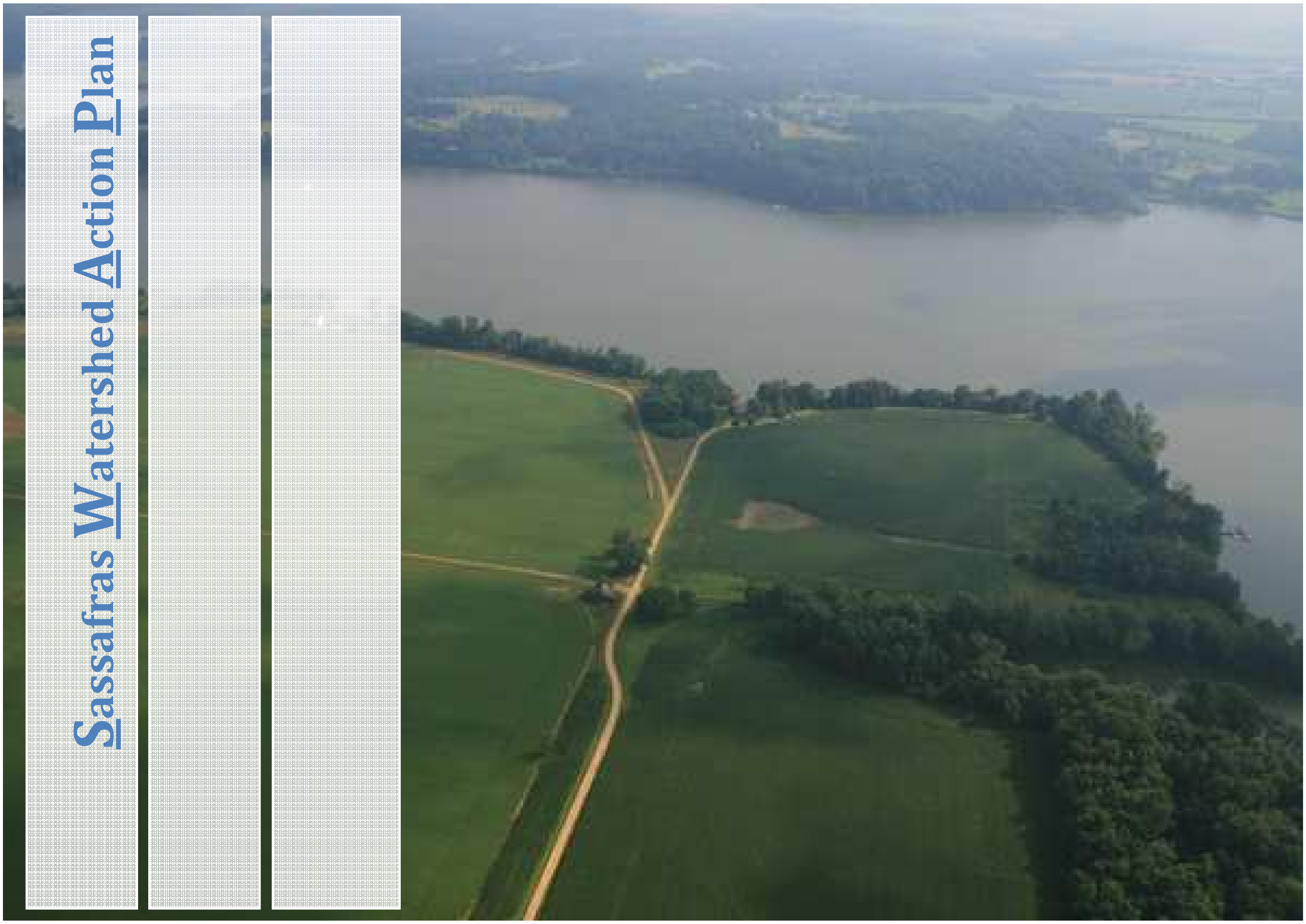
Sassafras Watershed Action Plan



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CENTER FOR WATERSHED PROTECTION

STATEMENT OF PURPOSE AND COMMITMENT

The Sassafras Watershed Action Plan, sponsored by the Sassafras River Association and supported by a scientific advisory committee known as the Core Team and wide and active stakeholder interests, sets forth a blueprint for the sustainable environmental health of the Sassafras River. The SWAP is based upon a comprehensive and scientific assessment of the Sassafras River Watershed. This assessment supports the Sassafras River's designation as impaired under Maryland's Clean Water Action Plan and demonstrates why it is given the highest priority for restoration. The SWAP science draws upon the historic data contributing to that designation, while updating and expanding that knowledge with a host of new data. This data describes and documents water quality, shoreline characteristics, development and farming impacts and a number of other impairments. This data shows that considerable restoration is needed.

By comprehensively assessing the Sassafras River's present state and by reaching deeply into its future, this plan and its background studies chart a clear course toward watershed improvements. That course is made up of specific action strategies that include:

- Assisting our towns in achieving the maximum feasible reduction of nitrogen and phosphorus in the municipal wastewater stream;
- Partnering with agriculture to increase participation in cost-share programs and implementation of best management practices such as cover crops, no till farming and buffer strips;
- Educating our residents of the environmental danger of poorly maintained septic systems, over-fertilized lawns, eroding shorelines and unbuffered streams;
- Educating our children of the benefits of a healthy watershed, promoting the next generation of environmental stewardship.

With diligent application of the principles of the SWAP and implementation of its recommendations, the Sassafras River one day will be de-listed as an impaired waterway. Accordingly, the principal stakeholder entities proclaim the following ethic and commitment:

WHEREAS the Sassafras River is one of the most scenic rivers of the upper Chesapeake with its 30 foot cliffs and lush vegetation; with tranquil waters bearing recreational and commercial value; with shoreline providing habitat to rare, threatened and endangered species, and towns of Galena, Betterton and Cecilton deriving historical and cultural benefit from her tides; and,

WHEREAS the Sassafras River Watershed is stressed by the chemistry of human impact upon land, by tides, and from the air; and,

WHEREAS the future of the Sassafras River and its environs, including the management of rural growth and development, enhancement of its wildlife habitat and aquatic resources, preservation and conservation of its commercially vital farmlands, and protection of the quality of life along its shores and tributaries is of foremost concern to the undersigned stakeholders;

THEREFORE IT IS RESOLVED that the undersigned stakeholders agree to work in concert to implement the recommendations of the Sassafras River Watershed Plan, to hold each other accountable for the implementation of the recommendations, to take bold strides to influence the direction of environmental planning and practice, thinking forward to a healthy watershed and working towards achieving it without delay, and to engage every watershed citizen as a steward of the Action Plan and the Watershed and to achieve the goals set forth herein.

Signed:

Sassafras River Association
Center for Watershed Protection
Cecil County Planning and Zoning
Cecil Soil Conservation District
Delaware Department of Natural Resources and Environmental Control
Kent County Planning, Housing, and Zoning
Kent Soil and Water Conservation District
Maryland Department of the Environment
Maryland Department of Natural Resources
McCrone Inc.
University of Maryland Center for Environmental Science
University of Maryland Environmental Finance Center
University of Maryland SeaGrant Extension
Upper Eastern Shore Tributary Strategy Team
Washington College Center for Environment and Society

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

E1.0 Introduction

The Sassafras River Watershed is located in the Lower Elk River Basin, with its head waters in Delaware and its mouth on the Eastern Shore of the Chesapeake Bay. Its geographic location lies across three counties: Cecil to the north, Kent to the South and New Castle to the east in Delaware. Since early colonization, the Sassafras Watershed has been a place rich in both land based and water based resources. When Captain John Smith's crew sailed the Sassafras River in 1607, "fish were so plentiful that Smith and his men jokingly attempted to catch them with frying pans," (Wennersten 2001, 23). Sassafras roots were a popular Chesapeake export in the seventeenth and eighteenth centuries, from which it was sold and boiled into teas that were thought to be good for "purifying the blood." The Sassafras River owes its name to "colonial root grubbers who believed they had found the magic cure all for disease" (Wennersten 2001, 53). However, much has changed since those times. Today the river is challenged by nutrient pollution from urban stormwater, agricultural runoff, sewage effluent and aging septic systems. This excess nutrient loading results in eutrophication which promotes unfavorable plant growth such as phytoplankton (algal blooms) over other types of plants, degrading water quality. This enhanced growth disrupts the normal function of the ecosystem by choking out submerged aquatic vegetation and decreasing oxygen, making survival difficult for the aquatic species that once thrived (Bartram et al. 1999).

The Sassafras River itself is roughly 20 navigable miles long and the watershed covers approximately 94 square miles. The watershed is mostly rural with land use comprised of 57% agriculture, 24% forest, and only about 5% developed (residential and industrial). There are two municipalities within the boundaries of the Sassafras Watershed, Betterton and Galena in Kent County, MD; and one municipality partially within the watershed, Cecilton in Cecil County, MD. Using year 2000 census blocks within the Sassafras Watershed boundary, the total population is estimated at 4,318 people. This is roughly 52 people per square mile of land within the watershed.

The Sassafras River is listed on the United States Environmental Protection Agency's (EPA's) list of federally impaired waters and the State of Maryland *303(d)* impaired list for nutrients, sediment (total suspended solids) and PCB's in the tidal portions as well as biological impairment in the non-tidal portions. The Sassafras is also listed on Delaware's *303(d)* list of impaired waters for biological and habitat impairment in the non-tidal portions of Delaware. These impairments were designated as a result of the Federal Clean Water Act established in 1972 which required all states, territories, and authorized tribes to: 1) develop water quality standards for all jurisdictional surface waters; 2) monitor these waters; and 3) identify and list those waters not meeting water quality standards. Known sources of pollution include two point source waste water treatment plants that serve residents within the towns of Betterton and Galena. Non-point sources of pollution dominate the remainder of the nutrient and sediment loads by more than half, and are a result of low density residential development, on-site septic systems, stormwater and agriculture runoff, as well as shoreline erosion and water resource based industry such as marinas and a very dense boating population. Through woodland gullies, a mixture of stable and unstable streams and a historic wetland loss of 11,651 acres, these nonpoint sources have delivered nutrients and sediment at an accelerated pace.

The Sassafras River Association (SRA), recognizing the need for an action plan to address the impairments in the River, secured private funding and organized an independent effort to create a blueprint for positive improvements to the health of the river and watershed. The Sassafras Watershed Action Plan (SWAP) includes prioritized restoration recommendations, milestone timelines and potential funding opportunities to begin implementation of the recommendations. In order to restore the fragile system of the Sassafras Watershed, sources of pollution must be directly addressed and the historical resiliency of the system must be revitalized. This can be achieved by recreating the natural kidneys of the system such as wetlands and forested buffers, both which have been lost due to human altered landscapes.

The Sassafras Watershed Action Plan (SWAP) details the actions necessary to improve conditions in the watershed, based on a series of fieldwork assessments and a stakeholder process. The SWAP was developed through a partnership between 15 public and private entities which formed a Core Team including: the Sassafras River Association; Center for Watershed Protection; Cecil County Planning and Zoning; Cecil Soil Conservation District; Delaware Department of Natural Resources and Environmental Control; Kent Planning, Housing and Zoning; Kent Soil and Water Conservation District; Maryland Department of the Environment; Maryland Department of Natural Resources; McCrone Inc.; Upper Eastern Shore Tributary Strategies Team; University of Maryland Center for Environmental Sciences; University of Maryland Environmental Finance Center; University of Maryland Sea Grant Extension Program; and Washington College Center for Environment and Society.

Existing Geographic Information System (GIS) data was the basis for much of the initial compilation of data. Field work assessments, Core Team meetings and stakeholder meetings provided additional data. The Core Team, consisting of representatives from each partnering agency, met monthly and served as a technical advisory committee, guiding the watershed planning process. In addition, three stakeholder meetings were held to provide community input to the process. A series of fieldwork assessments were conducted and included a stream impact assessment (Stream Corridor Assessment), an upland pollution source assessment of neighborhoods, institutions, hotspots and pervious areas (Unified Subwatershed and Site Reconnaissance), a tidal shoreline assessment, as well as a synoptic nutrient survey of the non-tidal streams. The protocols and results of the assessments are presented in Section 4.0, and complete data sets can be found in Appendix B. Overall watershed recommendations are first presented in Section 2.0 and later in Section 5.0 with associated costs, location, responsible parties, and milestones. A draft schedule for implementation and the expected benefits of implementation are also presented.

E2.0 Priority Pollutants and Concerns

As part of this report, a number of priority pollutants and concerns were identified for the Sassafras River watershed. Table E.1 lists each pollutant and concern, data source, potential sources of contamination and the negative effects it has on the watershed.

Table E.1 Priority Pollutants and Concerns in the Sassafras River Watershed

Pollutant or Concern	Data Source	Potential Sources of Contamination	Watershed Effects
1. Nutrients (Nitrogen and Phosphorus)* TMDL written for phosphorus[2]	MD 303d list[1]	• Point Sources • Urban runoff • Agricultural runoff • Turf grass and lawns • Atmospheric deposition • Septic systems • Pet waste	• Eutrophication • Contribution to Chesapeake Bay pollution and dead zones • Harmful Algal blooms • Decrease in SAV
2. Sediment (TSS – total suspended solids)	MD 303d list[1]	• Streambank erosion • Urban runoff • Construction sites • Agricultural runoff	• In-stream habitat loss • Reduced depth in tidal creeks • Reduced light penetration for SAV growth
3. Bacteria	County Health Departments have issued beach advisories and closures	• Urban stormwater runoff • Pet waste • Wildlife • Failing Septic systems • Improper disposal of boat waste	• Swimming and water contact related illnesses • Shellfish harvesting concerns
4. Biological Impairment	MD 303d list[1] DE 303d list[4]	• Streambank erosion • Agricultural runoff • Urban runoff • Point sources	• Loss of sensitive species • In-stream habitat loss
5. Polychlorinated Biphenyls (PCBs)	MD 303d list[1]	• Old electrical transformers • Landfills • Point Sources • Resuspension of bottom sediments[3] • Tidal influence of the Upper Chesapeake Bay	• Fish and biological contamination cautioning human consumption

Table E.1 Priority Pollutants and Concerns in the Sassafras River Watershed			
Pollutant or Concern	**Data Source**	**Potential Sources of Contamination**	**Watershed Effects**
		• Atmospheric Deposition	
Reference: [1] (MDE 2006); [2] (More detail on the TMDL can be found in the Watershed Characterization Report in Appendix F); [3](MDE 2008); [4](DNREC, 2008)			

E3.0 Goals and Recommendations

After receiving input from residents, farmers and a broad array of other watershed stakeholders, the following set of strategies were drafted in coordination with the Core Team to guide recommendations of the Sassafras Watershed Action Plan.

Overall Stakeholder Goal: A healthy clean river that is safe for swimming, fishing and crabbing and meets the TMDL for all impairments.

Stakeholder Strategies:

1. Quantify problems and chart a path to measure progress
2. Increase the knowledge and awareness of homeowners, developers and children of ways to improve conditions in the Sassafras – including Best Management Practices (BMPs), reduced impervious cover and improved lawncare practices
3. Increase forest buffers
4. Understand the causes of erosion and increase restoration efforts including State Highway and other potential stream restoration and shoreline stabilization efforts
5. Improved sewage treatment in Galena and Betterton
6. Increase the number of people pumping out their septics and upgrading their septics to remove nitrogen – also identify failing and leaking septics particularly in shared group systems
7. Improved enforcement and regulations including those pertaining to septic systems and pumpouts
8. Reduced impact of boaters on the Sassafras – increase awareness of need and access for sewage pump outs from boats
9. Continue to have the Sassafras as a priority funding area for cover crops
10. Increase availability of Agriculture Cost-Share programs to land and farmers that currently do not qualify
11. Increase peer-to-peer farmer interaction to make additional gains in conservation practices
12. Increased preservation of farmland in the watershed
13. Increase public access and public interaction with the River and the watershed
14. Monitor and track the measured results to insure conditions are improving in the River.
15. Use the SRA and the Stakeholder process as a model for other watersheds in the area

E4.0 Implementation Costs and Schedules

Table E.2 sets forth the goals achieved, location, responsible parties, and long-term milestones for implementation of each recommendation. Each recommendation has been linked to a Stakeholder Strategy, identified in Section 2.0. Table E.3 provides a draft implementation schedule over a 10 year period and associated costs for implementing each recommendation. The cumulative estimate for implementing the 30 recommendations presented in Section 2.0 over the next ten years exceeds $ 13 million dollars. The overarching goal which is aimed at achieving swimmable, fishable, and water contact recreation by 2020, aligns with all of the recommendations as it takes a multi-faceted approach to achieve this goal. Preliminary cost estimates and responsible partners have been identified so that financial resources can be allocated and staff roles can be defined. Real watershed restoration requires a multi-faceted approach, which combines land use decisions with on-the-ground implementation, education, and protection and restoration of watershed functions.

Table E.2 Recommendations, Responsible Parties, and Desired Outcomes for Restoration				
Stakeholder	**Recommendation**	**Location**	**Responsible Parties**	**Outcome**
4	1. Rt. 301 Highway retrofits and stream restoration	3 locations near town of Sassafras	• Maryland Dept of Transportation • Kent County • SRA	• 3 projects constructed • Reduce sediment loading
2,13	2. Stormwater retrofitting demo projects including rain gardens and rain barrels	Stormwater retrofits in specific locations then additional watershed wide	• SRA • CWP	• 4 retrofit projects • Reduce sediment and pollutant loads
2,14	3. Outreach and education of residents on lawn care practices through workshops	Target high nutrient areas identified in neighborhood assessments then watershed wide	• SRA • Cooperative Extension	• Reach 500 residents through annual workshops, Spring and Fall • 300 Soil Tests with results logged by SRA • 100 acres of urban nutrient management • Reduce Total Phosphorous
2	4. Advocate for phosphorous free fertilizers throughout the watershed	Watershed wide then county wide	• SRA	• All business in watershed carry P-free fertilizers • County and State legislation prohibiting or limiting residential use of fertilizers • Reduce Total Phosphorous
2,6	5. Assistance with inspections and outreach to homeowners on denitrifying septic upgrades	Target critical area then watershed wide	• MD Dept of Environment • Cecil and Kent County Health Departments • SRA	• 300 tests performed • 150 septic upgrades • Increase septic system maintenance • Reduce Total Nitrogen

Table E.2 Recommendations, Responsible Parties, and Desired Outcomes for Restoration

Stakeholder	Recommendation	Location	Responsible Parties	Outcome
2,6,7	6. Fix failing septics in Sassafras	Critical area then watershed wide	• MD Dept of Environment • Cecil and Kent County Health Departments • SRA	• Repair 25 failing septics • Reduce Total Nitrogen
5	7. Upgrade Galena WWTP to ENR	Galena, MD	• Town of Galena • MD Dept of Environment • SRA	• 1 ENR municipal WWTP • Reduce Phosphorus, Total Nitrogen and Ammonia
5	8. Upgrade Betterton WWTP to ENR	Betterton, MD	• Town of Betterton • MD Dept of Environment • SRA	• 1 ENR municipal WWTP • Reduce Phosphorus, Ammonia, Bacteria
2,6,7	9. Identify and test major combined community septic systems	Watershed wide	• Kent and Cecil County Health Departments • SRA	• Identify all major systems • Test 5 systems • Reduce Nutrient Discharge
2,6,7	10. Upgrade appropriate combined community septics to enhanced denitrification technology	Watershed wide	• Kent and Cecil County Health Departments • SRA	• Upgrade 50% of identified systems to enhanced denitfication technology • Reduce Nitrogen
1,4,10	11. Identify eroding wooded ravines	Watershed wide	• Natural Resource Conservation Service • Resource Conservation District • CWP • SRA	• Inventory of woodland gully issues that can be addressed
1,4,10	12. Prioritize and restore multiple sites of eroding stream and wooded ravines	Watershed wide	• Natural Resource Conservation Service • Resource Conservation District • CWP • SRA	• 1 mile of stream and wooded ravine restored • Reduce sediment loading

Table E.2 Recommendations, Responsible Parties, and Desired Outcomes for Restoration				
Stakeholder	**Recommendation**	**Location**	**Responsible Parties**	**Outcome**
4	13. Stabilize actively eroding shorelines, tidally induced and topdown induced	Lloyds Creek and Knights Island	• Eastern Shore Resource Conservation & Development • SRA	• Stabilize 1/2 miles of shoreline • Slow rate of erosion • Reduce sediment loading
4	14. Increase shoreline buffers and outreach to residents on buffer management	Critical Area	• SRA • Eastern Shore Resource Conservation & Development • Town of Betterton	• Increase 1 miles of shoreline buffers • Slow rate of erosion • Reduce sediment loading
2,3	15. Additional stream buffers for landowners (ag and residential)	Watershed wide (see Table 4.7)	• Natural Resource Conservation Service • SRA	• Increase stream buffers by 2 miles • Reduce sediments and nutrient loading
1, 9, 11	16. Needs Assessment to understand impediments to cost-share participation	Watershed wide	• SRA • U MD Cooperative Extension • UDEL	• Identify and address impediments to increase participation
1,9,11	17. Increased outreach and cost-share to farmers in locations with high nutrient concentrations	High nutrient areas as identified by MD Synoptic Survey, then watershed wide	• SRA • U MD Cooperative Extension • UDEL	• 5,000 acres of additional cover crops • Increase awareness of programs and environmental benefits • Reduce nutrient loads
9,11	18. Work on farm source control and nutrient export in high nutrient export areas	High nutrient areas	• U MD Cooperative Extension • UDEL • SRA	• 5 farms create and implement on-site measures to reduce loads including installing gutters on poultry houses and diverting clean flow away from the houses, cover crops and crops that remove P, continuous till, subsurface application of manures, • Reduce nutrient loading

Table E.2 Recommendations, Responsible Parties, and Desired Outcomes for Restoration				
Stakeholder	**Recommendation**	**Location**	**Responsible Parties**	**Outcome**
9,10,11	19. Increase acreages of cover crops via incentive payment	Watershed wide	• SRA	• 2,500 acres of additional cover crops (part of 5,000 above) • Reduce Total Phosphorous
1,11	20. Innovative ways of more efficient and effective use of nutrients	Watershed wide	• U MD Cooperative Extension • UDEL	• 100 acres implementing new and improved strategies
1	21. Identify and prioritize locations for up to 10 constructed wetlands in high input areas	High input areas	• Eastern Shore Resource Conservation & Development • SRA	• 5 wetlands constructed • Reduce Total Phosphorus
9,10,11	22. Extension of BMPs to farms with absentee owners and others that do not qualify for cost share	Watershed wide	• Kent and Cecil Soil Conservation Districts • SRA	• 500 acres with BMPs applied • Reduce Total Phosphorus
2,8	23. Encourage marinas to participate in the Maryland Clean Marina Program	Watershed wide	• SRA • Department of Natural Resources	• 2 additional marinas enrolled • Increase awareness of program and environmental/social benefits
2,13	24. Education and outreach to local school system and community youth groups	Watershed wide	• SRA	• Raise environmental awareness and develop next generation of stewardship

Table E.2 Recommendations, Responsible Parties, and Desired Outcomes for Restoration

Stakeholder	Recommendation	Location	Responsible Parties	Outcome
2,13	25. Engage local community in kayaking, bird watching and fishing	Watershed wide	• SRA	• Behavioral change increasing responsible recreation • Increased awareness and engagement
1,2	26. Participate in local codes and ordinance review	Kent, Cecil and New Castle Counties	• SRA • CWP	• Reduce future impacts from development • Develop a state of the knowledge
12	27. Advocate for preservation of forest and well-managed farmland	Watershed wide	• SRA	• No decrease in well-managed farmland • Additional 10% of forest and farmland preserved
1,7	28. Advocate for or create TMDLs for all impairments	Watershed wide	• SRA • MD Department of Natural Resources • MD Department of Environment	• TMDLs are developed for Sediments and other impairments
1,14	29. Monitor efforts to improve the water quality conditions in the watershed	Watershed wide	• SRA • U MD Center for Environmental Science • CWP	• Identify and quantify problems • Process and Impact Monitoring implemented
15	30. Support and engage with established and start-up watershed organizations	Eastern Shore then Chesapeake Bay Region	• SRA	• Share best practices • Increase knowledge • Partner on advocacy efforts

Table E.3 Logical Framework: Inputs, Activities, Outputs					
Recommendation	**Input**	**Activity**	**Output (year 1)**	**Output (years 2-4)**	**Output (year 5+)**
1. Rt. 301 Highway retrofits and stream restoration	• Staff Time • Approximately $ 1,000,000 per project for 3 projects = $ 3,000,000	• Meet with State Highway Authority • Implement highway retrofits	• Identify Funding • SHA Design and Plan	• 2 projects constructed	• 1 project constructed
2. Stormwater retrofitting demo projects including rain gardens and rain barrels.	• Staff Time • 5 workshops @ $2,500 = $12,500 • 4 projects @ $40,000 = $ 160,000 (see Table 4.10) • 100 rain barrels @ $ 75 = $ 7,500	• Identify site, recruit volunteers, design and construct 5 community projects • Annual workshops on rain gardens and rain barrels	• 1 workshop • 1 project • 15 rain barrels	• 4 workshops • 2 projects constructed • 85 rain barrels	• 1 project constructed
3. Outreach and education of residents on lawn care practices through workshops.	• Staff Time • 8 workshops @ $ 2,500 = $ 20,000 • 300 Soil tests @ $ 15 = $ 4,500	• Annual workshop on lawn care • Distribute soil tests and log results	• 2 workshops • 150 Soil Tests	• 6 workshops • 150 Soil Tests	• Workshops as needed
4. Advocate for phosphorous free fertilizers throughout the watershed	• Staff Time • Workshops (noted above)	• Identify suppliers and ensure P-free products are available • Educate landowners in workshops • Lobby for changes in legislation	• Local suppliers carry P-free products	• Change in Legislation	
5. Assistance with inspections and outreach to homeowners on septic upgrades to enhanced denitrification technology	• Staff Time • 8 workshops @ $ 2,500 = $ 20,000 • 300 Septic Tests @ $ 100 = 30,000 • 150 upgrades @ $ 18,000 = 2,700,000	• Host septic workshops • Identify septics in critical area for testing • Identify septic consultant for testing	• 2 workshops • 75 Septic Tests	• 6 workshops • 225 Septic Tests • 50 septic upgrades	• 100 septic upgrades

