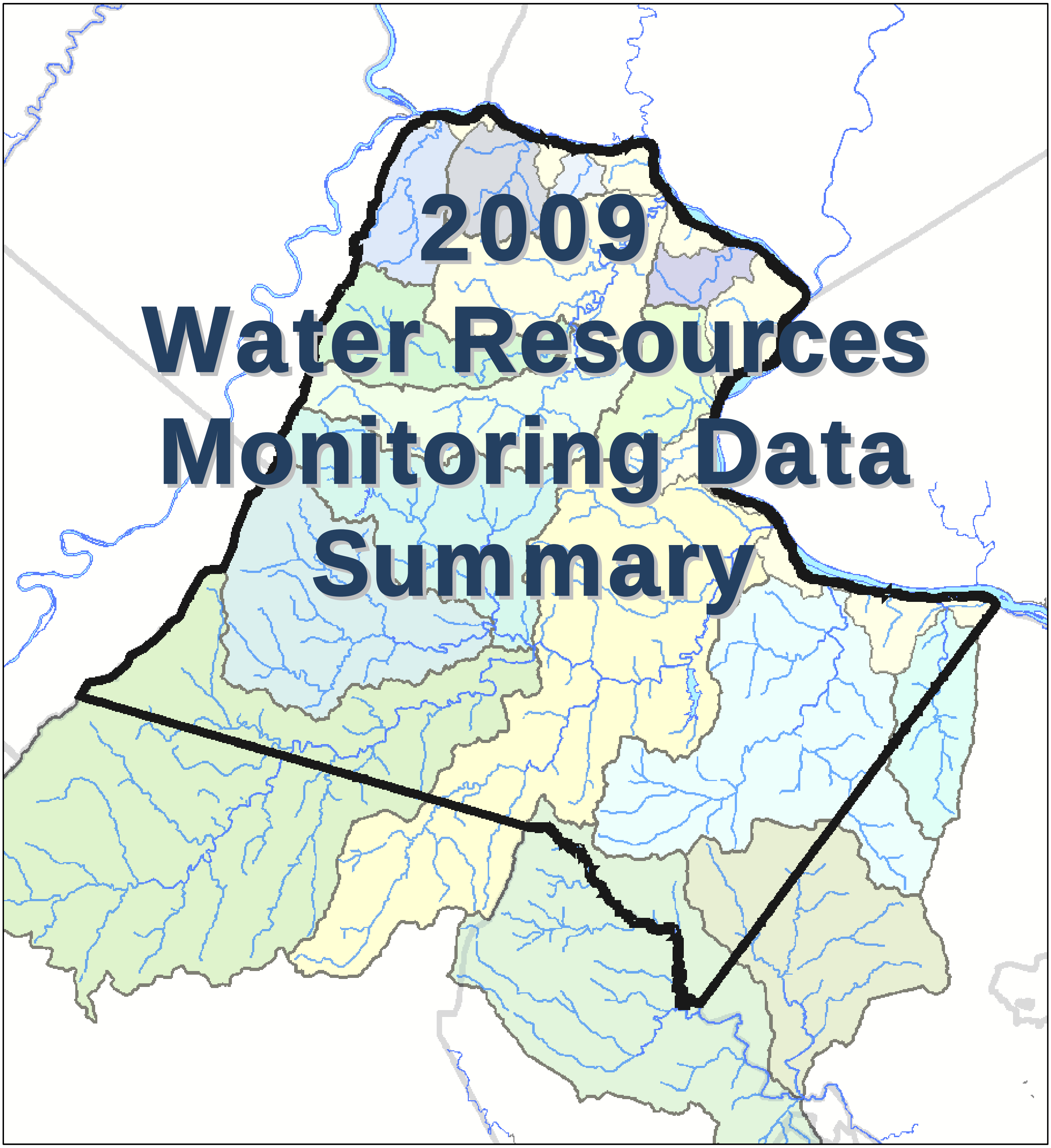
## Loudoun County, Virginia

# 2009 Water Resources Monitoring Data Summary



Prepared by
Department of Building & Development
Engineering Division, Water Resources Team
July 2010

# Loudoun County, VA
# 2009 Water Resources Monitoring Data Summary

## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| *cfs:* | *cubic feet per second* |
| *DEQ:* | *Virginia Department of Environmental Quality* |
| *EPA:* | *U.S. Environmental Protection Agency* |
| *MCL:* | *maximum contaminant level* |
| *mg/L:* | *milligrams per Liter* |
| *NWS-COOP:* | *National Weather Service Cooperative monitoring station* |
| *OWTS:* | *On-site Wastewater Treatment System* |
| *TDS:* | *Total Dissolved Solids* |
| *uS/cm:* | *microSiemens per centimeter* |
| *USGS:* | *U.S. Geological Survey* |
| *WRMP:* | *Water Resources Monitoring Program (Loudoun County)* |

## DATA LIMITATIONS

While efforts have been made to insure the accuracy of the data presented in this report, Loudoun County does not assume any liability arising from the use of these data. Reliance on these data is at the risk of the user. The U.S. Geological Survey (USGS) and the National Climatic Data Center (who distribute National Weather Service data) have data quality assurance procedures in which data are considered "provisional" until they are checked and corrected as needed. Data used in this report that are provisional are:

- USGS rainfall site Limestone/Leesburg, 1/1/2004 - 12/31/2009
- USGS rainfall site Catoctin/Lovettsville, 1/1/2005 - 12/31/2009
- USGS stream gauging station North Fork Catoctin Creek, 12/1/2009 - 12/31/2009
- USGS stream gauging station Catoctin Creek (Taylorstown), 10/1/2009 - 12/31/2009
- USGS stream gauging station Limestone Branch, 12/2/2009 - 12/31/2009
- USGS stream gauging station North Fork Goose Creek , 12/1/2009 - 12/31/2009
- USGS stream gauging station Goose Creek Leesburg , 10/1/2009 - 12/31/2009


## ACKNOWLEDGMENTS

A grant from the U.S. Environmental Protection Agency supplemented County funds to establish portions of the monitoring sites and infrastructure identified in this report including some of the stream gauges, monitoring wells, and precipitation stations. The grant also reimbursed a portion of the cost associated with time County staff spent developing the Water Resources Monitoring Program including program planning and implementation, data collection, data management, and analyses. The grant period ended September 30, 2009.

This document was prepared by County staff members Scott Sandberg, David Ward, Dennis Cumbie, and Glen Rubis of the Water Resources Team in the Engineering Division of the Department of Building and Development.

# INTRODUCTION AND SETTING

This document summarizes data collected during various water resources monitoring activities in and adjacent to Loudoun County, Virginia, by government and volunteer organizations during calendar year 2009. Specifically, data characterizing precipitation, stream flow, groundwater levels, and surface water and groundwater quality are presented. Loudoun County Department of Building and Development either collects these data or compiles them from other sources as part of the County's Water Resources Monitoring Program (WRMP). The data are presented and discussed in two sections: water quantity – measurements of precipitation, stream flows, and groundwater levels; and water quality – the chemical and biological characteristics of stream water and groundwater.

The WRMP was initiated in 2001 to help assess the conditions of water resources in Loudoun County which has been one of the fastest growing counties in the nation during the past decade. The current population of Loudoun is approximately 290,000 and is projected to reach almost 420,000 by 2030.

## General Characteristics of Loudoun County

Loudoun County is located in Northern Virginia approximately 30 miles west of Washington, D.C. The county covers an area of 520 square miles and is bordered on the north by the Potomac River and the west by the Blue Ridge Mountains (Figure 1).

Urban and suburban development is concentrated mostly in the eastern part of the county, generally from the Town of Leesburg to Washington Dulles International Airport and the border with Fairfax County. The western portion of the county is more rural, with crop farms, pastures, vineyards, several small towns, and numerous large-lot residential subdivisions.

Loudoun Water, an entity created by a resolution of the Loudoun Board of Supervisors in 1959, owns and operates a centralized water and sewer system that serves the developed area of eastern Loudoun as shown in Figure 1. (Also see www.loudounwater.org) Outside of Loudoun Water's central system area, county residents obtain water for drinking and other uses primarily from wells. In the rural towns and several of the subdivisions, sewage is treated in small wastewater treatment plants while the remaining single-family homes and businesses have on-site individual wastewater treatment systems such as a septic tank with drain field.

