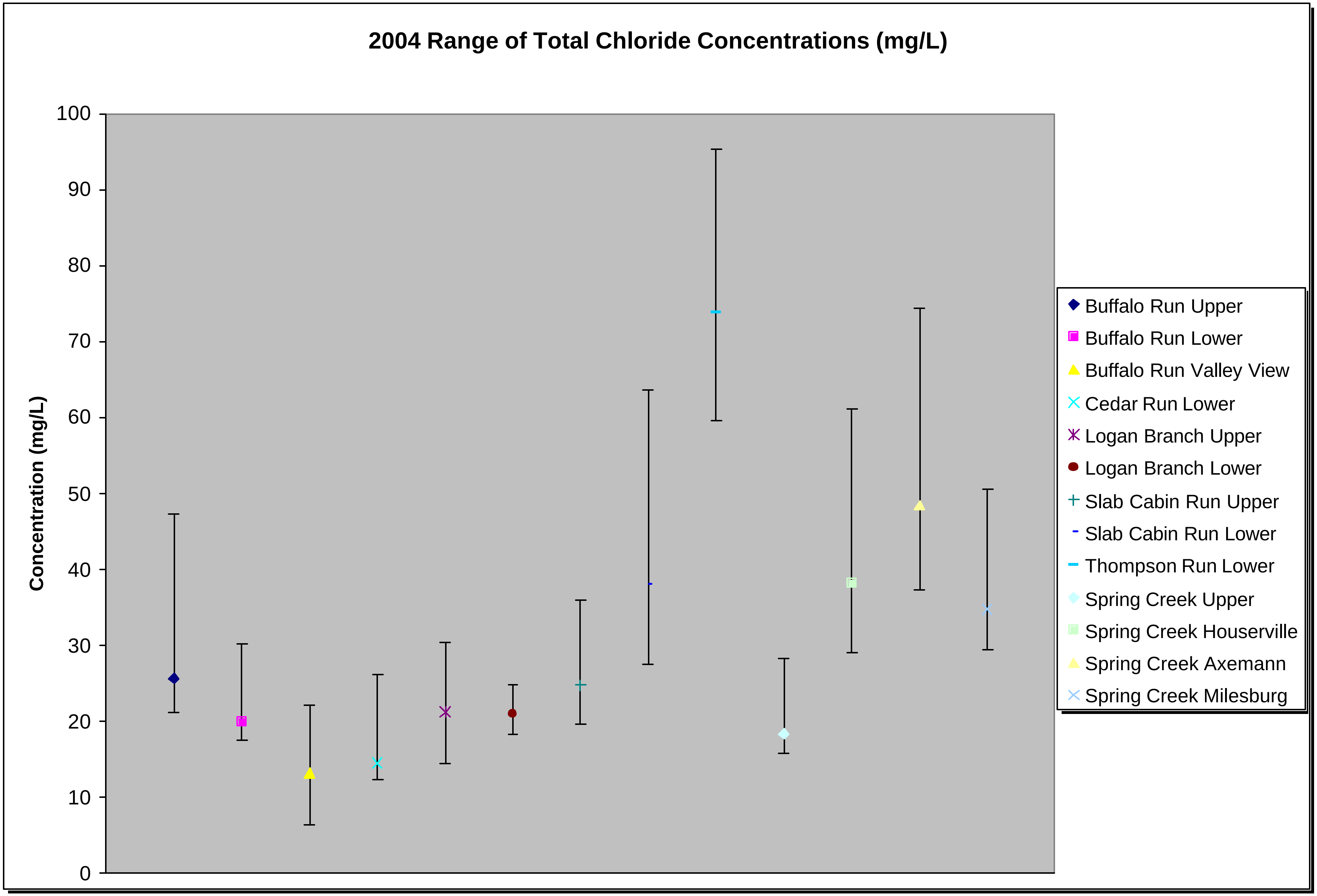


Figure 4. 2004 Range of Total Chloride Concentrations (mg/L).

Table 5. 2004 Range of Total Iron Concentrations (ug/L).

Buffalo Run Upper	495	246	99	99	246	495
Buffalo Run Lower	383	156	71	71	156	383
Buffalo Run Valley View	300	312	143	143	300	312
Cedar Run Lower	231	121	130	121	130	231
Logan Branch Upper		95	128	95		128
Logan Branch Lower		34	62	34		62
Slab Cabin Run Upper		181	474	181		474
Slab Cabin Run Lower		14200*	103	103		103
Thompson Run Lower	168	98	87	87	98	168
Spring Creek Upper		56	74	56		74
Spring Creek Houserville	128	95	141	95	128	141
Spring Creek Axemann		125	56	56		125
Spring Creek Milesburg		87	81	81		87

***** Suspected Lab Error

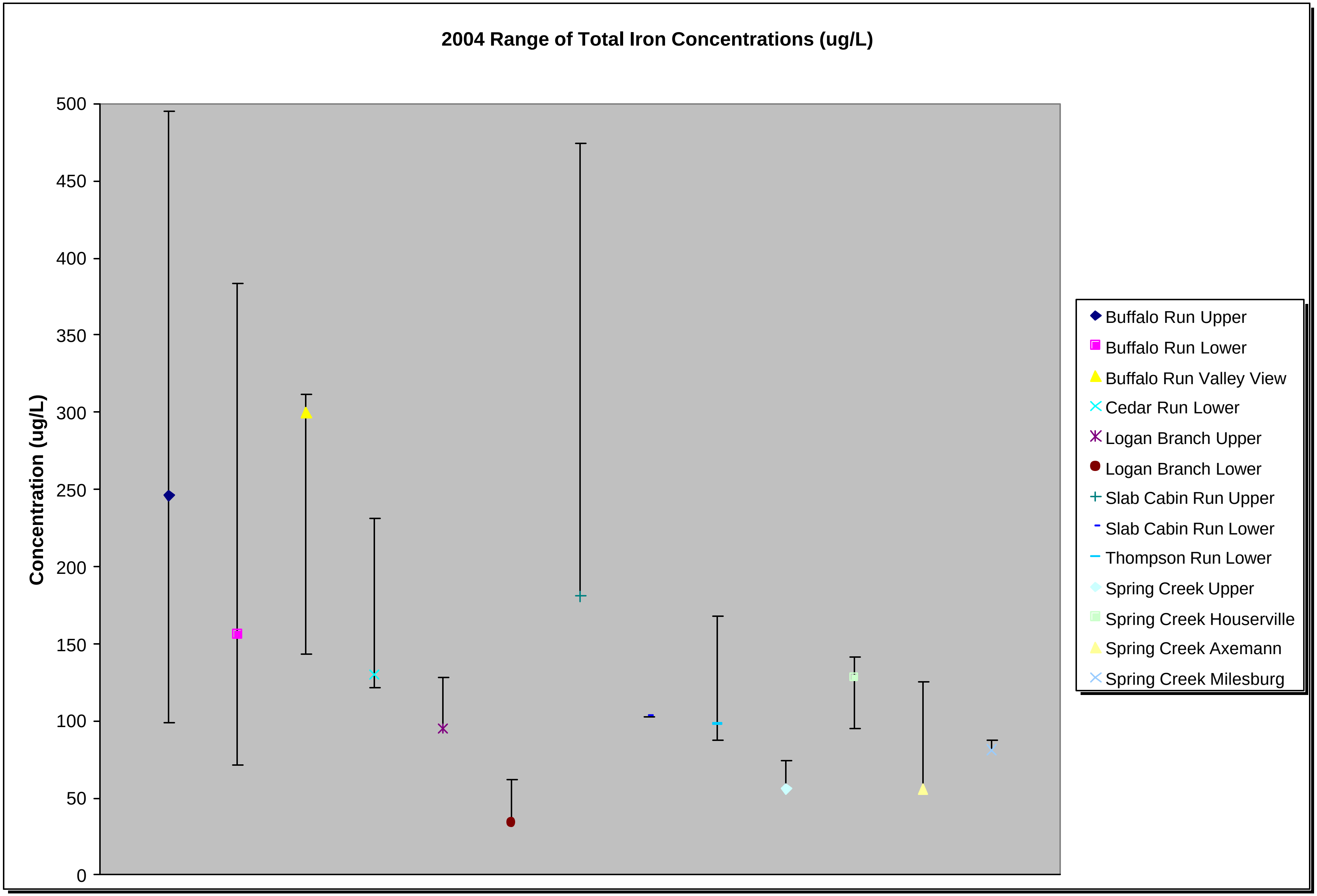


Figure 5. 2004 Range of Total Iron Concentrations (ug/L).