Table E.3 Logical Framework: Inputs, Activities, Outputs

Recommendation	Input	Activity	Output (year 1)	Output (years 2-4)	Output (year 5+)
6. Fix failing septics in Sassafras	• 25 septics repaired @ $ 15,000 = 375,000	• Hire contractor to design and install retrofits	• Shortlist of septic repairs from septic testing	• 15 septic systems repaired	• 10 septic systems repaired
7. Upgrade Galena WWTP to ENR	• Staff time • $ 1,500,000 for upgrade	• Identify funding opportunities for upgrade	• Secure funding	• Approve design and construct ENR plant	
8. Upgrade Betterton WWTP to ENR	• Staff time • $ 20,000 for design • $ 1,500,000 for upgrade	• Ensure ENR design • Identify funding opportunities for upgrade	• Secure funding	• Design	• Construct ENR plant
9. Identify and test major combined and community septic systems	• $2,000 per test for approximately 5 sites = $ 10,000	• Identify community septics watershed-wide • Test systems	• Inventory systems	• Test systems in critical area	• Test systems outside critical area
10. Upgrade appropriate combined and community septics to enhanced denitrification technology	• Cost will depend on size and number of units	• Upgrade combined and community septics to enhanced denitrification technology	• Determine appropriate technology and estimate cost	• Design and construct one system	• 1 - 2 septics upgraded
11. Identify eroding wooded ravines	• $ 30,000 based on 300 hours technical expertise	• Catalogue wooded ravines and recommend mitigation effort	• Identify wooded ravines	• Identify wooded ravines/ prioritize for restoration/ stabilization	• Technical memo containing restoration strategies for various scenarios
12. Prioritize and restore multiple sites of eroding stream and wooded ravines	• Staff time • $ 150-$200 per linear foot for 1 mile = $ 1,000,000	• Restore high priority sites of eroding stream and wooded ravines	• Ground truth and prioritize candidate sites	• Secure funding • Design restoration project	• Construct 1 mile of eroding steam and wooded ravines

Table E.3 Logical Framework: Inputs, Activities, Outputs					
Recommendation	**Input**	**Activity**	**Output (year 1)**	**Output (years 2-4)**	**Output (year 5+)**
13. Stabilize actively eroding shorelines, tidally induced and topdown induced	• Staff time • Approximately ½ mile of shoreline over 7 projects. Sum of 7 projects = $ 1,823,480	• Ground truth potential candidate sites, secure funding and construct sills, breakwaters, buffers	• Ground truth and prioritize candidate sites	• Secure funding and construct 1 project •	• Secure funding and construct 5 – 6 additional projects
14. Increase shoreline buffers and outreach to residents on buffer management	• Staff time • 1 miles = 60 acres of buffer strips @ $ 3000 per acre = $ 180,000	• Outreach to homeowners • Identify and implement buffer strips	• Target home owners with turf adjacent to shoreline • Outreach to waterfront residents to educate on buffer BMPs	• Plant 1/2 mile shoreline buffer strips	
15. Additional stream buffers for landowners (ag and residential)	• Staff time • 2 miles = 121.38 acres of buffer strips @ $ 3000 per acre = $ 364,140	• Promote buffer strips for residential and ag lands • Secure permission and funding for one community project(s)	• Secure landowner permission • Promote residential and ag buffers through media and workshops	• Plant 1 mile of buffer strips	• Plant 1 mile of buffer strips
16. Needs Assessment to understand impediments to cost-share participation for ag BMPs	• Staff Time • Workshop (included below*)	• Poll farmers on participation in cost share programs	• Identify barriers to participation and work to resolve	• Identify barriers to participation and work to resolve	• Identify barriers to participation and work to resolve

Table E.3 Logical Framework: Inputs, Activities, Outputs

Recommendation	Input	Activity	Output (year 1)	Output (years 2-4)	Output (year 5+)
17. Increased outreach and cost-share to farmers in locations with high nutrient concentrations	• Staff Time • 1 annual workshop* @ $ 2500 for 10 years = $ 25,000	• Peer to peer networking to farmers in areas with high nutrient concentrations initially, then watershed wide	• 1000 additional acres in cover crops • 1 annual workshop • Targeted outreach to 50 % of ag community in priority areas	• 2500 additional acres in cover crops • 3 workshops • Targeted outreach to 50% of ag community in priority areas	• 1500 additional acres in cover crops • 6 workshops • Watershed wide outreach to ag community
18. Identify farms with high nutrient export based on synoptic sampling work directly with farms to control nutrient losses	$ 10,000 per plan for 5 farms = $ 50,000	• Work directly with 5 farms to construct source reduction and transport reduction methods	• Identify and target key farm areas	• Identify farms and implement 2 plans	• Identify farms and implement 3 plans
19. Increase acreages of cover crops via incentive payment	• Staff Time • $ 10 per acre for 2,500 acres for 5 years = $ 125,000 • 1 annual workshop* (same as above)	• Peer to peer networking to farmers in areas with high nutrient concentrations initially then watershed wide	• 1000 additional acres in cover crops (part of total acres above) • 1 annual workshop • Targeted outreach to 50% of ag community in high nutrient areas	• 500 additional acres in cover crops (part of total acres above) • 3 workshops • Targeted outreach to 100% of ag community in high nutrient areas	• 1000 additional acres in cover crops (part of total acres above) • 6 workshops • Watershed wide outreach to ag community
20. Innovative ways of more efficient and effective use of nutrients	• Research funding $ 100,000	• Evaluate critical issues on farms with high nutrient exports – research and test methods to control nutrients	• Identify key subwatersheds and farm areas	• Secure funding and begin UMD Cooperative Ext meetings with selected farmers	• 100 acres with reduced nutrient export and data on enhanced practices

Table E.3 Logical Framework: Inputs, Activities, Outputs					
Recommendation	**Input**	**Activity**	**Output (year 1)**	**Output (years 2-4)**	**Output (year 5+)**
21. Identify and prioritize locations for up to 10 constructed wetlands in high input areas	• Staff Time • $ 50,000 per wetland for approximately 100 acres per site for 10 sites = $ 500,000	• Ground truth candidate sites, secure funding, design and construct wetlands	• Construct 1 treatment wetland	• Construct 3 treatment wetlands	• Construct 6 treatment wetlands
22. Extension of BMPs to farms with absentee owners and others that do not qualify for cost share	• Staff Time • $ 100 per acre for 500 acres = $ 50,000	• Identify funding gaps and farms without BMPs	• Begin outreach and relationship building with these landowners/ tenant farmers	• 300 additional acres in cover crops	• 200 additional acres in cover crops
23. Encourage marinas to participate in the Maryland Clean Marina Program	• Staff Time	• Targeted outreach to marina owners and boaters	• One on one outreach to 5 non participating marinas and 2 boatyards	• 2 additional marinas sign	• 1 additional marina signs on
24. Education and outreach to local school system and community youth groups	• Staff Time • Supplies @ $ 1,000 per year for 10 years = $ 10,000	• Participate in school based programs to educate youth on water quality and stewardship	• Reach every 4th grader in Kent and Cecil county	• Reach every 4th grader in Kent and Cecil county	• Reach every 4th grader in Kent and Cecil county
25. Engage local community in kayaking, bird watching and fishing	• Staff Time • $ 5,000 per large event for advertising, rentals, supplies = $ 50,000	• Create event(s) and activities that raise awareness and engage public in responsible recreation	• River festival with activity (kayaking, etc.) embedded within	• One large event and two smaller activities per year	• One large event and two smaller activities per year
26. Participate in local codes and ordinance review	• Staff Time	• Review Stormwater Plans, Water and Sewer Plans, Comp Plans, Permit renewals, etc. for water quality issues	• Increase knowledge • Reduce future impacts from development	• Increase knowledge • Reduce future impacts from development	• Increase knowledge • Reduce future impacts from development

Table E.3 Logical Framework: Inputs, Activities, Outputs					
Recommendation	**Input**	**Activity**	**Output (year 1)**	**Output (years 2-4)**	**Output (year 5+)**
27. Advocate for preservation of forest and well-managed farmland	• Staff Time	• Participate in public hearings, commission meetings, issue letters of support etc. to advocate for forest and farmland preservation	• No decrease in forest or well-managed farmland	• No decrease in forest or well-managed farmland	• No decrease in forest or well-managed farmland
28. Advocate for or create TMDLs for all impairments	• Staff Time	• Review and comment on Bay-wide TMDL for Phosphorus, Nitrogen and Sediments • Monitor biological impairments through Maryland Biological Stream Survey and Maryland Stream Waders Programs	• Input on Bay-wide TMDL • Continue to monitor biological impairments through MBSS and MD Stream Waders Programs	• Loading estimates for Sassafras impairments • Regulate impacts from discharge permits • Continue to monitor biological impairments through MBSS and MD Stream Waders Programs	• Regulate impacts from discharge permits • Continue to monitor biological impairments through MBSS and MD Stream Waders Programs
29. Monitor efforts to improve the water quality conditions in the watershed	• Staff Time • 3,000 per year for equipment costs for 10 years = $ 30,000 • 3,000 per year for lab tests for 10 years = $ 30,000	• Continue and increase monitoring efforts that track water quality improvements and issues	• Results are analyzed and publicized	• Results are analyzed and publicized	• Results are analyzed and publicized

Table E.3 Logical Framework: Inputs, Activities, Outputs					
Recommendation	**Input**	**Activity**	**Output (year 1)**	**Output (years 2-4)**	**Output (year 5+)**
30. Support and engage with established and start-up watershed organizations	• Staff Time	• Participate in watershed meetings and events and issue letters of support to promote grassroots environmentalism	• Increase awareness of grassroots watershed planning and restoration	• Increase awareness of grassroots watershed planning and restoration	• Increase awareness of grassroots watershed planning and restoration
Grand Total	**$ 13,697,120**				
Shading indicates projects have already been submitted for partial funding. *Staff time represents costs associated with Sassafras River Association full and part-time staff.*					

E6.0 Pollutant Load Reductions

Table E.4 shows the pollutant load reduction estimates based on the recommendations outlined in Section 2.0 as well as on-going implementation actions by the Sassafras River Association, Kent County and Cecil County. The load reductions are based on realistic implementation scenarios over the next ten years. Citations are provided for each of the load reduction calculations and are based on conservative assumptions. Each recommendation in Table E.4 is followed by the implementation goal, and the assumption leading to the load reduction. Table E.5 shows the annual pollutant loads to the Sassafras watershed post implementation and the % of nutrient load reduction achieved through restoration strategies. The overall effect of restoration implementation would result in a 34 % reduction in total phosphorus, a 9% reduction in total nitrogen, and close to a 15% reduction in total suspended solids.

This restoration strategy will allow implementation partners to meet the load allocation of 13, 875 lbs/yr of phosphorus. The Sassafras Watershed Action Plan TMDL strategy focuses on both reducing nutrients from urban sources including sewage treatment plants, septic systems and rural sources including agriculture. TMDLs for nitrogen and sediment have not been set for this watershed although load reductions for these pollutants have been calculated based on management practices for meeting the TMDL for phosphorus. In addition known sources of nitrogen and sediment such as septic systems, WWTPs, lawn care and cover crops have been targeted in the recommendations.

Table E.4 Pollutant Load Reduction Calculations for Total Nitrogen, Total Phosphorus, and Total Suspended Sediment

Recommendation	Project Goal	TN Reduction (lbs/year)	TP Reduction (lbs/year)	TSS Reduction (tons/year)	Citation
1. Rt. 301 Highway retrofits and stream restoration	• 3 projects constructed	35	465	211,000	Caraco, 2001
2. Stormwater retrofitting demo projects including rain gardens and rain barrels.	• 4 retrofit projects • 100 rain barrels • 100 acres of urban nutrient management	35	15	3,300	Caraco, 2001
3. Outreach and education of residents on lawn care practices through workshops.	• Reach 500 residents, • 300 Soil Tests •	4,000	103		Caraco, 2001

Table E.4 Pollutant Load Reduction Calculations for Total Nitrogen, Total Phosphorus, and Total Suspended Sediment					
Recommendation	**Project Goal**	**TN Reduction (lbs/year)**	**TP Reduction (lbs/year)**	**TSS Reduction (tons/year)**	**Citation**
4. Advocate for phosphorous free fertilizers throughout the watershed	• Ensure P-free products are available and landowners educated		500		Barton et. al., 2006
5. Assistance with inspections and outreach to homeowners on septic upgrades to enhanced denitrification technology	• 300 tests performed • 150 septic upgrades	900			MDE, 2008
6. Fix failing septics in Sassafras	• Repair 25 failing septics	150	25		Caraco, 2001
7. Upgrade Galena WWTP to ENR	• 1 ENR municipal WWTP	5,658	1,100		MDE, 2005
8. Upgrade Betterton WWTP to ENR	• 1 ENR municipal WWTP	1,200	160		MDE, 2005
9. Identify and test major combined and community septic systems	• Test 5 systems	Not Applicable			
10. Upgrade appropriate combined and community septics to enhanced denitrification technology	• Upgrade 50% of identified systems to BNR	5,000			MDE, 2008
11. Identify eroding wooded ravines	• Inventory of woodland gully issues that can be addressed	Not Applicable			
12. Prioritize and restore multiple sites of eroding stream and wooded ravines	• 1 mile of stream and wooded ravine restored		450	211,000	Caraco, 2001
13. Stabilize actively eroding shorelines, tidally induced and top down induced	• Stabilize ½ mile of shoreline	Primary load reduction will be TSS and will be calculated on a per project basis.			
14. Increase shoreline buffers and outreach to residents on buffer management	• Increase 1 miles of shoreline buffers	155	10	3500	CWP/DNR, 2005

Table E.4 Pollutant Load Reduction Calculations for Total Nitrogen, Total Phosphorus, and Total Suspended Sediment					
Recommendation	**Project Goal**	**TN Reduction (lbs/year)**	**TP Reduction (lbs/year)**	**TSS Reduction (tons/year)**	**Citation**
15. Additional stream buffers for landowners (agricultural and residential)	• Increase stream buffers by 2 miles (50' width)	352	30	20,000	CWP/DNR, 2005
16. Needs Assessment to understand impediments to cost-share participation	• Identify and address impediments to increase participation	Not Applicable			
17. Increased outreach and cost-share to farmers in locations with high nutrient concentrations	• 5,000 acre of additional cover crops	21,490	2,700	495,000	CWP/DNR, 2005
18. Identify farms with high nutrient export based on synoptic sampling, work directly with farms to control nutrient losses.	• 5 farms create and implement measures to reduce nutrient losses	Nutrient load reductions will be estimated on a per farm basis, based on BMPs implemented.			
19. Increase acreages of cover crops via incentive payment	• 2,500 acres of additional cover crops (part of 5,000 above)				
20. Innovative ways of more efficient and effective use of nutrients	• 100 acres implementing new and improved strategies	500	100		Frink, 1991
21. Identify and prioritize locations for up to 10 constructed wetlands in high input areas	• 10 wetlands constructed	5,000	500	450,000	CWP/DNR, 2005
22. Extension of BMPs to farms with absentee owners and others that do not qualify for cost share	• 500 acres additional cover crops	2,000	300	50,000	CWP/DNR, 2005
23. Encourage marinas to participate in the Maryland Clean Marina Program	• 2 additional marinas	Not Applicable			
24. Education and outreach to local school system and community youth groups	• Raise environmental awareness and develop next generation of stewardship				

Table E.4 Pollutant Load Reduction Calculations for Total Nitrogen, Total Phosphorus, and Total Suspended Sediment					
Recommendation	**Project Goal**	**TN Reduction (lbs/year)**	**TP Reduction (lbs/year)**	**TSS Reduction (tons/year)**	**Citation**
25. Engage local community in kayaking, bird watching and fishing	• Behavioral change increasing responsible recreation				
26. Participate in local codes and ordinance review	• Reduce future impacts from development				
27. Advocate for preservation of forest and well-managed farmland	• No decrease in well-managed farmland • Additional 10% of forest and farmland preserved from development				
28. Advocate for or create TMDLs for all impairments	• TMDLs are developed for all impairments				
29. Monitor efforts to improve the water quality conditions in the watershed	• Identify and quantify problems • Process and Impact Monitoring implemented				
30. Support and engage with established and start-up watershed organizations	• Share best practices • Increase knowledge • Partner on advocacy efforts				

Table E.5 Sassafras Watershed Annual Loads and Anticipated Restoration Strategy Reductions			
Loads	**TN (lb/year)**	**TP (lb/year)**	**TSS (lb/year)**
Sassafras Watershed total current loads	508,700	19,060	9,730,599
Restoration strategy	**46,475**	**6,458**	**1,443,800**
Watershed loading post implementation	**462,225**	**12,602**	**8,286,799**
Percent load reduction	**9.1%**	**33.9%**	**14.8%**
TMDL Loading Allocation		***13,875***	

1.0 INTRODUCTION

The purpose of this report is to provide guidance on the restoration of the Sassafras River Watershed. The report outlines a series of recommendations for watershed restoration, describes management strategies, and identifies priority projects for implementation. Planning level cost estimates are provided, where feasible, and a preliminary schedule for implementation over a ten-year horizon is outlined. Financial and technical partners for plan implementation are suggested for various recommendations and projects. The watershed plan is intended to assist the Sassafras River Association, Kent County, Cecil County and others with a vested interest in moving forward with restoration of the Sassafras River Watershed.

1.1 Background

The Sassafras River Association (SRA), recognizing the need of a Sassafras Watershed Action Plan (SWAP) to restore its watershed, raised private funding to support the development of this plan. SRA approached a wide range of experts in the watershed community to create a Core Team to provide technical assistance as well as to guide the development and implementation of the SWAP. This unique partnership includes Sassafras River Association (SRA); Center for Watershed Protection (CWP); Cecil County Planning and Zoning; Cecil Soil Conservation District; Delaware Department of Natural Resources and Environmental Control (DNREC); Kent Planning, Housing and Zoning; Kent Soil and Water Conservation District; Maryland Department of the Environment (MDE); Maryland Department of Natural Resources (MDNR); McCrone Inc.; Upper Eastern Shore Tributary Strategies Team; University of Maryland Center for Environmental Sciences (UMCES); University of Maryland Environmental Finance Center; University of Maryland Sea Grant Extension Program; and Washington College Center for Environment and Society. The SWAP was developed for the Sassafras River Watershed, with drainage between Kent and Cecil counties and New Castle County in Delaware. This one-year effort involved working with all partners to conduct a stream corridor assessment, upland assessment, shoreline assessment and synoptic survey to identify restoration opportunities and to draft a plan which will serve as the blueprint for future restoration efforts.

This study did not focus on subwatersheds but the entire Sassafras Watershed (Figure 1.1). Land use in the watershed is predominantly agricultural (57%), followed by forest cover (24%), and urban (4%) (MDP, 2007). Table 1.1 provides a summary of key characteristics of the watershed based on this report. Table 1.2 provides a list of priority pollutants and concerns affecting the Sassafras River Watershed.

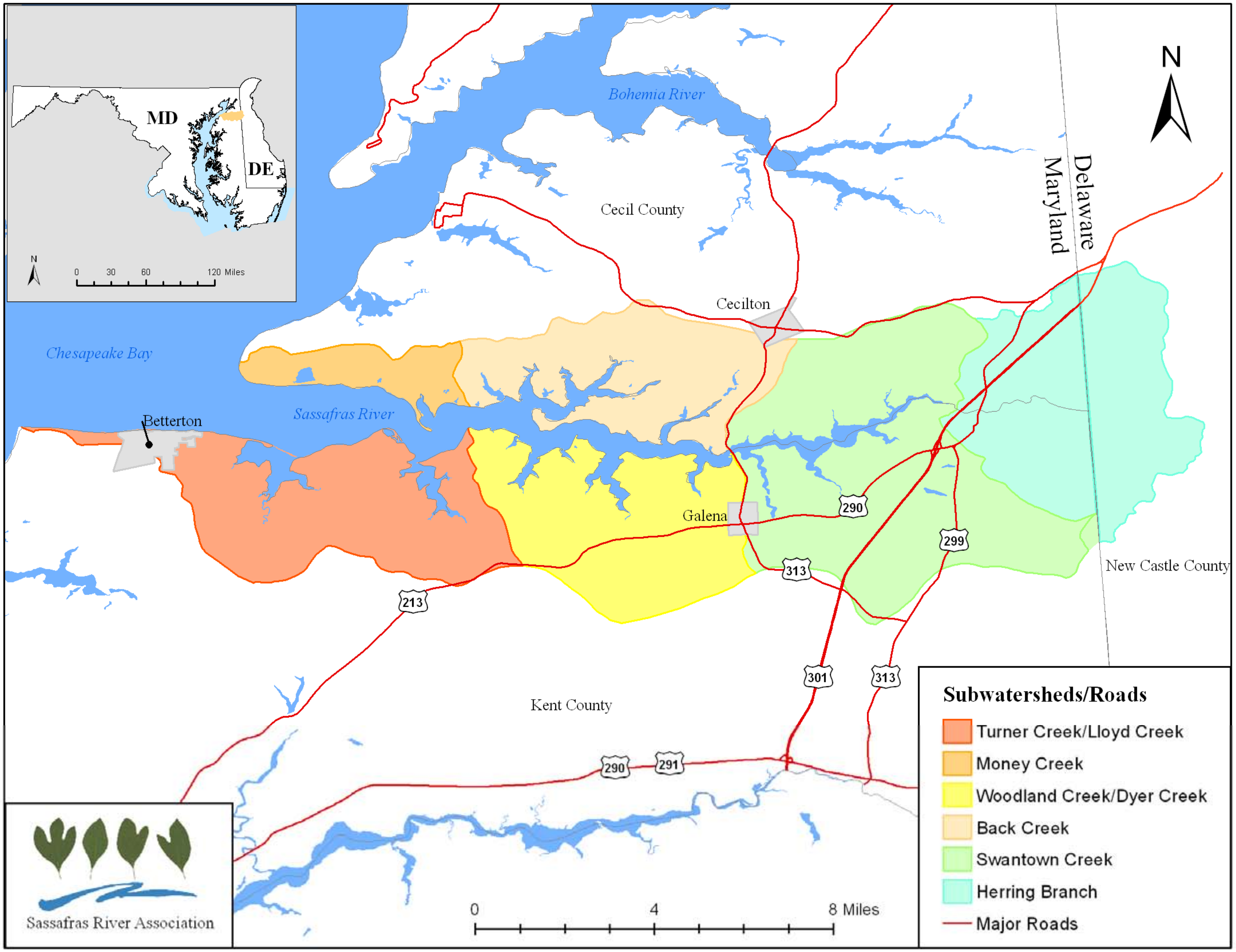

Figure 1.1 Map of the Sassafras River Watershed

Table 1.1 Key Characteristics of the Sassafras River Watershed	
Drainage Area	• 96.9 mi^2
Stream length	• 20.6 miles
Land Use	• Agriculture (57%) • Forest (24%) • Developed (4%) • Water (14%) • Wetland (1%)
Land Area by County as Percent of Total Watershed Area	• Kent County, MD (51%) • Cecil County, MD (28%) • New Castle County, DE (8%) • Surface Water (13%)
Current Impervious Cover	• 2.2 %
Dominant Groups by Hydrologic Soil Types	• 00.5% - A – well drained • 66.8% - B – moderately well drained • 23.3% - C – poorly drained, impeding layer • 05.7% - D – very poorly drained
Subwatersheds	• Sassafras River • Turner's Creek/Lloyd Creek • Money Creek • Woodland Creek/Dyer Creek • Back Creek • Swantown Creek • Herring Branch

Table 1.2 Priority Pollutants and Concerns in the Sassafras River Watershed			
Pollutant or Concern	**Data Source**	**Potential Sources of Contamination**	**Watershed Effects**
6. Nutrients (Nitrogen and Phosphorus)* TMDL written for phosphorus[2]	MD 303d list[1]	• Point Sources • Urban runoff • Agricultural runoff • Turf grass and lawns • Atmospheric deposition • Septic systems • Pet waste	• Eutrophication • Dead zones • Contribution to Chesapeake Bay pollution • Harmful Algal blooms
7. Sediment (TSS – total suspended solids)	MD 303d list[1]	• Streambank erosion • Urban runoff • Construction sites • Agricultural runoff	• In-stream habitat loss • Reduced depth in tidal creeks • Reduced light penetration for SAV growth
8. Bacteria	County Health Departments – some beach closures	• Urban runoff • Pet waste • Wildlife • Failing Septic systems • Improper disposal of boat waste	• Swimming and water contact related illnesses • Shellfish harvesting concerns
9. Biological Impairment	MD 303d list[1] DE 303d list[4]	• Hydrologic alteration stormwater • Thermal impacts	• Loss of sensitive species
10. Polychlorinated Biphenyls (PCBs)	MD 303d list[1]	• Old electrical transformers • Landfills • Resuspension of bottom sediments[3] • Tidal influence of the Upper Chesapeake Bay • Atmospheric Deposition	• Fish and biological contamination cautioning human consumption
Reference: [1] (MDE 2006); [2] (More detail on the TMDL can be found in the Watershed Characterization Report in Appendix F); [3](MDE 2008); [4](DNREC, 2008)			

As a first step, existing Sassafras River reports and data were reviewed in order to identify areas of the watershed where assessments had already been completed, identify any deficiencies in the data, and develop a list of assessment gaps. This review also included discussions with State and local agencies as well as stakeholders. A Watershed Characterization was written that compiles available water quality and natural resource information. The Characterization is divided across three areas: water quality, landscape, living resources and habitat. The Characterization serves as a framework for summarizing relevant information and issues, identifying data gaps and future monitoring needs, and providing a common base of knowledge about the Sassafras River Watershed for local governments, citizens, businesses and other organizations.

Starting in the spring of 2009, the project partners along with several volunteers conducted a series of assessments to identify sources and causes of water quality loads and impairments. These assessments included investigation of stream corridors, upland areas, shoreline and a synoptic survey. Potential opportunities were evaluated for stormwater retrofits, stream corridor restoration, pollution prevention, and agricultural best management practices in the watershed. More detail on assessment methods, findings, pollution sources and causes are found in *Section 4* of this plan.

Throughout this process, stakeholders were actively engaged through three public meetings. The first meeting presented existing conditions in the watershed, an overview of watershed planning and invited participants to identify issues and concerns for the watershed. The second introduced preliminary findings from the fieldwork and engaged stakeholders in a process of developing goals and strategies for restoration. The last presented well developed restoration strategies and key projects that correlate to stakeholder strategies. At each of these meetings, input was gathered from stakeholders and incorporated into a larger summary of goals for the watershed. This report provides the goals and recommendations, field findings, and restoration opportunities for the Sassafras River Watershed.

1.2 U.S. EPA Watershed Planning "A-I Criteria"

In 2003, the U.S. Environmental Protection Agency (EPA) began to require that all watershed restoration projects funded under Section 319 of the federal Clean Water Act to be supported by a watershed plan that includes the following nine minimum elements, known as the "a-i criteria":

a.) Identification of the causes and sources that will need to be controlled to achieve the load reductions estimated in the watershed plan
b.) Estimates of pollutant load reductions expected through implementation of proposed nonpoint source (NPS) management measures
c.) A description of the NPS management measures that will need to be implemented
d.) An estimate of the amount of technical and financial assistance needed to implement the plan
e.) An information/education component that will be used to enhance public understanding and encourage participation
f.) A schedule for implementing the NPS management measures
g.) A description of interim, measurable milestones
h.) A set of criteria to determine load reductions and track substantial progress towards attaining water quality standards

i.) A monitoring component to determine whether the watershed plan is being implemented

This watershed plan meets the *a-i* criteria. Table 1.3 shows where these criteria are addressed throughout this watershed plan.