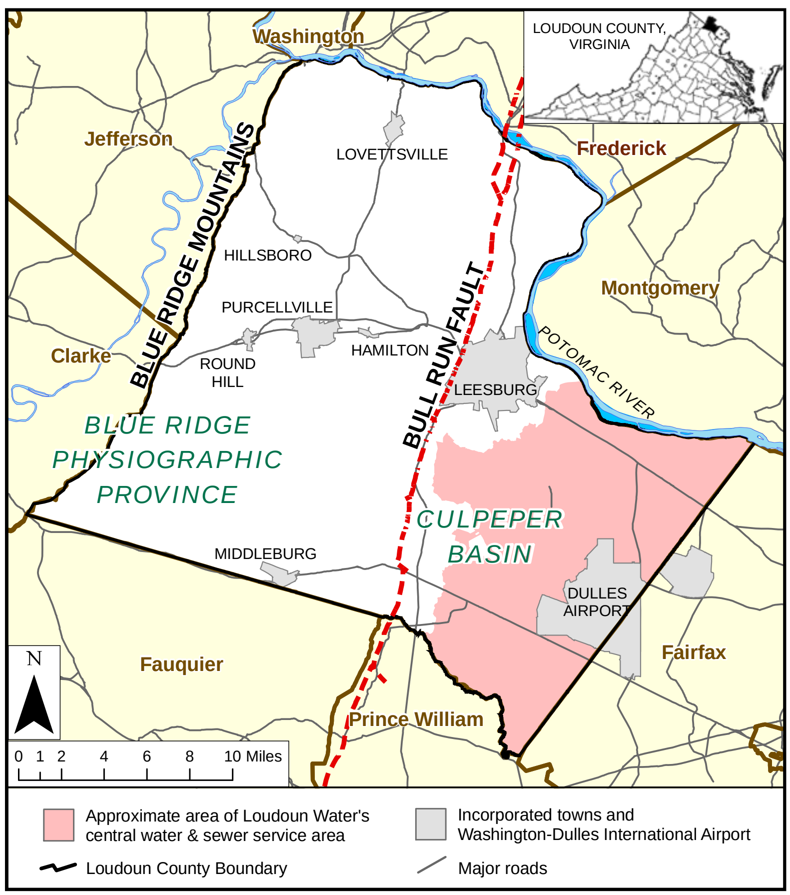



**Figure 1. Major features of Loudoun County, VA.**

## Physiography and Geology

Loudoun County intersects two physiographic provinces which are separated by the Bull Run Fault (Figure 1). The fault separates the Culpeper Basin (a Triassic-age rift basin) of the Piedmont Province on the east from the Blue Ridge Province on the west. The Culpeper Basin is comprised of sedimentary rocks and sedimentary-derived metamorphic rocks, both which may include intrusions of dense, igneous diabase rock. The north-eastern area of the county, generally from the Town of Leesburg northward, is underlain by limestone conglomerate rock (the Leesburg Member of the Balls Bluff Siltstone) and has the surface features and hydrogeologic characteristics of a karst environment. Western Loudoun is underlain by metamorphic rocks derived from both sedimentary and igneous parent material. Bedrock in the county is covered by regolith (unconsolidated sediments and soils) that is commonly between 20 and 50 feet thick, but ranges from 0 to more than 90 feet thick. Soils are generally less permeable in eastern Loudoun compared to western Loudoun.

## Watersheds

Watersheds are defined by topography and drain all of the surface water in an area to a single location such as a stream or lake. They are often used to delineate areas for monitoring, analyzing, and managing water resources. Watersheds can be defined at many different scales but the watershed scale that is most convenient for county-wide investigations in Loudoun is based on the 17 watershed areas shown in Figure 2. The majority of the county is covered by three major drainage areas that empty into the Potomac River by way of the following stream systems: Goose Creek, Catoctin Creek, and Broad Run.

The eastern and southern borders of the county share watersheds with the neighboring counties of Fairfax, Prince William and Fauquier. The upper reaches of Broad Run and Sugarland Run watersheds lie to the east in Fairfax County and Goose Creek originates to the southwest in Fauquier County, but all three streams/ watersheds drain into Loudoun County and, ultimately, the Potomac River.

The southeastern region of Loudoun includes the headwaters of Bull Run and Cub Run. These streams drain out of Loudoun County to the south and are tributaries to the Occoquan River which eventually, discharges into the Potomac River.

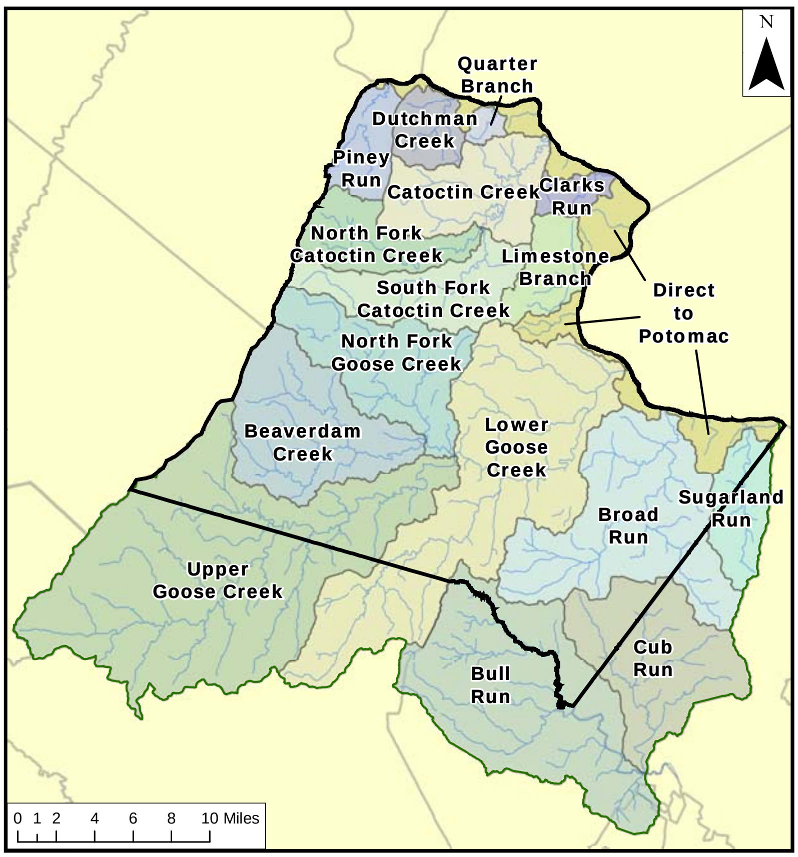



**Figure 2. Watersheds and streams in and adjacent to Loudoun County, VA.**

# WATER QUANTITY

This section presents information on the quantity of water resources with data on precipitation, stream flows, and groundwater levels in Loudoun County during calendar year 2009.

## Precipitation

Total annual precipitation was above normal during 2009, with almost 48 inches recorded at Dulles Airport. Precipitation data used in the WRMP are obtained from seven monitoring sites in or adjacent to the county (Figure 3). Five precipitation stations are part of the National Weather Service's (NWS) cooperative monitoring network and two rain gauges are operated by the U.S. Geologic Survey (USGS). The NWS sites have relatively long periods of record with one having nearly continuous data since 1930 (Table 1). During the preparation of this report, NWS had not received data from The Plains precipitation station and it is unclear if this site is still active. The two USGS rain gauges have mostly continuous data records beginning in 2004.

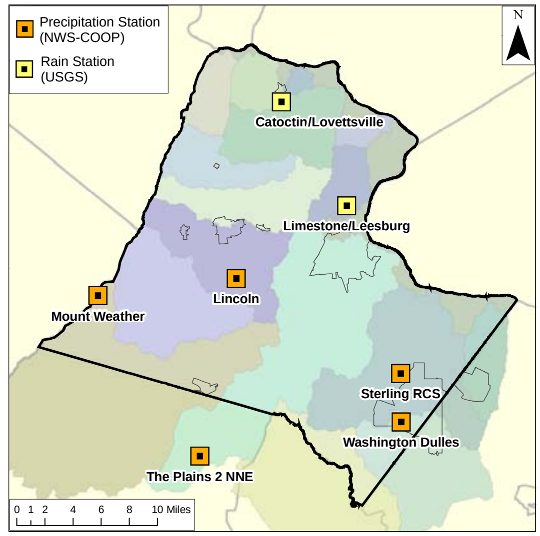



**Figure 3. Precipitation monitoring sites.**

Data from the long-term records indicate that annual precipitation has ranged from 20.4 inches (at the Lincoln station in 1930) to 67.7 inches (at the Sterling station in 2003). For the 30-year period 1978 through 2007, the normal (median) annual precipitation at the Dulles monitoring station was 40.0 inches. During 2009, frozen and liquid precipitation recorded at the two stations with complete daily records was 48.6 and 49.0 inches (Table 1).

**Table 1. Precipitation monitoring stations and data.**

| Precipitation Monitoring Station Name | Start of Record[1] | Station Operated by [2, 3] | Annual Statistics (Inches) for Period of Record[4] | | | 2009 Total (Inches)[3] | Days missing in 2009[5] |
|---|---|---|---|---|---|---|---|
| | | | Minimum | Median | Maximum | | |
| Dulles | 1964 | NWS-COOP | 27.0 | 38.9 | 65.7 | 48.6 | 0 |
| Limestone Branch | 2004 | USGS | 28.0 | 39.3 | 50.4 | 39.0 | 0 |
| Lincoln | 1930 | NWS-COOP | 20.4 | 41.3 | 63.5 | 43.9 | 29 |
| Lovettsville | 2005 | USGS | 30.3 | 40.4 | 45.4 | 33.3 | 3 |
| Mt. Weather | 1949 | NWS-COOP | 24.8 | 39.2 | 64.1 | 49.0 | 0 |
| Sterling RCS | 1978 | NWS | 30.2 | 40.5 | 67.7 | 50.4 | 1 |

[1] First full year that generally continuous data collection began.

[2] NWS-COOP = National Weather Service Cooperative weather station. USGS = U.S. Geological Survey.

[3] NWS-COOP stations record liquid and frozen precipitation; USGS stations record liquid precipitation only.

[4] Annual precipitation statistics based on site's period of available record through 2007 (see footnote 1).

[5] Precipitation occuring on a day with missing data may have been recorded on a subsequent day.

Figure 4 presents annual precipitation data from the Dulles station from 1978 through 2009. Figure 5 shows 2009 monthly precipitation at the Dulles station in relation to monthly data for the 30-year period from 1978 through 2007. Loudoun County had one very dry month during 2009, February, and four months with above normal precipitation: May, June, October and December. The 0.35 inches of rainfall received in February nearly equaled the record for the driest February and the 10.26 inches of rainfall received in May was comparable to the record for the wettest May.