Table 6. 2004 Range of Total Manganese Concentrations (ug/L).

Station Name	March	June	October	Min	Med	Max
Buffalo Run Upper	30.0	15.1	30.1	15.1	30.0	30.1
Buffalo Run Lower	ND	9.9	8.5	8.5	9.2	9.9
Buffalo Run Valley View	28.0	127.0	63.6	28.0	63.6	127.0
Cedar Run Lower	11.0	6.4	7.2	6.4	7.2	11.0
Logan Branch Upper		7.8	54.9	7.8		54.9
Logan Branch Lower		2.6	4.1	2.6		4.1
Slab Cabin Run Upper		29.3	33.2	29.3		33.2
Slab Cabin Run Lower		6.3	7.0	6.3		7.0
Thompson Run Lower	28.0	6.8	8.0	6.8	8.0	28.0
Spring Creek Upper		4.5	5.5	4.5		5.5
Spring Creek Houserville	29.0	8.4	8.8	8.4	8.8	29.0
Spring Creek Axemann		7.7	4.7	4.7		7.7
Spring Creek Milesburg		8.1	5.8	5.8		8.1

ND = Not Detected

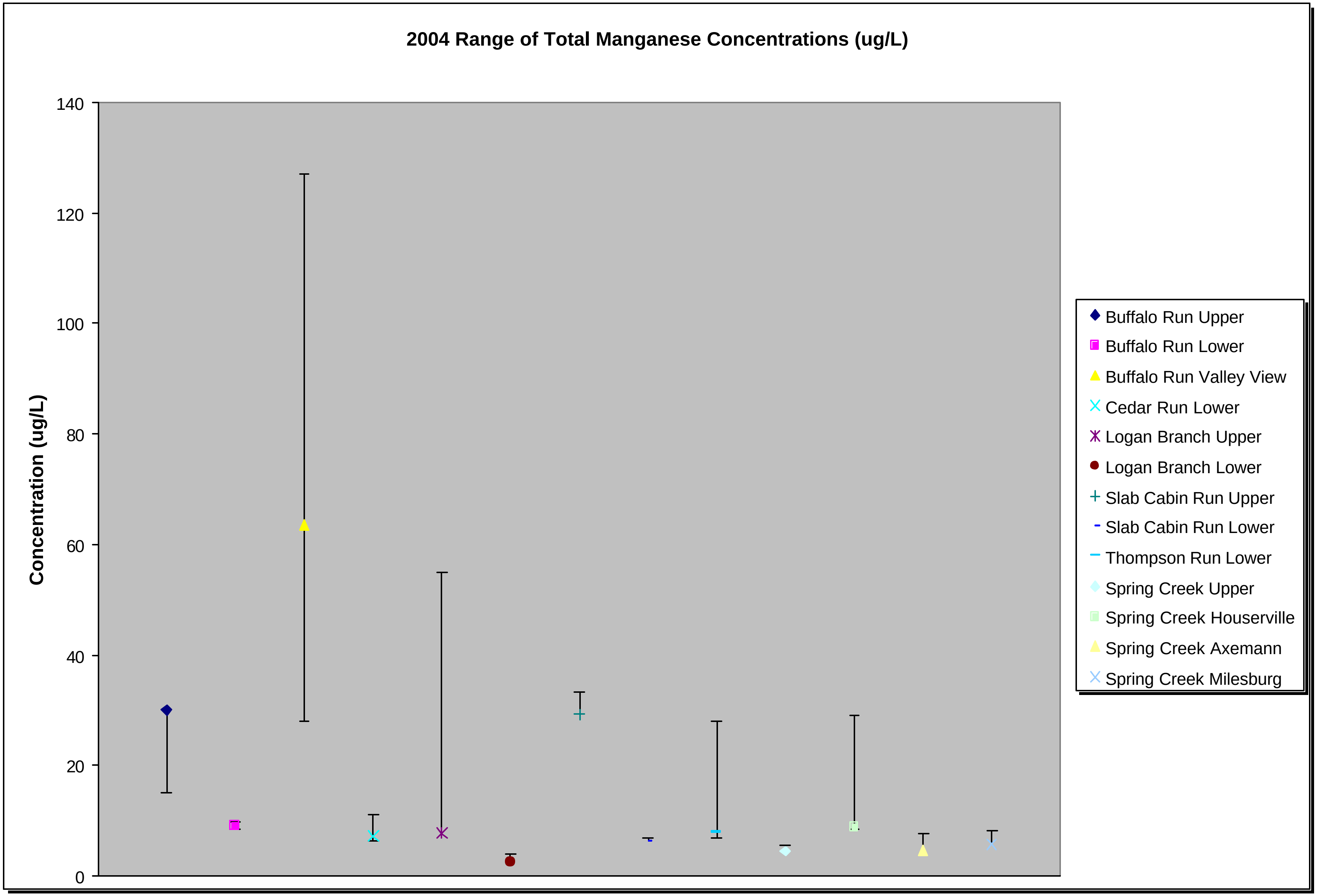


Figure 6. 2004 Range of Total Manganese Concentrations (ug/L).

Table 7. 2004 Range of Total Nitrate Concentrations (mg/L).

Station Name	Feburary	March	June	October	Min	Med	Max
Buffalo Run Upper	1.80	1.37	1.60	1.64	1.37	1.62	1.8
Buffalo Run Lower	1.66	1.47	2.10	2.20	1.47	1.88	2.2
Buffalo Run Valley View		0.29	0.43	0.31	0.29	0.31	0.43
Cedar Run Lower	4.88	4.39	4.72	4.61	4.39	4.67	4.88
Logan Branch Upper	3.99	2.39	4.01	3.56	2.39	3.78	4.01
Logan Branch Lower	3.62	3.12	3.51	3.62	3.12	3.57	3.62
Slab Cabin Run Upper	4.54	3.24	4.09	4.50	3.24	4.30	4.54
Slab Cabin Run Lower	4.04	3.15	3.56	4.28	3.15	3.8	4.28
Thompson Run Lower	4.01	4.00	3.94	4.18	3.94	4.01	4.18
Spring Creek Upper	2.88	1.85	2.90	2.55	1.85	2.72	2.90
Spring Creek Houserville	3.65	3.41	3.53	3.66	3.41	3.59	3.66
Spring Creek Axemann	4.84		4.52	4.26	4.26	4.52	4.84
Spring Creek Milesburg	3.96	2.94	3.65	3.75	2.94	3.70	3.96

