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Assessment of Water Resources and Watershed Conditions in Kennesaw Mountain National Battlefield Park, Georgia

Natural Resource Report NPS/SECN/NRR—2010/273

ON THE COVER
Heavily silted bottom of John Ward Creek, Kennesaw Mountain National Battlefield Park
Photograph by: Michael Mallin

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Executive Summary

The purpose of this report was to locate and examine existing information pertaining to the water quality in and around KEMO NBP, assess the present and likely future water conditions of the park, and make recommendations to fill existing information gaps. Water quality and quantity, habitat issues, the potential for invasive species, trends in park resource use, and watershed influences and other stressors were addressed insofar as possible through available data and first-hand observations.

KEMO NBP is a small park (2,923 acres) within the metropolitan area of the city of Atlanta, Georgia. The park's natural resources include the 1,808-foot peak of Kennesaw Mountain in the Appalachians, the 1,600-foot peak of Little Kennesaw Mountain, hundreds of acres of mixed hardwood/pine forests mixed with grassy fields, two perennial streams, and a wetland area. This small park represents 27% of the natural greenspace area remaining within the urban Atlanta area, and it is visited by nearly 1.5 million visitors per year. Because of multiple impacts from voracious surrounding urban/suburban development, it is also on the USDI's list of the top 25 most threatened national parks. The park's drinking water is supplied from the Cobb County water system; for waste treatment the park is connected the county sewage system except for the historic Kolb Farm House which is on a septic tank system.

The park's water and cultural resources are seriously threatened by upstream and encroaching urbanization, and by the multitude of the water and air pollutants and other stressors associated with rapid human population growth, land development, and natural resource destruction. The two perennial streams that flow through the park, Noses Creek and John Ward Creek, are the park's only significant surface waters. They have shown signs of degradation for more than 20 years, and for the past decade they have been designated as impaired waters for biota and/or for general recreation on the state's 303(d) lists. The causes of impairment have been identified as urban and other nonpoint source pollution, in particular, excessive sediment loading and high fecal coliform bacterial densities. Yet the aquatic flora and fauna of the park are poorly known, other than species lists, and the water quality data for these streams mostly have been/continue to be collected at a sporadic frequency of only seasonally to once or twice per year. Information is lacking, as well, on wetlands that are within park boundaries. Hydrologic data are not available for the park's surface- or groundwaters, although a USGS gaging station is on Noses Creek about six miles downstream from the park.

The airshed is in violation of federal ozone and fine particulate standards that threaten the health of park staff and frequent visitors, and the high ozone concentrations may be damaging terrestrial plant foliage. The park also lies in an area that is especially prone to atmospheric acid deposition, and acidification, especially acid spates, very likely is adversely affecting its surface waters.

Invasive/ exotic species are adversely affecting the park's land resources. The southern pine beetle infestation, for example, has killed thousands of pine trees and increased fire risk from the resulting deadfall debris, and several terrestrial plant species are also of concern. Increasing abundance of beavers and white-tailed deer also pose potential stresses on the park's natural resources. Information about aquatic invasive/exotic species is lacking.

Other stressors to the park's natural and historic resources include heavy use and erosion of hiking trails, equestrian activities that occur within and upstream from the park, the creation of multiple "social" trails through sensitive park lands because of shared boundaries between the park and suburban developments, and frequent illegal dumping of trash and other refuse. The looming major factor that will exacerbate virtually all of these stresses is the rapid, extreme population growth of the Atlanta metropolitan area.

Recommendations

The following additional recommendations can be addressed within NPS jurisdiction.

Water Quality

- A top priority is to conduct a two-year water quality monitoring program in the park segments of Noses Creek and John Ward Creek with biweekly (preferably, to capture effects of pollution from storm events) or monthly sampling frequency to track water quality conditions in the park. Two stations on each stream, including inflow and outflow from the park, should be sampled for, at a minimum, water temperature, pH, dissolved oxygen, suspended solids, turbidity, nutrients (TN, TP, nitrate, ammonium, BOD_5), fecal coliform densities, and chlorophyll *a* concentrations. This effort should be repeated at five-year intervals. Published benchmarks for acceptable water quality for streams with designated use for Fishing should be used to evaluate the information.

- Data should be collected at least annually on toxic substance concentrations (PCBs, heavy metals, pesticides, pharmaceuticals) in sediments and fish or benthic faunal tissues. Published benchmarks for acceptable water quality for streams with designated use for Fishing should be used to evaluate the information.

- The park should inventory changes in land use/land cover in the watersheds of the two perennial streams upstream from and surrounding the park, including traditional categories but also septic tanks in new subdivisions, new highway projects, new shopping centers, and other potential sources of water pollution. The data should be used to create GIS maps of these sources, which can be upgraded over time to help the NPS track pollution and its impacts in park waters.

Ecosystem and Community Health

- At least once per year during an appropriate seasonal timeframe, the macroinvertebrate communities in John Ward and Noses Creeks should be assessed in at least two stations, following published protocols. Benchmarks should consider published descriptions of healthy macroinvertebrate communities in warmwater streams. The data should be used to track stream ecological condition (rated from Excellent to Poor) over time.

- At least once per year during an appropriate seasonal timeframe, the fish community in the park segments of John Ward and Noses Creeks should be assessed, following published protocols. The fish data should be used to develop an Index of Biotic Integrity and an Index of Well-Being for fish population health over time.

- A sampling program should be developed to establish present conditions and track exotic invasive species affecting terrestrial as well as aquatic/wetland sources in the park. Assessment of exotic invasive species should be repeated at least at three-year intervals to enable detection of species that may rapidly invade.

- The park’s wetland ecosystems should be assessed at five-year intervals for indices of diversity, function, and overall health.

- An updated biological inventory should be completed for herpetofauna.

- A baseline biological inventory is needed for the composition and abundance of benthic microalgal assemblages. The benthic microalgal (periphyton) data should be used to develop an index of biotic integrity for the two perennial streams within the park area.

- The NPS should assess incidence of foliar injury to park plants from ozone pollution, including common wetland bioindicator species such as yellow poplar and American elder. More generally, data are needed to assess the extent to which air pollution is affecting the park, and to forecast how increasing air pollution from the greater Atlanta metropolitan area will affect its waters and other natural resources. Sampling devices should be installed to establish present conditions and track air pollutants such as ozone, $PM_{2.5}$, and mercury.

- Park staff should monitor the two perennial streams for erosion of the stream banks, which is commonly related to upstream urban watershed activities. Park staff should also check for tree damage from beavers, which can lead to increased bank erosion. Construction of beaver dams within the park should not be permitted, since this would increase on-site flooding and threaten cultural resources.

Groundwater

- Groundwater resources of the park should be assessed through partnership with the USGS, including recharge/discharge areas, movement, and chemical quality.

Education Outreach

- KEMO NBP is a critically important greenspace for the greater Atlanta metropolitan area. The park should strengthen its environmental education program to inform visitors about the importance of greenspaces in ecosystem sustainability.

Other Actions

- The NPS should pursue actions to protect remaining undeveloped lands (e.g. increase in greenspace setasides) adjacent to the park to target a goal of protecting and growing buffer areas around the park.

Acknowledgments

This study was funded by the National Park Service, Southeast Coast Network. In addition to the individuals listed as interviewed, I thank Eva DiDonato and Joe DeVivo of the National Park Service and Michael Mallin of the University of North Carolina Wilmington for facilitation and many helpful review comments.

I am very grateful to Lloyd Morris, Chief Ranger at Kennesaw Mountain National Battlefield Park, for his kindness in providing counsel and helpful insights. I also thank William Johnson, the park Historian, for his assistance. Sara McCort at the NPS provided GIS shapefiles for the park boundaries, hydrology, trails, and places. Allison Hughs at Georgia DNR-EPD provided water quality information for Noses and John Ward Creeks within the park that were collected as part of a volunteer monitoring project called "Adopt-A-Stream Georgia". She also provided spatial information for water quality source locations such as land application sites, landfills, and surface mining operations. Liz Kramer, the director of U-GA NARSAL, kindly confirmed that the GA DNR-EPD would be the best source for land use information. Meghan Rothenberger used GIS to produce the land use/land cover in the upper middle Chattahoochee River basin. Diane Whittaker analyzed a land use/land cover dataset from Cobb County and used GIS to produce the map of land use/land cover of Cobb County, contained in this report.

Erin Feichtner and Adam Sukenick of the Cobb County Water System Watershed Monitoring Program provided the County's water quality and macroinvertebrate data for Noses and John Ward Creeks. Patti Lanford of GA DNR provided the latitude/longitude information for two sites sampled for water quality data on one date in June 2003 by GA DNR-WRD. Mr. Michael Pettelle of North Cobb High School provided information from the high school's water quality sampling program. David Webster (University of North Carolina Wilmington) provided his survey and analysis of mammals in the park. Elle Allen, Carol Kinder, and Meghan Rothenberger assisted in data gathering and fact-checking, and Meghan Rothenberger and Diane Whittaker assisted in creating GIS maps.

Abbreviations

ACIP – Avian Conservation Implementation Plan
BMP – best-management practice
cfs – cubic feet per second
CFU – colony-forming units
DO – dissolved oxygen
GA – Georgia
GA DNR – Georgia Department of Natural Resources
EPD – Environmental Protection Division (of GA DNR)
GIS – Geographic Information System
KEMO NBP – Kennesaw Mountain National Battlefield Park
m – meter
mgd – million gallons per day
mg/L – milligrams per liter (= parts per million)
µg/L – micrograms per liter (= parts per billion)
MS4s – municipal separate storm sewer systems (MS4s)
NARSAL – Natural Resources Spatial Analysis Laboratory
N – nitrogen
NCSU CAAE – North Carolina State University's Center for Applied Aquatic Ecology
NPDES - National Pollutant Discharge Elimination System
NPS – National Park Service
NTU – nephelometric turbidity units
P - phosphorus
park – Kennesaw Mountain National Battlefield Park
$PM_{2.5}$ – particulate matter, diameter $\leq$ 2.5 µm (air pollutant)
SECN – Southeast Coast Network of the National Park Service
STORET – Storage and Retrieval Environmental Data System (of the U.S. EPA)
TMDL – total maximum daily load
USACE – United States Army Corps of Engineers
USDI – United States Department of the Interior
U.C. – unacceptable conditions
U.C.C. – unacceptable conditions common
U.S. EPA – United States Environmental Protection Agency
USGS – United States Geological Survey
WRD – Wildlife Resources Division of GA DNR
WUI – Wildland-Urban Interface

Park Description

Background

Location, Size, and Boundaries

Kennesaw Mountain National Battlefield Park (KEMO NBP) is an urban park (latitude 33.95444, longitude -84.59611) located in Cobb County immediately west of Marietta, GA (population 63, 152 as of 2007) (*Figure 1*). As of the early 1990s it was ~20 miles northwest of the city of Atlanta (population ~4 million people), but voracious development and urban sprawl have rapidly shrunk the distance of this park from the Atlanta metropolitan area. The park is an important greenspace in the Atlanta area – in fact, this relatively little park is the second most visited in the National Park System, with nearly 1.5 million visitors per year (Strack and Miller 2008).

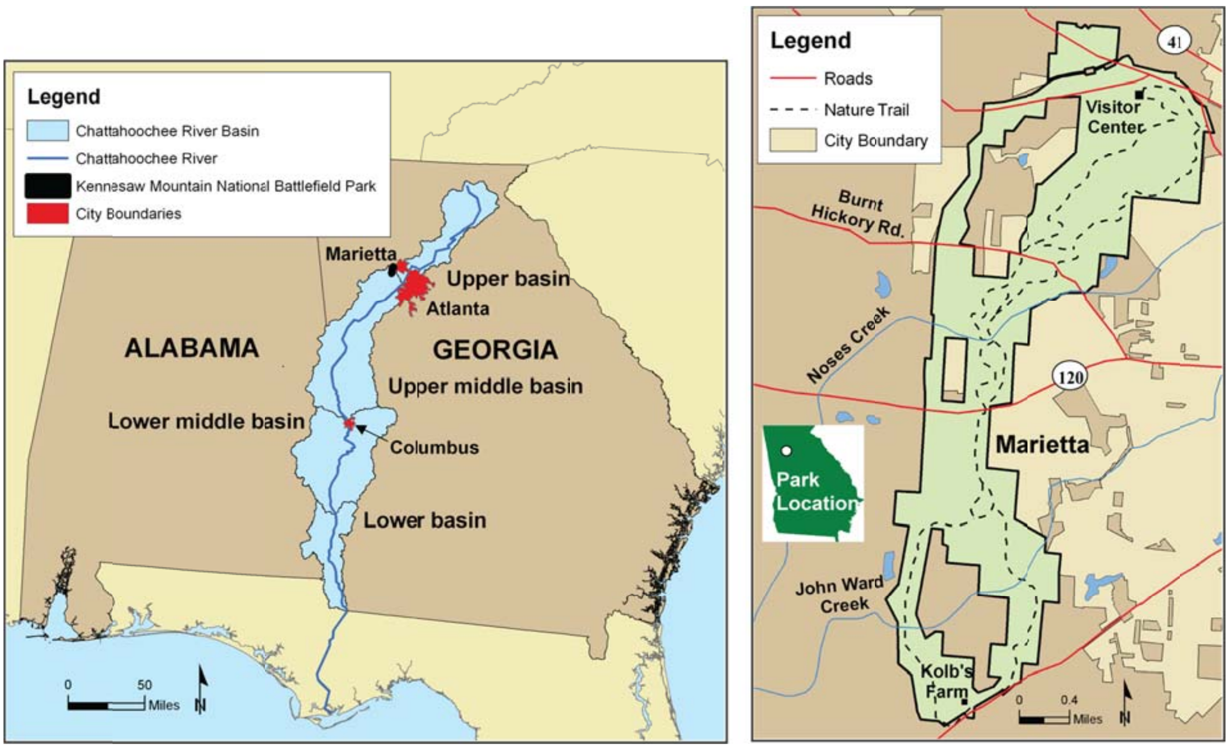


Figure 1. Left: Location of KEMO NBP within the upper Chattahoochee River basin. Right: Map of the park (NPS 2008).

The 2,923-acre park is about 8 miles long and 1 mile wide (NPS 2008a; *Figure 1*). It is under the jurisdiction of the U.S. NPS and was listed on the National Register of Historic Places in October 1966. The NPS currently maintains a Visitor Center, Civil War museum, 17.3 miles of nature and interpretive trails, picnic areas, Kolb's Farm and restored historic log house, the main battlefield at Cheatham Hill (in Civil War times, known as the Dead Angle) where the fiercest fighting between Confederate and Union armies took place, two other battlefield sites, and three monuments representing soldiers from states who fought there. The park Superintendent has an office on-site (http://www.nps.gov/KEMO/). Land use within park boundaries is primarily forested interspersed with open, grassy fields. The natural resources of the park include the

1,808-foot peak of Kennesaw Mountain of the Appalachians, the 1,600-foot peak of Little Kennesaw Mountain, hundreds of acres of mixed hardwood/pine forests mixed with grassy fields, two perennial streams, and a wetland area (DeVivo 2005). The park's location within the Atlanta metropolitan area has contributed to its being the second most visited battlefield in the National Park System, and to its inclusion on the Secretary of the Interior's list of the 25 most threatened parks (DeVivo 2005).

History of the Park

KEMO NBP preserves a Civil War battleground of the Atlanta Campaign, a series of battles fought in the area surrounding Atlanta, GA in the summer of 1864. More specifically, it preserves the battle lines where Confederate forces under General Joseph E. Johnston impeded General William Tecumseh Sherman's Union forces in their march from Chattanooga to Atlanta. These battles led to the eventual fall of Atlanta and hastened the end of the American Civil War. More correct to say that these battles led to the eventual fall of Atlanta which helped insure the re-election of Abraham Lincoln in 1864. Lincoln's re-election meant that the war would be prosecuted until the armed forces of the Confederate States were ultimately defeated and their surrender obtained.

In the Atlanta Campaign (May - Sep 1864), General Johnston and later General John Bell Hood, commanding about 60,000 Confederates took up a series of defensive positions which served to temporarily check the southward extension of General Sherman's men whose numbers exceeded 100,000. One of the defensive positions occupied by General Johnston's Confederate forces was the Kennesaw Mountain line which his forces occupied from June 19 until July 2, 1864. General Sherman tried to flank this position by marching a portion of his force to the southeast where on June 22 they were met by an attack by Confederate forces under Gen. John Bell Hood at Kolb's Farm (*Figure 1*). This attack temporarily checked the Union army's southward extension. Following this engagement General Sherman chose to order a frontal assault on the entrenched Confederates to take place at 8:00 in the morning on June 27. These attacks failed to dislodge the well dug-in Confederates but a flanking movement ordered at the same time was successful in forcing a withdrawal of Johnston's forces five days later. From 19 June through 2 July 1864, more than 5,350 Union and Confederate soldiers, more than two-thirds of them Union soldiers, were killed, wounded, or missing (Kelly 1990). The failure of Sherman's forces to break through the Kennesaw Mountain line was one of the few victories for the Confederates during the Atlanta Campaign. Kennesaw Mountain NBP is the only NPS property that commemorates the Atlanta Campaign. The park helps to preserve some of the historic earthworks, cannon emplacements, and monuments.

Creation of the Park

The process which led to the ultimate creation of Kennesaw Mountain NBP began in 1899 when Lasing J. Dawdy purchased 60 acres which included the site where his unit attacked the Confederates on June 27, 1864. In 1904 this property was transferred to the Dan McCook Brigade Association which led in the fund raising effort which culminated in the construction and dedication of the Illinois Monument on the date of the fiftieth anniversary of the battle – June 27, 1914. Realizing that the Association could not fund the upkeep of the monument, they offered it to the War Department in 1916. Legislation authorizing the acceptance of this gift was passed in 1917 but the actual acceptance was delayed until 1926 because of title issues. A commission was appointed in 1926 to study the feasibility of creating a national memorial military park. This commission recommended the expansion of the Kennesaw Mountain site and for the next ten years a bill was introduced annually calling for its creation. On June 26, 1935 legislation was finally enacted creating Kennesaw Mountain National Battlefield Park. At the time $70,000 was appropriated for land acquisition and $30,000 for development. Prior to the passage of this legislation control of the various National Military Parks was transferred from the War Department to the National Park Service. A prolonged process of land acquisition, involving numerous legal challenges was finally settled in 1945 and on October 24, 1947, the Secretary of the Interior declared Kennesaw Mountain officially established (Capps 1994).

Plate 1. Cheatham Hill in KEMO NBP, with the Illinois monument. Photo by M. Mallin.

Land Use / Land Cover

The upper middle Chattahoochee sub-basin, which includes KEMO NBP at its northernmost end, has an area of 3,049 square miles and includes all lands and surface waters that drain into the Calloosahatchee River between Marietta, GA in the north and Columbus, GA in the south (*Figure 1*). Urban development is concentrated in the upper sub-basin, surrounding the park (*Table 1*).

The NCSU CAAE generated a land use-land cover map for this sub-basin (*Figure 2*) using the following procedure. The sub-basin boundary (8-digit Hydrologic Unit Code) Geographic

Information System (GIS) data layer was provided by the U.S. Geological Survey (USGS), and National Land Cover data for 2001 (most recent dataset available) were downloaded from the USGS Seamless Data Distribution System (**http://seamless.usgs.gov/**). Using the Spatial Analyst extension of ArcGIS9.1, the land use classification system was modified to include eight general categories: urban areas, row crop agriculture, animal agriculture, forests, grasslands, water, wetland, and barren/disturbed. Once the grid was reclassified, the Spatial analyst "tabulate area" function was used to calculate the area of each land class within the sub-basin.

Table 1. Changes in land use / land cover in the upper Chattahoochee watershed during 1991-2005 (from the Georgia Land Use Trends [GLUT] Project, 2008).

Land cover (acres)	1991	1998	2001	2005	Change (1991-2005)
Beaches, dunes, mud	578	598	0	0	– 100%
Open water	44,725	43,370	46,148	46,253	+ 3%
Low-intensity urban	155,394	180,806	235,243	235,986	+ 51%
High-intensity urban	37,638	42,372	54,378	68,702	+ 83%
Clearcut, sparse	20,399	43,509	37,478	42,771	+ 110%
Quarries, strip mines, rocks	1,196	1,645	1,591	1,585	+ 33%
Deciduous forest	417,748	389,353	365,222	356,497	– 15%
Evergreen forest	176,204	159,882	137,691	94,905	– 46%
Mixed forest	25,755	26,526	28,337	45,282	+ 76%
Row crops, pasture	125,066	117,124	98,710	112,977	– 10%
Forested wetland	6,605	6,106	6,450	6,358	– 4%
Non-forested wetland (fresh)	91	116	151	84	– 8%
Overall change: Forest – 20%; Wetlands – 6%					
Overall change: Urbanized/ clearcut + 63%					

Land use/land cover in Cobb County, surrounding the park, was also analyzed. Land use, hydrology, roads and facilities layers were obtained from Cobb County, GA GIS (http://gis.cobbcountyga.gov/). No additional data reclassification was necessary because Cobb County reported land use by zoning codes. Classifications of residential density (very low density, low density, medium density, high density, and rural residential) are important land use categories to track, as they are the primary land use adjacent to the park. Land designated as "Industrial" and "Industrial Compatible" is important to consider also, considering that a large tract of property just north of the park is designated in these two zoning categories.

The analysis indicated that although the sub-basin is predominantly in forested land cover, the area in the vicinity of the park is mostly urbanized (*Table 1, Figure 1*). Zeroing in more closely on Cobb County (*Figure 2*), analysis of land use/land cover as of 2007 shows that the park is completely surrounded by immediately adjacent urban development, either as the City of Marietta (red, adjacent to park), or as residential development (mostly low and medium density) outside city limits.

The watersheds of Noses Creek and John Ward Creek, the two perennial streams in the park, still retain a major proportion as forest/shrubs because of the park (*Table 2*). Overall, the total land use in the Noses Creek watershed is ~16% urban, 58.8% forest/shrub, 23.8% row crops/pasture /other grasses, and ~1.4% wetland. The total land use in the John Ward Creek watershed is ~23.3% urban, 41% forest/shrub, 33.5% row crops/ pasture/ other grasses, and 1.6% wetland. The two watersheds upstream from the park, however, are mostly urbanized.

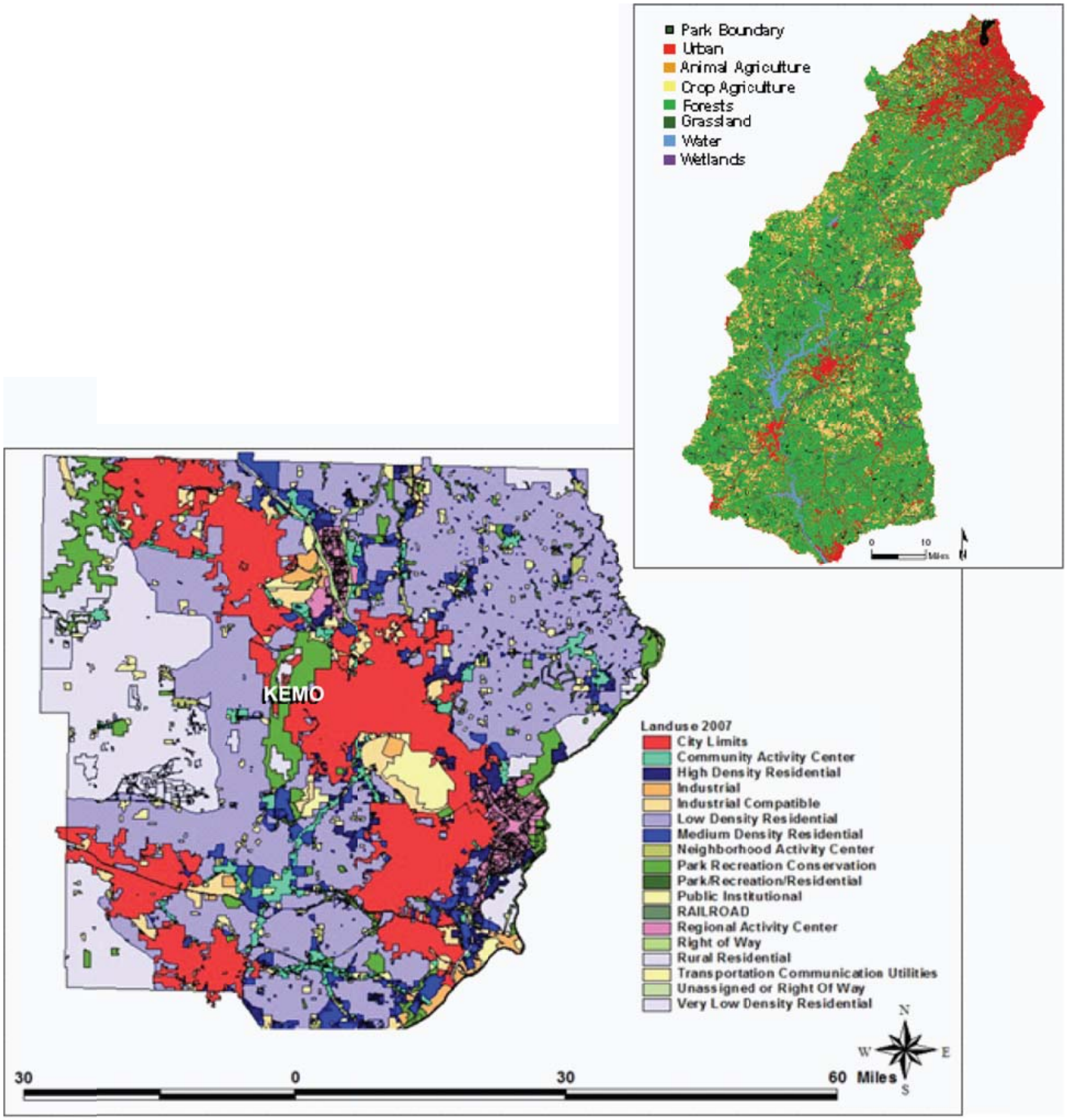


Figure 2. (Upper Right) Land use/land cover as of 2001 already showed KEMO NBP (blackened area, upper center) surrounded by urban development in the Upper Middle Chattahoochee sub-basin (HUC 03130002). Map prepared by the NCSU CAAE. (Lower Left) Land use/land cover in Cobb County as of 2007, showing detailed information for the land surrounding the park (data from Cobb County).

Table 2. Land use in the Noses Creek and John Ward Creek watersheds (GA DNR 2008a, based on 2001 land use-land cover data (Landsat Thematic Mapper images; Georgia National Land Cover Data).

