ROCKY RIVER GROUNDWATER ASSESSMENT


Rocky River at US Highway 15 - 501

CONTENTS

INTRODUCTION

This report was prepared by the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Quality (DWQ) Aquifer Protection Section (APS) as a general assessment of groundwater quality in a "typical" Piedmont watershed of the state. In contrast to other environmental media, groundwater data exists in many fragmented locations throughout state agencies. Each agency has responsibility for a specific regulatory program related to groundwater, such as underground petroleum storage tanks, land application of wastewater, or permitting of private wells, but there has been no recent attempt to examine the groundwater resource as a whole and to analyze the various sources of groundwater quality data from a resource management standpoint. This report represents the first attempt to do so at a sub-basin scale. The authors hope this information is useful to many stakeholders and citizens.

PURPOSE AND SCOPE

During the 1960's and 1970's, the NCDENR, in cooperation with the United States Geological Survey (USGS), provided a series of assessments of groundwater quality and quantity in North Carolina. The primary purpose of these assessments was to draw attention to the groundwater resource for development. Edwin O. Floyd of the USGS and Richard Pearce of the NCDENR prepared one such report in 1974 entitled "An Appraisal of the Groundwater Resources of the Upper Cape Fear River Basin, North Carolina".

Thirty seven years later, we are attempting to re-examine the groundwater resource in a portion of this basin, the Rocky River Watershed, using existing groundwater quality data. Overall, environmental awareness has increased during this time, and state and federal governments have instituted rules and regulations that are intended to protect the environment from degradation. In contrast to the early groundwater assessment reports that focused on providing a basis for development of the groundwater resource, this report attempts to provide a basis for evaluating the success of regulatory and non-regulatory programs designed to protect groundwater quality, and to provide useful information to local stakeholders who have concerns about groundwater quality. We hope to attain this objective by providing baseline data and initiating a long-term process to identify and track changes in groundwater quality resulting from human activities. The report does not draw conclusions about groundwater quality. It simply presents a common base of data and trends, where possible, for others to interpret and analyze.

In order to accomplish our objectives, we have obtained groundwater data from a multitude of sources. Groundwater quality data in North Carolina is very fragmented; that is, there are many different state and federal regulatory and natural resource management agencies that collect this data, and they store and manage it in many different forms. We have gathered this data together to present it in a concise and practical form. Finally, we have analyzed the existing groundwater quality data from a hydrogeologist's perspective in order to assess the trends in water quality and identify potential areas of concern. Because groundwater systems can be vulnerable to pollution, but take relatively long periods of time to remediate, it is essential to recognize declining water quality as soon as possible in order to prevent long term damage to the resource. The value of this assessment will be compounded if it can be repeated at regular intervals in a process similar to the current DWQ Basinwide Assessment series of reports.

WATERSHED OVERVIEW

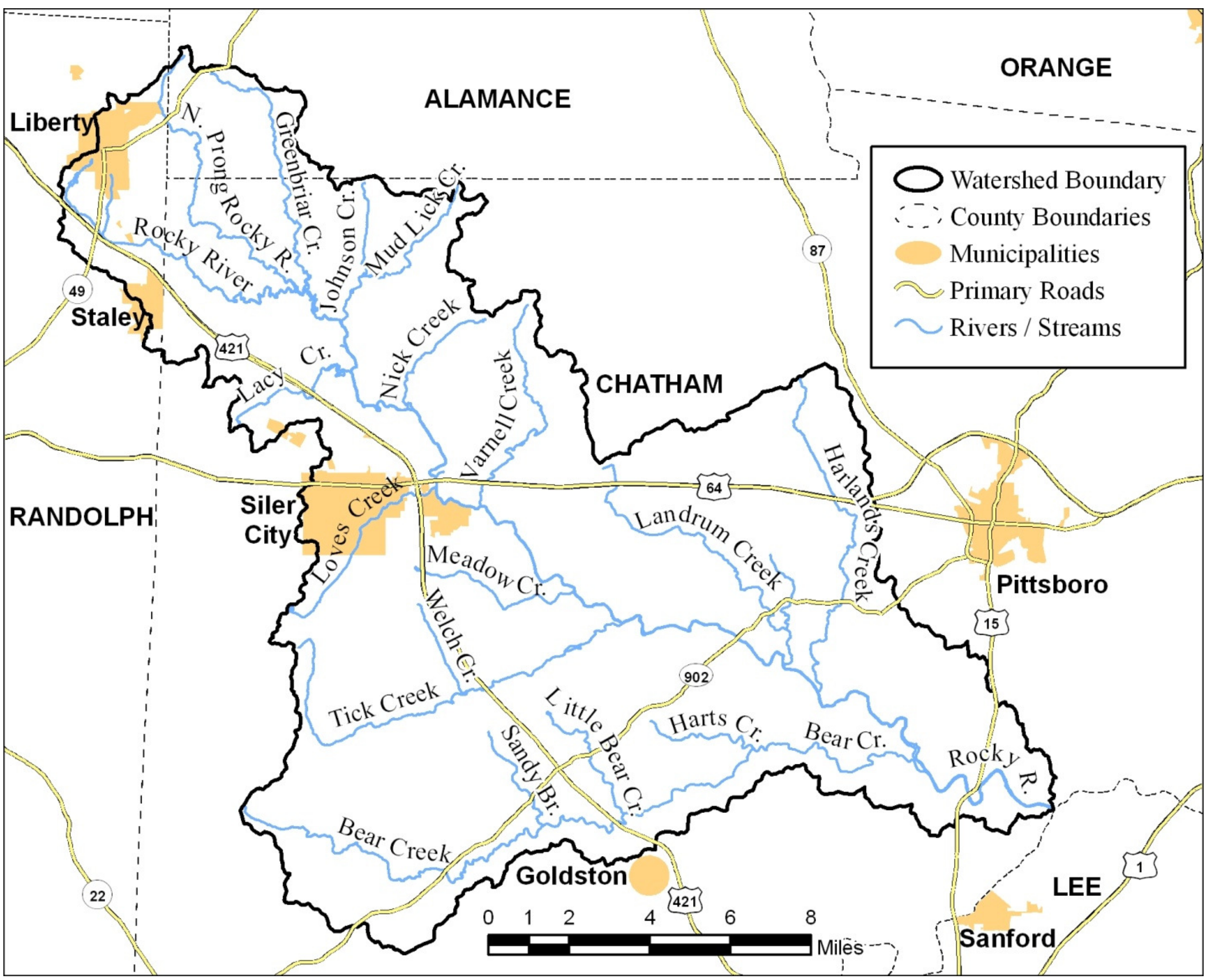
PHYSICAL CHARACTERISTICS

The Rocky River Watershed is located in the Piedmont physiographic province, which is located between the mountains and the coastal plain. Landscape relief is gentle to steep, and elevation ranges between approximately 200 feet to approximately 700 feet above mean sea level.

The Rocky River Watershed is part of the Upper Cape Fear River basin in North Carolina. The watershed is located mainly in Chatham County, but a small portion of this basin is located in Alamance and Randolph counties (Figure 1). The main hydrologic feature in the basin is its namesake, the Rocky River. The Rocky River drains into the Upper Cape Fear River in a generally northwest to southeast trend.

The climate in the Rocky River Watershed is humid sub-tropical, which is characterized by warm, humid summers and cool, wet winters. Rainfall averages approximately 47 inches per year in Pittsboro. The average July high for Pittsboro is 89 degrees Fahrenheit (F), and the average January low is 27 degrees F (homefacts.com).

Figure 1: General Map of the Rocky River Watershed



GEOLOGY

Groundwater travels through geologic features as it moves from areas of recharge - where water enters the ground from precipitation events, to discharge areas - where the groundwater provides flow to surface water features. Therefore, it is important to understand the nature and composition of the geologic material in order to understand how groundwater quality can be affected as it travels from recharge to discharge areas.

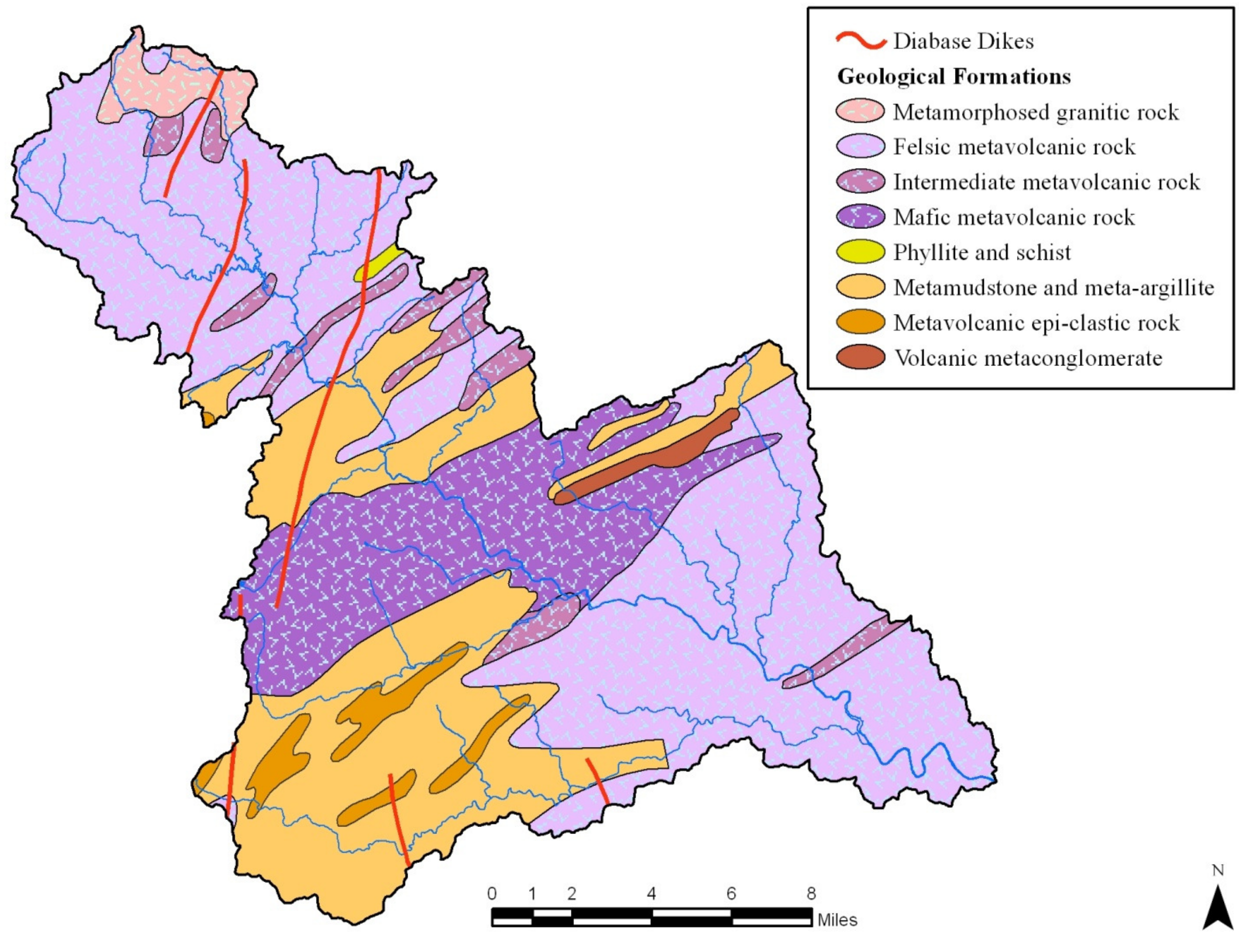
The watershed lies entirely within the geologic unit known as the Carolina Terrane, also known as the Carolina Slate Belt. The Carolina Terrane is believed to be an ancient island arc sequence of volcanic rocks with igneous intrusions similar to the geologic environment in modern day Japan. The area has also been subject to subsequent light to moderate metamorphic deformation resulting from increased temperatures and pressures caused by mountain building events.