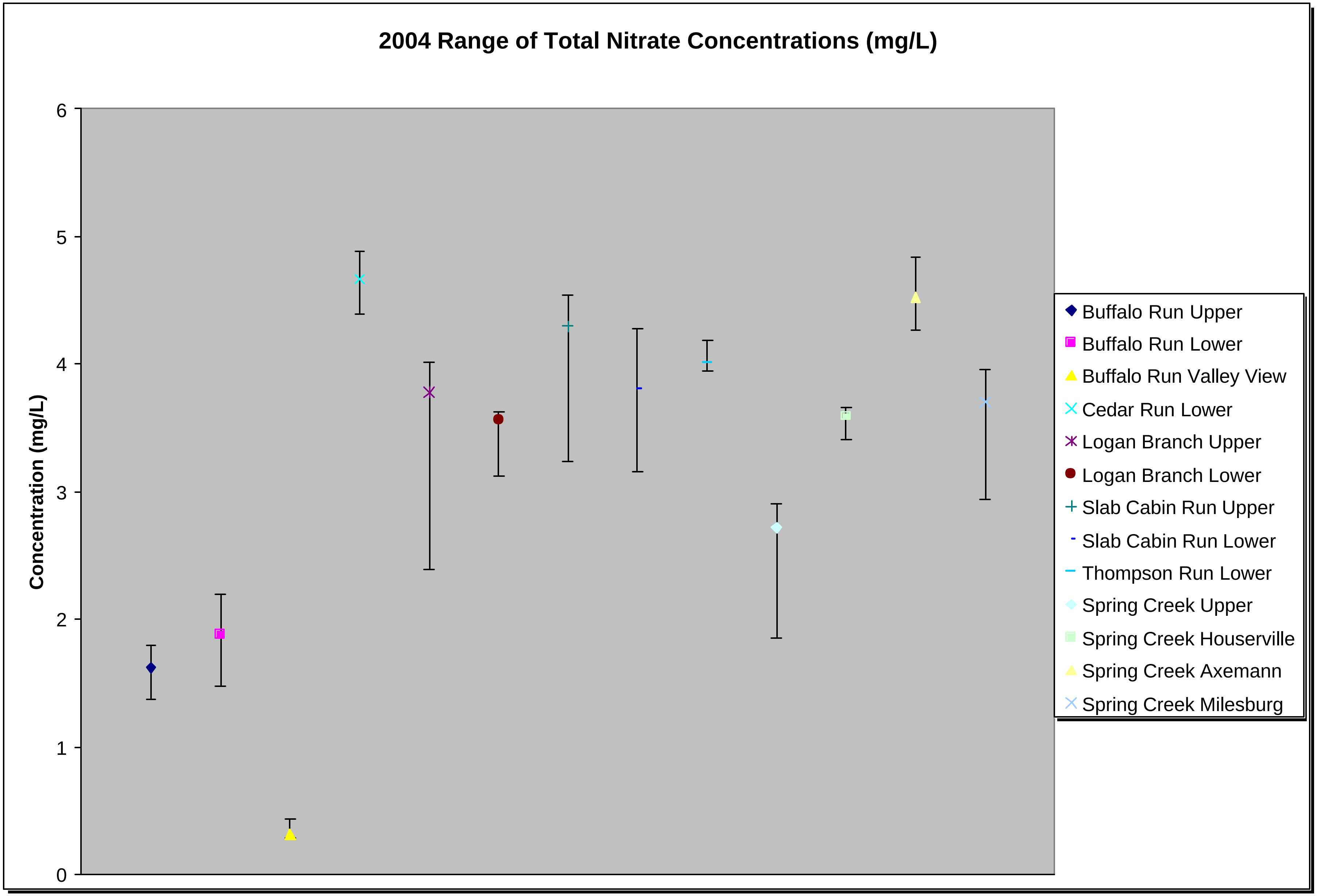


Figure 7. 2004 Range of Total Nitrate Concentrations (mg/L).

Table 8. 2004 Range of Total Orthophosphate Concentrations (mg/L).

Station Name	Feburary	March	June	October	Min	Med	Max
Buffalo Run Upper	ND	0.025	0.016	0.011	0.011	0.016	0.025
Buffalo Run Lower	ND	0.021	0.01	ND	0.01	0.0155	0.021
Buffalo Run Valley View		0.02	0.028	0.025	0.02	0.025	0.028
Cedar Run Lower	0.016	0.014	0.01	0.015	0.01	0.0145	0.016
Logan Branch Upper	0.028	0.022	0.023	0.03	0.022	0.0255	0.03
Logan Branch Lower	ND	0.015	ND	0.012	0.012	0.0135	0.015
Slab Cabin Run Upper	0.022	0.019	0.018	0.03	0.018	0.0205	0.03
Slab Cabin Run Lower	0.012	0.014	ND	0.017	0.012	0.014	0.017
Thompson Run Lower	0.019	0.013	0.019	0.026	0.013	0.019	0.026
Spring Creek Upper	ND	0.011	ND	ND	0.011	0.011	0.011
Spring Creek Houserville	0.011	0.017	0.012	0.014	0.011	0.013	0.017
Spring Creek Axemann	0.015		0.023	0.02	0.015	0.02	0.023
Spring Creek Milesburg	0.012	0.016	0.032	0.015	0.012	0.0155	0.032