Land cover (acres)	Noses Creek (5.85 sq. mi.)		John Ward Creek (7.13 sq. mi.)	
Open water	27	(0.7%)	27	(0.6%)
Low-intensity residential	432	(11.5%)	862	(18.9%)
High-intensity urban	103	(2.7%)	134	(2.9%)
High-intensity comm/ indust/ transp	47	(1.2%)	68	(1.5%)
Clearcut, sparse	8	(0.2%)	28	(0.6%)
Quarries, strip mines, rocks	10	(0.3%)	---	
Deciduous forest	1,270	(33.9%)	740	(16.2%)
Evergreen forest	909	(24.3%)	1,097	(24.0%)
Mixed forest	19	(0.5%)	31	(0.7%)
Deciduous shrubbed	5	(0.1%)	3	(0.1%)
Row crops, pasture	279	(7.5%)	141	(3.1%)
Other grasses (urban, recreational)	610	(16.3%)	1,385	(30.4%)
Forested wetland	28	(0.8%)	47	(1.0%)
Non-forested wetland (fresh)	---		---	

Hydrologic Information

The Chattahoochee River and its watershed, which includes KEMO NBP, originate in northern Georgia in the Blue Ridge physiographic province. The regional climate is moist and temperate (mean annual temperature 60°F, average annual range 46-69°F). Annual rainfall averages ~51 inches per year, with minimal snowfall (GA DNR 1997, Southeast Regional Climate Center 2007, GA DNR 2008a). Evaporation and transpiration account for approximately 30 inches of rainfall, resulting in about 18 inches annually available for streamflow and percolation to groundwater. A dry season typically occurs from mid-summer to late fall, whereas maximal precipitation and flow occur in March.

Within the park are swamp and bog wetlands, mountain seeps, and two small perennial streams, but no major impoundments or lakes (Zubricki 1993). The park has no groundwater use; its drinking water is supplied by Cobb County from the Chattahoochee River (Chief Ranger L. Morris, pers. comm., November 2006). Park grounds include a water pump lift off Burnt Hickory Road. The USACE previously rerouted Noses Creek (*Figure 1*) as it enters the park as part of freeway and other development (Chief Ranger L. Morris, pers. comm., Nov. 2006). Water distribution and quality in the park also have been affected by beaver dams (DeVivo 2004).

Surface Waters

Noses and John Ward Creeks are the two perennial second-order streams that transect KEMO NBP boundaries (*Figure 1, Plates 2* and *3*), and the only significant surface waters in the park. John Ward Creek becomes a tributary of Noses Creek downstream from the park, but in the park the streams are comparable in size. Their headwaters are in the urban setting of Marietta, GA, and they are tributaries of the upper middle Chattahoochee River. Noses Creek drains significant suburban development before entering the park. After leaving the park, it drains significant urban development before reaching its confluence with the Chattahoochee River. John Ward Creek drains suburban development before entering the park, then leaves the Park to flow through a tract of private land with suburban development surrounded by the park before reentering the park. After leaving the park, it drains urban/suburban development before its confluence with Noses Creek.

Plate 2. Noses Creek in the park. Photos by M. Mallin.

Plate 3. John Ward Creek (left panel) near the Illinois Monument and (right panel) near Cheatham Hill Road in the park. Photos by M. Mallin.

Flow data are lacking for John Ward Creek throughout its length, and for Noses Creek in the vicinity of the park. Since August 1998 the USGS has maintained a stream gaging station (USGS 02336968, hydrologic unit 03130002) in Noses Creek at Powder Springs Road in the city of Powder Springs, GA (drainage area 44.5 square miles, 883 feet above sea level), about 6.4 miles from the park (*Tables 3-5*, *Figures 3* and *4*). Mean annual discharge ranged from 4 to 32 cfs during a prolonged drought in 2007, and the maximum flow recorded was 103.3 cfs during high-precipitation year 2003 (*Table 4*). Average monthly discharge generally has been maximal in winter and minimal in late summer - early fall (*Table 5*).

Table 3. Stations with aquatic data that were mentioned or included in this Report.

Station / Years	Location	Latitude, Longitude	Parameters
John Ward Creek			
NPS_KEMO 0005 1993-1998	Outflow from park	22.9198, -84.6075	Environmental conditions, Water quality [a]
NPS_KEMO 0006 1993-1998	Upstream by park	33.9291, -84.5891	Environmental conditions, Water quality [a]
Cobb County - WR1 1998-present [c]	Highland Avenue, ~3 miles upstream from park	33.9518, -84.5646	Environmental conditions, Water quality [d]
22 Dec 2003, 14 Oct 2005			Macroinvertebrate data
Cobb County - WR2 1998-present [c]	Kirkpatrick Drive, ~2.7 miles upstream from park	33.9229, -84.6076	Environmental conditions, Water quality [d]
Cobb County - WR3 1998-present	Cheatham Hill Road, "island" surrounded by park	33.9207, -84.6014	Environmental conditions, Water quality [d]
Cobb County - WR4 1998-present	John Ward Road, ~0.5 mile down-stream from park	33.9165, -84.6174	Environmental conditions, Water quality [d]
GA DNR - WRD: very near WR4 site (12 June 2003)	John Ward Road, ~0.5 mile down-stream from park	33.9167, -84.6178	Environmental conditions, Water quality [b] (GA DNR 2008a)
Noses Creek			
USGS 02336968 1998 - present (data available through 2007)	Powder Springs Road, ~6.4 miles downstream from park	33.8592, -84.6528	Discharge, gage height
NPS_KEMO 0007 (1993-1998)	Outflow from park	33.9544, -84.6050	Environmental conditions, Water quality [a]

Table 3. (Continued).

Station / Years	Location	Latitude, Longitude	Parameters
Noses Creek (cont'd.)			
NPS KEMO 0009 (1993-1998)	Upstream at park boundary	33.9592, -84.5849	Environmental conditions, Water quality [a]
Cobb County - NS1 (1999-2008)	Mt. Calvary Road, 0.3 mile downstream from park	33.9532, -84.6121	Environmental conditions, Water quality [d]
GA DNR - WRD very near NS1 site (12 June 2003)	Mt. Calvary Road, ~0.3 mile downstream from park	33.9534, -84.6117	Environmental conditions, water quality [b] (GA DNR 2008a)
Cobb County - NS2 20 Feb 2004, 24 Oct 2005	Irwin Road, ~3.5 miles downstream from park	33.92207, -84.6260	Macroinvertebrate data

[a] Environmental conditions ≡ water temperature, specific conductance, pH, and/or discharge. Water quality ≡ turbidity, DO, $NO_3^-N+NO_2^-N$, SRP, and fecal coliform bacteria.

[b] Environmental conditions ≡ water temperature, specific conductance, pH, and/or discharge. Water quality ≡ turbidity, DO, total hardness, and alkalinity (GA DNR 2008a).

[c] Cobb County dataset extends from 1981 to the present for John Ward Creek (4 sites, usually sampled during dry periods), and from 1987 to the present for Noses Creek; this Report considers data from the past decade, 1999 - 2008.

[d] Environmental conditions ≡ water temperature, specific conductance, pH, and/or discharge. Water quality ≡ turbidity, DO, $NO_3^-N+NO_2^-N$, TKN, TP, BOD_5, COD, chlorides, TSS, fecal coliform bacteria, and metals (alkaline earth metals barium, calcium, magnesium, potassium and sodium; trace metal manganese; and potentially toxic metals aluminum, total cadmium, total copper, total iron, total lead, and total zinc).

Table 4. Mean monthly discharge at the USGS gaging station in Powder Springs on Noses Creek, downstream from the Park, during the period of record from August 1998 - 2007 (available thus far: http://nwis.waterdata.usgs.gov/nwis/qwdata; note that na ≡ not available).

00060, Discharge, cubic feet per second (cfs)
Monthly mean in cfs (Calculation Period: 1 August 1998 to 30 September 2007)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	---	---	---	---	---	---	---	23.6	12.3	9.08	21.0	27.7
1999	62.0	56.1	43.3	24.1	24.0	52.0	66.6	7.65	3.49	12.7	21.8	19.7
2000	44.6	45.5	60.1	63.4	13.6	6.42	2.89	24.2	77.8	10.2	69.5	39.3
2001	82.2	87.8	168.6	53.6	27.5	43.9	36.3	15.0	13.3	10.5	10.0	28.3
2002	82.8	39.1	82.1	32.4	56.7	11.1	35.3	4.15	77.1	64.2	143.6	146.6
2003	52.0	81.5	125.6	87.5	204.7	109.1	143.6	45.8	31.3	27.1	79.7	53.4
2004	61.5	103.9	43.1	55.4	36.5	51.0	32.9	25.0	110.2	31.6	128.0	98.5
2005	54.2	118.5	133.2	100.7	38.8	44.6	313.7	79.4	17.7	17.3	26.4	48.5
2006	114.3	131.0	80.8	59.3	33.8	15.4	8.10	31.1	23.2	21.2	59.6	29.2
2007	75.8	39.4	41.4	34.4	16.1	9.12	50.5	6.00	5.65	na	na	na
Mean	70	78	86	57	50	38	77	26	37	23	62	55

Table 5. Mean annual discharge at the USGS gaging station in Powder Springs, downstream from the Park, during the period of record from 1999 – 2007. More limited data, covering three years of record, are also shown for gage height.

Water Year	00065, Gage height (feet)	00060, Discharge (cubic feet per second)
1999	1.668	33.0
2000	1.578	32.6
2001	---	53.7
2002	---	39.2
2003	---	103.3
2004	---	56.2
2005	---	96.7
2006	1.740	48.6
2007	---	32.4

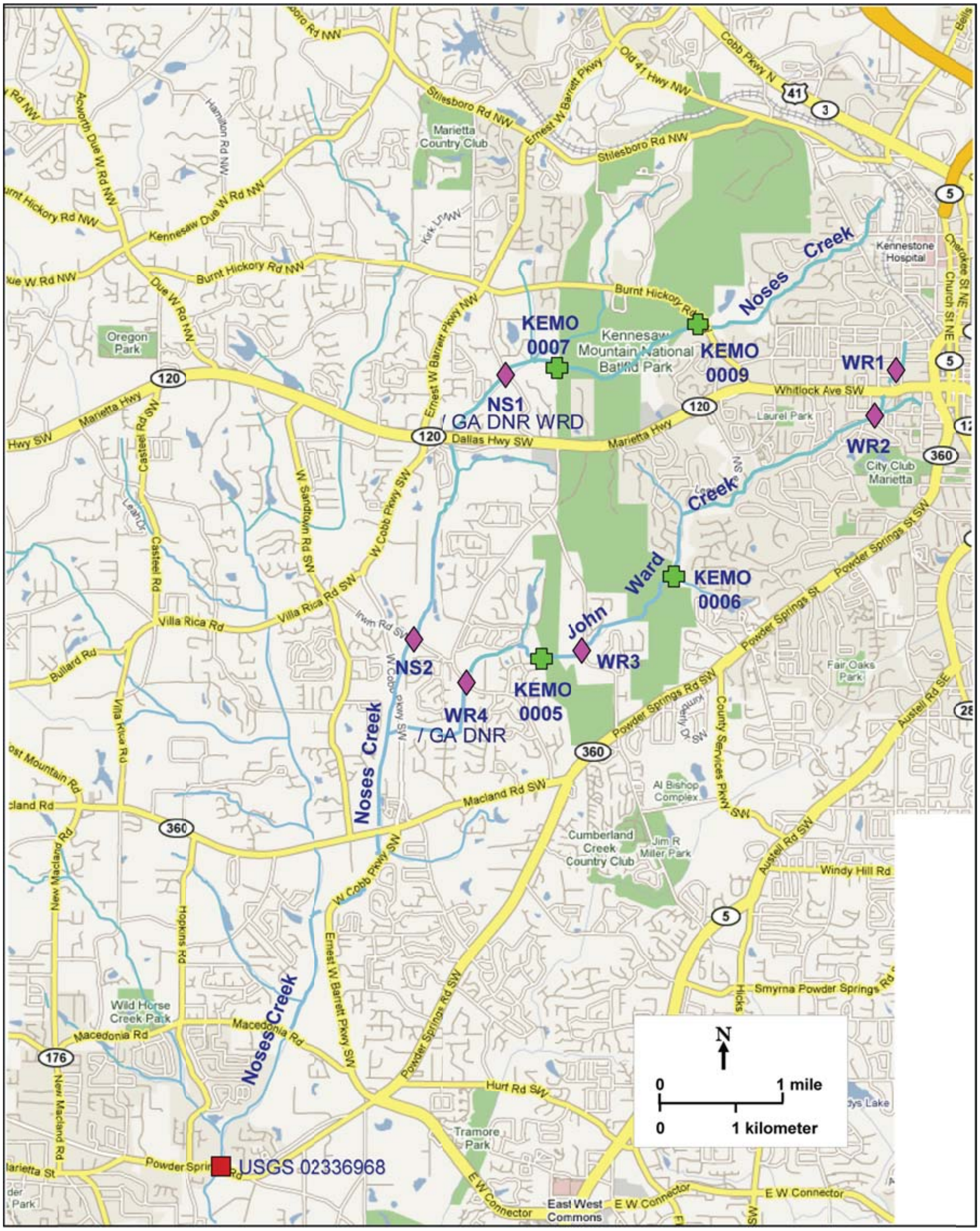


Figure 3. Map of the sampling stations with aquatic data that were mentioned or included in this Report (see *Table 3* for further information). Crosses ≡ NPS water quality sites (1993-1998); diamonds ≡ Cobb County water quality sites (WR1-4 and NS1, with more recent data available from 1999 - present) or a site sampled for macroinvertebrates (NS2, 1 date in 2004 and 2005); and the square ≡ the only USGS gaging site on either of the two perennial streams that flow through the park (1998 - present).

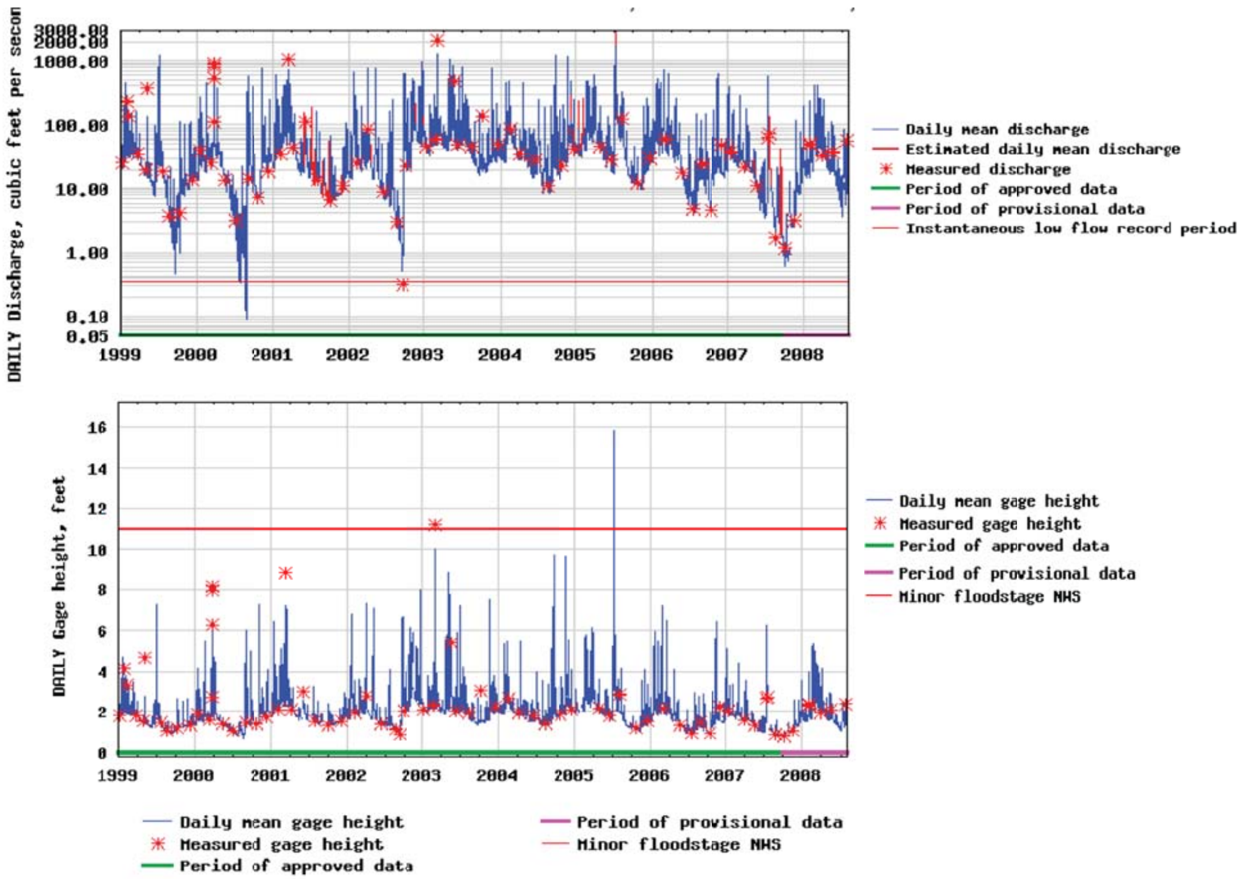


Figure 4. Daily discharge (upper panel) and daily gage height (lower panel) at the USGS stream flow gaging station at Powder Springs, GA, 6.4 miles downstream from KEMO during 1999 - 2007 (website from *Table 4*).

Wetlands

The largest wetland area occurs just north of Noses Creek. Information is not available about this area, the floodplain of John Ward Creek (*Plate 4*), or other swamp and bog wetlands in the park (Chief Ranger L. Morris, pers. comm., Nov. 2006).

Groundwater Resources

The area surrounding KEMO NBP is underlain by crystalline-rock aquifers (metamorphic and igneous rocks) with little to no porosity (Chapman and Peck 1997). Since 99% of the water demand in the Chattahoochee River basin is supplied by surface water withdrawals, especially in the metropolitan Atlanta area southeast of the park (GA DNR 1997), groundwater resources are considered to be under-utilized in this area and have been targeted as a potential supplemental resource during peak demand periods, under drought conditions, or as water demand increases in the metropolitan Atlanta area (Chapman and Peck 1997, Georgia Department of Audits and Accounts 2005).

Plate 4. View of the floodplain of John Ward Creek within the park. Photo by J. Burkholder.

Biological Resources

Surrounding, encroaching, rapidly expanding urban/suburban development is a major, enveloping threat to all of the biological resources at the park. The park's natural resources are effectively fragmented by the configuration of the park lands versus privately owned, developed lands (*Figure 1*). In addition, the two perennial streams in the park, Noses Creek and John Ward Creek, both have upstream portions outside the park boundaries. Thus, the park cannot protect the aquatic biota or water quality of these streams from inflowing pollution and other problems. The park is further hampered from efforts to protect these resources because little is known about them except for species lists. This lack of information seems unfortunate considering that both perennial streams are on the state's list of impaired waters that are not meeting their designated uses (GA DNR 2008b; see below).

Microalgae

There have been no published studies of the suspended or benthic microalgal assemblages in upstream reaches Noses or John Ward Creeks near the park.

Wetland and Aquatic Macrophytes

A total of 264 wetland vascular plant species, including only 1 predominantly aquatic species (the angiosperm watercress, *Nasturtium officinale*) and 8 wetland ferns, occur in the park (NPS 2008b; *Tables 6* and *7*). The wetland species comprise ~32% of the total vascular plant species in the park (considering ferns and higher vascular plants). A total of 20 higher vascular wetland plants and 1 wetland fern are non-native species (*Tables 6* and *7*).

Terrestrial Vegetation

A total of 557 species of terrestrial vascular plants, including 16 species of ferns, occur within the park (NPS 2008b). The terrestrial flora is dominated by mixed hardwood and pine forest, and the park also has several grassy fields (DeVivo 2004, NPS 2008b). The mountain is forested with second-growth hardwoods. Since 1993, infestation by the southern pine beetle (*Dentroctnus frontalis*) has killed thousands of pine trees throughout the park, and the resulting increase in dry timber on the forest floor may increase fire risk. If recovery can occur, hardwood forest would be expected to become dominant through natural succession. Of the 557 species of terrestrial plants, 143 species or 26% of the present-day flora are non-native.

Aquatic Macroinvertebrates

Although macroinvertebrate species information is lacking for park waters, Cobb County collected information on aquatic macroinvertebrates on one date each during winter 2003/4 and fall 2005 at a station in John Ward Creek upstream from the park, and in Noses Creek downstream from the park (Table 8). Highest species numbers were reported for midges, and a mix of other species were present including some larval aquatic beetles, mosquitoes, damselflies, caddisflies, and other dipterans. In John Ward Creek, the midge Polypedilum was the most abundant taxon in both seasons; black flies were also abundant in winter, and the midge Amblabesmyia was second highest in abundance during fall. Species numbers and abundance were low in Noses Creek during winter, when the midge Rheotanytarsus was most abundant. Both species numbers and abundance were notably higher in the fall season, especially larval mayflies, caddisflies, and crane flies. For both streams on both dates sampled, of possible rankings of Excellent, Good, Fair, and Poor, the data indicated Fair macroinvertebrate community health was fair, and stream health received a “B” rating.

Table 6. Wetland and aquatic plant flora, excluding ferns (based upon Godfrey and Wooten 1981a,b), that occur in KEMO NBP (NPS 2008b). Asterisks (*) ≡ non-native species.

Adam and Eve puttyroot (*Aplectrum hyemale*)
Alder (*Alnus serrulata*)
Allegheny monkey flower (*Mimulus ringens*)
American burnweed (*Erechtites hieraciifolia*)
American bur-reed (*Sparganium americanum*)
American elder (*Sambucus canadensis*)
American elm (*Ulmus americana*)
American germander (*Teucrium canadense*)
American holly (*Ilex opaca*)
American hornbeam (*Carpinus caroliniana*)
American pokeweed (*Phytolacca americana*)
American sycamore (*Platanus occidentalis*)
American wisteria (*Wisteria frutescens*)
American witchhazel (*Hamamelis virginiana*)
Aneilima (Asian spiderwort) (*Murdannia keisak*)
Angelicatree (*Aralia spinosa*)
Annual blue grass (walkgrass) (*Poa annua*)
Annual blue-eyed grass (*Sisyrinchium rosulatum*)
Arrowfeather threeawn (*Aristida purpurascens*)
Arrow-leaf tearthumb (*Polygonum sagittatum*)
Ashleaf maple (box elder) (*Acer negundo*)
Asiatic (common) dayflower (*Commelina communis*)
Azure bluet (*Houstonia caerulea*)
Barnyard grass (watergrass) (*Echinochloa crus-galli*)*
Beaked panicgrass (*Panicum anceps*)
Bedstraw (*Galium aparine*)
Bigroot morning glory (*Ipomoea pandurata*)
Bitter dock (*Rumex obtusifolius*)*
Black gum (sour gum) (*Nyssa sylvatica*)
Black-seed plantain (*Plantago rugelii*)
Black tupelo (*Nyssa sylvatica*)
Black willow (*Salix nigra*)
Blister flower (bulbous buttercup) (*Ranunculus bulbosus*)*
Blisterwort (*Ranunculus recurvatus*)
Blue eyegrass (*Sisyrinchium angustifolium*)
Blue huckleberry (*Gaylussacia frondosa*)
Blue (hirsute) sedge (*Carex complanata*)
Blunt broom sedge (*Carex tribuloides*)
Blunt spikerush (*Eleocharis obtusa*)
Bitternut hickory (*Carya cordiformis*)
Bog hemp (*Boehmeria cylindrica*)
Boneset (thoroughwort) (*Eupatorium perfoliatum*)
Bristled (tufted) knotweed (*Polygonum caespitosum*)
Bristly buttercup (*Ranunculus hispidus*)
Broadleaf arrowhead (wapato) (*Sagittaria latifolia*)
Broadleaf cattail (*Typha latifolia*)
Broadleaf plantain (*Plantago major*)
Broadleaf uniola (*Chasmanthium latifolium*)
Broomsedge (*Andropogon virginicus, A. virginicus* var. *virginicus*)
Brown widelip orchid (*Liparis lilifolia*)
Bulb bittercress (*Cardamine bulbosa*)
Bullbrier (*Smilax rotundifolia*)
Bulrush (woolgrass) (*Scirpus cyperinus*)
Bur marigold (devil's beggartick) (*Bidens frondos*
Bush-clover dodder (*Cuscuta pentagona*)
Bushy seedbox (*Ludwigia alternifolia*)
Buttercup (*Ranunculus carolinianus*)
Buttonbush (*Cephalanthus occidentalis*)
Camphor pluchea (*Pluchea camphorata*)
Canada clearweed (*Pilea pumila*)
Canada goldenrod (*Solidago canadensis)*
Carolina bristlemallow (*Modiola caroliniana*)
Carolina elephantsfoot (*Elephantopus carolinianu*
Cardinal flower (*Lobelia cardinalis*)
Carolina jessamine (*Gelsemium sempervirens*)
Carolina leaf-flower (*Phyllanthus caroliniensis*)
Carolina lily (*Lilium michauxii*)
Carolina ponysfoot (*Dichondra carolinensis*)
Carolina sedge (*Carex caroliniana*)
Carpetweed (green carpetweed) (*Mollugo verticil*
Cat greenbrier (*Smilax glauca*)
Celeryleaf buttercup (*Ranunculus sceleratus*)
Chamber bitter (*Phyllanthus urinaria*)*
Cherokee sedge (*Carex cherokeensis*)
Chervil (hairy-fruit chervil) (*Chaerophyllum taintu*
Chestnut oak (*Quercus prinus*)
Chinese (Japanese) honeysuckle (*Lonicera japo*
Climbing false buckwheat (*Polygonum scandens* var. *cristatum*)
Climbing hempvine (*Mikania scandens*)
Clustered mountainmint (*Pycnanthemum muticu*
Coastal plain willow (*Salix caroliniana*)
Common Chinese privet (*Ligustrum sinense*)*
Common cottonwood (*Populus deltoides*)
Common goldenrod (*Solidago altissima*)
Common goldstar (*Hypoxis hirsuta*)
Common honeylocust (*Gleditsia triacanthos*)
Common morning glory (*Ipomoea purpurea*)*
Common persimmon (*Diospyros virginiana*)
Common (lamp) rush (*Juncus effusus*)
Common reed (*Phragmites australis*)
Common sweetleaf (*Symplocos tinctoria*)
Common trumpetcreeper (*Campsis radicans*)
Common water hemlock (*Cicuta maculata*)
Common winterberry (*Ilex verticillata*)
Cross-vine (trumpet-flower) (*Bignonia capreolata* or *Anisostichus capreolata, A. crucifera*)
Curley dock (*Rumex crispus*)*
Curltop ladysthumb (*Polygonum lapathifolium*)
Cutleaf coneflower (*Rudbeckia laciniata*)

Table 6. (Continued).