Table 1.3 U.S. EPA Watershed Planning Criteria

Section of the Report	A	B	C	D	E	F	G	H	I
Section 1.0 Introduction	X								
Section 2.0 Watershed Goal Strategies and Recommendations			X						
Section 3.0 Watershed Restoration Practices			X		X				
Section 4.0 Watershed Characteristics and Restoration Opportunities			X		X				
Section 5.0 Implementation Costs and Schedules	X	X		X	X	X	X	X	X
Section 6.0 Monitoring Plan									X

1.3 Report Organization

The remainder of the report is organized as follows:

Section 2.0 presents watershed goals and recommendations. The 15 watershed strategies are based on input from residents and other watershed stakeholders and were drafted to guide recommendations of the Sassafras Watershed Action Plan. The 29 restoration recommendations are described herein at the concept-level.

Section 3.0 provides a brief description of the types of watershed restoration practices recommended for the Sassafras River Watershed. Restoration practices include stormwater retrofits, stream corridor restoration, illicit discharge detection and elimination, pollution prevention/source control education, public education and agricultural practices and programs.

Section 4.0 is dedicated to management strategies for the watershed. A prioritized list of restoration projects for each assessment is provided. In addition, an overview of the recommended restoration practices is provided. A detailed management map depicting project locations is included herein.

Section 5.0 provides planning level cost estimates and a schedule for implementing watershed recommendations over the next 5 - 10 years. Unit cost assumptions for the various restoration practices and cost estimates for priority projects are provided where feasible.

Section 6.0 outlines a basic monitoring and project tracking strategy to evaluate progress in plan implementation.

2.0 WATERSHED GOAL, STRATEGIES AND RECOMMENDATIONS

Since the public and other stakeholders will have to live with the decisions developed during the watershed planning process, they play a vital role in the creation and implementation of a watershed management plan. Their participation gives them a stake in the outcome and helps to ensure the implementation of the plan. Stakeholders also bring to the table issues that are important to the community, and participate in activities to achieve nutrient and water quality goals.

The stakeholder meetings resulted in the following set of strategies. These 15 strategies guided the development of restoration recommendations of the Sassafras Watershed Action Plan.

Watershed Goal:

A healthy, clean river that is safe for swimming, fishing, and crabbing and meets the TMDL for all impairments.

Stakeholder Strategies:

1. **Quantify problems** and chart a path to measure success. Identify issues affecting the Sassafras and develop a system to measure progress of restoration efforts.

2. **Increase the knowledge and awareness of homeowners, businesses, developers and children** of ways to improve conditions in the Sassafras such as utilization of Best Management Practices (BMPs), reduction of impervious cover and improved lawn care practices.

3. **Increase forest buffers** to improve water quality.

4. **Understand the causes of erosion and increase restoration efforts** including addressing highway runoff and other potential stream restoration and shoreline stabilization efforts.

5. **Improve sewage treatment in Galena and Betterton** municipal systems. Upgrade systems to best available technology to reduce nutrients.

6. **Increase the number of individual septic pump-outs and septic upgrades** to systems which remove increased levels of nitrogen. Also, identify failing and leaking septics, particularly in shared group systems.

7. **Improve enforcement and regulations** including those pertaining to septic systems and pump-outs.

8. **Reduce the impact of boaters on the Sassafras**. Increase awareness of need and access to sewage pump-outs from boats.

9. **Continue to identify the Sassafras Watershed as a priority funding area** for cover crops. Ensure the Sassafras Watershed remains a priority funding area for USDA cost-share programs.

10. **Increase availability of Agriculture Cost-Share programs** to landowners and farmers that currently do not qualify for federal cost-share programs. Some landowners may not qualify due to limited farming income, citizenship or other issues.

11. **Increase peer-to-peer farmer interaction** to make additional gains in conservation practices. Utilize farmer to farmer outreach to share knowledge around conservation practices and programs.

12. **Increase preservation of farmland** in the watershed. Do not let farmland fall into development.

13. **Increase public access and public interaction with the River** and the watershed. Promote responsible recreation.

14. **Monitor and track the measured results** to ensure conditions are improving in the River. Ensure that restoration efforts are bringing about desired results.

15. **Use the SRA and the stakeholder process as a model** for other watersheds in the area. Reach out to other watershed groups to encourage community-based watershed planning.

2.1 Recommendations

This section describes the 30 recommendations for restoration for the Sassafras River Watershed. These recommendations are based on the stakeholder strategies and fieldwork findings and are not listed in order of priority. As no single recommendation will bring about restored water quality, it is important that implementation of many recommendations occur simultaneously. Municipal waste system upgrades and stormwater retrofits on highways are both beneficial and expensive and when used alone do not solve the problem. These efforts need to be combined with cost-effective practices such as pollution prevention and education that leads to behavior change. Targeted outreach to homeowner and agricultural communities can have a significant beneficial impact while further funding is identified for more costly recommendations.

Over the next year, individual project designs will be further developed for each recommendation that has dedicated staff, partners and funding. SRA will serve as champion and project manager of this plan to ensure implementation is on-going, resources are secured and allocated strategically. Monitoring of implementation efforts and impact must be measured over time as well and serve as an adaptive management feedback loop to insure success. The Core Team will support SRA in these efforts.

The 30 recommendations are as follows:

1. **Rt. 301 Highway retrofits and stream restoration** (3 projects) At several locations stormwater runoff from Rt. 301 and adjacent land is creating significant erosion in receiving streams and runoff is being conveyed untreated into surrounding creeks and streams. Opportunities exist to treat stormwater runoff within the conveyance system and perhaps to re-route stormwater conveyance to reduce erosive flows in receiving streams.

2. **Stormwater retrofitting demo projects** including rain gardens and rain barrels. Rain garden and rain barrel workshops serve as effective methods to engage the community while reducing stormwater runoff. Rain gardens infiltrate stormwater runoff by catching runoff before it reaches storm drains. Diverting stormwater into rain gardens from roofs and other hard surfaces such as driveways or patios, helps improve the water quality and at the same time creates functioning gardens which support biodiversity. When sized and constructed properly, rain gardens are able to handle the amount of stormwater produced in an average event. Treating just the first inch of rainfall allows one to treat 90% of the average annual runoff. One inch of rain, covering an average 20’ X 20’ roof surface (typical drainage to a single downspout)   equals 400 square feet and can be effectively treated by a rain garden just 5’ X 8’ in size.

3. **Outreach and education of residents on lawn care practices** (soil tests and proper timing of fertilization) through workshops. Lawns make up a significant percent of the watershed area particularly in the Critical Area. The Critical Area is all land within 1,000 feet of tidal waters or adjacent tidal wetlands of the state (Maryland Critical Area Commission). This land has the greatest potential to affect water quality and wildlife habitat to the Chesapeake Bay and other tributaries. During the upland assessment 16 different neighborhoods and general residential areas were assessed as having high or medium percentages of high input lawn care. Lawn care education workshops will be developed to provide educational efforts targeting neighborhoods with high nutrient lawn care. Section 4.0 summarizes neighborhoods identified for education on lawn practices during field assessments. Workshops will provide guidance on best practices and free soil tests.

4. **Advocate for phosphorus-free fertilizers throughout watershed**. Homeowners can contribute significant amounts of phosphorous to the watershed. Too much phosphorous in the River results in an over-abundance of algae growth which lowers the oxygen levels, introduces poisonous toxins and results in fish kills. Homeowners will be encouraged to take advantage of soil testing to determine nutrient levels and

pH of soils before fertilization. Local businesses will be engaged to carry phosphorous-free fertilizers.

5. **Assistance with inspections and outreach to homeowners on septic upgrades to enhanced denitrification technology.** This program will educate homeowners in the critical area on Best Available Technology (BAT), cost and programs. Homeowners will be offered free inspection to assess eligibility for programs. Homeowners will be shortlisted for repairs and/or upgraded septics.

6. **Fix failing septic systems in the Sassafras**. Homeowners identified with failing septics will be shortlisted and/or enrolled in programs that provide assistance with failing septics. Septics that are repaired become eligible for enhanced denitrification technology upgrades.

7. **Upgrade the Galena Wastewater Treatment Plant** to Enhanced Nutrient Removal (ENR). The Galena WWTP currently uses outdated technology which contributes significant nutrients to the Sassafras River. This recommendation includes an evaluation of financing instruments and programs to assist with upgrades, advocacy with state and county officials to prioritize Galena in future funding cycles and coordination with Town Mayors and Councils to promote the need for upgrade.

8. **Upgrade the Betterton Wastewater Treatment Plant** to ENR. The Betterton WWTP currently uses outdated technology which contributes high concentrations of nutrients to the Sassafras River. This recommendation includes an evaluation of financing instruments and programs to assist with upgrades, advocacy with state and county officials to prioritize Betterton in future funding cycles and coordination with Town Mayors and Councils to promote the need for upgrade.

9. **Identify and test major combined community septic systems.** This program includes identification and assessment of community septic systems in both Maryland counties. Community septics utilizing outdated technologies will be further evaluated for possible upgrades which address nutrient reductions. Further investigation regarding community septics with seasonal use is needed.

10. **Upgrade appropriate combined community septics** to enhanced denitrification technology. Wherever possible, community septics should be upgraded to best available technology. This recommendation includes an evaluation of financing instruments and programs to assist with upgrades, advocacy with state and county officials to prioritize community septics in funding cycles and coordination with Town Mayors, Councils and corporate owners to promote the need for upgrade.

11. **Identify eroding wooded ravines.** Eroding gullies and headcuts contribute a significant amount of sediment and attached nutrients to the Sassafras River, reducing habitat and depths in coves and creeks as well as contributing to associated

water quality degradation. A number of eroding ravines have been identified on private lands but there is the potential for many more locations throughout the watershed. Geospatial data may be useful in helping to identify these locations but additional field determinations are also necessary.

12. **Prioritize and restore multiple sites of eroding stream and wooded ravines.** Prioritizing these eroding sites for restoration especially after more are identified is critical to addressing the sites in the most cost effective and beneficial way in reducing these sources of sediment and nutrients.

13. **Stabilize eroding shorelines as identified in shoreline assessment.** Erosion on the Sassafras shoreline is largely due to natural causes such as the interaction of tidal action with the bank face. The erosion may be accelerated by activities such as boat wakes, sea level rise and wave action during storms. For many shorelines along the moderate to lower energy areas of the Sassafras the use of fringing marshes, bank grading and/or natural vegetation is an effective, inexpensive option for the control of shoreline erosion. For higher energy areas a combination of wetlands plantings with low profile alternatives such as rip-rap sills or breakwaters can be an effective solution. Table 4.4 lists potential project candidates for erosion control.

14. **Increase shoreline buffer.** Shoreline buffers similar to riparian stream buffers reduce nutrient and sediment transport and often help provide stability to the shoreline. These areas are also important for habitat for wildlife including marsh birds and other species during high tides. They also help to buffer adjacent land use such as turf or cropland that may have higher loading rates. Options for shoreline buffers utilizing native grasses, herbaceous filter strips, deep rooted trees and shrubs should be fitted to landowner preferences and may even incorporate practices such as rain gardens to intercept runoff flowpaths.

15. **Additional stream buffer creation for homeowners and farmers.** Riparian buffers are important for good water quality. Riparian zones help to prevent sediment, nitrogen, phosphorus, bacteria, pesticides and other pollutants from reaching a stream. Riparian buffers utilizing native grasses, herbaceous filter strips, deep rooted trees and shrubs along the stream will be recommended for specific sites. *Buffer in a Bag* kits, wherein community participants are given instructions and enough seedlings to be planted along a specific stream reach or corridor, is a possible way to engage volunteers.

16. **Needs Assessment to understand impediments to participation in cost-share programs**. Before promoting cost-share programs it will be critical to understand the issues confronting farmers in participation. A needs assessment will be undertaken to better understand and address these issues. Future advocacy efforts could focus on removing these barriers to participation.

17. **Increased outreach and cost-share to farmers in locations with high nutrient concentrations**. Using data from the stream corridor assessment and synoptic survey, areas of high nutrient concentrations have been identified. These areas will be prioritized for peer to peer outreach activities with focus on increasing farmer participation in state and federal cost-share programs. Figures 4.5 and 4.6 identify these areas of high nutrient concentrations.

18. **Improve farm source control of nutrients and sediments.** Identify farms with high nutrient export based on synoptic sampling and work directly with farms to control nutrient losses. Create and implement on-site measures to reduce loads, this may include: installation of gutters on poultry houses and diverting clean flow away from the houses, cover crops and crops that remove P, continuous till, pivot irrigation for more predictable nutrient uptake and subsurface application of manures

19. **Increase acreage of cover crops via an incentive payment**. Secure grant funding to encourage farmers to participate in cost share programs. Incentive payment would be in addition to whatever fee the farmer receives from cost-share program. In particular, this may be applied to catchments that have higher nutrient concentrations.

20. **Innovative ways of more efficient and effective use of nutrients.** Poultry manure injection and/or irrigation for greater and more predictable uptake and production as well as other methods such as continuous no-till may be effective at reducing nutrient losses. Even well managed farms will lose greater levels of nutrients in years where lack of rainfall or drought periods reduce crop yields and hence nutrient uptake. Irrigation can help establish more predictable yields and less loss to downstream receiving waters.

21. **Identify and prioritize locations for up to 10 constructed treatment wetlands in high input locations**. In addition to improving or sustaining wildlife habitat, wetlands can be used as a low-cost, natural water quality treatment and for passive nonpoint runoff management in agricultural areas. Through the steam corridor assessment and synoptic survey, areas of high nutrient concentrations which would benefit from treatment wetlands have been identified. Figure 4.5 identifies some of the catchment locations where candidate sites could be developed for treatment wetlands.

22. **Extension of BMPs to farms with absentee owners and others that do not qualify for cost-share programs**. Some absentee land-owners in the Sassafras may be excluded from receiving cost-share money for reasons related to citizenship or lack of farming income. Targeted outreach should identify and include these owners for non-governmental incentive programs. Advocacy efforts at the state and federal level would include support for absentee owners with the goal of increasing BMPs across the watershed.

23. **Increase participation in the Maryland Clean Marina Program.** Advocate for participation in Clean Marina Program with local marinas, boat yards and public boat launches. Educate the public about Clean Boating practices and drive the demand for Clean Marina participation.

24. **Education and outreach to school aged children** through the local school system and community youth groups such as Boy and Girl Scouts. Today's youth are tomorrow's environmental stewards. This program will attempt to reach every 4th grader in the watershed. Suggested activities include partnering with local schools to engage students in water quality testing and benthic surveys. The objective is to further develop an understanding of the Sassafras ecosystem and its need of protection.

25. **Engage local community in kayaking, bird watching, and fishing with the goal of promoting responsible recreation**. This program is designed to reach people on a broad scale through direct engagement with the River. These low-impact activities can create an awareness and appreciation of the watershed's fragile ecosystem while advancing stewardship of its natural resources.

26. **Participate in local codes and ordinance review** with a focus on stormwater runoff and better site design. Develop a state of knowledge which compiles currently available knowledge on topics related to stormwater to inform and contribute to codes and review discussions. Reduce future impacts from development.

27. **Advocate for preservation of forest and well-managed farmland** through partnerships with groups such as the Eastern Shore Land Conservancy and Rural Legacy. 57% of the Sassafras watershed is in farmland; 24% is forest. Preservation of forest and farms ensures open space and protects important wildlife habitat, while securing the economic benefit that working lands provide to the community. This is often achieved through conservation easements, legal agreements that restrict the type and amount of development on a property while compensating the landowner for the value such development might represent. The end result: protected meadows, forests and well managed farmland which preserves the rural way of life that contributes to the environmental health of the watershed.

28. **Advocate for or create TMDLs for all impairments.** The Sassafras currently has a TMDL for Phosphorous and a draft TMDL for PCB's. Developing TMDLs for other impairments such as sediments and nitrogen would set forth allocations and require NPDES permits for discharges to surface waters. Refer to section 3.7 for how the Chesapeake Bay TMDL will help address the impairments of phosphorus, nitrogen and sediment for all watersheds.

29. **Monitor efforts to improve the water quality conditions** in the watershed and River. Monitoring efforts will be coordinated with State agencies to maximize data

collection. Sassafras Samplers currently sample 16 non-tidal and 5 tidal sites, once a month from April through October. The Sassafras RIVERKEEPER samples 7 tidal sites weekly from April through October. These efforts will be expanded to develop base lines in restoration areas as well as monitor impact post implementation.

30. **Support and engage with established and start-up watershed organizations.** Local watershed organizations can take the lead on impacting change in their communities through the development of community based watershed plans. Sassafras River Association can share lessons learned with communities interested in forming associations as well as established organizations in the process of developing watershed plans.

3.0 WATERSHED RESTORATION PRACTICES

This section presents an overview of the key recommended practices for restoring the Sassafras watershed. Watershed restoration must occur as collaboration among local, county and state government, watershed groups, businesses and residents. The actions of each partner are critical to the success of the total effort. Local and state governments are able to implement capital projects such as stream restoration, large-scale highway stormwater retrofits and changes in municipal operations. Complementing governmental efforts, watershed groups and citizens are able to implement smaller scale programs such as lawn care education, rain gardens, changes in agricultural practices, outreach to residents, and restoration of streams and wetlands. It is important that restoration occurs at all levels to ensure a wide range of projects are implemented and community objectives are achieved for the Sassafras River.

The variety of restoration practices recommended include stormwater retrofits, stream corridor and shoreline restoration, on-site sewage disposal system repairs and upgrades, municipal wastewater treatment plant (WWTP) upgrades, agricultural best management practices, pollution prevention/source control education, changes in state county and municipal practices and programs. The specifics of each practice are described in detail in Table 3.1 and the applicable partners are identified as local (watershed group and citizens), capital (local/state government) or both.

Table 3.1 Management Practices Recommended in Sassafras River Watershed

	Type	Practices	Partner
Restoration Practice	**Stormwater Retrofits**	• On-site residential and non-residential retrofits	Capital
		• Regenerative Stormwater Conveyance	Both
	Stream Corridor and Shoreline Restoration	• Stream repair (woodland gully identification, prioritization and repair, buffer reforestation)	Both
		• Shoreline restoration (buffer reforestation, vegetative bank and erosion stabilization, living shoreline creation)	Both
	On-site Sewage Disposal System Repair and Upgrade	• Septic system failure detection and repair	Both
		• Prioritization of septic systems for upgrade to denitrifying technology and homeowner outreach	Both
		• Identification and testing of community and combined septic systems	Both
	Municipal Wastewater Treatment Plants	• Upgrade of existing WWTPs to Enhanced Nutrient Removal systems	Capital
	Agricultural Programs and Practices	• Outreach and education around BMPs • Implementation of state and federal cost-share programs • Advocacy for forest/land preservation practices	Both

Table 3.1 Management Practices Recommended in Sassafras River Watershed			
Type		Practices	Partner
		• Nutrient source control (nutrient management plans, cover crops, treatment wetlands, continued research and development of nutrient application techniques)	Both
	Pollution Prevention/Source Control Education	• Residential pollution prevention (lawn care and bank management)	Both
		• Commercial pollution prevention (businesses, marinas)	Local
		• Partner with local school systems and youth groups (Boy and Girl Scouts) to promote environmental stewardship	Local
		• Engage local community in naturalist activities	Local
	State, County and Municipal Practices and Programs	• Participate in local codes and ordinance reviews	Both
		• TMDL development for all impairments	Both

3.1 Stormwater Retrofits

There are three categories of stormwater retrofits recommended for the Sassafras watershed, 1) onsite residential treatments, such as bioretention and filtering practices, 2) onsite non-residential treatments such as sand filters or underground storage and filtering systems, and 3) regenerative stormwater conveyances which include re-creation of in-stream wetlands and floodplain connection.

Storage retrofits including wetlands provide the widest range of watershed restoration benefits, but present a challenge due to the large space requirements. Residential retrofits comprised of bioretention, filtering, and impervious area reduction are small changes that can provide a substantial benefit when implemented broadly in neighborhoods across the watershed. Sand filters or underground storage and filtering systems work well on the intensively used, largely impervious surfaces typically found on commercial, industrial, or municipal properties. Through the evaluation of impervious cover, land use, and restoration goals, the optimal stormwater retrofit practice can be selected for a particular site, thereby helping to mitigate watershed water quality issues through the improvement of water treatment and recharge.

Residential

Bioretention and infiltration, pervious surface installation, and implementation of best management practices were the three key restoration practices identified as applicable in the residential areas of the Sassafras River watershed. Bioretention and infiltration retrofits are shallow, landscaped depressions that contain a layer of prepared soil, a mulch layer, and vegetation. These areas provide filtering of stormwater runoff by temporarily ponding water during storms, aiding in sediment and nutrient storage. Bioretention facilities have artificially constructed underground drainage systems, while infiltration facilities allow runoff to absorb into the existing soil at sites when infiltration rates are adequate (typically greater than 0.5 inches per hour). Neighborhoods in the Sassafras watershed require a range of different bioretention/infiltration implementations, from swales at cul-de-sacs, to rain gardens and rain barrels on high impact lawns and homes (Figure 3.1). The replacement of impervious asphalt parking lots with pervious pavement at larger multi-family complexes can provide significant benefits. This type of pavement slows the rate at which stormwater travels by holding and absorbing it, then passing it through a sand and gravel filter to reduce pollutants. While not technically a retrofit, the maintenance of catch basins and drains and the removal of sediment from roadside swales can mitigate the effects of stormwater pollution. These best management practices do not require design and construction, but implementing and maintaining them will help their proper function and performance in improving water quality. In areas where stormwater infrastructure routes runoff directly to the river, stencils or permanent stickers can be affixed to catch basin drains reminding residents that those drains are not a disposal facility.

a)

b)

Figure 3.1 Residential stormwater retrofit examples
a) cul-de-sac where bioretention or a grass island could be added. Swales and greenspace instead of curb and gutter produce less runoff, b) rain barrel retaining water from gutters that would otherwise runoff from roof and lawn. This water can then be used for watering gardens or other household uses.

Non-residential

Municipal, industrial, or commercial facilities that have large impervious areas in the form of roofs and driving/parking surfaces can generally benefit from rerouting stormwater from a direct storm sewer infrastructure connection to slower infiltrating areas. Downspouts on these types of properties could be rerouted to retention areas such as rain gardens, or reconnected to bypass areas where they may come into contact with harmful pollutants. Marinas would benefit from retrofits such as sand and gravel beds to filter and slow the rate of stormwater, as well as rain barrels, cisterns and rain gardens to detain runoff. Dry pond retrofits or conversion to more effective stormwater practices such as bioretention could be used at the Galena library (Figure 3.2a). The amended facility would allow a longer detention time, greater settling, interaction with native plants and soil and more denitrification in the system.   Trees and other native vegetation may increase the pollutant removal and trapping ability of a dry pond and improve its overall nutrient uptake. In addition, impervious cover removal and replacement with permeable paving are good options to help treat and reduce stormwater in parking lots at restaurants and businesses at the shoreline and in the watershed (Figure 3.2b).

a)

b)

Figure 3.2 Non-residential stormwater retrofit examples
a) Possible dry pond creation at Galena Public Library, b) Possible location for permeable pavement at the Granary Restaurant

Regenerative stormwater conveyance is a retrofit restoration method that can be used to address serious erosion problems along stream and stormwater channels. This method is especially applicable to headcutting and downcutting erosion observed in stream channels along road intersections in the watershed (Figure 3.3). Regenerative stormwater conveyances are wetland based systems that minimize potential for erosion and create aquatic and/or wetland habitat. They accomplish this by having stormwater pass through a series of cascading pools that allow for the treatment and removal of pollutants. Regenerative stormwater conveyances have been successfully constructed in many other coastal plain locations (Figure 3.4).

a) b)

Figure 3.3 Representative candidate sites for regenerative stormwater conveyance
a) erosion caused by highway (Rt. 301) stormwater runoff, b) erosion caused by stormwater runoff from highway and municipal property (weigh station).

Figure 3.4 Typical regenerative stormwater conveyance design
(source: Keith Underwood and Associates)

3.2 Stream Corridor and Tidal Shoreline Restoration

Stream and shoreline restoration practices are used to enhance the appearance, stability, and aquatic function of stream corridors and tidal shorelines. These practices are often combined with stormwater retrofits and riparian management to meet overall restoration objectives. Primary practices recommended for use in the Sassafras watershed stream corridors include woodland gully identification and restoration and forested buffer reforestation. For tidal shoreline restoration, vegetative bank and erosion stabilization through buffer reforestation, offshore breakwaters, sill structures and living shorelines are thought to be most appropriate.

Stream Corridor

Woodland Gullies

Woodland gullies are a natural landform feature common to the Sassafras River and are often subject to severe erosion. These gullies are difficult to access as they are predominantly located on tributaries to the river in upland areas where forests meet differing land uses such as agricultural fields or pervious surfaces. Although the streams in some of these gullies may not have perennial flow, runoff from storm events can cause these gullies to experience the deleterious effects of large volumes of water contacting steep unvegetated stream banks. The storm flow through these gully streams can mobilize significant amounts of sediment and nutrients, depositing them downstream to non-tidal areas of the river. The installation of drop structures or regenerative stormwater conveyances are currently considered the best approach to addressing this problem. Drop structures serve as a means to collect water at the top of a ravine and pipe it down to the stream corridor so that soil is not being transported with the high storm flow, thus limiting erosion and its associated nutrient transport. Regenerative stormwater conveyances, as previously mentioned in section 3.1, can also be used to safely convey stormwater runoff down a ravine by using a series of wetland pools. Additional restoration methods may include reconnecting the stream with its floodplain by removing floodplain sediments or using a series of structures to increase the invert of the stream thereby reducing erosion.

Stream Buffers

A buffer is generally defined as the vegetation in close proximity (~ 50 feet) along a stream or shoreline (Figure 3.5a). Forested buffers are critical for maintaining healthy streams through the provision of numerous benefits. Forest buffers help shade the stream preventing excessive solar heating and stabilize banks through root/soil adhesion which can significantly limit erosion during both base and stormflow. These buffers also attenuate nutrients, sediment, and other pollutants from runoff that would otherwise enter the immediate stream and ultimately the downstream reaches of the river. The leaves of trees are a major component of the stream's food web as aquatic insects thrive on the decomposing organic matter.

Tidal Shoreline

As with the stream corridors in the Sassafras there are many areas of the tidal shoreline of the Sassafras River experiencing erosion from both stormwater and tidal influences that could benefit from restoration.

Shoreline Buffers

Restoring buffers along tidal shoreline can limit erosion cutting on the tops of banks as expansive root structure of mature trees stabilizes the banks and absorbs rain water as it travels across the landscape. This prevents much stormwater from running directly off the bank and thereby cutting into the bank. Buffers along tidal shoreline have a similar benefit and function as those outlined in the stream buffer section.