ND = Not Detected

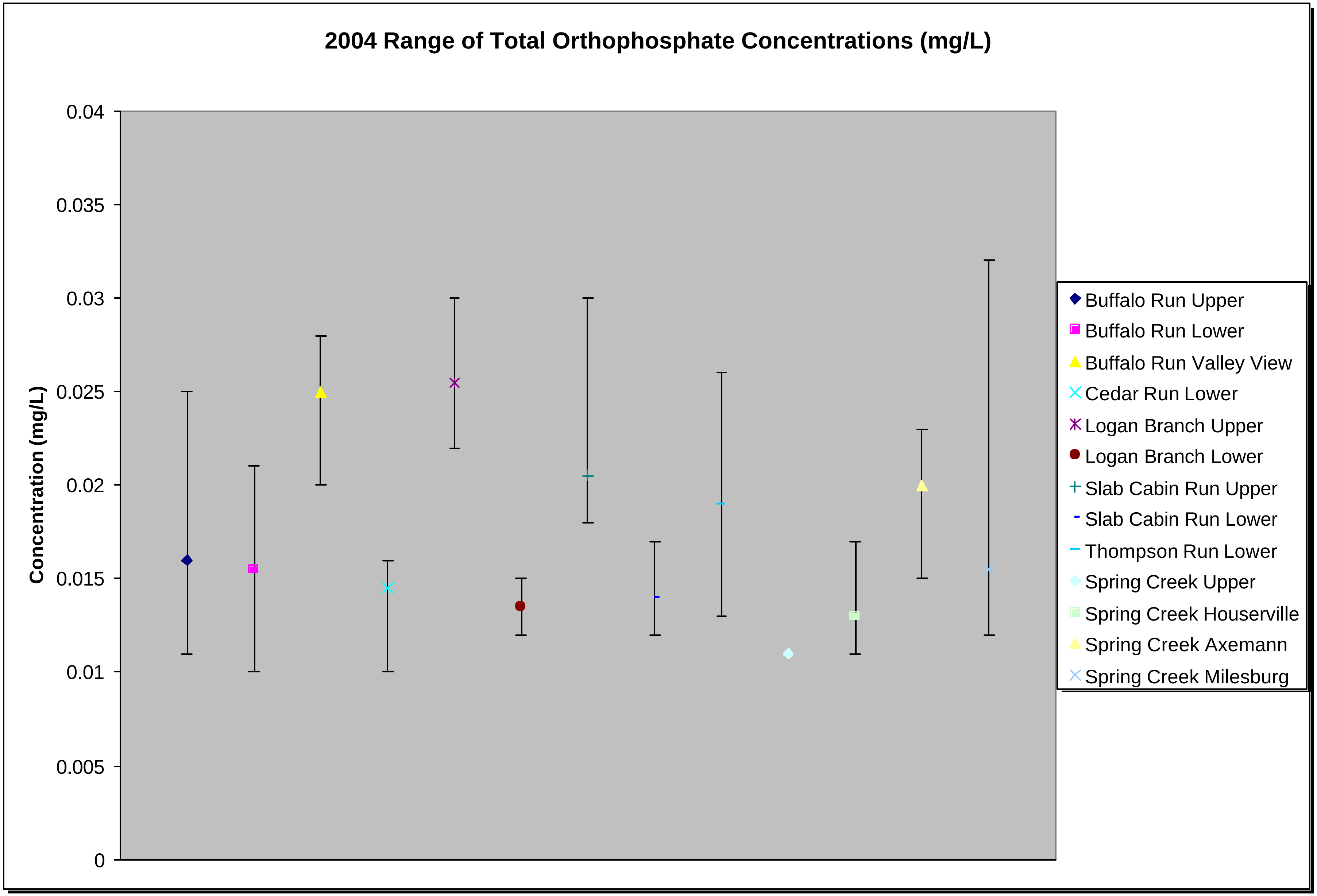


Figure 8. 2004 Range of Total Orthophosphate Concentrations (mg/L).

Table 9. 2004 Range of Dissolved Oxygen Concentrations (mg/L).

Station Name	Feburary	March	June	October	Min	Med	Max
Buffalo Run Upper	14.8	14.7	9.1	11.0	9.1	12.8	14.8
Buffalo Run Lower	13.7	13.8	10.1	12.1	10.1	12.9	13.8
Buffalo Run Valley View		13.3	9.1	10.8	9.1	10.8	13.3
Cedar Run Lower	13.5	12.8	10.2	11.5	10.2	12.2	13.5
Logan Branch Upper	12.5	12.4	11.3	11.9	11.3	12.2	12.5
Logan Branch Lower	12.4	11.5	10.4	11.3	10.4	11.4	12.4
Slab Cabin Run Upper	12.8	13.6	9.8	10.0	9.8	11.4	13.6
Slab Cabin Run Lower	14.3	13.1	10.7	11.9	10.7	12.5	14.3
Thompson Run Lower	12.7	11.7	10.7	10.7	10.7	11.2	12.7
Spring Creek Upper	10.9	12.3	8.0	8.8	8.0	9.8	12.3
Spring Creek Houserville	13.9	12.3	11.4	12.4	11.4	12.4	13.9
Spring Creek Axemann	14.8	14.0	10.7	12.3	10.7	13.1	14.8
Spring Creek Milesburg	12.9	12.3	10.1	10.8	10.1	11.5	12.9

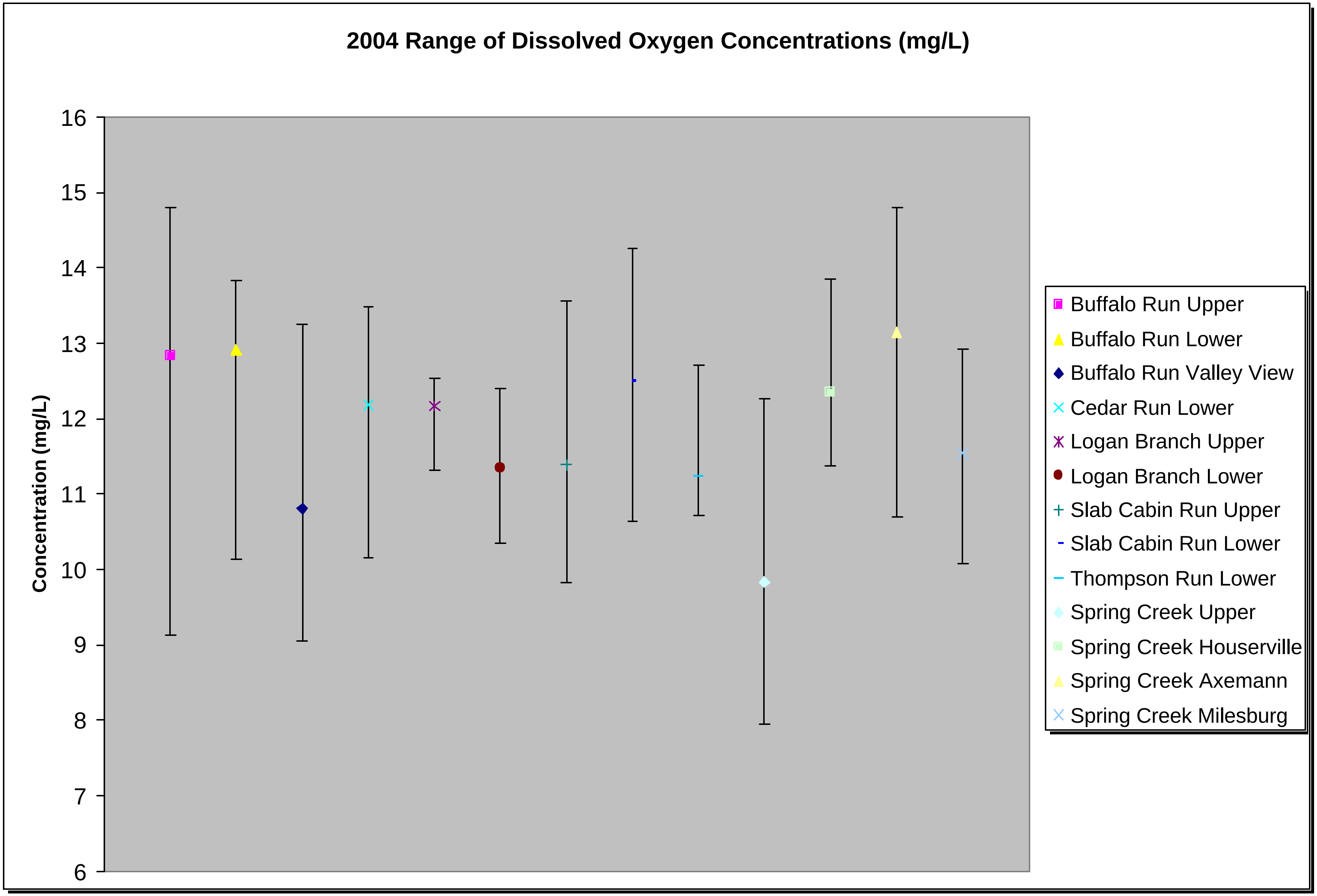


Figure 9. 2004 Range of Dissolved Oxygen Concentrations (mg/L).

Table 10. 2004 Range of pH Values (SU).

