RappFLOW Pilot Study Report

June 16, 2005

Community-Based Watershed Management Planning

For submission to Virginia Department of Conservation and Recreation
In fulfillment of DCR Project Number 1-TAPP-BAY-60A

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Study conducted by Volunteers of Rappahannock Friends and Lovers of Our Watershed (RappFLOW)

For more information about RappFLOW please see http://www.rappflow.org

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Summary

Approximately twenty volunteers conducted a six-month study of an area about four square miles within the Upper Thornton River subwatershed just south and west of Sperryville in Rappahannock County. (See Map 1). Our purposes were to:

- learn how to conduct a watershed assessment;
- construct a model process for conducting watershed assessments appropriate to our natural, cultural, political, and economic environment;
- develop and test out methods that can be carried out by diverse volunteers;
- produce results useful to landowners and community leaders.

The study team is diverse, including landowners, farmers, teachers, high school students, business people, realtor, health department septic specialist, hydrologist, conservation biologist, GIS specialist, photo interpreter. We received technical assistance from state and regional government agencies and the Center for Watershed Protection. We received a small grant ($5,000) from the Virginia Department of Conservation and Recreation. Our volunteers and partners provided $26,000 in matching contributions to this work.

We selected and defined a study area on the following bases:

- It drains into a segment of the Thornton River that the Virginia Department of Environmental Quality has designated as "303d impaired";
- It lies just below a small public sewage treatment plant and a village;
- A major land owner in the study area wanted to find out the causes of the stream impairment;
- The area includes a mix of land uses typical of our county, including forest, pasture, and low intensity residential;
- Both the topography and property ownership offered accessibility for field studies;
- The size -- 3.87 square miles or 2477 acres -- is appropriate for a pilot study.

We wanted to understand what data and study methods would be most productive for producing an assessment in such a way that land owners and land managers in the study area will find it useful in making decisions about ways to protect their watershed and water quality.

We sought all data in electronic form that are available and relevant for the purpose, from national, state, regional, and local sources, including historical data on water quality and water flow in the Upper Thornton River and factors relevant to topography, land use, land cover, hydrology, geology, soils, wetlands, conservation, wildlife, land ownership. We added each of these layers to our GIS data base and created thematic maps and charts to help guide field work, discussions and interpretations.

We analyzed water quality data in historic records from a water sampling station within the project area (DEQ 3-THO021.19). Total nitrogen, phosphorous, sediment loads, fecal coliform, temperature, dissolved oxygen, and pH data were analyzed. We also reviewed historical records from macroinvertebrate testing by Save Our Streams.

It became necessary to collect data from the field in addition to analyzing existing databases. We needed additional data in order to understand the nature of the water quality problem; to pinpoint locations of point and nonpoint source pollution**;** to characterize the Thornton River and a tributary to the Thornton, in terms of stream banks, habitat and vegetative buffers**;** and to ground truth our interpretations of land cover and land uses. [i] We sampled the main stem of the Thornton River and Tributary Creek at 17 selected locations and used fecal coliform levels as an indicator of water quality. We used that indicator because fecal coliform was used by the Virginia DEQ in defining the impairment, and because it was the one parameter that exceeded state water quality standards. We conducted fish and macroinvertebrate surveys to learn more about the health of the streams. We trained a team of high school students who helped make observations of the streams, created a database of the observations, and prepared maps that show areas where stream banks are eroded and vegetative buffers are lacking.

Results of the fecal coliform bacteria tests reported by a certified professional laboratory showed levels of bacteria in exceedance of Virginia standards for several of the sites, including just below the Sperryville Sewage Treatment Plant. We analyzed historic data from 6 + years of effluent monitoring from the Sewage Treatment Plant.

We are now working with key land owners in the study area where land uses and land cover are contributing to the stream impairment. We discussed our findings with Greg Wichelns, the Director of the Culpeper Soil & Water Conservation District, Joe Thompson, National Conservation Resource Service (NRCS), and Kenner Love the Agricultural Extension Agent, and worked out with them a detailed plan for approaching these land owners. After these land owners provide their input we will decide what types of information from the study to highlight in public reports and other educational materials.

We will apply the following “lessons learned” to future watershed studies:

- Our Rappahannock County community includes many people with skills, knowledge, and interests relevant to watershed analysis and planning, who are willing to volunteer time to such studies. Recruiting and coordinating these volunteers is an ongoing process that must be regularized.
- A major landowner in the study area participated actively on the study team on a day-to-day basis. We learned many different ways in which landowners within the study area can inform and guide the study process.
- Public disclosure of study information needs to be timed carefully in relation to landowner participation.
- All members of the study team need to participate in ongoing clarification and sharpening of the inquiry questions for the study, as well as continual study of the national, state and local policy and regulatory frameworks that affect our work.
- Field data collection is essential for addressing specific local issues and questions. State and national data sources do not provide the needed level of detail or scale.
- The cost in terms of volunteer time and coordination for in-depth study is very high. Therefore future study sites must be selected carefully in order to maximize the value of the study for landowner decisionmaking and public policy input.

- In future water quality sampling, ensure replicate samples, well-developed volunteer training techniques, and collection of flow, turbidity, and temperature data.
- Several different methods are possible to use in analyzing land cover and land use. These vary in terms of their accuracy, scale, and the cost to conduct the analysis. We need to conduct further research and comparisons of these methods and recommend an approach that is affordable as well as useful for our purposes.
- Analysis of the land cover categories must be informed by field observations. Additional field data collection is needed for assessments of forested areas.

Context and Purposes of this Study

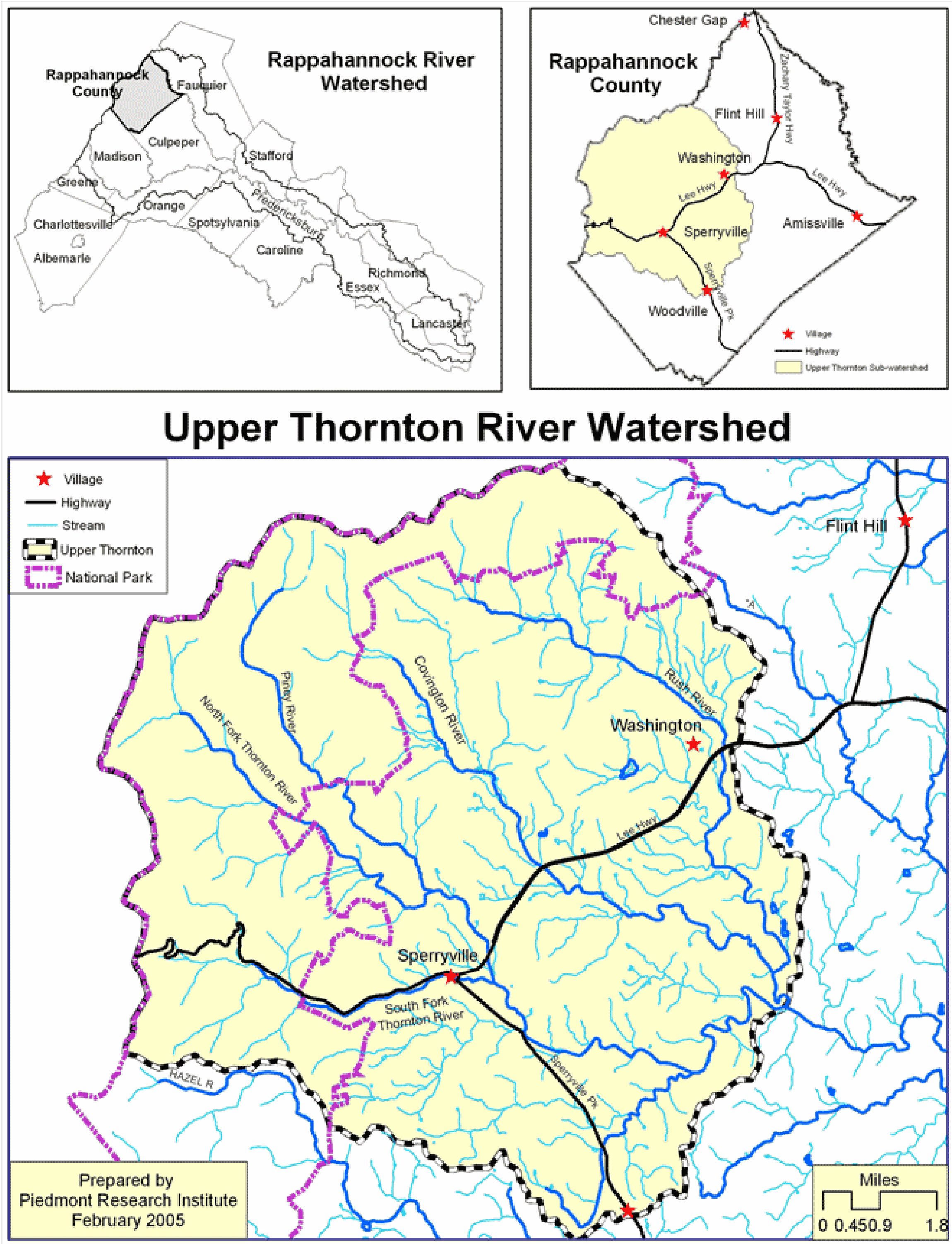
Rappahannock County is at the headwaters of the Rappahannock River watershed, and covers an area of about 267 square miles. The county seat is about 65 miles southwest of Washington, D.C. and 120 miles northwest of Richmond. The county is bounded on the northwest by the Blue Ridge Mountains; the Rappahannock River forms the northeastern boundary with Fauquier County. The county lies within the Piedmont physiographic province with elevations ranging from about 3,700 feet mean sea level in the Blue Ridge, to the lowest point at 360 feet near the Culpeper County border. Most of the County can be classified as steep hillside. It includes portions of six hydrologic units, including the Upper Thornton River. (Map 1). The watershed is dissected by over 1,000 stream segments (in the National Hydrology Database) and 96 % of drinking water comes from private wells, springs or streams.

The two main purposes of this study were:

1) To create and try out a model process for watershed assessment that can serve to guide future such assessments in our locality and other similar localities. The process should take into account scientific, economic, and cultural factors, be feasible for a volunteer group to conduct, and include a wide range of stakeholders.
2) To provide meaningful results that can be applied by landowners in this particular study area, the general public, and leaders in local government and other organizations.

The primary purpose of this report is to inform future watershed analysis studies in this watershed area and in similar rural communities.

Map 1: Context of Study



Study Tasks

RappFLOW originally planned to undertake the following main tasks for this study:

1. Identify a small subwatershed where stakeholders, especially landowners along a stream segment designated as “303d impaired”, indicate interest in participating in the study.
2. Attend a five-day Watershed Protection Institute to learn watershed assessment methodologies and adapt them to our situation.
3. Engage a wide range of stakeholders in the study, to include landowners, farmers, ecologists and other scientists, teachers, students, and leaders of local organizations.
4. Gather data already existing from federal, state, local agencies and organizations, as well as from local citizens.
5. Organize the data into a comprehensive data base, associated GIS maps, RappFLOW web site, and presentations for landowners and public.
6. Work with key landowners in the study area to interpret the data, identify opportunities for better land management practices and needs for additional field data collection, and present options for cost-sharing assistance.
7. Report to the Rappahannock County Planning Commission on progress and seek guidance on their needs for related information.

In addition to the tasks originally planned for this study, the team also conducted field data collection activities.

Task 1: Defining the Study Area and Inquiry Questions

A core group of about twelve volunteers defined the pilot study area shown in Map 2: Pilot Study Area and Map 3: Topography, Streams and Floodplains.

Factors in selecting the study area.

The reasons for choosing this area included the following characteristics which would provide opportunities for us to learn many facets of watershed assessment while providing useful information to the local community:

- The VA Department of Environmental Quality (DEQ) identified a segment of the Thornton River just below the study site as “303d impaired” and we wanted to find out what that means.
- A water monitoring station lies within the study area just upstream of the Fletcher Mill Road crossing, providing a source of historical water quality data.
- Landowners in this area expressed interest in identifying the causes of the stream impairment and provided access to the stream for study.
- The North and South Forks of the Thornton River converge in this area.
- The village of Sperryville and the Sperryville sewage treatment plant are immediately upstream of the study area.
- The study area includes a mix of land uses typical of our county, including forest, pasture, and low intensity residential.
- The study area size, 3.87 square miles or 2,477 acres, is appropriate for a small pilot study watershed assessment.

Defining study area boundaries

We used the above factors, local landowner knowledge of the streams and land uses, and maps of the streams and topography to outline the study area boundaries. See Map 3: Topography, Streams and Floodplains. The study area includes about 1.5 miles of the main stem of the Thornton River and approximately 15 miles of an adjacent tributary creek. The elevations in the study area range approximately from 700 to 1900 feet. The Thornton River and Tributary Creek are part of the Rappahannock River watershed.

Defining the inquiry questions

While we were defining the study area, the team asked the following questions:

- On what basis did the VA DEQ designate the segment of the Thornton River below the study area as "303d impaired"?
- How robust is the evidence for "impairment" of the river?
- What are the possible sources and causes of the impairment within or outside of the study area?
- What additional data, beyond the scope of this small study, would be needed to further understand the nature and causes of impairment?
- What possible changes in land use and land management could improve the water quality of the Thornton River and associated tributaries in this study area?

We also wanted to identify ways in which our methods of conducting this study could be applied in other subwatersheds in the county and in other similar locales.