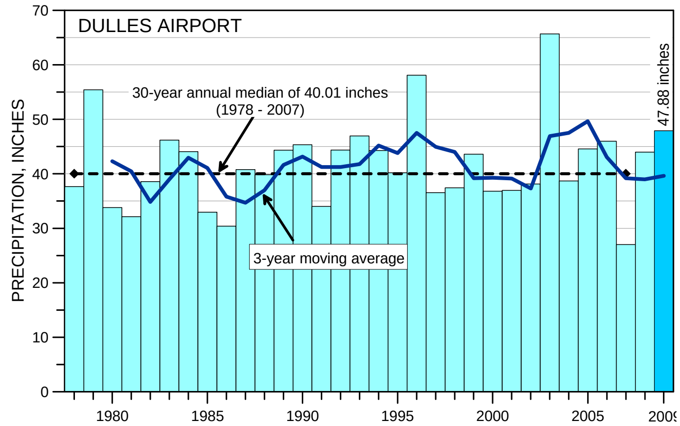



**Figure 4. Annual precipitation at Dulles Airport from 1978 through 2009.**

*Measurable precipitation was reported on 126 days during 2009 at the Dulles station. For those days with reported precipitation, the average accumulation was 0.38 inches and the median was 0.20 inches.*

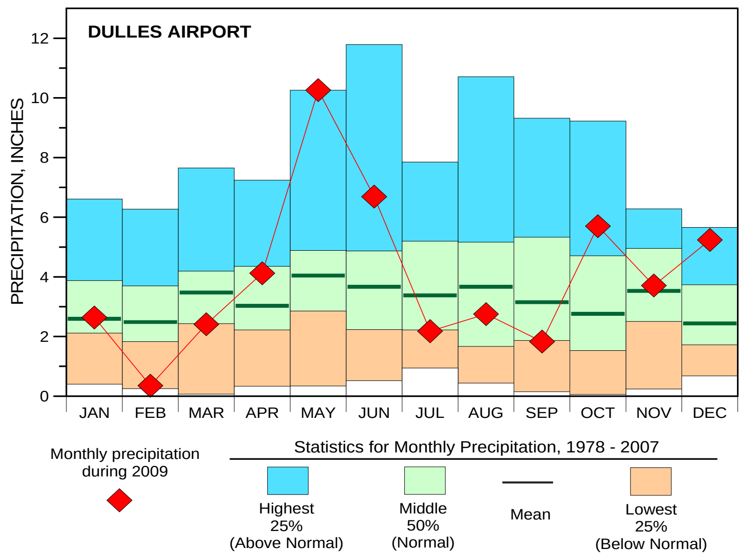



**Figure 5. Monthly precipitation at Dulles Airport.**

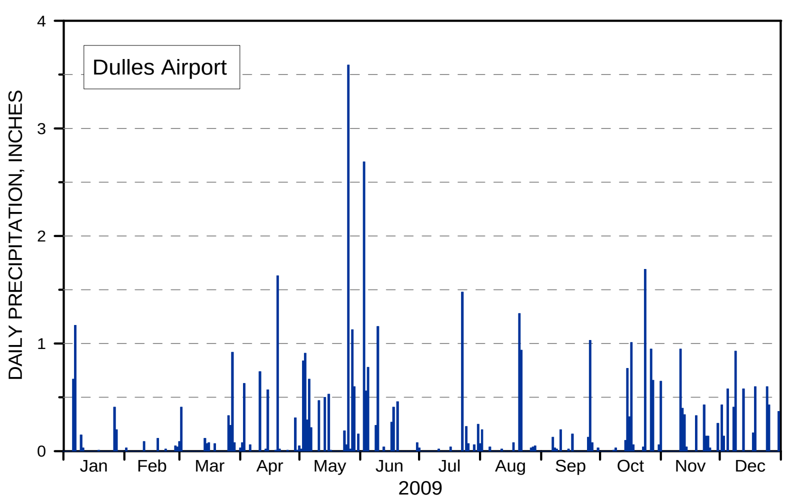



**Figure 6. Daily precipitation at Dulles Airport during 2009.**

In general, precipitation during 2009 was very consistent throughout the year. Two days had relatively large precipitation accumulation in 2009, 3.6 inches in May and 2.7 inches in June. A graph of daily precipitation is shown in Figure 6.

## Streamflow

Loudoun County has more than 1,500 miles of perennial stream channels (flow all or most of the year) as extrapolated from the 2009 stream assessment field survey conducted at 155 locations. Knowing how much water flows in the larger perennial streams and how it varies over both short and long time periods is useful in the assessment of flood control, stormwater structures, and environmental conditions. There are ten USGS stream gauges that measure and record water stage (level) in Loudoun County streams (Figure 7). Measured water levels at each gauging station are reported via telemetry to the USGS, correlated to historical site-specific stream discharges (flows), and the data made available in near real-time with updates every 15 minutes on the web site (http://va.water. usgs.gov/Loudoun/data.htm).

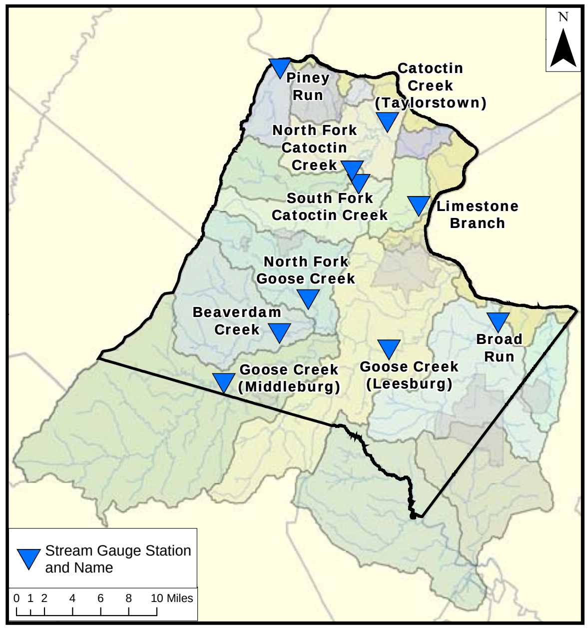



**Figure 7. Locations of stream gauging stations.**

The stream gauge stations are routinely checked and calibrated by the USGS to maintain accuracy but the data are considered provisional until passing the USGS's quality control process. A review of the 2009 gauging data indicates that, while stream flows were within normal ranges throughout most of the year, flows during portions of the year were also below or above normal. Loudoun County experienced wet periods in May, June and December and the resulting stormwater runoff produced pronounced spikes in the flow hydrographs during these times. Figure 8 illustrates the flow of Goose Creek near Route 621 during 2009. Goose Creek, the County's largest stream, flows through the county from its headwaters in Fauquier County to the Potomac River. As shown, flows in February and most of March were consistently below normal, and those in May, June and December were often above normal. Table 2 lists the ten gauging stations in the county along with selected data statistics. Almost all of the maximum flow rates for 2009 occurred on December 26th and the majority of low flows occurred in September and October. Frequent very high and extended very low flows can be stressful on stream habitats and riparian communities.

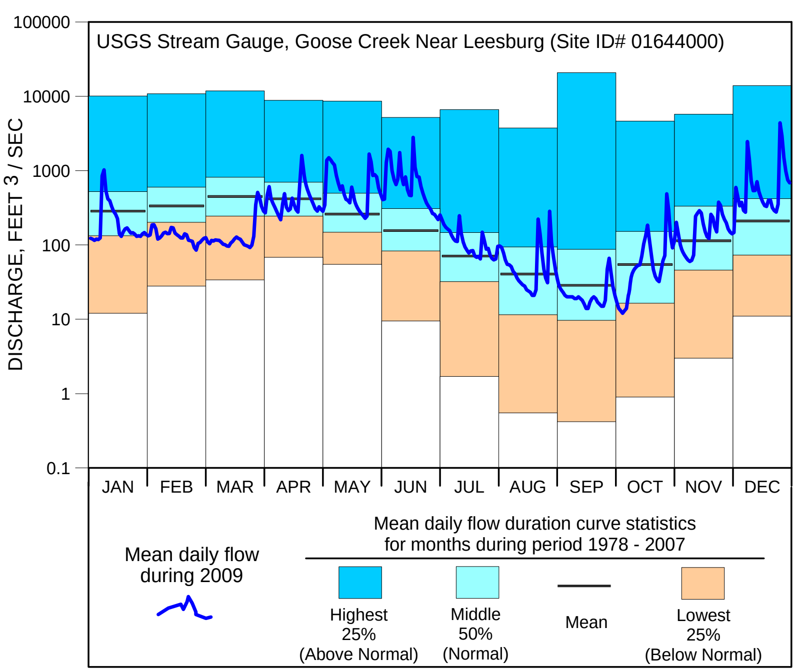



**Figure 8. Stream discharge hydrograph for Goose Creek during 2009.**

**Table 2. Stream gauging stations and basic statistics.**

| Stream Gauge Site Name | Start of Record | Drainage Area[1] (sq. miles) | 2009 Avg[2] (cfs) | 02-'07 Avg[3] (cfs) | 2009 Min[4] (cfs) | 02-'07 Min[5] (cfs) | 2009 Peak[6] (cfs) | 02-'07 Peak[7] (cfs) | 2009 0 Flow[8] (days) | 02-'07 0 Flow[8] (days) |
|---|---|---|---|---|---|---|---|---|---|---|
| Beaverdam Creek | Jul 2001 | 47.2 | 39.6 | 56.3 | 0.1 | 0.0 | 572 | 5000 | 4 | 118 |
| Broad Run | Oct 2001 | 76.1 | 177.3 | 123.9 | 12.0 | 1.6 | 3860 | 5510 | 0 | 0 |
| Catoctin Creek - Taylorstown | Oct 1970 | 89.5 | 78.4 | 107.2 | 3.6 | 0.1 | 1940 | 5400 | 0 | 22 |
| Goose Creek - Leesburg | Jul 1909 | 332.0 | 307.7 | 396.6 | 12.0 | 1.2 | 4400 | 20800 | 0 | 0 |
| Goose Creek - Middleburg | Oct 1965 | 122.0 | 127.5 | 143.9 | 3.4 | 0.0 | 1380 | 14000 | 0 | 55 |
| Limestone Branch | Aug 2001 | 7.9 | 6.6 | 9.5 | 1.1 | 0.5 | 156 | 976 | 0 | 0 |
| North Fork Catoctin Creek | Jul 2001 | 23.1 | 17.7 | 25.1 | 0.6 | 0.0 | 370 | 1060 | 0 | 51 |
| North Fork Goose Creek | Jul 2001 | 38.1 | 35.5 | 58.5 | 1.8 | 0.3 | 526 | 3040 | 0 | 0 |
| Piney Run | Oct 2001 | 13.5 | 9.9 | 14.9 | 1.0 | 0.0 | 181 | 436 | 0 | 17 |
| South Fork Catoctin Creek | Jul 2001 | 31.6 | 29.8 | 37.5 | 1.8 | 0.0 | 751 | 1840 | 0 | 33 |