Station Name	Feburary	March	June	October	Min	Med	Max
Buffalo Run Upper	8.2	8.1	8.2	8.2	8.1	8.2	8.2
Buffalo Run Lower	8.2	8.1	8.4	8.3	8.1	8.3	8.4
Buffalo Run Valley View		7.9	8.3	8.5	7.9	8.3	8.5
Cedar Run Lower	8.3	8.1	8.4	8.2	8.1	8.3	8.4
Logan Branch Upper	7.8	7.9	8.1	8.1	7.8	8.0	8.1
Logan Branch Lower	8.1	8.0	8.1	8.1	8	8.1	8.1
Slab Cabin Run Upper	8.0	7.8	7.9	7.7	7.7	7.9	8.0
Slab Cabin Run Lower	8.2	8.1	8.4	8.3	8.1	8.3	8.4
Thompson Run Lower	7.8	8.0	8.1	8.2	7.8	8.1	8.2
Spring Creek Upper	7.6	7.5	7.7	8.1	7.5	7.7	8.1
Spring Creek Houserville	8.3	8.4	8.4	8.3	8.3	8.4	8.4
Spring Creek Axemann	8.2	8.2	8.2	8.3	8.2	8.2	8.3
Spring Creek Milesburg	8.1	8.3	8.3	8.3	8.1	8.3	8.3

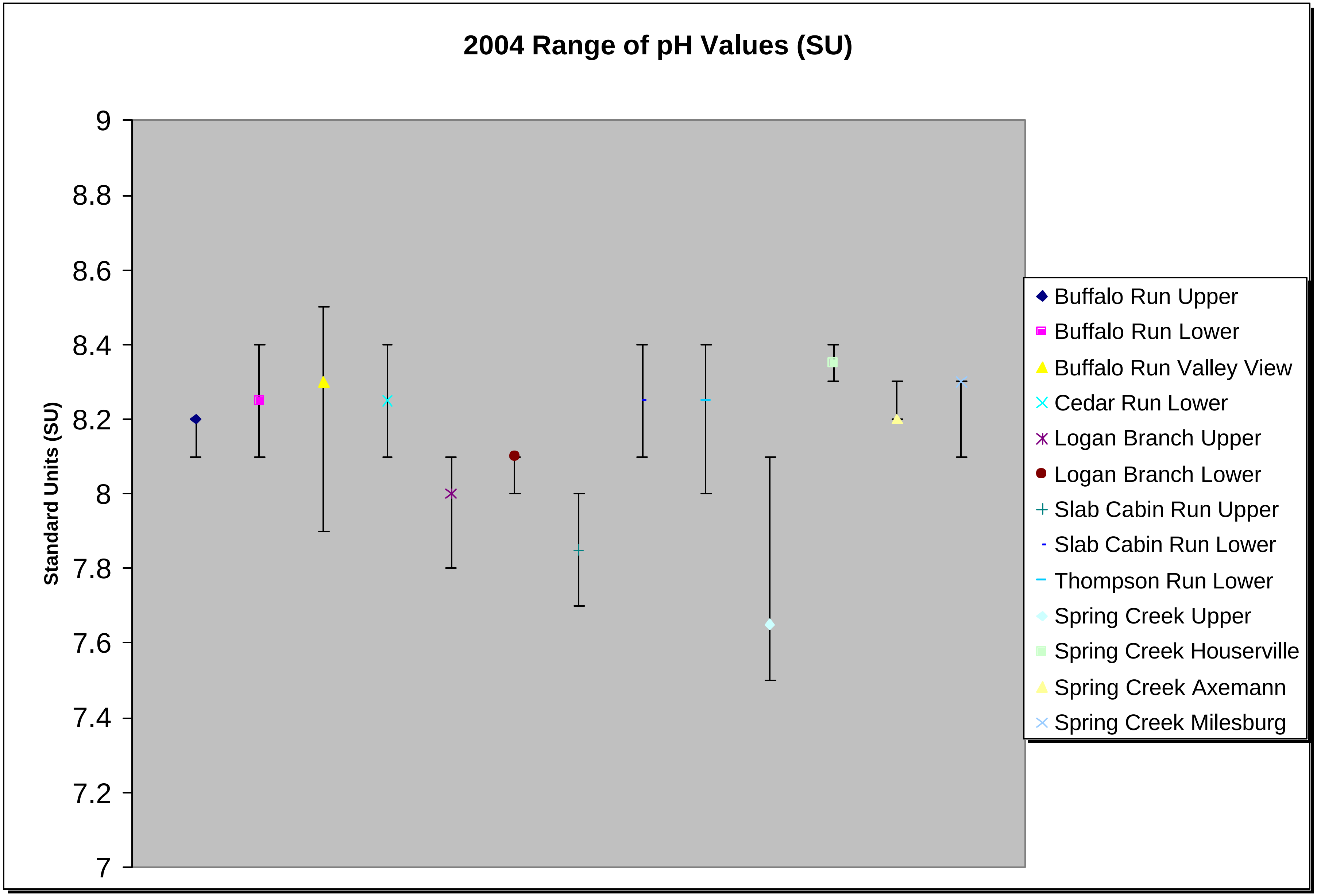


Figure 10. 2004 Range of pH Values (SU).

Table 11. 2004 Range of Total Sodium Concentrations (mg/L).

Station Name	March	June	October	Min	Med	Max
Buffalo Run Upper	13.4	16.4	13.4	13.4	13.4	16.4
Buffalo Run Lower	11.6	9.6	10.4	9.6	10.4	11.6
Buffalo Run Valley View	11.9	9.7	6.0	6.0	9.7	11.9
Cedar Run Lower	6.3	5.1	5.5	5.1	5.5	6.3
Logan Branch Upper		9.3	7.4	7.4		9.3
Logan Branch Lower		9.3	8.9	8.9		9.3
Slab Cabin Run Upper		11.3	9.3	9.3		11.3
Slab Cabin Run Lower		27.2	12.1	12.1		27.2
Thompson Run Lower	38.5	24.4	23.8	23.8	24.4	38.5
Spring Creek Upper		8.8	7.6	7.6		8.8
Spring Creek Houserville	16.1	16.2	13.0	13	16.1	16.2
Spring Creek Axemann		23.4	19.1	19.1		23.4
Spring Creek Milesburg		17.2	15.5	15.5		17.2