As a result of its geologic history, the predominant rock types in the Rocky River Watershed are volcanic and sedimentary rocks formed in the late Proterozoic era (roughly 550 million to 1 billion years ago). Geologists apply the terms “metavolcanic” and “metasedimentary” to these rocks to reflect the fact that these rocks have been weakly metamorphosed but retain many of the original features of volcanic and sedimentary rocks. The Rocky River Watershed also contains occasional granitic intrusions of late Proterozoic to late Cambrian age (roughly 520 to 650 million years ago). Diabase dike intrusions of Mesozoic age (roughly 150 to 200 million years ago) are common, cross-cutting the older igneous and sedimentary rocks. These diabase dikes are thin, planar features ranging in thickness from less than one meter to tens of meters thick.

The dominant structural features in this area are northeast-southwest oriented folding and faulting that resulted from the compression associated with mountain building events, and the subsequent tension associated with the opening of the Atlantic Ocean in the Mesozoic period. These folds and faults are important features affecting the local groundwater flow patterns in the basin.

A geologic map of the Rocky River Watershed, based on the 1985 Geologic Map of North Carolina (NC Dept. of Natural Resources and Community Development, 1985), is shown in Figure 2.

Figure 2: Rocky River Watershed Geology Map

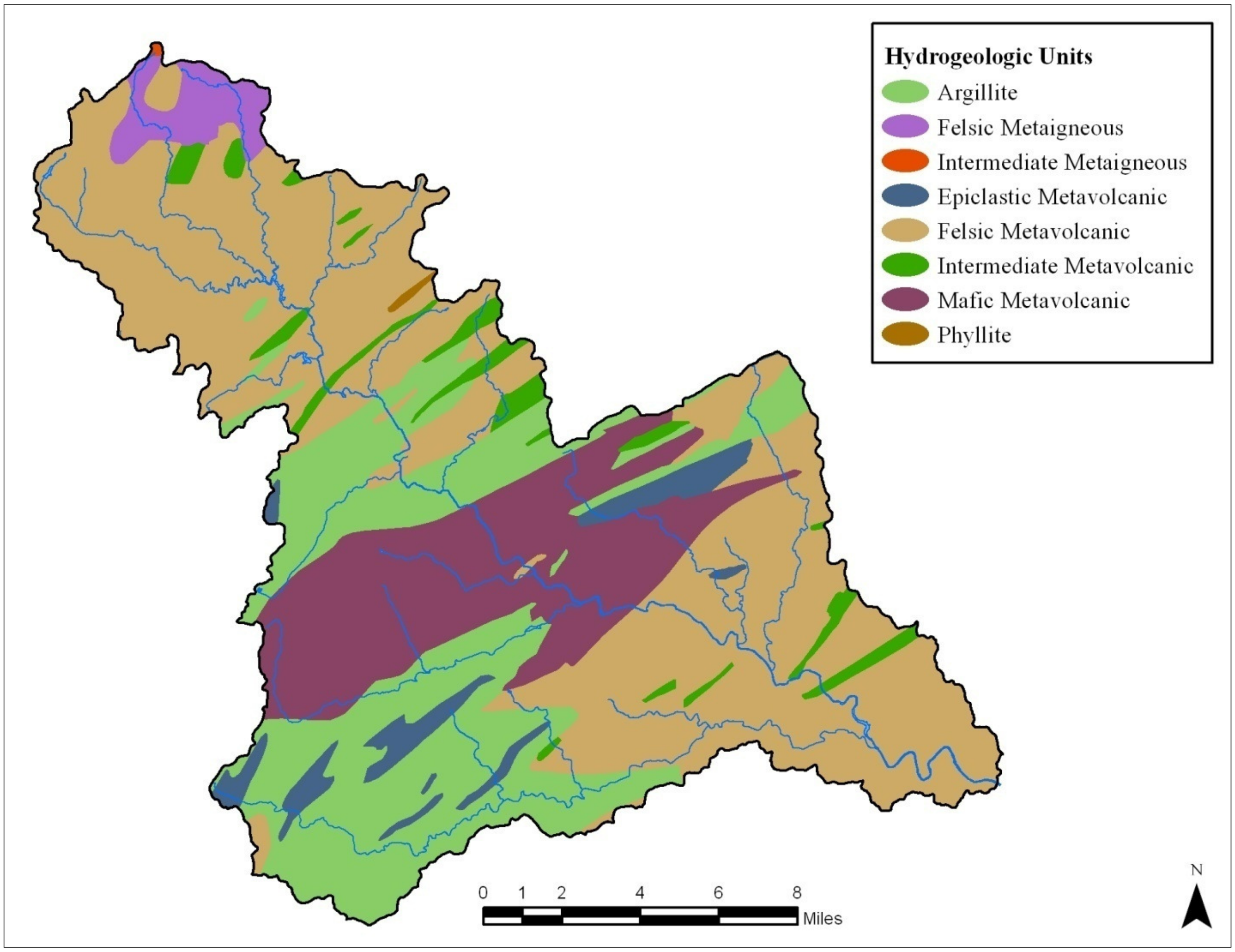


HYDROGEOLOGY

REGIONAL HYDROGEOLOGY

Daniel and Payne (1990) created a hydrogeologic unit map of North Carolina that is based on the 1985 "Geologic Map of North Carolina". This hydrogeologic unit map depicts areas of presumed similar basic groundwater quality based upon the major rock types found in the mapped geologic formations. Figure 3 shows the hydrogeologic unit map for the Rocky River Watershed. From this map it is apparent that the dominant rock types and hydrogeologic units are felsic, mafic, and intermediate composition metavolcanic rocks.

Figure 3: Rocky River Watershed Hydrogeologic Unit Map



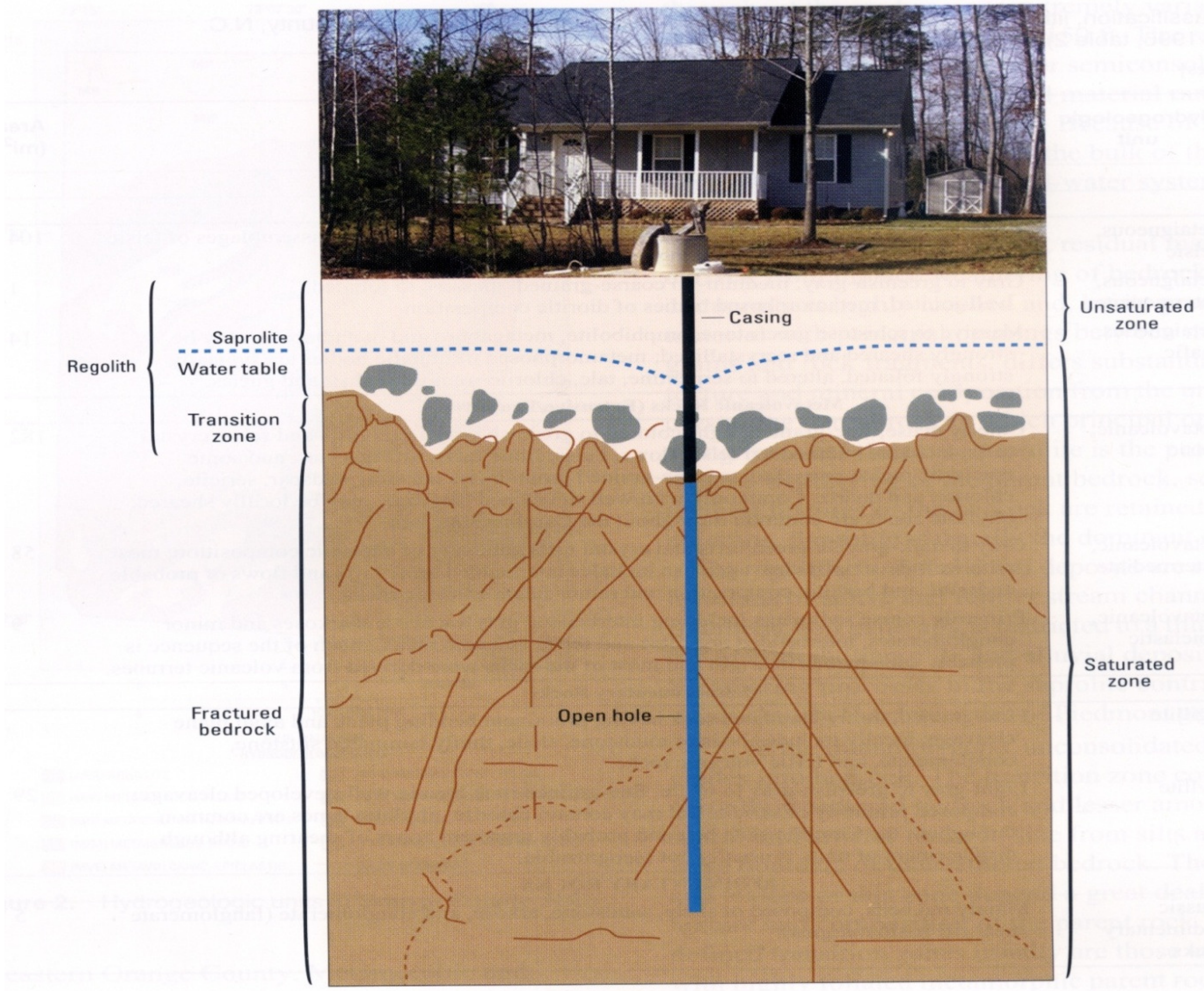
OCCURRENCE OF GROUNDWATER

The Rocky River Watershed is located within the Piedmont physiographic province which is characterized by moderate to steep slopes and well developed drainage features. In this setting, groundwater naturally flows from higher elevation to lower elevation under the influence of gravity. Groundwater recharge occurs mainly on topographic highs and slopes, and groundwater discharge occurs in lowland areas adjacent to surface water bodies.

The entire watershed lies in a crystalline rock hydrogeologic setting that is typical of the North Carolina Piedmont. Groundwater flow predominantly occurs through the granular deposits of soil and saprolite (highly weathered rock), and through interconnected fractures in the underlying crystalline bedrock. This general groundwater flow pattern of the Piedmont is often described as the "slope-aquifer" groundwater flow system (LeGrand, 2004). Groundwater occurs in bedrock fractures, in the transition zone between the bedrock and the overlying residual soil (regolith), and in the saprolite and regolith found near the surface. Figure 4 is a depiction of the crystalline bedrock aquifer system components.

Groundwater can also occur in sediments near rivers and streams. These sediments can serve as important natural groundwater filters that can improve groundwater quality before it discharges into these surface water bodies.