[1] Drainage area above the stream gauge (square miles)

[2] Average daily flow rate during 2009 ($ft^3$/sec)

[3] Average daily flow rate for the period of 2002–2007 ($ft^3$/sec)

[4] The lowest 7-day average flow rate during 2009 ($ft^3$/sec)

[5] The lowest 7-day average flow rate for the period of 2002–2007 ($ft^3$/sec)

[6] Peak daily flow rate during 2009 ($ft^3$/sec)

[7] Peak daily flow rate for the period of 2002–2007 ($ft^3$/sec)

[8] Number consecutive days with no detected flow for the period 2002-2007

[9] Number of consecutive days with no detected flow during 2009

## Groundwater Levels and Wells

Groundwater levels during 2009 were generally within the normal range of long-term recorded levels. There are approximately 14,000 active residential wells throughout Loudoun County and groundwater is the primary source of drinking water for the majority of residents in western Loudoun. In 2009, groundwater levels were recorded at 15 dedicated monitoring wells at the sites shown in Figure 9. Twelve of these wells were monitored by County staff from the Department of Building and Development and three were monitored by the USGS. Groundwater level data have been collected from the three USGS wells since the late 1960s or early 1970s. Table 3 shows well and groundwater level data from the 11 wells with complete datasets for the year. Wells ALPK-01, BRPK-01, THPK-01 and HRKN-01 were added to the monitoring network in 2009.

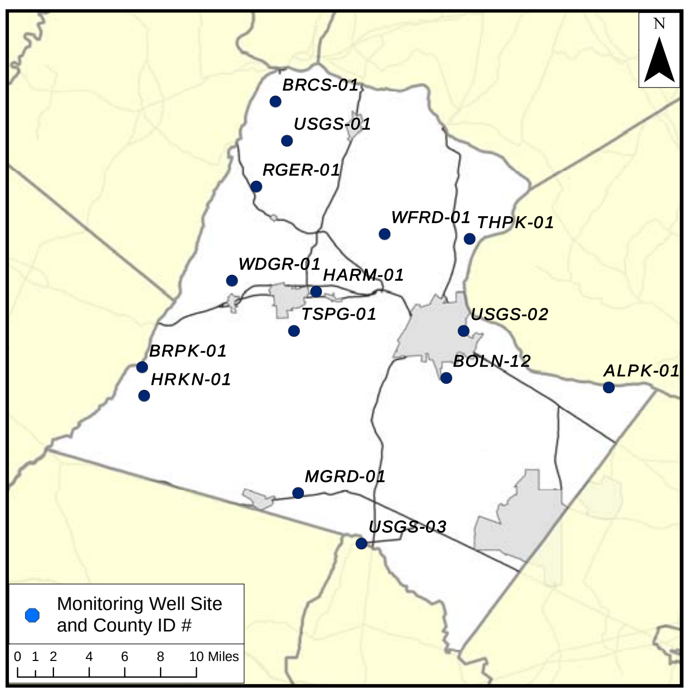



**Figure 9. Locations of groundwater monitoring wells.**

## Table 3. Monitoring well and groundwater level data.

| Well Site ID (see map for location) | Monitoring Organization | Well Depth (feet) | Rock Type | Period of Record | Groundwater Level (feet)[1] | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Historic High | 2009 High | Historic Low | 2009 Low |
| *USGS-01* | USGS | 516 | Meta-conglomerate/ metasiltstone | 8/1969 - Present | 51.67 | 53.99 | 61.5 | 60.51 |
| *USGS-02* | USGS | 535 | Fluvial, deltaic sandstone | 10/1977 - Present | 19.48 | 19.48 | 41.52 | 29.09 |
| *USGS-03* | USGS | 165 | Siltstone/sandstone | 11/1968 - Present | 6.7 | 6.7 | 13.09 | 10.91 |
| BOLN-12 | Loudoun | 515 | Fluvial, deltaic sandstone | 12/2006 - Present | 6.4 | 7.26 | 12.8 | 11.57 |
| BRCS-01 | Loudoun | 320 | Igneous intrusive | 12/2007 - Present | 21.43 | 21.93 | 31.16 | 31.16 |
| HARM-01 | Loudoun | 945 | Plutonic igneous intrusive | 2/2005 - Present | 35.14 | 41.66 | 54.99 | 49.94 |
| MGRD-01 | Loudoun | 400 | Plutonic igneous intrusive | 12/2007 - Present | -2.97 | -2.97 | 8.41 | 8.41 |
| RGER-01 | Loudoun | 700 | Igneous intrusive | 2/2005 - Present | 29.81 | 34.13 | 54.45 | 40.24 |
| TSPG-01 | Loudoun | 360 | Plutonic igneous intrusive | 2/2005 - Present | 65.93 | 70.63 | 82.1 | 79.18 |
| WDGR-01 | Loudoun | 940 | Mafic igneous intrusive | 3/2005 - Present | 8.96 | 12.61 | 22.4 | 22.4 |
| WFRD-01 | Loudoun | 400 | Plutonic igneous intrusive | 11/2002 - Present | 8.42 | 13.28 | 29.68 | 26.46 |

[1] Feet below ground surface. Negative number indicates feet above ground surface (flowing artesian condition).

Figure 10 shows hydrographs for selected monitoring wells that are representative of groundwater levels for the years 2008 through 2009. Groundwater levels began 2009 at relatively average levels and in general ended the year higher due to a wet December. The hydrographs show how the groundwater levels in these wells directly responded to the rainfall events in May and December. Short-term natural increases in groundwater levels occur because of recharge from precipitation. In the absence of additional recharge from precipitation and outside influences such as nearby pumping, groundwater levels typically exhibit a steady, slow decline over time after rain events.

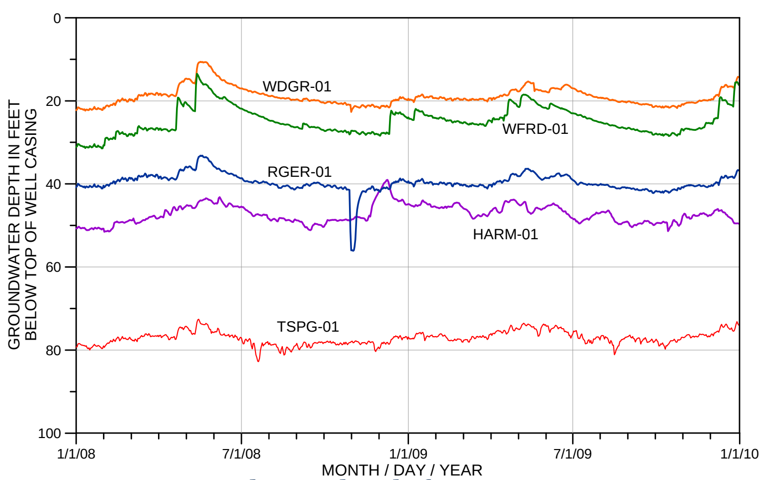



**Figure 10. Groundwater levels from County WRMP monitoring wells with at least three years of monitoring data.**

Figure 11 is a hydrograph from a monitoring well during 2009 with daily precipitation also plotted to show the effects of precipitation on groundwater levels.

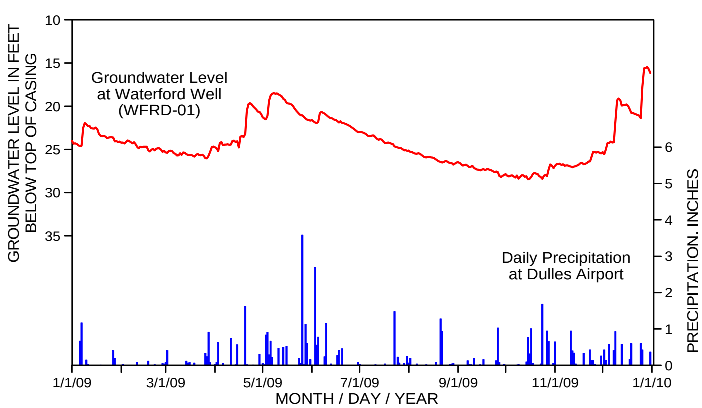



**Figure 11. Daily precipitation and groundwater level changes during 2009.**

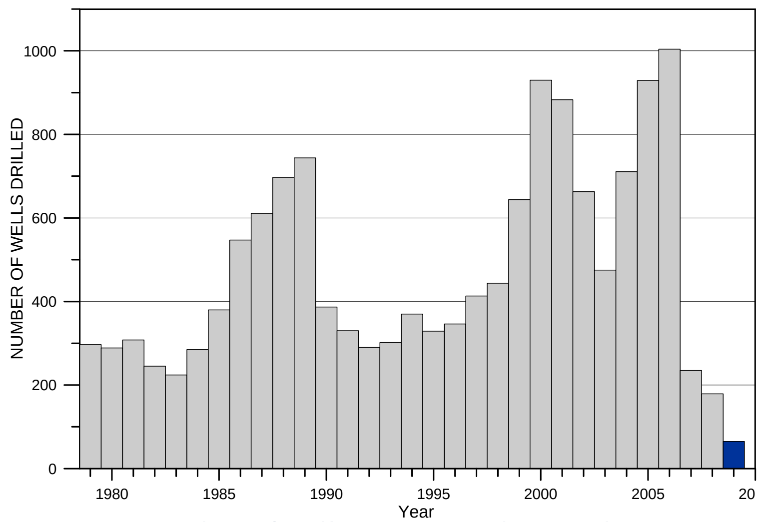



**Figure 12. Number of wells constructed in Loudoun County between 1978 and 2009.**

During 2009, 65 new water wells were constructed. Figure 12 presents the number of wells drilled each year since 1979. The installation of new wells is primarily driven by the pace of residential construction and zoning changes affecting residential development potential. In 2009, the weak economy resulted in the fewest number of wells installed since the early 1950's. The median total depth of wells installed in 2009 was 420 feet and the median estimated yield (based on air-lift pumping) was 15 gallons per minute. The median total depth and median estimated yield of wells installed during the previous 10 years was 400 feet and 10 gallons per minute, respectively. These increases in depths and yields are not considered indicative of changes to groundwater availability.