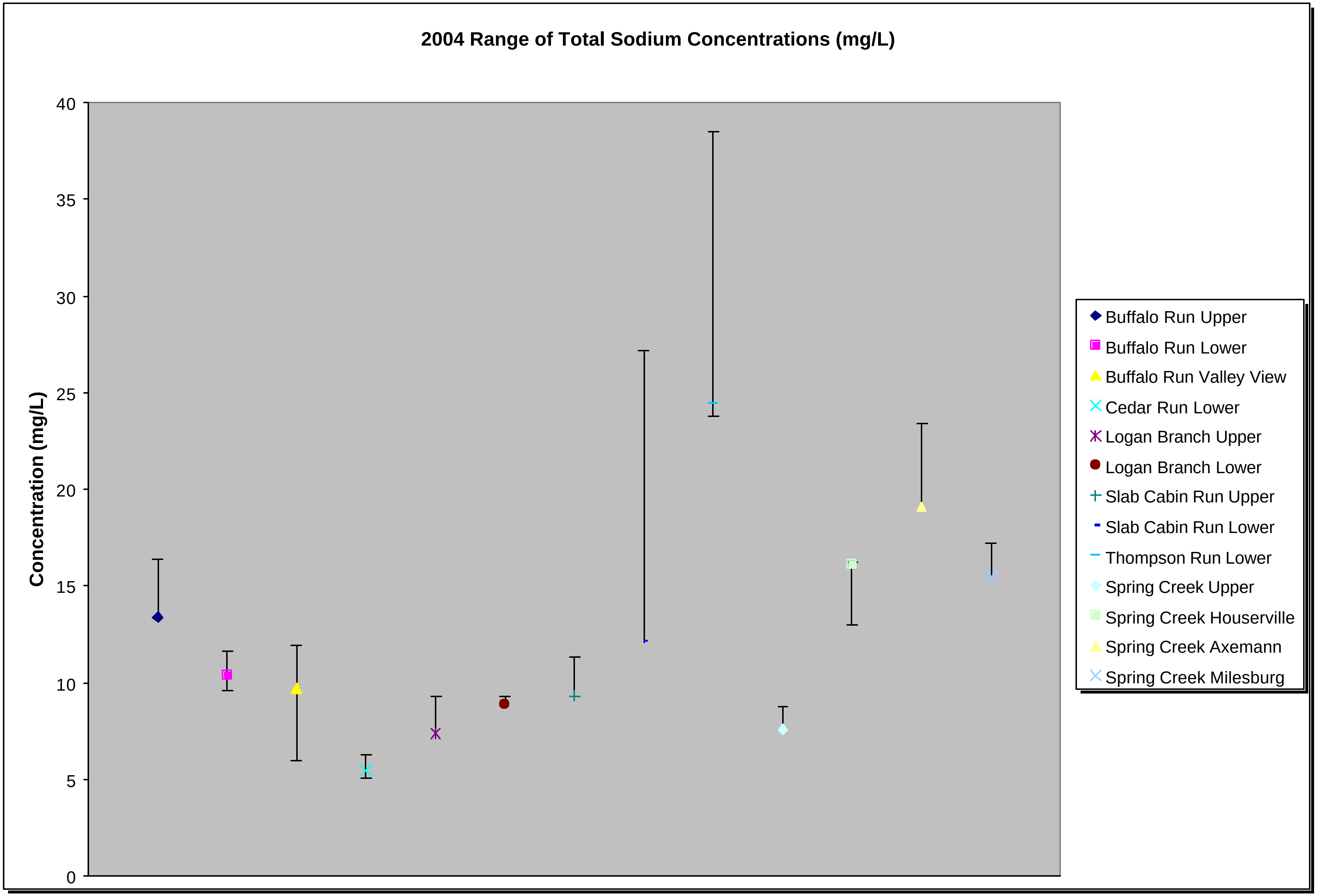


Figure 11. 2004 Range of Total Sodium Concentrations (mg/L).

Table 12. 2004 Range of Total Organic Carbon Concentrations (mg/L).

Station Name	Feburary	March	June	October	Min	Med	Max
Buffalo Run Upper	1.2	1.2	1.6	1.2	1.2	1.2	1.6
Buffalo Run Lower	1.0	1.1	1.4	1.2	1.0	1.1	1.4
Buffalo Run Valley View		0.9	1.3	1.2	0.9	1.2	1.3
Cedar Run Lower	1.0	1.2	1.2	1.0	1.0	1.1	1.2
Logan Branch Upper	1.7	1.4	1.9	1.6	1.4	1.6	1.9
Logan Branch Lower	0.7	0.9	0.8	0.8	0.7	0.8	0.9
Slab Cabin Run Upper	1.1	1.3	1.4	1.3	1.1	1.3	1.4
Slab Cabin Run Lower	1.2	1.1	1.6	1.2	1.1	1.2	1.6
Thompson Run Lower	1.1	1.2	1.8	1.0	1.0	1.2	1.8
Spring Creek Upper	0.8	1.1	1.0	0.9	0.8	0.9	1.1
Spring Creek Houserville	1.1	1.3	1.4	1.2	1.1	1.2	1.4
Spring Creek Axemann	1.6		1.8	1.3	1.3	1.6	1.8
Spring Creek Milesburg	1.2	1.2	1.4	1.1	1.1	1.2	1.4

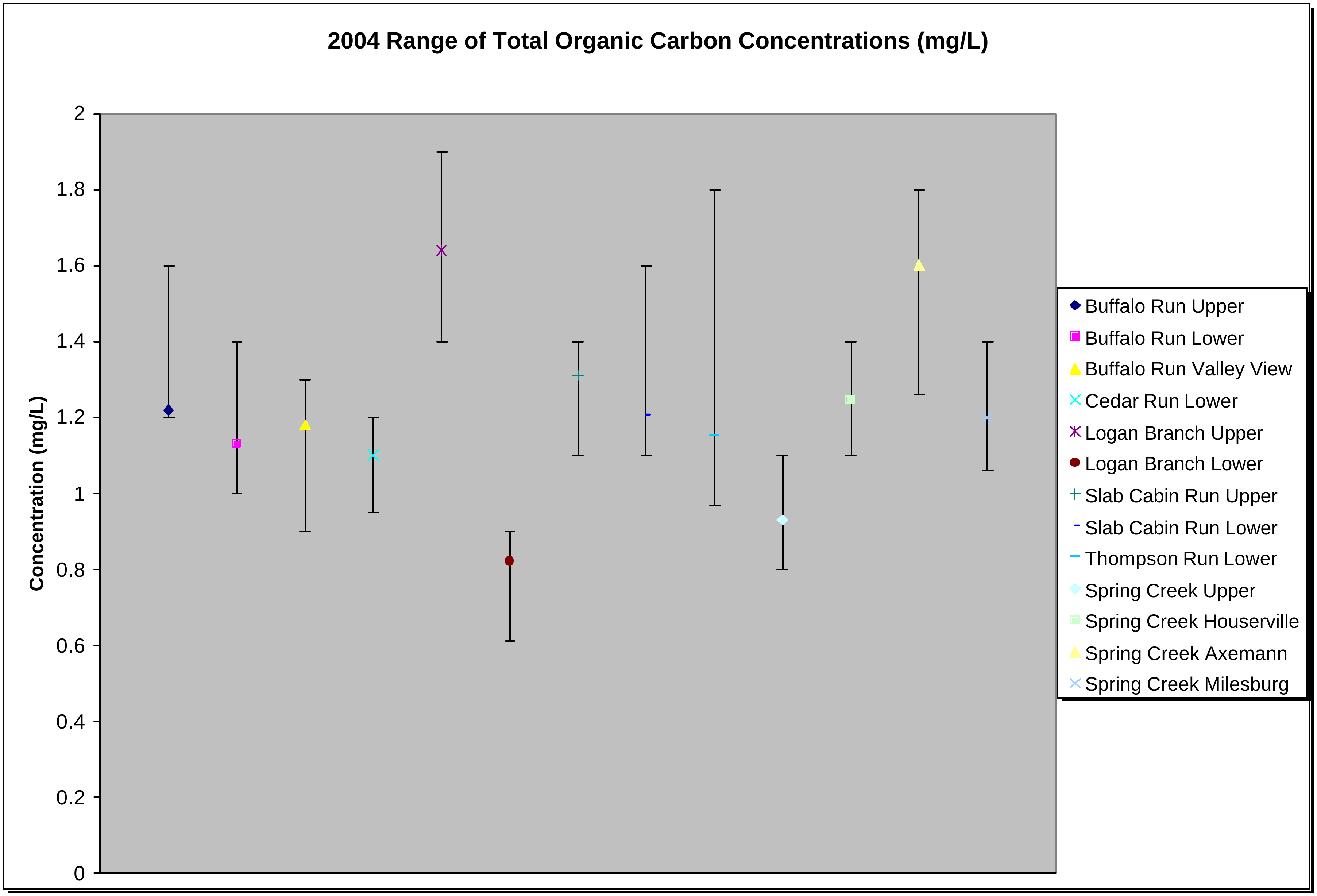


Figure 12. 2004 Range of Total Organic Carbon Concentrations (mg/L).