Figure 4: Cross-Section of the Crystalline Bedrock Aquifer System (from Cunningham & Daniel, 2001)



The shallowest zone of the crystalline-bedrock aquifer system is the regolith, which includes the soil, saprolite, and the transition zone.

Soil and saprolite comprise the uppermost portion of the regolith. Silt and clay are the most common type of material found in the soil and saprolite in the Rocky River Watershed. Due to the predominance of silt and clay, there is a high degree of hydraulic storage capability in the soil and saprolite due to the high degree of porosity of these materials. Precipitation can be stored in the soil and saprolite, which slowly recharges the fractured bedrock system found underneath the soil and saprolite. In addition to its storage capacity, the soil and saprolite also provides important filtration and buffering capacity for groundwater recharge. Thus, a thick soil-saprolite cover provides greater storage and filtration capacity than areas where it is thin or non-existent. Therefore, groundwater in areas of thin soil-saprolite cover is more vulnerable to contamination from pollution sources and it is more vulnerable to depletion during drought periods.

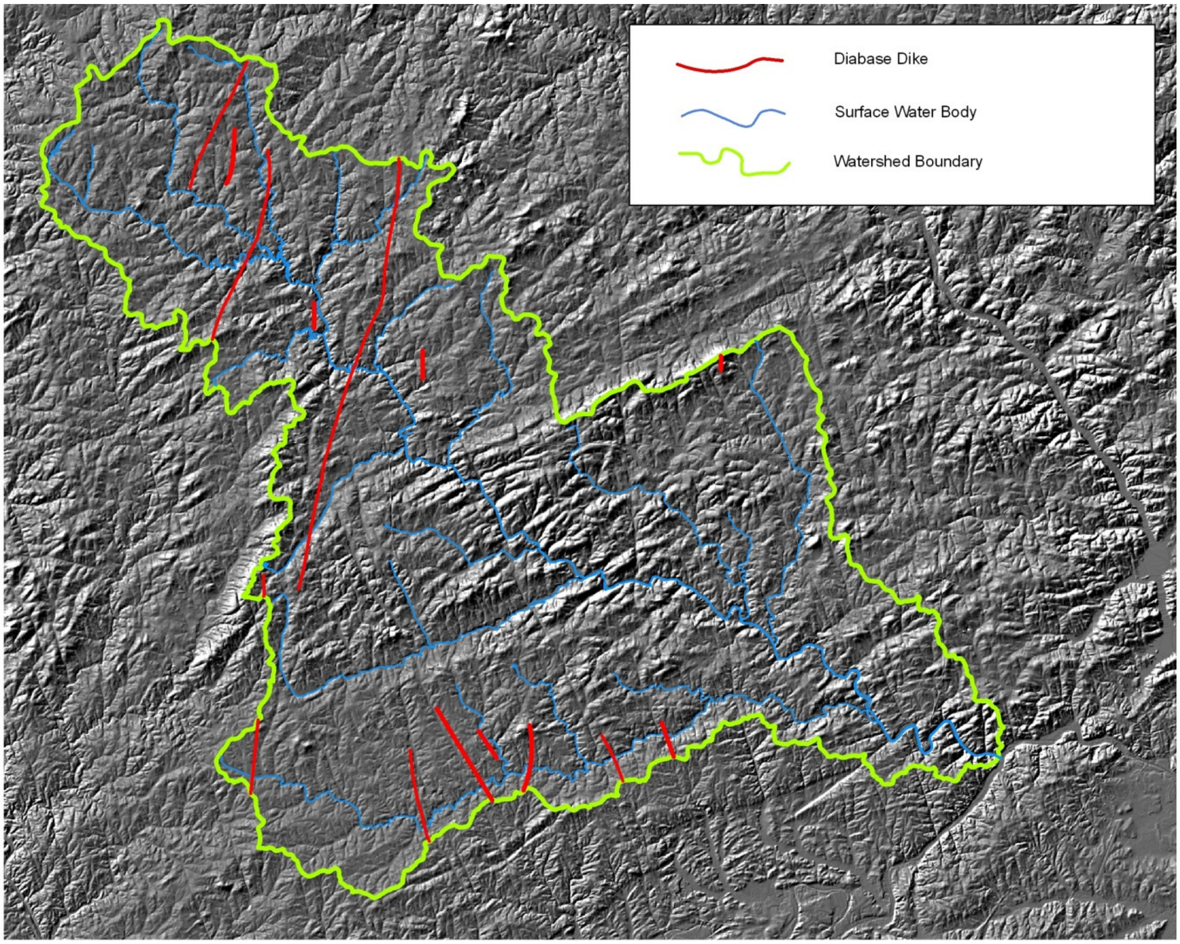
The transition zone, composed of partially weathered bedrock, underlies the soil and saprolite and can vary in thickness from several feet to being non-existent. The composition of the transition zone varies from rock to sand, but it is usually the most permeable part of the regolith, and can act as a preferred pathway for the migration of groundwater and, subsequently, groundwater contaminants. In areas where streams and rivers are deeply incised due to the forces of erosion, these surface water bodies often erode the entire soil and saprolite, leading to a direct hydraulic connection between the transition zone groundwater and the surface water. When this occurs, groundwater contaminants are less likely to be filtered by the soil and saprolite before discharging into surface water, making surface water more vulnerable to contamination in areas of severe stream erosion.

The transition zone is considered to be part of the regolith, and it is usually cased off during water supply well construction, since well casing must be seated 5 feet into competent rock according to current North Carolina well construction rules. However, anecdotal evidence provided from well construction records and standard well drilling practice suggests that casing for water supply wells is often seated in the transition zone, which can make a well more vulnerable to contamination from surface sources of pollution.

The majority of water supply wells in the Rocky River Watershed are completed as open-hole bedrock wells that are designed to intercept water bearing fractures in the underlying crystalline bedrock. The types of rocks that are typically found in the Rocky River Watershed contain little primary pore space that can store water. However, groundwater can travel through fractures in the bedrock in the areas where such fractures occur. The network of bedrock fractures constitutes what is commonly referred to as the “bedrock aquifer”.

Since groundwater travels through fractures in crystalline bedrock, it is desirable to place and construct wells in such a manner as to intercept as many of these fractures as possible to achieve the desired water yield. Many hydrogeologists and well drillers use geologic and topographic maps in order to identify regional fracture patterns that can help improve the chances of siting a well in an area where water yielding fractures are more likely to be encountered. Figure 5 is a high resolution digital elevation map generated from Light Detection and Ranging (LIDAR) elevation data that reveals many linear features in the topography, known as lineaments, which indicate underlying geologic structures such as faults and fratctures. LIDAR elevation maps such as this one can be used to can be used to help find desirable locations for water supply wells, since the lineaments often reflect the presence of potential water-bearing fractures in the bedrock. The dominant bedrock fracture orientations in the Rocky River Watershed, as revealed by the LIDAR elevation map, are northwest-southeast and, to a lesser extent, northeast-southwest.

Figure 5: Locations of Diabase Dikes and Major Lineaments Revealed by LIDAR Data



Sources: N.C. Dept of Natural Resources and Community Development (1985); Burt et al (1978); and Phil Bradley, L.G., personal communication.

Diabase dikes are thin, tabular basaltic intrusions that are typically highly fractured. Water well drillers often look for signs of diabase dikes and try to intercept them while drilling, which can improve the chances of obtaining a sufficient volume of water for a supply well. Diabase dikes have a distinct weathering product that can sometimes be seen at the surface in the form of dark reddish brown clayey soil and rounded, spheroidal grayish brown cobbles and boulders. Figure 5 shows the locations of the larger, more extensive diabase dikes in the Rocky River Watershed, however, there are numerous smaller diabase dikes that can be located based on finding their weathering products at the surface or by geophysical methods such as a precision magnetic survey, since they often contain high concentrations of magnetic minerals. Diabase dikes can intrude into pre-existing fractures, thus the orientation of diabase dikes often coincides with the orientation of major fractures. This relationship between the diabase dikes and major fractures is clearly visible in Figure 5.

Groundwater eventually discharges into surface water or is withdrawn from water supply wells. Baseflow is the amount of water that is carried by a surface water body in the absence of direct runoff. Groundwater makes up a significant portion of this important ecological index. Studies that determine the amount of baseflow in water bodies take several years to compile and are very costly. As a result, there are few published estimates of baseflow in the vicinity of the Rocky River Watershed, and none are currently available for the Rocky River Watershed itself.

The closest baseflow estimate to the Rocky River is from stream gauges at the Flat River in Durham County, N.C, which has a similar hydrogeologic framework as the Rocky River Watershed. According to data obtained and analyzed by Rutledge and Mesko (1996), average baseflow was 5.31 inches per year, and average streamflow at the Flat River station was 13.01 inches per year for the years 1961-1990. Based on these data, the baseflow contributed by groundwater accounts for approximately 40 percent of the total average streamflow in the nearby Flat River. This indicates that groundwater discharges are significant in supporting surface water bodies in this region.

PRINCIPAL AQUIFERS USED

Groundwater usage data is not available for the Rocky River Watershed. However, groundwater usage data for Chatham County is available and is probably representative of the overall prevalence of groundwater usage. According to the latest available data on water usage (Kenny et al, 2009), approximately 58% of the total population of Chatham County relied upon groundwater for potable water in 2005, as shown in Table 1. The vast majority of the groundwater users in the watershed are supplied by private water supply wells. With over half the population in the watershed dependent on groundwater, it is an important resource in this watershed in terms of human consumption.

Table 1: Chatham County Groundwater Usage for Potable Water Supply (from Kenny et al, 2009)

Groundwater Source	Population Served in 2005	2005 Population Served as a Percentage of Total Population
Public Water Systems	1,760	3%
Private Wells	32,080	55%
Public + Private	33,840	58%
Total Population	58,002	

The dominant aquifer used for water supply in the Rocky River Watershed is the fractured bedrock aquifer. Groundwater flows through faults and fractures in the bedrock that were created as a result of natural weathering processes and from geologic movement over time. The bedrock aquifer is found throughout the basin, although there are occasional zones where there are not enough fractures to produce a sustainable water supply well. Fractures are more numerous in the shallow portion of the bedrock, and typically become less numerous and have smaller apertures (widths) with increasing depth.

A few, typically older, water supply wells obtain water from the soil/saprolite portion of the regolith. These wells are usually larger diameter (approx. 2 feet) wells that are excavated by hand or by a bucket auger or cable tool drilling rig and may be referred to as "bored wells." The soil/saprolite system is capable of yielding low to moderate amounts of water to wells, but the typical high silt and clay content of this material often results in low well yields. Hence, the soil/saprolite system is not a major source of water in this area. However, the soil/saprolite system is an important water storage and filtering feature for the bedrock aquifer, so it is desirable to have a thick soil/saprolite layer on top of the bedrock for reliable well yields. Wells completed in the soil/saprolite are vulnerable to contamination from surface spills and other releases, and they are prone to going dry during periods of extended drought.

Another aquifer system found in the Rocky River Watershed is derived from the sediments found on the banks and floodplains of rivers and streams, known as alluvial aquifers. While these aquifers are seldom used for water supplies, they are capable of yielding large quantities of water when a supply well taps into thick, coarse sediments such as sand and gravel. The alluvial aquifers are is usually relatively thin and discontinuous, and are subject to periodic flooding during major storm events. For these reasons, few wells in the area tap into the alluvial aquifers.