# WATER QUALITY

The quality of surface water in Loudoun County was quantified in 2009 using several metrics including chemical, microbiological, and benthic macroinverte-brates. Groundwater quality was assessed through chemical and bacteria analyses conducted on well water samples. Monitoring results from each of these data types are discussed below.

## Surface Water Chemistry

Chemical sampling and analysis of surface water in 2009 was primarily conducted by the Virginia Department of Environmental Quality (DEQ) as part of their state-wide surface water quality sampling program (see http://www.deq.state.va.us/ watermonitoring/). In 2009, DEQ collected 122 samples from 19 sites in Loudoun County.

Nutrient enrichment has been identified as the cause of approximately half of the reported stream impairments nationwide. Nutrient enrichment can lead to low dissolved oxygen, fish kills, shifts in flora and fauna and blooms of nuisance algae. Figure 13 illustrates the results of sampling by DEQ for nitrogen and phosphorus in the surface waters of the county during 2009. Using categories developed by DEQ, the charts indicate that nutrient concentrations may be higher than anticipated.

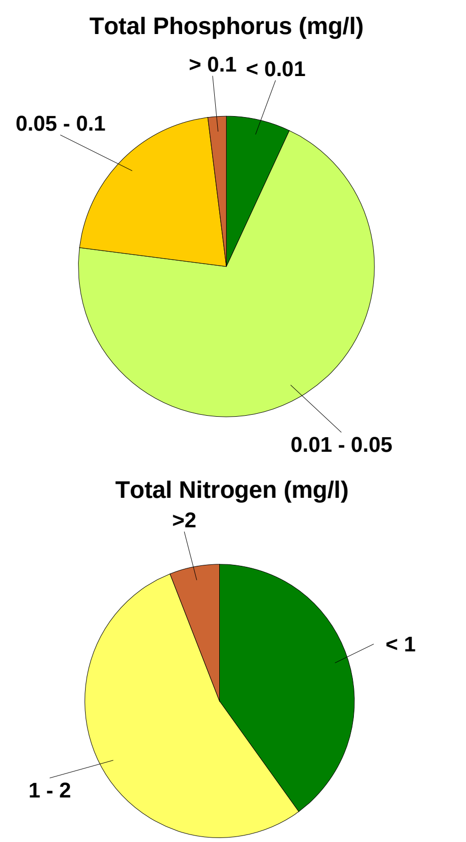



**Figure 13. Nutrient concentrations as portions of samples collected in Loudoun County streams by DEQ during 2009.**

For example, DEQ indicates that 90 percent of stream miles in the state have Total Nitrogen concentrations below 1 mg/l whereas only 40 percent of the samples from Loudoun met the criteria. Similarly, DEQ indicates that 30 percent of stream miles in Virginia have Total Phosphorus concentrations below 0.01 mg/l whereas only 7 percent of the samples from Loudoun met the criteria. With pending implementation of EPA's Chesapeake Bay Total Maximum Daily Load (TMDL) for the pollutants nitrogen, phosphorus and sediment, these results may indicate that Loudoun County will be required to reduce these concentrations to meet the Chesapeake Bay TMDL load allocations.

## Surface Water Microbiology

The primary microbiological area of concern for surface water relates to pathogens that may adversely affect human health. An accepted practice to test for pathogens from human and warm-blooded animal waste is to test water for *Escherichia coli* (E. coli) bacteria as an indicator of waste contamination. One of the criteria used by the U. S. Environmental Protection Agency (EPA) for E. coli is if the water is considered safe for humans after casual contact. This criterion is identified by EPA as "recreational use" and includes activities such as swimming, fishing and boating.

In 2009, DEQ collected and analyzed approximately 180 samples in Loudoun County and found that approximately 24 percent were above the recreational limit of 235 E. coli colonies per 100 milliliters. Stream segments that are tested and exceed the recreational use criteria more than 10 percent of the time may be identified as "impaired" by DEQ. Using a similar approach, Table 4 summarizes the number of sites in which more than 10.5 percent of the samples exceeded the recreational limit in the last 5 years. Several programs are in place to reduce bacterial contamination in the impaired surface waters of Loudoun County including initiatives to repair or upgrade on-site wastewater treatment systems (e.g., septic systems and drain fields), reduce pet waste, and fence live-stock out of streams.

**Table 4. Summary of surface water microbiological testing.**

| Year | Number of Samples | Number of Monitoring Sites | Number Sites Exceeding | Percent Sites Exceeding |
|---|---|---|---|---|
| 2005 | 161 | 40 | 24 | 60% |
| 2006 | 153 | 36 | 30 | 83% |
| 2007 | 152 | 30 | 16 | 53% |
| 2008 | 152 | 27 | 18 | 67% |
| 2009 | 180 | 29 | 24 | 83% |

Stream water sampling in the Catoctin watershed by citizen volunteers (Loudoun Watershed Watch) has resulted in almost 1,000 bacteriological samples collected from 2004 to 2009, of which almost 40 percent were above the recreational use limit for E. coli. These data indicate that microbiological contamination is highly variable, but generally increases with stormwater runoff.

The Catoctin TMDL Implementation Plan organized by the Virginia Department of Conservation and Recreation and the volunteer-based Catoctin monitoring project were both concluded in 2009. Many corrective measures were implemented during the 5-year program; however, direct improvements to water quality may take longer to be realized.

*Elevated levels of pathogens in surface water can be minimized by:*

- *Repair and maintenance of on-site waste water treatment systems*
- *Cleaning up pet waste*
- *Fencing livestock away from streams*
- *Covering manure piles*
- *Vegetated riparian stream buffers*

## Benthic Macroinvertebrates

Benthic macroinvertebrates are stream bottom-dwelling invertebrate organisms (mostly insect larvae) that can be seen without magnification. Their tolerance of poor water quality varies depending on the species and, as a result, these organisms are used as indicators of water quality.

Sampling a stream for benthic macroinvertebrates usually involves collecting all the organisms within a small area of the stream bottom, identifying the types of organisms collected to the order or family taxa level, and counting the number of each type. These results are then converted to a "macroinvertebrate score" which is used to qualitatively grade the water quality at one of several levels ranging from excellent to poor. In 2009, two techniques were used to evaluate the benthic macroinvertebrate populations: the Virginia Stream Condition Index (VA SCI) used by DEQ and the Virginia Save Our Streams (VA SOS) index used by several citizen volunteer organizations in and adjacent to the county. In 2009, DEQ sampled 12 locations in Loudoun and calculated VA SCI scores which ranged from moderate stress to excellent. Figure 15 illustrates the average stream conditions from benthic samples collected by DEQ between 2004 and 2009.

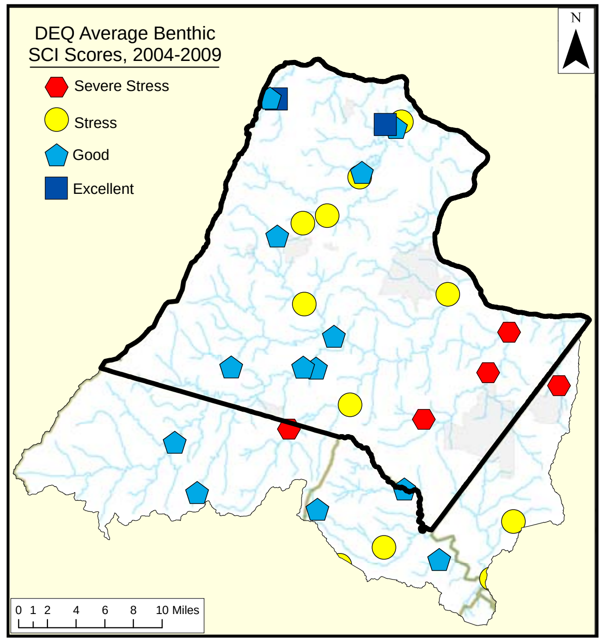



**Figure 14. Summary of DEQ benthic monitoring results.**

Several volunteer organizations work within the watersheds of the county to collected benthic macroinvertebrate data. From 2004 through 2009, the volunteer organizations Loudoun Wildlife Conservancy, Goose Creek Association and other groups collected 405 samples from approximately 44 locations using the VA SOS methodology. Results ranged from acceptable to unacceptable. Figure 15 illustrates the average VA SOS scores from 2004 and 2009.