Task 2: Attending the Watershed Protection Institute

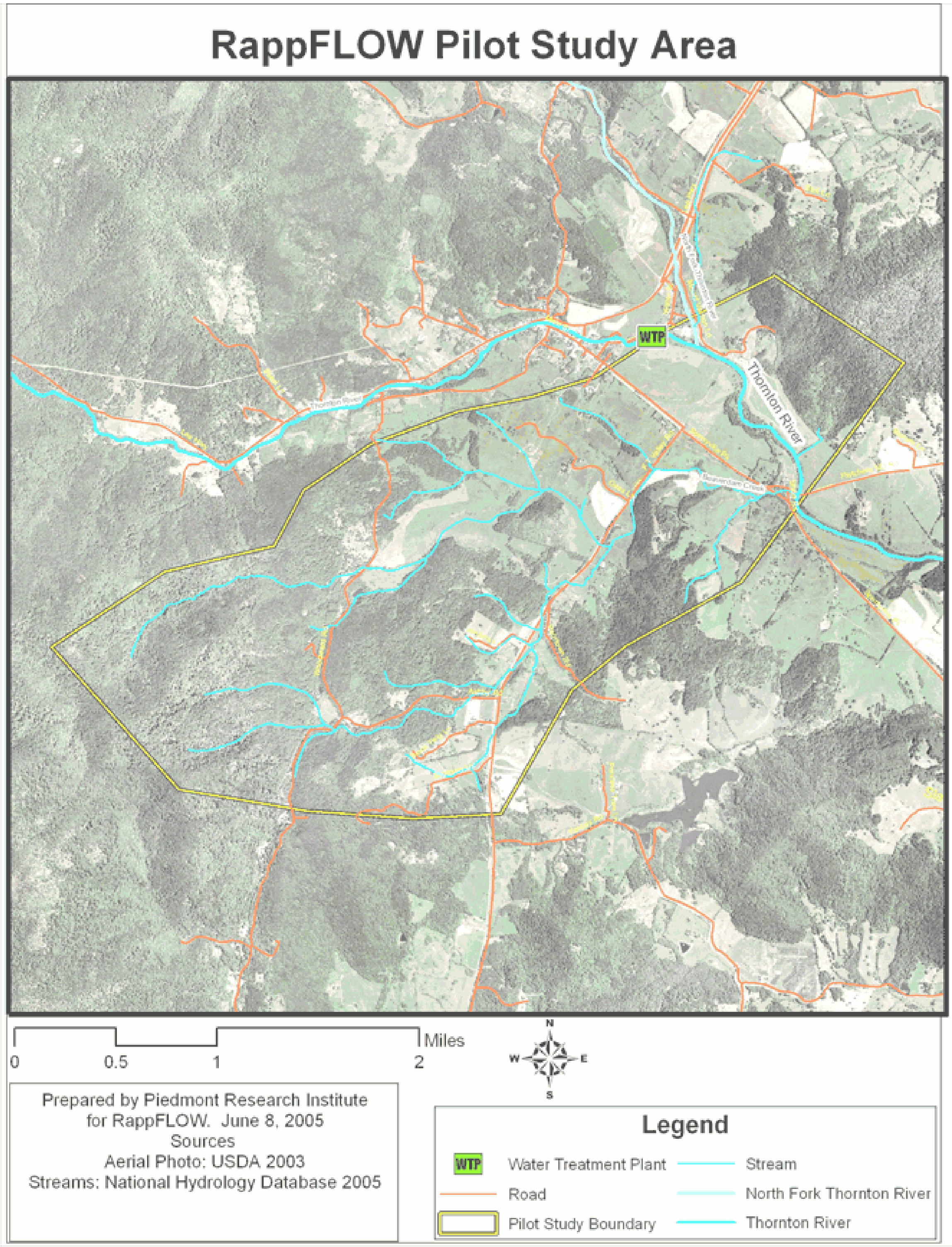
Three members of the study team attended in April 2005 a five-day Water Protection Institute run by the Center for Watershed Protection (ref) at the National Conservation Training Center. Our purpose was to learn methodologies and receive technical assistance in tailoring these methods to our study purposes and situation. Three main ways in which we are modifying their methodology include the following:

- Place more emphasis on supporting local landowner decision making as outcome of the study, as opposed to the focus on public policy, zoning ordinances, etc. which are emphasized by CWP.
- Place more weight on conservation factors such as forest areas, wildlife habitat and stream buffers, rather than on impervious surface analysis appropriate in more developed jurisdictions.
- Begin with more in-depth study of a small area rather than broad study of large areas, so as to identify data sources, try out methods of interpreting different types of data, and engage and interest local landowners regarding issues of importance in a small subwatershed area.

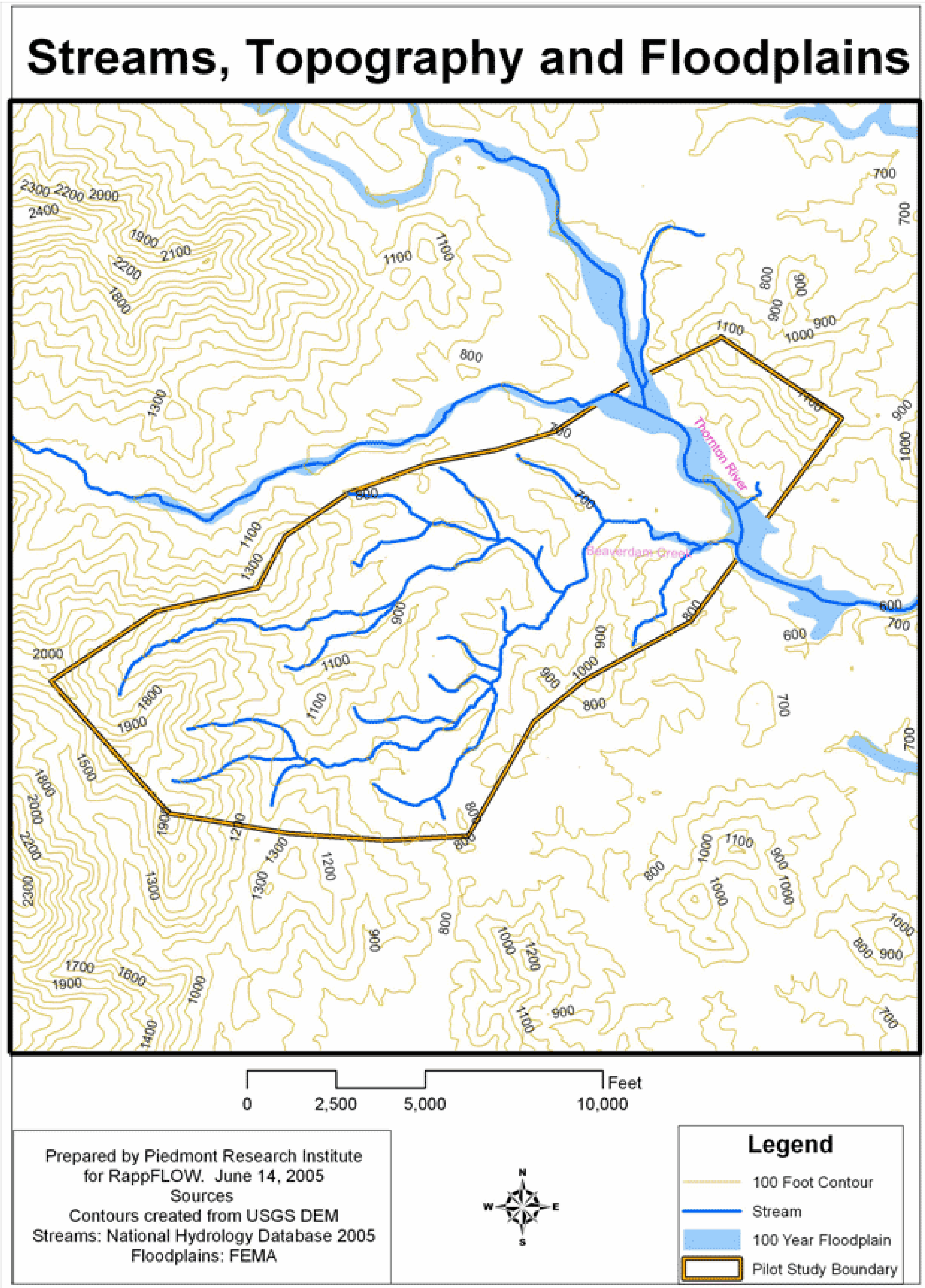
Task 3: Building the Study Team

The study team includes the Core Team, high school students, landowners and residents of the study area, local government officials, and partner organizations. Methods of communicating among these diverse groups included email and telephone; workshops, meetings, and field trips; website www.rappflow.org; and articles in the local newspaper andRappFLOW newsletter.

Map 2: Study Area



Map 3: topography etc



Core Team Members

The following persons contributed directly to this pilot study as volunteers.

- Don Audette. Rappahannock League of Environmental Protection (RLEP) Board Member. Writes articles for RappFLOW for local newspaper.
- Tim Bondelid. Resident of Woodville, Virginia since 1987. He is a professional environmental and water resources engineer specializing in water quality data systems, GIS and data analysis. He obtained many digital data bases and assisted in interpreting and graphing the data for the Pilot Study.
- Lorinda Bosch. Joined the RappFLOW team in 2004 to help organize & keep track of details. She does similar administrative work with local businesses and a local environmental nonprofit organization. She has lived in Rappahannock County since 1991.
- Medge Carter. Rappahannock County Health Department specialist in septic systems. RappFLOW volunteer since 2002. Assisted in obtaining historical data from Sperryville Sewage Treatment Plant.
- Sarah Gannon. She lives in Rappahannock County. Sarah is a certified wildlife biologist, Land Conservation Officer for PEC. She assisted in field data collection, training volunteers, and interpreting data.
- Ken Giles. Washington, Virginia native and a '96 graduate of Virginia Tech's School of Forestry and Wildlife. Employed as a photo interpreter at an environmental consulting firm. He conducted land cover analysis and categorization.
- Hal Hunter, Ph.D. Targeted Learning Corporation, Rappahannock County Conservaton Alliance Board Member, Secretary of the Rappahannock League for Environmental Protection. He assisted with data collection and printed hundreds of color copies of maps, reports and newsletters.
- Beverly Hunter. Initiated and directed the pilot study. Landowner on Rappahannock River near Amissville since 1968 and resident of Jackson District since 1976. Develops natural resource applications of GIS. Rappflow co-coordinator, Director of Piedmont Research Institute.
- Jill Keihn. RappFLOW science coordinator, environmental scientist and certified wetland ecologist with experience in writing environmental assessments. She is a teacher at Hearthstone School. She provided field data collection methodologies and assisted in data interpretation.
- Richard Lykes. Writer and photographer, resident of Rappahannock County. He took digital photos at several RappFLOW activities.
- Cliff Miller. Member of the Board of Directors, Culpeper Soil & Water Conservation District; Board of Directors Rappahannock County Conservation Alliance. Owner of Mount Vernon Farm in the pilot study area in Sperryville, a model for sustainable agriculture and forestry. Through the CREP program the farm placed 175 acres into riparian buffers. Mt. Vernon produces and sells grass-fed beef and lamb, and free range pork and eggs at the farm, over the internet and at farmer's markets. The farm in 2003 placed over 600 acres in conservation easement.
- Rappahannock County High School Team. Under the guidance of Ron Vickers, Geospatial RCHS teacher and Beverly Hunter, GIS advisor, five students from RCHS’s geospatial technologies class adopted RappFLOW as its spring 2005 GIS project. Jenkins Dove, Christina Narramore, Steven Rodden, Malcolm Sonnett, and Dustin Torrance assisted in RappFLOW field studies and mapping.
- Mitzi Young. Rappahannock County Cconservaton Alliance (RCCA) Board Member, realtor. Volunteer for RappFLOW since its founding. She provided strategic guidance for the pilot study.

Landowners and residents of the study area

As noted above, a major landowner in the study area is a member of the Core Team for this study. Based on parcel maps and the tax database from Rappahannock County, we identified landowners in the study area. Prior to field site visits, we contacted landowners or land managers to obtain permission to walk their streams.

Our strategy for working with other landowners in the study area is discussed below under Task 6.

Local government

RappFLOW leaders provided updates at meetings of the Rappahannock County Planning Commission and the Board of Supervisors. Three RappFLOW Core Team members (Carter, Folsom, Hunter) serve on the County's Water Quality Advisory Committee and share findings with that coordinating group at bi-monthly meetings. Other members of that committee serve as technical advisors to the pilot study. RappFLOW posts minutes of the WQAC on its website.

Partner organizations

Piedmont Environmental Council (PEC) provided staff time, paid for Sarah Gannon's participation at the Water Protection Institute, and paid for some of the lab analyses of fecal coliform water samples. Culpeper Soil & Water Conservation District's Greg Wichelns provided technical assistance. USDA NRCS Joe Thompson is providing technical assistance to the key landowners in the study area. Piedmont Research Institute's Beverly Hunter did GIS mapping, some of the data analysis, and report writing. Kenner Love, Agricultural Extension Agent, provided project review and assistance with land management practice improvements. The High School provided transportation for student field studies, and GPS units. Cliff Miller, owner of Mount Vernon Farm, provided meeting and field study venues. He has been instrumental in land access and key landowner discussions regarding improved land management practice options. Jim Atkinson, Wildlife Fisheries Biologist at Shenandoah National Park, and Larry Mohn, Department of Game and Inland Fisheries, led a field study of fish species and populations in the study area on the Thornton River. James Beckley, VA Department of Environmental Quality (DEQ) Water Quality Data Liasion, provided technical assistance in acquiring and interpreting water quality data. The Rappahannock-Rapidan Regional Commission (Jeff Walker) served as our fiscal agent for this study. The Virginia Department of Conservation and Recreation provided a small grant to reimburse expenses. Targeted Learning Corporation provided equipment and supplies for printing and copying.

Task 4: Gathering Data

The study team gathered data in electronic form from state and national agencies. We began with a list of possible data types and sources provided in the booklet *A Community Water Quality Approach: Local Watershed Management Planning in Virginia* published by the Virginia Department of Conservation & Recreation in 2004. [4] The list of data types and sources is shown in Table 1: GIS Layers and Data Files in RappFLOW Pilot Study. The most important of these data types and sources for purposes of this pilot study are shown in **bold** in the table.

Locating the data.

The project began with several GIS layers for the county already in hand at Piedmont Research Institute, such as topography, public and private roads, streams, parcel owners, easements, the Virginia Base Mapping System's Digital Ortho Quad aerial photography, and the USDA's aerial photography from 2003.

The tasks of locating additional files and obtaining them involved several attempts by study team members contacting various individuals in state agencies. The search for data and sources for the pilot study was initiated in December 2004. We placed highest priority on obtaining data most directly relevant to the inquiry questions listed above.

Gathering data from the field.

It became apparent early in the study that state and national data would not be sufficient to answer our inquiry questions. We conducted eight field data collection sessions over a period of six weeks, to obtain more detailed measures of the following:

- Fecal coliform levels at seventeen different points above the study area, along the main stem of the Thornton River within the study area, and within the Tributary Creek that joins the Thornton River just above the water quality monitoring station. See Map 3: Water Quality Monitoring Sites on Thornton River[ii].
- Observations of stream characteristics including bank heights and erosion levels, 35-foot vegetated buffers along the streams, and stream habitat factors.
- GPS waypoints for each water sample site and stream observation point.
- Digital photos for selected observation points.
- Fish and macroinvertebrate counts .