Vegetative Banks

These banks are also susceptible to tidal influences from wave action and currents that scour and erode the bank where it meets the water (Figure 3.5b). Revegetating banks protects riverbanks as well as buildings and other infrastructure that can be subject to damage associated with erosion. Vegetative banks also maintain a level of biodiversity and natural appearance that can be more cost-effective than engineered solutions such as rip-rap. Grasses and shrubs aid in bank stabilization and flood scour protection by providing flow interference, soil surface cover, root reinforcement, and soil restraint. However, the use of vegetation alone for stabilization is generally limited to a maximum slope angle, and depends on the nature of the soil material forming the bank.

Sill Structures and Breakwaters

Given that steeper slopes are often observed on the Sassafras shoreline, vegetation restoration may need to be combined with other off-shore methods to control the erosive effects of wave energy. In addition to the general difficulty in the revegetation of steep slopes, some bare bank locations along the Sassafras River serve as habitat for the endangered Tiger Beetle and other bank dwelling species such as the King Fisher. In these areas, revegetation is not an option; therefore offshore practices must be implemented. There are also areas, such as Lloyd's Creek, where shoreline is broken and revegetation is not possible. Here there must also be offshore practices implemented as there is no bank to revegetate. One recommendation is the installation of sills. Construction of a low retaining sill to trap sand results in what is known as a perched beach, or one that is elevated above its original level. Perched beaches are appropriate erosion control measures where a beach is desired and sand loss is too rapid for convenient or economical replacement. They can also be used to create a new beach for recreation and shore protection. Breakwaters are generally shore-parallel structures that reduce the amount of wave energy reaching the protected area. They are similar to natural bars, reefs, or near-shore islands and are designed to dissipate wave energy. The reduction in wave energy slows the littoral drift, produces sediment deposition and a shoreline bulge or salient feature in the sheltered area behind the breakwater.

a) **b)**

Figure 3.5 Vegetative bank issues
a) inadequate buffer along an agricultural field, b) example of tidal shoreline erosion along the Sassafras at Lloyd's Creek

Living Shoreline

Living shorelines are another option to slow erosion of tidal shorelines. Living shorelines are plantings of native wetland plants, grass, and shrubs at various points along the tidal water line that are often coordinated with carefully placed bioengineering materials such as manmade coconut-fiber rolls (or bio-logs) to protect vegetation and soils (Figure 3.6). Projects may include stone elements or hardened elements, as long as they do not cut off access to the shore. These structures absorb wave energy so that reflected waves do not scour the shallow sub-tidal zone, thereby hampering the growth of underwater grasses. Living shorelines improve water quality by settling sediments and filtering nutrients. They provide shoreline access to wildlife, such as nesting turtles, and shorebirds as well as provide shallow water habitat and a diversity of plant species for aquatic and terrestrial animals.

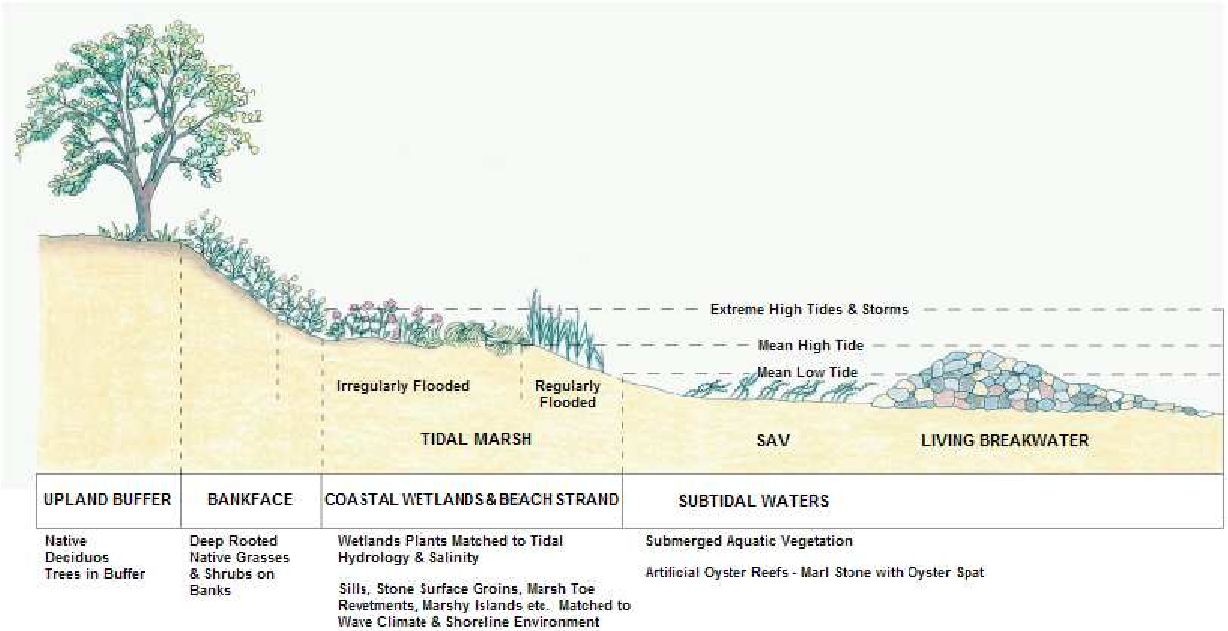

Figure 3.6 Schematic of living shoreline restoration
(source: National Oceanic and Atmospheric Association)

3.3 On-site Sewage Disposal System Repair and Upgrade

As of January 2008, Maryland Department of the Environment estimated 420,000 On-site Sewage Disposal Systems (OSDS) in the state of Maryland. The Chesapeake Bay Program estimates that almost 80 percent of nitrogen from conventional septic systems, or an average of 12.2 pounds of nitrogen per year per OSDS (5,000,000 pounds per year) reaches surface water. In the Sassafras River Watershed there are approximately 1718 homes that use private septics for wastewater treatment and roughly 824 of these homes are located in the critical area (within 1000ft of tidal shoreline). If the formula is applied to the Sassafras an estimated 21,000 pounds of nitrogen per year are being deposited into the River from septic systems alone. In addition to individual on-site homeowner septic systems there are larger community shared septic systems.

Recognizing the impact of all septic systems on both local and downstream water quality in the Sassafras Watershed, recommended practices in the Sassafras consist of septic system failure identification through testing, repair and upgrade in nutrient prone areas, and upgrades for existing septic systems that are not utilizing the best available technology (BAT) to reduce nutrients. An enhanced denitrification system is an example of BAT that utilizes bacteria to biologically remove nitrogen from wastewater. These types of systems can typically reduce wastewater levels of total nitrogen (TN) to 8 mg/L (MDE, 2009). This represents at least a 50% improvement in nutrient reduction over a typical OSDS found in the watershed. One resource that will be utilized to repair and upgrade OSDS in the Sassafras Watershed is the Bay Restoration Fund. Effective October 1, 2005, a $30 annual fee is collected from each home served by an on-site system. The total estimated program income is $12.6 million per year with 60% of these funds used for septic system upgrades and the remaining 40% used for cover crops.

3.4 Municipal Wastewater Treatment Plant Upgrades

When population densities exceeds certain levels, OSDS are no longer an adequate or cost effective method to dispose of human household waste and more intensive practices such as wastewater treatment plants must be employed. Currently there are two WWTPs in the Sassafras Watershed, in Betterton and Galena. Both plants continue to be operated with aging technology that is unable to remove nutrients to acceptable levels for optimal river health. Figure 3.7 includes pictures of the current lagoon system utilized at Galena WWTP as well as an ENR system. It is recommended that both Betterton and Galena WWTPs be upgraded or replaced to incorporate technological advances that are able to remove a much large proportion of nitrogen and phosphorus from the effluent. Specifically it is recommended that both facilities upgrade to Enhanced Nutrient Removal (ENR) systems. Enhanced Nutrient Removal takes wastewater that has gone through a biological nutrient removal process and sends it through additional physical, biological, or chemical processes, to provide further treatment and reduce average TN concentrations to 3 mg/L and average TP concentrations to 0.3 mg/L. Replacing the existing wastewater treatment with a new treatment plant equipped with BNR or ENR would greatly reduce the amount of both phosphorus and nitrogen that are delivered to the Sassafras River.

As part of the Bay Restoration Fund, the Wastewater Treatment Plant Fund was created to finance upgrades to the state of Maryland's largest treatment facilities to decrease nitrogen and phosphorus discharges to surface waters of the state. The program is funded by users and a $2.50 monthly fee is collected from each home served by a wastewater treatment plant. Commercial and industrial users are charged at the rate of $2.50 per month per equivalent dwelling unit (EDU). An EDU is a measure where one unit is equivalent to wastewater effluent from one home, which is 250 gallons per day per home (1 EDU = 250 gallons per day). Fees from wastewater treatment plant users generate an estimated $60 million per year. To expedite the implementation of the program, the Department will issue bonds backed in full or in part by funds generated under this program. The 66 major facilities discharging to the Chesapeake Bay have priority (MDE, 2009). Other facilities will be considered on case-by-case basis in consideration of cost-effectiveness, water quality benefits, readiness to proceed, and nitrogen/phosphorus load.

a) **b)**

Figure 3.7 Waste Water Treatment Methods
a) lagoon system utilized at Galena WWTP, b) ENR treatment system

3.5 Agricultural Practices and Programs

Agricultural strategies identified in SWAP include targeted outreach with the farm community to encourage implementation of BMPs with a goal of reducing nutrient and sediment loading to the Sassafras River. The strategies recommended are intended to balance the needs of crop production and farmer livelihood with water quality goals of the River. These strategies commence with an assessment of participation in cost share programs, and progress to targeted outreach to agricultural landowners on BMPs, education on state and federal conservation programs, as well as the availability of cost share funds and incentives to assist with implementation. Outreach efforts will be focused in areas where there are higher nutrient exports as determined by water quality data collection and analysis. Recommended agricultural related practices in the Sassafras Watershed include BMPs such as nutrient management planning, increased buffers, cover crops, and wetlands, as well as promotion of land preservation and easement programs.

Nutrient Management Plans (NMP)

The Water Quality Improvement Act passed in 1998 required NMPs for all farms in the state of Maryland. Nutrient management plans reduce input costs and protect water quality by assisting farmers with the improved matching of crop nutrient requirements to fertilizer/manure application and therefore limiting excess nutrient contributions to the stream network.
The Maryland Nutrient Management Program provides technical assistance to farmers to help them meet the requirement of having a NMP. University of Maryland and Maryland Department of Agriculture (MDA) certify nutrient management consultants to provide technical assistance in developing and implementing NMPs. These agencies also hold trainings for farmers to prepare their own plans. A further recommended strategy is partnering with local universities to research innovative techniques to manage and apply fertilizer and manure to areas prone to excessive

nutrient export. These techniques yield a better benefit to water quality while still producing a profitable yield.

Agricultural Buffers & Cover Crops

Grass and forested buffers and cover crops are voluntary conservation practices that significantly decrease nutrient loading and thereby enhance water quality. Buffers along the edges of farm fields and livestock pastures function similarly to the stream and shoreline buffers mentioned previously. Buffers reduce the amount of pollutants that run off the fields and potentially flow into nearby streams. Vegetative strips of grass, shrubs, and trees slow or intercept water flow capturing or providing temporary retention of pollutants like sediment, pesticides, and nutrients.

Cover crops are vegetation planted after the primary crop has been harvested. They are selected for maximum coverage and have the ability to absorb unused nutrients remaining in the soil and prevent leaching losses (Figure 3.8). They act as a ground cover to protect soil from wind and water erosion in the winter months. In the Spring they add organic matter to soil and may reduce weed competition which in turn may reduce fertilizer requirements. Cover crops are often recommended when low residue producing crops such as soybeans or corn silage are grown on erodible land, as is the case in the Sassafras.

a)

b)

Figure 3.8 Cover crops
a) diagram of cover crop benefits, b) early rye cover crop planted over corn residue

Constructed Wetlands

Nutrient source control can also be addressed in part with the creation of treatment wetlands and the enhancement of existing wetlands. Wetland enhancement work includes small structures built to add water or regulate water levels in an existing or pre-existing wetland. Concrete and earthen structures, usually dikes or embankments, are built to trap water. These practices maintain a predetermined water level in an existing or pre-existing wetland. Adjustable outlets allow the landowner to fluctuate the water level during different seasons. Enhancement also includes planting native wetland vegetation if plant populations need to be supplemented. Wetlands filter nutrients, chemicals, and sediment before water infiltrates into groundwater supplies. They also provide habitat for waterfowl and other species, as well as add beauty and value to a farm. Treatment wetlands are sized and constructed to treat the levels of pollutants particularly nitrogen and phosphorus that are being transported to them. The sizing, plants, and depth are all considered in order to maximize pollutant removal for a given wetland system. These systems can also be used to target those areas in the landscape that may have high pollutant loads and may have lost their historic filtering capacity due to historic loss of wetlands and forest buffers.

Cost Share Programs

There are many cost share programs that assist farmers and landowners in implementing BMPs on agricultural landscapes. These programs will be promoted through targeted outreach and advocacy with a goal of increasing knowledge and participation in the various federal and state programs that provide assistance for utilizing best conservation practices. Table 3.2 describes the various cost share programs in more detail.

Easements

As the population of the Chesapeake Watershed grows at a rate of 10,000 people every three months, there is continued pressure to develop land resulting in the loss of much of the Eastern Shore's farms and sensitive habitats. Educating landowners and advocating for preservation and easement programs is one way to combat this expanding loss. The Sassafras Watershed consists of largely undeveloped lands, therefore, one strategy is to retain as much natural landscape as possible, protecting it from the threat of development as long as possible. The goal is to preserve land and keep it available as a resource for farming, wildlife, and future generations. There are a variety of options available to landowners to voluntarily preserve their land while allowing current and future landowners to continue owning, using, and enjoying the property (Table 3.3).

Table 3.2 Cost-Share Programs Details			
Program	**Grant Administrator**	**Cost-Share Incentive**	**Projects Involved**
The Maryland Agricultural Water Quality Cost-Share (MACS) Program	Maryland Department of Agriculture (MDA)	• 87.5% of installation cost	Wide variety of soil and erosion control BMPs
Cover Crop Program	MDA	• Up to $85/acre	Cover crops planted, managed , and harvested in a manner to promote optimum soil conservation and nutrient management
The Environmental Quality Incentives Program (EQUIP)	USDA – NRCS	• 75% of installation cost • (90% for historically underserved producers)	Expanded list of eligible projects, including installation or implementation of structural and management practices on eligible agricultural land, to control erosion and nutrient runoff
Conservation Reserve Program (CRP)	USDA-NRCS & FSA	• Rental payment: percentage based on type of conservation practice installed. • Up to 87.5% of installation cost	Converts highly erodible cropland and environmentally sensitive areas to permanent cover
Conservation Reserve Enhancement Program (CREP)	USDA-NRCS	• Up to 87.5% of installation cost • Federal and State signing incentive payment of $100/acre • Practice incentive payment of 40% of installation cost • Rental payment: percentage based on type of conservation practice installed. • Maintenance payment: based on conservation practice installed	Protection of highly erodible land and other sensitive farmland through creation of riparian buffers and wetland restoration.

Table 3.2 Cost-Share Programs Details			
Program	**Grant Administrator**	**Cost-Share Incentive**	**Projects Involved**
Wildlife Habitat Incentives Program (WHIP)	USDA-NRCS	• Technical and financial assistance of up to 75% (90% for historically underserved producers) in cost-share ranging from five to ten years in duration	Restoration and management of wildlife habitat on private land including grassland habitat, riparian buffers and wetlands, and forested corridors
The Wetland Reserve Program (WRP)	USDA – NRCS	• Permanent easement: 100% of easement value and restoration cost • 30 Year Easement: 75% of easement value and restoration cost • Cost-Share: no easement placed on land and 75% of restoration cost	Restoration, protection and enhancement of wetlands in exchange for retiring eligible land from agriculture.
Landowner Incentive Program	MD Department of Natural Resources	• Up to 75% cost share on installation costs	Enhancement and restoration of habitat benefitting species-at-risk in MD including reforestation, grass buffers, invasive species control, vegetation management, livestock exclusion, and restoring wetland hydrology
Agricultural Management Assistance Program	USDA-NRCS	• Up to 75% (90% for historically underserved producers) in cost-share ranging from one to nine years in duration	Conservation practices related to organic production (including filter strips, buffers, and cover crops)and irrigation practices

Table 3.3 Conservation Easement Programs			
Program	**Administrator**	**Value paid for easement**	**Purpose**
Farm and Ranch Land Protection Program (FRPP)	NRCS	50% of Fair Market Value paid for easement	Assist in the purchase of development rights to keep productive farm and ranchland in agricultural uses
Maryland Rural Legacy Program	MD Department of Natural Resources (MDNR)	Local governments and private land trusts to competitively apply for funds to complement existing land conservation efforts or create new ones	Protect large, contiguous tracts of land from sprawl development and to enhance natural resource, agricultural, forestry and environmental protection
Maryland Agricultural Land Preservation Foundation	MD Department of Agriculture (MDA)	Owner places bid based on 100% Easement Value minus owner determined tax incentive discount and competitive discount	Preserve large (50 acres or more) of productive agricultural ground to maintain a viable local base of food and fiber production
Donated Conservation Easement	Eastern Shore Land Conservancy (ESLC)	Owner donates Easement and receives various income, property, and estate tax discounts and exclusions	Preserve rural and open land on MD Eastern Shore and keep it available as a resource for farmers, wildlife, and future generations
Wetland Reserve Program	NRCS	100% of Easement Value	Restore, protect, and enhance wetlands, achieve the greatest wetland functions and values, along with optimum wildlife habitat, and establish long-term conservation and wildlife practices and protection

3.6 Pollution Prevention/Source Control Education

Residents and businesses can engage in behaviors and activities that influence water quality. Behaviors that negatively influence water quality include over-fertilizing lawns, excessive use of pesticides, vegetation destruction on eroding banks, and general poor housekeeping practices such as inappropriate disposal of paints, cleaners or automotive fluids, and dumping into storm drains. Whether a pollution prevention program is designed to discourage negative behaviors or encourage positive ones, targeted education is needed to deliver a specific message that promotes behavior changes. Local watershed organizations and other civic groups such as the Master Gardeners are in a position to influence these changes using pollution prevention education and outreach to teach citizens how to properly care for the watershed.

In the Sassafras watershed there are a total of 824 properties within the critical area, and therefore adjacent to tidal waters of the Sassafras River. Strategies involved with residential pollution prevention and source control education focus primarily on lawn care practices such as soil tests to ensure proper fertilization, rain barrels and rain gardens to control stormwater runoff pollution and erosion. Many residential waterfront properties on the Sassafras River have high banks that are prone to erosion. Source control education will also include bank management so that landowners are aware of what can cause and help control erosion.

Pollution source control also includes the management of “hotspots” which are certain commercial, industrial, institutional, municipal, and transport-related operations in the watershed. These hotspots tend to produce higher concentrations of polluted stormwater runoff than other land uses and also have a higher risk for spills. In the Sassafras watershed these hot spots consist primarily of marinas. There are six marinas and one boat yard along the shores of the Sassafras River, that maintain approximately 1,800 boat slips. This concentrated and seasonal boating population can serve as a potential source of pollution as some boaters are not aware of clean boating practices, such as pumping out boat sewage at a pump out station versus dumping sewage overboard. A recommended strategy towards pollution prevention is advocating for the DNR sponsored Clean Marina Program. By enrolling in the Clean Marina Program, marina owners are certified in voluntary maintenance of their facilities in order to manage water resources more consciously. In order to obtain Clean Marina status, a certain percentage of best management practices must be implemented to mitigate environmental impacts. The categories of BMPs include vessel maintenance and repair, emergency planning, stormwater management and sewage handling. Some specific BMPs include: having a spill prevention, control and countermeasure plan, using environmentally neutral materials, conserving water, using oil absorbent materials at the fuel dock, containing dust from sanding and blasting, and having training and drills for staff across all areas. In exchange for enrollment, marina owners are entitled to advertising benefits, improved relationship with regulatory agencies, and reduced insurance rates. Participation in the Clean Marina Program also promotes an environmental ethic and stewardship among boaters who patron those marinas and travel throughout the watershed.

Educating both the current and next generation of environmental stewards is an essential aspect of source control education and pollution prevention. Without present and future concern for the state of the Sassafras Watershed, restoration efforts could prove futile. Recommended strategies include partnering with existing public school conservation programs as well as direct outreach to youth groups such as Boy and Girl Scouts. Water quality sampling is an effective hands-on tool to educate school-aged children on identifying potential problems in the River. Collection and identification of aquatic insects is a simple and fun way of determining stream health. Tablet tests for various water quality parameters such as dissolved oxygen, phosphorus and nitrogen are available to gather a basic understanding of aquatic health. Engaging not only young people, but adults, in naturalist activities such as kayaking and bird/wildlife watching can develop and enhance an appreciation for the natural beauty of the Sassafras River. Interaction with the natural setting of the Sassafras Watershed through promotion of responsible recreation will motivate changes in lifestyles that ultimately improve water quality and the overall health of the watershed.

3.7 State, County and Municipal Practices and Programs

There are many programs developed and implemented by county and state government that can directly support watershed restoration efforts. Frequently, these programs are developed as a result of codes and ordinances set forth by the county or state. An important strategy to restore the Sassafras Watershed is participation in local code and ordinance reviews, such as those relating to stormwater and erosion. Every county is required to have a Stormwater Management Program (SWMP) which includes stormwater pollution prevention activities, tracking and evaluation. Erosion and sediment control at construction sites is a requirement under the SWMP. Under current state law, construction sites disturbing over 5,000 square feet must have an approved erosion and sediment control plan. Advocating for better site design, now a component of the new Maryland Stormwater management regulations, will help prevent and control stormwater runoff.

In addition to SWMP, counties and towns within urban areas (currently only Cecil County and its municipal jurisdictions falls into this category – though this will be changing over time due to Bay TMDL), must also engage in stormwater pollution prevention efforts in accordance with Maryland's general permit for stormwater discharges from small municipal separate storm sewer systems (MS4s). MDE defines an MS4 as "a conveyance or system of conveyances owned and operated by a State, city, town or other public body having jurisdiction over disposal of sewage, industrial waste, stormwater, or other wastes. These systems are used for collecting or conveying stormwater, are not combined sewers, and are not part of a Publicly Owned Treatment Works." MS4s are also required to obtain coverage under the NPDES general permit. This means that any conveyance associated with construction site run off, illicit discharges, etc. must be controlled by the county or municipality under which the operation received the permit.

Another program that has been developed by the Federal Government and implemented by the State Government as a requirement under the Clean Water Act, is the Total Maximum Daily Load (TMDL) program. The purpose of the TMDL is to establish a baseline pollutant load that a water body can maintain while meeting its designated uses. If a river is listed for various impairments, a TMDL is supposed to be written for each one. The Sassafras River is impaired by nutrients, PCB's, sediment and biological/habitat impairments, but only a TMDL for Phosphorus and a TMDL for PCB's have been written to address those impairments. One recommended strategy is to advocate for or investigate the science needed to set TMDLs for the remaining impairments that also inhibit the Sassafras River from meeting its designated uses.

The Chesapeake Bay TMDL

The Chesapeake Bay TMDL is a work in progress, actually a combination of 92 smaller TMDLs for individual Chesapeake Bay tidal segments, which will include limits on nutrients and sediment sufficient to achieve state clean water standards for dissolved oxygen, water clarity and algae. Pollution limits will be divided among the major river basins across Maryland, Virginia, Pennsylvania, Delaware, New York, West Virginia and Washington D.C. The loadings and target reductions will then be further divided among local sources. This Bay-wide TMDL will assist with the process of establishing TMDLs for impairments of the Sassafras that have yet to be addressed. All states in the Chesapeake Bay watershed will be required to prepare Watershed Implementation Plans indicating how they will accomplish their shares of the pollution loading and reductions. The plans will identify targets by geographic location and source sector and will include a description and schedule of actions to be taken to achieve the reductions. The plans will be supported by a series of two-year milestones for achieving specific near-term pollution reduction actions and targets needed to keep pace with commitments.

The states and EPA will monitor the effectiveness of the pollution reduction actions to assess progress and water quality response, and employ consequences if commitments are insufficient or there is failure to meet established milestones. The EPA is working towards a completion date of December 2010, and the TMDL as well as accompanying draft implementation plans will be offered for public comment.

4.0 WATERSHED CHARACTERISTICS AND RESTORATION OPPORTUNITIES

The Sassafras River Watershed is located on the upper eastern shore of the Chesapeake Bay. The headwaters begin in western Delaware and flow westward 20 miles to the Chesapeake Bay, draining approximately 97 square miles of land area, the majority of which is used for agriculture. The watershed lies in part of three counties, predominately Cecil and Kent in Maryland and a small portion in New Castle County, Delaware. Three municipalities lie within the watershed, Betterton and Galena in Kent County and a portion of Cecilton in Cecil County. Selected watershed characteristics are given in Table 4.1 and more detailed description watershed can be found in the Sassafras River Watershed Characterization (Appendix 6.0).

The methodology, characteristics, restoration opportunities, and implementation priorities of the Sassafras River Watershed are detailed according to the four assessment types (shoreline, stream corridor, upland, and synoptic) and are addressed subsequently in their respective sections. Restoration opportunities include stream and shoreline restoration, stormwater retrofits, onsite sewage disposal system repairs and upgrades, municipal wastewater treatment plant upgrades, agricultural practices and programs, and source control education. Implementation priorities are determined by conditions at the time of each assessment, the widespread application of the restoration practice, cost-benefit analysis, and the feasibility of implementation. Estimated implementation costs, a project schedule, and relationship between restoration projects and overall watershed strategies can be found in Section 5.0.

Table 4.1 Key Characteristics of the Sassafras River Watershed	
Drainage Area	• 96.9 mi^2
Stream length	• 20.6 miles
Land Use	• Agriculture (57%) • Forest (24%) • Developed (4%) • Water (14%) • Wetland (1%)
Land Area by County as Percent of Total Watershed Area	• Kent County, MD (51%) • Cecil County, MD (28%) • New Castle County, DE (8%) • Surface Water (13%)
Current Impervious Cover	• 2.2 %
Dominant Soil Types by Hydrologic Groups	• 00.5% - A – well drained • 66.8% - B – moderately well drained • 23.3% - C – poorly drained, impeding layer • 05.7% - D – very poorly drained
Subwatersheds	• Sassafras River • Turner's Creek/Lloyd Creek • Money Creek • Woodland Creek/Dyer Creek • Back Creek • Swantown Creek • Herring Branch

4.1 Shoreline Assessment

Overview & Methods

The Shoreline Assessment provides the location and description of potential environmental problems along a watershed's tidal shorelines. The assessment of the Sassafras shoreline was a combination of three different surveys, the Virginia Institute of Marine Science (VIMS), Sassafras River Association (SRA)/Maryland Department of Natural Resources (DNR), and SRA/United States Fish and Wildlife (USFW). The VIMS survey is a rapid method of examining and cataloguing the observable environmental problems within a watershed in order to better target future monitoring, management, and restoration efforts. As part of the VIMS survey, specially trained personnel slowly cruised along the shoreline in a small boat and recorded the location and characteristics of readily observable potential problems. Each site is then ranked on a scale of one to five for its severity, correctability, and access for restoration work. More detailed methodology can be found in (Berman *et al.*, 2006). The shoreline fieldwork results referenced were initially conducted during the summer of 2004 by VIMS for DNR and completed in the summer of 2009 by DNR Watershed Services Unit and SRA using spatially referenced videography. Verification of the data was conducted by SRA and restoration engineers using high resolution photography and ground-truthing. This data is representative of the existing shoreline conditions of the Sassafras Watershed. The survey resulted in the assessment of 74.1 miles of shoreline or approximately 84.6% of total tidal shoreline in the watershed. Although this survey does not represent all of the tidal shoreline it contains most of the high energy areas along the river where the majority of potential problems are expected to be located. The remaining unsurveyed shoreline is typically located in low energy well buffered areas close to the non-tidal tributaries where minimal problems would be expected to be found.