TYPICAL WELL CONSTRUCTION

Well contractors are required to submit a well construction record to NCDENR for every water supply well they drill. The NCDENR maintains a database of these well construction records. The database includes information such as the location, date, and owner of the well in addition to well depth, well yield, grouting information and other data on well construction. These well construction records are transcribed into the electronic database by the Business Operations Group of the NCDENR Division of Water Quality. Due to the large number of well construction records and staffing shortages, only a portion of the total number of well construction records have been entered into the electronic database in recent years.

The well construction database includes information on 108 wells from the Rocky River Watershed with reliable location information available as of June of 2011. These wells were installed during the period of March 24, 2001 to November 16, 2009. Well records outside of this date range have not been entered into the electronic well records database or do not contain reliable location information.

According to the available well construction records with reliable location information, the average depth for a water supply well in the Rocky River Watershed is 348 feet. This average well construction total depth is slightly deeper than the average water supply well depth in the N.C. Piedmont of approximately 300 feet, based on anecdotal information obtained from state and county well inspectors in this region.

The average depth of water supply well casing in this basin is 54 feet, which represents an approximate average thickness for soil/saprolite. This well casing depth is consistent with the average thickness of soil/saprolite in the N.C. Piedmont. The average depth to water (non-pumping) is 28 feet, which is also consistent with the average depth to water found elsewhere in Piedmont water supply wells.

Well yields for water supply wells in the Rocky River Watershed ranged from zero to 60 gallons per minute. No correlation was found between well yield and hydrogeologic unit. The arithmetic mean well yield is 12 gallons per minute, while the geometric mean is 8 gallons per minute. The well yields reported on the well construction form are determined based on the well driller’s observation and are not a quantitative assessment. However, the average well yields reported for the Rocky River Watershed are similar to well yields reported from other areas within the N.C. Piedmont.

HUMAN FACTORS

POPULATION GROWTH AND TRENDS

Ninety- one percent of the Rocky River Watershed lies within Chatham County; the remainder of the watershed is located within Alamance and Randolph counties. Table 2 presents population data for the three largest municipalities located partially in the watershed and Chatham County.

Overall, the population in the Rocky River Watershed has not seen as much growth as Chatham County, although the Siler City area has seen moderate growth. Siler City is located within the Love Creek – Rocky River subwatershed, the most densely populated subwatershed in the Rocky River Watershed. The second most densely populated subwatershed is the North Prong Rocky River – Headwaters Rocky River subwatershed containing portions of both Liberty and Staley. The rest of the watershed is sparsely populated although the Landrum Creek subwatershed is currently the fastest growing area. Population estimates by subwatersheds identified by the Hydrologic Unit Code (HUC) for 1990, 2000, and 2010 can be found in Table 3. Figure 6 illustrates the distribution of population by subwatersheds in 2010.

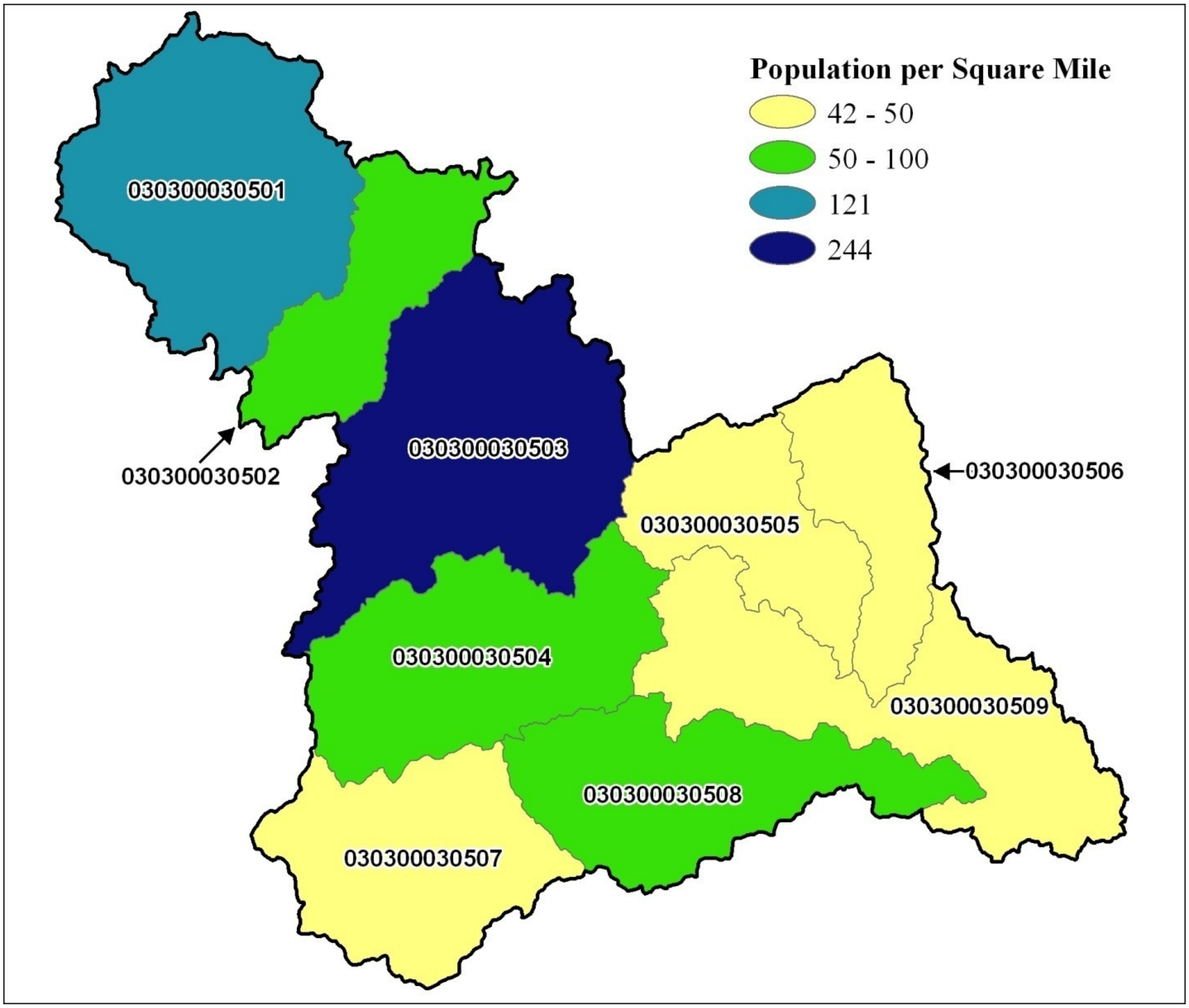
Table 2: Municipal and County Populations

Municipality or County	2000 Pop.	2010 Pop.	Percent Change
Siler City	6,966	7,887	13.2
Liberty	2,661	2,656	-0.2
Staley	347	393	13.3
Chatham County	49,329	63,505	28.7
Source: 2000 and 2010 US Census			

Table 3: Population Density by 12-Digit Subwatershed

12-Digit HUC	Subwatershed Name	Population Density per Square Mile			Percent Change 1990 - 2010
		1990	2000	2010	
030300030501	North Prong Rocky River – Headwaters Rocky River	93	110	121	29.5
030300030502	Lacys Creek – Rocky River	52	60	62	18.2
030300030503	Loves Creek – Rocky River	173	221	244	41.5
030300030504	Tick Creek – Rocky River	43	53	59	36.7
030300030505	Landrum Creek	23	32	45	95.9
030300030506	Harlands Creek	32	41	42	31.1
030300030507	Headwaters Bear Creek	43	46	46	3.7
030300030508	Harts Creek – Bear Creek	44	47	58	30.7
030300030509	Rocky River	29	38	47	64.1
Total		69	85	94	36.4
Source: 1990, 2000, and 2010 US Census					

Figure 6: 2010 Population Density by 12-Digit Subwatershed



POPULATION, LAND COVER, AND IMPERVIOUS SURFACE

As population increases, so does the amount of developed land. As an area becomes more densely developed, the amount of impervious surfaces increases. It is important to minimize impervious surface in order to maintain recharge rates. As an area becomes more impervious, less water is infiltrated as groundwater and more water runs off into streams. This creates flashiness during rainfall events and less base flow during times of drought because instead of infiltrating and slowly moving through the ground to the stream the water quickly flows overland into the stream. In addition, stormwater runoff carries pollution from the land surface into waterbodies.

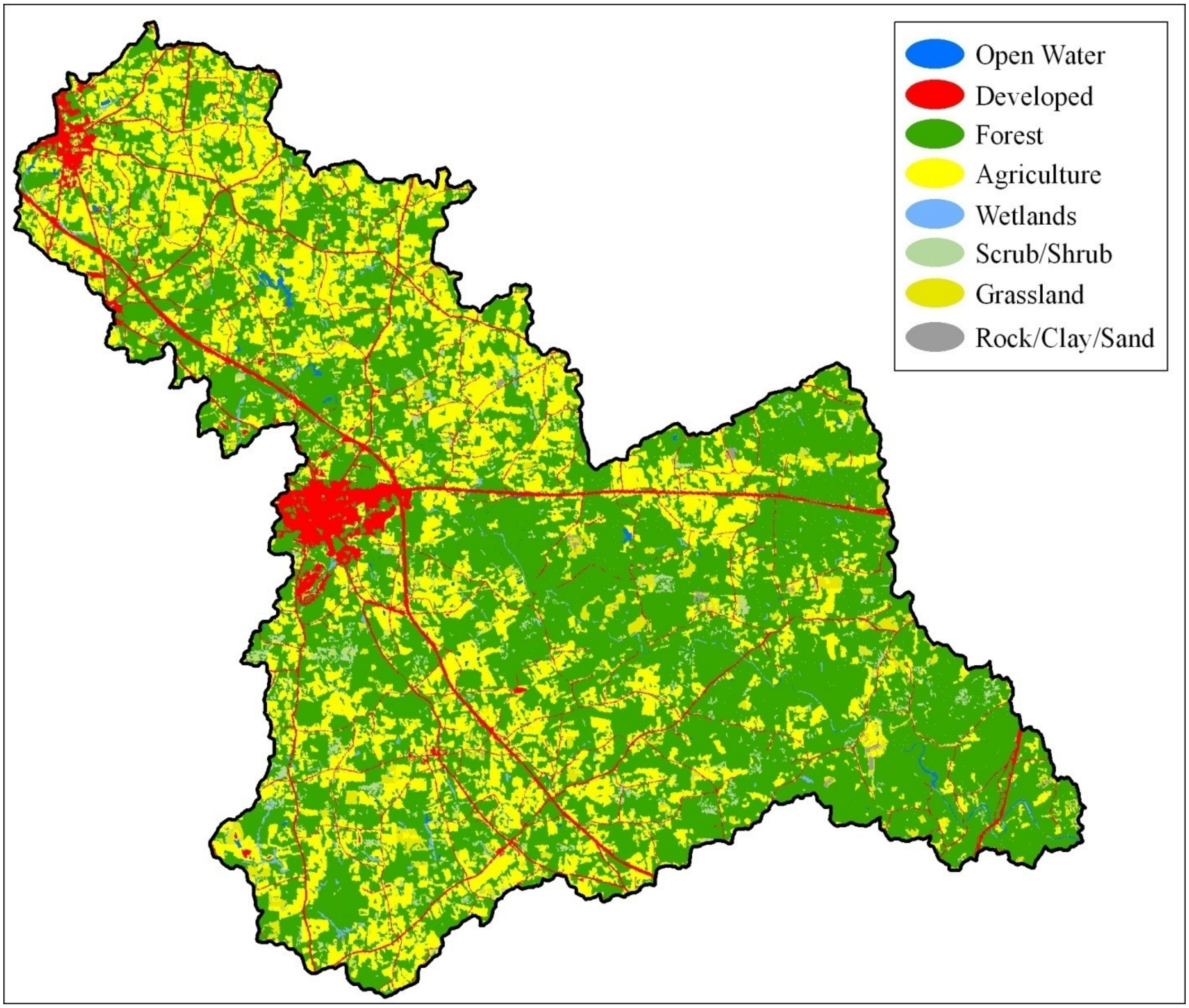
There are ways to minimize impervious surfaces while continuing to develop. Rainfall can be captured from rooftops using rain barrels and cisterns. Retention Ponds can help infiltrate water from parking lots. Alternative paving methods can be implemented instead of tradition impervious pavements. Reducing or limiting the amount of impervious surfaces means greater recharge to groundwater supplies.