Task 5: Organizing the Data

The primary data organization tasks involved the following:

1. mapping, analyzing and summarizing historical and new water quality data,
2. mapping, interpreting and symbolizing stream characteristics observations,
3. mapping, categorizing and summarizing land use and land cover data,
4. mapping, categorizing and summarizing 35 foot stream buffer vegetation (land cover)
5. developing maps to depict spatial relationships among these factors.
6. presenting the findings of our pilot study to our organization, our local government, and the public in an informative, succinct style.

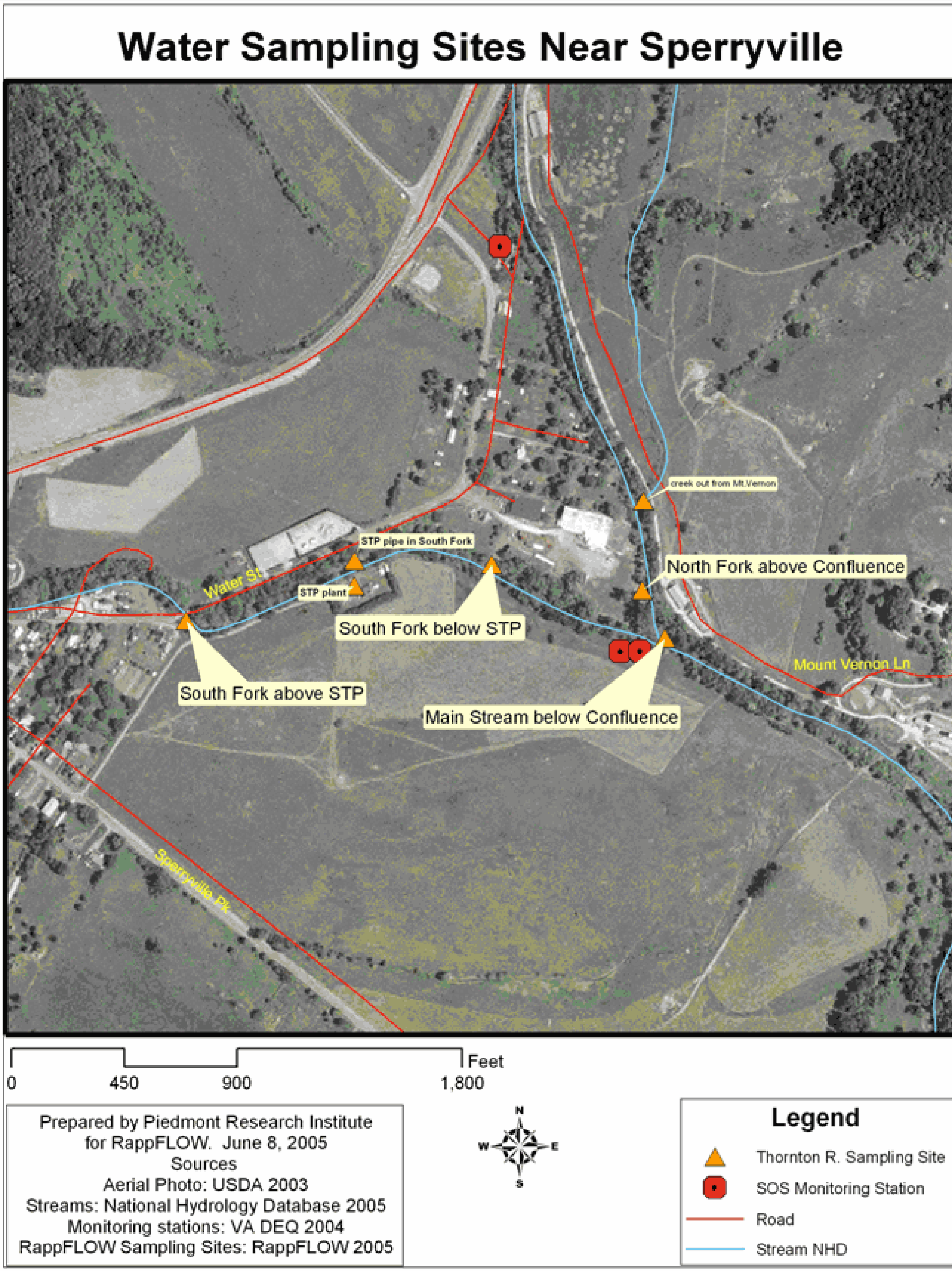
Table 1: GIS Layers in RappFLOW Pilot Study as of May 8, 2005

CATEGORY	TOPIC	File Names	Sources*	Last Updated	Notes
Riparian System	**Streams & Ponds (REACH files)**	**pilotreach.shp**	**National Hydrology Database**	**2005**	**For more information: http://www.nhd.usgs.gov**
Riparian System	Streams & Ponds	numerous	VBMS DLGs	2002	Geographically more accurate Than NHD for buffer analysis
Riparian System	**DEQ WQ Monitoring Station locations**	**DEQthornton.shp**	**VA DEQ**	**05/08/2005**	**extracted from va_04_assess_monitoring_stations**
Riparian System	**RappFLOW WQ monitoring station locations**	**RappFLOW_sampling.shp**	**RappFLOW**	**June 8, 2005**	**GPS waypoints used to locate sampling sites.**
Riparian System	**water chemistry: historical from DEQ**	**FC_thornton0515**	**VA DEQ**	**June 2005.**	**Station 3-3-THO021.19 from http://www.deq.state.va.us/info/edata.html**
Riparian System	**water chemistry: sewage treatment plant**	**Sperryville.xls**	**VA DEQ**		**Sperryville WTP effluent**
Riparian System	biological monitoring		SOS		Macroinvertebrate counts. No complete dataset available.
Riparian System	stream buffers: field observations	(several)	RappFLOW	June 2005	RCHS team creating attribute tables & GPS waypoints
Riparian System	stream banks: field observations	(several)	RappFLOW	June 2005	RCHS team created attribute tables & GPS waypoints
Riparian System	Water flow		USGS	Real time	http://waterdata.usgs.gov/nwis For Laurel Mills station
Riparian System	habitat				
Riparian System	RTE species				
Riparian System	Fish Species Counts		NPS/VDGIF	2005	Field studies conducted May 31 & June 13, 2005.
Physical Attributes	wetlands	washin_p; thorng_p	NWI		http://waterdata.usgs.gov/nwis
Physical Attributes	soils	STATSGO (many files)	STATSGO		Metadata for GIS projection needs to be implemented for our system..
Physical Attributes	Floodplains 1:24000 scale	FEMA Q3 100 year	FEMA	1996	Obtained from RRRC. UTM 17N

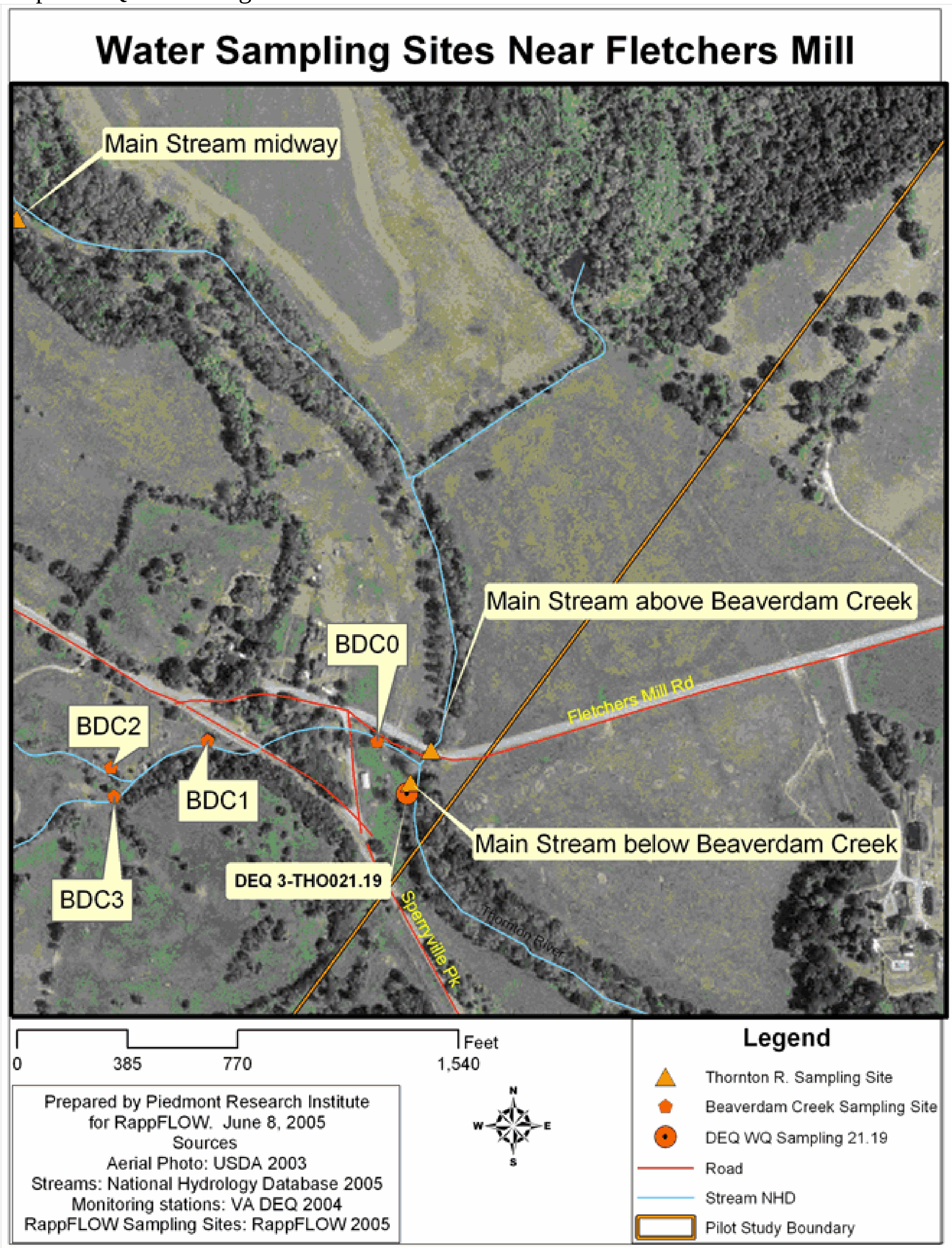
		floodplains.			NAD27.
Physical Attributes	topography - DEM	vbasinrc	USGS		Used to create slopes, contours, hillshade.
Physical Attributes	topography - slopes	studyslopes.shp	rappFLOW		
Physical Attributes	topography - hillshade	hlshdzconvert.shp	rappFLOW		Study area is not steep and large enough to use this effectively.
Physical Attributes	topography - contours	contours20.shp	rappFLOW		Used primarily to assist in defining study area
Physical Attributes	stream morphology				
land use/land cover	**aerial photo/DOQ**	**do_n16_5941_00.tif**	**VBMS**	**2002**	**Used for land cover analysis**
Land use/land cover	**aerial photo/DOQ**	**do_n16_5952_00.tif**	**VBMS**	**2002**	**Used for land cover analysis**
Land use/land cover	**aerial photo/DOQ**	**do_n16_5951_00.tif**	**VBMS**	**2002**	**Used for land cover analysis**
Land use/land cover	**aerial photo/DOQ**	**do_n16_5962_00.tif**	**VBMS**	**2002**	**Used for land cover analysis**
Land use/land cover	**aerial photo/DOQ**	**do_n16_5971_00.tif**	**VBMS**	**2002**	**Used for land cover analysis**
land use/land cover	**aerial photo/DOQ**	**ortho_1-1_1n_s_va157_20 0310a.sid**	**USDA**	**2003**	**Used as basemap for most of our maps.**
land use/land cover	**land cover categorization**	**landcover_2002_projected.shp**	**RappFLOW**	**2005**	**Developed by Kenny Giles and Bev Hunter**
land use/land cover	land cover raster	2987021.shp	NLCD		Not at large enough scale for small study area purposes.
Land use/land cover	Land cover polygons	Nlcd_poly_studyareas	RappFLOW		Created from NLCD land cover raster
Land use/land cover	35 ft stream buffer land cover	Nlcd_poly_streamburffers	RappFLOW	May 2005	Uses digital line graphs for streams from VBMS 2003
Land use/land cover	conservation easements		VOF		get latest from sarah
Land use/land cover	land ownership	pilot_study_parcels.shp	PRI	2003	Land owner database updated jan. 2005
Land use/land cover	zoning & subdivision				Study area is all zoned agricultural

Land use/land cover	**permitted point source discharges**	**sperryville_WTP.shp**	**Rapp County**		**Location of the WTP**
Land use/land cover	**Permitted point source discharges**	**Sperryville.xls**	**DEQ**	**May 2005**	**5+ years effluent data**
Land use/land cover	NPS pollutant sources				Interpreted from many study sources.
Land use/land cover	highways & roads	roads_pilotstudy.shp	Rapp County		Subset from Rapp. Co. roads shapefile
Land use/land cover	forest cover (raster)	vatree	VA DOF		Resolution not useful for study purposes.
Land use/land cover	**NLCD categories**	**landcoverGiles.shp**	**RappFLOW**		
Land use/land cover	recreation sites				
Land use/land cover	historical sites				we could map this; we have the data…
Land use/land cover	political boundaries	county.shp	Rapp County		
Regulatory	VA water uses		VA DEQ		http://www.deq.virginia.gov/wqs/designated.html
Regulatory	VA WQ standards	wqs04.pdf	VA DEQ	2005	
Regulatory	Tributary Strategy			2005	From VA dept natural resources

Map 4: Water Quality Monitoring Locations Near Sperryville



Map 5: WQ monitoring near fletcher mill



Task 5.1 Analyzing and summarizing water quality data

Summary

Based on interpretation of over ten years of water quality monitoring data and additional water quality samples taken in this study, we found that fecal coliform (FC) bacteria concentration levels in the Thornton River and its tributary in the study area have exceeded acceptable limits. In 2004, the Virginia DEQ and the U.S. EPA designated a 4.28 mile segment of the Thornton River as "303d impaired." [1] This impairment designation was based upon elevated FC levels from two samples collected in the study area. Recent FC samplings indicate continued elevated bacteria concentrations that appear in several locations.