Dallas (water) grass (*Paspalum dilatatum*)*
Dark-green (green) bulrush (*Scirpus atrovirens*)
Deadly (poison) hemlock (*Conium maculatum*)*
Dense blazing star (*Liatris spicata*)
Densetuft hairsedge (*Bulbostylis capillaris*)
Desert false indigo (*Amorpha fruticosa*)
Devil’s darning needles (*Clematis virginiana*)
Ditch stonecrop (*Penthorum sedoides*)
Dogfennel (*Eupatorium capillifolium*)
Dogfennel eupatorium (yankeeweed) (*Eupatorium compositifolium*)
Dogtooth violet (*Erythronium americanum*)
Dotted smartweed (*Polygonum punctatum*)
Dwarf huckleberry (*Gaylussacia dumosa*)
Dwarf St. Johnswort (*Hypericum mutilum*)
Dye bedstraw (stiff marsh bedstraw) *Galium tinctorium*)
Early meadow-rue (*Thalictrum dioicum*)
Early saxifrage (*Saxifraga virginiensis*)
Early woodbuttercup (*Ranunculus abortivus*)
Eastern bluestar (*Amsonia tabernaemontana*)
Eastern poison ivy (*Toxicodendron radicans*)
Eastern smooth beardtongue (*Penstemon laevigatus*)
Eastern sweetshrub (*Calycanthus floridus*)
Eight-flower six-weeks grass (*Vulpia octoflora*)
Eyebane (nodding spurge) (*Chamaesyce nutan*s)
Fairywand (*Chamaelirium luteum*)
Fall panic (*Panicum dichotomiflorum*)
Fescue sedge (*Carex festucacea*)
Field paspalum (*Paspalum laeve*)*
Flypoison (*Amianthium muscitotoxicum*)
Fowl manna grass (*Glyceria striata*)
Fox grape (*Vitis labrusc*a)
Frank’s sedge (*Carex frankii*)
Fringed loosestrife (*Lysimachia ciliata*)
Fringed yelloweyed grass (*Xyris fimbriata*)
Fringetree (*Chionanthus virginicus*)
Georgia bulrush (*Scirpus georgianus*)
Giant cane (*Arundinaria gigantea*)
Granite stonecrop (*Sedum pusillum*)
Graybark grape (*Vitis cinerea* var. *baileyana*)
Great blue lobelia (*Lobelia siphilitica*)
Greater straw sedge (*Carex normalis*)
Green ash (*Fraxinus pennsylvanica*)
Green rein (small wood) orchid (*Platanthera clavellata,* or *Habenaria clavellata*)
Hairawn muhly (*Muhlenbergia capillaris*)
Hairy bittercress (*Cardamine hirsuta*)
Hairy jointgrass (*Arthraxon hispidus*)*
Hairy woodrush (*Luzula acuminata*)
Heart-leaf alexanders (*Zizia aptera*)
Heartwing dock (*Rumex hastatulus*)
Helmet flower (*Scutellaria integrifolia*)
Hop sedge (*Carex lupulina*)
Hyssop spurge (*Chamaesyce hyssopifolia*)
Indian cucumber (*Medeola virginiana*)
Ivyleaf morning glory (*Ipomoea hederacea*)*
Jack-in-the-pulpit (*Arisaema triphyllum*)
Japanese mazus (*Mazus pumilus*)*
Japanese stiltgrass (Nepalese browntop)* (*Microstegium vimineum*)
Jewelweed (*Impatiens capensis*)
Johnson grass (*Sorghum halepense*)*
Jungle rice (*Echinochloa colonum*)*
Lanceleaf loosestrife (*Lysimachia lanceolata*)
Large (spotted) spurge (*Chamaesyce maculata*)
Late eupatorium (*Eupatorium serotinum*)
Laurel greenbrier (*Smilax laurifolia*)
Little bluestem (*Schizachyrium scoparium*, or *Andropogon scoparius*)
Little quakinggrass (*Briza minor*)
Longleaf spikegrass (*Chasmanthium sessiliflorun*
Low spikesedge (*Kyllinga pumila*)
Maryland meadowbeauty (*Rhexia mariana*)
Mountain azalea (*Rhododendron canescens*)
Mulberry (white mulberry) (*Morus alba*)*
Muscadine grape (*Vitis rotundifolia*)
Narrowleaf mountainmint (*Pycnanthemum tenuif*
Needle-tip blue-eyed grass (*Sisyrinchium mucror*
New York ironweed (*Veronia noveboracensis*)
Nimblewill (*Muhlenbergia schreberi*)
Nodding ladies’-tresses (*Spiranthes cernua*)
Northern spicebush (*Lindera benzoin*)
Oneflower stitchwort (*Minuartia uniflora*)
Overcup oak (*Quercus lyrata*)
Owlfruit (sawbeak) sedge (*Carex stipata*)
Pale flatsedge (*Cyperus flavescens*)
Pale-spike lobelia (*Lobelia spicata*)
Parsley hawthorn (*Crataegus marshallii*)
Partridgeberry (*Mitchella repens*)
Pennsylvania knotweed (*Polygonum pensylvanic*
Petticoat-climber (purple lovegrass) (*Eragrostis spectabilis*)
Philadelphia daisy (*Erigeron philadelphicus*)
Piedmont false pimpernel (*Lindernia monticola*)
Pignut hickory (*Carya glabra*)
Pitted (white) morning glory (*Ipomoea lacunosa*)
Poor-joe (rough buttonweed) (*Diodia teres*)
Post oak (*Quercus stellata*)
Prairie wedgegrass (*Sphenopholis obtusata*)
Prickly Florida blackberry (*Rubus argutus*)
Primrose violet (*Viola primulifolia*)
Rattail smutgrass (*Sporobolus indicus* or *Sporobolus poiretii*)

Table 6. (Continued).

Red maple (*Acer rubrum*)	Swamp smartweed (*Polygonum hydropiperoide*
Red mulberry (*Morus rubra*)	Sweetgum (*Liquidambar styraciflua*)
Rice button aster (*Aster dumosus*)	Switchgrass (*Panicum virgatum*)
Rice cut grass (*Leersia oryzoides*)	Three-lobe beggarticks (*Bidens tripartita*)
Ridged yellow flax (rigid flax) (*Linum striatu*m)	Thymeleaf bluet (*Houstonia serpyllifolia*)
Rough flatsedge (*Cyperus retrofractus*)	Tiny bluet (*Houstonia pusilla*)
St. Andrew's cross (*Hypericum hypericoides*)	Trumpet honeysuckle (*Lonicera sempervirens*)
Sampson's snakeroot (*Psoralea psoralioides*, or *Orbexilum pedunculatum*, *O. pedunculatum* var. *psoralioides*)	Tulip tree (tulip poplar) (*Liriodendron tulipifera*)
Saw greenbrier (*Smilax bona-nox*)	Vasey grass (*Paspalum urvillei*)*
Scarlet creeper (*Ipomoea hederifolia*)	Virginia bunchflower (*Melanthium virginicum*)
Shagbark hickory (*Carya ovata*)	Virginia buttonweed (*Diodia virginiana*)
Shallow sedge (*Carex lurida*)	Virginia dayflower (*Commelina virginica*)
Sheep (common sheep, red) sorrel (*Rumex acetosella*)*	Virginia dwarfdandelion (*Krigia virginica*)
Silky dogwood (*Cornus amomum*)	Virginia sweetspire (*Itea virginica*)
Silver maple (*Acer saccharinum*)	Virginia threeseed mercury (*Acalypha rhomboid*
Slender woodoats (*Chasmanthium laxum*)	Virginia wild rye (*Elymus virginicus*)
Smallhead beaksedge (*Rhynchospora microcephala*)	Watercress (*Nasturtium officinale*, or *Rorippa nasturtium-aquaticum*)
Southern dewberry (*Rubus trivialis*)	Water oak (*Quercus nigra*)
Southern lobelia (*Lobelia amoena* var. glandulifera)	Weedy dwarf-dandelion (*Krigia cespitosa*)
Southern magnolia (*Magnolia grandiflora*)	White avens (*Geum canadense*)
Southern red oak (*Quercus falcata*)	White verbena (Verbena urticifolia)
Spotted joy-pye-weed (*Eupatorium maculatum*)	Whiteleaf mountainmint (*Pycnanthemum albesc*
Stiff cowbane (*Oxypolis rigidior*)	Whorled loosestrife (*Lysimachia quadrifolia*)
Stout wood reed-grass (*Cinna arundinacea*)	Willow oak (*Quercus phellos*)
Strawcolored flatsedge (*Cyperus strigosus*)	Winged elm (*Ulmus alata*)
Sugar berry (sugar hackberry) (*Celtis leavigata*)	Wingleaf primrose-willow (*Ludwigia decurrens*)
Summer grape (*Vitis aestivalis*)	Winter bentgrass (*Agrostis hyemalis* or *A. hiema*
Swamp chestnut oak (*Quercus michauxii*)	Woodvamp (*Decumaria barbara*)
	Yellow sunnybell (*Schoenolirion croceum*)
	Yellowroot (*Xanthorhiza simplicissima*)
	Yellow thistle (*Cirsium horridulum*)

Table 7. Wetland fern species that occur in the park (NPS 2006a). Asterisks (*) ≡ non-native species.

Species	**Habitat**
Asplenium ladyfern (*Athyrium filix-femina* spp. *asplenioides*)	shaded woods, swamps, stream banks, acid bogs
Broad beechfern (*Thelypteris hexagonoptera*, or *Phegopteris hexagonoptera*)	moist woodlands
Chainfern (*Woodwardia areolata*)	acidic bogs, wet woods
Maidenfern (maidenhair) (*Adiantum pedatum*)	stream banks, shady moist woods
New York fern (*Thelypteris noveboracensis*)	moist, humus-rich, deciduous woods
Royal fern (*Osmunda regalis*)	swampy areas, fens, damp woodlands
Sensitive fern (*Onoclea sensibilis*)	open swamps, marshes, low woods
Swordfern (*Macrothelypteris torresiana*)*	shorelines of lakes

Table 8. Macroinvertebrate data for John Ward Creek (station WR1 upstream from the park – 1 date each in 2003 and 2005)) and Noses Creek (station NS2 at Irwin Road, downstream from the park – 1 date each in 2004 and 2005), collected by Cobb County personnel using standard techniques (count from collections along a 100-meter segment of stream length; GA DNR 2007a).

Family	Identification	Adjusted Count
John Ward Creek WR1 – 22 Dec 2003		
Family Calopterygidae	Leaches (*Calopteryx*)	6
Family Culicidae	Mosquitos (*Anopheles*)	1
Family Chironomidae	Midges (*Chironomus*)	1
	Midges (*Cricotopus*)	1
	Midges (*Paratendipes*)	1
	Midges (*Phaenopsectra punctipes* group)	4
	Midges (*Polypedilum*)	57
	Midge (*Potthastia longimana*)	2
	Midge (*Rheocricotopus robacki*)	1
	Midges (*Rheotanytarsus*)	18
	Midges (*Thienemanniella*)	3
	Midges (*Thienemannimyia* group)	6
	Midges (*Tvetenia* group)	3
Family Dryopidae	Long-toe water beetles (*Helichus*)	1
Family Elmidae	Riffle beetles (*Stenelmis*)	1
Family Empididae	Aquatic dance fly (*Hemerodromia*)	1
Family Hydropsychidae	Caddisflies (*Hydropsyche*)	42
	Sedges – little spotted sedge (*Cheumatopsyche*)	18
Family Philopotamidae	Sedges – little black sedge (*Chimarra*)	2
Family Simuliidae	Black flies (*Simulium*)	33
Family Tipulidae	Crane flies (*Tipula*)	4
Analysis: Plecopterans 0%, Trichopterans 94.73% (metric score); 100% of taxa pollution-tolerant Final Index Score 56; Hilsenhoff Biotic Index 5.3 Macroinvertebrate Community Health - Fair Stream Health Rating *B*		
John Ward Creek WR1 – 14 Oct 2005		
Family Baetidae	Mayflies (*Baetis*)	6
Family Calopterygidae	Leaches (*Calopteryx*)	4
Family Chironomidae	Midges (*Ablabesmyia*)	41
	Midge (*Brillia flavifrons*)	1
	Midges (*Corynoneura*)	3
	Midges (*Cricotopus / Orthocladius* complex)	4
	Midges (*Parametriocnemus*)	1
	Midges (*Paratanytarsus*)	1
	Midges (*Phaenopsectra punctipes* group)	4
	Midges (*Polypedilum*)	44
	Midge (*Rheocricotopus robacki*)	17
	Midges (*Rheotanytarsus*)	5
	Midges (*Tanytarsus*)	1
	Midges (*Thienemannimyia* group)	2
	Midges (*Zavrelimyia*)	1

Table 8. (Continued).

Family	Identification	Adjusted Count
John Ward Creek WR1 – 14 Oct 2005 (cont'd.)		
Family Empididae	Aquatic dance flies (*Hemerodromia*)	1
Family Hydropsychidae	Caddisflies (*Hydropsyche*)	9
	Sedges – little spotted sedge (*Cheumatopsyche*)	29
Family Simuliidae	Black flies (*Simulium*)	11
Family Tipulidae	Crane flies (*Tipula*)	6
Family Philopotamidae	Sedges – little black sedge (*Chimarra*)	2

Analysis:
Plecopterans 0%, Trichopterans 65.2% (metric score); 100% of taxa pollution-tolerant
Final Index Score 51; Hilsenhoff Biotic Index 5.6
Macroinvertebrate Community Health - Fair
Stream Health Rating *B*

Family	Identification	Adjusted Count
Noses Creek NS2 – 20 Feb 2004		
Family Baetidae	Mayflies (*Baetis*)	1
Family Calopterygidae	Leaches (*Calopteryx*)	1
Family Chironomidae	Midges (*Ablabesmyia*)	4
	Midges (*Brillia*)	3
	Midges (*Cricotopus*)	2
	Midges (*Cricotopus/Orthocladius* complex)	4
	Midges (*Eukiefferiella*)	1
	Midges (*Orthocladius*)	3
	Midges (*Paratanytarsus*)	3
	Midges (*Phaenopsectra*)	1
	Midges (*Polypedilum*)	1
	Midge (*Rheocricotopus robacki*)	1
	Midges (*Rheotanytarsus*)	11
	Midges (*Thienemannimyia* group)	4
	Midge (*Tribelos juncundus*)	1
	Midge (*Xylotopus par*)	1
Family Elmidae	Riffle beetle (*Ancyronyx variegatus*)	1
	Riffle beetle (*Oulimnius latiusculus*)	1
Family Empididae	Aquatic dance flies (*Chelifera*)	1
	Aquatic dance flies (*Hemerodromia*)	1
Family Heptageniidae	Mayflies (*Stenonema*)	1
Family Hydropsychidae	Caddisflies (*Hydropsyche*)	2
	Sedges – little spotted sedge (*Cheumatopsyche*)	8
Family Leptoceridae	Caddisflies (*Triaenodes*)	1
Family Tipulidae	Crane flies (*Tipula*)	3

Analysis:
Plecopterans 0%, Trichopterans 100% (metric score); 100% of taxa pollution-tolerant
Final Index Score 48; Hilsenhoff Biotic Index 5.7
Macroinvertebrate Community Health - Fair
Stream Health Rating *B*

Table 8. (Continued).

Family	Identification	Adjusted Count
Noses Creek NS2 – 24 Oct 2005		
Family Baetidae	Mayflies (*Baetis*)	10
Family Elmidae	Riffle beetle (*Ancyronyx variegatus*)	1
	Riffle beetle (*Macronychus glabratus*)	2
Family Chironomidae	Midges (*Ablabesmyia*)	2
	Midges (*Brillia*)	1
	Midges (*Corynoneura*)	1
	Midges (*Crytpochironomus*)	1
	Midges (*Labrundinia*)	1
	Midges (*Polypedilum*)	7
	Midges (*Stenochironomus*)	1
	Midges (*Tanytarsus*)	1
	Midges (*Thienemannimyia* group)	9
	Midge (*Xylotopus par*)	1
Family Coenagrionidae	Pond damselflies (*Argia*)	3
Family Empididae	Aquatic dance flies (*Hemerodromia*)	2
Family Heptageniidae	Mayflies (*Stenonema*)	34
Family Hydropsychidae	Caddisflies (*Hydropsyche*)	18
	Sedges – little spotted sedge (*Cheumatopsyche*)	41
Family Leptoceridae	Long-horn caddisflies (*Oecetis*)	1
	Long-horn caddisflies (*Triaenodes*)	3
Family Philopotamidae	Sedges – little black sedge (*Chimarra*)	19
Family Simuliidae	Black flies (*Simulium*)	1
Family Tipulidae	Crane flies (*Tipula*)	26

Analysis:
Plecopterans 0%, Trichopterans 100% (metric score); 100% of taxa pollution-tolerant
Final Index Score 64; Hilsenhoff Biotic Index 4.2
Macroinvertebrate Community Health - Fair
Stream Health Rating *B*

Amphibians and Reptiles

According to information gathered in 2004, KEMO NBP contains 44 native species of amphibians and reptiles equally split among the two groups (Tuberville et al. 2005) (*Table 9*). The amphibians include 11 species of frogs and toads, and 11 species of newts and salamanders. The reptiles include 4 species of lizards, 13 snakes, and 5 turtles. In addition, an exotic snake species, the rough green snake (*Opheodrys aestivus*), occurs in the park. In a comparison of 16 parks including KEMO NBP, Tuberville et al. (2005) noted that larger parks had higher species richness, which would suggest that because of its small size, this park is a more fragile ecosystem (*Figure 5*).

Table 9. Herpetofauna of KEMO NBP, documented from field surveys, museum specimens, literature records, and reliable personal communications (Tuberville et al. 2005).

AMPHIBIANS

Frogs and Toads

American bullfrog (*Rana catesbeiana*)
American toad (*Bufo americanus*)
Fowler's toad (*Bufo fowleri*)
Gray treefrog (*Hyla versicolor*)
Green frog (*Rana clamitans*)
Green treefrog (*Hyla cinerea*)
Northern cricket frog (*Acris crepitans*)
Pickerel frog (*Rana palustris*)
Southeastern chorus frog (*Pseudacris feriarum*)
Southern leopard frog (*Rana spenocephala*)
Spring peeper (*Pseudacris crucifer*)

Newts and Salamanders

Dusky salamander (*Desmognathus fuscus*)
Marbled salamander (*Ambystoma opacum*)
Red salamander (*Pseudotriton ruber*)
Seal salamander (*Desmognathus monticola*)
Slimy salamander (*Plethodon glutinosus*)
Southern redbacked salamander (*Plethodon serratus*)
Southern two-lined salamander (*Eurycea cirrigera*
Spotted salamander (*Ambystoma maculatum*)
Spring salamander (*Gyrinophilus porphyriticus*)
Three-lined salamander (*Eurycea guttolineata*)
Webster's salamander (*Plethodon websteri*)

REPTILES

Lizards

Eastern fence lizard (*Sceloporus undulatus*)
Five-lined (common) skink (*Eumeces fasciatus*)
Green anole (*Anolis carolinensis*)
Little brown skink (*Scincella lateralis*)

Snakes (** = exotic introduced)

Common gartersnake (*Thamnophis sirtalis*)
Common kingsnake (*Lampropeltis getula*)
Corn snake (*Elaphe guttata*)
Cottonmouth (*Agkistrodon piscivorus*)
DeKay's (Florida) brown snake (*Storeria dekayi*)
Eastern rat snake (*Elaphe obsoleta*)
Eastern worm snake (*Carphophis amoenus*)
Plain-bellied watersnake (*Nerodia erythrogaster*)
Racer (eastern racer) (*Coluber constrictor*)
Red-bellied snake (*Storeria occipitomaculata*)
Ring-necked snake (*Diadophis punctatus*)
Rough green snake (*Opheodrys aestivus*)**
Southern (common) copperhead (*Agkistrodon contortrix)*
Timber rattlesnake (*Crotalus horridus*)

Turtles

Common (eastern) box turtle (*Terrapene carolina*)
Common musk turtle (stinkpot) (*Sternotherus odoratus*)
Common (pond) slider (*Trachemys scripta*)
Common snapping turtle (*Chelydra serpentina*)
Eastern painted turtle (*Chrysemys picta*)

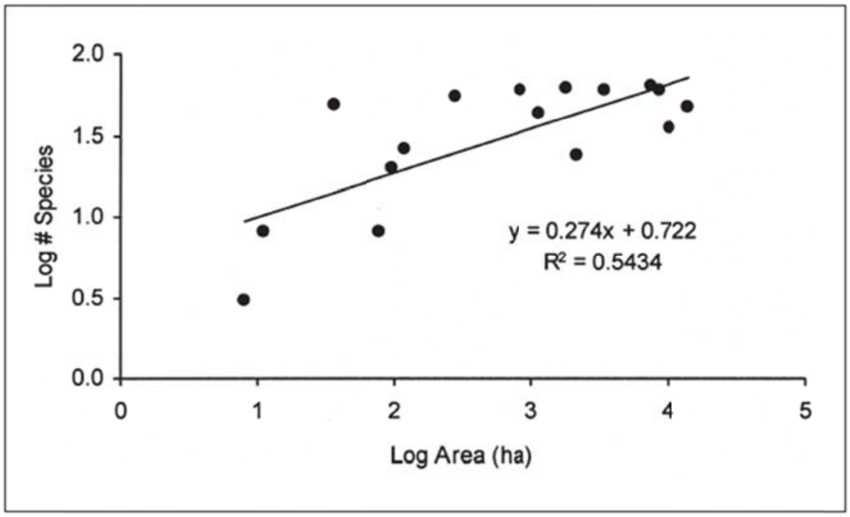


Figure 5. Relationship between land area (in hectares) and species richness, excluding exotic (introduced) species, among 16 parks within the Southeast Coast Network of the NPS, including KEMO, showing the strong positive linear relationship between (log-transformed) land area and species richness (P = 0.001). From Tuberville et al. (2005), with permission from Southeastern Naturalist.

Fish

Fish species were surveyed in the park only once in 2003, so there is no historic information on fish communities (Johnston 2004; C. Johnston, Auburn University, pers. comm., July 2008). Only 11 species were found in the survey, of uncertain abundance or health (C. Wright, NPS database): bluefin stoneroller (*Campostoma pauciradii*), bandfin shiner (*Luxilus zonistius*), blackbanded darter (*Percina nigrofasciata*), bluegill (*Lepomis macrochirus*), bluehead chub (*Nocomis leptocephalus*), creek chub (*Semotilus atromaculatus*), Dixie chub (*Semotilus thoreauianus*), green sunfish (*Lepomis cyanellus*), redbreast sunfish (*Lepomis cyanellus*), spotted sunfish (*Lepomis punctatus*), and yellow bullhead (*Ameiurus natalis*).

Noses Creek and John Ward Creek were also sampled for fish species (including abundance and weight) in June 2003 by GA DNR WRD less than 1 mile downstream from the park (*Table 3, Figure 3*). From that survey, 15 species were found in Noses Creek: All of the above species were reported except for the bluefin stoneroller and the Dixie chub. In addition, the downstream site had the Alabama hogsucker (*Hypentelium etowanum*), black crappie (*Pomoxis nigromaculatus*), eastern mosquitofish (*Gambusia holbrooki*), largemouth bass (*Micropterus salmoides*), southern studfish (*Fundulus stellifer*), and warmouth (*Lepomis gulosus*). Green sunfish, redbreast sunfish, and bluegills predominated, and bandfin shiners, blackbanded darters, and Alabama hogsuckers were also common. In contrast, the downstream site in Ward Creek had only eight species, including the Alabama hogsucker, blackbanded darter, bluehead chub, bluegill, green sunfish, redbreast sunfish, snail bull-head (*Ameiurus brunneus*), and warmouth. Bluegills and redbreast sunfish dominated, but with lower abundance than in Noses Creek, and few individuals of the other four species were found.

Birds

The location of KEMO NBP at the southern terminus of the Appalachian Mountains and forest acreage make it an especially attractive habitat for birds, especially during spring and fall migrations (*Table 10*). The park has been designated a globally IBA (Important Bird Area; IBA Programme of BirdLife International: http://www.birdlife.org), the first area designated in the state, and a focus area for bird conservation (Cooper 2000). A total of 185 species have been documented in the park (NPS 2003; *Table 9*), including a large percentage of neotropical migrants. Of the total, 21 species (11% of the total) are associated with aquatic habitats.

An Avian Conservation Implementation Plan (ACIP) was recently prepared for KEMO NBP in 2005 (Watson 2005). The ACIP was developed to help identify and prioritize bird conservation efforts and opportunities, and to guide successful implementation of conservation activities. No federally listed threatened or endangered avian species are known to nest in the park (Watson 2005). Audubon WatchList indicated that the cerulean warbler is declining, and that during spring migra-tion, this species has been seen more frequently at KEMO NBP than anywhere else in the Southeast. The major threat mentioned for this species is development and urban sprawl (Audubon 2002).

Mammals

Based on a survey of the park in 2003 (excluding bats), together with information from museum collections, a total of 30 species of mammals are present (18) or probably present (12) in the park, including 5 non-native species as domestic dogs, feral cats, feral horses, house mice, and Norway rats (D. Webster, UNC Wilmington – NPS database; Table 11). The USGS (2008) also indicated a high probability for the big brown bat (Eptesicus fuscus), eastern red bat (Lasiurus borealis), ground skink (Scincella lateralis), and hoary bat (Lasiurus cinereus) to be present in the park vicinity. The large number of carnivores (ten species) that apparently no longer inhabit the park was considered surprising (notes from D. Webster, UNC Wilmington). Three species(American black bear, *Ursus americanus*; mountain lion, *Puma concolor*; red wolf, *Canis rufus*) have been extirpated, and six others, (American mink, bobcat, eastern spotted skunk, muskrat, northern river otter, striped skunk) were evaluated as "probably extirpated" because encroaching development and habitat degradation have reduced most of the habitats that these species need.

Several reasons were suggested for the low mammalian species diversity in the park (notes from D. Webster, UNC Wilmington): The park is relatively small and narrow, with a large perimeter that is surrounded by development that prevents immigration and emigration (Heaney and Patterson 1986, Trani 2002) and accelerates impacts of pollution within the isolated park grounds. Carnivores, which generally have large home ranges, are disproportionately affected (Matthiae and Stearns 1981). As other contributing factors, coyotes, which have extended their natural range, and exotic feral cats are carnivores that are better adapted to live near urbanized settings and at least partially occupy the niches that previously were occupied by the carnivores that have been extirpated.

White-tailed deer and beavers have been identified as two species of concern in the park (DeVivo 2005). Populations of both appear to be on the increase. Beavers are infamous "ecosystem engineers" whose dam-building activities alter water flow and water quality. In terrestrial habitats, high deer populations consume forest understory species, so their grazing can lead to depressed forest regeneration.

Table 10. Bird species that have been observed in KEMO NBP (NPS 2003).