Table 13. 2004 Range of Total Suspended Solids Concentrations (mg/L).

Station Name	Feburary	March	June	October	Min	Med	Max
Buffalo Run Upper	4	10	8	4	4	6	10
Buffalo Run Lower	4	6	10	6	4	6	10
Buffalo Run Valley View		6	ND	4	4		6
Cedar Run Lower	16	16	12	6	6	14	16
Logan Branch Upper	2	ND	10	10	2	10	10
Logan Branch Lower	ND	2	6	8	2	6	8
Slab Cabin Run Upper	44	6	6	18	6	12	44
Slab Cabin Run Lower	4	16	6	8	4	7	16
Thompson Run Lower	2	4	ND	10	2	4	10
Spring Creek Upper	ND	4	2	6	2	4	6
Spring Creek Houserville	2	10	2	ND	2	2	10
Spring Creek Axemann	ND		18	ND	18		
Spring Creek Milesburg	6	2	2	2	2	2	6

ND = Not Detected

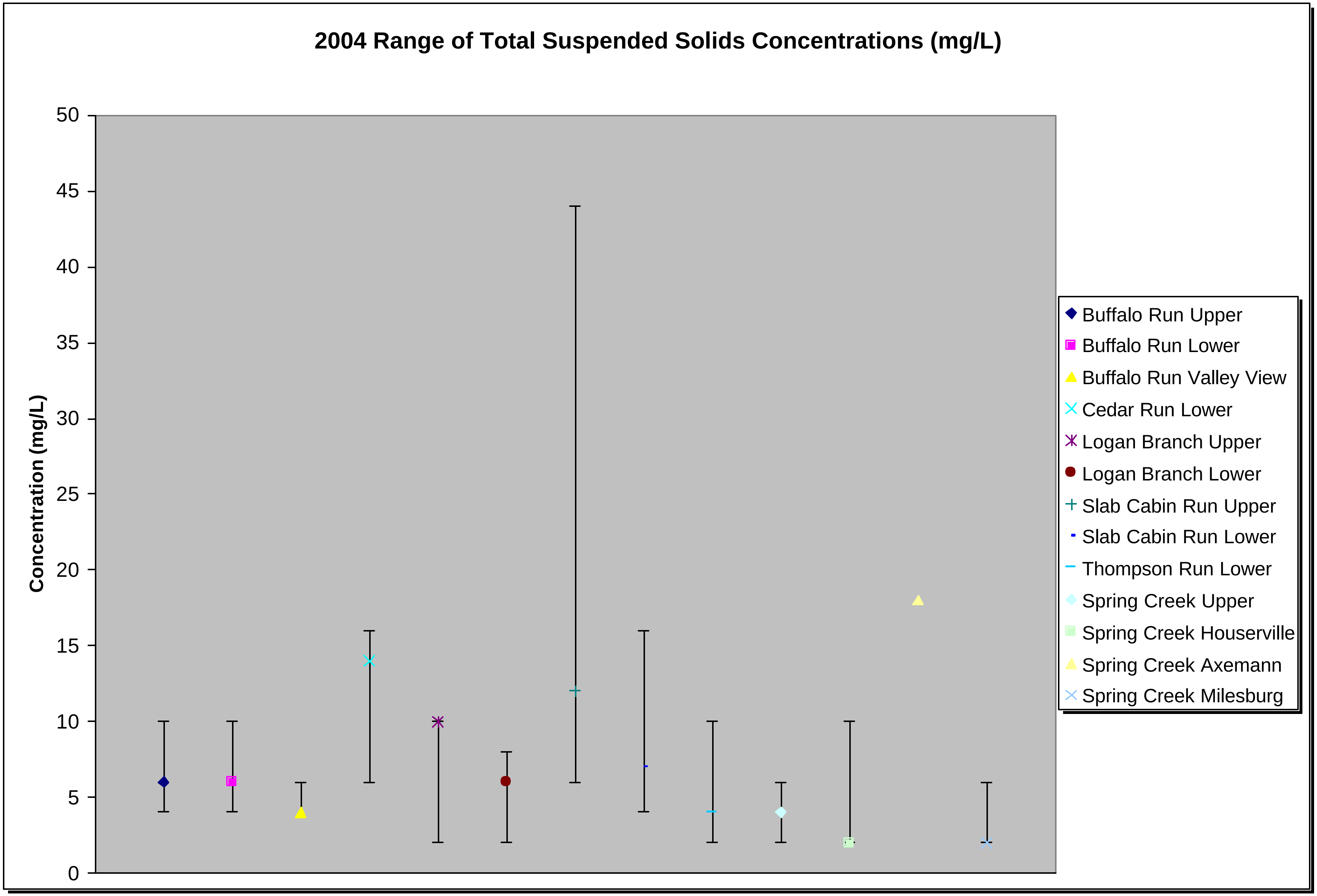


Figure 13. 2004 Range of Total Suspended Solids Concentrations (mg/L).

Table 14. 2004 Range of Total Turbidity Levels (NTU).

Station Name	Feburary	March	June	October	Min	Med	Max
Buffalo Run Upper	2.0	11.0	5.4	1.9	1.9	3.7	11.0
Buffalo Run Lower	1.3	8.9	4.3	1.3	1.3	2.8	8.9
Buffalo Run Valley View		5.4	3.2	1.3	1.3	3.2	5.4
Cedar Run Lower	5.6	4.1	3.2	3.7	3.2	3.9	5.6
Logan Branch Upper	3.2	6.1	3.3	3.6	3.2	3.4	6.1
Logan Branch Lower	1.0	3.6	1.3	1.2	1.0	1.3	3.6
Slab Cabin Run Upper	14.7	4.0	4.6	11.7	4.0	8.2	14.7
Slab Cabin Run Lower	1.1	3.2	1.8	3.1	1.1	2.5	3.2
Thompson Run Lower	2.7	2.4	2.4	1.7	1.7	2.4	2.7
Spring Creek Upper	ND	1.6	1.5	1.4	1.4	1.5	1.6
Spring Creek Houserville	1.5	3.4	2.6	1.8	1.5	2.2	3.4
Spring Creek Axemann	1.4		3.5	1.3	1.3	1.4	3.5
Spring Creek Milesburg	2.0	4.4	2.4	1.5	1.5	2.2	4.4