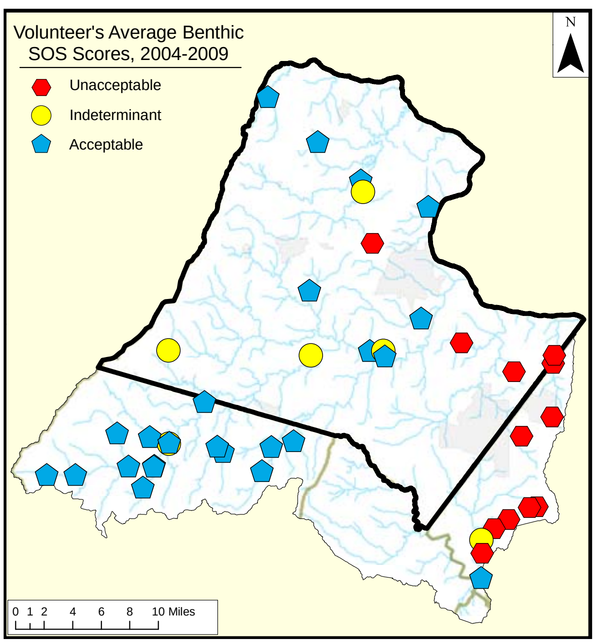



**Figure 15. Summary of volunteer benthic monitoring results.**

*Benthic macroinvertebrate species vary in their tolerance of poor water quality. Monitoring benthic populations is an efficient way for professionals and volunteers to assess stream water quality.*

## Stream Impairments

Each year, DEQ tests a statistically significant fraction of Virginia's rivers, lakes, and tidal waters as part of their water quality assessment. Over 130 different pollutants are monitored to determine whether the waters can be safely used for swimming, fishing and drinking. Waters that do not meet standards are reported to EPA in the Clean Water Act 303(d) Impaired Waters Report. DEQ has developed lists of impaired waters every even calendar year since 1992. In Loudoun County, DEQ water quality impairments have included:

- recreational/swimming (bacteria)
- aquatic life (benthic macroinvertebrates)
- fishing/consumption (tissue analysis)

In the last report released in 2008, there was a total of 160 stream miles in Loudoun County identified as impaired for one or more criteria. Figure 16 and Figure 17 illustrate the impairments for recreational/swimming and aquatic life uses, respectively.

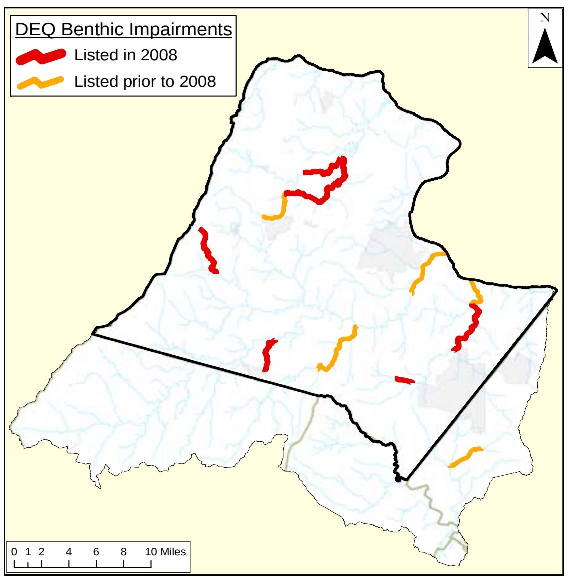



**Figure 17. Aquatic life use (benthic macroinvertebrates) impaired stream segments.**

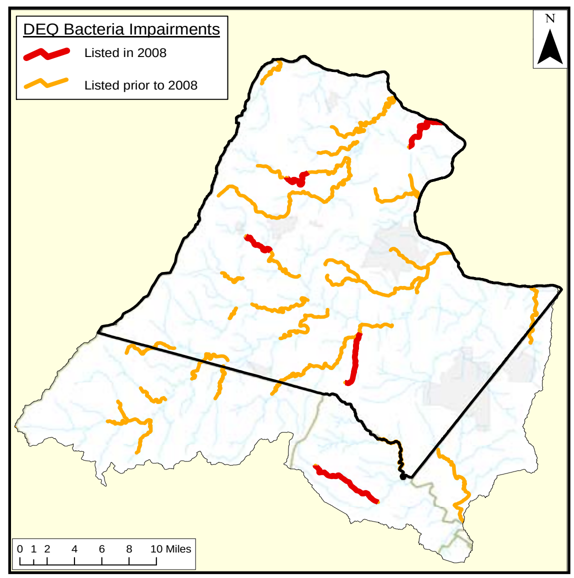



**Figure 16. Recreational/swimming use (bacteria) impaired stream segments.**

*Surface water quality impairments are reported to the Environmental Protection Agency every two years by the Virginia Department of Environmental Quality (DEQ). The Final 2008 305(b)/303(d) Water Quality Assessment Integrated Report (Integrated Report) was released on December 22, 2008. The 2008 Integrated Report is a summary of the water quality conditions in Virginia from January 1, 2001, to December 31, 2006.*
*(http://www.deq.state.va.us/wqa/ir2008.html)*

## Stream Assessment

In 2009, as part of the Water Resources Monitoring Program, Loudoun County conducted a county-wide assessment of stream health. The purpose of the study was to assess stream conditions using benthic and habitat rapid assessment methods and develop field-based information to refine the extent of perennial streams. The assessment was conducted between March and June of 2009 and included:

- probability-based benthic sampling at 177 sites
- targeted benthic sampling at 23 sites
- stream habitat evaluations at 500 sites
- perenniality determinations at 155 sites

The benthic macroinvertebrate investigations employed the Virginia Stream Condition Index at all sites.

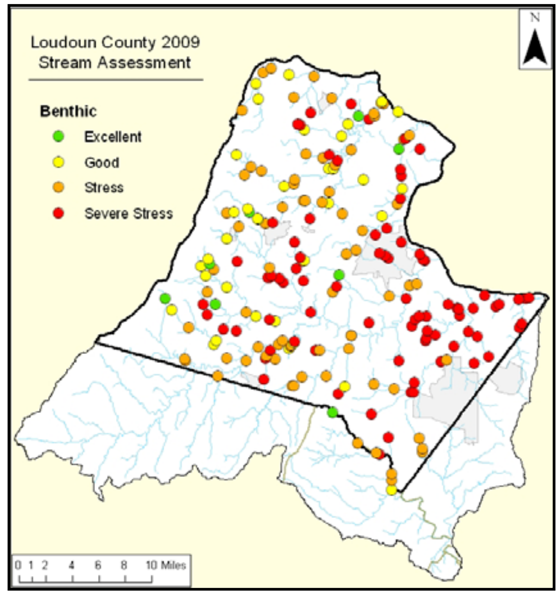



**Figure 18. Summary of the benthic results from the Loudoun County 2009 stream assessment.**

Overall, the results indicated that benthic macroinvertebrates have been degraded throughout all of the County's watersheds. Countywide, the benthic health as measured in stream miles was statistically summarized as: 4% excellent, 18% good, 42.5% stressed and 35.7% severely stressed; the last two categories, representing 78% of stream miles that would be assessed by DEQ as being impaired. Degraded biological conditions were particularly noteworthy in the eastern and southeastern parts of the county.

The sample locations are shown in Figure 18 and a box and whisker plot of the benthic assessment results is shown in Figure 19. The assessment results are statistically summarized by watershed group.

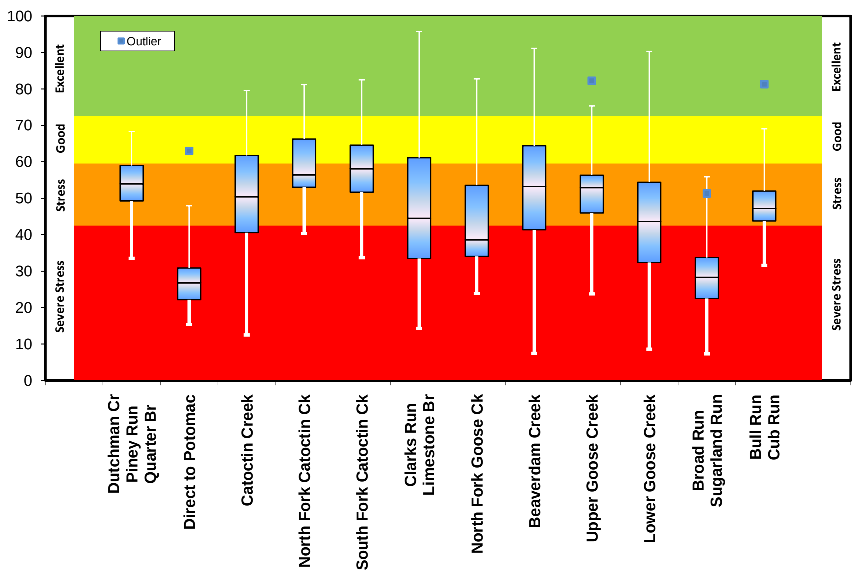



**Figure 19. Box and whisker plot of the benthic macroinvertebrate sampling results from the Loudoun County 2009 stream assessment.**

During the spring of 2009, Virginia DEQ conducted benthic macroinvertebrate monitoring at nine of the 23 sites targeted by the County's investigation. A comparison of the scores from the two studies showed substantial agreement in the results.

In the probability-based habitat survey, the habitat health as calculated in percent of stream miles is statistically summarized as: 19 percent optimal, 75 percent suboptimal, 5 percent marginal and 0 percent poor. Overall, stream habitat was found to be better in the northwestern corner of the county with generally poorer conditions in the east. Most notable from the habitat assessment was that nearly half of the streams surveyed had a least one bank in marginal or poor condition, suggesting that altered flow regimes from changes in land use (impervious cover) may be having a negative impact on stream habitat.