Species associated with aquatic habitats

American coot (*Fulica americana*)
Belted kingfisher (*Ceryle akyon*)
Black-crowned night heron (*Nycticorax nycticorax*)
Bonaparte's gull (*Larus philadelphia*)
Canada goose (*Branta canadensis*)
Common loon (*Gavia immer*)
Common merganser (*Mergus merganser*)
Double-crested cormorant (*Phalacrocorax auritus*)
Great blue heron (*Ardea herodias*)
Great egret (*Casmerodius albus*)
Greater yellowlegs (*Tringa melanoleuca*)
Green heron (*Butorides striatus*)
Lesser yellowlegs (*Tringa flavipes*)
Mallard (*Anas platyrhynchos*)
Northern pintail (*Anas acuta*)
Osprey (*Pandion haliaetus*)
Red-throated loon (*Gavia stellata*)
Red-winged blackbird (*Agelaius phoeniceus*)
Ring-billed gull (*Larus delawarensis*)
Sandhill crane (*Grus canadensis*)
Wood duck (*Aix sponsa*)

Other species (** = exotic species)

Acadian flycatcher (*Empidonax virescens*)
Alder flycatcher (*Empidonax alnorum*)
American coot (*Fulica americana*)
American crow (*Corvus brachyrhynchos*)
American goldfinch (*Carduelis tristis*)
American kestrel (*Falco sparverius*)
American redstart (Setophaga ruticilla)
American robin (*Turdus migratorius*)
American woodcock (*Scolopax minor)*
Bald eagle *(Haliaeetus leucocephalus*)
Baltimore oriole (*Icterus galbula*)
Bank swallow (*Riparia riparia*)
Barn swallow (*Hirundo rustica*)
Barred owl (*Strix varia*)
Bay-breasted warbler (*Dendroica castanea*)
Belted kingfisher (*Megaceryle alcyon*)
Black vulture (*Coragyps atratus*)
Black-and-white warbler (*Mniotilta varia*)
Black-billed cuckoo (*Coccyzus erythropthalmus*)
Blackburnian warbler (*Dendroica fusca*)
Black-crowned night heron (*Nycticorax nycticorax*)
Blackpoll warbler (*Dendroica striata*)
Black-throated blue warbler (*Dendroica caerulescens*)
Black-throated green warbler (*Dendroica virens*)
Blue grosbeak (*Passerina caerulea*)
Blue jay (*Cyanocitta cristata*)
Blue-gray gnatcatcher (*Polioptila caerulea*)
Blue-headed vireo (*Vireo solitarius*)
Blue-winged warbler (*Dendroica tigrina*)
Bobolink (*Dolichonyx oryzivorus*)
Bonaparte's gull (*Larus philadelphia*)
Broadwinged hawk (*Buteo platypterus*)
Brown creeper (*Certhia americana*)
Brown thrasher (*Toxostoma rufum*)
Brown-headed cowbird (*Molothrus ater*)
Brown-headed nuthatch (*Sitta pusilla*)
Canada goose (*Branta canadensis*)
Canada warbler (Wilsonia canadensis)
Cape May warbler (*Dendroica tigrina*)
Carolina chickadee **(***Poecile carolinensis*)
Carolina wren (*Thryothorus ludovicianus*)
Cedar waxwing (*Bombycilla cedrorum*)
Cerulean warbler (*Dendroica cerulea*)
Chestnut-sided warbler (*Dendroica pensylvanica*
Chimney swift (*Chaetura pelagica*)
Chipping sparrow (*Spizella passerina*)
Chuck-will's-widow (*Caprimulgus carolinensis*)
Cliff swallow **(***Petrochelidon pyrrhonota*)
Common grackle (*Quiscalus quiscula*)
Common loon (*Gavia immer*)
Common merganser (*Mergus merganser*)
Common nighthawk (*Chordeiles minor*)
Common yellowthroat (*Geothlypis trichas*)
Connecticut warbler (*Oporornis agilis*)
Coopers hawk (*Accipiter cooperii*)
Dark-eyed junco (*Junco hyem*)
Double-crested cormorant (*Phalacrocorax auritus*
Downy woodpecker *(Picoides puscens*)
Eastern bluebird (*Sialia sialis*)
Eastern kingbird (*Tyrannus tyrannus*)
Eastern meadowlark (*Sturnella magna*)
Eastern phoebe (*Sayornis phoebe*)
Eastern screech owl (*Megascops asio*)
Eastern towhee (*Pipilo erythrophthalmus*)
Eastern wood-pewee (*Contopus virens*)
European starling *(Sturnus vulgaris*)**
Evening grosbeak *(Coccothraustes vespertinus*)
Field sparrow (*Spizella pusilla*)
Fish crow (*Corvus ossifragus*)

Table 10. (Continued).

Fox sparrow (*Passerella iliaca*)
Golden-crowned kinglet (*Regulus satrapa*)
Golden-winged warbler (*Vermivora chrysoptera*)
Grasshopper sparrow (*Ammodramus savannarum*)
Gray catbird (*Dumetella carolinensis*)
Gray-cheeked thrush (*Catharus minimus*)
Great blue heron (*Ardea herodias*)
Great egret (*Ardea alba*)
Great horned owl (*Bubo virginianus*)
Great-crested flycatcher (*Myiarchus crinitus*)
Greater yellowlegs (*Tringa melanoleuca*)
Hairy woodpecker (*Picoides villosus*)
Hermit thrush (*Picoides villosus*)
Hooded warbler (*Wilsonia citrina*)
House finch (*Carpodacus mexicanus*)
House sparrow (*Passer domesticus*)**
House wren (*Troglodytes aedon*)
Indigo bunting (*Passerina cyanea*)
Kentucky warbler (*Oporornis formosus*)
Killdeer (*Charadrius vociferus*)
Least flycatcher (*Empidonax minimus*)
Lincoln's sparrow (*Melospiza lincolnii*)
Louisiana waterthrush (*Seiurus motacilla*)
Magnolia warbler (*Dendroica magnolia*)
Marsh wren (*Cistothorus palustris*)
Merlin (*Falco columbarius*)
Mississippi kite (*Ictinia mississippiensis*)
Mourning dove (*Zenaida macroura*)
Mourning warbler (*Oporornis philadelphia*)
Nashville warbler (*Vermivora ruficapilla*)
Northern bobwhite (*Colinus virginianus*)
Northern cardinal (*Cardinalis cardinalis*)
Northern flicker (*Colaptes auratus*)
Northern harrier (*Circus cyaneus*)
Northern mockingbird (*Mimus polyglottos*)
Northern parula (*Parula americana*)
Northern rough-winged swallow (*Stelgidopteryx serripennis*)
Northern waterthrush (*Seiurus noveboracensis*)
Olive-sided flycatcher (*Contopus cooperi*)
Orange-crowned warbler (*Vermivora celata*)
Orchard oriole (*Icterus spurius*)
Ovenbird (*Seiurus aurocapilla*)
Palm warbler (*Dendroica palmarum*)
Pectoral sandpiper (*Calidris melanotos*)
Peregrine falcon (*Falco peregrinus*)
Philadelphia vireo (*Vireo philadelphicus*)
Pileated woodpecker (*Dryocopus pileatus*)
Pine siskin (*Carduelis pinus*)
Pine warbler (*Dendroica pinus)*
Prairie warbler (*Dendroica discolor*)
Prothonotary warbler (*Protonotaria citrea*)
Purple finch (*Carpodacus purpureus*)
Purple gallinule (*Porphyrio martinica*)
Purple martin (*Progne subis*)
Red crossbill (*Loxia curvirostra*)
Red-bellied woodpecker (*Melanerpes carolinus*)
Red-breasted nuthatch (*Sitta canadensis*)
Red-eyed vireo (*Vireo olivaceus*)
Red-headed woodpecker (*Melanerpes erythroce*
Red-shouldered hawk (*Buteo lineatus*)
Red-tailed hawk (*Buteo jamaicensis*)
Rock dove (rock pigeon) (*Columba livia*)**
Rose-breasted grosbeak (*Pheucticus ludovicianu*
Ruby-crowned kinglet (*Regulus calendula*)
Ruby-throated hummingbird (*Archilochus colubri*
Rusty blackbird (*Euphagus carolinus*)
Song sparrow (*Melospiza melodia*)
Sora (*Porzana carolina*)
Summer tanager (*Piranga rubra*)
Swainson's thrush (*Catharus ustulatus*)
Swainson's warbler (*Limnothlypis swainsonii*)
Swamp sparrow (*Melospiza georgiana*)
Tennessee warbler (*Vermivora peregrina*)
Tree swallow (*Tachycineta bicolor*)
Tufted titmouse (*Baeolophus bicolor*)
Turkey vulture (*Cathartes aura*)
Veery (*Catharus fuscescens*)
Vesper sparrow (*Pooecetes gramineus*)
Virginia's warbler (*Vermivora virginiae*)
Warbling vireo (*Vireo gilvus*)
Whip-poor-will (*Caprimulgus vociferus*)
White-breasted nuthatch (*Sitta carolinensis*)
White-eyed vireo (*Vireo griseus*)
White-throated sparrow *(Zonotrichia albicollis*)
Wild turkey (*Meleagris gallopavo*)
Willow flycatcher (*Empidonax traillii*)
Wilson's warbler (*Wilsonia pusilla*)
Winter wren (*Troglodytes troglodytes*)
Wood thrush (*Hylocichla mustelina*)
Worm-eating warbler (*Helmitheros vermivorum*)
Yellow warbler (*Dendroica petechia*)
Yellow-bellied flycatcher (*Empidonax flaviventris*)
Yellow-bellied sapsucker (*Sphyrapicus varius*)
Yellow-billed cuckoo (*Coccyzus americanus*)
Yellow-breasted chat (*Icteria virens*)
Yellow-rumped warbler (*Dendroica coronata*)
Yellow-throated vireo (*Vireo flavifrons*)
Yellow-throated warbler (*Dendroica dominica*)

Table 11. Mammals of KEMO NBP (*, probably present; **, exotic introduced species; D. Webster, UNCW data for the NPS, with supporting information from USGS 2008).

American beaver (*Castor canadensis*)	Least shrew (*Cryptotis parva*)
Big brown bat (*Eptesicus fuscus*)	Long-tailed weasel (*Mustela frenata*)*
Coyote (*Canis latrans*)	Marsh rice rat (*Oryzomys palustris*)*
Domestic dog (feral) (*Canis familiaris*)**	Meadow jumping mouse (*Zapus hudsonius*)*
Eastern chipmunk (*Tamias striatus*)	Meadow vole (*Microtus pennsylvanicus*)*
Eastern cottontail (*Sylvilagus floridanus*)	Northern raccoon (*Procyon lotor*)
Eastern gray squirrel (*Sciurus carolinensis*)	Northern short-tailed shrew (*Blarina brevicauda*)
Eastern harvest mouse (*Reithrodontomys humulis*)	Norway rat (*Rattus norvegicus*) **
Eastern mole (*Scalopus aquaticus*)	Red fox (*Vulpes vulpes*)*
Eastern red bat (*Lasiurus borealis*)	Southern flying squirrel (*Glaucomys volans*)*
Feral cat (*Felis catus*)**	Southeastern shrew (*Sorex longirostris*)
Golden mouse (*Ochrotomys nuttalli*)*	Swamp rabbit (*Sylvilagus aquaticus*)*
Gray fox (*Urocyon cinereoargenteus*)*	Virginia opossum (*Didelphis virginiana*)
Hispid cotton rat (*Sigmodon hispidus*)	White-footed mouse (*Peromyscus leucopus*)*
Hoary bat (*Lasiurus cinereus*)	White-tailed deer (*Odocoileus virginianus*)
House mouse (*Mus musculus*)*	Woodland vole (*Microtus pinetorum*)*

Rare and Threatened Species

Information is lacking to assess whether aquatic and wetland rare and threatened species occur within in the park. Four federally endangered and two federally threatened mussel species are known from the Chattahoochee-Flint river basin. The four endangered mussel species are the fat threeridge (*Amblema neislerii*), shinyrayed pocketbook (*Lampsilis subangulata*), Gulf moccasinshell (*Medionidus penicillatus*), and oval pigtoe (*Pleurobema pyriforme*). These species have been federally listed as endangered since 1997. The two threatened mussel species are the chipola slabshell (*Elliptio chipolaensis*) and purple bankclimber (*Elliptoideus sloatianus*). All six species prefer main channel or large-stream sandy habitats with slow to moderate currents, so historically they may not have occurred in the two small streams within the park.

Regarding terrestrial species, the granite outcroppings on Kennesaw and Little Kennesaw Mountains within the park provide habitats that support various state-protected plant species of special concern, including openground draba (*Draba aprica*), green rockcress (*Arabis missouriensis*), and Stone Mountain mint (*Pycnanthemum curvipes*) (DeVivo 2004).

Exotic / Invasive Species

As mentioned, 20 higher vascular wetland plants and 1 wetland fern that occur in the park are non-native species (*Table 5*). Information is lacking about their abundance, or the extent of the threat they pose to native wetland species. The Asian swamp eel (*Monopterus albus*, also known as the rice eel, ricefield eel, belut, rice paddy eel, and taunagi; other scientific names, *Monopterus alba, Fluta alba, Monpterus javanenesis*) has been found in three spring-fed impoundments connected to the Chattahoochee River, and in the Chattahoochee River National Recreation Area (Tilmant 1999, but is not known to occur in KEMO NBP.

More than 15 years ago, a proposed park project called for removal of exotic terrestrial plant species (NPS 1992a). Among the present-day 143 non-native terrestrial species (see p.17), common species in the park include mimosa (*Albizia julibrissin*), garlic mustard (*Alliaria petiolata*), privet (*Ligustrum* spp.), tree of heaven (*Ailanthus altissima*), Japanese honeysuckle

(*Lonicera japonica*), and kudzu (*Pueraria montana*) (DeVivo 2004). Escaped cultivars from nearby private lands are also a concern. There is an ongoing program, although very limited by funding, to remove exotic plant species.

Among terrestrial invasive animals, as mentioned the southern pine beetle has caused considerable damage to terrestrial vegetation in the park. It is considered the most destructive forest insect pest in the southeastern U.S. (Clarke 1995), and continues to be a potential threat to other internal stands in the park and neighboring lands. Mechanical removal of this material is a major focus on 105 acres within the park. Other standard best-management practice (BMP) to control this insect are more difficult to use, such as cutting all pines within 150 meters of infested trees as they are identified. A BMP involving reintroduction of fire cannot be used at the park because of wildland-urban interface (WUI) and smoke concerns (DeVivo 2005).

The red fire ant, *Solenopsis invicta*, also in the park, is an invasive species from South America that was introduced to the U.S. in the 1930s (Porter and Savignano 1990). This aggressive species largely has displaced the two fire ant species native to the Southeast, the tropical fire and (*Solenopsis geminata*) and the southern fire and (*Solenopsis exloni*) (Porter and Savignano 1990).

Assessment of Park Water Resources

The park's drinking water is supplied from the Cobb County water system; for waste treatment the park is connected to the county sewage system, except for the historic Kolb Farm House which is on a septic tank system (park Historian W.R. Johnson, pers. comm., Aug. 2008). The Visitors Center, two houses (now used as park offices), and maintenance shop were added to the county sewage system in 2008. It is not known whether the septic leachate from the house is contributing nutrients or other contaminants to park waters.

Surface Water Quality

Locations for sampling stations near or within KEMO NBP, discussed in this section, were obtained from the U.S. EPA STORET. Latitudes and longitudes for these sites were imported from Microsoft Excel into ArcMap and converted to GIS point files.

Based on previous data inventories and analyses carried out by the NPS (1997a) within KEMO NBP over a 21-year period (1976-1997), Noses and John Ward Creeks historically were impacted by high fecal coliform bacteria and low pH. These earlier inventories indicated that pH was outside the pH range of 6.5-9 (U.S. EPA chronic criteria for freshwater aquatic life) in ~25% of the samples taken in both creeks during 1976-1997. All of the observations were less than or equal to pH 6.5. Although data were not collected with sufficient frequency to enable calculation of geometric means, used for the State standards (see pp. 41-42 of this Report), the high fecal coliform concentrations in Noses and John Ward Creeks exceeded the bacteria water quality standard values in 72% of these samples. The highest value of 32,000 counts/100 mL was reported in John Ward Creek near the upstream park boundary in November 1993. Lead levels commonly exceeded Georgia water quality standards within KEMO NBP (Byrne 2004).

In 1993 KEMO NBP developed a Water Resources Monitoring Study Plan (Zubricki 1993), which was designed as an implementation strategy for a project (KEMO 1992b) within the KEMO NBP Resource Management Plan. The park's two perennial streams historically had not been monitored. The Plan recognized that as development progressed adjacent to the park boundaries, it was essential for the park to generate baseline water resources data and to monitor the status of water resources through development of a long-term monitoring strategy. The goal of the plan was to detect changes in the relative health of stream ecosystems in the park and identify external factors that adversely affect their functional integrity. It was hoped that in the event that a case was made for a cause-and-effect relationship between specific external factors and park water resources, appropriate local, state and federal officials would be notified and the situation would be corrected by educating and working with those responsible for the problem.

The Plan called, in part, for monthly water quality (nitrate + nitrite [NO_3^-], ammonium [NH_4^+], total phosphorus [TP], fecal coliform bacteria, conductivity, pH, dissolved oxygen [DO], turbidity) and stream discharge sampling and field evaluations at four stations in partnership with the USGS and the Cobb County Water System, and for periodic sampling of benthic macro-invertebrates at four permanent stations following standardized protocols. The data were to be compared with data from healthy (unpolluted, baseline) streams of similar size within the region.

A little more than a decade ago, the NPS (1997a) inventoried the data available on Noses and John Ward Creeks, and two other streams in the area. They examined the U.S. EPA's Storage and Retrieval (STORET) water quality database, River Reach File (RF3), Industrial Facilities Discharge (IFD), Drinking Water Supplies (DRINKS), water gages (GAGES), and water impoundments (DAMS). The analysis located two industrial/municipal dischargers (no longer operational – see below) upstream from the park on Noses or John Ward Creeks, no drinking water intakes, no water gages, and no water impoundments. The majority of the observations from one source (~45%) were reported by the NPS from the above-mentioned program that was adopted, in part (excluding macroinvertebrate data) for the park during 1993-1996 (eventually, through 1998) to monitor water quality at four stations where Noses and John Creeks enter and exit the park (2 within the park boundary: KEMO 0009, Noses Creek upstream, and John Ward Creek upstream, KEMO 0006; 2 outside the park: John Ward Creek downstream, KEMO 0005; Noses Creek downstream, KEMO 0007) (*Figure 3*). The total data available for the NPS stations from 1993-1998 indicated that all four NPS KEMO stations sometimes had high fecal coliform indicating unacceptable conditions for maintenance of Fish (GA DNR 2008d), with maximal values at 6,400 mpn/100 mL in Noses Creek and 32,000 mpn/100 mL in John Ward Creek. Summaries of the NPS 1993-1998 data are compiled in *Table 12*. Post-1998 further data collection has not been conducted by the park (Chief Ranger L. Morris, pers. comm., Nov. 2006).

Since that time, over the past decade the Cobb County Water Protection Division's Water Quality Laboratory has conducted chemical monitoring during dry weather, usually several times per year, at four sites in John Ward Creek and one site on Noses Creek near the park (*Tables 13* and *14*, *Figure 3*). The County's data for John Ward Creek are part of a larger effort that involves sampling nine other streams in the Chattahoochee and Etowah. There were no samples with a pH lower than 6, and few samples with a DO concentration below 5 mg/L. Although these data generally have been collected only seasonally and sometimes less frequently – which would miss many storm events with most nonpoint pollution inputs – the dataset shows some high fecal coliform densities in John Ward Creek near the park, suggestive of degraded conditions (*Tables 13* and *14*, *Appendix 1*). In addition, consistently worse water quality for fecal coliforms has been indicated for John Ward Creek at stations upstream from the park (significantly higher mean and median fecal coliform concentrations – *Table 13*; upstream data not available from the County for Noses Creek).

The nitrate and suspended solids data from the 1999-2008 Cobb County dataset also merit mention (*Tables 13* and *14*, *Appendix 1*). In most samples throughout the data record, nitrate concentrations generally exceeded 100 µg/L, indicating a nutrient over-enriched condition that can stimulate noxious algal blooms in river systems (see review in Mallin 2000). Nitrate is highly soluble and in turbid, light-limited waters, this form of nitrogen can travel substantial distances (many miles) before reaching areas where light conditions are conducive for algal blooms (Mallin et al. 1993), such as lakes and run-of-river impoundments (Burkholder and Cuker 1991, Touchette et al. 2007, Burkholder et al. 1998). Both streams are heavily impacted by suspended sediment loading (GA DNR 2008a; see below). The streams were relatively infrequently sampled (sometimes seasonally or less often), but several large spikes of suspended sediment loading were detected nonetheless.

A subset of the Cobb County data from 1995-2005 were evaluated in trend analysis (Rashleigh and Bourne 2007). Sites WR3 and WR4, nearest to the park (*Figure 3*), showed similar, favorable conditions in the park, also showed a favorable trend for decreasing fecal coliform densities. However, both sites showed trends suggestive of more degraded water quality for BOD_5, total Kjeldahl nitrogen (organic N + ammonium), and chlorides, and site WR4 also showed a trend suggestive of decreasing dissolved oxygen (*Table 15*). "Suggestive" is used here because quarterly data are insufficient to capture many nonpoint loading events from storms, waste spills, etc.; biweekly sampling frequency is needed over an annual cycle, or monthly sampling frequency over longer periods (e.g. Burkholder et al. 2006). The park's *Water Resources Monitoring Study Plan* (Zubricki 1993) aptly stated that "…the need for KEMO NBP to establish a long-term record documenting the status of water resources far exceeds the need for comprehensive data over an extremely short temporal scale". Overall the data point to increasingly degraded conditions over the past ~decade for organic loads (BOD_5) and organic N + ammonium loads, and higher salt content, likely related to increased urbanization in the watershed (Rashleigh and Bourne 2007).

The GA DNR-WRD reported limited data from one date (12 June 2003) for water temperature (21.0 - 24.1^{o}C), DO (6.94-7.04 mg/L), conductivity (75.1 - 81.9 µS), pH (7.0), turbidity (8.9-10.6 NTU), total hardness (36 mg/L and 51 mg/L for Noses Creek and John Ward Creek, respectively), and alkalinity (40 mg/L) in Noses Creek and John Ward Creek segments that included the park, as part of an assessment of fish habitat and fish population health (GA DNR 2008a) (Table 3, Figure 3). Volunteer students from North Cobb High School have collected limited temperature and conductivity data (but no fecal coliform data as mentioned by DeVivo 2005 – Mr. Michael Pettelle, North Cobb High School, pers. comm.). Finally, Byrne (2004) reported a "potential red flag" listing for KEMO NBP with respect to water quality parameters pH, total and fecal coliforms, and lead, considering U.S. EPA guidelines (see pp. 39-42 below), and based upon lead data available for adjacent watersheds. Data on lead contamination were collected by GA DNR-EPD during 1998-2003 (U.S. EPA STORET), but the nearest station (ID #12118001) was ~6.6 miles downstream from the southern edge of the park boundary (Powder Springs, the GA DNR station nearest the park, in the same location as USGS station 02336968 - see Figure 3).

Noses Creek and John Ward Creek, including the park segments, are listed on the state's 303(d) list of impaired waters (GA DNR 2008b) that only partially support their designated uses. Both streams are impaired for fishing, and John Ward Creek is also impaired for recreational use because of high fecal coliform densities (see below).

Table 12. Water quality conditions in the mid-1990s: Parameters measured at two stations each in Noses Creek and John Ward Creek (entry and exit the park) during 1993-1998 (EPA STORET data; sampling dates per year ranged from 3 to 17; nd ≡ non-detectable). **Underline and bold** ≡ data in violation of state standard (GA DNR 2008d – see pp. 40-41 of this Report), except for fecal coliforms for which the data suggest degraded conditions[a]. **Blue and bold** ≡ can support noxious algal blooms ($NO_3^-+NO_2^-$ – see Mallin 2000), or data exceeded recommended values to protect aquatic life (BOD_5 - see Mallin 2006). **Bold shaded** ≡ data exceeded recommended values for acceptable water quality (U.S. EPA 2000: for TSS, 25 mg/L maximum, and < 10 mg/L increase from a sudden spike; for metals (Al, Cu, Hg, Pb, Ni, Zn), see pp. 39-42 of this Report). Note that U.S. EPA (2002) recommends that pH should be maintained within the range 6.5-9; this Report, however, follows Georgia regulations (pH ≥ 6.0).