Results

Shoreline Features

A total of 406 individual shoreline features were identified by the VIMS survey along the Sassafras. The majority of features were private docks (286), followed by private boat ramps (51), and pipe outfalls (26). Nine groinfields, 4 jetties and 1 breakwater were located. Of the approximately 74 miles surveyed 10.6 miles were considered altered shoreline falling onto one of 6 categories (Table 4.2). Significant areas of altered shoreline were primarily bulkheads and riprap, representing 43% and 41% of the total altered shoreline surveyed. A small portion of the bulkheaded shoreline was considered seriously dilapidated (0.26 miles). A significant portion of the shoreline was also found to be debris laden (1.19 miles). Hardened shoreline features such as bulkheads and riprap are generally undesirable because they can cause habitat fragmentation and are generally not as effective as natural shorelines at mitigating erosion and nutrient contributions. Future efforts to improve the ratio of hardened to natural shoreline will attempt outreach to homeowners informing them of the benefits of a non-hardened shorelines. This outreach effort will especially target those areas with failing or dilapidated structures.

Table 4.2 Altered Shoreline Features							
		Miles of					
Plate Number	Miles Surveyed	debris	unconventional	bulkhead	dilapidated bulkhead	riprap	wharf
1	4.37	0.00	0.03	0.40	0.01	0.51	0.00
2	7.34	0.00	0.03	1.07	0.03	0.65	0.00
3	7.22	0.00	0.00	0.00	0.00	0.26	0.00
4	5.53	0.00	0.00	1.34	0.00	0.74	0.00
5	5.63	0.00	0.06	0.50	0.00	0.26	0.00
6	3.72	0.00	0.00	0.00	0.00	0.02	0.00
7	2.62	0.14	0.04	0.21	0.04	0.60	0.00
8	3.08	0.13	0.00	0.01	0.00	0.04	0.00
26	3.98	0.07	0.00	0.66	0.13	0.24	0.00
27	4.69	0.29	0.00	0.00	0.00	0.14	0.00
28	6.40	0.53	0.00	0.05	0.00	0.49	0.07
29	8.95	0.00	0.02	0.03	0.00	0.16	0.00
30	5.60	0.03	0.00	0.28	0.05	0.22	0.00
31	4.95	0.00	0.00	0.00	0.00	0.00	0.00
Total	**74.08**	**1.19**	**0.18**	**4.55**	**0.26**	**4.33**	**0.07**

Shoreline Landcover and Buffers

Landcover along the Sassafras tidal shoreline was dominated by forest, residential, and agriculture (Figure 4.1). A total of 5.2 miles of shoreline were found to have inadequate buffers in the tidal reaches of the Sassafras River. Inadequate shoreline buffers were considered as such when the forested buffer did not extend more than 50ft beyond the bank of the river or the vegetation was sufficiently sparse that the net effect would be the same. These buffers were identified using aerial images from 2007 National Agriculture Imagery Program (NAIP). The majority of the 47 sections of inadequate buffers are located on the main stem between Ordinary Pt. and Georgetown. The longest section is 0.38 miles long with an average length of 0.11 miles. Shoreline sections of inadequate buffers with the highest priority for restoration are sections that overlap with erosion and bank stabilization opportunities detailed in Table 4.4. Where other restoration opportunities cannot be coupled to sections of inadequate buffers, additional investigation into nutrient loadings and available wave energy at the specific sites will be used to better prioritize these sections of shoreline.

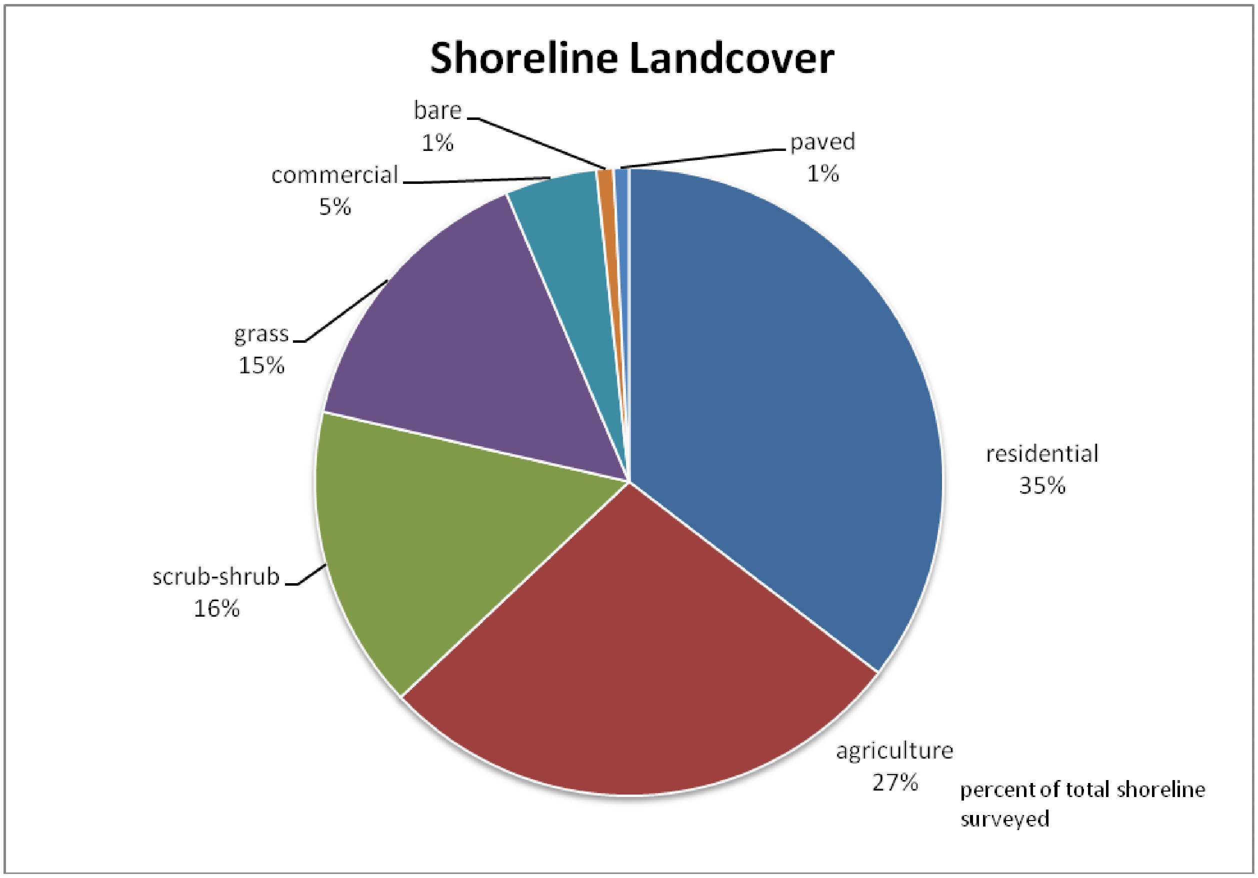

Figure 4.1 Shoreline landcover by type as a percentage of total miles surveyed.

Shoreline Erosion Sites

Estimates of shoreline erosion in the VIMS survey were classified according to 4 categories of bank height (0-5 ft., 5-10 ft., 10-30 ft., >30 ft.) and three subcategories of erosion type (low, high, and undercut (uc)) (Table 4.3). A total of 15.0 miles (20.2%) of shoreline was classified as a high erosion sections over all of the four height classifications. Of the approximately 80% of shoreline remaining most consist of low erosion sections, with a few small sections of undercut bank (0.35 miles). Further field investigation of the high erosion shoreline sections previously classified by VIMS was conducted by SRA and restoration engineers to identify priority locations based on additional erosion investigation and restoration potential. From this analysis 54 sections were identified along the Sassafras River for potential restoration, accounting for over 4.0 miles of shoreline; high priority sites are listed in Table 4.4 and representative sites can be seen in Figure 4.2. These sites represent the best locations to target future restoration efforts to reduce sediment and nutrient contribution from the tidal shorelines. Each site was rated one, three or five depending on the severity of the problem. One means most severe and this case means active erosion due to either human impact or strong tidal impact. This rating could also be due to a threat to a natural resource or infrastructure. Three indicates that erosion could be active and there might be some undercutting of banks but no threat to infrastructure. Five indicates minor erosion with fairly stable banks and buffers. These sites have an insignificant impact to the system and most likely cost more to correct than the benefit is worth.

Table 4.3 VIMS Shoreline Assessment Bank Erosion Conditions

Plate Number	Total Miles Surveyed	0-5 ft			5-10ft			10-30ft			>30ft		
		low	high	uc	low	high	uc	low	high	uc	low	high	uc
1	4.37	0.63	0.11	0.00	0.36	0.13	0.00	1.50	0.22	0.00	0.74	0.68	0.00
2	7.34	1.24	0.05	0.00	1.16	0.14	0.00	2.47	0.59	0.00	1.51	0.13	0.00
3	7.22	3.01	0.80	0.00	1.41	0.88	0.00	0.19	0.61	0.00	0.00	0.00	0.00
4	5.53	4.22	0.00	0.00	1.04	0.11	0.00	0.12	0.02	0.00	0.00	0.00	0.00
5	5.63	2.98	0.00	0.00	1.04	0.31	0.00	1.05	0.06	0.00	0.07	0.12	0.00
6	3.72	2.53	0.00	0.00	0.07	0.24	0.00	0.41	0.30	0.00	0.17	0.00	0.00
7	2.62	0.77	0.00	0.00	0.25	0.15	0.00	0.65	0.23	0.00	0.05	0.53	0.00
8	3.08	1.50	0.02	0.00	0.07	0.03	0.00	1.05	0.03	0.00	0.33	0.06	0.00
26	3.98	1.67	0.00	0.00	0.30	0.12	0.00	0.06	1.12	0.00	0.12	0.59	0.00
27	4.69	2.68	0.00	0.00	0.34	0.41	0.00	0.31	0.41	0.00	0.12	0.40	0.00
28	6.40	3.22	0.05	0.00	1.00	0.55	0.00	0.50	0.77	0.00	0.09	0.23	0.00
29	8.95	5.86	0.24	0.02	0.43	0.35	0.15	0.75	0.40	0.00	0.70	0.05	0.00
30	5.60	2.22	0.13	0.00	0.53	0.35	0.10	1.17	0.48	0.04	0.50	0.09	0.00
31	4.95	0.79	0.14	0.00	0.40	0.56	0.04	1.52	0.38	0.00	0.50	0.63	0.00
Total	**74.08**	**33.32**	**1.54**	**0.02**	**8.40**	**4.33**	**0.29**	**11.75**	**5.62**	**0.04**	**4.90**	**3.51**	**0.00**

Table 4.4 High Priority Shoreline Sites

Site ID	Site Name	Bank Characteristic	Inadequate Buffer	Bank Height (ft)	Bank Length (m)	Bank Condition	Severity	Recommended Practice
BL03	Betterton Bluff	Bluff with Forest Buffer		>30	344	vegetation on bank stable, top down issue with some top slumping	1	outreach to homeowner on buffer management and planting, and offshore breakwater
SE01	Lloyd's Creek 1	Actively Eroding Natural Resource Concern Site		5	18	from top of bank towards the water there is active erosion.	1	stone sill to replenish beach and fill in sand up to spit

Table 4.4 High Priority Shoreline Sites								
						no beach and trees are dying.		
SE02	Lloyd's Creek 2	Actively Eroding Natural Resource Concern Site		5	39	from top of bank towards the water there is active erosion. No beach and trees are dying.	1	stone sill to replenish beach and fill in sand up to spit
SE03	Kentmore 1	Erosion Overland Flow	Yes	>30	185	top down slumping from water flow over	1	outreach to landowner on buffer management
SE04	Kentmore 2	Erosion Overland Flow and Tidal Influence	Yes	5	77	both top down slumping as well as tidal affects making bank unstable	1	segmented sill and living shoreline
SE06	Knights Island	Erosion Tidal Influence		10	110	threat to house and possible near shore septic.	1	near shore breakwater and build off sediment
SE18	Cassidy Wharf	Erosion Tidal Influence		20	194		1	offshore breakwater
BL14	Money Creek	Bluff with Forest Buffer	Yes	15	95	erosion from field going over with vertical gullies	1	divert water from overflow and plant buffer
SE19	Grove Point	Erosion Tidal Influence		>30	360	high erosion with no vegetation on bank. Stressed due to seasonal camp use.	1	offshore breakwater

a)

b)

Figure 4.2 Priority shoreline site examples
a) Site ER06 – active erosion with possible threat to infrastructure, b) Site ER01 – tidally influenced erosion at Lloyd's Creek.

4.2 Stream Corridor Assessment

Overview

The purpose of the stream corridor assessment (SCA) was to assess the current conditions within the riparian zone of the non-tidal stream network. Potential problems impacting these streams fall into the following general categories:

- Erosion sites
- Inadequate stream buffers
- Barriers to fish migration
- Visible pipe discharges
- Trash dumping sites
- In or near stream construction
- Channelized sections of stream
- Any other unusual conditions

The identification of the location and characteristics of these typical environmental issues provides a comprehensive view of potential problems impacting the upland drainage system and possible sites for the implementation of future restoration strategies. This is an invaluable tool as these typically small streams ultimately influence the larger tidal waters of the Sassafras River and Chesapeake Bay. A more detailed description of the history, objectives, and methodology associated with the SCA can be found through the Maryland Department of Natural Resources Stream Corridor Assessment manual (Yetman, 2001).

Methods

Due to the size of the Sassafras River watershed and overall length of non-tidal stream corridors, specific streams were targeted for sampling based on perennial streamflow. Prior to the SCA, the Sassafras River Association notified landowners adjacent to targeted streams through a mailed letter outlining the SCA process. Response cards were included in the mailing allowing landowners to grant access permission to the survey crews. The SRA was granted access to approximately 30% of the parcels identified to be adjacent to a perennial stream. The SRA believes this sample represents an adequate representation of the conditions impacting the non-tidal riparian corridors of the Sassafras, but given the limitations of accessing all the streams the assessment should not be considered a comprehensive survey.

Teams composed of members of the Maryland Conservation Corp (MCC) and SRA staff were trained by Maryland Department of Natural Resources, according to methods outlined in MD-DNR SCA survey protocols manual (Yetman, 2001). The teams were equipped with maps, aerial photographs, parcel information, digital cameras, and global positioning systems (GPS) to locate and document the condition of the stream corridors. They noted various stream characteristics including natural areas, healthy ecological stream systems, as well as areas of erosion, limited buffers, fish blockages, pipe outfalls, and other points of environmental interest. After documenting the location with GPS and acquiring digital photographs, each potential problem was rated on a scale of 1 to 5 across three categories: severity, correctability, and accessibility.

The severity rating ranks the severity of problem relative to other problems in the same categories within the watershed, from 1 (most severe) to 5 (minor severity). The correctability ratings describe the degree to which the potential problem is deemed fixable from 1 (minor problems) to 5 (major restoration efforts). Accessibility is the ease (1) or difficulty (5) of reaching the site assuming permission to access is granted from landowners. It should be noted that all ratings are relative to the specific category and the Sassafras River watershed. Additionally, while the survey teams are well trained they are typically not engineers or scientists familiar with these issues and their remediation, therefore survey crew ratings are treated as indicators for future investigation rather than the absolute characterization of the issue. Upon completion of the field survey, data and images were compiled, verified, and entered, into a database and geographic information system (GIS).

Results

Over the course of multiple days during the months of February, March, and April of 2009, 236 potential problems were identified along the surveyed stream corridor (Table 4.5). Representative examples of the various impairments are pictured in Figure 4.3. Barriers to fish movement represented the largest number of identified features followed by channel alterations, unusual conditions, erosion, inadequate buffers, trash dumping sites and pipe outfalls.

Table 4.5 Summary of SCA Potential Problem Sites	
Stream Impact	Number of Identified Sites (total estimated length)
Channel Alteration	36 (1579 ft)
Erosion	21 (3556 ft)
Fish Barrier	123
Inadequate Buffer	11 (9130 ft)
Pipe Outfall	9
Trash Dumping	11
Unusual Conditions	25
Total	**236**

Erosion

Of the 21 erosion sites identified through the SCA, 10 were classified by the survey teams with a maximum severity of 1. However, after further analysis most of these locations were not deemed to be high priority sties at which to target erosion given their location within the stream network and the associated low flow volumes. Details for two sites identified through the SCA are included in Table 4.6. During the visual inspection of prime runoff locations from streets, parking lots, and storm drains, the Center for Watershed Protection (CWP) identified a total of 5 eroded stream sites (Table 4.6). The problem sites located represent significant sources of sediment and nutrient input into the stream network due to large contributing areas generating considerable erosion from headcutting, downcutting, and widening of the stream channel from both banks (Figure 4.4). Three sites ER-100, ER-101, ER-102 were ranked at severity level of 4 or greater and are recommended as potential retrofit candidates using a regenerative stormwater conveyance as described in Section 3.1. This type of retrofit uses a wetland based system that minimizes potential for erosion.

a)

b)

c)

d)

e)

f)

Figure 4.3 Potential problems found during the stream corridor assessment
a) pipe outfall, b) inadequate buffer, c) erosion, d) fish barrier, e) trash, and f) unusual condition (bridge collapse).

Table 4.6 Summary of Selected Erosion Sites							
Site ID	**Process**	**Bank Height (ft) (LT, RT)**	**Bank angle (°) (LT, RT)**	**Bottom Width (ft)**	**Top Width (ft)**	**Wetted Width (ft)**	**Severity**
ER-100	downcutting, widening, headcutting	6, 6	60, 60	8	12	8	4
ER-110	downcutting, widening, headcutting	8, 8	> 75, > 75	10	14	10	4+
ER-120	downcutting, widening, headcutting	15-18, 15-18	> 75, > 75	6-15	8-18	6-6	4+
ER-130	downcutting, headcutting	4, 4	> 75, > 75	4	6	4	3
ER-223201	headcutting	3,3	60,60	2	13	N/A	3
ER-226201	headcutting	15,15	60,60	2	20	N/A	2
ER-140	headcutting	1, 1	> 75, > 75	2	3	N/A	1


a)


b)

Figure 4.4 Examples of severe erosion and priority project sites
a) ER-100 Rt. 301, b) ER-110 Near weigh station on Rt. 301

Inadequate Buffers

Over 3.6 miles of inadequate buffers were identified over 11 sections of stream during the SCA. These sections were primarily located within or along the borders of agricultural fields. In addition to the field based survey, 2007 aerial images from the National Agricultural Image Program were analyzed for inadequate buffers along non-tidal stream corridors. Buffers were considered inadequate at widths less than 50 feet per each bank. Approximately 25.7 miles of inadequate buffers were identified using this method across the entire watershed. The identified inadequate buffers were predominately associated with agricultural areas. Typically they were located along drainage swales (12.7 miles) or upland ponds (13 miles) within the stream system. The extent to which the swales contain perennial flows or significant stormflow requires additional field investigation, but given their proximity to potentially high nutrient and sediment sources improving buffers along these reaches is likely warranted where access permission is available and downstream hydrology is not ideal for additional nutrient retention. Eighteen locations were identified as potential targets for restoration based on the assessment and correlations with areas of existing high nutrient export found through the synoptic survey. These selected sections total approximately 4.51 miles and are listed in Table 4.7.

Table 4.7 Prioritized Inadequate Buffers in Upland Stream Corridors

Name	Length (mi)	Type
SCIB_01	0.32	drainage swale
SCIB_02	0.31	drainage swale
SCIB_03	0.57	stream/swale
SCIB_04	0.53	stream/swale
SCIB_05	0.33	stream/swale
SCIB_06	0.33	stream/swale
SCIB_07	0.13	stream/swale
SCIB_08	0.13	stream/swale
SCIB_09	0.06	stream
SCIB_10	0.05	stream
SCIB_11	0.39	pond
SCIB_12	0.29	pond
SCIB_13	0.24	pond
SCIB_14	0.21	pond
SCIB_15	0.19	pond
SCIB_16	0.14	pond
SCIB_17	0.12	pond
SCIB_18	0.08	pond
Total	**4.43**	

Trash Dumping

Nine locations of trash accumulation were discovered over the course of the survey. The majority of these represent old dump sites for tires and larger equipment. None of the sites appeared to be an active dumping location. Given the inaccessibility of some locations not all are good candidates for clean up, however, select sites may present good opportunity for volunteer cleanup efforts.

Fish Barriers

While fish barriers represented the largest number of sites identified through the SCA, their prevalence is not in proportion to their potential impact on the watershed. The majority of fish barriers identified are small logs or collections of brush and debris that cause a temporary restriction in the stream channel. Because a large portion of the stream corridors within the watershed are forested there is always significant material to generate the smaller debris dams and can be considered a naturally occurring component of a woodland stream. A small number of beaver dams were identified, but the nutrient retention ability of beaver ponds is considered to outweigh the potential impact of fish movement so far upstream. Researchers in Virginia have found that beaver dams often do not function as fish barriers because they are relatively porous and fish can make their way through small crevices in the dam (CES-VCU, 2003). A significant fish barrier exists at the Mill Pond Dam where a large drainage area is blocked from upstream movement of anadramous and resident fish. However, the miles of habitat that would be created by providing passage are limited due to upstream ponds and other barriers. To a lesser degree Indian Acres Dam also serves as a barrier though less than one mile of perennial stream exists above the pond in this relatively small drainage area. Inspection of the dam culvert also led us to believe there are some potential maintenance issues at the dam and failure is possible if a large event or series of large events occurred.

Pipe Outfalls

The pipe outfalls identified were primarily large diameter pipe used for stormwater drainage from outlying areas. Given the antecedent moisture conditions at the time of survey, little or no discharge was observed. At some outfalls there was adequate erosion prevention material such as rip rap, but even at non-engineered outfalls there is little evidence of erosion. The addition of sediment and nutrients from these outfalls is unknown, but there was no physical evidence observed that suggested the discharge of substances other than stormwater. The majority of identified outfalls warrant no additional action at this time, however further investigation of one outfall identified from afar would be desirable as it is potentially draining a high sediment generating area.

4.3 Upland Assessment

Overview

The upland assessment is a rapid method that combines desktop and field work to quickly identify, locate, and characterize potential pollution sources in the non-riparian areas of the watershed. After evaluation, the resulting data serves as a comprehensive inventory of potential projects for future restoration. The assessment is based on the Unified Subwatershed and Site Reconnaissance (USSR) developed by the Center for Watershed Protection (CWP). It is composed of four distinct components, 1) Neighborhood Sources Assessment (NSA), 2) Hotspot Site Investigation (HSI), 3) Pervious Area Assessment (PAA), and 4) Streets and Storm Drains (SSD).

Methods

Prior to the actual field investigation significant analysis is put into the assessment through the gathering of information such as neighborhood locations, census data, municipal maintenance schedules, and current development projects. After gathering this background information it is compiled and field maps generated that delineate subwatershed and neighborhoods and serve as the basis for field investigation. The field investigation involves driving all roads within the watershed, and conducting the evaluation of neighborhoods, hotspots, pervious areas, and roads and storm drains. These locations are recorded with GPS and characterized according to criteria specific to each of the assessment subcomponents. Post-field analysis is conducted to verify data and maps, enter data into databases and geographic information system, and compile data for the development of initial restoration strategies. More detailed information on the USSR process can be found in the Urban Stormwater Restoration Manual produced by the Center for Watershed Protection (Wright, 2005).

Results

The upland assessment was conducted by members of the Center for Watershed Protection and Sassafras River Association over the course of three days in April 2009. A total of 39 sites were located and characterized across three of four components of the USSR process highlighted in the Urban Stormwater Restoration Manual. The Streets and Storm Drains (SSD) was not done due to the infrequency of curb and gutter and traditional stormdrains in this primarily rural watershed. The Pervious Area Assessment (PAA) results are not presented separately, but integrated into the HIS and NSA.

Hotspot Site Investigation (HSI)

Hotspots are defined as commercial, industrial, institutional, municipal, or transportation related infrastructure or properties that are known to have a higher potential for pollution from spills, leaks, or illicit discharges. Potential pollutants include nutrients, pesticides, herbicides, fuels, road salt, bacteria, trace metals, and volatile organic compounds. While each hotspot location is unique, and to a certain extent must be assessed individually, there are six common operations that are typically found at all sites. These include vehicle operations, wastewater discharge, outdoor material storage, waste management, turf/landscaping, and stormwater infrastructure.

A total of 7 hotspots and 3 potential hotspots in the Sassafras River Watershed were identified during the upland assessment. They included 5 marinas, 2 wastewater treatment plants (WWTP), 2 municipal properties, and one large campground and are detailed below in Table 4.8. Five marinas were identified as either hotspots or potential hotspots. While each marina is unique to a certain extent, many of the marinas identified have the capacity to address runoff from large impervious or hardened areas. All marinas identified should also be included in targeted education efforts and introduction and inclusion into the Clean Marina Program. Two municipal locations, the Galena Fire Department and Cecilton Public Works Yard, could both benefit from downspout disconnection and rerouting to pervious areas or rain gardens.

One large campground was identified as a potential hotspot in the Sassafras watershed. This campground, Indian Acres, was originally established as a part time residency. On the campground there are approximately 2150 parcels: roughly 1700 privately owned and 450 owned by the management company that maintains the property. At the individual campsites, residents have holding tanks where waste and grey water is collected (Figure 4.5a.) When these tanks are full, they are pumped out and the waste is transported to one of nine large community septics, where the waste settles out in the larger drain field (Figure 4.5b.) Over the years, more residents began living at the campground on a full time basis, but the infrastructure for handling waste was not adequately upgraded to account for this increase in waste flow and septic usage. A recommended strategy based upon the hotspot investigation includes an upgrade in the current system of waste handling and disposal to account for increased flows, as well as testing and monitoring of the larger septics to ensure adequate capacity and function.

a)

b)

Figure 4.5 Indian Acres Campground
a) waste disposal at individual campsite, b) community septic fields where waste is discharged from individual campsites

The two largest point sources of pollution in the Sassafras Watershed are Betterton and Galena Wastewater Treatment Plants (WWTPs). Galena’s plant was built in 1962, and it currently discharges at or near its 60,000 gallons of wastewater per day permitted capacity which is treated using a lagoon system. Although this system has been used to treat wastewater for many years in small communities like Galena, it is not capable of matching the pollutant removal efficiencies provided by new wastewater treatment technologies. Both nitrogen and phosphorus are causes of water quality degradation in the Sassafras River and lagoons systems do not provide the environment needed to remove significant amounts of these nutrients. Betterton’s plant was built in 1969 and discharges effluent at a rate of about 15,000 gallons per day, approximately 7.5% of its permitted value. At Galena raw wastewater is mechanically screened, treated in an aeration tank and clarifier-digester that is housed in a single tank. While this method has been maintained for many years, like the lagoon system, it is an outdated facility that is incapable of reducing nitrogen and phosphorus to anywhere near the same levels as current treatment technologies.