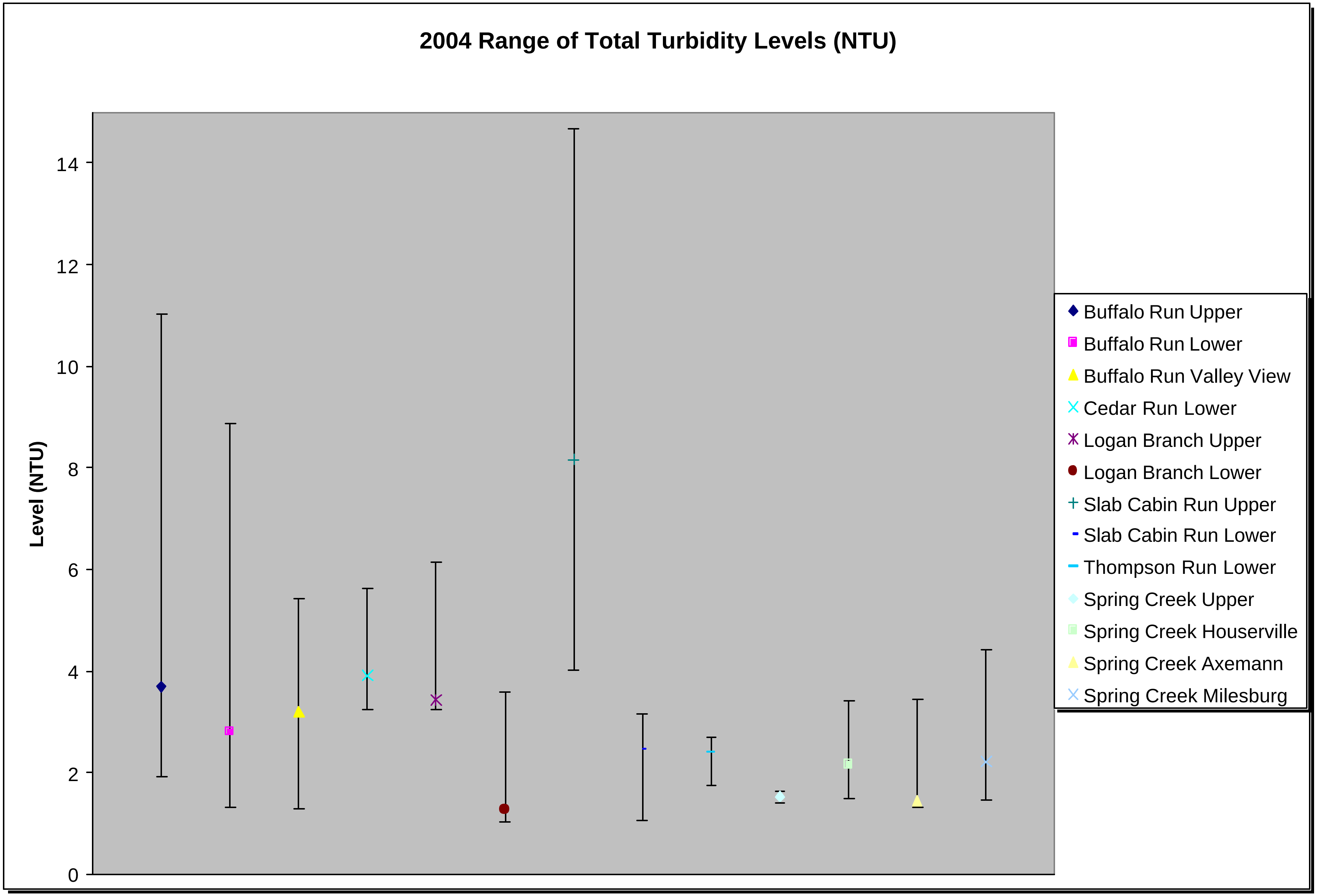


Figure 14. 2004 Range of Total Turbidity Levels (NTU).

Table 15. 2004 Range of Total Zinc Concentrations (ug/L).

Station Name	Feburary	March	June	October	Min	Med	Max
Buffalo Run Upper	ND	12	ND	ND	12		
Buffalo Run Lower	ND	ND	ND	ND			
Buffalo Run Valley View		ND	ND	ND			
Cedar Run Lower	ND	ND	ND	ND			
Logan Branch Upper	ND	ND	ND	12	12		
Logan Branch Lower	29	28	24	25	24	27	29
Slab Cabin Run Upper	ND	ND	114	ND	114		
Slab Cabin Run Lower	ND	233	125	ND	125		233
Thompson Run Lower	34	ND	11	14	11		
Spring Creek Upper	ND	ND	117	17	17		117
Spring Creek Houserville	ND	ND	ND	ND			
Spring Creek Axemann	ND		ND	ND			
Spring Creek Milesburg	15	14	23	19	14	17	23

ND = Not Detected

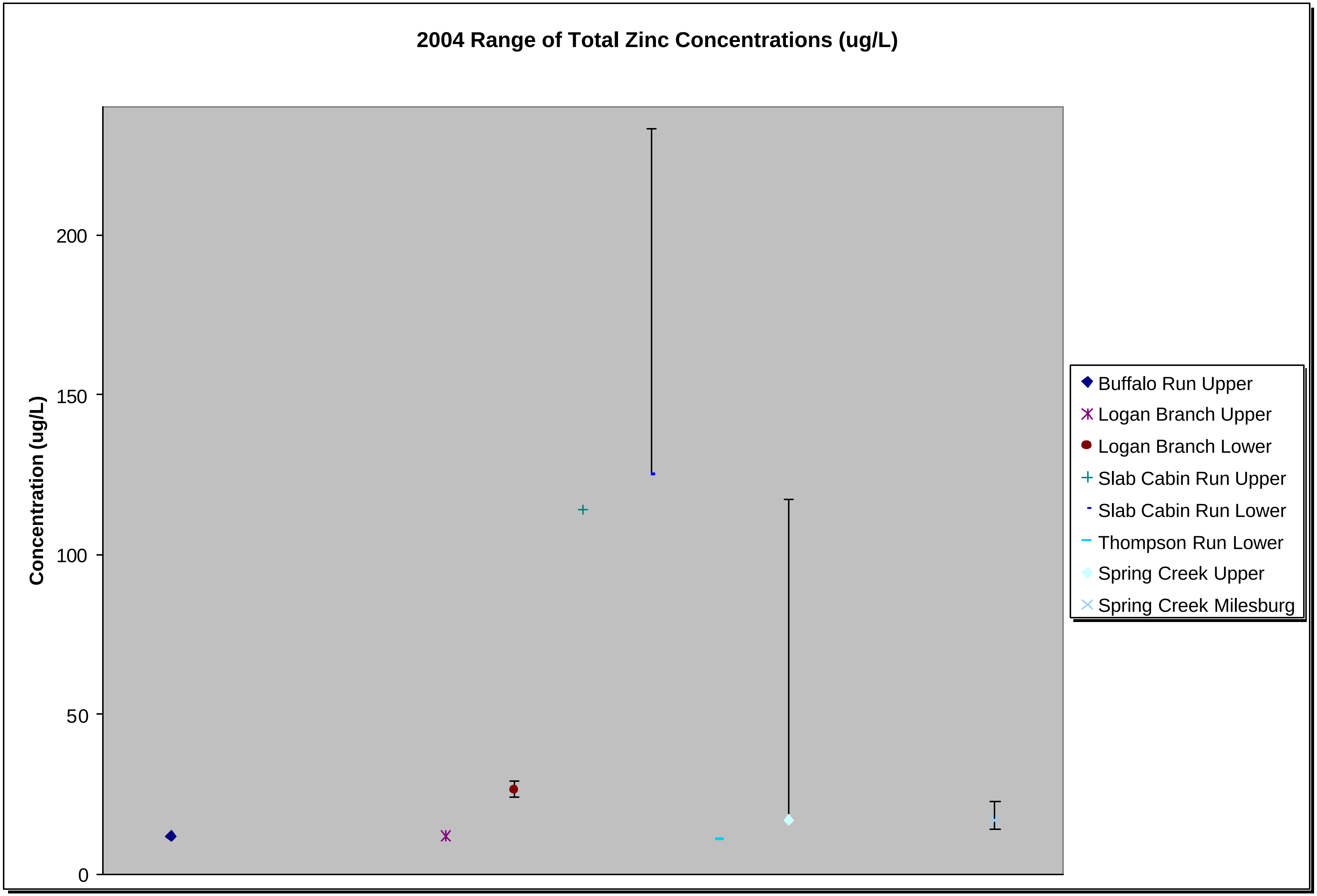


Figure 15. 2004 Range of Total Zinc Concentrations (ug/L).