Table 4 summarizes and compares the percentage of each land cover in the watershed in 2001 and 2006. Figure 7 illustrates the spatial distribution of the land cover types in 2006.

Table 4: 2001 and 2006 Land Cover Percentages

Land Cover/Land Use Type	2001 Percentage	2006 Percentage
Developed – Open Space	4.73	4.83
Developed – Low Intensity	1.26	1.26
Developed – Medium Intensity	0.37	0.37
Developed – High Intensity	0.18	0.18
Developed	6.54	6.64
Forest – Deciduous	40.63	41.34
Forest – Evergreen	11.88	11.36
Forest – Mixed	5.52	2.34
Forest	58.02	57.96
Pasture / Hay	27.72	27.59
Cultivated Crops	0.83	0.41
Agriculture	28.55	28.00
Emergent Herbaceous Wetlands	0.00	0.00
Woody Wetlands	0.59	0.60
Wetlands	0.59	0.60
Barren Land (Rock/Clay/Sand)	0.24	0.18
Grassland Herbaceous	3.09	4.27
Shrub / Scrub	2.96	2.34
Source: Multi-resolution Land Characteristics Consortium		

Figure 7: 2006 Rocky River Watershed Land Cover



LIVESTOCK PRODUCTION

Cattle, swine, and wet poultry facilities that are over a certain size are required to obtain coverage under a general permit from the Division of Water Quality. Facilities below the individual permit threshold are deemed permitted and required to manage wastewater properly. Some activities, such as dry poultry operations, do not require a permit. Table 5 provides a summary of animal operation facilities in the watershed with active permits. Table 6 gives estimates of overall livestock production in Chatham County.

Table 5: Permitted Animal Operations in the Rocky River Watershed

Permit Type	Facilities	Animal Counts
Cattle	4	1,900
Swine	2	657
Wet Poultry	0	0
Dry Poultry	N/A	N/A
Source: DWQ BIMS Database		

Table 6: Estimated Livestock Production in Chatham County

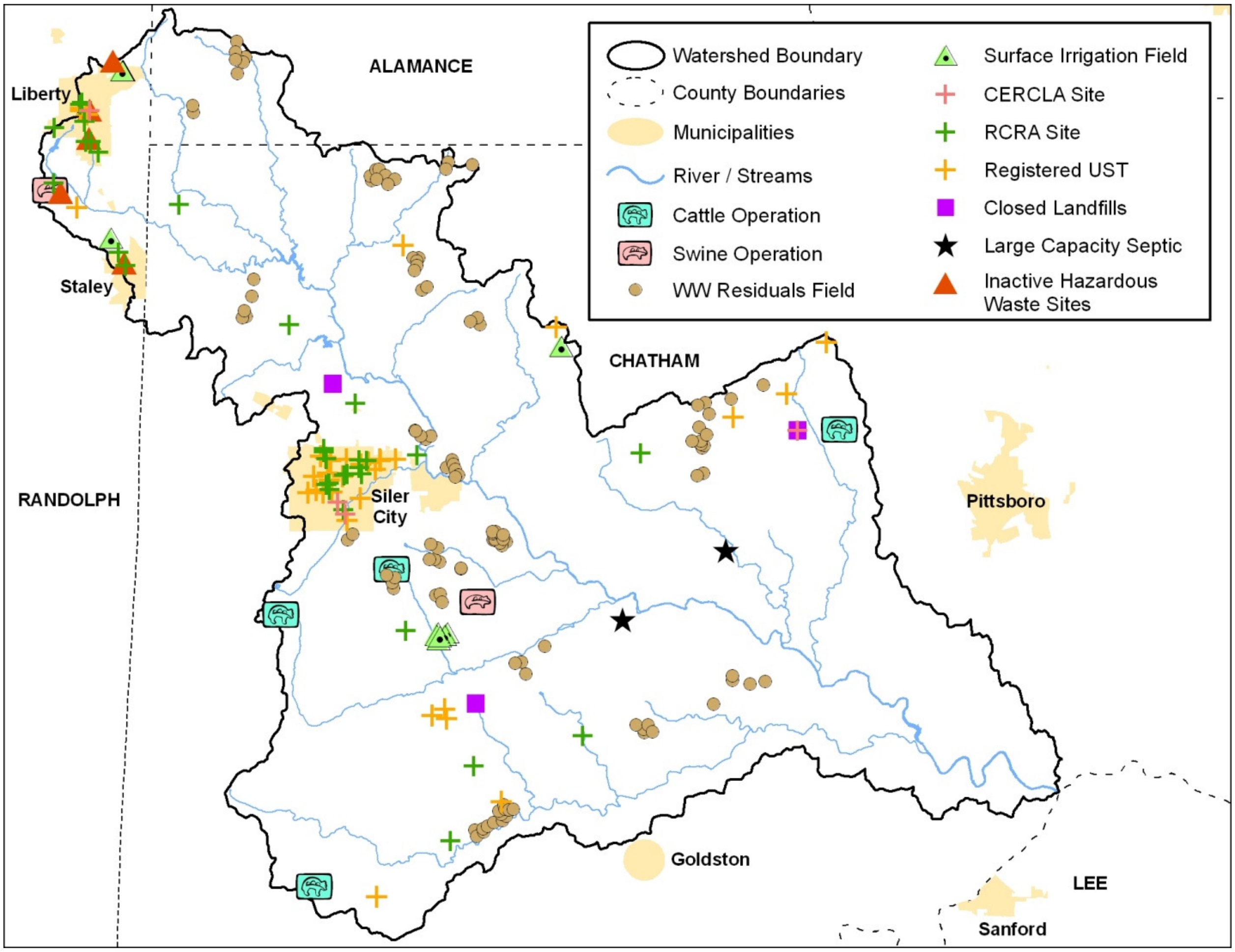
Animal Type	2008	2009	2010
Broiler Chickens (produced yearly)	25,000,000	25,000,000	26,800,000
Non-Broiler Chickens (on farms Dec. 1)	620,000	725,000	Not Reported
Turkeys	Not Reported	Not Reported	Not Reported
Hogs (on farms Dec. 1)	10,300	24,000	10,000
Cattle – All (on farms Jan. 1)	36,000	37,000	31,500
Source: NC Department of Agriculture and Consumer Services, Agriculture Statistics Division			

POTENTIAL CONTAMINATION SOURCES

The purpose of this section is to improve awareness of factors that affect groundwater quality and catalog data on potential contamination sources in the watershed from various agencies. The geographic distribution of various potential groundwater contamination sources within the watershed is shown in Figure 8.

The data provided in this section for land applied wastewater residuals was extracted from the DWQ's Basinwide Information Management System (BIMS) database and from annual reports submitted by the permit owners. The data provided for disposal sites and contaminated sites were obtained using geographic information system (GIS) data obtained from the North Carolina Division of Waste Management (DWM) and the United States Environmental Protection Agency (US EPA).

Figure 8: Potential Groundwater Contamination Sources in the Rocky River Watershed



LAND APPLIED WASTEWATER AND RESIDUALS

Treated wastewater and wastewater residuals are sometimes applied to fields for disposal and for use as fertilizer. Table 7 summarizes the acres of permitted land application activities in the watershed by type of application. This summary excludes land application fields used under Distribution of Residuals permits or septage permit. Septage permits are issued by the Division of Waste Management and are discussed in the section on disposal sites. Distribution of Residuals permits (Class A residuals) are not included because these residuals have undergone additional pathogen reduction and are not required to be tracked.

Table 7: Land Application Fields in the Rocky River Watershed

Permit Type	Fields Permitted	Acres Permitted	Fields Utilized 2010	Acres Utilized 2010
Land Application of Residuals (Class B)	115	1,564	32	500
Surface Irrigation	16	160	16	160
High Rate Infiltration	0	0	0	0
Reuse (Reclaimed)	0	0	0	0
Source: DWQ BIMS database				

DISPOSAL SITES

There are only a few disposal sites in the watershed. The Chatham County Landfill, which is now closed, is a known source of groundwater contamination and has been shown to have contaminated nearby private drinking water wells. Other than closed landfills there are no known disposal sites located in the watershed.

Table 8: Waste Disposal Sites in the Rocky River Watershed

Disposal Site Type	Open Landfill	Closed Landfill	Hazardous Waste Site	Septage
Count	0	3	0	0
Source: North Carolina Division of Waste Management				

CONTAMINATED SITES

There are five Inactive Hazardous Site Program (IHSP) sites and four archived Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites. No Dry-cleaning Solvent Cleanup Act (DSCA) Program sites or National Priorities List (NPL) sites have been identified in the watershed.

Table 9: Contaminated Sites in the Rocky River Watershed

Contaminated Site Type	IHSP	DSCA	NPL	Active CERCLA	Archived CERCLA
Count	5	0	0	0	4
Source: North Carolina Division of Waste Management and the US Environmental Protection Agency					

OTHER POTENTIAL GROUNDWATER CONTAMINATION SOURCES

Based on the 1990 U.S. census, 60% of residents in the Rocky River Watershed relied on septic systems as a means for treatment and disposal of waste (Pradhan, S.S., et al., 2007). In addition to these individual septic systems, there are two large capacity septic systems designed for higher volumes of waste in the watershed. Properly sited and well maintained septic systems are a safe way to dispose of wastewater, however malfunctioning or improperly sited septic systems have the potential to contaminate groundwater and surface water.

Resource Conservation Recovery Act (RCRA) Hazardous Waste Generators and Transporters sites and underground storage tanks (USTs) have the potential for toxic chemical releases. Table 10 shows that there are currently 34 registered USTs and 35 RCRA sites in the watershed.