Table 4.8 Summary of Hotspot Site Recommendations								
Location			Pollution Prevention Opportunities					
Status	Site ID	Description	Vehicle Operations	Wastewater Discharge	Outdoor Storage	Dumpster Management	Proposed Retrofit	Recommended Actions
Potential	P1	Galena Volunteer Fire Department	Y	N	Y	Y	Downspout disconnect, rain gardens	Site inspections, include future education effort, onsite non-residential retrofit
Potential	P2	Cecilton Public Works Yard	Y	N	Y	N	Downspout disconnect, determine if there is existing stormwater management	Include future education effort
Potential	P3	Gregg Neck Boat Yard (Marina)	Y	unk	Y	Y	Potential sand/gravel bed	Suggest follow up on site inspection. Include in future education effort. Engage in cleanup and Clean Marina program.
Confirmed	H-100	Betterton WWTP						Upgrade/replace
Confirmed	H-110	Sailing Associates (Marina)	Y		Y	Y	Rain barrel , rain garden or native landscaping	Include in future education effort. Engage in Clean Marina program.
Confirmed	H-120	Skipjack Cove (Marina)	Y		Y	Y	Dry swale	Include in future education effort. Continue to engage in Clean Marina program. On-site non-residential retrofit.
Confirmed	H-130	Sassafras Harbor (Marina)	Y		Y	Y	Proprietary device (for power wash area)	Include in future education effort. Engage in Clean Marina program. Assist with on-site non-residential retrofit.
Confirmed	H-140	Granary (Restaurant/ Marina)	N		Y	Y	Permeable paver parking lot retrofit on upper parking lot	Suggest follow up on-site inspection. Include in future education effort. Catch basin clean out. On-site non-residential retrofit.
Confirmed	H-150	Galena WWTP						Upgrade/replace
Potential	H-160	Indian Acres (Campground)	N				Assess for stormwater retrofit possibility and gully erosion	Engage in upgrade of septic using Flush fund program

Neighborhood Source Assessment (NSA)

A total of 16 neighborhoods were investigated over the course of two days in April, 2009. Prevention opportunities to address stormwater volume and pollutants include public education on lawn care (nutrient management through soil tests/fertilization), stormwater management (rain gardens/rain barrels), and bank and buffer management (vegetation as a bank stabilizer – tree planting). These are outlined in Table 4.9. Stenciled storm drains were absent from most of the neighborhoods and may be a potential low cost project that would both engage homeowners and increase awareness. Large impervious areas represented by rooftops could be disconnected and redirected to existing pervious areas or directed to new rain gardens or rain barrels. There is minimal opportunity for the removal of impervious cover, however one multi-family parking lot in Betterton was considered to be a good candidate for the incorporation of pervious pavement. Four neighborhoods have potential for cul-de-sac bioretention installations and multiple neighborhoods could benefit from incorporation of best management practices to remove sediment from roadside swales and catch basins (Figure 4.6). Additional investigation is warranted for two subdivisions to better determine existing septic practices and assess potential for improvement. A summary of proposed retrofits identified is listed in Table 4.10.

a) **b)**

Figure 4.6 Neighborhood Source Assessment

a) Bioretention installation site candidate b) BMP needed here to remove sediment

Table 4.9 Summary of Neighborhood Assessment Recommendations

Location	Neighborhood Name	City/Town Name	Pollution Severity	Restoration Potential	Impervious Cover Removal	Storm drain stencil	Downspout Disconnection	Rain Barrels and/or Gardens	Fertilizer reduction	Pet waste management	Bayscaping/Landscaping	Trash education/management	Percent high lawn care	Percent med lawn care	Percent low lawn care	Retrofit Potential	Retrofit Description	Recommended Actions
N1	Evergreen Knoll	Betterton	Moderate	Low	n	n	n	y	n	n	y	n	0	0	100	n		
N2	Rigbie Bluff	Betterton	Moderate	Moderate	y	y	y	y	n	y	y	n	0	100	0	y	Pervious pavement for multi-family parking lot area	
N3	Crews Landing	Betterton	Moderate	High	y	y	y	y	n	y	y	n	0	100	0	n		Clean/Maintain Storm Drains
N4	General	Betterton	Moderate	High	n	n	y	y	n	y	y	n	0	80	20	n		Better management of common space and BMP maintenance.
N5	Dogwood Village	Galena	Moderate	Moderate	n	n	y	y	y	y	y	n	25	75	0	y	Cul-de-sac bioretention.	
N6	Phelps, Seminary Way	Galena	Moderate	Moderate	n	y	n	y	n	y	y	n	0	75	25	y	Cul-de-sac bioretention.	BMP maintenance to remove sediment from roadside swales.
N7	off Jim Davis Rd., Mark & Hickory	Galena	Moderate	Moderate	n	n	y	y	n	n	y	n	0	100	0	y	Cul-de-sac bioretention.	BMP maintenance to remove sediment from roadside swales.
N8	Indian Acres	Fredericktown	Moderate	Moderate	n	n	n	n	n	y	y	y	0	0	100	y	Assessment and updating the pump out stations.	Determine septic practices
N9	Ceciltown, Waters Ave.	Ceciltown	Moderate	Moderate	n	y	n	y	n	n	y	n	0	10	90	n		BMP maintenance to clean out sediment and organic matter from the stormwater catch basins.
N10	Cheshaven, Chesapeake Civil Assoc.	Cheshaven	Moderate	Moderate	n	n	n	y	n	n	y	n	0	80	20	n		
N11	Tockwah St/Beginning of Cheshaven	Cheshaven	Moderate	Moderate	n	n	n	y	n	n	y	n	0	60	40	n		
N12	Foxhole Estate	Galena	High	Moderate	n	n	n	y	n	n	y	n	0	80	20	n		BMP maintenance

Table 4.9 Summary of Neighborhood Assessment Recommendations

N13	Shorewood	Galena	Moderate	Moderate	n	n	n	y	n	n	y	n	10	70	20	y	Cul-de-sac bioretention.	
N14	Hunter's Run	Galena	Moderate	Moderate	n	n	n	y	y	y	y	y	0	75	25	y	Plantings in the bioretention area and remove back polyfiber in the pond.	
N15	Beechwood Glen	Galena	Moderate	Moderate	n	n	n	y	n	n	y	n	10	65	25	y	Ravine with erosion beginning at near Gregg Neck Road.	Determine septic practices. Lots are very small for septic, but neighborhood is older (>10 yrs)
N16	Kentmore Estates/Kentmore Park	Galena	Moderate	Moderate	n	n	y	y	y	n	y	y	0	75	25	n		

4.4 Synoptic Assessment

Overview

As a follow up for the TMDL, a synoptic nutrient survey was conducted by the Maryland Department of the Environment (MDE) during 2006-2007 throughout watersheds in the upper eastern shore of the Chesapeake Bay. This survey included 27 sites within the Sassafras River Watershed that were sampled during that period. As an update for SWAP, MDE sampled 18 sites in the Spring and Fall of 2009 throughout the Sassafras watershed. Nitrogen and phosphorus were targeted during sampling periods in September 2006, April 2007 and in 2009. Sampling was conducted during a period of high ground water recharge in the spring and during a period of minimal ground water recharge in the fall. This was done to capture seasonal variations in streamflow.

Methods

Sites were primarily chosen by MDE based on public access, therefore, most sampling sites were located at road/stream intersections or in some cases selected based on the ability to require landowner permissions. Grab samples of water (500 ml) were collected just below the surface at mid-stream and filtered using a 0.45 micron pore size (Gelman GF/C) filter. Sampling was halted for a minimum of 24 hours after rainfall events totaling more than .25 inches. The samples were stored on ice and frozen on the day of collection. Filtered samples were analyzed by the Nutrient Analytical Services Laboratory at the University of Maryland's Chesapeake Biological Laboratory (CBL) for total nitrogen (TN), total phosphorus (TP), orthophosphate (PO_4) and Nitrate/Nitrite (NO_2 + NO_3). All analyses were conducted in accordance with U.S. Environmental Protection Agency (EPA) protocols. Stream discharge measurements were taken at the time of all water chemistry samples. Water temperature, dissolved oxygen, pH, and conductivity were measured in the field with Hydrolab Surveyor II at selected sites at the time of water quality collections. The contribution area related to each sample location was determined using a digital elevation model within a GIS. Where sites are nested in a watershed, the mapped concentration data for the downstream site is shown only for the area between the sites. Yield calculations for a downstream site are based on the entire area upstream of the site, but are mapped showing just the area between sites. The downstream sites therefore illustrate the cumulative impact from all upstream activities.

There are no water quality standards for nutrients in Maryland, but for the purpose of this analysis, nitrate levels above 1 mg/L were considered anthropogenic. Nitrate/Nitrite levels between 3 and 5 mg/L were considered high and those over 5 mg/L were considered excessive. For phosphates, levels of 0.01 to 0.015 mg/L were considered high and those above 0.015 mg/L were considered excessive. Total phosphorus levels greater than 0.09 mg/L were considered excessive.

Results

During the Fall of 2006 approximately half of the stream locations were dry and no samples was taken for analysis. Mean total phosphorus concentrations across all available sites for the three testing periods was 0.071 mg/L (Figure 4.7), while mean total nitrogen concentration was 4.71 mg/L (Table 4.11). Concentrations of total nitrogen were greater than 1.0 mg/L for all but one of the sample locations. There were total of 5 subwatersheds that tested above 0.09 mg/L the excessive threshold for total phosphorus.

Table 4.11 Summary of Synoptic Nutrient Testing

Sampling Period	Mean Total Phosphorus mg/L	Total Phosphorus Range (min-max) mg/L	Mean Total Nitrogen mg/L	Total Nitrogen Range (min-max) mg/L
Fall 2006	0.074	0.005 – 0.239	5.36	1.25 – 12.26
Spring 2007	0.054	0.016 - 0.220	4.86	0.59 – 10.25
Spring 2009	0.127	0.014 – 0.616	5.13	0.96 – 10.28
Fall 2009	**Data Pending**			
All Periods	**0.081**	**0.005 – 0.616**	**5.06**	**0.59 – 12.26**

Subwatersheds with consistently elevated nutrients, as identified by the synoptic survey, will be the focus of restoration efforts such as improving inadequate buffers and the creating of wetlands. The synoptic sites as well as additional sites where access is available should be monitored (once or twice a year during same time each year) to help to track improvements with implementation and continue to identify and isolate areas with higher concentrations of nutrients to focus implementation efforts.

Expanded synoptic surveys and nutrient analysis to cover more catchments will allow further completion of the maps shown in Figures 4.7 and 4.8. In addition, in stream soil samples should be taken to help target and further quantify catchment areas with high soil phosphorus concentrations. This will assist targeting efforts for both on-farm implementation of BMPs and targeting for wetland creation projects. The location of all the prioritized potential restoration sites can be found in Figure 4.9.

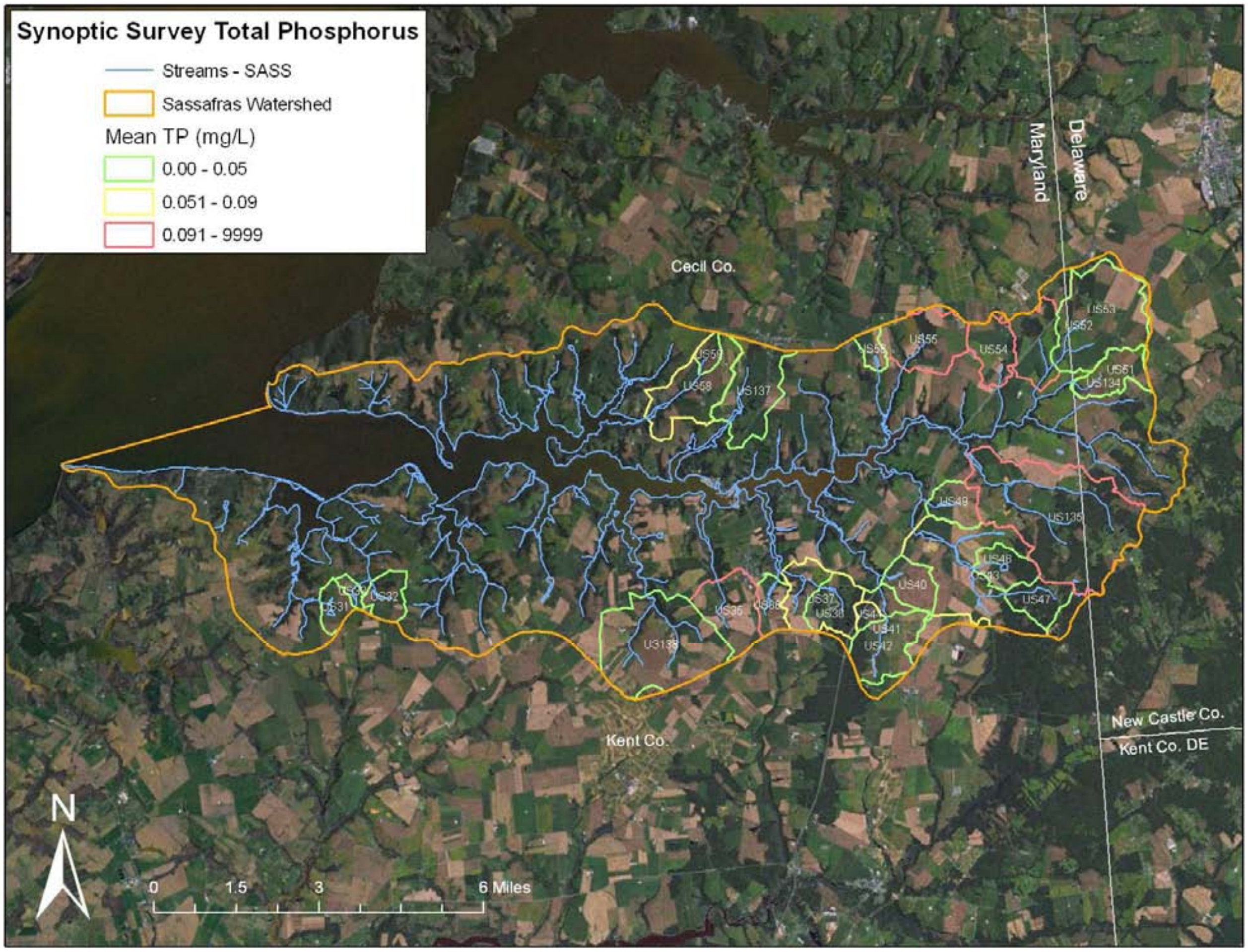

Figure 4.7 Synoptic survey total phosphorus nutrient concentrations.

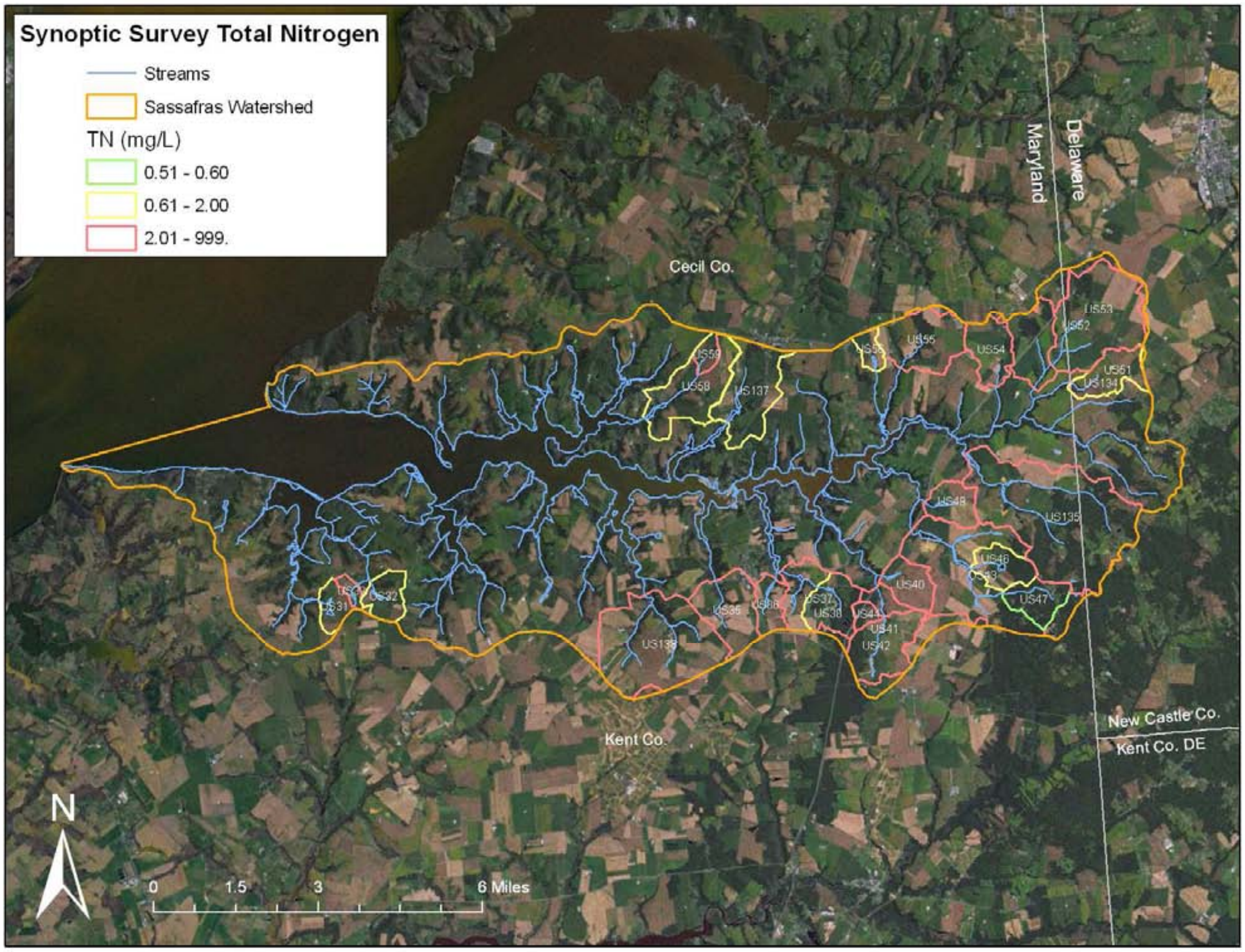

Figure 4.8 Synoptic survey total nitrogen nutrient concentrations.

Overleaf - Figure 4.9 Prioritized problem sites and restoration opportunities

SWAP Priority Restoration Locations
Erosion (ER)
Neighborhood (N)
Hotspot (H)
Potential Hotspot (P)
Shoreline (SE & BL)
Non-tidal Inadequate Buffers (IB)
Synoptic High TP (US)
Streams
Major Roads
Sassafras Watershed
N
0
1.5
3
6 Miles
Maryland
Delaware

5.0 IMPLEMENTATION

Implementation is the longest and most expensive step in the watershed restoration process. Restoration costs for the watershed are estimated at $ 13,697,120. Capital projects (i.e. WWTP upgrades, Highway 301 erosion issues) and construction of restoration projects account for a majority of these costs. A minimum of ten years is usually needed to design and construct all the necessary restoration projects, which are normally handled in several annual phases. Sustaining progress over time and adapting the plan as more experience is gained are vital aspects of implementation.

This section presents planning level costs, phasing for implementing watershed recommendations, and planning partners for stormwater retrofits, stream corridor and shoreline restoration, municipal wastewater treatment plant upgrades, agricultural best management practices, pollution prevention and source control education, and state, county, and municipal programs. Overall costs presented here are planning level estimates only and should be used to guide SRA, Kent County, Cecil County and other entities in estimating annual operational and implementation budgets for the Sassafras River Watershed. Estimates should be adapted to include more appropriate local costs where available.

The implementation costs should be distributed across implementation partners, existing programs, and responsible property owners (i.e. Town of Galena, Town of Betterton, Kent County, Cecil County, MD DOT, SRA, academic institutions, businesses and landowners).

5.1 Costs and Schedule

Table 5.1 sets forth the goals achieved, location, responsible parties, and long-term milestones for implementation of each recommendation. Each recommendation has been linked to a Stakeholder Strategy, identified in Section 2.0. Table 5.2 provides a draft implementation schedule and associated costs for implementing each recommendation. The cumulative estimate for implementing the 30 recommendations presented in Section 2.0 over the next ten years exceeds $ 13 million dollars. The overarching goal which is aimed at achieving swimmable, fishable, and water contact recreation by 2020, aligns with all of the recommendations as it takes a multi-faceted approach to achieve this goal. Preliminary cost estimates and responsible partners have been identified so that financial resources can be allocated and staff roles can be defined. Real watershed restoration requires a multi-faceted approach, which combines land use decisions with on-the-ground implementation, education, and protection and restoration of watershed functions.

Table 5.1 Recommendations, Responsible Parties, and Desired Outcomes for Restoration				
Stakeholder	**Recommendation**	**Location**	**Responsible Parties**	**Outcome**
4	1. Rt. 301 Highway retrofits and stream restoration	3 locations near town of Sassafras	• Maryland Dept of Transportation • Kent County • SRA	• 3 projects constructed • Reduce sediment loading
2,13	2. Stormwater retrofitting demo projects including rain gardens and rain barrels	Stormwater retrofits in specific locations then additional watershed wide	• SRA • CWP	• 4 retrofit projects • Reduce sediment and pollutant loads
2,14	3. Outreach and education of residents on lawn care practices through workshops	Target high nutrient areas identified in neighborhood assessments then watershed wide	• SRA • Cooperative Extension	• Reach 500 residents through annual workshops, Spring and Fall • 300 Soil Tests with results logged by SRA • 100 acres of urban nutrient management • Reduce Total Phosphorous
2	4. Advocate for phosphorous free fertilizers throughout the watershed	Watershed wide then county wide	• SRA	• All business in watershed carry P-free fertilizers • County and State legislation prohibiting or limiting residential use of fertilizers • Reduce Total Phosphorous
2,6	5. Assistance with inspections and outreach to homeowners on denitrifying septic upgrades	Target critical area then watershed wide	• MD Dept of Environment • Cecil and Kent County Health Departments • SRA	• 300 tests performed • 150 septic upgrades • Increase septic system maintenance • Reduce Total Nitrogen

Table 5.1 Recommendations, Responsible Parties, and Desired Outcomes for Restoration				
Stakeholder	**Recommendation**	**Location**	**Responsible Parties**	**Outcome**
2,6,7	6. Fix failing septics in Sassafras	Critical area then watershed wide	• MD Dept of Environment • Cecil and Kent County Health Departments • SRA	• Repair 25 failing septics • Reduce Total Nitrogen
5	7. Upgrade Galena WWTP to ENR	Galena, MD	• Town of Galena • MD Dept of Environment • SRA	• 1 ENR municipal WWTP • Reduce Phosphorus, Total Nitrogen and Ammonia
5	8. Upgrade Betterton WWTP to ENR	Betterton, MD	• Town of Betterton • MD Dept of Environment • SRA	• 1 ENR municipal WWTP • Reduce Phosphorus, Ammonia, Bacteria
2,6,7	9. Identify and test major combined community septic systems	Watershed wide	• Kent and Cecil County Health Departments • SRA	• Identify all major systems • Test 5 systems • Reduce Nutrient Discharge
2,6,7	10. Upgrade appropriate combined community septics to enhanced denitrification technology	Watershed wide	• Kent and Cecil County Health Departments • SRA	• Upgrade 50% of identified systems to enhanced denitfication technology • Reduce Nitrogen
1,4,10	11. Identify eroding wooded ravines	Watershed wide	• Natural Resource Conservation Service • Resource Conservation District • CWP • SRA	• Inventory of woodland gully issues that can be addressed

Table 5.1 Recommendations, Responsible Parties, and Desired Outcomes for Restoration				
Stakeholder	**Recommendation**	**Location**	**Responsible Parties**	**Outcome**
1,4,10	12. Prioritize and restore multiple sites of eroding stream and wooded ravines	Watershed wide	• Natural Resource Conservation Service • Resource Conservation District • CWP • SRA	• 1 mile of stream and wooded ravine restored • Reduce sediment loading
4	13. Stabilize actively eroding shorelines, tidally induced and topdown induced	Lloyds Creek and Knights Island	• Eastern Shore Resource Conservation & Development • SRA	• Stabilize 1/2 miles of shoreline • Slow rate of erosion • Reduce sediment loading
4	14. Increase shoreline buffers and outreach to residents on buffer management	Critical Area	• SRA • Eastern Shore Resource Conservation & Development • Town of Betterton	• Increase 1 miles of shoreline buffers • Slow rate of erosion • Reduce sediment loading
2,3	15. Additional stream buffers for landowners (ag and residential)	Watershed wide (see Table 4.7)	• Natural Resource Conservation Service • SRA	• Increase stream buffers by 2 miles • Reduce sediments and nutrient loading
1, 9, 11	16. Needs Assessment to understand impediments to cost-share participation	Watershed wide	• SRA • U MD Cooperative Extension • UDEL	• Identify and address impediments to increase participation
1,9,11	17. Increased outreach and cost-share to farmers in locations with high nutrient concentrations	High nutrient areas as identified by MD Synoptic Survey, then watershed wide	• SRA • U MD Cooperative Extension • UDEL	• 5,000 acres of additional cover crops • Increase awareness of programs and environmental benefits • Reduce nutrient loads

Table 5.1 Recommendations, Responsible Parties, and Desired Outcomes for Restoration				
Stakeholder	**Recommendation**	**Location**	**Responsible Parties**	**Outcome**
9,11	18. Work on farm source control and nutrient export in high nutrient export areas	High nutrient areas	• U MD Cooperative Extension • UDEL • SRA	• 5 farms create and implement on-site measures to reduce loads including installing gutters on poultry houses and diverting clean flow away from the houses, cover crops and crops that remove P, continuous till, subsurface application of manures, • Reduce nutrient loading
9,10,11	19. Increase acreages of cover crops via incentive payment	Watershed wide	• SRA	• 2,500 acres of additional cover crops (part of 5,000 above) • Reduce Total Phosphorous
1,11	20. Innovative ways of more efficient and effective use of nutrients	Watershed wide	• U MD Cooperative Extension • UDEL	• 100 acres implementing new and improved strategies
1	21. Identify and prioritize locations for up to 10 constructed wetlands in high input areas	High input areas	• Eastern Shore Resource Conservation & Development • SRA	• 5 wetlands constructed • Reduce Total Phosphorus
9,10,11	22. Extension of BMPs to farms with absentee owners and others that do not qualify for cost share	Watershed wide	• Kent and Cecil Soil Conservation Districts • SRA	• 500 acres with BMPs applied • Reduce Total Phosphorus