Parameter	Date	n	Mean (range)	Median	Unacceptable (#)
NPS KEMO 0005 (John Ward Creek outflow from park)					
Temperature (°C)	Oct 93 - Jul 96	29	13.8 (2.8 - 23.9)	14	----
Discharge (cfs)	Oct 93 - Jul 96	27	11.6 (1.4 - 73.5)	6	----
Turbidity (NTU)	Jan 94 - Mar 96	16	15.0 (0.2 - 49.8)	8.8	----
Spec. cond. (μmhos/cm)	Oct 93 - Dec 98	62	93.5 (56.8 - 121.0)	94.3	----
DO (mg/L)	Oct 93 - Jul 96	29	8.84 (5.80 - 15.80)	8.70	----
pH	Oct 93 - Dec 98	38	6.79 (6.20 - 7.42)	6.8	----
$NO_3^-N+NO_2^-N$ (μg/L)	Oct 93 - Dec 98	33	**381** (80 - **630**)	**420**	**30**
SRP (μg/L)	Oct 93 - Dec 98	33	all at or below detect.	----	----
Chlorides (mg/L)	Oct 93 - Dec 98	33	4.1 (2.2 - 6.7)	4.2	----
Fecal coliforms (mpn/100 mL)[a]	Oct 93 - Dec 98	43	**1,479** (nd - **26,800**)	450	**22** (**22**)
NPS KEMO 0006 (John Ward Creek upstream near park)					
Temperature (°C)	Sep 93 - Dec 98	54	14.6 (2.5 - 23.6)	14.7	----
Discharge (cfs)	Sep 93 - May 98	33	6.8 (1.1 - 35.3)	4.2	----
Turbidity (NTU)	Jan 94 - Dec 97	31	11.1 (0.2 - 28.1)	8.5	----
Spec. cond. (μmhos/cm)	Sep 93 - Dec 98	84	104.0 (66.2 - 134.0)	106.0	----
DO (mg/L)	Sep 93 - Dec 98	53	8.65 (**3.75** - 14.30)	8.60	**1**
pH	Sep 93 - Dec 98	58	6.76 (6.00 - 7.40)	6.7	----
$NO_3^-N+NO_2^-N$ (μg/L)	Sep 93 - Dec 98	52	**753** (nd - **7,920**)	**495**	**48**
NH_4^+N (μg/L)	May 97 - Dec 98	17	**655** (nd - **2,100**)	**600**	**15**
SRP (μg/L)	Sep 93 - Dec 98	51	(nd - **1,250**)[b]	----	**2**
Fecal coliforms (mpn/100 mL)[a]	Sep 93 - Dec 98	44	**2,060** (50 - **32,000**)	500	**21** (**22**)
NPS KEMO 0007 (Noses Creek outflow from park)					
Temperature (°C)	Sep 93 - Jul 96	28	13.6 (1.9 - 26.8)	13.4	----
Discharge (cfs)	Sep 93 - Jul 96	26	5.9 (0.4 - 34.3)	2.6	----
Turbidity (NTU)	Jan 94 - Mar 96	15	11.2 (0.8 - 37.3)	6.0	----
Spec. cond. (μmhos/cm)	Sep 93 - Dec 98	62	97.2 (72.1 - 123.2)	98.2	----
DO (mg/L)	Sep 93 - Jul 96	28	9.02 (5.90 - 14.70)	8.85	----
pH	Sep 93 - Dec 98	37	7.0 (6.4 - 7.7)	6.9	----
$NO_3^-N+NO_2^-N$ (μg/L)	Sep 93 - Dec 98	34	**459** (nd - **800**)	**500**	**32**
SRP (μg/L)	Sep 93 - Dec 98	34	all nd	---	----
Chlorides (mg/L)	Sep 93 - Dec 98	34	4.0 (2.4 - 5.8)	4.0	----
Fecal coliforms (mpn/100 mL)[a]	Sep 93 - Dec 98	43	**639** (20 - **6,050**)	200	**16** (**15**)

Table 12. (Continued)

Parameter	Date	n	Mean (range)	Median	Unacceptable (#)
NPS KEMO 0009 (Noses Creek upstream at park boundary)					
Temperature (oC)	Sep 93 - Dec 98	52	13.8 (2.4 - 23.0)	14.2	----
Discharge (cfs)	Sep 93 - Jul 98	44	4.0 (0.4 - 25.1)	1.9	----
Turbidity (NTU)	Feb 94 - Dec 97	30	13.6 (0.2 - 95.4)	8.3	1
Spec. cond. (µmhos/cm)	Sep 93 - Dec 98	82	106.0 (67.7 - 199.0)	107.1	----
DO (mg/L)	Sep 93 - Dec 98	51	8.94 (5.40 - 15.50)	8.90	----
pH	Sep 93 - Dec 98	55	6.7 (6.3 - 7.4)	6.6	----
NO3-N+NO2-N (µg/L)	Sep 93 - Dec 98	53	**1,465** (nd - **35,200**)	**700**	**44**
NH4+N (µg/L)	May 97 - Dec 98	18	**728** (nd - **3,600**)	**560**	**15**
SRP (µg/L)	Sep 93 - Dec 98	53	----- (nd - **1,300)**b	----	**2**
Chlorides (mg/L)	Sep 93 - Dec 98	34	4.9 (2.6 - 7.3)	4.9	----
Fecal coliforms (mpn/100 mL)a	Sep 93 - Dec 98	43	**1,020** (nd - **6,400**)	300	**24 (18)**

[a] Data were not collected with sufficient frequency to enable calculation of geometric means, used for the State standards (see pp. 41-42 of this Report). Unacceptable water quality (last column of table, 1st numb exceeded the fecal bacteria water quality standard values considered for geometric means (> 200 mpn/1 mL in May - Oct; > 1,000 mpn/100 mL during Nov - Apr) and suggest degraded conditions. The 2nd numb in the "Unacceptable" column, in parentheses, is the number of samples with fecal coliform densities > 4(mpn/100 mL, in consideration of the U.S. EPA's (2003) recommendation for data collected with insufficie frequency to determine geometric means by the State's criteria.

[b] Only 2 samples with values; all others below detection with the analytical technique used.

Table 13. Water quality conditions during the past decade: Parameters measured at one station in Noses Creek and four stations in John Ward Creek during 1999-2008 (Cobb County data; sampling dates per year ranged from 1 to 5). Data are presented as in *Table 12*.

Parameter	Date	n	Mean (range)	Median	Unacceptable (#)
NS1 (Noses Creek, Mt. Calvary Road)					
Temperature (°C)	Sep 99 - Jan 08	31	15.0 (3.5 – 23.0)	16	----
Turbidity (NTU)	Sep 99 - Jan 08	31	8.0 (4.1 - 24.1)	6.2	----
Spec. cond. (µmhos/cm, field)	Sep 99 - Jan 08	30	108 (84 - 173)	106	----
DO (mg/L)	Sep 99 - Jan 08	31	8.2 (**4.2** - 11.2)	8.0	**1**
pH	Sep 99 - Jan 08	30	7.0 (6.5 - 7.5)	7.0	----
$NO_3^-N+NO_2^-N$ (µg/L)	Sep 99 - Jan 08	31	**277** (80 - **400**)	**270**	**30**
TKN (µg/L)	Sep 99 - Jan 08	31	525 (50 - 2,160)	350	----
TP (µg/L)	Sep 99 - Jan 08	31	46 (5 - **150**)	50	**1**
BOD_5 (mg/L)	Sep 99 - Jan 08	31	1.1 (0.5 - 2.5)	1.0	---
COD (mg/L)	Sep 99 - Jan 08	31	all < 20.0	----	----
Chlorides (mg/L)	Sep 99 - Jan 08	30	4.2 (2.4 - 7.7)	4.0	----
TSS (mg/L)	Sep 99 - Jan 08	31	5.1 (0.5 - **28**)	3.7	**1**
Fecal coliforms (mpn/100 mL)	Sep 99 - Jan 08	31	**1,963** (2.0 - **51,600**)	200	**12** (**4**)
Aluminum (µg/L)	Jan 08	1	**172.1**	----	**1**
Barium (µg/L)	Jan 08	1	29.2	----	----
Cadmium (µg/L)	Sep 99 - Jan 08	31	all < 0.7	----	Uncertain
Calcium (mg/L)	Jan 08	1	8.2	----	----
Copper (µg/L)	Sep 99 - Jan 08	31	2.6 (2.5 - 5.3)**	2.5	----
Iron (µg/L)	Jan 08	1	633.7	----	----
Lead (µg/L)	Sep 99 - Jan 08	31	0.6 (0.5 - 2.4)**	0.5	----
Magnesium (mg/L)	Jan 08	1	3.4	----	----
Manganese (µg/L)	Jan 08	1	197.4	----	----
Potassium (mg/L)	Jan 08	1	1.5	----	----
Sodium (mg/L)	Jan 08	1	4.2	----	----
Zinc (µg/L)	Sep 99 - Jan 08	31	6.2 (5.0 - 17.3)	5.0	----

Table 13. (Continued).

Parameter	Date	n	Mean (range)	Median	Unacceptable (#)
WR1 (John Ward Creek)					
Temperature (^oC)	Jul 99 - Mar 08	33	14.8 (4.0 – 22.0)	16.5	----
Turbidity (NTU)	Jul 99 - Mar 08	33	2.1 (1.1 - 7.1)	1.8	----
Spec. cond. (µmhos/cm, field)	Jul 99 - Mar 08	33	130 (101 - 165)	130	----
DO (mg/L)	Jul 99 - Mar 08	33	7.8 (**4.1** - 12.4)	7.2	**1**
pH	Jul 99 - Mar 08	33	6.9 (6.4 - 7.3)	6.9	----
$NO_3^-N+NO_2^-N$ (µg/L)	Jul 99 - Mar 08	32	**1,114** (**200** - **1,680**)	**1,220**	**23**
TKN (µg/L)	Jul 99 - Mar 08	33	413 (50 - 1,080)	330	----
TP (µg/L)	Jul 99 - Mar 08	33	47 (5 - **150**)	50	**2**
BOD_5 (mg/L)	Jul 99 - Mar 08	33	1.0 (0.5 - 1.8)	1.0	----
COD (mg/L)	Jul 99 - Mar 08	32	all < 20.0**	----	----
Chlorides (mg/L)	Jul 99 - Nov 07	32	7.3 (3.2 - 12.1)	7.3	----
TSS (mg/L)	Jul 99 - Mar 08	33	1.8 (0.5 - 23.4)	1.2	----
Fecal coliforms (mpn/100 mL)	Jul 99 - Mar 08	32	781 (20 - **4,400**)	450	**17** (**17**)
Aluminum (µg/L)	Nov 07, Mar 08	2	59.7 (32.7 - 86.7)	----	----
Barium (µg/L)	Nov 07, Mar 08	2	36.3 (35.8 - 36.8)	----	----
Cadmium (µg/L)	Jul 99 - Mar 08	33	**0.4** (**0.35** - **2.2**)**	**0.35**	**1**; Uncertain
Calcium (mg/L)	Nov 07, Mar 08	2	9.8 (9.5 - 10.0)	----	----
Copper (µg/L)	Jul 99 - Mar 08	33	all < 5.0**	----	----
Iron (µg/L)	Nov 07, Mar 08	2	231.7 (182.1 - 281.2)	----	----
Lead (µg/L)	Jul 99 - Mar 08	33	1.2 (0.5 - **19.9**)**	0.5	**1**
Magnesium (mg/L)	Nov 07, Mar 08	2	3.3 (2.9 - 3.7)	----	----
Manganese (µg/L)	Nov 07, Mar 08	2	67.3 (60.4 - 74.1)	----	----
Potassium (mg/L)	Nov 07, Mar 08	2	1.6 (1.3 - 1.8)	----	----
Sodium (mg/L)	Nov 07, Mar 08	2	7.1 (6.9 - 7.3)	----	----
Zinc (µg/L)	Jul 99 - Mar 08	33	7.9 (5.0 - 20)**	5.0	----

Table 13. (Continued).

Parameter	Date	n	Mean (range)	Median	Unacceptable (#)
WR2 (John Ward Creek)					
Temperature (^{o}C)	Jul 99 - Mar 08	33	14.9 (3.0 - 22.6)	17.0	----
Turbidity (NTU)	Jul 99 - Mar 08	33	2.9 (0.9 - 26.0)	1.6	----
Spec. cond. (µmhos/cm)	Jul 99 - Mar 08	33	149 (100 - 191)	148	----
DO (mg/L)	Jul 99 - Mar 08	33	8.8 (**4.9** - 13.0)	8.1	**1**
pH	Jul 99 - Mar 08	33	7.1 (6.5 - 7.6)	7.2	----
$NO_3^-N+NO_2^-N$ (µg/L)	Jul 99 - Mar 08	32	**914** (50 - **1,720**)	**1,025**	**17**
TKN (µg/L)	Jul 99 - Mar 08	33	538 (120 - 1,380)	390	----
TP (µg/L)	Jul 99 - Mar 08	33	49 (5 - **150**)	50	**2**
BOD_5 (mg/L)	Jul 99 - Mar 08	32	1.2 (0.5 - **4.7**)	1.0	**1**
COD (mg/L)	Jul 99 - Mar 08	33	10.4 (10.0 - 22.0)	10.0	----
Chlorides (mg/L)	Jul 99 - Nov 07	32	7.6 (3.3 - 10.4)	8.2	----
TSS (mg/L)	Jul 99 - Mar 08	33	2.3 (0.5 - 21.0)	1.2	----
Fecal coliforms (mpn/100 mL)	Jul 99 - Mar 08	32	854 (50 - **3,350**)	480	**18** (**18**)
Aluminum (µg/L)	Nov 07, Mar 08	2	37.5 (13.9 - 61.1)	----	----
Barium (µg/L)	Nov 07, Mar 08	2	36.7 (34.9 - 38.4)	----	----
Cadmium (µg/L)	Jul 99 - Mar 08	33	**0.4** (**0.35** - **1.2**)**	**0.35**	**1**; Uncertain
Calcium (mg/L)	Nov 07, Mar 08	2	12.3 (11.9 - 12.6)	----	----
Copper (µg/L)	Jul 99 - Mar 08	33	all < 5.0**	----	----
Iron (µg/L)	Nov 07, Mar 08	2	142.6 (104.4 - 180.8)	----	----
Lead (µg/L)	Jul 99 - Mar 08	33	0.8 (0.5 - **5.5**) **	0.5	**1**
Magnesium (mg/L)	Nov 07, Mar 08	2	4.1 (4.0 - 4.2)	----	----
Manganese (µg/L)	Nov 07, Mar 08	2	28.7 (19.6 - 37.7)	----	----
Potassium (mg/L)	Nov 07, Mar 08	2	2.3 (1.9 - 2.7)	----	----
Sodium (mg/L)	Nov 07, Mar 08	2	6.9 (6.5 - 7.3)	----	----
Zinc (µg/L)	Jul 99 - Mar 08	33	8.5 (5.0 - 19.5)**	5.0	----

Table 13. (Continued).

Parameter	Date	n	Mean (range)	Median	Unacceptable (#)
WR3 (John Ward Creek)					
Temperature (^{o}C)	Jul 99 - Mar 08	33	14.7 (3.0 - 22.9)	17.0	----
Turbidity (NTU)	Jul 99 - Mar 08	33	6.1 (1.0 - 17.0)	5.2	----
Spec. cond. (µmhos/cm)	Jul 99 - Mar 08	33	111 (79 - 135)	111	----
DO (mg/L)	Jul 99 - Mar 08	33	8.0 (5.0 - 11.7)	7.4	----
pH	Jul 99 - Mar 08	33	7.1 (6.5 - 7.4)	7.2	----
$NO_3^-N+NO_2^-N$ (µg/L)	Jul 99 - Mar 08	32	**379** (60 - **720**)	**420**	**30**
TKN (µg/L)	Jul 99 - Mar 08	33	526 (50 - 1,570)	390	----
TP (µg/L)	Jul 99 - Mar 08	33	46 (5 - **150**)	50	**2**
BOD_5 (mg/L)	Jul 99 - Mar 08	33	1.1 (0.5 - 2.4)	1.0	----
COD (mg/L)	Jul 99 - Mar 08	33	10.4 (10.0 - 24.3)	10.0	----
Chlorides (mg/L)	Jul 99 - Nov 07	32	4.8 (3.2 - 6.8)	4.8	----
TSS (mg/L)	Jul 99 - Mar 08	33	3.4 (1.2 - 8.8)	3.0	----
Fecal coliforms (mpn/100 mL)	Jul 99 - Mar 08	31	323 (50 - **950**)	250	**12** (**9**)
Aluminum (µg/L)	Nov 07, Mar 08	2	**120.4** (72.8 - **167.9**)	----	**1**
Barium (µg/L)	Nov 07, Mar 08	2	35.0 (33.2 - 36.8)	----	----
Cadmium (µg/L)	Jul 99 - Mar 08	33	all < 0.7**	----	Uncertain
Calcium (mg/L)	Nov 07, Mar 08	2	8.7 (8.3 - 9.0)	----	----
Copper (µg/L)	Jul 99 - Mar 08	33	2.6 (2.5 - 5.5)**	2.5	----
Iron (µg/L)	Nov 07, Mar 08	2	1,594 (1,100 - 2,088)	----	----
Lead (µg/L)	Jul 99 - Mar 08	33	1.0 (0.5 - **10.6**)**	0.5	**1**
Magnesium (mg/L)	Nov 07, Mar 08	2	3.2 (3.1 - 3.3)	----	----
Manganese (µg/L)	Nov 07, Mar 08	2	910 (583 - 1,236)	----	----
Potassium (mg/L)	Nov 07, Mar 08	2	2.0 (1.5 - 2.4)	----	----
Sodium (mg/L)	Nov 07, Mar 08	2	4.6 (4.5 - 4.7)	----	----
Zinc (µg/L)	Jul 99 - Mar 08	33	7.1 (5.0 - 28.4)**	5.0	----

Table 13. (Continued).

Parameter	Date	n	Mean (range)	Median	Unacceptable (#)
<u>**WR4** (John Ward Creek)</u>					
Temperature (^{o}C)	Jul 99 - Mar 08	33	15.3 (4.0 - 24.4)	17.0	----
Turbidity (NTU)	Jul 99 - Mar 08	33	8.9 (5.3 - 18.3)	8.1	----
Spec. cond. (µmhos/cm)	Jul 99 - Mar 08	33	102 (77 - 133)	101	----
DO (mg/L)	Jul 99 - Mar 08	33	7.9 (5.0 - 11.8)	7.7	----
pH	Jul 99 - Mar 08	33	7.0 (6.5 - 7.3)	7.1	----
$NO_3^-N+NO_2^-N$ (µg/L)	Jul 99 - Mar 08	32	**313** (20 - **560**)	**305**	**30**
TKN (µg/L)	Jul 99 - Mar 08	33	487 (50 - 1,420)	410	----
TP (µg/L)	Jul 99 - Mar 08	33	48 (5 - **150**)	50	**2**
BOD_5 (mg/L)	Jul 99 - Mar 08	33	1.1 (0.5 - 1.7)	1.0	----
COD (mg/L)	Jul 99 - Mar 08	33	all < 20.0**	----	----
Chlorides (mg/L)	Jul 99 - Nov 07	32	4.4 (2.7 - 6.5)	4.4	----
TSS (mg/L)	Jul 99 - Mar 08	33	5.1 (2.1 - 15.4)	4.0	----
Fecal coliforms (mpn/100 mL)	Feb 00 - Mar 08	31	286 (40 - <u>**1,600**</u>)	200	<u>**10**</u> (<u>**5**</u>)
Aluminum (µg/L)	Nov 07, Mar 08	2	**174** (48 - **300**)	----	**1**
Barium (µg/L)	Nov 07, Mar 08	2	32.4 (30.8 - 33.9)	----	----
Cadmium (µg/L)	Jul 99 - Mar 08	33	all < 0.7**	----	Uncertain
Calcium (mg/L)	Nov 07, Mar 08	2	7.5 (7.4 - 7.6)	----	----
Copper (µg/L)	Jul 99 - Mar 08	33	3.0 (2.5 - **15.7**)**	2.5	**1**
Iron (µg/L)	Nov 07, Mar 08	2	1,901 (1,845 - 1,956)	----	----
Lead (µg/L)	Jul 99 - Mar 08	33	0.9 (0.5 - **4.0**)**	0.5	**2**
Magnesium (mg/L)	Nov 07, Mar 08	2	3.0 (2.8 - 3.1)	----	----
Manganese (µg/L)	Nov 07, Mar 08	2	641 (617 - 665)	----	----
Potassium (mg/L)	Nov 07, Mar 08	2	1.8 (1.4 - 2.2)	----	----
Sodium (mg/L)	Nov 07, Mar 08	2	4.2 (4.0 - 4.3)	----	----
Zinc (µg/L)	Jul 99 - Mar 08	33	7.9 (5.0 - 25.7)**	5.0	----

* All BOD, COD, TP, TKN, TSS, cadmium, copper, lead and zinc values reported less than the level of detection were replaced with ½ the value.
** More than 50% of samples below detection with the analytical technique used.

Table 14. Summary information from the Cobb County dataset for stations near KEMO NBP (past decade), based upon the data in *Appendix 1* (note that nitrate here ≡ $NO_3^-N + NO_2^-N$).

Station	Nitrate (µg/L; mean; median; maximum)	Samples >100 µg/L	Fecal coliforms (mpn/100 mL; mean; median; maximum)	Samples >200 mpn/100 mL (May-Oct) or >1,000mpn/100 mL (Nov - Apr); <u>or</u> > 400 mpn/100 mL (2nd number)	
Noses Creek, NS1 downstream from park	277; 270; 400 (n = 31)	97%	1,963; 200; 51,600 (n = 31)	39%	(13%)
John Ward Creek, WRI, upstream from park	1,114; 1,220; 1,680 (n = 32)	72%	781; 450; 4,400 (n = 32)	53%	(53%)
John Ward Creek, WR2, upstream from park	914; 1,025; 1,720 (n = 32)	53%	854; 480; 3,350 (n = 32)	56%	(56%)
John Ward Creek, WR3 ("island" surrounded by park)	379; 420; 720 (n = 32)	94%	323; 250; 950 (n = 31)	39%	(29%)
John Ward Creek, WR4, downstream from park	313; 305; 560 (n = 32)	94%	286; 200; 1,600 (n = 31)	32%	(16%)

Table 15. Results of regression analysis for trends in water quality variables over time (conductivity, turbidity, total suspended solids, dissolved oxygen (% saturation and concentration), 5-day biochemical oxygen demand, total Kjeldahl nitrogen, nitrate+nitrite, fecal coliforms, and chloride; quarterly sampling by Cobb County, 1995 - 2005) at four sites in John Ward Creek (WR1, Highland Avenue; WR2, Kirkpatrick Drive; WR3, Cheatham Hill Rd., downstream from part of the park and just upstream from another area of the park; and WR4, John Ward Road; *Figure 6*). Only statistically significant results are shown (positive or negative; $p < 0.05$).

SITE	COND	TURB	TSS	DO	BOD_5	TKN	NO_X	FC	CHLD
WR1									
WR2	+					+		-	
WR3	+		-		-	+		-	+
WR4			-	-	-	+			+

Drinking Water
Drinking water is supplied to the park from an offsite treatment system operated by Cobb County as mentioned (Chief Ranger L. Morris, pers. comm., Nov. 2006) and, so, is not at risk from fecal bacteria.

Groundwater Quality
Data are not available to assess groundwater quality in the park.

Sources of Pollutants
Water quality in an urbanized watershed is degraded by both point and nonpoint source pollution. Urban development commonly causes undesirable habitat alteration, hydrologic modifications, erosion and sedimentation from land disturbance, stormwater runoff, combined sewer overflows, illegal discharges, improper storage and/or disposal of deleterious materials, and failure of sewerage systems (GA DNR 2008b).

Point Sources
There are no NPDES dischargers in the park. Two point sources were listed by NPS (1997a) upstream from the park: the Williams Brothers Concrete Plant (Blue Circle Williams, #GA0001627, ~3.5 miles upstream) in the upper Noses Creek watershed, and the Westside sewage treatment plant (#GA0025267, Chestnut Hill Road, ~1.8 miles upstream) in the John Ward Creek watershed. However, these point sources are no longer operational (permit on the first point source expired 31 January 2005, no longer discharging, based on a U.S. EPA PCS search; and confirmation on cessation of discharge by the wastewater treatment plant by T. Bailey, Chief Engineer, Engineering and Records Division, Cobb County Water System, pers. comm., July 2008).

Nonpoint Sources
Impervious surface coverage, which concentrates pollutants and increases stormwater runoff pollution, is high surrounding the park and upstream from it (see pp. 8-10 of this Report). The two perennial streams in KEMO NBP both have upstream portions outside the park boundaries that are degraded from watershed urban development (see pp. 29-37 of this Report), and the park has no direct control over various factors that influence its surface water resources. Moreover, the location of the park within the greater metropolitan area of the city of Atlanta makes it extremely vulnerable to water quality degradation from air pollution (see below). The wide range of urban land uses and activities occurring in the watersheds are harmful to the park's water resources. These sources also contribute to acid deposition which can contribute to acidification and nutrient over-enrichment of surface waters (Baker and Christensen 1992). The park area lies within a region that has been evaluated as most at risk in the U.S. for continued acid deposition (Herlihy et al. 1991; below).

Considering all of the pollutants – from suspended sediments to nutrients to a wide array of toxic substances – that are known to be contained in urban runoff and air pollution, data to evaluate the effects on the park's aquatic resources from upstream water quality and atmospheric deposition are very sparse and have not been collected with adequate frequency to capture loadings from storm events or spills.

The most easily detected among these pollutants, however, has left clear visible signs. Excessive sediment loading can make streams shallower and wider, and more susceptible to flooding.

Stream temperature, dissolved oxygen, flow rate, and velocity are affected as well. Benthic flora and fauna can be buried, spawning habitat destroyed, and aquatic plants eliminated because of the light reduction imposed by high turbidity. The suspended sediments also add nutrients such as adsorbed phosphorus and ammonium, as well as toxic substances such as heavy metals and pesticides. The overall net effect is depressed biodiversity and loss of beneficial aquatic life (Olsen 1984, Hadley and Ongley 1989). The effects of high suspended sediment loading from upstream urban sources in the Marietta area on degradation of stream habitats within the park are visibly obvious (*Plate 5*), and both Noses Creek and John Ward Creek, including the park segments, are impaired and only partially supporting their designated uses for fish/fishing because of habitat degradation from excessive sedimentation and other urban runoff effects (see below). John Ward Creek is also impaired because of excessive fecal coliform concentrations.

Fecal coliform loads can be contributed by domestic animals, other animals such as horses, leaks and overflows of sanitary sewers, illicit waste discharges, leaking septic tanks, and wildlife and waterfowl (GA DNR 2003).

Assessment of Biological Resources With Respect To Water and Air Quality

Water Quality Standards

The state of Georgia has ambient water quality standards for common water quality parameters in streams such as John Ward and Noses Creeks with designated use for Fishing (GA DNR 2008c) (*Table 16, Appendices 2* and *3*). Samples that have a geometric mean fecal coliform count exceeding 200 mpn/100 mL during May through October, or exceeding 1,000 mpn/100 mL during November through April, are in violation of the bacteria water quality standard.

Georgia's *Rules and Regulations for Water Quality Control*, Chapter 391-3-6-.03(5)(c) also state that “All waters shall be free from material related to municipal, industrial or other discharges which produce turbidity, color, odor or other objectionable conditions which interfere with legitimate water uses”. Stream segments are placed on the state’s Impaired Waters (303(d)) list based on water quality and biota sampling data. For the water use classification of Fishing, the criterion violated is listed as Biota Impacted (Bio(F)), reflecting the fact that studies have shown a significant impact of water quality-related habitat degradation on fish (GA DNR 2008a). Potential causes may be urban runoff, (other) nonpoint sources, and/or a municipal facility(s) (point sources). For fecal coliforms (microbial pathogens), the standards were developed in consideration of general recreational uses, although the state’s general policy is not to encourage swimming in any surface waters (GA DNR 2003). A stream is placed on the “partial support” list if more than 10% of the samples exceed the fecal coliform criteria and on the not support list if more than 25% of the samples exceed the standard.

Other recommended guidelines for acceptable water quality in waters designated for use as Fishing and general recreation have been published by the U.S. EPA (2000, 2002, 2003) and other sources (*Table 17*). The Clean Water Act requires the U.S. EPA to develop criteria (i.e. recommendations) for water that are designed in part to protect aquatic life. The criteria are supposed to reflect accurately the up-to-date scientific knowledge. Whereas the State of Georgia has imposed regulations, an EPA water quality criterion is not a regulation; it does not impose legally binding requirements on the EPA or the states. States have discretion to adopt approaches that differ from the U.S. EPA water quality criteria, but these criteria are meant to provide useful guidance.

In addition to these standards, Phase I NPDES permits regulate stormwater discharges associated with specific industrial activities (including construction sites ≥ 1 acre in area) and large and medium municipal separate storm sewer systems (MS4s) that serve populations of 100,000 or more. MS4 permits prohibit non-stormwater discharges (i.e., illicit discharges) from entering into storm sewer systems and require controls or best-management practices to reduce pollutant discharges to the "maximum extent practicable" (GA DNR 2003). The intent is to reduce exposure of stormwater to pollutants. John Ward Creek is surrounded by MS4 permittees (Phase I permits listed for Cobb County and for the City of Marietta).