Table 10: Other Potential Sources of Groundwater Contamination in the Rocky River Watershed

Source Type	Registered Underground Storage Tanks	RCRA Sites
Count	34	35
Source: North Carolina Division of Waste Management and the US Environmental Protection Agency		

GROUNDWATER QUALITY ASSESSMENT

There are several sources of groundwater quality data available for the Rocky River Watershed. The largest amount of groundwater quality data is from public and private drinking water wells. Public water supply wells, which serve some businesses, schools, churches, and communities, are required to test their well water quality regularly and report the results to the state. Since 2008, all new private wells are also required to be tested for a limited number of parameters. The water quality for the public water supply wells was made available for this study by the NCDENR Public Water Supply Section, and the private well water quality data was obtained from the NCDHHS Public Health Laboratory. A limited amount of water quality data is available for this watershed from published reports and from the USGS water quality monitoring programs. The following sections summarize the available groundwater quality data from these sources.

PUBLIC AND PRIVATE DRINKING WATER WELL QUALITY

PRIVATE DRINKING WATER WELLS

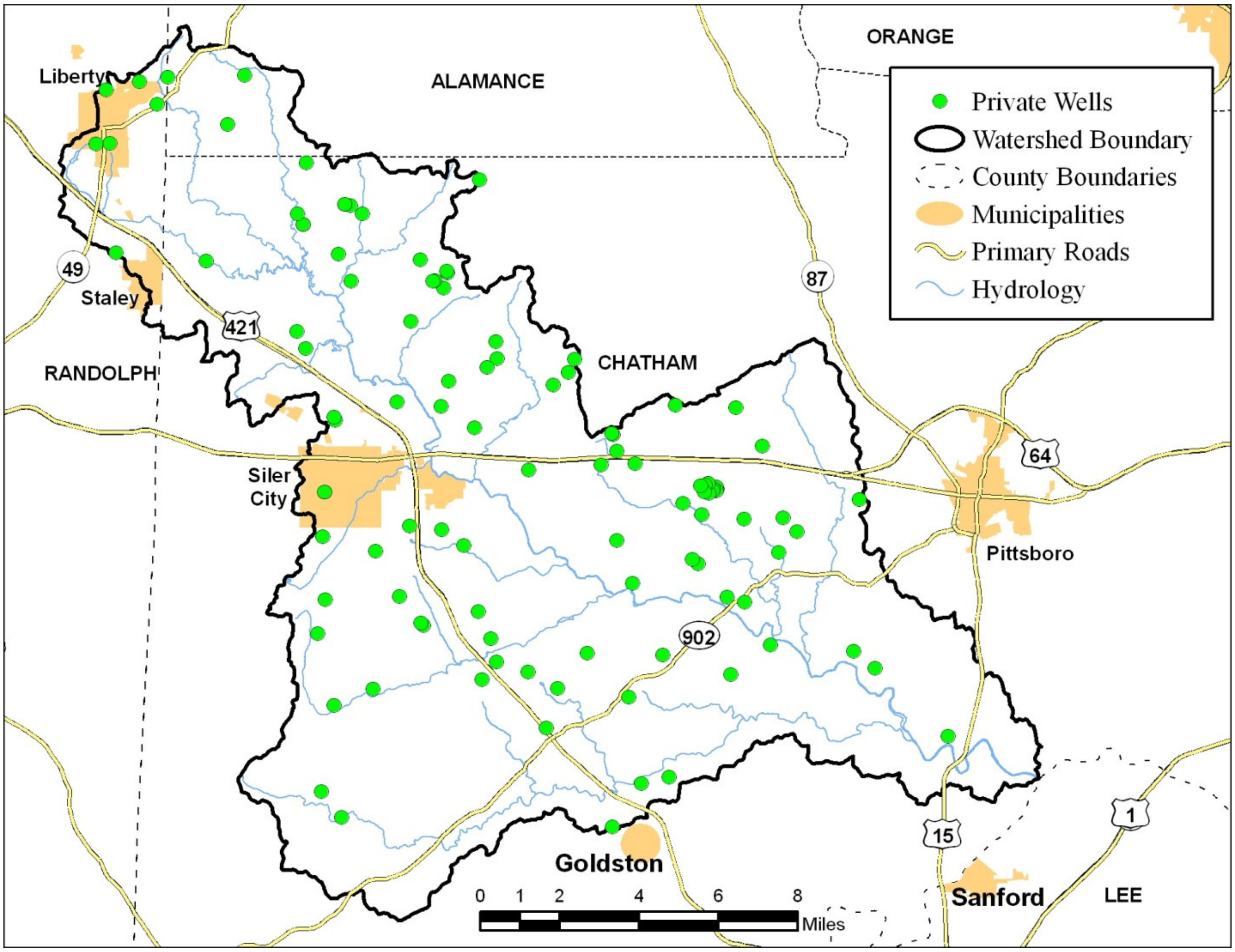
State law requires that all new private water supply wells installed after July 1, 2008 be tested for metals, chloride, fluoride, sulfate, nitrate, nitrite, and coliform bacteria. Due to the large number of samples taken under this requirement, the private well sample results provide the most valuable indicator of overall groundwater quality of all publicly available data sources. Before this legislation was passed, DWQ and local county health departments would sample private wells upon request, but only if there was evidence of contamination or improper well construction. As a result, private wells sampled before July 1, 2008 yield water quality results that are somewhat biased towards “poor” water quality and improper well construction. The new legislative well sampling requirement removes this bias somewhat, although well samples resulting from citizen complaints are still included in the groundwater quality data that is available from the DHHS Public Health Laboratory database.

Though this dataset provides a rich source of information on groundwater quality, it has two major deficiencies as a groundwater quality monitoring source. First, the dataset lacks consistent, reliable location information. Only about 20 percent of samples in the database have sufficient location information (street address, GPS coordinates, etc.) to locate them on a map with reasonable precision. For this reason, the data is primarily useful in aggregate for drawing broad inferences about groundwater quality, rather than making specific correlations to patterns of land use or geology, factors which are very important to groundwater quality.

Second, the private well sampling dataset does not include consistent information about organic contaminants, such as those in gasoline or pesticides. Sampling of private wells for these types of contaminants is still driven by well owner complaints or special requests, which means that the dataset for organic contaminants will tend to be biased towards sites where such contaminants are most likely to be found.

Figure 9 shows the locations of the small number of private water supply wells in the Rocky River Watershed that have reliable location data. While this only represents a small portion of all private wells in the watershed, it does provide an illustration that reliance on groundwater as a major source of water supply is fairly evenly distributed throughout the entire Rocky River Watershed.

Figure 9: Known Locations of Private Wells Sampled From 2001 to 2009



In order to use this dataset as a gauge of overall groundwater quality in the Rocky River watershed, the results of private water supply wells sampled during the period July 1, 2008 to April 30, 2009 were compared to North Carolina groundwater standards (established in 15A NCAC 2L) and federal primary drinking water standards. The number and percentage of samples exceeding each standard were then tallied from this comparison. Results of this comparison are presented in Table 11. Coliform bacteria results were not analyzed as a part of this report because coliform problems generally indicate a very localized problem with well construction or maintenance, or very localized contaminant sources, rather than a pervasive problem with groundwater quality.

The most common exceedances of state groundwater standards were for iron (25.9%) and manganese (39.1%). These two naturally-occurring elements are commonly found in groundwater in the Piedmont. They do not normally pose a health hazard for human consumption but can present an esthetic concern because they can discolor water, plumbing fixtures, or laundry. Zinc occurred at levels above the state groundwater standard in approximately 14 percent of the private wells sampled during this period, although it is not a significant constituent in the bedrock in the region. It is likely that most, if not all, zinc detected in the private well samples originated from the galvanized coating of steel pipe used for well casing. Eighteen percent of the private well samples had pH values outside the range of 6.5 to 8.5 set by the North Carolina groundwater standards. Low pH could result from naturally occurring organic acids. High pH could be the result of potential well grout contamination if the well was improperly grouted. Arsenic occurred at levels above the state groundwater standard in 2 percent of private wells sampled during the period. Arsenic concentrations in groundwater are discussed further in the "Naturally Occurring Contaminants" section of this report.

Table 11: Private Wells Sampled In Chatham County July 1, 2008-April 30, 2009

Parameter	Number of Samples Analyzed	NC Groundwater Standard (mg/L)	Number of Samples Exceeding NC Groundwater Standard	Percent of Samples Exceeding NC Groundwater Standard	EPA Primary Drinking Water Standard (mg/L)	Number of Samples Exceeding Primary Drinking Water Standard	Percent of Samples Exceeding Primary Drinking Water Standard
Arsenic	133	0.01	3	2.3	0.01	3	2.3
Barium	67	0.7	0	0.0	2	0	0.0
Cadmium	67	0.002	0	0.0	0.005	0	0.0
Chloride	95	250	1	1.1	NA	0	0.0
Chromium	67	0.01	1	1.5	0.1	1	1.5
Copper	133	1	0	0.0	NA	0	0.0
Fluoride	133	2	0	0.0	4	0	0.0
Iron	133	0.3	34	25.6	NS	0	0.0
Lead	133	0.015	2	1.5	0.015	2	1.5
Manganese	133	0.05	52	39.1	NA	0	0.0
Mercury	67	0.001	0	0.0	0.002	0	0.0
Nickel	113	0.1	0	0.0	NA	0	0.0
Nitrate	87	10	0	0.0	10	0	0.0
Nitrite	87	1	0	0.0	1	0	0.0
pH	133	6.5-8.5	24	18.0	NA	0	0.0
Selenium	67	0.02	0	0.0	0.05	0	0.0
Silver	67	0.02	0	0.0	NA	0	0.0
Sulfate	19	250	0	0.0	NA	0	0.0
Zinc	133	1	19	14.3	NA	0	0.0

PUBLIC WATER SUPPLY WELLS

Public water systems are those which provide piped drinking water to at least 15 connections or 25 or more people for 60 days or more per year. The NCDENR Division of Water Resources Public Water Supply (PWS) Section regulates public water supply wells. Public water supply wells are required to test water samples from their systems on a regular basis in order to comply with state and federal requirements. Many public water supply systems obtain their water from wells, therefore the compliance monitoring samples from PWS systems that use wells provide a very good source of groundwater quality data. Public water supply wells are routinely tested for metals, bacteria, volatile and semi-volatile organic compounds, nitrate and nitrite, and certain radionuclides.

Currently, there are 32 public water supply wells located within the Rocky River Watershed. The locations of these wells are shown on Figure 10. Data obtained from the Public Water Supply Section from wells within the watershed from the period of January 2005 to January 2011 reveal very few water quality standard violations during this period (Table 12). The only exceedences noted during this period were from volatile organic compounds (VOCs) detected in one well. These VOCs may have originated from many potential sources, but are most likely an indication of a leaking underground petroleum storage tank or from a release of dry cleaning solvents. There were no groundwater quality standard exceedences noted for any of the other tested parameters during this time period.