No other water quality parameters we studied for the pilot study area have exceeded state or federal standards. The phosphate and nitrogen nutrient levels are not a problem in the segment of the Thornton River that we studied.[iii] However, the sedimentation and temperature of the Thornton and its tributary are less than ideal.

Fish and macroinvertebrate surveys indicated abundant and diversified populations. The robust fish population and fairly good benthic score (9) in a stream with elevated FC levels indicates that the adverse impacts of FC contamination is human health problems, not health impacts to the aquatic community. FCs showed no direct effects on the aquatic species, but indirectly it may indicate other potential pollutants.

Analyzing Historical Water Quality Data

We obtained (http://www.deq.state.va.us/info/edata.html) water quality data from sampling station 3-THO021.19 which is located on the main stem of the Thornton River just below the point where a tributary Creek enters the main stem. (see Map 5: Water Quality Monitoring Locations Near Fletcher's Mill). These data cover 1991-2001 and 2004-2005 time periods. [iv]

We evaluated the water quality data from the sampling station and compared dates of these samples to corresponding water flow data from the nearest USGS gauging station at Laurel Mills to ascertain possible impacts of flow conditions on stream water quality. In general, fecal coliform levels did not correlate to water flow fluctuations noted this season.

Below, our discussion of water quality parameters is divided into three categories:

- chemical water quality indicators (including nutrients, dissolved oxygen, biological oxygen demand, and pH);
- biological parameters; and
- physical parameters (including temperature and turbidity).

Chemical Parameters

Nitrogen (in all its forms) and phosphorous are nutrients which in heavy loading can become pollutants. The nitrogen concentrations collected within the Thornton River at the 3-THO021.19 monitoring station between 1991 and 2001 indicate total nitrogen concentration levels within accepted limits. Total nitrogen is a calculated sum of both nitrite (NO3) and total Kjelhalh. However, a nitrite level of 0.55 mg/l was exceeded three times (Sept 98, Jan 1999, and June 99). The acceptable high range standard for nitrite is 0.55 mg/l, which caused “brown blood” disease in some fish (Virginia Citizens Water Quality Monitoring Program, DEQ, July 2003). Phosphorus concentrations were well below the recommended 0.2 mg/l level.

Dissolved oxygen (DO) levels were relatively high, which is a positive attribute. High DO means sufficient levels of saturated oxygen available for fish and benthos. Levels at 10 or greater are considered good for the in-stream species (Virginia Citizen Water Quality Monitoring Program). The 10-year monthly average DO level was 9.5 (calculated from April to October). Usually rivers such as the Thornton with many riffle and run segments contain high DO while slow moving stagnant waters have very little. Dissolved oxygen levels in water below 5.0 mg/l put aquatic life under stress.

The pH, a measure of alkalinity and acidity, levels were within the normal limits.

Biological Parameters[v]

Fecal bacteria are bacteria from the fecal coliform bacteria group originating in the intestinal tract of warm-blooded animals that passes into the environment in feces. Fecal coliform bacteria are often used as an indicator of pathogens in water. Elevated FC levels pose threats to public health. [3] Over the 10 year sampling period between 1991 and 2001, the FC levels exceeded state standards 8 times, with elevated concentrations ranging from 230 colonies of bacteria/100 ml water to 3500 colonies of bacteria/100 ml water. In 2004, the FC levels exceeded state standards in three of the six samples taken, indicating the continued presence of an impaired stream segment. (see Chart 1: Fecal Coliform levels from 3-THO021.19 monitoring station). In 2004 the Virginia DEQ and the U.S. EPA listed the Thornton River at this location as “303d impaired” based upon two samples which violated their limit during their assessment window of 1998 to 2001.

Physical Parameters

Turbidity is a measure of the cloudiness of water. Water cloudiness is caused by material suspended in water. Therefore, turbidity is an indirect measure of total suspended solids (TSS). Although there is no standard for TSS, a reference stream in rural mountainous Virginia usually has a TSS concentration of 30 mg/l. (J. Beckley, DEQ, personal communication May 11, 2005). The average TSS concentration from the monitoring station data covering 1991 to 2001 is 50.5 mg/l, which is higher than a reference stream level.

The average April to September temperature of the Thornton River over the ten years was 17.2 degrees Celsius (63 degrees F). Virginia standard levels are 68 degrees F for stockable trout waters and 60 F for natural trout waters. Although the levels in the Thornton are within standard limits, the temperatures tend to be warmer than desirable especially since there are no natural springs nearby to allow for cooling in warmer times. Increased canopy cover with forested vegetation would decrease temperatures and improve trout habitat in the future.

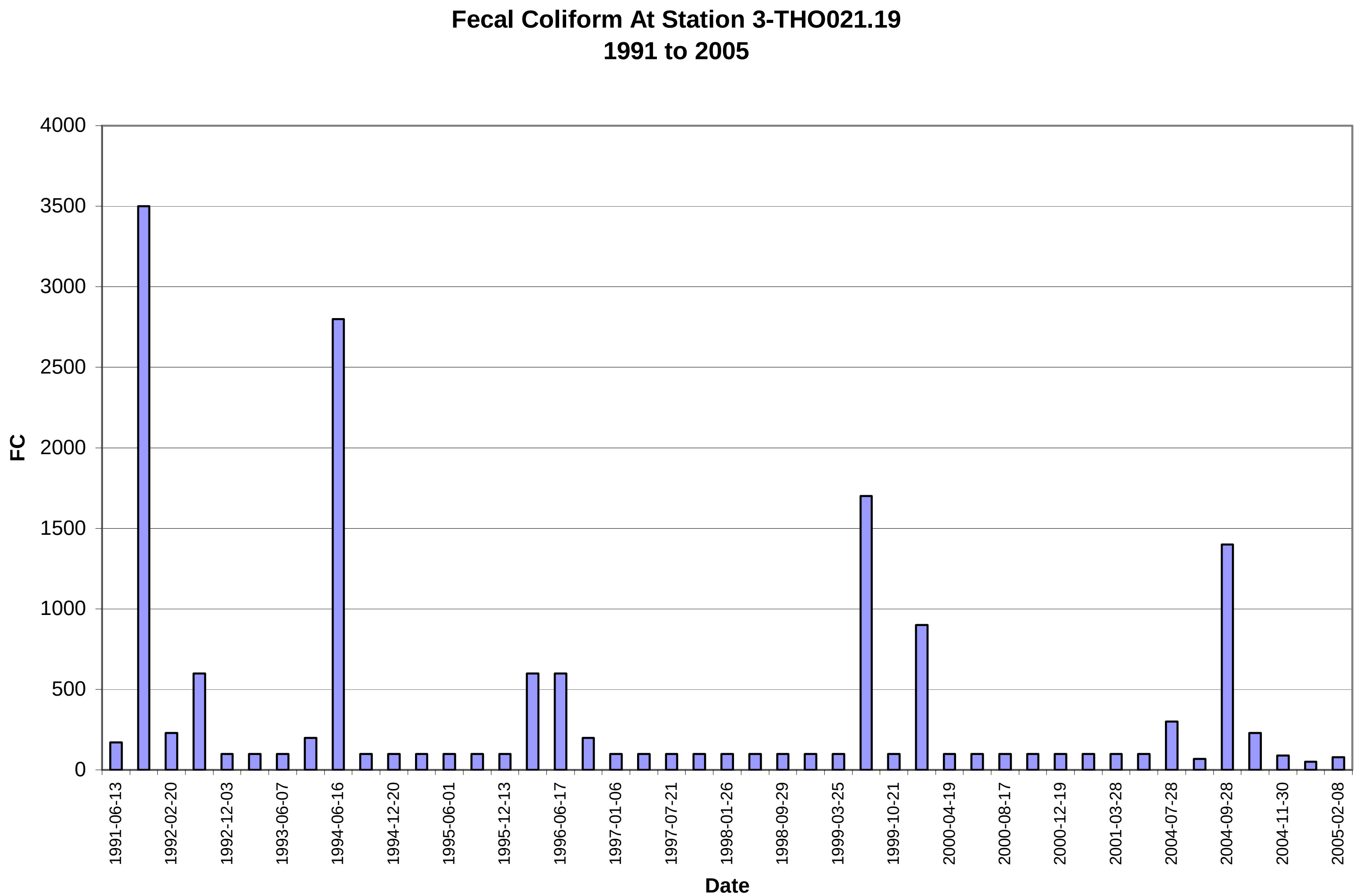


Chart 1: Historical Fecal Coliform Readings from Monitoring Station 3-THO021.19

Analyzing Sperryville Sewage Treatment Plant (STP) Data

The Sperryville Sewage Treatment Plant (STP) is required by its DEQ permit to monitor certain water quality parameters from its effluent on a monthly basis and send this information to DEQ. We obtained historical data from VA DEQ for the Sperryville Sewage Treatment Plant covering a six-year period from February 1999 to April 2005. We compared the monthly parameter values to allowable limits set forth in the STP DEQ National Pollutant Discharge Elimination System Permit # VA0062880. Secondary wastewater treatments such as STP with design flows of 55,000 gallons per day are small package plants. They do not have a FC standard in their permit limits and they do not test for FC in their effluent or in the stream. Instead, they treat with chlorine levels suitable to kill bacteria. When chlorine levels measured as Total Contact Chlorine are equal to or greater than 1.0 mg/l, the levels are considered sufficient to kill FC to acceptable concentrations (<200 colonies per 100 mls water). In the 6-year effluent data the average Total Contact Chlorine level was 0.79mg/l. Prior to January 2002, the monthly average Total Contact Chlorine was 0.57 mg/l. No level of 1.0 mg/l Total Contact Chlorine was reached between February 1999 and January 2002. Whether the current Total Contact Chlorine level is sufficient to remove the bacteria warrants further study. Additional investigation is also needed to determine the duration of time the waste is exposed to the chlorine to ensure proper contact for efficient bacterial removal.

Water quality parameters we evaluated for the STP included ammonia, biological oxygen demand, dissolved oxygen, sediment loadings, and pH. There were four exceedances of allowable STP permit levels over the 6-year time period. These exceedances were for ammonia levels above the permitted 5.1 mg/l in the wastewater effluent. These occurred in 2000 and 2001 (ammonia levels of 6.2 mg/l, 9.8, 5.5, and 25.8). There was no correlation between the elevated ammonia concentrations and water flow levels. The average dissolved oxygen in the STP effluent was 7.6 mg/l, thereby meeting their permit requirements for being above a minimum of 6.0.
The Biological Oxygen Demand (BOD_5) in the STP effluent was a monthly average of 8.0, well within the allowable 30 mg/l permit requirement, although several peaks were near 30 mg/l. Typical streams in our area have a BOD_5 of 2-4 mg/l.

Sampling for Fecal Coliform in the Thornton River

Because the FC levels measured at the water quality monitoring station 3-THO021.19 were the reason for the “impaired” designation, we sampled a variety of locations on three separate dates to try to locate more precisely the source of FC in the Thornton River within the study area. We collected water samples in sterile containers from locations in the South Fork, North Fork, the main stem of the Thornton River, and tributary creek. The samples were analyzed for fecal coliform by Joiner Micro Laboratories in Warrenton Virginia. Chart 2 shows the results of these tests at various locations on the Thornton River. These locations are shown on Map 4: Water Quality Monitoring Locations near Sperryville, and Map 5: Water Quality Monitoring Locations near Fletchers Mill.

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The water in the South Fork of the Thornton River above the Sperryville Sewage Treatment Plant tested well within acceptable limits for FC (50 and 140 counts on the two samples). Similarly, water coming into our study area from the North Fork above the confluence of the North and South Forks was also well within limits (50 and 70 counts on the two samples).

On our first sampling, FC levels just downstream of the Sperryville STP were elevated and exceeded standards compared to FC levels collected upstream of the STP but this result was not repeated in the second testing. We collected a sample where the wastewater effluent pipe outlet enters the Thornton River. This level of 300 colonies was notably higher than the 140 colonies collected just upstream of the effluent discharge location. This elevated level exceeds the standard and suggests the possibility of the STP being a causative factor in Thornton River water quality impairment. However, DEQ often allows wastewater treatment plants to maintain a mixing zone downstream of their effluent location so the river can dilute the waste and to reach acceptable levels.

Along the main stem of the Thornton River, we tested for FC levels both above and below where the tributary creek enters the Thornton River. FC levels were higher below the creek than above. We then collected samples at ten different locations along the tributary creek. Elevated FC levels exceeding acceptable limits were present in all of these samples, as shown in Chart 3. The FCs ranged from 800 colonies to greater than or equal to 16,000 colonies (at or above instrument detection limit). The water within the tributary creek in places was observed to contain sediment and was opaque and the rocks in the substrate were embedded with silt.

The location "BDC0" is on the creek, just before it enters the main stem of the Thornton River. Readings of 800 colonies per 100 mls water were obtained for both sample dates at that location.

Conducting a Fish Survey

In late May 2005, a biologist from Shenandoah National Park led a fish survey along four 100-foot sections of the Thornton River within the study area, to assess the population and diversity of fish. A total of 24 fish species were captured and released back in the Thornton River. This diversity of 24 species is well within the range of expectation for a stream of this size within the upper Rappahannock (James Atkinson, SNP Biologist, personal communication June 1, 2005). The majority of fish present were native species. The following nonnative (or introduced) fish were also identified during the survey: Rainbow trout; Green sunfish; Rock bass; large and smallmouth bass; torrent suckers; and the brook lamprey. Overall, the fish population present indicates good fish habitat. Fish species collected were robust.