Plate 5. Degradation to streams in the Park from upstream sources of sediment loading in the urbanized Marietta area: Noses Creek, showing (A) a large sediment deposit and (B) an undercut from bank erosion; John Ward Creek, showing (C) a large sediment deposits and (D) a heavily silted bottom). Photos by M. Mallin and J. Burkholder.

Table 16. Georgia water use classifications and in-stream water quality standards for each use (GA DNR 2008d; Georgia's Rules and Regulations for Water Quality Control, Chapter 391-3-6-.03(6)(a), 391-3-6-.03(6)(b), and 391-3-6-.03(6)(c)).

	BACTERIA (fecal coliforms)		DISSOLVED OXYGEN (except trout streams)[a]		pH	TEMPERATURE (except trout streams)[a]	
USE CLASSIFICATION	30-day geom. mean[b]	Maximum	Daily Avg. (mg/L)	Minimum (mg/L)	Std. Units	Maximum Rise (°F)	Maximum (°F)
Drinking Water requiring treatment	1,000 Nov-Apr 200 May-Oct	4,000 Nov-Apr ----	5.0	4.0	6.0-8.5	5	90
Recreation	200 (frw.)[c] 100 (coastal)	----	5.0	4.0	6.0-8.5	5	90
Fishing	1,000 Nov-Apr 200 May-Oct	4,000 Nov-Apr	5.0	4.0	6.0-8.5	5	90
Coastal Fishing[d]							
Wild River	No alteration of natural water quality						
Scenic River	No alteration of natural water quality						

[a] Standards for Trout Streams for dissolved oxygen are an average of 6.0 mg/L and a minimum of 5.0 mg/L. No temperature alterati allowed in Primary Trout Streams, and a temperature change of 2°F is allowed in secondary Trout Streams.

[b] Fecal coliform densities are in units of number / 100 mL (Geom. ≡ geometric). Geometric means should be "based on at least 4 sa collected from a given sampling site over a 30-day period at intervals not less than 24 hours". The geometric mean of a series of N the Nth root of their product. Example: the geometric mean of 2 and 18 is the square root of 36. Note: U.S. EPA (2003) recommend consideration of 400 mpn/100 mL as the highest acceptable level of fecal coliforms if samples are taken less frequently.

[c] Frw. ≡ freshwater.

[d] Standards are the same as for Fishing with exception of dissolved oxygen, which is site-specific.

Table 17. Summary of Georgia state standards for acceptable water quality in waters classified as Fishing designated use (GA DNR – excluding temperature) and of conditions for acceptable water quality recommended by other sources, and status of the two KEMO streams in the past decade (U.C. ≡ unacceptable condition(s); U.C.C. ≡ unacceptable conditions common). See *Table 12* and text description for more information on available data.

Parameter	GA DNR	Other Recommendation(s) or Guideline(s)	KEMO NBP
General Water Quality Parameters			
Dissolved oxygen (mg/L)	≥ 5 daily avg.; minimum 4	≥ 4 (U.S. EPA 2000)	Few dates with DO < 5
pH	≥ 6.0, ≤ 8.5	> 6.5, < 9.0 (U.S. EPA 2000)	No violations
Fecal Coliforms (cfu/100 mL)	≤ 1,000 Nov-Apr; ≤ 200 May-Oct (g.m.)	400 for data collected with insufficient frequency to calculate g.m.s by the State's criteria (U.S. EPA 2003)	Insufficient data collection for g.m.s, but some values > 400 indicate degraded conditions (max. 51,600)
Nutrients	----	< 100 µg/L for total phosphorus and for inorganic nitrogen nitrate+nitrite, and/or ammonium) to discourage noxious algal blooms (Mallin 2000)	Data indicate excessive conditions especially for inorganic N
Biochemical oxygen demand	----	Less than 3.0 mg/L as the 5-day biochemical oxygen demand (BOD_5) (Mallin et al. 2006)	Limited data - 1 U.C.
Total suspended solids (TSS)	----	≤ 25 mg/L, and < 10 mg/L increase from a sudden spike (U.S. EPA 2000)	Limited data - no U.C.s
Toxic metals (µg/L)			
Aluminum	Equations*	CMC 750, CCC 87 (U.S. EPA 2000, 2002**	Limited data – U.C.C.
Cadmium	"	CMC 2, CCC 0.25 (U.S. EPA 2000, 2002)**	Limited data – U.C.C. In John Ward Cr.
Chromium III	"	CMC 570, CCC 74 (U.S. EPA 2000, 2002)**	Data not available
Chromium IV	"	CMC 16, CCC 11 (U.S. EPA 2000, 2002)**	Data not available
Copper	"	CMC 13, CCC 9 (U.S. EPA 2000, 2002)**	1 U.C.C.
Lead	"	CMC 65, CCC 2.5 (U.S. EPA 2000, 2002)**	Several U.C.
Mercury	"	CMC 1.4, CCC 0.77 (U.S. EPA 2000, 2002)**	Data not available
Nickel	"	CMC 470, CCC 52 (U.S. EPA 2000, 2002)**	Data not available
Zinc	"	CMC 120, CCC 87 (U.S. EPA 2000, 2002)**	No U.C.

* Dissolved concentrations; equations have been developed that express the total recoverable concentration depending upon the water hardness or pH.

** Water quality guidelines (reference condition, 25^{th} percentile – also see Byrne 2004). CMC ≡ the criterion maximum concentration; CCC ≡ the criterion continuous concentration, within a pH range of 6.5-9.

Impaired Surface Water Quality and Habitat

In 1996 and 1998, both Noses Creek and John Ward Creek, including the park segments, were on Georgia's 303(d) list of impaired waters as not supporting fish/fishing, because of fecal coliform bacteria and lead pollution that was attributed to urban runoff/stormwater effects. By 2004, the U.S. EPA (2004) listed John Ward Creek as impaired but listed Noses Creek as "fully attaining" its designated uses, despite the fact that several streams draining into Noses Creek were listed as impaired, and fecal coliform densities were comparably high in Noses and John Ward Creeks.

The most recent GA DNR (2008b) 303(d) list of impaired streams contains Noses Creek (headwaters down to [John] Ward Creek – 7 miles of stream length) based upon not meeting its designated use to support fish communities [Bio(F)]), and [John] Ward Creek from its headwaters to Noses Creek (6 miles of stream length) based upon fish habitat degradation (Bio(F)) – including the park segments for both streams. The potential cause listed for the degradation of Noses Creek and John Ward Creek was (unspecified) nonpoint runoff and urban runoff, respectively. In addition, John Ward Creek (headwaters down to Noses Creek) is listed as impaired for unacceptably high fecal coliform concentrations and sediment loads (GA DNR 2008a,b). The sources of the sediment loads are listed in *Table 18*; such partitioning among land use types was not attempted for sources of fecal coliforms.

Table 18. Estimated contribution of land use type to sediment loading for biota-impacted Noses Creek and John Ward Creek (GA DNR 2008a).

Source	Noses Creek (tons per year)		John Ward Creek (tons per year)	
Open water	0.0	(0.00%)	0.0	(0.00%)
Low-intensity residential	91.8	(6.77%)	229.4	(29.57%)
High-intensity residential	1.9	(0.14%)	4.6	(0.59%)
High-intensity comm/ indust/ transp	0.4	(0.03%)	0.4	(0.05%)
Roads	200.6	(14.80%)	420.8	(54.24%)
Clearcut, sparse	0.0	(0.00%)	0.0	(0.00%)
Quarries, strip mines, rocks	928.4	(68.49%)	---	
Deciduous forest	15.4	(1.14%)	4.5	(0.58%)
Evergreen forest	7.4	(0.55%)	5.7	(0.74%)
Mixed forest	0.2	(0.02%)	0.3	(0.04%)
Deciduous shrubbed	0.8	(0.06%)	0.2	(0.02%)
Row crops, pasture	74.4	(5.49%)	23.5	(3.03%)
Other grasses (urban, recreational)	26.7	(1.97%)	73.1	(9.43%)
Forested wetland	7.4	(0.54%)	13.3	(1.71%)
Non-forested wetland (fresh)	---		---	

John Ward Creek was evaluated for a TMDL targeting sediment loads in 2003, and a TMDL for fecal coliforms was also completed in 2003 (GA DNR 2003; **http://oaspub.epa.gov/tmdl/enviro.control?p_list_id=GA-R031300020208**). for Draft TMDL plans targeting Bio(F) became available for Noses Creek and John Ward Creek in 2007, and a TMDL targeting fecal coliform loads was completed for John Ward Creek in 2007 (*Table 19*).

GA DNR's management strategies to reduce contamination in impaired streams in urban areas include sustained compliance with NPDES permit limits and requirements; adoption of National Resource Conservation Service Conservation Practices; application of best-management practices that are appropriate to specific agricultural and urban land uses; further development and streamlining of mechanisms for identifying, reporting, and correcting illicit connections, breaks, and other sanitary sewer or waste containment problems; for fecal coliforms, adoption of local ordinances requiring periodic septic system inspection, pumpout, and maintenance; and public education (GA DNR 2003, 2008a).

Table 19. TMDLs developed for Noses Creek and John Ward Creek, including stream segments within KEMO NBP (GA DNR 2003, 2008a).

Stream	Present Load	Reduction Needed	Allowable Average Load	Waste Allocation	Maximum Daily Load
Sediment TMDL (Biota-Impacted, 2003)					
Noses Creek	1,356.6 tons/year	79.59%	276.9 tons/year	193.0 tons/year	35.7 tons
John Ward Creek	775.8 tons/year	57.51%	337.4 tons/year	236.2 tons/year	43.5 tons
Fecal Coliform TMDL (General Recreation, 2008)*					
John Ward Creek	5.79×10^{11} counts/30 days	37%	3.65×10^{11} counts/30 days	2.11×10^{11} counts/30 days	see footnote

*30-day geometric mean for bacterial counts (colony-forming units)

Air Quality

Air Quality Standards

The federal Clean Air Act has set standards for six "criteria" pollutants (*Table 20*). These standards are fairly straightforward except for the $PM_{2.5}$ standard: To be in compliance with the federal air $PM_{2.5}$ standard, an area must have an annual arithmetic mean concentration of $\leq$ 15 µg $PM_{2.5}$ /m^3. As an additional requirement (recently altered as of Dec. 2006), the 98th percentile 24-hour concentration must be $\leq$ 35 µg $PM_{2.5}$ /m^3 (GA DNR 2007b).

The Ambient Monitoring Program of the Air Protection Branch of GA DNR-EPD has monitored the state's air quality for more than 30 years, now including more than 200 pollutants. The regulatory standard is health-based, and concentrations above the standards are considered unhealthy for sensitive groups (GA DNR 2007b). Another set of compounds, for which ambient air regulatory standards have not been set, is monitored in the Air Toxics Network; sources of these substances include vehicle emissions, stationary source emissions, and natural sources. Data from EPD's continuous monitors are published on EPD's web site at http://www.georgiaair.org/amp. The data are updated hourly.

An ambient air monitoring station (site #130670003 – National Guard) at Kennesaw, GA monitors for ozone and fine particulate matter. Ozone is monitored in March through October since that period is when ozone production mostly occurs. Ozone is a serious health concern because it attacks the mammalian respiratory system, causing coughs, chest pain, throat irritation, increased susceptibility to respiratory infections, and impaired lung functioning. In fact, moderate ozone levels can interfere with performance of normal daily activities by people who have asthma or other respiratory diseases. Of more concern than acute affects are potential chronic effects of repeated exposure to ozone, which can lead to lung inflammation and permanent scarring of lung tissue, loss of lung function, and reduced lung elasticity. All of Cobb County is in an ozone non-attainment area (GA DNR 2007b).

Fine particulate matter ($PM_{2.5}$) is $\leq$ 2.5 µm in diameter, and is produced by various sources including industrial combustion, residential combustion, and vehicle exhaust, or when combustion gases are chemically transformed into particles (GA DNR 2007b). The state monitors 53 particle species such as gold, sulfate, lead, arsenic and silicon. Recent research has indicated that $PM_{2.5}$ is a human health concern because it can penetrate into sensitive areas of the lungs and cause persistent coughs, phlegm, wheezing, more serious respiratory and cardiovascular disease, cancers, and premature death at particle levels well below the existing

standards (U.S. EPA 2004, GA DNR 2007b). Mounting evidence indicates that $PM_{2.5}$ also enhances delivery of other pollutants and allergens deep into lung tissue where the effects are exacerbated. Especially sensitive groups include children, the elderly, and people with cardiovascular or lung diseases such as asthma. $PM_{2.5}$ also impair visibility and contribute to haze in the humid conditions that characterize the north Georgia climate (U.S. EPA 2004).

Air Resources

Air quality is a major concern in the park, since the adjacent City of Atlanta has high levels of air pollution and haze that, at least as far back as 1992, sometimes obscured the view of the park's historic landscape (NPS 1992c,d). The Georgia metropolitan area is in compliance for four criteria air pollutants, but is commonly in violation of the ozone and $PM_{2.5}$ standards (e.g. *Figure 6*). The data from the state's Kennesaw ambient air quality monitoring site show that all of Cobb County has been in violation of the ozone standard every year for the past five years (GA DNR 2007b; *Figure 7*).

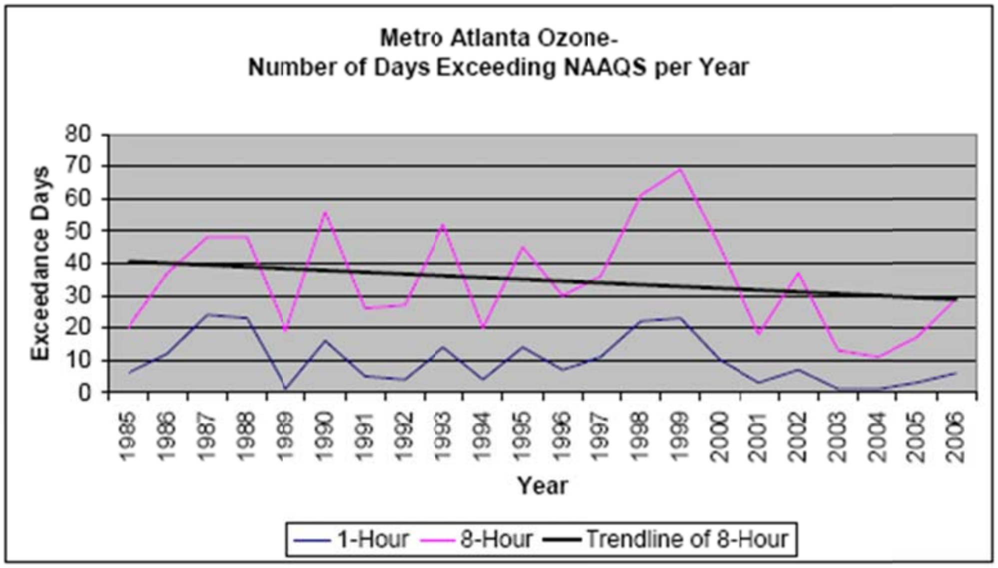
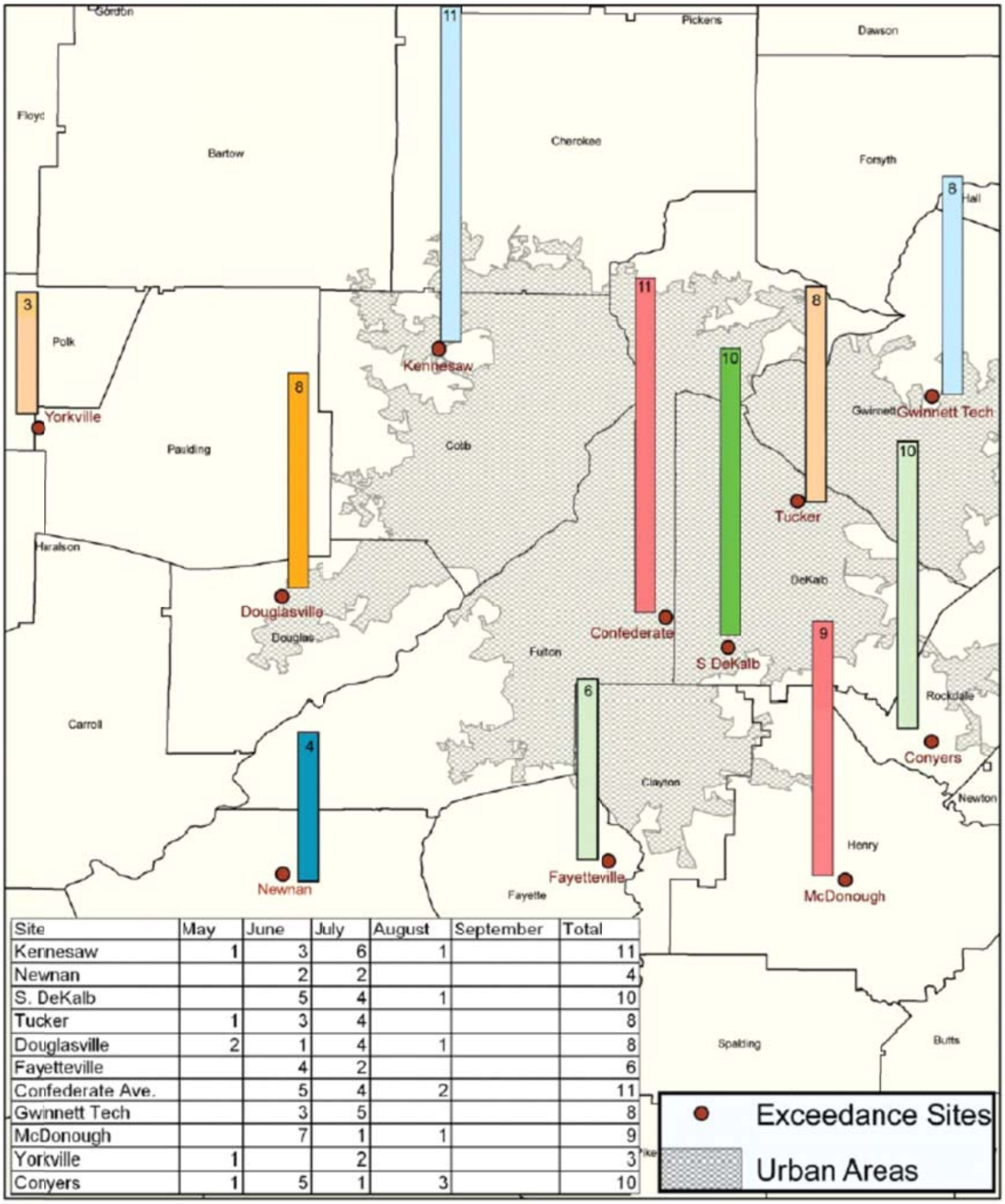


Figure 6. Metropolitan Atlanta ozone – number of violation days per year (GA DNR 2007).

Moreover, all of Cobb County has been in violation of the annual arithmetic mean $PM_{2.5}$ concentration ($\leq$ 15 µg $PM_{2.5}$ /m^3) each year for the past five years, and also in violation of the 98^{th} percentile 24-hour concentration ($\leq$ 35 µg $PM_{2.5}$ /m^3) (*Figure 8*). It is anticipated that air quality, including smog, ozone, particulates, and many other contaminants (GA DNR 2007b), will continue to degrade with increasing growth of the Atlanta metropolitan area (Atlanta Regional Commission 2007). In addition, more than 15 million cars travel through the park each year (DeVivo 2005), adding nitrous oxide, lead and other heavy metals, carbon monoxide, ozone, particulates and other pollutants. Other traffic with air pollution is contributed by diesel trucks going to/from the nearby Cobb County landfill located ~1 mile south of the park.

Table 20. U.S. EPA standards for six “criteria” pollutants as required by the Clean Air Act, indicating recent modifications (cross-outs; GA DNR 2007b).

Compound	Primary Standard	Secondary Standard	Units	Time Interval
Sulfur dioxide (SO2)	----	0.50	ppm	3-hour
	0.14	----	ppm	24-hour
	0.03	----	ppm	annual mean
Particulate matter (PM2.5)	15.0	same as primary	µg/m3	annual arithmetic mean (3 years)
	98th percentile 65.0 a/35.0	same as primary	µg/m3	24-hour
Particulate matter (PM10) mean	50.0 b	same as primary	µg/m3	annual arithmetic
	150.0	same as primary	µg/m3	24-hour
Carbon monoxide (CO)	2nd maximum 35.0	----	ppm	1-hour
	2nd maximum 9.0	----	ppm	8-hour average
Ozone (O3)	4th maximum 0.085	same as primary	ppm	8-hour average
Nitrogen dioxide (NO2)	0.053	same as primary	ppm	annual mean
Lead (Pb)	1.5	same as primary	µg/m3	calendar quarter



Site	May	June	July	August	September	Total
Kennesaw	1	3	6	1		11
Newnan		2	2			4
S. DeKalb		5	4	1		10
Tucker	1	3	4			8
Douglasville	2	1	4	1		8
Fayetteville		4	2			6
Confederate Ave.		5	4	2		11
Gwinnett Tech		3	5			8
McDonough		7	1	1		9
Yorkville	1		2			3
Conyers	1	5	1	3		10

Figure 7. Ozone monitors in metropolitan Atlanta that exceeded the 8-hour ozone standard in 2006, including the monthly breakdown of exceedances.

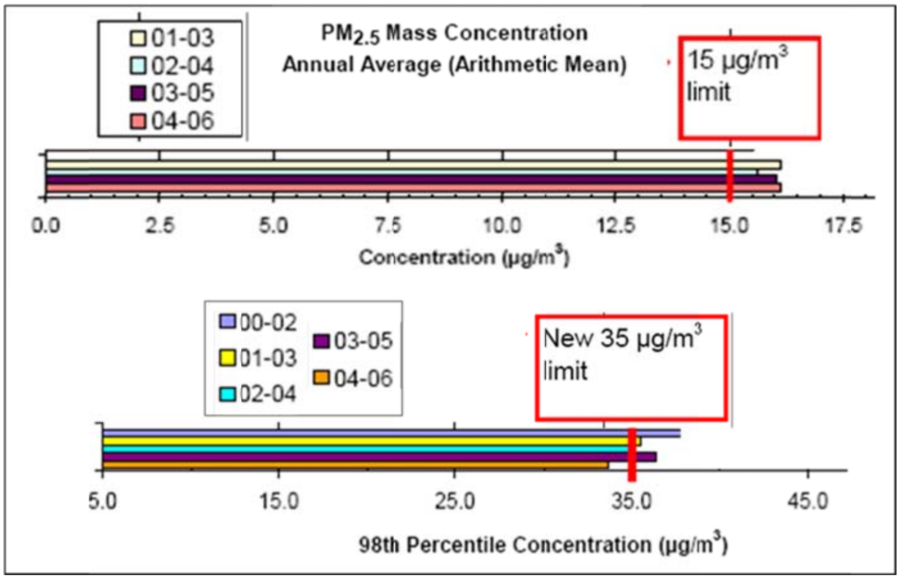


Figure 8. $PM_{2.5}$ design value, daily standard, showing exceedances at Kennesaw of the old standard in all years, and exceedances of the new standard.

Acid deposition can adversely affect or kill aquatic life and harm human health (Abelson 1987, Baker and Christensen 1992), and can act synergistically with ozone to harm human health as well (Abelson 1987). The state of Georgia has four acid deposition sites, including three in north Georgia (Summer- Dawsonville, and Hiawassee) and one in central eastern Georgia (McDuffie County). As mentioned, among regions throughout the country, north Georgia has been evaluated as most at risk for continued acid deposition (Herlihy et al. 1991). The four sites monitor acid deposition weekly, and the data show a significant increasing trend for acid deposition in north Georgia (*Figure 9*).

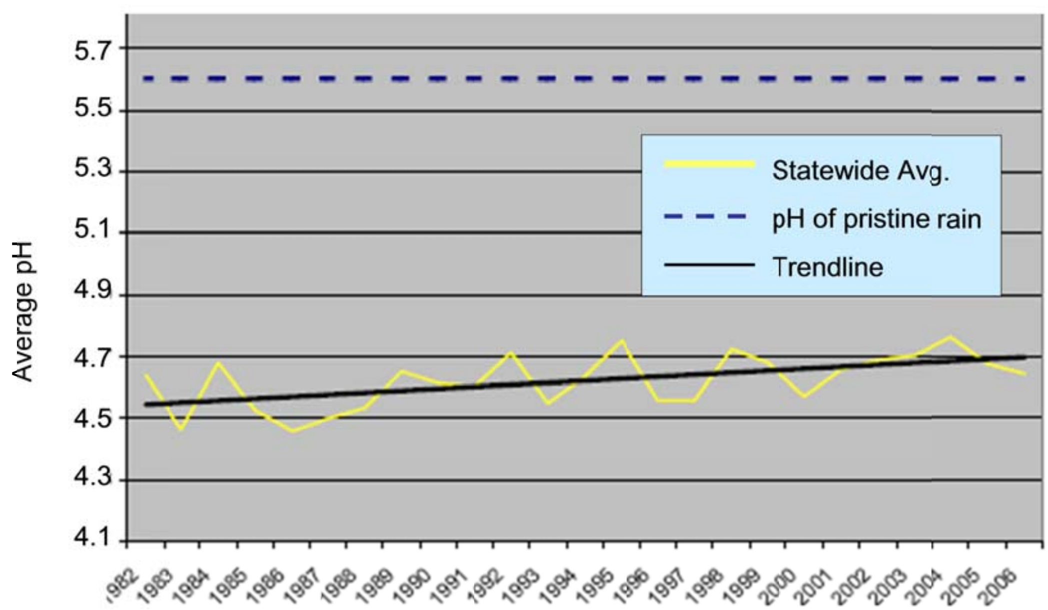


Figure 9. Statewide acid deposition trends (1982-2006; GA DNR 2007).

The effects of the many air pollutants on the park's natural resources remain to be examined, and likely include synergistic interactions. It is thought, for example, that the risk of foliar ozone injury to terrestrial plants in the park probably is high because the park is exposed to potentially harmful levels of ozone each year.

Drinking Water

Treated water from the Chattahoochee River is the potable water source for the park (Georgia Department of Audits and Accounts 2005). Cobb County is within the Metropolitan North Georgia Water Planning District, a planning entity for 16 counties that was created to address increasing water resource requirements in the area. It is predicted that by 2030, all major sources of water supply in this area may be fully tapped because of rapid population growth (Georgia Department of Audits and Accounts 2005).

Groundwater

As mentioned, groundwater resources are considered to be under-utilized in Cobb County and have been targeted as a potential supplemental resource during peak demand periods, under drought conditions, or as water demand increases in the metropolitan Atlanta area (Chapman and Peck 1997, GA Department of Audits and Accounts 2005).