The habitat sample locations are shown in Figure 20 and a box and whisker plot of the habitat results is shown in Figure 21. In general, the habitat assessment results had less variability than the benthic assessment with the majority of the sites receiving a score in the suboptimal range. The Clarks Run/Limestone Branch watersheds scored somewhat lower than the other watersheds.

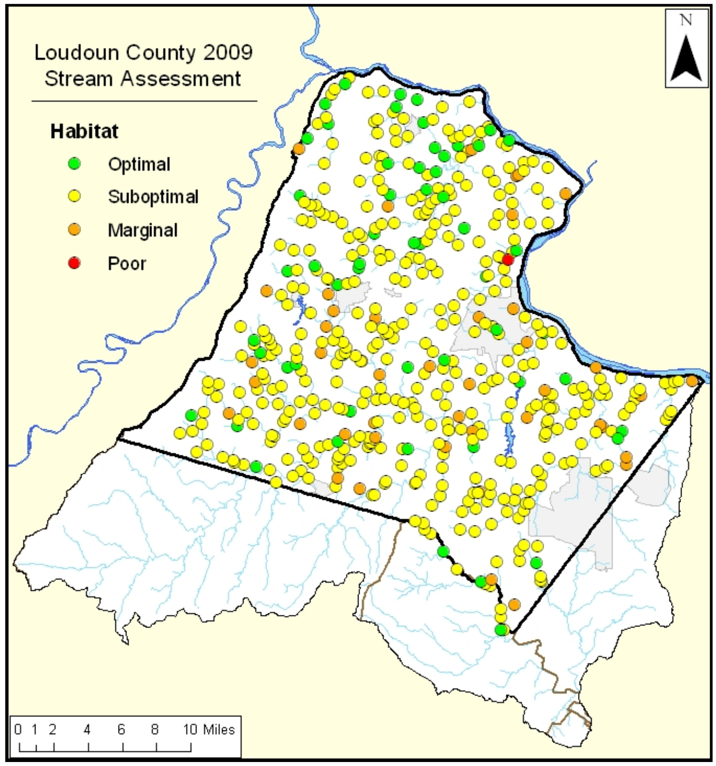



**Figure 20. Summary of the habitat results from the Loudoun County 2009 stream assessment.**

The points of perenniality, the location in the stream where the stream generally transforms from intermittent to perennial flow, were determined using a methodology developed by Fairfax County. Overall, the majority of points were located above the target locations which were roughly based on the perennial stream locations as defined by the National Hydrography Dataset high resolution data. Based on this limited examination, stream channels in Loudoun County typically exhibit perennial flow when they have a contributing drainage area between 25-50 acres.

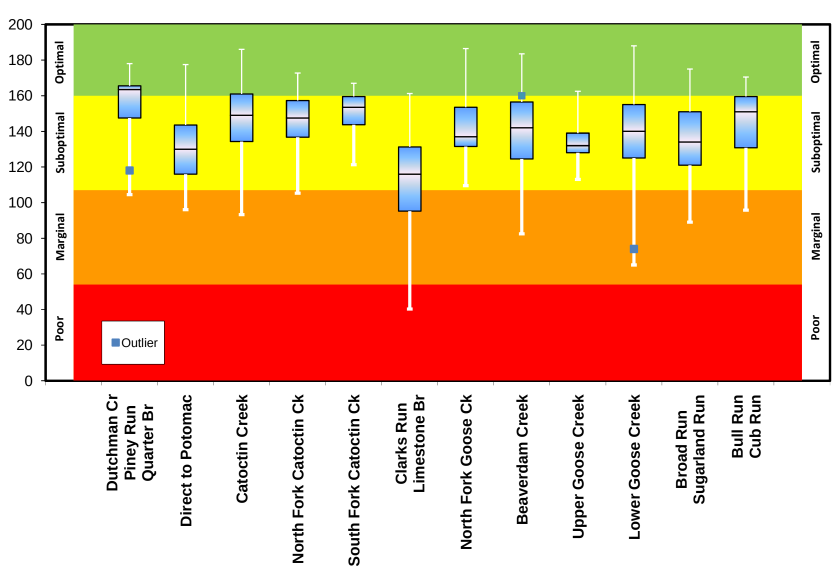



**Figure 21. Box and whisker plot of the habitat results from the Loudoun County 2009 stream assessment.**

## Groundwater Quality

Groundwater is the source of drinking water for most of Loudoun County outside of Loudoun Water's central service area and the Town of Leesburg. Information on groundwater quality is obtained from several sources. Before new potable water wells can be used, they must be tested and pass drinking water quality standards for a wide range of chemical parameters listed by the County Health Department. In 2009, groundwater samples collected and analyzed from new wells were generally consistent with historical data (Table 5). There are some areas of the county that have elevated levels of iron and manganese which are aesthetic contaminants and do not adversely affect human health at the concentrations found in the county. In general, the county has excellent groundwater quality.

**Table 5. Statistics for selected groundwater chemistry parameters.**

| Analyte | MCL(mg/L) | Samples | | # above MCL | % above MCL |
|---|---|---|---|---|---|
| Nitrate | 10 | *All* | 2864 | 8 | 0.3 |
| | | *2009* | 99 | 1 | 1.0 |
| Sulfate | 250 | *All* | 2864 | 8 | 0.3 |
| | | *2009* | 99 | 1 | 1.0 |
| Lead | 0.015 | *All* | 2865 | 28 | 1.0 |
| | | *2009* | 99 | 1 | 1.0 |
| Fluoride | 4 | *All* | 2864 | 4 | 0.1 |
| | | *2009* | 99 | 0 | 0.0 |
| Arsenic | 0.01 | *All* | 2869 | 15 | 0.5 |
| | | *2009* | 99 | 1 | 1.0 |
| Manganese | 0.05** | *All* | 2864 | 1838 | 64.2 |
| | | *2009* | 99 | 43 | 43.4 |
| Iron | 0.3** | *All* | 2864 | 2021 | 70.6 |
| | | *2009* | 99 | 61 | 61.6 |
| TDS | 500** | *All* | 2864 | 13 | 0.5 |
| | | *2009* | 99 | 1 | 1.0 |

* Standard pH units.
** Secondary Maximum Contaminant Level (MCL) for taste, color, and odor.

In 2009, as part of the WRMP, Loudoun County conducted groundwater monitoring in existing residential wells to characterize the overall quality. The county has extensive data from existing wells following construction, but very little data exists from wells after being put into service. This well sampling program compared the quality of the groundwater from newly constructed wells to those wells that have been in service for various periods of time.

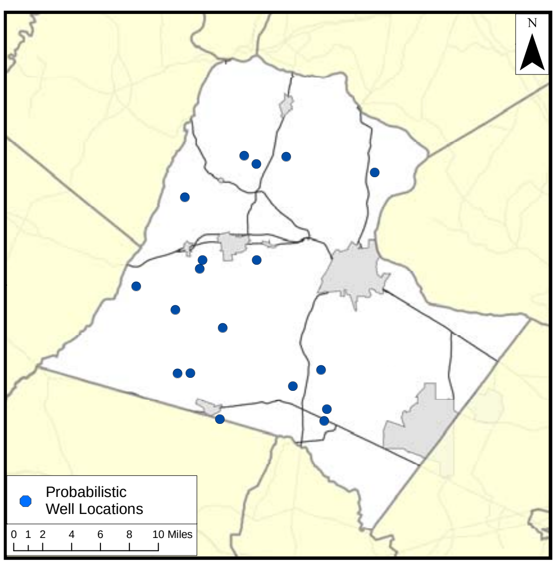



**Figure 22. Probabilistic groundwater sampling sites.**

Groundwater sampling was conducted in four phases. The first phase utilized a probabilistic sampling methodology. This methodology involves selecting sampling locations at random and then using statistical methods to characterize the regional environment. The county was divided up into a grid with 701 squares. Thirty squares were selected from this grid at random. All residences within the first twenty of those thirty squares were mailed a postcard offering a free groundwater sample and analysis. From within the group of responding individuals, one well from each grid cell was randomly selected as a sample site. If no active domestic wells were located within a square, or there were no responses from residents, the next square from the original thirty squares was selected, and new postcards were sent to residents until the sample size reached at least twenty. The locations of the sampled wells are shown in Figure 22 and a summary of the results from these analyses is given in Table 6.

**Table 6. Summary of targeted groundwater sampling results.**

| Statistic | NO3-N (mg/l) | Chloride (mg/l) | Flouride (mg/l) | Iron (mg/l) | Manganese (mg/l) | Sodium (mg/l) | pH | Sulfate (mg/l) | Specific Conductance (uS/cm) |
|---|---|---|---|---|---|---|---|---|---|
| Count | 22 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 |
| Mean | 3.4 | 7.6 | 1.28 | 0.27 | 0.04 | 21.1 | 7.18 | 20.0 | 0.280 |
| Median | 1.4 | 6.7 | 0.25 | 0.05 | 0.02 | 6.86 | 7.39 | 15.5 | 0.26 |
| Min | ND | ND | ND | ND | ND | 2.2 | 5.88 | ND | 0.146 |
| Max | 22.4 | 28 | 5.7 | 3.8 | 0.28 | 119 | 8.81 | 36.9 | 0.506 |

The overall results indicated that, in the short-term, current land-use practices are not adversely affecting the quality of groundwater withdrawn from wells. A few wells did exhibit elevated levels of nitrate; however, this occurred in areas where past agricultural practices, such as fertilization, may still be having a negative impact on groundwater quality.

A second phase of well sampling was conducted at targeted locations. Locations were selected from subdivisions that previously had hydrogeologic investigations conducted as required by the county's development approval process. Two or more samples were collected from each subdivision (Figure 23).