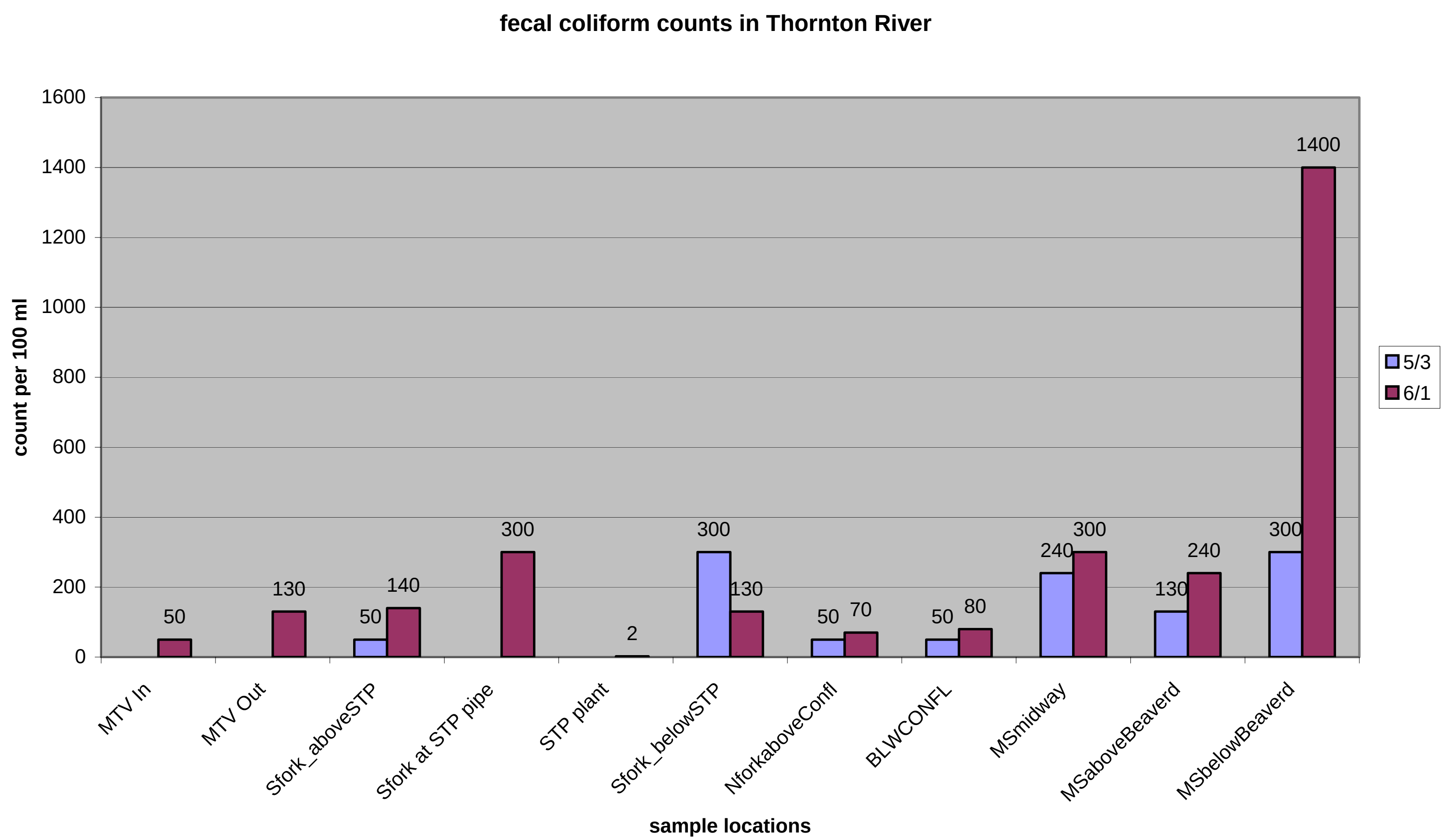

Chart 2: Spring 2005 Fecal Coliform Readings for Thornton River.[vi]

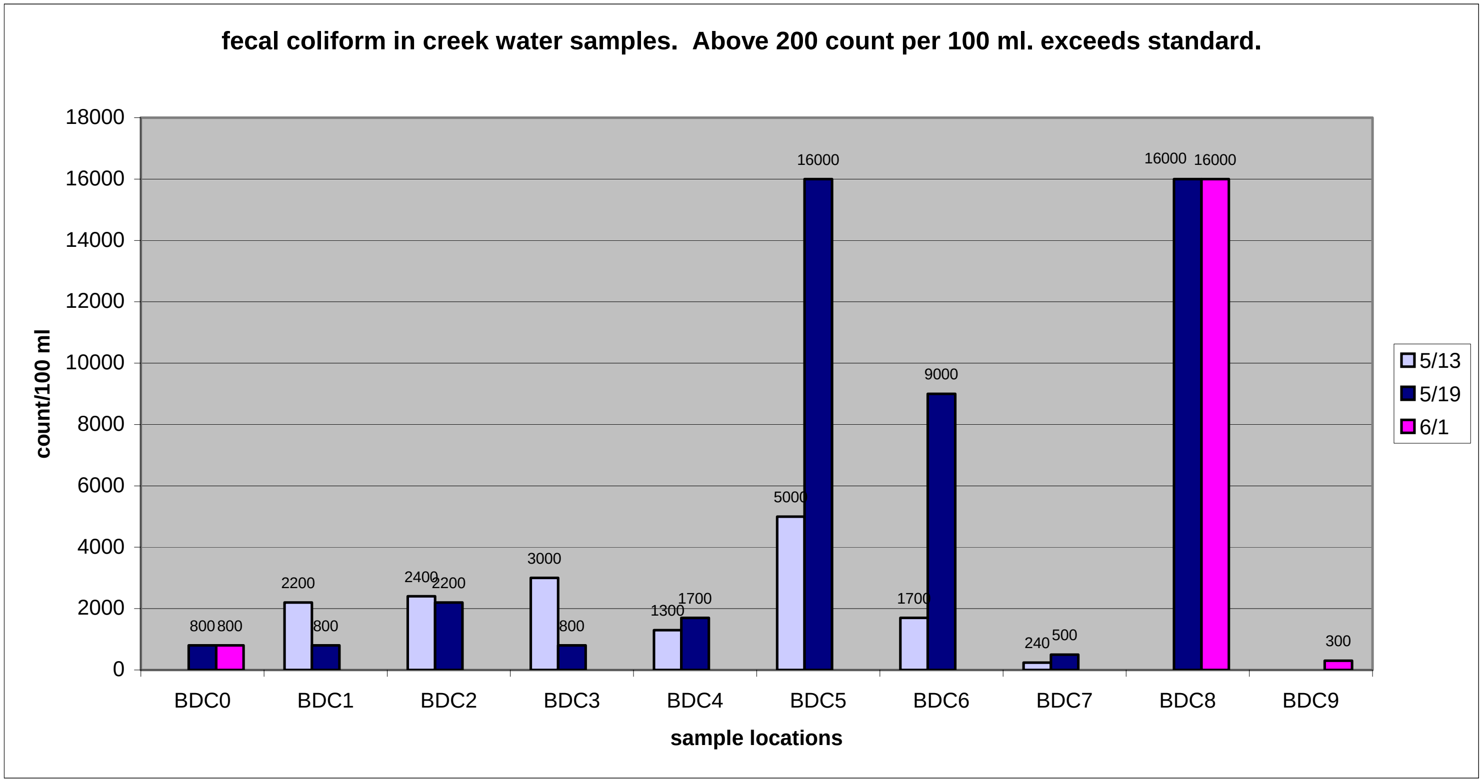

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Chart 3: Spring 2005 Fecal coliform bacteria readings for tributary creek

We also conducted a fish survey along a 450-foot segment of the Tributary Creek. A total of 22 fish species were captured. Of those 22 species, nine fish species were likely present due to the influence of the Thornton River. Likely intrusions from the Thornton River that would not otherwise be present in the stream included: Fallfish, White Sucker, Redbreast Sunfish, Bluegill, Rock Bass, Margined Madtom, Smallmouth bass, Torrent Sucker and Northern Hogsucker. The Tributary Creek contained sandbar habitat suitable for supporting swallowtail shiners (James Atkinson, SNP, June 13, 2005).

Assessing Macroinvertebrate Benthic Communities

In every body of water there live a multitude of organisms, from microscopic bacteria to vertebrates such as fish. In between are the macroinvertebrates. Healthy waters teem with varieties of these organisms, but when degradation occurs their living communities change in predictable and measurable ways. This makes monitoring macroinvertebrates a sensitive test of stream condition through time, particularly with regard to dissolved oxygen.

Virginia Save Our Streams (VA SOS) trains and certifies volunteer water monitors throughout the state. Data collected by their certified monitors is sent to state and regional agencies for use in water quality assessments. Using a VA SOS seine net, monitors capture samples from a section of stream. The catch is then sorted by type into trays, counted, and using a calculator (and the standardized forms provided), percentages are arrived at giving an estimate of the numbers and distribution of macroinvertebrates inhabiting the stream.

As shown in Map 4, there are two SOS monitoring stations in our study area, on the North and South Forks of the Thornton River just before the confluence (Stations R5 and R7). For more information see http://www.rappmonitor.va.nacdnet.org/r05.htm. The highest score for this measure of water quality is 12, which indicates a healthy stream. Both stations had readings of 11 or 12 in the years for which data are available.

Our Core Team includes two members who are certified SOS volunteer water monitors. They conducted macroinvertebrate studies in the tributary creek and found "acceptable" water quality results there (score of 9). However, the score on tributary creek was less than scores collected on the Thornton River. Additional benthic surveys along portions of the Tributary Creek would be useful in future studies to further quantify the benthic habitat and overall water quality.

Task 5.2 Interpreting and symbolizing stream characteristics

Team members developed and revised a protocol and data collection form for characterizing stream buffers, banks, and habitat. We trained a team of five high school students who assisted in making these observations along portions of the Thornton River and the tributary creek. The students created a database of all the stream observations, and made maps to help visualize stream conditions. See Map 6: Bank Erosion and Map 7: Road Crossings and Adjacent Roads.

The bank erosion map shows clearly the difference between the medium and high levels of stream bank erosion in the tributary stream area where there are not vegetative buffers, and the low erosion found on the banks of the main stem of the Thornton River as it flows through a farm where CREP plantings were made along the stream and animals were fenced away from the stream three years ago. Of the 20 observation sites along the main stem of the Thornton River, 18 did not show erosion while two sites were observed to have a medium level of erosion. On tributary creek, 17 sites were observed for erosion with only three sites of low or no erosion. Fourteen sites on the tributary creek had medium or high erosion. Sediment, likely from eroded banks, was present in the stream. The lack of mature vegetation to stabilize banks contributes to the erosion.

Habitat parameters observed in our protocol include percent canopy cover; percent woody debris; percent riffle, run and pool; and substrate characteristics. We did not conduct a large enough sample of systematic stream habitat observations to be able to combine the multiple habitat parameters in a meaningful way for analysis and mapping. We will need to obtain or develop training materials and methods for making habitat observations that are reliable, complete, and systematic. Further research is also needed to establish methods for combining the multiple habitat parameter values into meaningful categories for analysis and mapping.

Task 5.3 Categorizing and summarizing land use/land cover data

One objective of this pilot study was to advance our understanding of methods we can use to analyze land cover. In this section we address intended uses for land cover categorization, sources of land cover data, two methods we tried out for categorizing land cover for the study area, and our assessment of these methods in relation to our purposes.

Uses of the land cover categorization

The types of vegetative cover and their locations on a study area are central to watershed assessment. Land cover categorization is used to:

- identify high priority areas for conservation, such as contiguous forests, wildlife corridors, and forested stream buffers;
- identify and summarize the type of vegetation within a 35-foot or 100-foot buffer along streams
- determine potential sources of stream impairment
- summarize percentages of each category of land cover in the study area for purposes of analysis such as calculating stormwater runoff.

Sources of land cover/land use data

The study team has five sources of data to assist in this purpose:

1. Direct field observations as discussed in Task 5.2 above.
2. Aerial photography in the form of Digital Ortho Quads from the Virginia Base Mapping System, taken before leaf-out in spring 2002.
3. Aerial photography in the form of Digital Ortho from the USDA, taken in summer 2003.
4. The National Land Cover Database (NLCD), developed by USGS.
5. Virginia forest cover raster from the VA Department of Forestry.

Methods for categorizing land cover/land use

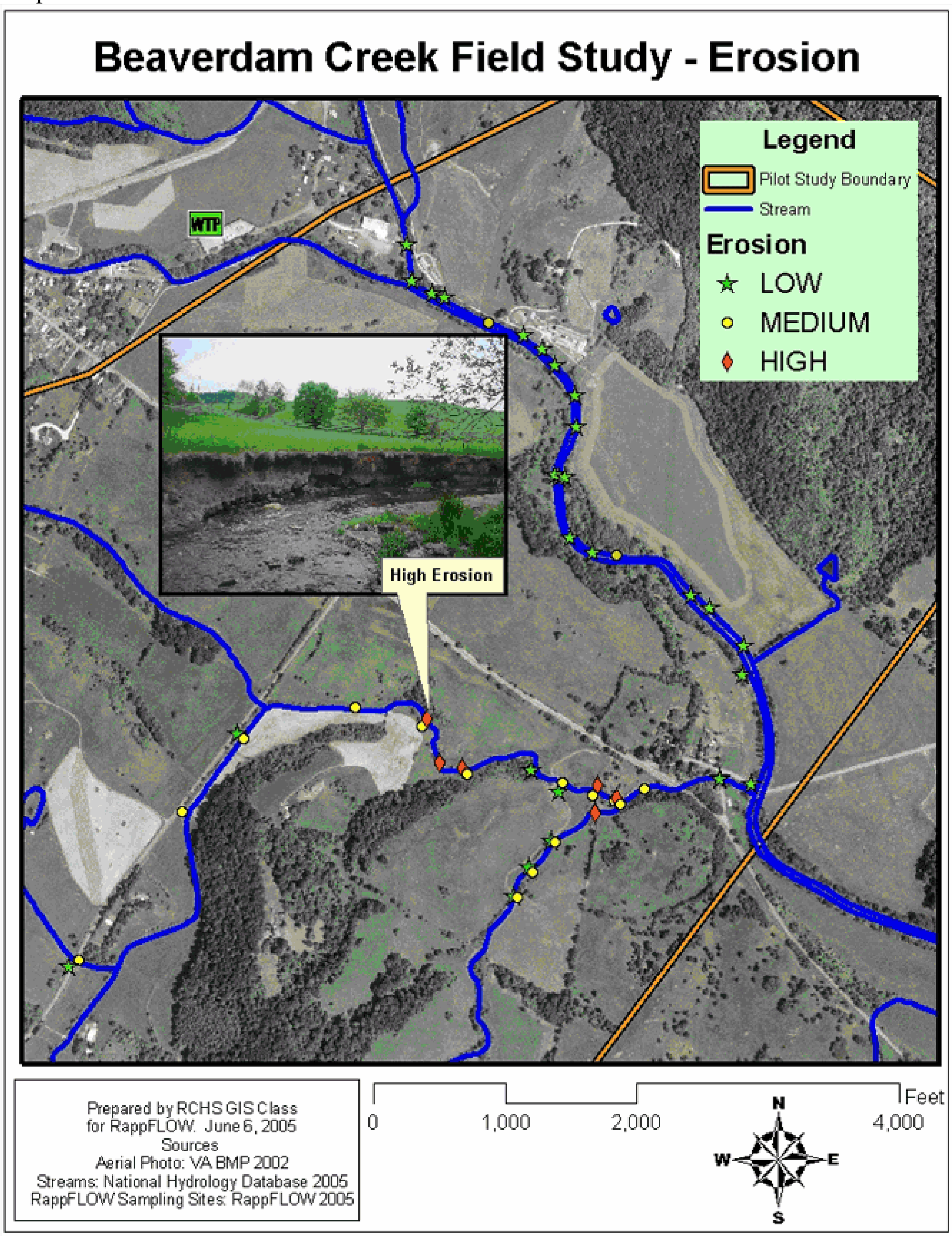
To help inform future watershed assessment studies, the study team tried out two different computer-based methods for categorizing land use and land cover, and compared these in terms of the cost (time) to conduct the analysis and the accuracy of the results.