Table 5.1 Recommendations, Responsible Parties, and Desired Outcomes for Restoration				
Stakeholder	**Recommendation**	**Location**	**Responsible Parties**	**Outcome**
2,8	23. Encourage marinas to participate in the Maryland Clean Marina Program	Watershed wide	• SRA • Department of Natural Resources	• 2 additional marinas enrolled • Increase awareness of program and environmental/social benefits
2,13	24. Education and outreach to local school system and community youth groups	Watershed wide	• SRA	• Raise environmental awareness and develop next generation of stewardship
2,13	25. Engage local community in kayaking, bird watching and fishing	Watershed wide	• SRA	• Behavioral change increasing responsible recreation • Increased awareness and engagement
1,2	26. Participate in local codes and ordinance review	Kent, Cecil and New Castle Counties	• SRA • CWP	• Reduce future impacts from development • Develop a state of the knowledge
12	27. Advocate for preservation of forest and well-managed farmland	Watershed wide	• SRA	• No decrease in well-managed farmland • Additional 10% of forest and farmland preserved
1,7	28. Advocate for or create TMDLs for all impairments	Watershed wide	• SRA • MD Department of Natural Resources • MD Department of Environment	• TMDLs are developed for Sediments and other impairments

Table 5.1 Recommendations, Responsible Parties, and Desired Outcomes for Restoration				
Stakeholder	**Recommendation**	**Location**	**Responsible Parties**	**Outcome**
1,14	29. Monitor efforts to improve the water quality conditions in the watershed	Watershed wide	• SRA • U MD Center for Environmental Science • CWP	• Identify and quantify problems • Process and Impact Monitoring implemented
15	30. Support and engage with established and start-up watershed organizations	Eastern Shore then Chesapeake Bay Region	• SRA	• Share best practices • Increase knowledge • Partner on advocacy efforts

Table 5.2 Logical Framework: Inputs, Activities, Outputs					
Recommendation	**Input**	**Activity**	**Output (year 1)**	**Output (years 2-4)**	**Output (year 5+)**
1. Rt. 301 Highway retrofits and stream restoration	• Staff Time • Approximately $ 1,000,000 per project for 3 projects = $ 3,000,000	• Meet with State Highway Authority • Implement highway retrofits	• Identify Funding • SHA Design and Plan	• 2 projects constructed	• 1 project constructed
2. Stormwater retrofitting demo projects including rain gardens and rain barrels.	• Staff Time • 5 workshops @ $2,500 = $12,500 • 4 projects @ $40,000 = $ 160,000 (see Table 4.10) • 100 rain barrels @ $ 75 = $ 7,500	• Identify site, recruit volunteers, design and construct 5 community projects • Annual workshops on rain gardens and rain barrels	• 1 workshop • 1 project • 15 rain barrels	• 4 workshops • 2 projects constructed • 85 rain barrels	• 1 project constructed
3. Outreach and education of residents on lawn care practices through workshops.	• Staff Time • 8 workshops @ $ 2,500 = $ 20,000 • 300 Soil tests @ $ 15 = $ 4,500	• Annual workshop on lawn care • Distribute soil tests and log results	• 2 workshops • 150 Soil Tests	• 6 workshops • 150 Soil Tests	• Workshops as needed
4. Advocate for phosphorous free fertilizers throughout the watershed	• Staff Time • Workshops (noted above)	• Identify suppliers and ensure P-free products are available • Educate landowners in workshops • Lobby for changes in legislation	• Local suppliers carry P-free products	• Change in Legislation	

Table 5.2 Logical Framework: Inputs, Activities, Outputs					
Recommendation	**Input**	**Activity**	**Output (year 1)**	**Output (years 2-4)**	**Output (year 5+)**
5. Assistance with inspections and outreach to homeowners on septic upgrades to enhanced denitrification technology	• Staff Time • 8 workshops @ $ 2,500 = $ 20,000 • 300 Septic Tests @ $ 100 = 30,000 • 150 upgrades @ $ 18,000 = 2,700,000	• Host septic workshops • Identify septics in critical area for testing • Identify septic consultant for testing	• 2 workshops • 75 Septic Tests	• 6 workshops • 225 Septic Tests • 50 septic upgrades	• 100 septic upgrades
6. Fix failing septics in Sassafras	• 25 septics repaired @ $ 15,000 = 375,000	• Hire contractor to design and install retrofits	• Shortlist of septic repairs from septic testing	• 15 septic systems repaired	• 10 septic systems repaired
7. Upgrade Galena WWTP to ENR	• Staff time • $ 1,500,000 for upgrade	• Identify funding opportunities for upgrade	• Secure funding	• Approve design and construct ENR plant	
8. Upgrade Betterton WWTP to ENR	• Staff time • $ 20,000 for design • $ 1,500,000 for upgrade	• Ensure ENR design • Identify funding opportunities for upgrade	• Secure funding	• Design	• Construct ENR plant
9. Identify and test major combined and community septic systems	• $2,000 per test for approximately 5 sites = $ 10,000	• Identify community septics watershed-wide • Test systems	• Inventory systems	• Test systems in critical area	• Test systems outside critical area
10. Upgrade appropriate combined and community septics to enhanced denitrification technology	• Cost will depend on size and number of units	• Upgrade combined and community septics to enhanced denitrification technology	• Determine appropriate technology and estimate cost	• Design and construct one system	• 1 - 2 septics upgraded

Table 5.2 Logical Framework: Inputs, Activities, Outputs

Recommendation	Input	Activity	Output (year 1)	Output (years 2-4)	Output (year 5+)
11. Identify eroding wooded ravines	• $ 30,000 based on 300 hours technical expertise	• Catalogue wooded ravines and recommend mitigation effort	• Identify wooded ravines	• Identify wooded ravines/ prioritize for restoration/ stabilization	• Technical memo containing restoration strategies for various scenarios
12. Prioritize and restore multiple sites of eroding stream and wooded ravines	• Staff time • $ 150-$200 per linear foot for 1 mile = $ 1,000,000	• Restore high priority sites of eroding stream and wooded ravines	• Ground truth and prioritize candidate sites	• Secure funding • Design restoration project	• Construct 1 mile of eroding steam and wooded ravines
13. Stabilize actively eroding shorelines, tidally induced and topdown induced	• Staff time • Approximately ½ mile of shoreline over 7 projects. Sum of 7 projects = $ 1,823,480	• Ground truth potential candidate sites, secure funding and construct sills, breakwaters, buffers	• Ground truth and prioritize candidate sites	• Secure funding and construct 1 project •	• Secure funding and construct 5 – 6 additional projects
14. Increase shoreline buffers and outreach to residents on buffer management	• Staff time • 1 miles = 60 acres of buffer strips @ $ 3000 per acre = $ 180,000	• Outreach to homeowners • Identify and implement buffer strips	• Target home owners with turf adjacent to shoreline • Outreach to waterfront residents to educate on buffer BMPs	• Plant 1/2 mile shoreline buffer strips	

Table 5.2 Logical Framework: Inputs, Activities, Outputs					
Recommendation	**Input**	**Activity**	**Output (year 1)**	**Output (years 2-4)**	**Output (year 5+)**
15. Additional stream buffers for landowners (ag and residential)	• Staff time • 2 miles = 121.38 acres of buffer strips @ $ 3000 per acre = $ 364,140	• Promote buffer strips for residential and ag lands • Secure permission and funding for one community project(s)	• Secure landowner permission • Promote residential and ag buffers through media and workshops	• Plant 1 mile of buffer strips	• Plant 1 mile of buffer strips
16. Needs Assessment to understand impediments to cost-share participation for ag BMPs	• Staff Time • Workshop (included below*)	• Poll farmers on participation in cost share programs	• Identify barriers to participation and work to resolve	• Identify barriers to participation and work to resolve	• Identify barriers to participation and work to resolve
17. Increased outreach and cost-share to farmers in locations with high nutrient concentrations	• Staff Time • 1 annual workshop* @ $ 2500 for 10 years = $ 25,000	• Peer to peer networking to farmers in areas with high nutrient concentrations initially, then watershed wide	• 1000 additional acres in cover crops • 1 annual workshop • Targeted outreach to 50 % of ag community in priority areas	• 2500 additional acres in cover crops • 3 workshops • Targeted outreach to 50% of ag community in priority areas	• 1500 additional acres in cover crops • 6 workshops • Watershed wide outreach to ag community
18. Identify farms with high nutrient export based on synoptic sampling work directly with farms to control nutrient losses	$ 10,000 per plan for 5 farms = $ 50,000	• Work directly with 5 farms to construct source reduction and transport reduction methods	• Identify and target key farm areas	• Identify farms and implement 2 plans	• Identify farms and implement 3 plans

Table 5.2 Logical Framework: Inputs, Activities, Outputs					
Recommendation	**Input**	**Activity**	**Output (year 1)**	**Output (years 2-4)**	**Output (year 5+)**
19. Increase acreages of cover crops via incentive payment	• Staff Time • $ 10 per acre for 2,500 acres for 5 years = $ 125,000 • 1 annual workshop* (same as above)	• Peer to peer networking to farmers in areas with high nutrient concentrations initially then watershed wide	• 1000 additional acres in cover crops (part of total acres above) • 1 annual workshop • Targeted outreach to 50% of ag community in high nutrient areas	• 500 additional acres in cover crops (part of total acres above) • 3 workshops • Targeted outreach to 100% of ag community in high nutrient areas	• 1000 additional acres in cover crops (part of total acres above) • 6 workshops • Watershed wide outreach to ag community
20. Innovative ways of more efficient and effective use of nutrients	• Research funding $ 100,000	• Evaluate critical issues on farms with high nutrient exports – research and test methods to control nutrients	• Identify key subwatersheds and farm areas	• Secure funding and begin UMD Cooperative Ext meetings with selected farmers	• 100 acres with reduced nutrient export and data on enhanced practices
21. Identify and prioritize locations for up to 10 constructed wetlands in high input areas	• Staff Time • $ 50,000 per wetland for approximately 100 acres per site for 10 sites = $ 500,000	• Ground truth candidate sites, secure funding, design and construct wetlands	• Construct 1 treatment wetland	• Construct 3 treatment wetlands	• Construct 6 treatment wetlands
22. Extension of BMPs to farms with absentee owners and others that do not qualify for cost share	• Staff Time • $ 100 per acre for 500 acres = $ 50,000	• Identify funding gaps and farms without BMPs	• Begin outreach and relationship building with these landowners/ tenant farmers	• 300 additional acres in cover crops	• 200 additional acres in cover crops

Table 5.2 Logical Framework: Inputs, Activities, Outputs					
Recommendation	**Input**	**Activity**	**Output (year 1)**	**Output (years 2-4)**	**Output (year 5+)**
23. Encourage marinas to participate in the Maryland Clean Marina Program	• Staff Time	• Targeted outreach to marina owners and boaters	• One on one outreach to 5 non participating marinas and 2 boatyards	• 2 additional marinas sign	• 1 additional marina signs on
24. Education and outreach to local school system and community youth groups	• Staff Time • Supplies @ $ 1,000 per year for 10 years = $ 10,000	• Participate in school based programs to educate youth on water quality and stewardship	• Reach every 4th grader in Kent and Cecil county	• Reach every 4th grader in Kent and Cecil county	• Reach every 4th grader in Kent and Cecil county
25. Engage local community in kayaking, bird watching and fishing	• Staff Time • $ 5,000 per large event for advertising, rentals, supplies = $ 50,000	• Create event(s) and activities that raise awareness and engage public in responsible recreation	• River festival with activity (kayaking, etc.) embedded within	• One large event and two smaller activities per year	• One large event and two smaller activities per year
26. Participate in local codes and ordinance review	• Staff Time	• Review Stormwater Plans, Water and Sewer Plans, Comp Plans, Permit renewals, etc. for water quality issues	• Increase knowledge • Reduce future impacts from development	• Increase knowledge • Reduce future impacts from development	• Increase knowledge • Reduce future impacts from development
27. Advocate for preservation of forest and well-managed farmland	• Staff Time	• Participate in public hearings, commission meetings, issue letters of support etc. to advocate for forest and farmland preservation	• No decrease in forest or well-managed farmland	• No decrease in forest or well-managed farmland	• No decrease in forest or well-managed farmland

Table 5.2 Logical Framework: Inputs, Activities, Outputs					
Recommendation	**Input**	**Activity**	**Output (year 1)**	**Output (years 2-4)**	**Output (year 5+)**
28. Advocate for or create TMDLs for all impairments	• Staff Time	• Review and comment on Bay-wide TMDL for Phosphorus, Nitrogen and Sediments • Monitor biological impairments through Maryland Biological Stream Survey and Maryland Stream Waders Programs	• Input on Bay-wide TMDL • Continue to monitor biological impairments through MBSS and MD Stream Waders Programs	• Loading estimates for Sassafras impairments • Regulate impacts from discharge permits • Continue to monitor biological impairments through MBSS and MD Stream Waders Programs	• Regulate impacts from discharge permits • Continue to monitor biological impairments through MBSS and MD Stream Waders Programs
29. Monitor efforts to improve the water quality conditions in the watershed	• Staff Time • 3,000 per year for equipment costs for 10 years = $ 30,000 • 3,000 per year for lab tests for 10 years = $ 30,000	• Continue and increase monitoring efforts that track water quality improvements and issues	• Results are analyzed and publicized	• Results are analyzed and publicized	• Results are analyzed and publicized
30. Support and engage with established and start-up watershed organizations	• Staff Time	• Participate in watershed meetings and events and issue letters of support to promote grassroots environmentalism	• Increase awareness of grassroots watershed planning and restoration	• Increase awareness of grassroots watershed planning and restoration	• Increase awareness of grassroots watershed planning and restoration
Grand Total	**$ 13,697,120**				

Table 5.2 Logical Framework: Inputs, Activities, Outputs

Recommendation	Input	Activity	Output (year 1)	Output (years 2-4)	Output (year 5+)
Shading indicates projects have already been submitted for partial funding. *Staff time represents costs associated with Sassafras River Association full and part-time staff.*					

5.2 Pollutant Load Reductions

Table 5.3 shows the pollutant load reduction estimates based on the recommendations outlined in Section 2.0 as well as on-going implementation actions by the Sassafras River Association, Kent County and Cecil County. The load reductions are based on realistic implementation scenarios over the next ten years. Citations are provided for each of the load reduction calculations and are again based on conservative assumptions. Each restoration practice in Table 5.3 is followed by the recommendations that it meets, the implementation goal, and the assumption leading to the load reduction shown in parentheses. Overall the effect of restoration implementation would result in a 34 % reduction in total phosphorus, a 9% reduction in total nitrogen, and close to a 15% reduction in total suspended solids (Table 5.4).

This restoration strategy will allow implementation partners to meet the load allocation of 13, 875 lbs/yr of phosphorus. The Sassafras Watershed Action Plan TMDL strategy focuses on both reducing nutrients from urban sources including sewage treatment plants, septic systems and rural sources including agriculture. TMDLs for nitrogen and sediment have not been set for this watershed although load reductions for these pollutants have been calculated based on management practices for meeting the TMDL for phosphorus. In addition known sources of nitrogen and sediment such as septic systems, WWTPs, lawn care and cover crops have been targeted in the recommendations.

Description of the WTM

The Watershed Treatment Model (WTM), version 3.1 (Caraco, 2002) is a simple spreadsheet model typically used to: estimate pollutant loading under current watershed conditions; determine the effects of current management practices; estimate load reductions associated with implementation of structural and non-structural management practices; evaluate the effects of future development. The model is based on the Simple Method (Schueler, 1987) for pollutant load calculations where impervious cover is used to estimate primary loads from various urban land uses. Loading for rural areas uses literature reported values and is primarily based on the area dedicated to row crops and forest and are based on literature values reported in Frink (1991) and Chesapeake Bay Program Model loading rates. Specific concentration assumptions used for urban/suburban loading estimates in the WTM model are based on values for different land uses summarized in the National Stormwater Quality Database (NSQD), a summary of national stormwater data from over 200 communities nationwide (Pitt et. al., 2003). Estimated runoff volumes are multiplied by pollutant concentration data to compute stormwater loads. All loads are computed based on an annual time step.

The ***existing management practices*** and ***future management practices*** components of the WTM assess the ability of the treatment options in a watershed to reduce the uncontrolled pollutant loads from primary and secondary sources. The pollutant removal efficiencies associated with various structural and nonstructural urban and agricultural stormwater management practices are based on existing research and studies in the National Pollutant Removal Performance Database for

Stormwater Treatment Practices (Winer, 2000), research compiled in the WTM (Caraco, 2002), and in A User's Guide to Watershed Planning in Maryland (CWP/DNR, 2005).

Table 5.3 Pollutant Load Reduction Calculations for Total Nitrogen, Total Phosphorus, and Total Suspended Sediment

Recommendation	Project Goal	TN Reduction (lbs/year)	TP Reduction (lbs/year)	TSS Reduction (tons/year)	Citation
1. Rt. 301 Highway retrofits and stream restoration	• 3 projects constructed	35	465	211,000	Caraco, 2001
2. Stormwater retrofitting demo projects including rain gardens and rain barrels.	• 4 retrofit projects • 100 rain barrels • 100 acres of urban nutrient management	35	15	3,300	Caraco, 2001
3. Outreach and education of residents on lawn care practices through workshops.	• Reach 500 residents, • 300 Soil Tests •	4,000	103		Caraco, 2001
4. Advocate for phosphorous free fertilizers throughout the watershed	• Ensure P-free products are available and landowners educated		500		Barton et. al., 2006
5. Assistance with inspections and outreach to homeowners on septic upgrades to enhanced denitrification technology	• 300 tests performed • 150 septic upgrades	900			MDE, 2008
6. Fix failing septics in Sassafras	• Repair 25 failing septics	150	25		Caraco, 2001
7. Upgrade Galena WWTP to ENR	• 1 ENR municipal WWTP	5,658	1,100		MDE, 2005
8. Upgrade Betterton WWTP to ENR	• 1 ENR municipal WWTP	1,200	160		MDE, 2005
9. Identify and test major combined and community septic systems	• Test 5 systems	Not Applicable			
10. Upgrade appropriate combined and community septics to enhanced denitrification technology	• Upgrade 50% of identified systems to BNR	5,000			MDE, 2008

Table 5.3 Pollutant Load Reduction Calculations for Total Nitrogen, Total Phosphorus, and Total Suspended Sediment					
Recommendation	**Project Goal**	**TN Reduction (lbs/year)**	**TP Reduction (lbs/year)**	**TSS Reduction (tons/year)**	**Citation**
11. Identify eroding wooded ravines	• Inventory of woodland gully issues that can be addressed	Not Applicable			
12. Prioritize and restore multiple sites of eroding stream and wooded ravines	• 1 mile of stream and wooded ravine restored		450	211,000	Caraco, 2001
13. Stabilize actively eroding shorelines, tidally induced and top down induced	• Stabilize ½ mile of shoreline	Primary load reduction will be TSS and will be calculated on a per project basis.			
14. Increase shoreline buffers and outreach to residents on buffer management	• Increase 1 miles of shoreline buffers	155	10	3500	CWP/DNR, 2005
15. Additional stream buffers for landowners (agricultural and residential)	• Increase stream buffers by 2 miles (50' width)	352	30	20,000	CWP/DNR, 2005
16. Needs Assessment to understand impediments to cost-share participation	• Identify and address impediments to increase participation	Not Applicable			
17. Increased outreach and cost-share to farmers in locations with high nutrient concentrations	• 5,000 acre of additional cover crops	21,490	2,700	495,000	CWP/DNR, 2005
18. Identify farms with high nutrient export based on synoptic sampling, work directly with farms to control nutrient losses.	• 5 farms create and implement measures to reduce nutrient losses	Nutrient load reductions will be estimated on a per farm basis, based on BMPs implemented.			
19. Increase acreages of cover crops via incentive payment	• 2,500 acres of additional cover crops (part of 5,000 above)				
20. Innovative ways of more efficient and effective use of nutrients	• 100 acres implementing new and improved strategies	500	100		Frink, 1991

Table 5.3 Pollutant Load Reduction Calculations for Total Nitrogen, Total Phosphorus, and Total Suspended Sediment					
Recommendation	**Project Goal**	**TN Reduction (lbs/year)**	**TP Reduction (lbs/year)**	**TSS Reduction (tons/year)**	**Citation**
21. Identify and prioritize locations for up to 10 constructed wetlands in high input areas	• 10 wetlands constructed	5,000	500	450,000	CWP/DNR, 2005
22. Extension of BMPs to farms with absentee owners and others that do not qualify for cost share	• 500 acres additional cover crops	2,000	300	50,000	CWP/DNR, 2005
23. Encourage marinas to participate in the Maryland Clean Marina Program	• 2 additional marinas	Not Applicable			
24. Education and outreach to local school system and community youth groups	• Raise environmental awareness and develop next generation of stewardship				
25. Engage local community in kayaking, bird watching and fishing	• Behavioral change increasing responsible recreation				
26. Participate in local codes and ordinance review	• Reduce future impacts from development				
27. Advocate for preservation of forest and well-managed farmland	• No decrease in well-managed farmland • Additional 10% of forest and farmland preserved from development				
28. Advocate for or create TMDLs for all impairments	• TMDLs are developed for all impairments				
29. Monitor efforts to improve the water quality conditions in the watershed	• Identify and quantify problems • Process and Impact Monitoring implemented				

Table 5.3 Pollutant Load Reduction Calculations for Total Nitrogen, Total Phosphorus, and Total Suspended Sediment					
Recommendation	**Project Goal**	**TN Reduction (lbs/year)**	**TP Reduction (lbs/year)**	**TSS Reduction (tons/year)**	**Citation**
30. Support and engage with established and start-up watershed organizations	• Share best practices • Increase knowledge • Partner on advocacy efforts				

Table 5.4 Sassafras Watershed Annual Loads and Anticipated Restoration Strategy Reductions			
Loads	**TN (lb/year)**	**TP (lb/year)**	**TSS (lb/year)**
Sassafras Watershed total current loads	508,700	19,060	9,730,599
Restoration strategy	**46,475**	**6,458**	**1,443,800**
Watershed loading post implementation	**462,225**	**12,602**	**8,286,799**
Percent load reduction	**9.1%**	**33.9%**	**14.8%**
TMDL Loading Allocation		***13,875***	

Caveats

- Fate and transport of nutrients and sediments is not accounted for in this modeling scenario (nor is it accounted for in typical modeling scenarios including the Chesapeake Bay Model). Stream channel simplification and incision (disconnection from the floodplain) present in this watershed are likely to reduce some of the natural processing of nutrients and storage of sediment that would have occurred if this was a watershed unaltered by land use and humankind.
- In-stream ponds in the watershed likely store sediment and process nutrients. This potentially alters the sediment and nutrient transport regime within the watershed as do natural wetlands and well functioning streams connected to their floodplain.
- Based on the bullets listed above, load reductions do not fully represent the load that is ultimately transported to the receiving waters. Fate and transport will be considered by

expanding the synoptic monitoring in the future to identify subwatersheds with good in-stream processing as well as poor in-stream processing. Catchments with high nutrient loads unreduced by in-stream factors and natural wetlands will receive extra attention and focus in outreach and BMP treatment.

- Modeling scenario does not account for impact of potential future development outlined in county and town zoning ordinances and comprehensive plans which could result in increased density, changes to infrastructure and possible increases in nutrient loads. See Appendix E for details.

6.0 MONITORING PLAN

The SRA, funders, and other restoration partners have a vested interest in measuring whether the restoration projects they implement are successful. Success can be measured in a number of ways including direct improvements in watershed indicators (e.g. reduced pollutant loading or improved submerged aquatic vegetation, reduced harmful algal blooms) or indirectly through process indicators (e.g. number of rain gardens installed, number of participants, acres conserved). The monitoring plan includes the assessment of individual restoration projects as well as the monitoring of stream indicators at sentinel monitoring stations. Information will be input to a tracking system and then used to revise or improve the restoration plan over a five to ten-year cycle. Each part of the monitoring plan is described below:

• *Project monitoring* at a small scale (reach or smaller) to illustrate benefits of individual restoration efforts will be carried out by the Sassafras River Association in conjunction with University of Maryland and Center for Watershed Protection. SRA's current volunteer and RIVERKEEPER monitoring programs will be tailored to assess impact of restoration efforts. For specific restoration projects (i.e. a constructed wetland) several pre-tests for TP, TN and TSS will be performed in both wet and dry conditions to establish a baseline. Post implementation will include monthly sampling (inflow/outflow) over an appropriate period of time (minimum 36 months). Table 6.1 references SRA's current monitoring programs which will be modified to address impact from restoration activities.

Table 6.1 Sassafras River Association Monitoring Programs

Responsible Party	Sampling Frequency	Parameters	Site ID	Latitude	Longitude
Volunteers	2009 - Monthly - April to October 2010 - Monthly - Year round	Temperature, pH, Dissolved Oxygen, Turbidity, Phosphate, Nitrate-Nitrogen, Ammonia-Nitrogen, Copper	NT01	39.3357220	-76.0241310
			NT04	39.3362940	-75.9134400
			NT05	39.3400450	-75.8895350
			NT06	39.3420420	-75.8684250
			NT07	39.3469290	-75.8420270
			NT08	39.3382050	-75.8347020
			NT09	39.3530990	-75.8228920
			NT10	39.3485260	-75.8099580
			NT11	39.3643640	-75.8200240
			NT12	39.3722640	-75.8035950
			NT13	39.3775300	-75.8018190
			NT18	39.3818040	-75.8844930
			NT19	39.3831540	-75.9149560
			NT21	39.3797630	-75.8496480
			NT22	39.3951670	-75.8340150
			NT23	39.3959400	-75.8260360
			NT24	39.3917660	-75.7925950

Table 6.1 Sassafras River Association Monitoring Programs					
Responsible Party	**Sampling Frequency**	**Parameters**	**Site ID**	**Latitude**	**Longitude**
			NT25	39.3901410	-75.7797140
			T03	39.3757104	-75.9927750
			T09	39.3701370	-75.9285736
			T14	39.3617761	-75.8840275
			T16	39.3666203	-75.8642006
			T19	39.3717958	-75.8394814
Sassafras RIVERKEEPER	2009-2010 - Weekly - May to October	Temperature, pH, Dissolved Oxygen, Salinity, Conductivity, Turbidity - Secchi Disc, Turbidity - Turbidimeter (NTU's)	WK02	39.3674833	-75.8490667
			WK03	39.3629667	-75.8909333
			WK04	39.3703611	-75.9303333
			WK07	39.3805833	-75.9479500
			WK07 A	39.3796167	-75.9328500
			WK08	39.3704000	-75.9849833
			WK09	39.3815833	-76.0631833

• *Sentinel station monitoring* to track long-term health and water quality trends.
Sentinel monitoring stations are fixed, long-term monitoring stations which are established to measure trends in key indicators over many years. Sentinel monitoring is perhaps the best way to determine if conditions are changing in a subwatershed or watershed. The Department of Natural Resources currently maintains sentinel stations that will continue to be monitored. Should DNR leave the area, University of Maryland or Sassafras River Association may be able to maintain sentinel stations. Table 6.2 represents DNR's monitoring efforts in the Sassafras. The Sassafras RIVERKEEPER has monitored in close approximation to address data gaps post 2009 when DNR terminates their efforts.