Figure 10: Map of Public Water Supply Wells

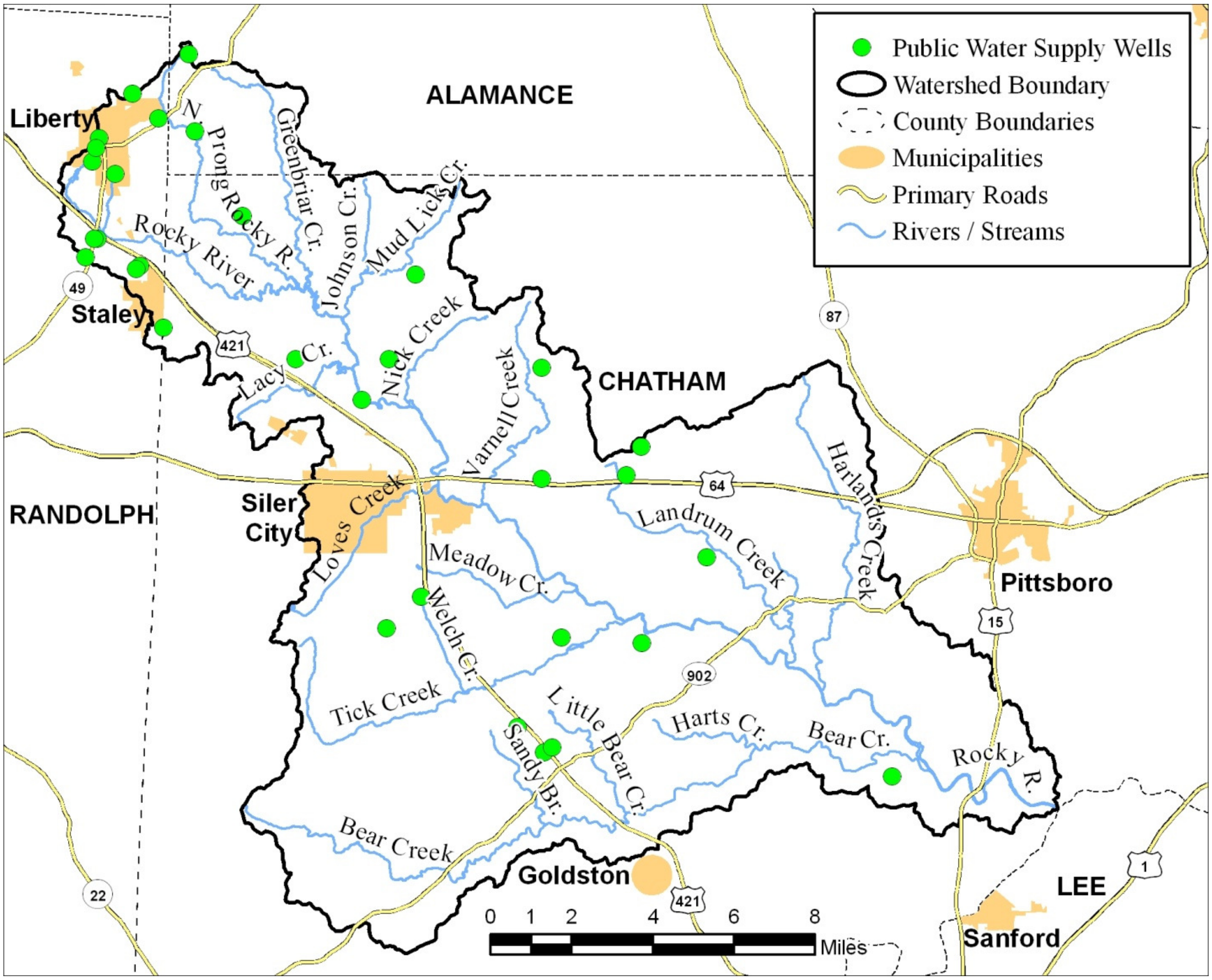


Table 12: Public Water Supply Well Water Quality Data Summary, January 2005-January 2011

Parameter	Wells Sampled	Samples Collected	Non-Detects	Samples exceeding MCL	Wells with Samples exceeding MCL
Inorganic					
Antimony	9	15	15	0	0
Arsenic	9	18	18	0	0
Barium	9	15	14	0	0
Beryllium	9	15	15	0	0
Cadmium	9	15	15	0	0
Chromium	9	15	15	0	0
Cyanide	9	15	15	0	0
Fluoride	9	15	9	0	0
Mercury	9	15	15	0	0
Selenium	9	15	15	0	0
Thallium	9	15	15	0	0
Volatile Organic Compounds					
1,1-Dichloroethylene	9	45	31	4	1
1,1,1-Trichloroethane	9	45	45	0	0
1,1,2-Trichoroethane	9	45	45	0	0
1,2-Dichloroethane	9	45	45	0	0
1,2-Dichloropropane	9	45	45	0	0
1,2,4-Trichlorobenzene	9	45	45	0	0
Benzene	9	45	45	0	0
Carbon Tetrachloride	9	45	45	0	0
Chlorobenzene	9	45	45	0	0
CIS-1,2-Dichloromethane	9	45	45	0	0
Dichloromethane	9	45	43	0	0
Ethylbenze	9	45	45	0	0
O-Dichlorobenzene	9	45	45	0	0
P-Dichlorobenzene	9	45	45	0	0
Styrene	9	45	45	0	0
Tetrachloroethylene	9	45	45	0	0
Toluene	9	45	45	0	0
Trans-1,2-Dichloroethylene	9	45	45	0	0
Trichloroethylene	9	45	37	0	0
Vinyl Chloride	9	45	45	0	0
Total Xylenes	9	45	45	0	0
Semi-Volatile Organic Compounds					
1,2-Dibromo-3-Chloropropane	9	20	20	0	0
2,4-D	9	24	24	0	0
2,4,5-TP	9	24	24	0	0
Atrazine	9	20	20	0	0
Benzo(A)Pyrene	9	20	20	0	0
BHC-Gamma	9	20	20	0	0
Carbofuran	9	20	20	0	0
Chlordane	9	20	20	0	0
Dalapon	9	25	25	0	0

Parameter	Wells Sampled	Samples Collected	Non-Detects	Samples exceeding MCL	Wells with Samples exceeding MCL
Di(2-Ethlhexyl) Adipate	9	20	20	0	0
Di(2-Ethlhexyl) Phthalate	9	20	20	0	0
Dinoseb	9	24	24	0	0
Endrin	9	20	20	0	0
Ethylene Dibromide	9	20	20	0	0
Heptachlor	9	20	20	0	0
Heptachlor Epoxide	9	20	20	0	0
Hexachlorobenzene	9	20	20	0	0
Hexachlorocyclpentadiene	9	20	20	0	0
Lasso	9	20	20	0	0
Methoxychlor	9	20	20	0	0
Oxamyl	9	20	20	0	0
Pentachlorophenol	9	24	24	0	0
Picloram	9	24	24	0	0
Simazine	9	20	20	0	0
PCBs	9	20	20	0	0
Toxaphene	9	20	20	0	0
Nutrients					
Nitrate	30	154	74	0	0
Nitrite	18	38	37	0	0
Radionuclides					
Radionuclides	6	20	12	0	0

HISTORICAL GROUNDWATER QUALITY DATA

The United States Geological Survey (USGS) maintains a database of historical groundwater and surface water quality data. This database is referred to as the National Water Information System (NWIS). The NWIS database includes groundwater quality data from only four monitoring wells with verifiable locations in the Rocky River Watershed.

In the late 1970's the USGS coordinated a nationwide assessment of potential uranium resources known as the National Uranium Resource Evaluation (NURE) project in which water supply wells were analyzed for radioactive elements and other indicators for the possible presence of uranium. Approximately 25 water supply wells from the Rocky River Watershed were sampled as part of this project. Due to the limited scope of the NURE project and subsequent limited number of sample parameters and lack of standard inorganic compound parameter analyses, this data is not very useful for the purposes of standard groundwater quality analysis and historical comparisons.

Very little published historical groundwater quality data exists for the Rocky River Watershed. Limited groundwater quality data is contained in "Groundwater Conditions in the Liberty Area, Randolph County, North Carolina" (Berry, 1965), and "An Appraisal of the Groundwater Resources of the Upper Cape Fear River Watershed, North Carolina" (Floyd and Peace, 1974). The groundwater quality data from the Berry publication contains field measurements of temperature, pH, hardness, and specific conductance only. That data is included in Table 13. The groundwater data from the Floyd and Peace (1974) publication contains only generalized groundwater quality that has been averaged for regional rock types.

Table 13: Summary of Historical Groundwater Quality Data (USGS, 2011 and Floyd and Peace, 1974)

	Well Identification							
	CH-086[a]	CH-038[a]	CH-034[a]	Liberty Well 4[b]	Liberty Well 1[b]	Liberty Well 2[b]	Liberty Well 5[b]	Town Well 3[b]
Latitude	79.384167	79.435278	79.444722	--	--	--	--	--
Longitude	35.742222	35.800278	35.824722	--	--	--	--	--
Well Depth (feet)	115	220	112	397	262	231	600	232
Date Sampled	1958	1958	1962	1964	1965	1964	1964	1964
Total Dissolved Solids (mg/L)	138	194	634	--	--	--	--	--
Hardness (mg/L)	88	125	492	60	80	45	85	65
pH	7.2	7.5	7.5	7.0	7.8	7.5	8.0	7.0
Color	10	5	--	--	--	--	--	--
Specific Conductance (µS/cm)	208	287	--	140	180	120	200	160
Silica (mg/L)	28	30	35	--	--	--	--	--
Iron (mg/L)	0.05	0.01	0.05	--	--	--	--	--
Manganese (mg/L)	0.08	0.00	0.05	--	--	--	--	--
Calcium (mg/L)	18.0	37.0	142.0	--	--	--	--	--
Magnesium (mg/L)	10.0	8.1	33.0	--	--	--	--	--
Sodium (mg/L)	9.3	15.0	42.0	--	--	--	--	--
Aluminum (mg/L)	0.00	0.00	0.20	--	--	--	--	--
Lithium (mg/L)	0.00	0.10	0.40	--	--	--	--	--
Fluoride (mg/L)	0.1	0.1	0.02	--	--	--	--	--