Method 1: Use GIS tools to create land use/land cover polygons based on aerial photography and the National Land Cover classification scheme.

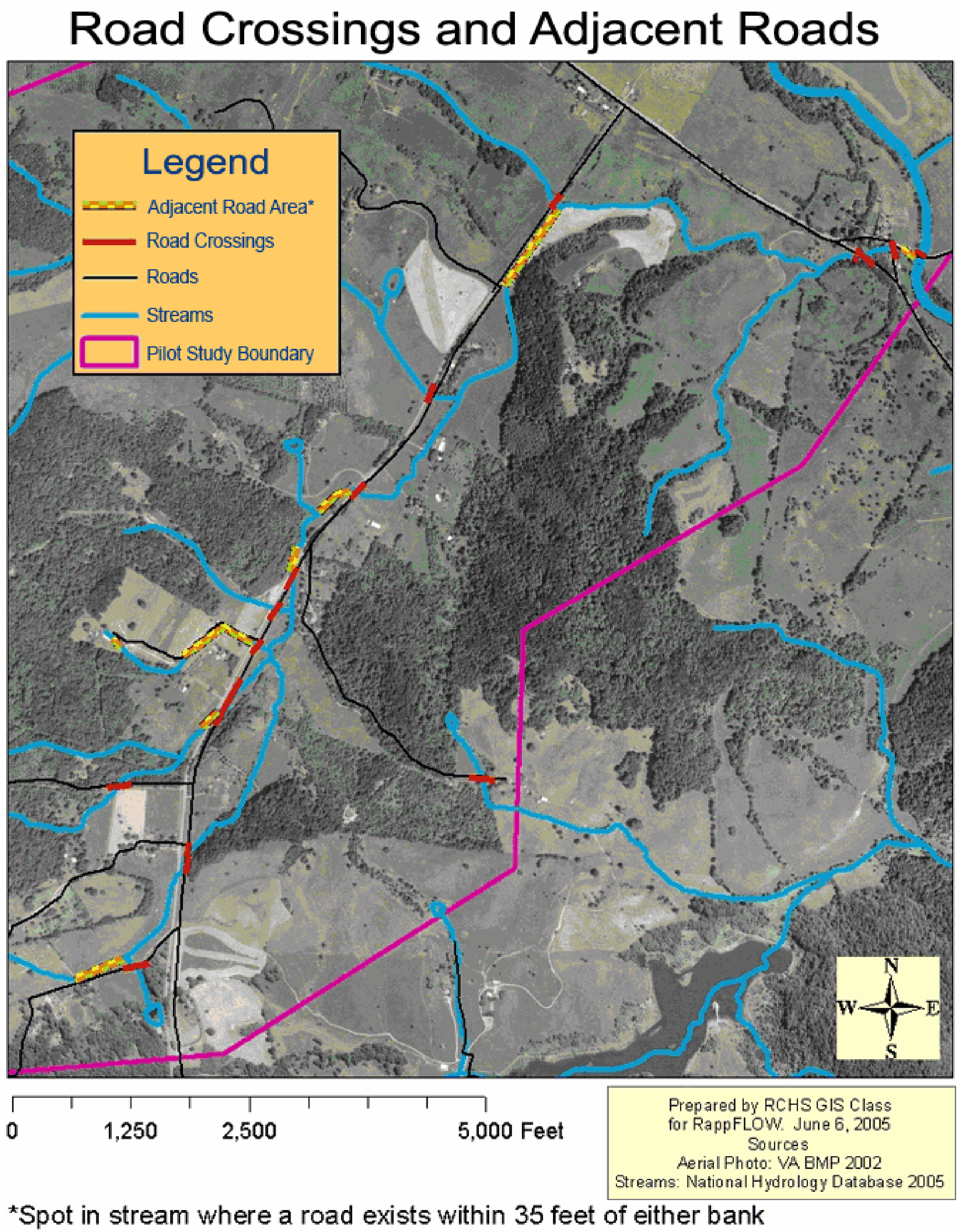
The aerial photography from the Virginia Base Mapping System (VBMS, 2002) is the most comprehensive source currently available to the study team with the highest resolution and utility for the purpose. (One cell in the raster equals two feet on the ground.) This data is made available by the Rappahannock County government as a sponsor of this study. Some limitations of this source are that tree plantings along streams that were planted in 2002 are not visible; changes in land use since 2002 are not visible.

We used ESRI ArcMap 9 to hand-digitize a land cover polygons file overlaid on the VBMS aerial photo of the study site. We refer here to this method as the "Giles Method" in reference to Kenny Giles, our Core Team member who specializes in analyzing aerial photography. We used land cover category definitions from the NLCD [3] (see Appendix). This product was revised based on field observations and other available sources of information. The results are shown as Map 8: Land Cover Giles Method. The percentage of each land cover type in the study area calculated from the Giles method is shown in Chart 4: Land cover percentages in Study Area.

Map 6: stream observations…



May 7: stream observations



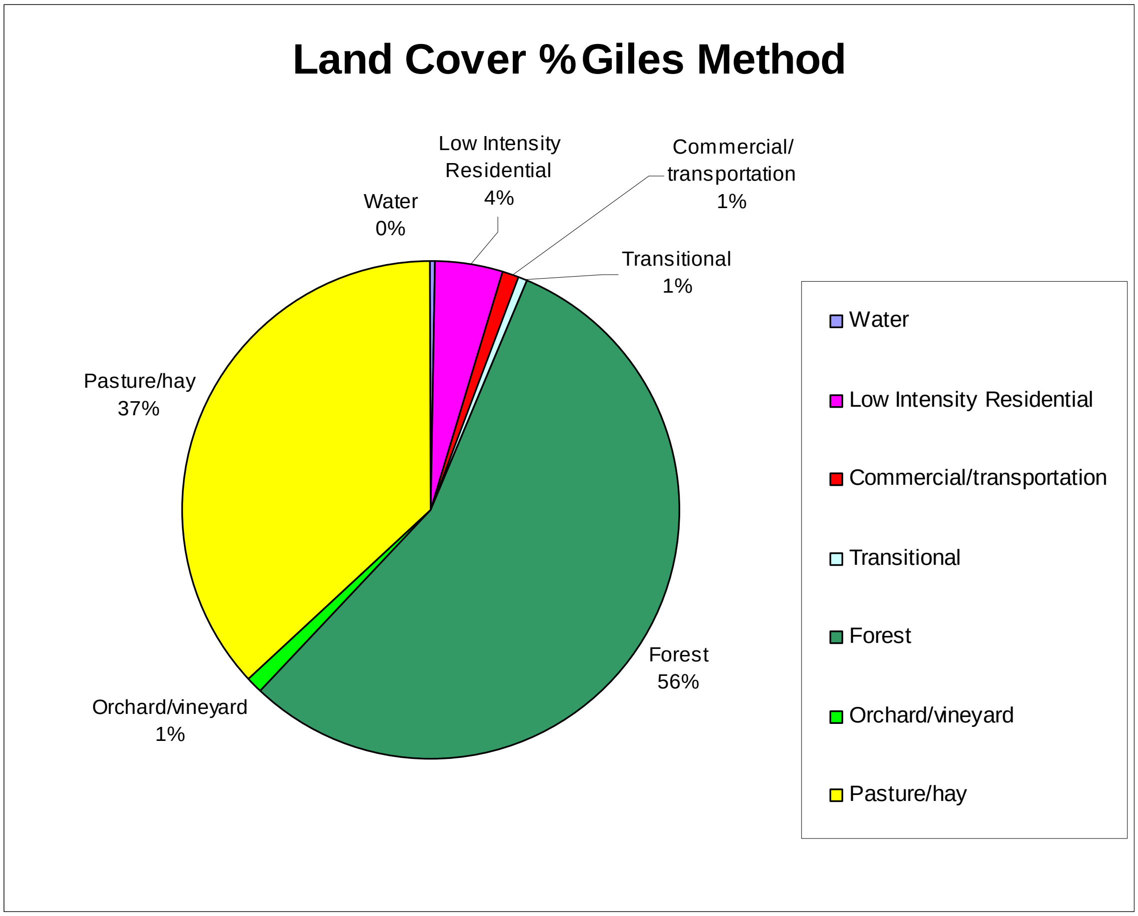
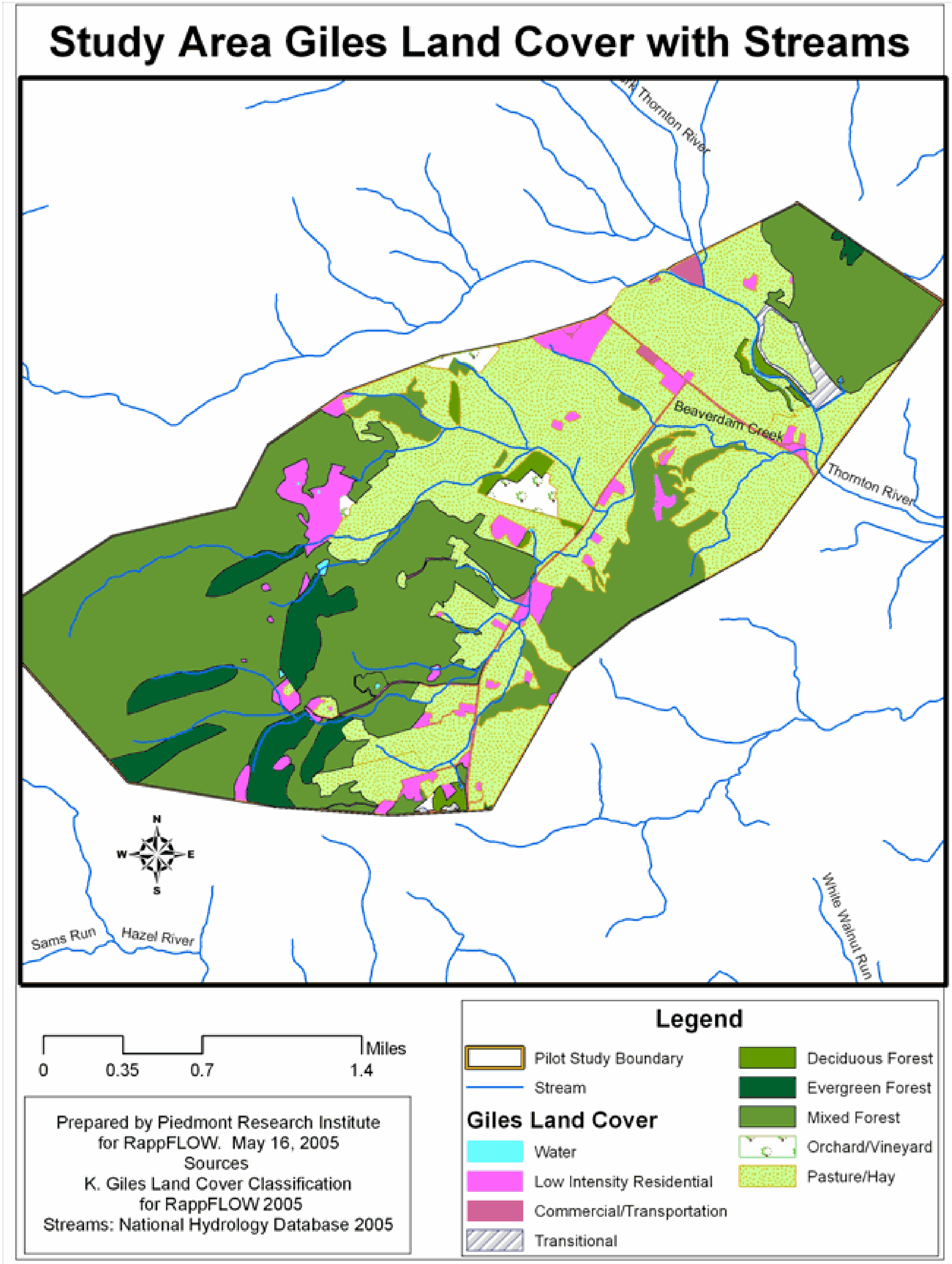


Chart 4: Land Cover Acres and Percentages based on Giles Method

Method 2: Calculate land cover percentages from NLCD.
The National Land Cover Dataset was compiled from Landsat satellite TM imagery, circa 1992. It has a spatial resolution of 30 meters. The analysis and interpretation of the satellite imagery was conducted using very large, sometimes multi-state image mosaics. Using a relatively small number of aerial photographs for ground truth, the interpretations were necessarily conducted from a spatially-broad perspective. This dataset was not designed to be used for such small areas as our study site.

Map 8: NLCD Land Cover shows the NLCD land cover raster for the study area. A streams layer is overlaid on the NLCD map to aid in comparing the two methods of land cover classification. The percentage of each land cover type based on this source is shown as Chart 5: NLCD land cover percentages.