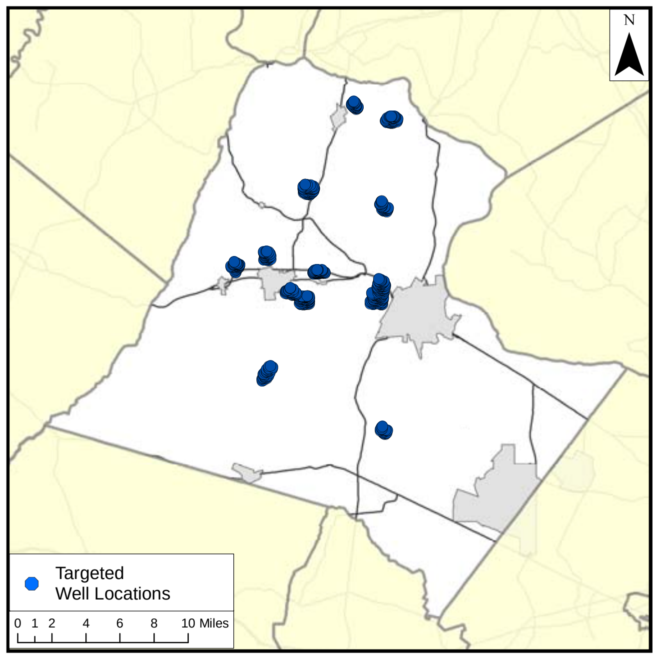



**Figure 23. Targeted groundwater sampling sites.**

The second phase of sampling specifically compared the water chemistry results obtained when the well was originally drilled with the current water chemistry. The wells targeted for sampling ranged in age from 4 to 21 years. Forty-eight samples were collected and the results are summarized in Table 7. There was natural variation in the results but overall, the current groundwater quality was relatively consistent with the initial hydrogeologic study results and the overall groundwater quality remains excellent. Modern well construction requirements were used for all of these wells and therefore these wells should represent a good test of modern well and septic construction. Ideally, a similar round of testing can be conducted in another ten years to provide a longer-term assessment.

**Table 7. Groundwater sampling results from the targeted monitoring sites.**

| Statistic | NO3-N (mg/l) | Chloride (mg/l) | Flouride (mg/l) | pH | Sulfate (mg/l) | Specific Conductance (uS/cm) |
|---|---|---|---|---|---|---|
| Count | 25 | 25 | 25 | 19 | 25 | 24 |
| Mean | 3.7 | 10.46 | -- | 6.78 | -- | 0.411 |
| Median | 3.8 | 10.10 | -- | 6.7 | -- | 0.4115 |
| Min | ND | 3.40 | ND | 6.57 | ND | 0.234 |
| Max | 9.2 | 19.50 | ND | 7.67 | ND | 0.597 |

The third phase of groundwater sampling was conducted in the limestone area of the county. These samples were collected to assess groundwater in this unique hydrogeologic environment of Loudoun County (Figure 24).

*Groundwater in the county is generally of good quality. Some wells have elevated levels of iron and manganese which diminish the aesthetics of the water but do not adversely affect human health.*

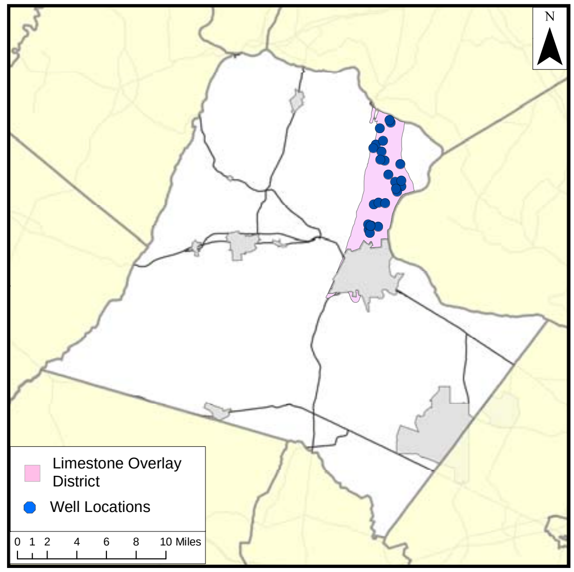



**Figure 24. Groundwater monitoring sites in the Limestone Overlay District.**

Twenty five samples were collected and the results are summarized in Table 8. The samples from this area did show some minor differences when compared to other areas. Specifically, chloride and specific conductance were elevated compared to other areas of the county.

**Table 8. Groundwater sampling results from the Limestone Overlay District monitoring sites.**

| Statistic | NO3-N (mg/l) | Chloride (mg/l) | Flouride (mg/l) | Iron (mg/l) | Magnesium (mg/l) | Sodium (mg/l) | pH | Sulfate (mg/l) | Specific Conductance (uS/cm) |
|---|---|---|---|---|---|---|---|---|---|
| Count | 48 | 44 | 44 | 44 | 44 | 44 | 43 | 44 | 44 |
| Mean | 1.1 | 12.1 | 0.51 | 0.54 | 0.12 | 12.01 | 6.71 | 16.4 | 0.221 |
| Median | 0.5 | 8.0 | 0.25 | 0.05 | 0.02 | 7.40 | 6.84 | 15.0 | 0.206 |
| Min | ND | 0.5 | ND | ND | ND | ND | 6.57 | ND | 0.079 |
| Max | 7.6 | 80.5 | 0 | 0.21 | 0.44 | 79.91 | 8.01 | 49.6 | 0.444 |

During the fourth phase of groundwater sampling, seven of the wells in the County's dedicated monitoring well network were sampled for a variety of chemical parameters. These same wells had been previously sampled in October of 2008. A list of the analytes which were detected is shown in Table 9. The results were consistent with the 2008 findings with two samples exceeding the secondary maximum contaminant limit (SMCL) for iron (0.3 mg/L) and six samples exceeding the SMCL for manganese (0.05 mg/L).

**Table 9. Groundwater sampling results from the County's monitoring wells.**

| ID | Temperature (ºC) | pH | Specific Conductance (uS/cm) | Iron (mg/l) | Manganese (mg/l) | Alkalinity (mg/l) | Chloride (mg/l) | Hardness (mg/l) | TDS (mg/l) | Sulfate (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| WDGR-01 | 15.7 | 8.16 | 238 | 0.069 | 0.069 | 100 | ND | 100 | 120 | 9 |
| HARM-01 | 13.3 | 6.99 | 170.1 | 0.397 | 0.11 | 74 | 8 | 72 | 99 | 12 |
| TSPG-01 | 15.7 | 7.02 | 265 | 0.348 | 0.078 | 70 | 22 | 120 | 130 | 16 |
| WFRD-01 | 13.6 | 8.19 | 174.2 | 0.119 | 0.024 | 90 | 5 | 72 | 100 | 10 |
| BRCS-01 | 12.9 | NM | 256 | ND | 0.085 | 95 | 21 | 130 | 150 | 20 |
| MGRD-01 | 14.6 | 7.93 | 298 | 0.187 | ND | 110 | 6 | 130 | 130 | 8 |

NM = Not Measured  ND = Not Detected  TDS = Total Dissolved Solids

There are a few isolated spots in the county where serious groundwater contamination is known to exist, the most notable being Hidden Lane Landfill in northeast Loudoun, which was placed on EPA's National Priorities List (i.e., superfund site) in 2008. (For additional information on the Hidden Lane Landfill, see www.loudoun.gov/tce.) The Environmental Protection Agency is currently conducting an investigation of the landfill. Separately, the Virginia Department of Environmental Quality is investigating groundwater contamination in four wells of the Richland Acres subdivision in Sterling. In 2007, low levels of the gasoline additive, methyl t-butyl ether, and perchloroethylene were detected in water samples from the four wells.

The most prevalent sources of potential groundwater pollution are the on-site wastewater treatment systems (OWTS) serving homes and small businesses in the rural areas of the county. There are approximately 14,000 active OWTSs in the county and during 2009, 62 new OWTSs were installed. An OWTS that is properly installed and serviced should not pose a threat to groundwater quality. However, improper OTWS installation or maintenance can cause wastewater to be untreated or undertreated and lead to groundwater or surface water contamination. Because OWTS are typically used in areas with private water wells, it is important to properly maintain the OWTS and regularly have the well water sampled and tested to assure that it is safe to drink.

## OUTLOOK FOR 2010

**With the completion in September 2009 of the EPA grant that had funded a significant portion of the development and activities of the Water Resources Monitoring Program (WRMP) since 2003, monitoring activities in 2010 will be dependent on more limited funding. Although no major monitoring projects are planned this year, the monitoring objectives for 2010 include:**

- **Precipitation/rainfall – continue to monitor and/or obtain data from eight stations operated by NOAA, USGS, or Loudoun County.**
- **Stream flow – continue the cooperative funding agreement with the USGS to monitor stream stage and discharge (flow) within 10 of the county's major watersheds.**
- **Groundwater levels – maintain continuous groundwater level recording instrumentation in the 15 dedicated monitoring wells operated by Loudoun County or the USGS. Additional wells may be brought into the monitoring network through the County's monitor well donation program in which either wells with easements are given to the County or the County is provided long-term use of an inactive well for monitoring by the owner.**
- **Water quality sampling – groundwater and/or surface water quality sampling may be conducted depending on available funding.**

**The Department of Building & Development, among others, will continue to pursue support for the development of a comprehensive, county-wide watershed management program. An integral part of this program will involve monitoring and analyses of water resources and various other watershed data. The existing WRMP provides a solid foundation to accomplish this task.**

**County staff will continue to explore grant opportunities to supplement County funding for monitoring and watershed management programs.**