Sources:
[a] USGS NWIS data
[b] Floyd and Peace, 1974

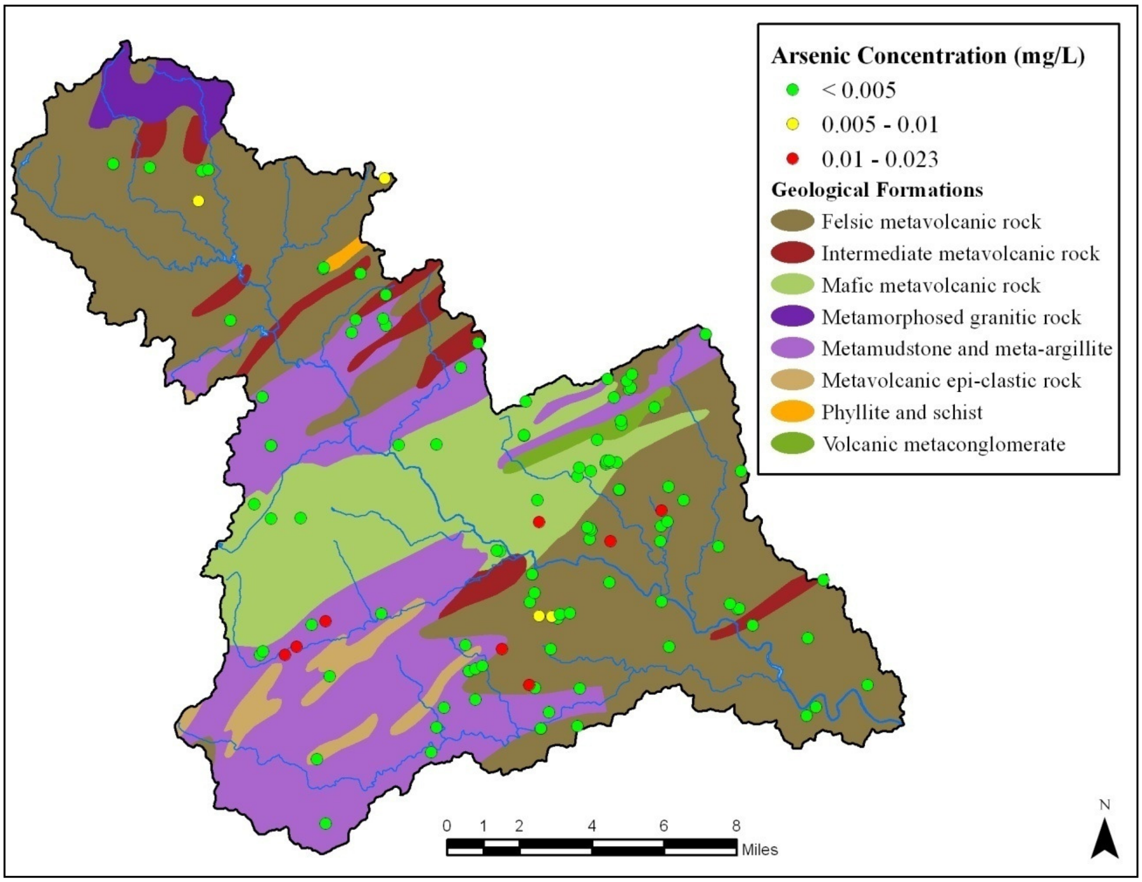
GROUNDWATER QUALITY ISSUES

NATURALLY OCCURRING CONTAMINANTS

Groundwater flowing through the bedrock aquifer can interact with the minerals in the rock matrix, which can result in elevated levels of naturally occurring toxic elements such as arsenic, lead, and radionuclides. An analysis of the available groundwater quality data from the Rocky River Watershed reveals that groundwater quality in this area is generally good, and is usually suitable for human consumption with little or no treatment. However, this watershed is located entirely within the Carolina Terrane, which is known to be an area with elevated levels of naturally occurring arsenic in groundwater.

Since there is essentially no ambient groundwater quality monitoring data available for this basin, the DHHS private well sampling data can be used to help provide information on groundwater arsenic concentrations, since arsenic is a required testing parameter for private wells. There were 173 private well samples for arsenic with reliable locations in the Rocky River Watershed with arsenic data during the period of May 2006 to October 2009. Note that this time period includes private wells sampled prior to the implementation of the state well testing rule and therefore, this data set includes wells that may have been sampled as a result of a water quality complaint. However, this data set includes more samples with reliable locations than the less-biased sampling data from July 1, 2008 to April 2009, which makes this dataset useful for evaluating the occurrence of naturally occurring arsenic in groundwater relative to the bedrock geology of the watershed. Figure 10 shows the concentration of arsenic in these well samples superimposed on the hydrogeologic unit map for the watershed. A small number of these 173 samples may have been duplicates and/or re-samples, but this data provides for a reasonable assessment of the concentration of arsenic in groundwater for the Rocky River Watershed.

Figure 11: Arsenic Concentrations in Private Wells from 2006 to 2009



As indicated on the map in Figure 11, arsenic was detected at levels greater than 0.010 mg/L only in areas underlain by mafic metavolcanic rock, felsic metavolcanic rock, and metamudstone. This suggests there may be a correlation between geologic unit and arsenic concentration. This possibility is supported by the experience of DWQ staff. However, this may not be a valid comparison due to the small size of the watershed and the relatively small number of samples representing each geologic unit found there.

In addition to arsenic, another common naturally occurring element in groundwater that is potentially harmful to humans is radon. Unfortunately, there is only one groundwater sample with available radon concentration in all of Chatham County, and that sample came from outside of the Rocky River Watershed. However, radon is usually associated with felsic igneous intrusions such as granite, and there is only a relatively minor amount of granite in the Rocky River Watershed. That granite occurs in the northwestern-most portion of the watershed. Thus, this watershed is not an area where the geologic conditions are conducive to elevated radon levels, but there is very little empirical data with which to form any conclusions on radon levels.

ANTHROPOGENIC CONTAMINANTS

Since the Rocky River Watershed is located within an area considered to be mostly rural by eastern United States standards, one would not expect to see very many instances of groundwater contamination from human activities except those that could be attributed to agricultural practices. The groundwater quality data collected for this report is generally consistent with expectations for a rural portion of the North Carolina Piedmont. Public water supply monitoring results do not show pervasive problems with volatile organic compounds (VOCs) or other contaminants from industrial or commercial sources; however, public water supply well locations are very carefully researched and monitored to ensure that the risk of such contamination is minimized. There is no consistent sampling of private wells for VOCs. Well users near the potential contamination sources indicated in Figure 7 should consult with their local health department to determine their needs for well sampling.

DISCUSSION AND RECOMMENDATIONS

CURRENT DATA EVALUATION

It is clear that there is a scarcity of long term groundwater quality monitoring for the Rocky River Watershed. At present there is not a means to identify which of multiple potential groundwater contamination sources is the most critical. There are a large number of animal farms in the watershed, but we have no long term monitoring data that can be used to evaluate impacts to the groundwater resource as a result of the large number of animal farms. There are occasional elevated levels of nitrates noted in private well sampling data, but there is not enough information to determine the exact source of the nitrate pollution, and we have not been tracking this data set long enough to evaluate trends.

The most comprehensive data on groundwater quality in the Rocky River Watershed is from the private well testing program. Samples of well water are analyzed for each new private water supply well that is drilled in North Carolina and analyzed at the NCDHHS Public Health Laboratory. Up until 2008, when the well testing bill was passed by the state legislature, private wells would be sampled in response to citizen complaints about their well water quality such as objectionable taste or odor, or if there was reason to suspect contamination. Therefore, the private well testing data available prior to 2008 is biased towards potential problems with groundwater quality. The post-2008 private well data provides the most extensive and valuable indicator of groundwater quality in this watershed, but even that data is subject to some bias from trends in population growth. Additionally, this dataset does not include any information on VOCs.

ADDRESSING POTENTIAL WATER QUALITY ISSUES

As the population and business operations in the Rocky River Watershed increase, the demand for a reliable source of clean water will increase. Water supply wells may be capable of supplying an increased demand for clean water, but only if the resource is protected and growth is managed. In fact, the Rocky River Watershed could become a source of water not only for the residents within the watershed, but also for nearby urban centers. It is likely that suburban housing development will start to accelerate in this area as the population spreads out from nearby urban areas. This will create an increased demand for drinking water, which will likely be provided by groundwater.

Future development onto areas currently occupied by farming operations may encounter residual agricultural chemicals and nutrients in the groundwater. In addition to the existing private and public water supply well testing programs, some private wells should be re-tested at a two to five-year frequency in areas of former agricultural use, in the vicinity of waste disposal operations, and in areas of commercial development. This sampling frequency is recommended due to the highly variable groundwater flow velocities typical for the North Carolina Piedmont. Well users living on former agricultural land may also wish to have their wells tested for parameters such as volatile organic compounds and pesticides, which are beyond the standard suite of parameters required for new wells.

Proper management of human and animal waste applications is a critical issue for the Rocky River Watershed. The watershed's location on the fringes of the fast growing Triangle and Triad areas and its rural character will undoubtedly result in increased pressure to accept biosolids residuals that are generated from the nearby urban centers. Biosolid application fields tend to be prevalent on the perimeters of large population centers because they require large expanses of arable land, but are often located close to the sources of the biosolids in order to reduce transportation costs.

The watershed's proximity to urban areas and its rural character also play a role in the relatively large number of poultry and cattle farming operations found in the watershed. Increasing populations in the surrounding urban centers will likely result in increasing demand for poultry and cattle products, which will in turn result in increasing volumes of animal waste for disposal.

The data examined in this assessment do not suggest that human and animal wastes are currently creating significant groundwater contamination that would pose public health concerns. However, increasing volumes of biosolids and animal waste products disposed of in the Rocky River Watershed will result in larger nitrogen and phosphorus loads. Proper management of these waste products is essential to protect groundwater and surface water quality. Nutrient contamination of groundwater is a potential threat to human health, and nutrient contamination to surface water is a threat to aquatic ecosystems.

DATA NEEDS, FURTHER STUDY

Targeted long term groundwater quality monitoring stations in appropriate locations would be an invaluable tool for use in assessing any potential impacts from large scale animal farming operations and other anthropogenic pollution sources. The groundwater monitoring stations should be placed in strategic locations hydraulically downgradient from representative areas of concern for the Rocky River Watershed such as poultry farms, biosolids application fields, or other waste disposal areas. A "background" ambient groundwater quality monitoring station located in an undeveloped area of the watershed would be useful for comparison and to monitor groundwater quality changes over time.

It is possible that much of this monitoring network could be implemented through data mining of permit-required groundwater monitoring and by periodic re-sampling of existing water supply wells which have been strategically selected based on location, construction, depth, and land use. In either case, the collection and storage of groundwater quality data needs to be standardized throughout the regulatory programs that collect this data if either of these options is to be feasible. Accurate well location information is a critical element for groundwater quality assessments. A shared, standardized method to identify well locations in the databases maintained by DENR-DWQ, the DENR Division of Waste Management and the DHHS Public Health Lab would be of great value. The development of a centralized groundwater monitoring database to be used for all groundwater data collected by DENR is underway and will also be an invaluable tool for providing the public and decision makers with better information about groundwater quality. In addition to these data management needs, there is a need to develop quality assurance plans and statistical tools that specifically address the development of regional (watershed or county-level) assessments from data that was collected for the purposes of site-specific assessments.

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GLOSSARY OF TERMS

Alluvial – Sediment that has been deposited or re-shaped by modern rivers and streams.

Baseflow – Groundwater that seeps into surface water under normal conditions.

Discharge – The flow of groundwater into surface water or an adjacent aquifer.

Felsic - Rock that is rich in silica and typically light-colored, such as granite and rhyolite.

Igneous – Rock created by the cooling of magma or lava.

Lineament – Linear landscape feature that forms as a result of underlying geologic structure.

Mafic – Rock that is rich in iron and magnesium that is typically dark-colored, such as basalt and gabbro.

Mesozoic diabase dike – Vertically oriented tabular basaltic intrusion emplaced in early Mesozoic (approximately 250 – 150 million years ago) times.

Metamorphic – Rock created by exposure of parent rock to extreme heat and/or pressures.

Metavolcanic – Volcanic rock that has been exposed to some degree of heat and/or pressure to slightly alter its mineral composition and texture.

Physiographic province – A region of similar geologic structure and climate that has had a unified geomorphic history.

Recharge – The entry of water into the groundwater system, generally from rainfall or other precipitation soaking into the ground.

Tensional stress – Geologic stress created when rock masses get pulled apart, such as during the opening of an ocean basin.