Map 8: Land Cover Polygons Giles Method



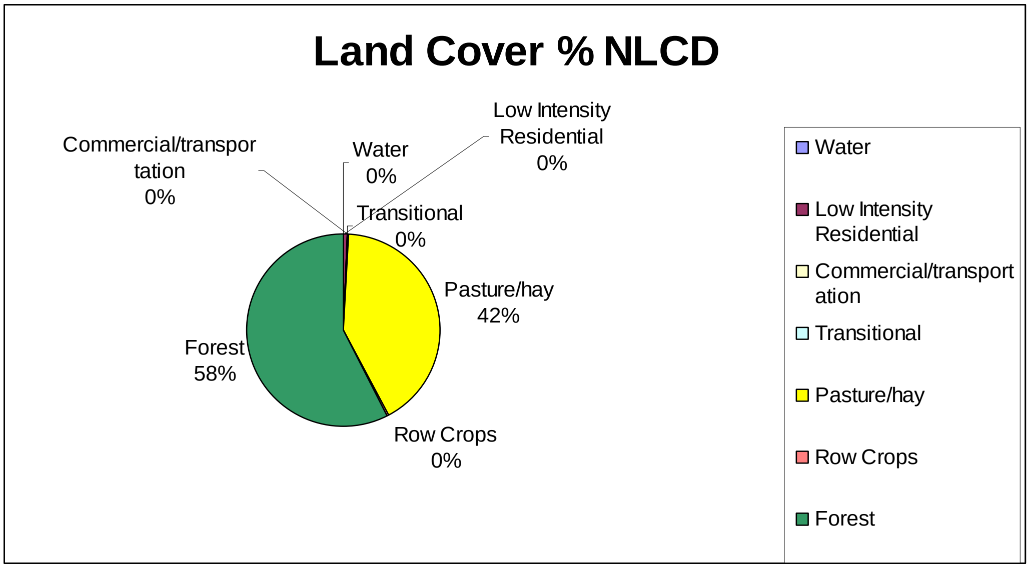


Chart 5: Land Cover Percentages based on NLCD

Assessing the two methods

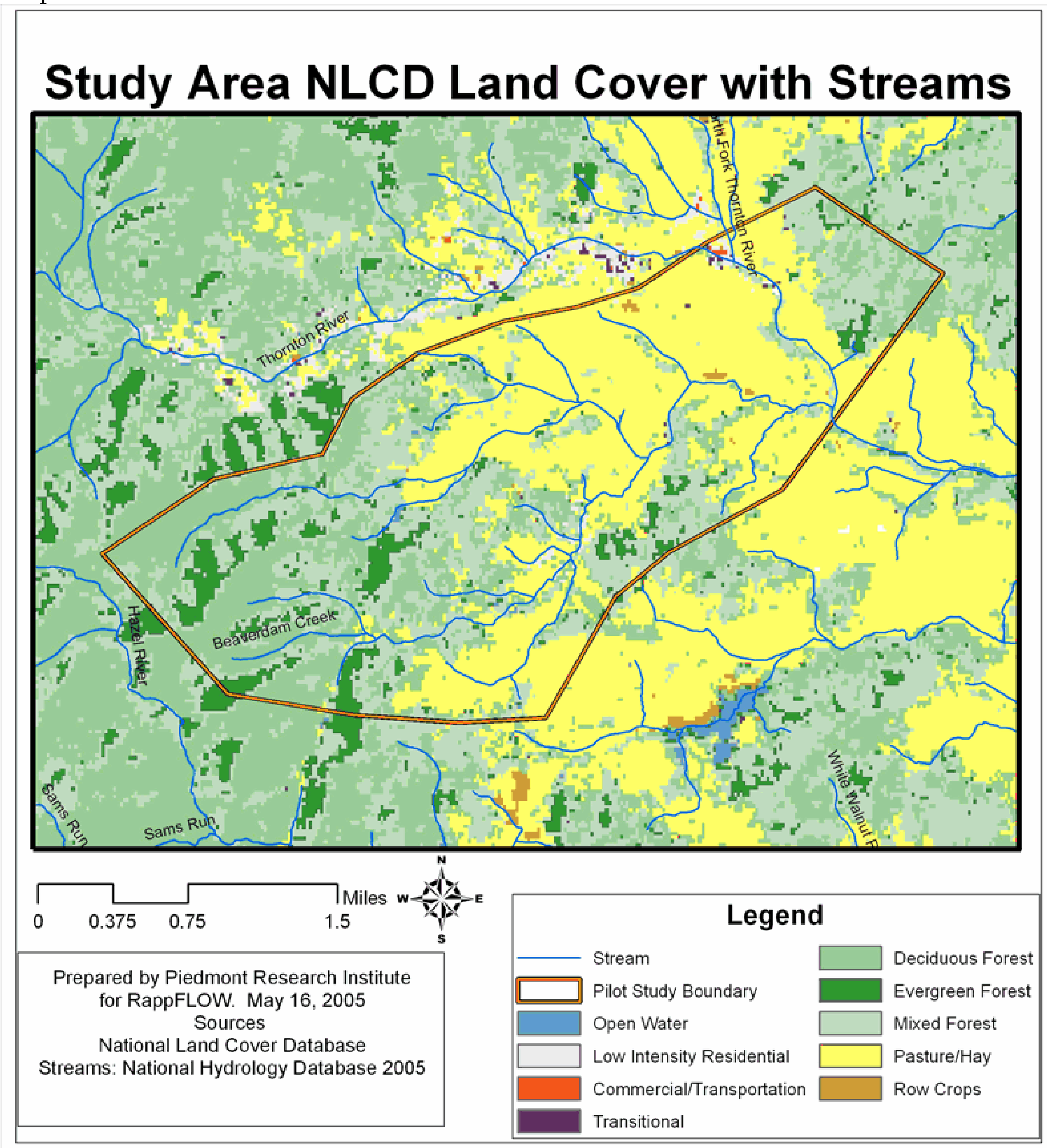
The Giles method did prove to differentiate better in some cases, especially with regard to low intensity residential (4% for Giles method vs 0% for the NLCD). The differences in the land cover area percentages between the two methods are small, e.g. 58% forest for the NLCD vs 56% forest for the Giles method; pasture 42% and 37% respectively for the NCLD and Giles methods. However, for larger areas of analysis, such as the entire county or the entire Upper Thornton watershed, these differences may prove to be important.

Preliminary analysis showed different results from the two methods in terms of the size of contiguous forested areas. The NLCD method produced four forested polygons over 100 acres in size: ranging from 102 to 283 acres each. The Giles method produced four forested polygons over 100 acres in size also, but these were 1137, 213, 187, and 140 acres in size.

Stream buffer analysis using these two methods is discussed in section 5.4 below.

We intend to conduct further research and try other methods, to produce a method that is cost-affordable, accurate, and timely with respect to current land cover.

Map 9: Land Cover from NLCD



Task 5.4 Analyzing stream buffers

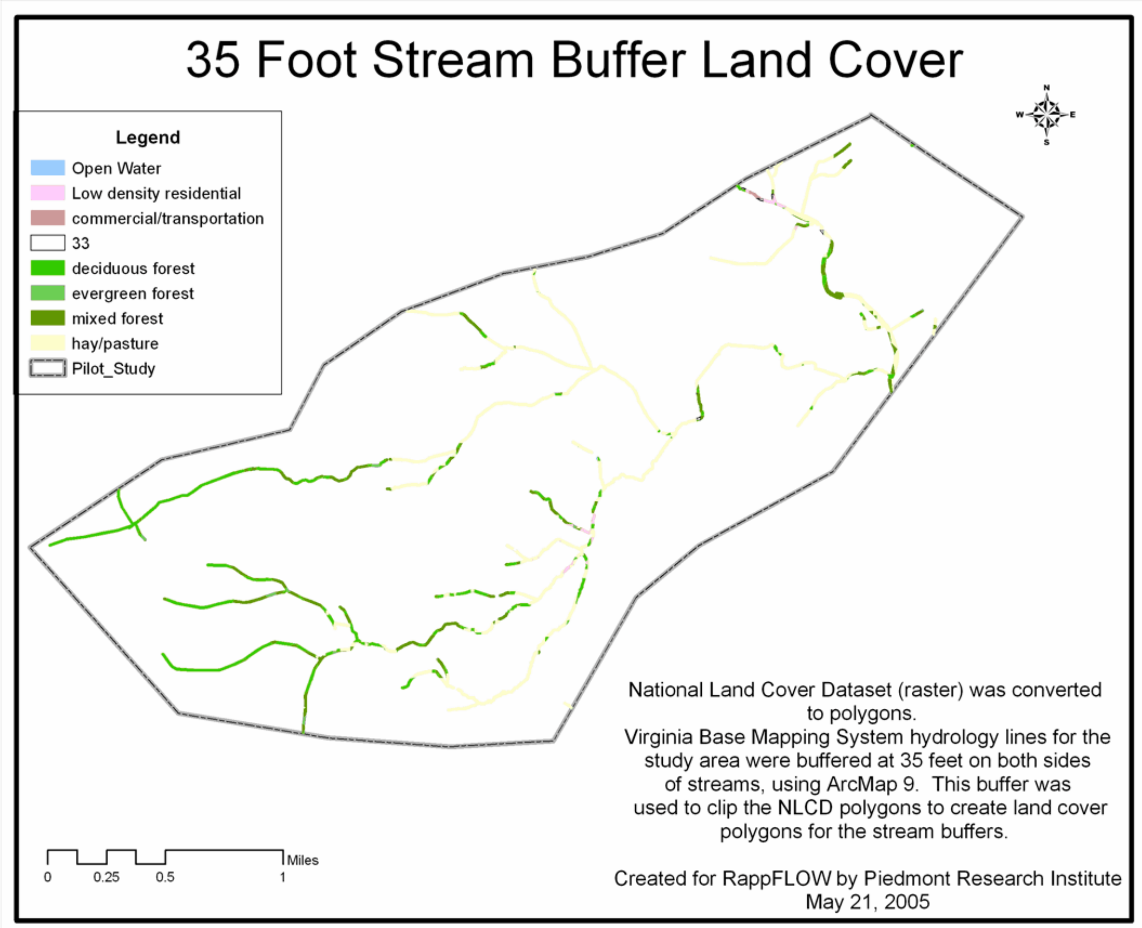
In addition to field observations, we used two analytic methods for classifying a 35-foot buffer along streams with respect to the vegetation in that buffer zone. For such an analysis to be as accurate as possible, the GIS layer for the stream lines should be as close as possible to the actual locations of the streams on the ground. To obtain greatest possible accuracy, we used the Virginia Base Mapping System (VBMS) Digital Line Graphs (DLG) to identify and extract stream lines. These are more accurate spatially than the stream lines in the National Hydrology Database, primarily because they are at a higher resolution (and are derived from a higher resolution source). We combined the stream lines for all of the quadrangles in the study area using ArcMap 9 “append” function. We then generated a polygon for a 35-foot buffer along both sides of these streams. This buffer polygon was used to clip the land cover category polygons that we had created from the NLCD raster (see above). The resulting land cover buffers for the streams are shown as Map 10.
It is obvious from this map that the majority of the streams in the study area do not have a forested buffer zone. However, tree plantings have been made through the CREP program in the northeast end of the study area in the past three years, and some of these plantings are not reflected in the NLCD database.

We repeated the stream buffer analysis using the Giles land cover polygon file, to compare with the NLCD version. This is shown as Map 11.

Task 5.5 Analyzing forests
Forested lands are the most valuable asset for the health of the watershed and water quality. Fragmentation of forests is a serious threat to watershed health, and protection and enhancement of contiguous forest land is high priority for watershed protection. Therefore the study team plans to analyze forested areas in as much detail as possible, using several sources of input. Forest assessments will be a component of future field data collection that volunteers can be trained to assist in.

Since forest analysis is dependent upon land cover categorization, we were able within this pilot study to just begin this analysis. As discussed above, we obtained quite different results for contiguous forest areas over 100 acres using the two land cover methods. We also found more fragmentation of forest than we originally expected by looking for low intensity residential land use inside of apparently forested areas. Further work to identify contiguous forested areas will also depend upon our establishing rules to define contiguity.

Map 10: 35-foot stream buffer land cover, based on NCLD analysis.

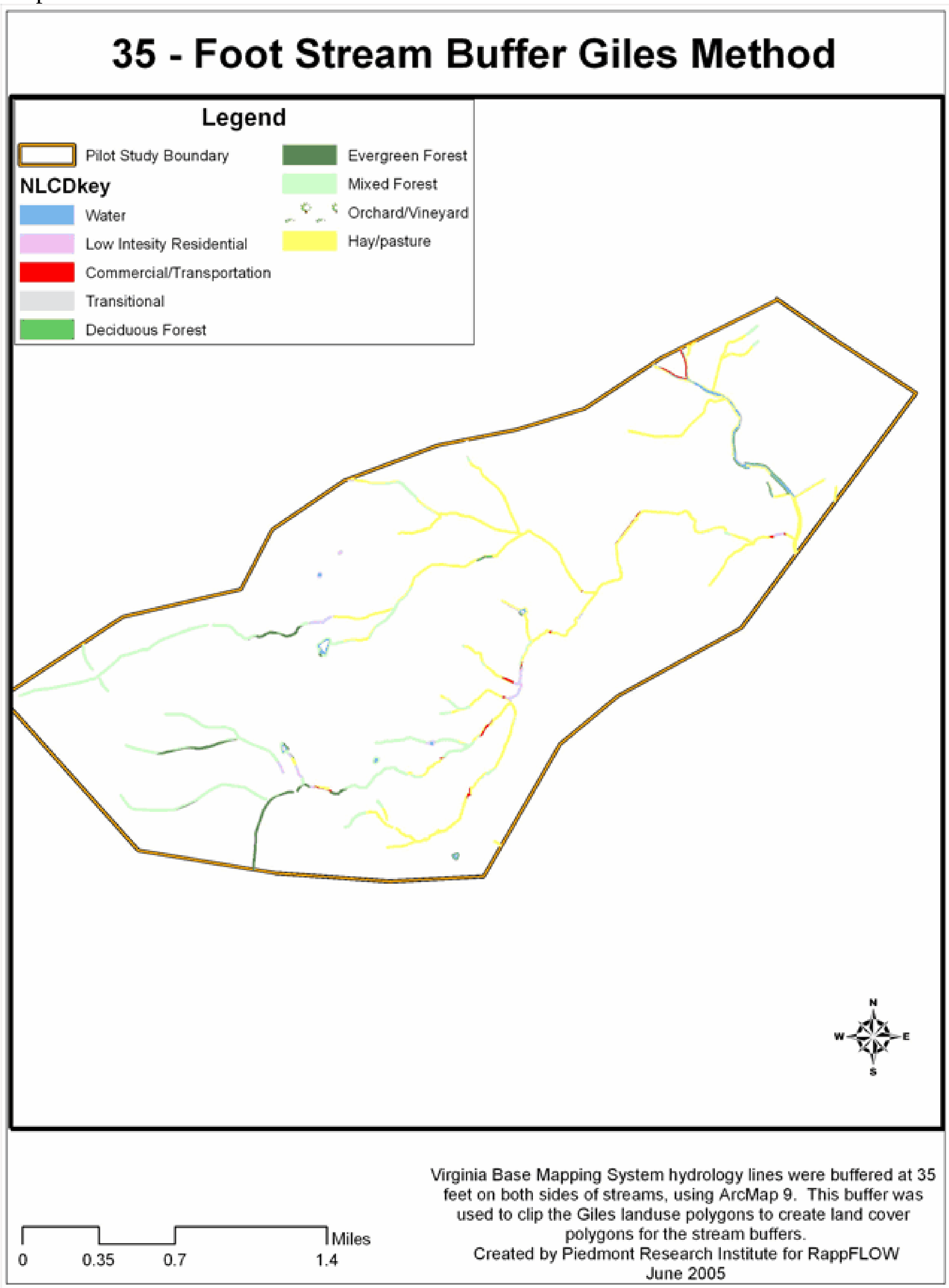


Task 5.6 Developing GIS layers and map series
Our primary method for organizing the data to assist in the watershed assessment study is to develop maps that show the geographic and spatial relationships among the factors that affect the health of the watershed and the quality of the streams. Since our time resources are limited, we have to prioritize this work. Our approach has been to develop the GIS layers in response to the needs of the study team at each stage of the inquiry. Typically, these get revised as more information is generated. For instance, during the stage of defining the study area we prepared several versions of topographic and stream maps. Study team members used these in workshops to aid in defining the study area. Similarly, we prepared five different versions of the maps showing locations of water quality monitoring sites as these sites were developed over time. Study team members used these maps in the field work and in communicating with each other about test results.