Ecosystem Effects

Urban Pollution and Aquatic Food Webs: During 1998-2003, GA DNR studied fish populations in the Chattahoochee River basin, and used an Index of Biotic Integrity (IBI) and modified Index of Well-Being (IWB) to identify fish population health as Excellent, Good, Fair, Poor, or Very Poor. Noses Creek and John Ward Creek were among the 25 stream segments in the Piedmont ecoregion with fish populations that were evaluated as impaired. Noses Creek received a Fair ranking from the IWB but a Poor IBI score, and John Ward Creek was evaluated by both indices as Very Poor. As mentioned, the general cause identified for the impairment is lack of viable fish habitat due to stream sedimentation (GA DNR 2008a). Fish are at the apex of the stream food webs. Their Fair/Poor to Very Poor rankings suggest that urban pollution has caused serious degradation and loss of biodiversity for the park's aquatic flora and fauna in other trophic levels, as well. The stream and wetland food webs likely are also affected by pathogenic microbes whose presence is indicated, to some extent, by high fecal coliform bacteria densities, and by toxic substances from urban runoff.

Air Pollution and Park Land Resources: There is a high potential that terrestrial communities in the park are being adversely affected by air pollutants such as ozone that can cause foliar injury, but data for assessment are not available (DeVivo 2005).

Invasive/Exotic Species: The southern pine beetle infestation has killed thousands of pine trees throughout the park since the early 1990s, and the resulting increase in fuels lying on the forest floor are an increased fire risk. Some terrestrial plant species are also of concern. Little is known about the potential for impacts from exotic/invasive terrestrial animal species, and information is lacking as to whether exotic aquatic species threaten the park's surface waters and wetlands.

Nuisance Species: Two terrestrial animal species have been identified as species of concern, both of which appear to be increasing in number within the park: Overgrazing activity by white-tailed deer can depress forest regeneration. Beavers' damming activities can alter water flow and water quality. Feral dogs and cats have been mentioned as a concern, especially the potential for feral cats to affect various bird species (Watson 2005). An additional concern is that increased urbanization surrounding the park may promote an increase in foxes, coyotes, and deer (the latter, leading to more car accidents and poaching; Chief Ranger L. Morris, pers. comm., November 2006).

Human Health Issues

The routinely high fecal coliform densities in the park's two perennial streams jeopardize use of these surface waters for general recreation, including water contact during fishing activities. Moreover, there is strong potential for adverse chronic impacts of ozone and $PM_{2.5}$ air pollutants on the health of park staff and frequent visitors.

Other Issues of Concern

Population Growth

Upstream from the park, the city of Marietta is also rapidly growing; between 2000 and 2007, its population increased by 7.5%, and in the Marietta area there are 2,883 people per square mile (**http://www.bestplaces.net/city/ Marietta-Georgia.aspx**). Casting a bit wider net to consider the adjacent Atlanta-Sandy Springs-Marietta metropolitan area, as of 2007 the area population was 5,138,233 people, more than the populations of 24 other states combined (U.S. Census 2006). *From 2000 - 2007, the population has grown by 21%, an increase of nearly 130,000 people per year* (**http://www.bestplaces.net/Metro/Atlanta-Sandy_Springs-Marietta-Georgia.aspx**). It has been estimated that by 2025-2030, 2,206,000 people will be employed in the Atlanta metropolitan area, representing growth of 40% over the 2000 employment base (ARC 2001). The overall population is projected to increase more than 50% by about the same period (2030; CH2MHill 2003). Major construction of industrial, commercial, and housing developments has occurred over the past two decades and continues to rapidly expand around the park periphery. The fact that this national battlefield park ironically is under chronic, progressive siege from increasing urbanization is yet clearer considering that KEMO NBP represents more than a quarter of the natural greenspace area left within the Atlanta metropolitan area.

Physical Impacts From Park Activities

The park is not planning further development except for minor improvements to accommodate visitor parking at interpretative areas (NPS 1997b; L. Morris, pers. comm., Nov. 2006).

Continuous Land Impacts

Visitation numbers for KEMO NBP reflect the rapidly growing population of the greater Atlanta metropolitan area: In 1990 park attendance was 784,310. In 2006, it was almost 1.5 million (Strack and Miller 2008). Hiking trails in the park receive increasingly heavy use, and the trail system is affected by heavy foot traffic and heavy rains especially during summer months. Storms can cause washout as deep as 12 inches in some trail sections, and trail shortcuts create serious potential damage to fragile Civil War earthworks. The eroded trails also are a potential safety problem.

Horse trails and in-stream crossings within the watersheds of the streams that flow through the park, and equestrian activities that occur in the park, may contribute to degraded stream structural integrity and water quality (Zubricki 1993).

Directly related to urban encroachment surrounding the park, the numerous shared boundaries between the park and private landowners have led to multiple "social" trails, especially along the park's southwest boundary (DeVivo 2005). In addition, this urban park sustains frequent illegal dumping of trash and other refuse by adjacent land owners, developers, etc. (DeVivo 2005).

Impacts From Dobbins Air Force Base

The park lies within the in-flight path for Dobbins Air Force Base, and increased air traffic over the park has contributed to both air pollution and increased noise (DeVivo 2005).

Synopsis of Stressors to KEMO NBP

The present and potential stressors that are affecting or may affect KEMO NBP are summarized in *Table 21*. Overwhelmingly, the most pressing stress on the natural resources of the park is encroaching and upstream urban development, and its multitude of associated impacts. In the past two years, park natural resources have continued to be pressured by increasing suburban land use – as examples, 42 acres have been developed off old Highway 41 NW adjacent to the park, as well as areas east and south of the park. Cobb County continues plans for road and highway expansions near the park (NPS 1997b; Chief Ranger L. Morris, pers. comm., Nov. 2006). The amount of stormwater runoff from urban areas has increased dramatically over the past 30 years in the metropolitan Atlanta area, including Cobb County (Georgia Department of Audits and Accounts 2005).

Table 21. Present-day and potential stressors that are affecting or may affect KEMO NBP (ND ≡ no data or insufficient data to make judgment; --- ≡ not applicable; NP ≡ no problem; EP ≡ existing problem; PP ≡ potential problem).

Stressor	Surface Waters	Groundwater	Airshed	Forest	Human Health
Acidification	EP	ND	EP	EP	EP
Air traffic (noise and air pollution)	ND	ND	EP	ND	ND (PP)
Algal blooms	ND	---	---	---	ND
Encroaching urbanization*	EP	ND (PP)	EP	EP	EP
Erosion (including dust)	EP	ND	EP	EP	NP
Excessive nutrients**	EP	ND	EP	ND	NP
Exotic invasive species	ND (PP)	---	ND	EP	ND
Fecal bacteria, other microbial pathogens	EP	ND	ND	ND	EP
Habitat disruption	EP	ND	---	EP	EP
Highway construction*	EP	ND (PP)	ND (PP)	ND	EP*
Hypoxia	ND	---	---	---	NP
Metals contamination	EP	ND (PP)	ND (PP)	ND	ND
Ozone pollution	ND	---	EP	EP	EP
Other toxic substances	ND (PP)	ND (PP)	EP	ND	EP
Particulate matter pollution	EP	ND	EP	EP	EP
Sedimentation	EP	ND	EP	---	EP
Trash/refuse pollution	EP	ND	---	EP	ND
Water demand	NP (PP)	NP	---	NP	NP (PP)

* Will increase likelihood of collisions with wildlife.
** Via more air pollution because of car exhausts as well as other sources.

The increasing demands on water supplies from human population growth may pose a threat to groundwater resources in the vicinity of the park in the coming decades. At present, though, human population growth and urban sprawl with accompanying water and air degradation are the major stressors affecting the park's surface waters and other natural resources. In a situation that typifies many other parks in the SECN (Byrne 2004), the surface waters of this park are downstream from 303(d)-listed degraded waters outside NPS jurisdiction. Thus, it is not surprising that the park's surface waters also are included in the state's 303(d) list as impaired for supporting fish because of excessive sedimentation (both streams), and impaired for general recreation (John Ward Creek) because of high fecal coliforms. Although Noses Creek presently is not on the state's 303(d) list for high fecal coliforms, fecal coliform densities in that stream are comparable to those of John Ward Creek based upon data from Cobb County. Sedimentation from development-related land disturbance upstream of the park, and surrounding the park, is seriously affecting the park's stream segments, both water quality and aquatic life. There is high potential that associated pollutants such as excessive nutrients, heavy metals, pesticides, and other toxic contaminants are adversely affecting the park's streams as well. Microbial pathogens that may be present, indicated to some extent by high fecal coliforms, may be adversely affecting fish and other aquatic life.

There is also high potential that surface water quality and aquatic communities are sustaining impacts from air pollution including acidification, mercury and other heavy metals, pesticides etc. The seasonal or lower frequency of sampling to evaluate water quality is insufficient to detect the spikes in these pollutants that are known to occur depending upon weather patterns. Thus, for example, available pH data are inadequate to evaluate the extent to which acid spates (sudden influxes of highly acidic water at the beginning of storm events) are affecting the aquatic food webs (e.g. Morris et al. 1989). Air pollution likely is also adversely affecting terrestrial vegetation, for example, as foliar damage from high ozone in the park area. In addition, the high ozone and $PM_{2.5}$ levels in the Park airshed pose a threat to the health of park staff and frequent visitors.

Invasive/ exotic species are adversely affecting the park's land resources. The southern pine beetle infestation, for example, has killed thousands of pine trees and increased fire risk from the resulting deadfall debris, and several terrestrial plant species are also of concern. Increasing abundance of beavers and white-tailed deer also pose potential stresses on the park's natural resources. Information about aquatic invasive/exotic species is lacking.

Other stressors to the park's natural and historic resources include heavy use and erosion of hiking trails, equestrian activities that occur within and upstream from the park, the creation of multiple "social" trails through sensitive park lands because of shared boundaries between the park and suburban developments, and frequent illegal dumping of trash and other refuse.

The looming major factor that will exacerbate virtually all of these stresses is the rapid, extreme population growth of the Atlanta metropolitan area.

Recommendations To Address Impairments, Potential Impacts, and Undocumented Water Bodies

General Comments

Government-managed lands comprise 29% of the U.S. land area (Gibbons et al. 1997), including more than 32 million hectares set aside within the National Park System (Stohlgren et al. 1995). Thus, the National Park System is a major factor in the potential for this nation to protect natural lands and biodiversity. The parks and their natural resources are supposed to be “protected lands” for present and future generations of U.S. citizens, but external encroaching stressors from watershed development and habitat fragmentation are seriously threatening these critically important refuge areas, including KEMO NBP. Another major threat is the lack of fundamental data to evaluate present status. Such data are needed to guide improved management strategies to protect these important national resources.

KEMO NBP, within the Atlanta metropolitan area, is vulnerable to encroaching and surrounding urbanization. The NPS is ill-equipped to protect its vitally important water resources from airshed and watershed pollution and other stressors because the stressors, for the most part, are outside of NPS control. In addition, there is inadequate information on water quality conditions or aquatic community health. Few data are available on aquatic flora and fauna, mostly limited to surveys of species occurrence.

About 15 years ago, KEMO NBP’s Water Resources Monitoring Study Plan (NPS 1992b, Zubricki 1993) identified concerns about upstream and surrounding construction and other municipal and industrial activities that were expected to adversely affect water quality, including acidification of park streams from atmospheric acid deposition. Other expressed concerns included agricultural runoff from upstream horse facilities and septic tank leachate within the watersheds of the two streams draining the park. None of these concerns have changed, except for a dramatic increase of all of the urban stressors that have accompanied the past 15 years of rapid human population growth and development in the area. Nor, as of yet, have the concerns identified 15 years ago begun to be effectively addressed.

Within the past five years, the state has developed several TMDLs for Noses Creek and John Ward Creek. They are supposed to be “platforms for establishing courses of actions to restore water quality” (GA DNR 2003); procedures are to be set in place to track and evaluate implementation of corrective management practices and activities. Considering that KEMO NBP was set aside, as an important par of this nation’s heritage, to honor more than 65,000 U.S. soldiers who were wounded or died there – and considering that the upstream and surrounding impacts of urbanization are beyond the park’s direct control – it is imperative that the state of Georgia legislature and environmental agency track and ensure the effectiveness of the TMDLs for Noses Creek and John Ward Creek. The following additional recommendations can be addressed within NPS jurisdiction.

Specific Recommendations

Water Quality

- A top priority is to conduct a two-year water quality monitoring program in the park segments of Noses Creek and John Ward Creek with biweekly (preferably, to capture effects of pollution from storm events) or monthly sampling frequency to track water quality conditions in the park. Two stations on each stream, including inflow and outflow from the park, should be sampled for, at a minimum, water temperature, pH, dissolved oxygen, suspended solids, turbidity, nutrients (TN, TP, nitrate, ammonium, BOD_5), fecal coliform densities, and chlorophyll a concentrations. This effort should be repeated at five-year intervals. Benchmarks for acceptable water quality should consider the information contained in Table 17.

- Data should be collected at least annually on toxic substance concentrations (PCBs, heavy metals, pesticides, pharmaceuticals) in sediments and fish or benthic faunal tissues. Published benchmarks for acceptable water quality for streams with designated use for Fishing should be used to evaluate the information.

- The park should inventory changes in land use/land cover in the watersheds of the two perennial streams upstream from and surrounding the park, including traditional categories but also septic tanks in new subdivisions, new highway projects, new shopping centers, and other potential sources of water pollution. The data should be used to create GIS maps of these sources, which can be upgraded over time to help the NPS track pollution and its impacts in park waters.

Ecosystem and Community Health

- At least once per year during an appropriate seasonal timeframe, the macroinvertebrate communities in John Ward and Noses Creeks should be assessed in at least two stations, following the protocol in Barbour et al. (1999). Benchmarks should consider published descriptions of healthy macroinvertebrate communities in warmwater streams (e.g. Barbour et al. 1999, GA 2007). The data should be used to track stream ecological condition (rated from Excellent to Poor) over time.

- At least once per year during an appropriate seasonal timeframe, the fish community in the park segments of John Ward and Noses Creeks should be assessed, following the protocol outlined in Barbour et al. (1999). The fish data should be used to develop an Index of Biotic Integrity and an Index of Well-Being for fish population health over time (Barbour et al. 1999).

- A sampling program should be developed to establish present conditions and track exotic invasive species affecting terrestrial as well as aquatic/wetland sources in the park. Assessment of exotic invasive species should be repeated at least at three-year intervals to enable detection of species that may rapidly invade.

- The park's wetland ecosystems should be assessed at five-year intervals for indices of diversity, function, and overall health.

- An updated biological inventory should be completed for herpetofauna, following the protocol outlined in Tuberville et al. (2005).

- A baseline biological inventory is needed for the composition and abundance of benthic microalgal assemblages following protocols in Wetzel and Likens (2001). The benthic microalgal (periphyton) data should be used to develop an index of biotic integrity (e.g. following Hill et al. 2000) for the Ocmulgee River and Walnut Creek in the park area.

- The NPS should assess incidence of foliar injury to park plants from ozone pollution, including common wetland bioindicator species such as yellow poplar and American elder. More generally, data are needed to assess the extent to which air pollution is affecting the park, and to forecast how increasing air pollution from the greater Atlanta metropolitan area will affect its waters and other natural resources. Sampling devices should be installed to establish present conditions and track air pollutants such as ozone, $PM_{2.5}$, and mercury.

- Park staff should monitor the two perennial streams for erosion of the stream banks, which is commonly related to upstream urban watershed activities. Park staff should also check for tree damage from beavers, which can lead to increased bank erosion. Construction of beaver dams within the park should not be permitted, since this would increase on-site flooding and threaten cultural resources.

Groundwater

- Groundwater resources of the park should be assessed through partnership with the USGS, including recharge/discharge areas, movement, and chemical quality.

Education Outreach

- KEMO is a critically important greenspace for the greater Atlanta metropolitan area. The park should strengthen its environmental education program to inform visitors about the importance of greenspaces in ecosystem sustainability.

Other Action

- The NPS should pursue actions to protect remaining undeveloped lands (e.g. increase in greenspace setasides) adjacent to the park to target a goal of protecting and growing buffer areas around the park.

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Appendix A. Available data for water quality conditions at or near the park

Table A-1. Available data for water quality conditions at or near the park over the past ~decade, also indicating unacceptable conditions (not replicated; n = 1). See Figure 3 for station locations. Turb. ≡ turbidity, cond ≡ specific conductance, NOx ≡ nitrate+nitrite, FC ≡ fecal coliforms, SS ≡ total suspended solids, and n.a. ≡ not available. Underline and bold ≡ data in violation of state standard (GA DNR 2008d), except for fecal coliforms. Data for fecal coliforms were not collected with sufficient frequency to enable calculation of geometric means, used for the State standards for the Fishing designated use (see pp. 41-42 of this Report). The values underlined in bold exceeded the bacteria water quality standard values considered for geometric means (> 200 mpn/100 mL during May – October; > 1,000 mpn/100 mL during November – April) and suggest degraded conditions. Blue and bold ≡ can support noxious algal blooms (see Table 17). Bold shaded ≡ data exceeded recommended values for acceptable water quality (see Table 17). Note that the U.S. EPA (2002) recommends that pH be maintained within the range 6.5-9; this Report, however, follows Georgia regulations (pH > 6.0).

Date	DO (mg/L)	pH	TURB (ntu)	BOD_5 (mg/L)	COND (µmhos/cm)	TP (µg/L)	TKN (µg/L)	NO_X (µg/L)	Fecal Coliforms (mpn/100 mL)	TSS (mg/L)
John Ward Creek WR1										
19-Mar-98	10.1	7	2.4	1	123	**150**	200	**1,500**	250	1.8
1-Jun-98	8.9	7.1	2.2	<1.0	124	**150**	200	**1,250**	**2,500**	1.8
23-Jul-98	6.4	7.3	9.1	**4**	82	**150**	270	**1,170**	n.a.	7.2
8-Jul-99	6.7	6.5	7.1	<1.0	101	**150**	520	**1,020**	**4,400**	23.4
16-Feb-00	9.6	7.1	2.7	1.2	123	**150**	550	**1,310**	220	4.4
3-Jul-00	4.1	6.4	2.7	1	110	**100**	570	**330**	300	2.4
31-Oct-00	5.5	7.3	1.1	1	130	**100**	300	**490**	**1,872**	1.4
21-Mar-01	11.2	7.2	2.4	<1.0	165	50	670	**1,460**	200	<1.0
18-Jun-01	7.1	7.2	2.9	1	138	50	520	**1,220**	**1,250**	<1.0
2-Aug-01	7.2	7.3	2.7	<1.0	133	50	700	**1,220**	**700**	<1.0
7-Nov-01	7.9	6.8	1.3	1	145	50	540	**410**	**250**	1.4
27-Feb-02	12.4	6.7	3.1	1	116	50	940	n.a.	33	1.3
10-Jun-02	6.8	6.7	2.1	1	141	50	260	**810**	**650**	<1.0
20-Aug-02	5.7	6.5	2.7	1	118	50	700	**200**	**1,050**	<1.0
14-Nov-02	8.7	6.8	2	1	138	50	280	**990**	300	<1.0
19-Feb-03	10.2	6.8	1.9	1.2	133	50	330	**1,480**	**1,250**	<1.0
5-May-03	7.2	6.9	2	1	137	50	480	**1,170**	**3,000**	1.9
9-Sep-03	7.2	6.9	1.2	1	123	50	1,080	**1,320**	475	1.5
2-Dec-03	9.7	6.7	1.4	1	129	50	1,020	**1,310**	50	<1.0
4-Mar-04	8.4	6.5	1.3	1	127	50	710	**1,190**	140	2.2

Table A-1. (Continued).

Date	DO (mg/L)	pH	TURB (ntu)	BOD_5 (mg/L)	COND (µmhos/cm)	TP (µg/L)	TKN (µg/L)	NO_X (µg/L)	Fecal Coliforms (mpn/100 mL)	TSS (mg/L)
26-May-04	6.5	6.9	2.2	1	125	50	270	**1,260**	**450**	1.2
18-Aug-04	7	6.7	1.2	1	123	50	330	**1,240**	**600**	<1.0
27-Dec-04	10.8	6.5	1.5	1	139	50	480	**1,560**	**750**	2
19-Apr-05	8.8	6.7	1.3	1	127	20	140	**1,400**	160	<1.0
28-Jul-05	7.4	6.9	1.8	1	124	20	250	**1,680**	350	1.3
15-Sep-05	7.1	7.2	1.4	1	134	20	250	**1,450**	**1,100**	<1.0
12-Jan-06	5.5	7	1.3	1	126	20	340	**1,190**	20	<1.0
5-Apr-06	8.9	6.9	1.6	1	135	<10	280	**1,320**	100	<1.0
12-Jun-06	6.5	7	2.3	1	140	30	190	**1,110**	**2,250**	1.3
18-Sep-06	7.4	7.1	1.9	1	130	20	180	**1,050**	n.a.	2.2
18-Dec-06	8.5	6.7	1.8	<1.0	136	20	<100	**1,220**	100	<1.0
8-Mar-07	10	6.9	1.5	1	116	<10	160	**1,460**	**450**	<1.0
24-May-07	6.6	6.9	2.5	1	126	40	230	**870**	**460**	2
1-Aug-07	6.4	7	1.6	1	139	20	<100	**980**	200	1.3
20-Nov-07	5.7	6.8	1.5	1.8	117	20	140	**480**	**1,450**	1.3
24-Mar-08	10.2	6.8	1.7	<1.0	142	20	120	**1,450**	400	1.1
John Ward Creek WR2										
19-Mar-98	11.1	7.4	3	1.6	137	**150**	200	**1,020**	250	1.6
1-Jun-98	8.1	7.4	3	1.1	141	**150**	200	**970**	**3,000**	8.2
23-Jul-98	6.5	7	10.8	**5.6**	91	**150**	590	**1,020**	n.a.	8
8-Jul-99	7.3	6.8	26	1.5	100	**150**	590	**1,000**	**3,250**	7.2
16-Feb-00	10.5	7.6	6.6	2	129	**150**	300	**1,160**	**1,120**	1.8
3-Jul-00	4.9	6.9	1.3	1	147	**100**	470	**250**	**300**	21
31-Oct-00	7.3	7.2	8.8	1	162	**100**	390	**200**	186	2.6
21-Mar-01	10.7	7.4	3.5	**4.7**	191	90	980	**1,400**	**3,000**	2
18-Jun-01	7.9	7.2	3.2	1	157	50	1,060	**950**	**3,350**	1.8
2-Aug-01	7.4	7.2	1.7	<1.0	166	50	1,110	**870**	**1,000**	1.7
7-Nov-01	8.6	6.9	1	1.3	182	50	790	**200**	400	<1.0
27-Feb-02	13	7.2	2.1	1	129	50	860	n.a.	460	1.4
10-Jun-02	7.6	7.1	1.2	1	184	50	220	**610**	**2,050**	1.4
20-Aug-02	6.8	6.9	1.4	1	118	50	1,310	**200**	**1,700**	1.2
14-Nov-02	9.9	7.1	4.4	1	152	50	200	**1,060**	400	12
19-Feb-03	11.6	7.1	2.6	1.9	142	50	650	**1,360**	200	1.4
5-May-03	6.5	7.4	2	1	152	50	400	**990**	**350**	<1.0
9-Sep-03	8.1	7.2	1.2	1	151	50	1,380	**1,070**	**425**	<1.0
2-Dec-03	11.1	6.8	3.1	1	137	50	840	**1,160**	50	1.6
4-Mar-04	9.6	6.6	1.6	1	139	50	1,110	**1,010**	100	1.2

Table A-1. (Continued).

Date	DO (mg/L)	pH	TURB (ntu)	BOD$_5$ (mg/L)	COND (µmhos/cm)	TP (µg/L)	TKN (µg/L)	NO$_X$ (µg/L)	Fecal Coliforms (mpn/100 mL)	TSS (mg/L)
26-May-04	7.7	6.9	1.3	1	149	50	680	**1,050**	**900**	<1.0
18-Aug-04	8.4	7.3	1.3	1	143	50	380	**1,040**	**500**	<1.0
27-Dec-04	12	6.5	2.1	1	150	50	510	**1,720**	200	1.6
19-Apr-05	9.3	6.9	1.7	1	143	20	140	**1,230**	180	<1.0
28-Jul-05	7.4	7	1.4	1	148	20	250	**1,350**	**350**	1.4
15-Sep-05	7.8	7.2	0.9	1	159	20	250	**1,150**	**500**	<1.0
12-Jan-06	8	7.4	1.8	1	131	30	470	**950**	**1,140**	<1.0
5-Apr-06	9.8	7.2	2	n.a.	145	<10	370	**1,040**	100	<1.0
12-Jun-06	7.7	7.4	1.9	1	157	30	260	**750**	**1,100**	1.9
18-Sep-06	7.7	7.4	1.5	1	147	20	220	**600**	n.a.	<1.0
18-Dec-06	10.4	7.1	1.3	<1.0	147	20	140	**820**	850	<1.0
8-Mar-07	10.7	7.3	1.6	1	125	<10	340	**1,130**	300	<1.0
24-May-07	8.1	7.3	1.6	1	149	30	150	**590**	**860**	5.4
1-Aug-07	7.4	7.4	1.3	1	148	30	250	**640**	**600**	1.2
20-Nov-07	8.5	7.2	1.3	1.2	149	20	190	50	400	<1.0
24-Mar-08	11.3	7.2	1.6	<1.0	166	20	120	**1,260**	1,000	<1.0
John Ward Creek WR3										
19-Mar-98	9.8	7.1	4.5	1	96	**150**	200	**450**	950	3
1-Jun-98	7.3	7.1	5.6	<1.0	99	**150**	200	**270**	**1,600**	4
23-Jul-98	6.7	6.8	13.8	2.7	89	**150**	220	**290**	n.a.	21.2
8-Jul-99	6.6	6.5	17	1.8	79	**150**	1,260	**420**	n.a.	7.6
16-Feb-00	9.6	7.1	8.8	1.8	92	**150**	250	60	200	3.8
3-Jul-00	5.8	6.6	6.4	1	112	100	350	**200**	**300**	3.6
31-Oct-00	6.8	7.2	2.4	1	135	100	550	**200**	**709**	1.8
27-Mar-01	10.6	7	4.5	1.3	130	50	350	**640**	450	1.6
18-Jun-01	7.1	7.2	5.6	1	117	50	720	**380**	**850**	2.2
2-Aug-01	7.1	7.2	6.2	<1.0	125	50	950	**360**	**300**	2.3
7-Nov-01	9	6.9	2.8	1	131	50	630	**200**	150	1.2
27-Feb-02	11.3	7.2	4.8	1	107	50	850	---	140	2
10-Jun-02	6.7	7.2	7.8	1	120	50	340	**200**	200	8.8
20-Aug-02	5.9	6.9	6.3	1	111	50	630	**200**	**950**	4.6
14-Nov-02	9.4	7.1	5.2	1	109	50	1,090	**450**	250	2.4
19-Feb-03	10.7	7.2	4.1	1.6	101	50	430	**670**	100	3.3
5-May-03	5	7.2	5	1	111	50	420	**420**	**500**	4.6
9-Sep-03	7.7	7.4	1	1	103	50	1,570	**440**	250	2.9
2-Dec-03	10.6	6.8	5	1	104	50	1,040	**470**	550	2.8
4-Mar-04	9.1	6.7	4	1	102	50	1,130	**480**	140	3.4

Table A-1. (Continued).