For some layers, or themes, in our GIS system we tried using different sources of georeferenced data as they became available. For instance, we used three different sources of data for mapping the streams. There are advantages and disadvantages to each. The currently available version of the National Hydrology Database (NHD), for example, contains information that can be used for hydrological modeling. It also includes the names of some of the smaller streams. The stream lines in the NHD are not as accurate spatially as the digital line graphs (DLG) that were produced as part of the Virginia Base Mapping System (VBMS). However, the VBMS DLG contains only the stream lines and not any data about the streams.
The maps included in this report address the themes that our study team has addressed most frequently in this particular study to date. Spatial layers for other themes, such as conservation easements, soils, geology, historical sites, will be integrated into the study for future analyses and public presentations.

Task 6: Working with Land Owners
A central goal of our study is to produce information that will be useful to land owners and land managers in making decisions about best management practices. One major landowner in the study area worked as a member of the Core Team on a day-to-day basis, helping to guide the inquiry and prioritize data collection and analysis.
During a meeting with the USDA NRCS, Culpeper SWCD, and the agricultural extension agent on May 31, 2005 we decided to engage land owners in the study area in a phased approach. In the current phase of the study, four key land owners are being contacted. Joe Thompson of the USDA NRCS and a local landowner with a history of successful best management practices will meet with these landowners individually to discuss the current water quality problems, invite their participation in the study, discuss land management practices that could improve the water quality, and discuss cost-sharing programs available to assist in implementing best management practices. Thompson and Miller will also walk the property and meet with land managers. The goal is to engage major landowners in identifying changes in land management that they are interested in implementing, and to work out an implementation plan with them.
After key landowners have had opportunities to make decisions about their involvement in this work, other land owners in the study area will be invited to join this effort.

Map 11: Giles Method stream buffers



Task 7: Reporting to Planning Commission and Board of Supervisors
Since RappFLOW's founding in 2002 we have reported on a fairly regular basis to the Rappahannock County Board of Supervisors and Planning Commission on our activities. Questions and suggestions made by members of these local government agencies help RappFLOW members stay in tune with local political considerations and also help to prioritize our work. Members of the planning commission have suggested that RappFLOW studies can help future planning activities by the local government.

The results of this pilot study will be summarized for the Board of Supervisors and the Planning commission at their July and August meetings. We also plan to present our study to the Board of the Culpeper Soil and Water Conservation District in August 2005.

Answering Our Inquiry Questions

The following summarizes our understanding to this point in our inquiry.

On what basis did the VA DEQ designate the segment of the Thornton River below the study area as "303d impaired"?
DEQ uses two standards to determine impairment based on fecal coliform levels. One standard is based on one sample per month; the other is based on multiple samples per month. The single sample threshold is 400 colonies of bacteria per 100 ml of water. If 10.5% or more of all the samples taken once per month (or less frequently) exceeds 400 colonies the water body is placed on the impaired list.

The Thornton section was assessed by DEQ during the five-year period January 1998 through December 31, 2002. DEQ collected sixteen samples from 1998 to 2001 and found that the 400-colony limit was exceeded in December 1999 (900 colonies) and June 1999 (1,700 colonies). Those two sample violations constituted 12.5% of the total number of samples, which exceeded the 10.5% threshold. This is the basis on which that section of the Thornton River was placed on the 303 (d) impaired list.

How robust is the evidence for "impairment"?
Water samples taken by DEQ in 2004-2005 and samples taken for this study in 2005 continue to reveal FC concentrations exceeding DEQ acceptable standards. In fact, FC levels have increased.

We wanted to understand whether there are other measures besides fecal coliform that indicate this section of the Thornton River is impaired. We found that all of the water quality parameters we examined for the Thornton River itself -- other than fecal coliform -- indicate a fairly healthy stream. Turbidity, temperature, and possibly nitrite levels indicate less than ideal conditions for continued health of the tributary stream and hence the main stem of the Thornton River. These could be due to bank erosion, lack of vegetative buffers in many places, and sedimentation.

What additional data would be needed to further understand the nature of the impairment?

Microbial Source Tracking (MST), also commonly referred to as bacterial source tracking (BST), is a method used to determine the sources of *fecal bacteria* and establish whether fecal bacteria are being introduced into water bodies through human, wildlife, agricultural, or pet wastes. [3] The use of MST is rapidly becoming widespread as more researchers and states are recognizing its potential. The MST differentiates the sources into livestock, human, and wildlife percentages that are contributing to the FC levels. There are now several different methods used to accomplish BST. In addition, more water samples might be taken at locations along the main stem of the Thornton River and the tributary creek. Future sampling would include water samples further upstream than were taken in this study.

What are the possible sources and causes of the impairment within or outside of the study area?

One question that has been asked within our local community concerning the possible sources of the impairment, is whether the source could be further upstream in the North or South Fork of the Thornton River, for example from a point source or wildlife in Shenandoah National Park. We found the water in the South Fork of the Thornton River just above the Sperryville Sewage Treatment Plant tested well within acceptable limits for FC. Similarly, water coming into our study area from the North Fork above the confluence of the North and South Forks was also well within limits. Therefore, we conclude that the sources of the impairment lie within the study area and/or the STP, and not further upstream in either fork of the Thornton River.

Four possible sources within the study area were suggested at various times in this study:
1) lack of adequate forest buffer along the tributary stream,
2) livestock in the tributary stream,
3) the sewage treatment plant, and
4) leaking septic fields.

Lack of adequate forested buffer was documented on a significant proportion of the tributary creek. In areas where FC levels exceeded 400 colonies, livestock were observed grazing in adjacent pastures and standing in the stream.

We do not know what, if any, is the contribution of the STP wastewater effluent. Spring 2005 sampling in the river at the discharge pipe indicated FC levels greater than 200 colonies, but a test of the effluent itself, at the plant, showed only 2 colonies per 100 ml. The STP effluent data from February 1999 to April 2005 indicates a monthly Total Contact Chlorine level of 0.8 mg/l, which is below the DEQ recommended 1.0 contact chlorine level but above the minimum of 0.6 mg/l. Current levels of Total Contact Chlorine and/or contact time with the effluent may not be sufficient to kill bacteria prior to discharge into the river.

The role of septic fields was not addressed in this study. Bacterial source tracking could indicate leaking septic fields.

What are the possible changes that could improve the water quality of the Thornton River and associated tributaries in this study area?

This question is now being addressed by key landowners within the study area, in consultation with the Natural Resources Conservation Service specialist who is providing technical assistance to this study.

If further study of the Sewage Treatment Plant indicates that it is contributing to the FC levels in the river, options for improvement could include:

- increase the monthly Total Contact Chlorine level to 1.0mg/l,
- expose the waste to the contact chlorine for longer periods of time,
- disinfect the waste with UV radiation, and/or
- upgrade equipment if high-maintenance chlorine feeder tubes are clogged.

Challenges and Lessons Learned

The following are lessons learned from our pilot study December 2004 – June 2005, that could be applied to future studies by volunteer groups in similar settings.

1) Focus of a watershed inquiry. One of our central goals is to produce watershed assessments that are meaningful, interesting, and useful to local landowners in making informed decisions about management of their land. To accomplish this goal, we must give highest priority to the following with regard to the focus of any particular study:

- Ensure that at least one local landowner from each locality under study is fully engaged in all phases of the study, which we were able to do in this pilot study.
- Pay attention to the ideas, questions, and knowledge of local landowners in focusing the inquiry.
- Sharpen the focus of the inquiry through discussion among all team members, including the participating landowners, until all involved are in agreement on the priorities for the inquiry.
- Clear inquiry questions should shape the scope of the study and these inquiry questions remain consistent throughout the project, unless there is group consensus to change or redefine these.
- Derive priorities for project activities, resources, data collection and analysis from this shared understanding of the inquiry focus.
- Ensure that study results address the specifics of the landowner(s) issues, in addition to other goals and objectives.

2) Field data collection.
To address specific local issues and questions it is necessary to gather data from the field in support of the inquiry. Existing data bases from national and state sources do not provide the needed detail, scale, and dimensionality needed to address subwatershed issues.

We need to develop or adapt field techniques suitable for training multiple volunteers while still providing scientifically accurate and replicable data. The stream observation protocol should include quantifiable habitat parameters to facilitate assessment of a habitat suitability index.

If improved land management practices are implemented in a study area, ongoing field data collection will be needed in order to evaluate the impact of changes in land management on changes in water quality. Beyond fecal coliform, additional parameters to sample include flow, total suspended solids, dissolved oxygen, and temperature. Bacterial source testing will provide useful information on the type and percentage of bacteria present within the water

3) <u>Priorities for studies in Rappahannock County watersheds.</u>
As soon as resources allow us to do so, we should perform a “rapid watershed assessment” across the overall Upper Thornton watershed or across the entire land area of the County. This type of assessment, which we learned from the Center for Watershed Protection, is used to identify those highest priority subwatersheds for which more detailed study is warranted. Criteria for these priorities may be based on a combination of vulnerability and conservation value. Given the costs in terms of time and funds of pursuing an inquiry requiring landowner knowledge and field data collection, we must ensure that we are doing so in those subwatersheds where the most beneficial long-term watershed protection and improvement effects can be achieved.

4) <u>Data Sources.</u>
Acquiring data in electronic form from state government agencies requires more interactions and longer calendar time than we anticipated. Fortunately, this pilot study has provided us with key contacts for data sources, especially at the State level, so that future searches will be quicker and more productive than were our initial efforts.

5) <u>Land cover/land use analysis.</u>
Several different methods are possible to use in analyzing land cover and land use. These vary in terms of their accuracy, scale, and the cost to conduct the analysis. We need to conduct further research and comparisons of these methods and recommend an approach that is affordable as well as useful for our purposes. Analysis of contiguous forest areas, and the quality of forest areas, needs further investigation.

6) <u>Sources of bacterial contamination.</u>
For future studies involving bacterial contamination of streams, bacterial source tracing methods should be a part of the analysis plan and budget in order to identify and quantify point and nonpoint contributions to the contamination.

7) <u>Policy and regulatory frameworks.</u>
As recommended in *A Community Water Quality Approach: Local Watershed Management Planning in Virginia*, we have started to become familiar with some of the policy and regulatory frameworks and government programs that have implications for our work. We will continue to learn about the institutional contexts at the local, state,

and national levels, and to assist our various stakeholders in becoming aware of developments and trends. Of special interest are the following:

- Rappahannock County Comprehensive Plan and Ordinances
- State and local erosion and sediment control ordinances
- Rappahannock River Basin Tributary Strategy
- Virginia DEQ Total Maximum Daily Load processes
- Virginia Scenic Rivers Program
- Conservation Reserve Enhancement Program (CREP)
- Virginia Agricultural Best Management Practices Cost Share Programs
- Virginia Department of Forestry Riparian Buffer Implementation Plan
- Virginia Citizen Water Quality Monitoring Program

References

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[3] Hagedorn, Charles III, Brian L. Benham, and Sara C. Zeckoski (2005). Microbial Source Tracking and the TMDL (Total Maximum Daily Loads) Process. VA Agricultural Cooperative Extension Publication Number 442-554. Available:
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Endnotes

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[i] The name of the tributary creek is omitted in this report to help preserve privacy of the landowners in the study area.

[ii] Locations of the points along the tributary are not provided here, for reasons of landowner privacy.

[iii] . This may be significant in view of the increased emphasis on reducing nutrients (as opposed to fecal coliform) in the new Rappahannock River Tributary Strategy.

[iv] Starting in 2001 DEQ went to a rotational sampling, which means that in order to sample the entire state, certain segments of the river are sampled on a rotational basis. For example: from 2000-01 DEQ sampled the lower Rappahannock only, in 2002-03 the middle Rappahannock sites were sampled, and in 2004-05 DEQ is sampling the Upper Rappahannock sites, including the Thornton River station. Therefore, there was no DEQ data between 2002-6/04 to review.

[v] As of January 2003, the Virginia bacteria water quality standard changed from fecal coliform (FC) as an indicator of bacterial pollution to Escherichia coli (E. coli). E. coli are a type of bacteria found within FC that are specifically found in the intestinal tract (and therefore in the feces) of warm-blooded animals. E. coli standards are 235 colonies/100ml water for a single sample or a monthly geometric average of 126 colonies/100 ml water.

An interim FC standard is in effect until 2008 (or until 12 or more E. coli samples are taken within a year) stating that 10% of the number of samples within a month should not exceed 400 colonies/100 ml water or the geometric average of 2 samples collected within the same month should not exceed 200 colonies/100 ml water.

[vi] Water samples were analyzed by Joiner Micro Laboratories in Warrenton VA. Method of analysis: fermentation technique (MPN Methodology) SM 18th ed. 9221E.1