Date	DO (mg/L)	pH	TURB (ntu)	BOD_5 (mg/L)	COND (µmhos/cm)	TP (µg/L)	TKN (µg/L)	NO_X (µg/L)	Fecal Coliforms (mpn/100 mL)	TSS (mg/L)
26-May-04	7.4	7	6.2	1	109	50	510	430	250	5
18-Aug-04	7	7.3	4.5	1	108	50	530	350	550	3.2
27-Dec-04	11.7	6.6	4.5	1	111	50	490	720	250	3.2
19-Apr-05	8.7	7	5.2	1	107	20	<100	550	100	2.8
28-Jul-05	6.4	7.1	6.8	1	110	20	250	600	400	5.8
15-Sep-05	6.8	7.3	5.1	1	118	20	250	460	100	3
12-Jan-06	7.6	7.2	5	1	99	20	390	440	60	2.7
5-Apr-06	9.2	7.2	5.2	1	109	<10	330	460	300	2.7
12-Jun-06	6.6	7.2	9.8	1	115	20	220	330	450	5.6
18-Sep-06	6.2	7.2	6.5	1	109	20	240	210	---	3.4
18-Dec-06	9.5	7.5	6.6	<1.0	117	<10	230	290	300	2.1
8-Mar-07	9.6	7.3	5.3	1	95	20	350	480	50	3
24-May-07	6.2	7.2	10.4	1	118	20	220	260	116	2.2
1-Aug-07	6.2	7.4	8.4	1	118	20	280	260	600	3.3
20-Nov-07	6.2	7.1	9.1	2.4	116	20	310	60	200	3.8
24-Mar-08	9.8	7.2	5.2	<1.0	117	20	140	450	250	3
John Ward Creek WR4										
19-Mar-98	9.9	7.1	3	1	137	150	200	340	350	7.4
1-Jun-98	7.2	7.1	9.9	1.1	91	150	200	210	1,300	13.5
23-Jul-98	6.4	6.8	22.8	1.3	90	150	550	390	---	64
8-Jul-99	6.6	6.5	16	1.6	77	150	830	320	---	10
16-Feb-00	9.7	7.1	14.2	1.7	78	150	310	20	210	10.6
3-Jul-00	5.5	7	17.3	1	95	100	510	200	1,600	12.2
31-Oct-00	7.1	7.2	5.5	1	122	100	450	200	67	4
27-Mar-01	10.5	6.8	7.1	1.4	112	50	340	530	200	2.1
18-Jun-01	7.8	7.2	8.2	1	100	550	310	300	5	
2-Aug-01	7.1	7.2	9.9	<1.0	114	50	720	270	450	4.2
7-Nov-01	8.6	6.9	6	1.5	120	50	750	200	100	4.4
27-Feb-02	10.7	7.1	5	1	107	50	260	---	680	2.6
10-Jun-02	6.5	7.1	13.1	1	119	50	410	200	200	8.2
20-Aug-02	6.2	6.9	8.4	1	103	50	670	200	1,150	5.2
14-Nov-02	9.6	7.1	7.3	1	102	50	1,420	330	50	3.6
19-Feb-03	11.1	7.1	5.5	1.4	95	50	450	510	50	4
5-May-03	8	7.2	7.1	1	101	50	420	300	50	3.2
9-Sep-03	7.7	7.3	9.1	1	94	50	1,330	320	325	5.4
2-Dec-03	10.1	6.8	8.1	1	100	50	1,070	410	100	4.6
4-Mar-04	8.9	6.7	5.3	1	92	50	950	370	340	3.4

Table A-1. (Continued).

Date	DO (mg/L)	pH	TURB (ntu)	BOD_5 (mg/L)	COND (µmhos/cm)	TP (µg/L)	TKN (µg/L)	NO_X (µg/L)	Fecal Coliforms (mpn/100 mL)	TSS (mg/L)
26-May-04	6.6	7	7.9	1	100	50	460	**280**	50	5.2
18-Aug-04	6.5	7.2	4.2	1	91	50	430	**220**	**400**	2.7
27-Dec-04	11.8	6.6	5.5	1	101	50	380	**560**	150	3.6
19-Apr-05	8.8	7	7.7	1	98	20	<100	**460**	160	6
28-Jul-05	6.8	7.2	18.3	1	99	30	250	**490**	**400**	15.4
15-Sep-05	7.4	7.3	5.5	1	110	20	250	**340**	100	2.4
12-Jan-06	7.4	7.1	6.7	1	92	20	460	**420**	40	3.8
5-Apr-06	9.1	7.2	6.4	1.6	99	<10	330	**370**	300	3.7
12-Jun-06	6.5	7.1	8.2	1	106	20	220	**270**	**500**	3.8
18-Sep-06	5.9	7	8.9	1	98	20	260	**220**	---	4.6
18-Dec-06	8.8	6.9	13.8	1.1	110	20	290	**250**	200	5.5
8-Mar-07	9.1	7.2	7.1	1	88	20	310	**440**	50	3.9
24-May-07	5.6	7.1	11.2	1	108	30	210	**270**	107	3.8
1-Aug-07	5	7.2	9.6	1	111	20	300	**250**	**350**	3.4
20-Nov-07	5.7	7.9	8.5	1.6	103	20	270	80	50	3.8
24-Mar-08	9.6	7.2	8.9	<1.0	109	30	170	**410**	100	5.5
Noses Creek NS1										
30-Mar-98	8.3	7.1	9.4	1.1	85	**150**	310	**200**	200	14.4
28-May-98	5.6	7	9	**3.4**	118	**200**	1,916	**260**	**12,000**	11.9
23-Sep-99	7.8	6.5	4.1	1	100	**150**	400	**200**	**400**	4.8
8-Jun-00	7.6	6.7	22.3	1	97	100	590	**240**	100	2.4
5-Oct-00	8.1	7.2	6.4	1	117	100	210	**300**	50	2.3
29-Jan-01	11	7.4	6.2	1	84	50	390	**370**	100	3.4
24-Apr-01	8	7.2	15.3	1	122	50	290	**300**	180	10.6
28-Jun-01	7.1	7.5	15.4	2.5	113	100	1,430	**400**	**51,600**	8.4
17-Sep-01	8	---	6.6	<1.0	107	50	510	**200**	**300**	4.4
1-Jan-02	11	6.8	5.9	1.3	100	50	400	**350**	50	2.8
17-Apr-02	7.6	6.8	8.4	1	117	50	710	**180**	300	5.1
25-Jun-02	6.1	6.8	7	1.1	173	50	460	**200**	200	3.7
9-Sep-02	**4.2**	6.9	5.2	1.9	123	50	570	**200**	**250**	**28**
16-Dec-02	11.2	7	4.9	1	---	50	350	**240**	2	2
20-Feb-03	10.4	7	5.2	1	85	50	380	**250**	50	4.1
10-Jun-03	7.7	6.9	8.2	1	102	50	1,260	**220**	150	6.7
19-Aug-03	6.9	6.6	9.2	1.1	105	50	1,590	**240**	**350**	4.2
12-Nov-03	8.8	6.8	7.1	1	116	50	810	**200**	100	3.3
5-Apr-04	9.8	7.3	6.3	1	101	50	710	**270**	**3,460**	3.9
23-Jul-04	7.2	6.8	4.6	1	108	50	340	**320**	200	1.4

Table A-1. (Continued).

Date	DO (mg/L)	pH	TURB (ntu)	BOD_5 (mg/L)	COND (μmhos/cm)	TP (μg/L)	TKN (μg/L)	NO_X (μg/L)	Fecal Coliforms (mpn/100 mL)	TSS (mg/L)
6-Oct-04	8.1	7.1	5.7	1	114	50	320	**360**	**300**	2.9
10-Jan-05	10.7	6.7	5.1	1	98	50	200	**320**	250	<1.0
18-Apr-05	8.1	6.7	4.5	1	94	<10	<100	**390**	100	3.2
27-Jul-05	8.4	6.9	7.2	1	100	20	250	**400**	**350**	6.2
22-Sep-05	7	6.9	4.9	1	124	20	250	**340**	**300**	2.3
20-Jan-06	7.4	7.1	7.1	1	90	20	270	**350**	150	4.4
11-Apr-06	9.1	7	4.7	1	99	<10	280	**310**	50	2.9
10-Jul-06	7.2	7.4	4.9	<1.0	104	20	180	**250**	**450**	2.7
10-Oct-06	7.5	7	14.4	1.1	110	20	150	80	**570**	6.6
12-Jan-07	10.3	7	5.6	1	94	<10	300	**330**	50	2.9
23-Apr-07	8.4	7.1	24.1	1.2	108	20	2,160	**210**	142	16.6
10-Jul-07	5.7	7.2	5.5	1	124	20	270	**180**	**250**	2.8
10-Jan-08	9.2	6.9	4.6	1.3	114	20	180	**380**	50	3.9

Appendix B. Water quality standards in Georgia for toxic substances – streams and lakes (GA DNR 2008c).

TABLE 3-3
GEORGIA INSTREAM WATER QUALITY STANDARDS FOR ALL WATERS: TOXIC SUBSTANCES

(Excerpt from Georgia's Rules and Regulations for Water Quality Control Chapter 391-3-6-.03 - Water Use Classifications and Water Quality Standards)

(i) Instream concentrations of the following chemical constituents which are considered to be other toxic pollutants of concern in the State of Georgia shall not exceed the criteria indicated below under 7-day, 10-year minimum flow (7Q10) or higher stream flow conditions except within established mixing zones:

1. 2,4-Dichlorophenoxyacetic acid (2,4-D)	70 µg/l
2. Methoxychlor	0.03 µg/l*
3. 2,4,5-Trichlorophenoxy propionic acid (TP Silvex)	50 µg/l

(ii) Instream concentrations of the following chemical constituents listed by the U.S. Environmental Protection Agency as toxic priority pollutants pursuant to Section 307(a)(1) of the Federal Clean Water Act (as amended) shall not exceed the acute criteria indicated below under 1-day, 10-year minimum flow (1Q10) or higher stream flow conditions and shall not exceed the chronic criteria indicated below under 7-day, 10-year minimum flow (7Q10) or higher stream flow conditions except within established mixing zones or in accordance with site specific effluent limitations developed in accordance with procedures presented in 391-3-6-.06. Unless otherwise specified, the criteria below are listed in their total recoverable form. Because most of the numeric criteria for the metals below are listed as the dissolved form, total recoverable concentrations of metals that are measured instream will need to be translated to the dissolved form in order to compare the instream data with the numeric criteria. This translation will be performed using guidance found in "Guidance Document of Dynamic Modeling and Translators August 1993" found in Appendix J of EPA's Water Quality Standards Handbook: Second Edition, EPA-823-B-94-005a or by using other appropriate guidance from EPA.

		Acute	Chronic
1.	Arsenic		
	(a) Freshwater	340 µg/l [1]	150 µg/l [1]
	(b) Coastal and Marine Estuarine Waters	69 µg/l [1]	36 µg/l [1]
2.	Cadmium		
	(a) Freshwater	2.0 µg/l [1,3]	1.3 µg/l [1,3]
	(b) Coastal and Marine Estuarine Waters	42 µg/l [1]	9.3 µg/l [1]
3.	Chromium III		
	(a) Freshwater	320 µg/l [1,3]	42 µg/l [1,3]
	(b) Coastal and Marine Estuarine Waters	--	--
4.	Chromium VI		
	(a) Freshwater	16 µg/l [1]	11 µg/l [1]
	(b) Coastal and Marine Estuarine Waters	1,100 µg/l [1]	50 µg/l [1]
5.	Copper		
	(a) Freshwater	7.0 µg/l [1,2*,3]	5.0 µg/l [1,2*,3]
	(b) Coastal and Marine Estuarine Waters	4.8 µg/l [1,2]	3.1 µg/l [1,2]
6.	Lead		
	(a) Freshwater	30 µg/l [1,3]	1.2 µg/l [1,2*,3]
	(b) Coastal and Marine Estuarine Waters	210 µg/l [1]	8.1 µg/l [1]
7.	Mercury		
	(a) Freshwater	1.4 µg/l	0.012 µg/l [2]
	(b) Coastal and Marine Estuarine Waters	1.8 µg/l	0.025 µg/l [2]
8.	Nickel		
	(a) Freshwater	260 µg/l [1,3]	29 µg/l [1,3]
	(b) Coastal and Marine Estuarine Waters	74 µg/l [1]	8.2 µg/l [1]
9.	Selenium		
	(a) Freshwater	--	5.0 µg/l
	(b) Coastal and Marine Estuarine Waters	290µg/l [1]	71 µg/l [1]

10.	Silver	-- [4]	-- [4]
11.	Zinc		
	(a) Freshwater	65 µg/l [1,3]	65 µg/l [1,3]
	(b) Coastal and Marine Estuarine Waters	90 µg/l [1]	81 µg/l [1]
12.	Lindane [Hexachlorocyclohexane (g-BHC-Gamma)]		
	(a) Freshwater	0.95 µg/l	
	(b) Coastal and Marine Estuarine Waters	0.16 µg/l	

[1] The in-stream criterion is expressed in terms of the dissolved fraction in the water column. Conversion factors used to calculate dissolved criteria are found in the EPA document – National Recommended Water Quality Criteria – Correction, EPA 822-Z-99-001, April 1999.

[2] The in-stream criterion is lower than the EPD laboratory detection limits (A "*" indicates that the criterion may be higher than or lower than EPD laboratory detection limits depending upon the hardness of the water).

[3] The aquatic life criteria for these metals are expressed as a function of total hardness (mg/l) in a water body. Values in the table above assume a hardness of 50 mg/l $CaCO_3$. For other hardness values, the following equations from the EPA document – National Recommended Water Quality Criteria – Correction; EPA 822-Z-99-001, April 1999 should be used. The minimum hardness allowed for use in these equations shall not be less than 25 mg/l, as calcium carbonate and the maximum shall not be greater than 400 mg/l as calcium carbonate.

Cadmium
acute criteria = $(e^{(1.128[\ln(hardness)] - 3.6867)})(1.136672-[(\ln hardness)(0.041838)]$ µg/l
chronic criteria = $(e^{(0.7852[\ln(hardness)] - 2.715)})(1.101672-[(\ln hardness)(0.041838)]$ µg/l

Chromium III
acute criteria = $(e^{(0.8190[\ln(hardness)] + 3.7256)}(0.316)$ µg/l
chronic criteria = $(e^{(0.8190[\ln(hardness)] + 0.6848)})(0.860)$ µg/l

Copper
acute criteria = $(e^{(0.9422[\ln(hardness)] - 1.700)})(0.96)$ µg/l
chronic criteria = $(e^{(0.8545[\ln(hardness)] - 1.702)})(0.96)$ µg/l

Lead
acute criteria = $(e^{(1.273[\ln(hardness) - 1.460)})(1.46203 - [(\ln hardness)(0.145712)])$ µg/l
chronic criteria = $(e^{(1.273[\ln(hardness) - 4.705)})(1.46203 - [(\ln hardness)(0.145712)])$ µg/l

Nickel
acute criteria = $(e^{(0.8460[\ln(hardness)] + 2.255)})(.998)$ µg/l
chronic criteria = $(e^{(0.8460[\ln(hardness)] + 0.0584)})(.997)$ µg/l

Zinc
acute criteria = $(e^{(0.8473[\ln(hardness)] + 0.884)})(0.978)$ µg/l
chronic criteria = $(e^{(0.8473[\ln(hardness)] + 0.884)})(0.986)$ µg/l

[4] This pollutant is addressed in 391-3-6-.06.

(iii) Instream concentrations of the following chemical constituents listed by the U.S. Environmental Protection Agency as toxic priority pollutants pursuant to Section 307(a)(1) of the Federal Clean Water Act (as amended) shall not exceed criteria indicated below under 7-day, 10-year minimum flow (7Q10) or higher stream flow conditions except within established mixing zones or in accordance with site specific effluent limitations developed in accordance with procedures presented in 391-3-6-.06.

1.	Chlordane	
	(a) Freshwater	0.0043 µg/l*
	(b) Coastal and Marine Estuarine Waters	0.004 µg/l*
2.	Cyanide	
	(a) Freshwater	5.2 µg/l*
	(b) Coastal and Marine Estuarine Waters	1.0 µg/l*
3.	Dieldrin	
	(a) Freshwater	0.056 µg/l*
	(b) Coastal and Marine Estuarine Waters	0.0019 µg/l*
4.	4,4'-DDT	0.001 µg/l*
5.	a-Endosulfan	
	(a) Freshwater	0.056 µg/l*
	(b) Coastal and Marine Estuarine Waters	0.0087 µg/l*
6.	b-Endosulfan	
	(a) Freshwater	0.056 µg/l*
	(b) Coastal and Marine Estuarine Waters	0.0087 µg/l*

7.	Endrin	
	(a) Freshwater	0.036 µg/l*
	(b) Coastal and Marine Estuarine Waters	0.0023 µg/l*
8.	Heptachlor	
	(a) Freshwater	0.0038 µg/l*
	(b) Coastal and Marine Estuarine Waters	0.0036µg/l*
9.	Heptachlor Epoxide	
	(a) Freshwater	0.0038 µg/l*
	(b) Coastal and Marine Estuarine Waters	0.0036 µg/l*
10	Pentachlorophenol	
	(a) Freshwater	2.1 µg/l*
	(b) Coastal and Marine Estuarine Waters	7.9 µg/l*
11.	PCBs	
	(a) Freshwater	0.014 µg/l*
	(b) Coastal and Marine Estuarine Waters	0.03 µg/l*
12.	Phenol	300 µg/l
13.	Toxaphene	0.0002 µg/l*

*The in-stream criterion is lower than the EPD laboratory detection limits.

(iv) Instream concentrations of the following chemical constituents listed by the U. S. Environmental Protection Agency as toxic priority pollutants pursuant to Section 307(a)(1) of the Federal Clean Water Act (as amended) shall not exceed criteria indicated below under annual average or higher stream flow conditions:

1.	Acenaphthene	2700 µg/l
2.	Acenaphthylene	**
3.	Acrolein	780 µg/l
4.	Acrylonitrile	0.66 µg/l
5.	Aldrin	0.00014 µg/l
6.	Anthracene	110000 µg/l
7.	Antimony	4300 µg/l
8.	Arsenic	50 µg/l
9.	Benzidine	0.00054 µg/l
10.	Benzo(a)Anthracene	0.049µg/l
11.	Benzo(a)Pyrene	0.049µg/l
12.	3,4-Benzofluoranthene	0.049µg/l
13.	Benzene	71 µg/l
14.	Benzo(ghi)Perylene	**
15.	Benzo(k)Fluoranthene	0.049µg/l
16.	Beryllium	**
17.	a-BHC-Alpha	0.013 µg/l
18.	b-BHC-Beta	0.046 µg/l
19.	Bis(2-Chloroethyl)Ether	1.4 µg/l
20.	Bis(2-Chloroisopropyl)Ether	170000 µg/l
21.	Bis(2-Ethylhexyl)Phthalate	5.9 µg/l
22.	Bromoform (Tribromomethane)	360 µg/l
23.	Butylbenzyl Phthalate	5200
24.	Carbon Tetrachloride	4.4 µg/l
25.	Chlorobenzene	21000 µg/l
26.	Chlorodibromomethane	34 µg/l
27.	2-Chloroethylvinyl Ether	**
28.	Chlordane	0.0022 µg/l
29.	Chloroform (Trichloromethane)	470 µg/l
30.	2-Chloronaphthalene	4300 µg/l
31.	2-Chlorophenol	400 µg/l
32.	Chrysene	0.049 µg/l
33.	Dibenzo(a,h)Anthracene	0.049 µg/l
34.	Dichlorobromomethane	46 µg/l
35.	1,2-Dichloroethane	99 µg/l
36.	1,1-Dichloroethylene	3.2 µg/l
37	1,2 – Dichloropropane	39 µg/l
38.	1,3-Dichloropropylene	1700 µg/l
39.	2,4-Dichlorophenol	790 µg/l
40.	1,2-Dichlorobenzene	17000 µg/l
41.	1,3-Dichlorobenzene	2600 µg/l

42.	1,4-Dichlorobenzene	2600 µg/l
43.	3,3'-Dichlorobenzidine	0.077 µg/l
44.	4,4'-DDT	0.00059 µg/l
45.	4,4'-DDD	0.00084 µg/l
46.	4,4'-DDE	0.00059 µg/l
47.	Dieldrin	0.00014 µg/l
48.	Diethyl Phthalate	120000 µg/l
49.	Dimethyl Phthalate	2900000 µg/l
50.	2,4-Dimethylphenol	2300 µg/l
51.	2,4-Dinitrophenol	14000 µg/l
52.	Di-n-Butyl Phthalate	12000 µg/l
53.	2,4-Dinitrotoluene	9.1 µg/l
54.	1,2-Diphenylhydrazine	0.54 µg/l
55.	Endrin	0.81 µg/l
56.	Endrin Aldehyde	0.81 µg/l
57.	alpha – Endosulfan	240 µg/l
58.	beta – Endosulfan	240 µg/l
59.	Endosulfan Sulfate	240 µg/l
60.	Ethylbenzene	29000 µg/l
61.	Fluoranthene	370 µg/l
62.	Fluorene	14000 µg/l
63.	Heptachlor	0.00021 µg/l
64.	Heptachlor Epoxide	0.00011 µg/l
65.	Hexachlorobenzene	0.00077 µg/l
66.	Hexachlorobutadiene	50 µg/l
67.	Hexachlorocyclopentadiene	17000 µg/l
68.	Hexachloroethane	8.9 µg/l
69.	Indeno(1,2,3-cd)Pyrene	0.049 µg/l
70.	Isophorone	2600 µg/l
71.	Lindane [Hexachlorocyclohexane (g-BHC-Gamma)]	0.063 µg/l
72.	Methyl Bromide (Bromomethane)	4000 µg/l
73.	Methyl Chloride (Chloromethane)	**
74.	Methylene Chloride	1600 µg/l
75.	2-Methyl-4,6-Dinitrophenol	765 µg/l
76.	3-Methyl-4-Chlorophenol	**
77.	Nitrobenzene	1900 µg/l
78.	N-Nitrosodimethylamine	8.1 µg/l
79.	N-Nitrosodi-n-Propylamine	1.4 µg/l
80.	N-Nitrosodiphenylamine	16 µg/l
81.	PCBs	0.00017 µg/l
82.	Pentachlorophenol	8.2 µg/l
83.	Phenanthrene	**
84.	Phenol	4,600,000 µg/l
85.	Pyrene	11,000 µg/l
86.	1,1,2,2-Tetrachloroethane	11 µg/l
87.	Tetrachloroethylene	8.85 µg/l
88.	Thallium	6.3 µg/l
89.	Toluene	200000 µg/l
90.	Toxaphene	0.00075 µg/l
91.	1,2-Trans-Dichloroethylene	140000
92.	1,1,2-Trichloroethane	42 µg/l
93.	Trichloroethylene	81 µg/l
94.	2,4,6-Trichlorophenol	6.5 µg/l
95.	1,2,4-Trichlorobenzene	940 µg/l
96.	Vinyl Chloride	525 µg/l

**These pollutants are addressed in 391-3-6-.06.

(v) Site specific criteria for the following chemical constituents will be developed on an as-needed basis through toxic pollutant monitoring efforts at new or existing discharges that are suspected to be a source of the pollutant at levels sufficient to interfere with designated uses:

1. Asbestos

(vi) instream concentrations of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) must not exceed 0.0000012 µg/l under long-term average stream flow conditions.

(f) Applicable State and Federal requirements and regulations for the discharge of radioactive substances shall be met at all times.

Appendix C. Criteria for classification of surface waters as meeting or not meeting their designated use(s) (GA DNR 2008b).

Substantial changes have been made to the format of Georgia's 2008 305(b)/303(d) List of Waters assessed from earlier listing years. The USEPA has required States to move to a five-part categorization of their waters. The GAEPD adopted the five-part categorization method with the 2008 305(b)/303(d) report. Assessed waters were placed into the five categories as described below:

Category 1 – Data indicate that waters are meeting their designated use(s). The placement of a water body in Category 1 is comparable to a water body having been on the "supporting" list in previous 305(b)/303(d) lists.

Category 2 – A water has more than one designated use and data indicate that at least one designated use is being met, but there is insufficient evidence to determine that all uses are being met. GAEPD did not have a designation similar to Category 2 on previous 305(b)/303(d) lists.

Category 3 – There is insufficient data or other information to make a determination as to whether or not the designated use(s) is being met.

Category 4a – Data indicate that at least one designated use is not being met, but TMDL(s) have been completed for the parameter(s) that are causing a water not to meet its use(s). In GAEPD's previous 305(b)/303(d) lists, a water body that was determined not to be supporting its use, but a TMDL had been completed for the parameter of concern would have been indicated by the presence of the number "3" in the 303(d) column of the report.

Category 4b - Data indicate that at least one designated use is not being met, but there are actions in place (other than a TMDL) that are predicted to lead to compliance with water quality standards. In previous 305(b)/303(d) lists, waters meeting this condition would have been indicated by the presence of the number "2" in the 303(d) column of the report.

Category 4c - Data indicate that at least one designated use is not being met, but a pollutant does not cause the impairment. The Clean Water Act (502(6)) defines a pollutant as dredged spoil, solid waste, incinerator residue, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, salt, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. An example of a situation that may call for a water to be placed in Category 4c is the case of a highly modified stream (such as a stream that has been channelized) and therefore has insufficient habitat to support an acceptable biological community.

Category 5 - Data indicate that at least one designated use is not being met and TMDL(s) need to be completed for one or more pollutants. In previous 305(b)/ 303(d) lists, a water body that was determined not to be supporting its use and for which a TMDL still needed to be completed was indicated by the presence of an "x" in the 303(d) column of the report.

In accordance with Section 303(d) of the Clean Water Act, the 303(d) list is a list of waters not meeting their uses and for which TMDL(s) have not been completed for the parameter(s) of concern. Once the TMDL is completed, the water may still not be supporting its use; however, it is no longer on the 303(d) list. In the new 5-part categorization method, waters that are assessed as "not supporting" their uses will either be placed in Category 4a, 4b, 4c or 5. Only those waters in Category 5 make up the federally mandated 303(d) list.

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