Table 6.2 MDNR Sassafras Sentinel Monitoring Program					
Responsible Party	**Frequency**	**Parameters**	**Site ID**	**Latitude**	**Longitude**
Maryland Department of Natural Resources	2006-2009 - Continuous 24hr	dissolved oxygen, salinity, temperature, pH, turbidity, chlorophyll-a	XJH2362	39.371700	-76.062517
			XJI2396	39.372250	-75.839867
	2006-2009 - Monthly - April to October	dissolved oxygen, salinity, temperature, pH, turbidity, chlorophyll-a, total nitrogen, total phosphorus, total suspended solids	XJI2112	39.368883	-75.979233
			XJI2342	39.371183	-75.928617
			XJI1871	39.363583	-75.881317
	1985-2009 - Monthly - Year Round	dissolved oxygen, salinity, temperature, pH, chlorophyll, total nitrogen, total phosphorus, turbidity - secchi	ET3.1	39.364780	-75.882456

Table 6.3 Measurable Indicators for Monitoring Effort			
Recommendation	**Project Goal**	**Process Indicator**	**Impact Indicator**
1. Rt. 301 Highway retrofits and stream restoration	• 3 projects constructed	• # of projects constructed	• Reduced erosion • Synoptic survey
2. Stormwater retrofitting demo projects including rain gardens and rain barrels.	• 4 retrofit projects : table 4.10 • 100 rain barrels	• # of projects constructed • # of rainbarrels	• Pre/post sampling of project sites
3. Outreach and education of residents on lawn care practices through workshops.	• Reach 500 residents, • 300 Soil Tests	• # of residents attending workshop • # of soil tests	• lbs of fertilizer/pesticides conserved in homes • results of same parcel soil tests over time
4. Advocate for phosphorous free fertilizers throughout the watershed	• Stores carry phosphorus free fertilizer	• # of participating businesses	• Pre/post survey of workshop participants
5. Assistance with inspections and outreach to homeowners on septic upgrades to enhanced denitrification technology	• 300 tests performed • 150 septic upgrades	• # of test performed • # of septic upgrades	• Pre/post sampling
6. Fix failing septics in Sassafras	• Repair 25 failing septics	• # of septics repaired	• Pre/post sampling

Table 6.3 Measurable Indicators for Monitoring Effort			
Recommendation	**Project Goal**	**Process Indicator**	**Impact Indicator**
7. Upgrade Galena WWTP to ENR	• 1 ENR municipal WWTP	• WWTP upgraded	• Pre/post monitoring reports
8. Upgrade Betterton WWTP to ENR	• 1 ENR municipal WWTP	• WWTP upgraded	• Pre/post monitoring reports
9. Identify and test major combined and community septic systems	• Test 5 systems	• # of systems tested	• N/A
10. Upgrade appropriate combined and community septics to enhanced denitrification technology	• Upgrade 50% of identified systems to enhanced denitrification technology	• % of systems upgraded	• Pre/post monitoring reports
11. Identify eroding wooded ravines	• Inventory of woodland gully issues that can be addressed	• Inventory	• N/A
12. Prioritize and restore multiple sites of eroding stream and wooded ravines	• 1 mile of stream and wooded ravine restored	• # of feet restored	• Erosion pins and stream stability measurements
13. Stabilize actively eroding shorelines, tidally induced and topdown induced	• Stabilize 1/2 miles of shoreline •	• # of miles stabilized	• Analysis of aerial photo or other data over time • Erosions pins
14. Increase shoreline buffers and outreach to residents on buffer management	• Increase 1 mile of shoreline buffers	• # of miles of buffer planted	• Pre/post sampling
15. Additional stream buffers for landowners (ag and residential)	• Increase stream buffers by 2 miles	• # of feet of buffers planted	• Pre/post sampling
16. Needs Assessment to understand impediments to cost-share participation	• Identify and address impediments to increase participation	• List of impediments	• # of new farmers participating in cover crop program • # of new acres enrolled in programs
17. Increased outreach and cost-share to farmers in locations with high nutrient concentrations	• 5,000 acre of additional cover crops	• # of new acres of cover crops	• Decrease in nutrient concentrations as measured in synoptic survey
18. Work on farm source control and nutrient balances in high nutrient export areas	• 5 farms create and implement nutrient balance plan	• # of farms with nutrient balance plan	• Pre/post sampling
19. Increase acreages of cover crops via incentive payment	• 2,500 acres of additional cover crops (part of 5,000 above)	• # of new acres of cover crops	• Decrease in nutrients - synoptic survey

Table 6.3 Measurable Indicators for Monitoring Effort			
Recommendation	**Project Goal**	**Process Indicator**	**Impact Indicator**
20. Innovative ways of more efficient and effective use of nutrients	• 100 acres implementing new and improved strategies	• # of acres implementing new strategies	• Decrease in nutrients -synoptic survey
21. Identify and prioritize locations for up to 10 constructed wetlands in high input areas	• 5 wetlands constructed	• # of wetlands constructed	• Decrease in nutrients - synoptic survey
22. Extension of BMPs to farms with absentee owners and others that do not qualify for cost share	• 500 new acres of cover crops	• # of new acres of cover crops with absentee owners	• Decrease in nutrients - synoptic survey
23. Encourage marinas to participate in the Maryland Clean Marina Program	• 3 additional marinas	• # of marinas enrolled	• Post survey of marina implementation
24. Education and outreach to local school system and community youth groups	• Raise environmental awareness and develop next generation of stewardship	• # of youth aged children participating	• # of youth involved in ongoing activities
25. Engage local community in kayaking, bird watching and fishing	• Behavioral change increasing responsible recreation	• # of participants • # of activities	• Pre/post survey over time
26. Participate in local codes and ordinance review	• Reduce future impacts from development	• Comments submitted to local entity	• Future development utilizes BAT
27. Advocate for preservation of forest and well-managed farmland	• No decrease in well-managed farmland • Additional 10% of forest and farmland preserved development	• Acres of forest/farm decreased • Acres of forest/farm preserved	• Land use comparison over time
28. Advocate for or create TMDLs for all impairments	• TMDLs are developed for all impairments	• TMDL established and enforced • # of permits • # of violations	• Dischargers are compliant with TMDL
29. Monitor efforts to improve the water quality conditions in the watershed	• Identify and quantify problems • Process and Impact Monitoring implemented	• # of sites tidal/non-tidal sampling • # of lab tests	• Sampling/test results are maintained and analyzed by implementation partners
30. Support and engage with established and start-up watershed organizations	• Share best practices • Increase knowledge • Partner on advocacy efforts	• # of outreach events, letters of supports	• # of new grassroots watershed groups in Chesapeake Region

6.1 Project Tracking

Managing the delivery of a large group of restoration projects within a watershed can be a complex enterprise. A master project spreadsheet linked to a GIS system will track the status of individual projects through final design, permitting, construction, inspection, maintenance and any performance monitoring. For non-structural efforts, tracking systems will include measures such as number of acres planted, number of participants involved, number of septic systems installed, or number of rain barrels implemented. By tracking the delivery of restoration projects, implementation progress can be assessed over time, which in turn, helps explain future changes in stream quality. Project tracking can also improve the delivery of future projects, and creates reports that can document implementation progress for key funders and stakeholders.

Sassafras River Association will manage implementation tracking. To this end, SRA has established a Geodatabase and Access database to track information on participants, parcels and projects. Quantitative data will be aggregated and transferred to a spreadsheet. Periodic reporting on the status of implementation will be distributed quarterly to the SWAP Core Team. Qualitative data will be summarized and presented as well. SWAP stakeholders will be presented with cumulative data at an annual meeting. The tracking system will account for all restoration practices undertaken in the watershed plan regardless of their type or size, and track the progress of outlined milestones.

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APPENDICIES

Appendix A. Property Owner Notification Letters

A.1 Property Owner Notification Letter

January 26, 2009

OWNNAME1
OWNNAME2
OWNADD1
OWNADD2
OWNCITY, OWNSTATE, OWNZIP

Re: Sassafras Watershed Action Plan

Parcel PARCEL1, Map MAP1
Parcel PARCEL2, Map MAP2
Parcel PARCEL3, Map MAP3

Dear OWNNAME1,

As fellow Sassafras River watershed residents, the Sassafras River Association (SRA) invites you to join with Kent, Cecil and Newcastle Counties and other watershed partners in an effort to inventory the condition of the streams and shorelines in our 95 square mile watershed. Our watershed has been identified by the Maryland Clean Water Action Plan as one in need of restoration. This field survey is being performed as part of SRA's efforts to restore and protect the natural resources within the Sassafras River watershed. Because tributaries to the Sassafras cross your land, your help is crucial to our success.

Our goal from this work is to develop a watershed plan, called the Sassafras Watershed Action Plan (SWAP) that identifies potential projects that will help us to protect and restore the health of the River for current and for future generations. Projects that could be recommended include: stream bank improvements, stream habitat restoration, enhanced wooded and grassy buffers, run-off management, stream road crossing improvements, land or rural preservation approaches, and enhanced nutrient reduction from our wastewater treatment plants in Betterton and Galena. In addition, we will prioritize these projects and identify possible sources of funding.

The first step in the program is to walk the streams, observing and noting various stream characteristics including natural areas, healthy ecological stream systems, as well as areas of erosion, limited buffers, fish blockages, or pipe outfalls, and other points of environmental interest. Water samples will be taken for testing from multiple sites within the watershed, one of which may be along your stream frontage. Information regarding the overall health of the watershed will be compiled and presented at a public meeting in Galena later in the year. Your participation in this meeting is welcomed and encouraged.

The Maryland Conservation Corps has been contracted by the SRA to perform the field work for this Stream Corridor Assessment. We are requesting your permission to allow a 2 or 3 member, trained team to visit your property as noted above by tax map and parcel. Each member of the team will be appropriately identified and will observe proper protocols and avoid any areas of your property which you may elect to restrict. We anticipate that the teams will be in your area between mid-February and early April. We will notify you and invite you to accompany the team on its visit if you like.

Permission to walk your property will allow this important phase of the project to move forward. Please take this opportunity to reply with the enclosed postcard by **February 6**. Whether you grant us permission or not, we greatly appreciate your reply and hope you will join us to review the results of our survey later this year.

Your knowledge and current stewardship efforts are invaluable to us. We thank you for your support and hope you will join us for our watershed public meetings. During these meetings you will have the opportunity to meet with many of the partners participating in this effort including Kent and Cecil Planning and Zoning and Soil Conservation Districts, Maryland and Delaware Departments of Natural Resources, University of Maryland, Washington College, members of the farming community and the Sassafras Riverkeeper. Please feel free to contact Kascie Herron if you should have any questions, or concerns or would like to be involved to a greater degree. She can be reached at 410-708-3303.

Sincerely,

Kim Kohl
Executive Director
Sassafras River Association

www.sassafrasriver.org

Appendix B. Data Assessments

Table B.1 SCA - Inadequate Buffer Characteristics									
Site ID	Severity	Correctability	Accessibility	Wetland Potential	Length (ft)	Buffer Width (L/R)	Inadequate Buffer Sides	Unshaded Sides	Land Use (L/R)
0327601IB	1	2	1	-1	2500	0/0	Both	Both	Crop field/Crop field
0327602IB	1	2	1	-1	1500	0/0	Both	Both	Crop field/Lawn
0403202IB	1	3	1	3	1000	0/0	Both	Both	Crop field/Crop field
0403201IB	2	3	1	-1	2000	20/20	Left	Both	Crop field/Crop field
1101502IB	3	2	3	-1	1334	200/30	Right	Both	Forest/Crop field
0212201IB	3	1	1	5	0	500/10	Right	Neither	Forest/Pasture
0213201IB	3	1	1	5	480	20/20	Both	Neither	Crop field/Crop field
0213202IB	3	1	1	5	650	20/20	Both	Neither	Crop field/Crop field
0417501IB	4	2	2	2	0	200/50	Right	Both	Forest/Crop field
0324601IB	4	2	2	-1	1000	500/75	Right	Neither	Forest/Forest
0226201IB	4	1	1	-1	0	20/20	Both	Neither	Crop field/Crop field

Table B.2 SCA - Representative Site Characteristics

Site ID	Macro. Sites	Fish Shelter	Channel Alt.	Sediment Dep.	Velocity & Depth	Bank Vegetation	Bank Condition	Riparian Zone Width	Bottom Type	Riff Width (in)	Riff Depth (in)	Run Width (in)	Run Depth (in)	Pool Width (in)	Pool Depth (in)
0419501REa	Suboptimal	Suboptimal	Optimal	Optimal	Suboptimal	Optimal	Optimal	Optimal	Sands	48	10	72	8		
0419501RE	Optimal	Marginal	Optimal	Marginal	Suboptimal	Optimal	Optimal	Optimal	Sands	18	3	36	3		
0417502RE	Marginal	Optimal	Optimal	Optimal	Marginal		Optimal	Optimal	Silts						
0417503RE	Poor	Optimal	Optimal	Marginal	Suboptimal	Optimal	Marginal	Suboptimal	Silts	360		360			
0417504RE	Suboptimal	Suboptimal	Poor	Poor	Suboptimal	Suboptimal	Marginal	Suboptimal	Silts	11	18	24	12		
0403201RE	Marginal	Marginal	Poor	Marginal	Marginal	Marginal	Marginal	Optimal	Silts	8	4	36	8		
0212201RE	Poor	Poor	Optimal	Optimal	Poor	Optimal	Suboptimal	Optimal	Sands	0		48	4	0	0
0213201RE	Poor	Poor	Optimal	Suboptimal	Marginal	Optimal	Optimal	Optimal	Gravel	4	0.5	36	1.5	36	4
0213202RE	Poor	Poor	Optimal	Suboptimal	Marginal	Optimal	Optimal	Optimal	Sands	12	1	36	1		
0216201RE	Marginal	Marginal	Optimal	Optimal	Suboptimal	Optimal	Optimal	Optimal	Silts	2	1	5	12		
0217201RE	Marginal	Poor	Optimal	Poor	Marginal	Suboptimal	Optimal	Poor	Silts	0	0	96	36	0	0
0220201RE	Marginal	Poor	Optimal	Optimal	Optimal	Optimal	Suboptimal	Suboptimal	Silts			60	6		
0220202RE	Optimal	Suboptimal	Optimal	Suboptimal	Optimal	Suboptimal	Marginal	Suboptimal	Sands	24	2	48	3		
0223202RE	Marginal	Marginal	Optimal	Optimal	Suboptimal	Optimal	Suboptimal	Optimal	Silts	18	4	42		6	
0224201RE	Marginal	Marginal	Optimal	Optimal	Optimal	Optimal	Suboptimal	Suboptimal	Silts	12	3	36	3		
0224202RE	Marginal	Marginal	Optimal	Suboptimal	Optimal	Optimal	Suboptimal	Optimal	Sands	32	2	54	3		
0323201RE	Marginal	Poor	Optimal	Suboptimal	Poor	Marginal	Marginal	Optimal	Silts	0	0	48	6		0
0326201RE	Suboptimal	Marginal	Optimal	Optimal	Optimal	Suboptimal	Suboptimal	Optimal	Sands	48	3	54	8	36	30
0326202RE	Suboptimal	Marginal	Optimal	Suboptimal	Suboptimal	Suboptimal	Marginal	Suboptimal	Sands	18	2	48	6	72	24
0323601RE	Suboptimal	Marginal	Optimal	Optimal	Suboptimal	Suboptimal	Suboptimal	Optimal	Sands	84	3	84	6		
0323602RE	Marginal	Marginal	Optimal	Optimal	Suboptimal	Suboptimal	Suboptimal	Optimal	Sands	24	4	36	10		
0324601RE	Marginal	Suboptimal	Optimal	Suboptimal	Suboptimal	Optimal	Suboptimal	Optimal	Silts	24	8	96	10		
0324602RE	Optimal	Suboptimal	Optimal	Optimal	Optimal	Suboptimal	Suboptimal	Suboptimal	Gravel	24	4	48	8		
0325601RE	Marginal	Marginal	Optimal	Suboptimal	Suboptimal	Optimal	Suboptimal	Optimal	Sands	18	2	24	4		
0326061RE	Poor	Marginal	Optimal	Suboptimal	Suboptimal	Optimal	Optimal	Optimal	Sands	12	2	4	4	0	0

Table B.3 SCA - Fish Barrier Characteristics															
Site ID	Severity	Correctability	Accessibility	Extent	Type	Blockage	Water Drop (in)	Site ID	Severity	Correctability	Accessibility	Extent	Type	Blockage	Water Drop (in)
0324608FB	1	5	3	Total	Unknown	Too High	36	0213202FB	5	2	3	Total	Natural Falls	Too High	6
0213216FB	1	2	4	Total	Unknown	Too High	18	0213203FB	5	-1	3	Partial	Debris Dam	Too Shallow	0
0323203FB	1	5	1	Total	Unknown	Too Shallow	0	0213204FB	5	3	4	Total	Debris Dam	Too High	6
0403201FB	2	5	1	Total	Channelized	Too Fast	10	0213205FB	5	2	4	Total	Natural Falls	Too High	12
0224203FB	2	5	1	Total	Dam	Too High	108	0213206FB	5	3	4	Partial	Road Cross.	Too Shallow	0
0419502FB	3	5	1	Total	Road Cross.	Too High	12	0213207FB	5	2	5	Total	Debris Dam	Too High	12
0419501FB	5	3	1	Partial	Debris Dam	Too High	8	0213208FB	5	3	4	Total	Natural Falls	Too High	24
0417504FB	5	5	4	Partial	Beaver Dam	Too High	36	0213209FB	5	2	4	Total	Debris Dam	Too High	8
0417505FB	5	5	5	Total	Beaver Dam	Too High	36	0213210FB	5	3	4	Total	Debris Dam	Too High	24
0224601FB	5	2	2	Total	Other	Too Shallow	0	0213211FB	5	3	4	Total	Debris Dam	Too High	18
0224602FB	5	2	2	Total	Other	Too Shallow	0	0213212FB	5	4	4	Total	Debris Dam	Too High	36
0224603FB	5	2	2	Total	Debris Dam	Too High	5	0213213FB	5	1	4	Total	Natural Falls		12
0224605FB	5	3	2	Total	Debris Dam	Too High	12	0213214FB	5	2	4	Total	Debris Dam	Too High	8
0224606FB	5	2	2	Total	Debris Dam	Too High	8	0213215FB	5	4	4	Total	Debris Dam	Too High	36
0224607FB	5	2	2	Total	Debris Dam	Too High	12	0216201FB	5	2	4	Total	Beaver Dam	Too High	6
0224608FB	5	2	2	Total	Debris Dam	Too High	12	0216202FB	5	2	4	Total	Debris Dam	Too High	5
0224609FB	5	1	2	Total	Debris Dam	Too High	4	0216203FB	5	2	4	Partial	Debris Dam	Too Fast	3
0224611FB	5	1	2	Total	Debris Dam	Too High	8	0216204FB	5	2	2	Total	Beaver Dam	Too High	18
0224613FB	5	3	2	Total	Debris Dam	Too High	8	0216205FB	5	2	4	Total	Debris Dam	Too High	6
0224615FB	5	3	2	Total	Debris Dam	Too High	16	0216206FB	5	3	4	Partial	Dam	Too High	6

Table B.3 SCA - Fish Barrier Characteristics

0224616FB	5	3	2	Total	Debris Dam	Too High	18	0216207FB	5	1	4	Partial	Debris Dam		2
0224617FB	5	2	2	Total	Debris Dam	Too High	4	0216208FB	5	1	4	Total	Debris Dam	Too High	6
0224620FB	5	1	2	Total	Debris Dam	Too High	4	0216209FB	5	3	3	Unknown	Debris Dam	Too High	0
0323601FB	5	3	2	Partial	Debris Dam	Too Shallow	4	0216210FB	5	4	5	Total	Beaver Dam	Too High	24
0323602FB	5	3	3	Partial	Debris Dam	Too High	6	0216211FB	5	5	5	Total	Beaver Dam		48
0323603FB	5	-1	3	Total	Beaver Dam	Too High	12	0216212FB	5	4	1	Partial	Beaver Dam	Too High	18
0323605FB	5	4	3	Total	Debris Dam	Too High	18	0219201FB	5	2	2	Total	Beaver Dam	Too High	36
0323606FB	5	-1	3	Total	Beaver Dam	Too High	32	0220201FB	5	1	3	Partial	Debris Dam	Too High	24
0323607FB	5	-1	3	Total	Beaver Dam	Too High	24	0220202FB	5	1	3	Total	Debris Dam	Too High	6
0323608FB	5	-1	3	Total	Beaver Dam	Too High	12	0220203FB	5	2	2	Total	Debris Dam	Too High	10
0323609FB	5	4	3	Total	Debris Dam	Too High	6	0220204FB	5	1	3	Partial	Debris Dam		1.5
0324601FB	5	1	1	Partial	Beaver Dam	Too High	5	0220205FB	5	3	3	Total	Debris Dam		4
0324602FB	5	2	3	Total	Debris Dam	Too High	4	0220206FB	5	3	3	Total	Debris Dam		2
0324603FB	5	2	3	Total	Debris Dam	Too High	6	0220207FB	5	2	3	Partial	Debris Dam	Too High	1
0324604FB	5	4	3	Total	Beaver Dam	Too High	18	0220208FB	5	2	3	Total	Debris Dam	Too High	36
0324605FB	5	4	3	Total	Beaver Dam	Too High	24	0223201FB	5	1	1	Total	Debris Dam	Too High	5
0324606FB	5	3	2	Total	Beaver Dam	Too High	10	0223202FB	5	2	2	Total	Debris Dam	Too High	12
0324609FB	5	3	4	Total	Beaver Dam	Too High	18	0223203FB	5	2	2	Partial	Debris Dam	Too High	8
0324610FB	5	2	3	Total	Beaver Dam	Too High	18	0223204FB	5	2	2	Total	Debris Dam	Too High	12
0324611FB	5	4	4	Partial	Beaver Dam		24	0223205FB	5	2	5	Total	Debris Dam	Too High	6
0324612FB	5	3	1	Total	Beaver Dam	Too High	18	0223206FB	5	2	5	Partial	Debris Dam	Too High	1
0325601FB	5	2	2	Total	Debris Dam	Too High	6	0223207FB	5	2	5	Total	Debris Dam	Too High	4
0325602FB	5	3	2	Total	Debris Dam	Too High	18	0224201FB	5	1	1	Temp.	Debris Dam	Too Shallow	0
0325603FB	5	2	2	Total	Debris Dam	Too High	6	0224202FB	5	2	2	Total	Debris Dam	Too Shallow	0
0325604FB	5	2	2	Total	Debris Dam	Too High	12	0224204FB	5	2	2	Partial	Debris Dam	Too Shallow	0
0325605FB	5	1	3	Partial	Debris Dam	Too Shallow	0	0224205FB	5	-1	3	Total	Beaver Dam		18
0325606FB	5	2	2	Total	Debris Dam	Too High	12	0224206FB	5	2	3	Total	Debris Dam		13
0326601FB	5	1	3	Total	Debris Dam	Too High	4	0224207FB	5	-1	-1	Total	Beaver Dam	Too High	36

Table B.3 SCA - Fish Barrier Characteristics															
0326602FB	5	1	1	Total	Debris Dam	Too High	3	0224208FB	5	2	4	Total	Debris Dam	Too High	5
0327601FB	5	2	1	Total	Debris Dam	Too High	8	0224209FB	5	2	3	Total	Debris Dam	Too High	10
0212201FB	5	5	3	Total	Debris Dam	Too Shallow	0	0323201FB	5	1	3	Total	Debris Dam	Too High	6
0212202FB	5	1	3	Partial	Debris Dam	Too High	12	0323202FB	5	3	3	Total	Debris Dam	Too High	24
0212203FB	5	1	3	Partial	Debris Dam	Too High	6	0326201FB	5	2	2	Partial	Debris Dam	Too High	4
0212204FB	5	3	4	Total	Natural Falls	Too High	12	0326202FB	5	2	2	Total	Debris Dam	Too High	4
0212205FB	5	2	2	Total	Natural Falls		12	0326203FB	5	-1	3	Total	Beaver Dam	Too High	18
0213201FB	5	2	3	Temp.	Debris Dam	Too Shallow	0	0326204FB	5	-1	2	Total	Beaver Dam	Too High	30
0326210FB	5	-1	3	Total	Beaver Dam	Too High	24	0326205FB	5	-1	3	Total	Beaver Dam	Too High	36
0327201FB	5	2	1	Total	Debris Dam	Too High	5	0326206FB	5	-1	3	Total	Debris Dam	Too High	24
0327202FB	5	2	1	Total	Debris Dam		3	0326207FB	5	2	3	Total	Debris Dam	Too High	8
0327203FB	5	2	1	Total	Debris Dam	Too High	14	0326208FB	5	2	1	Total	Debris Dam	Too High	18
0327204FB	5	-1	1	Total	Debris Dam	Too High	15	0326209FB	5	2	1	Total	Debris Dam	Too High	10
0327205FB	5	1	1	Total	Debris Dam	Too High	10								

Table B.4 SCA - Erosion Site Characteristics								
Site ID	Severity	Correctability	Accessibility	Length (ft.)	Bank Height (ft.)	Land Use	Type	Cause
0212201ES	2	4	1	1200	3	Forest	Unknown	Unknown
0213201ES	2	3	2	610	15	Crop field	Unknown	Landuse Change
0324604ES	3	-1	1	362	3	Forest	Unknown	Unknown
0219201ES	3	-1	2	350	5	Shrubs/Small Trees	Unknown	Unknown
0226201ES	3	-1	1	148	15	Crop field	Unknown	Unknown
0326601ES	4	-1	1	103	2	Forest	Unknown	Unknown
0326602ES	4	-1	1	30	25	Forest	Unknown	Bend at steep Slope
0213202ES	4	3	4	100	4	Forest	Headcutting	Bend at steep Slope
0213203ES	4	4	4	140	5	Forest	Unknown	Unknown
0220201ES	4	5	4	30	35	Forest	Unknown	Unknown
0327201ES	4	-1	1	100	50	Forest	Unknown	Unknown
0419501ES	5	-1	2	50	5	Forest	Unknown	Unknown
0419502ES	5	-1	2	40	6	Forest	Headcutting	Unknown
0224601ES	5	3	2	25	6	Forest	Unknown	Unknown
0224602ES	5	3	2	15	8	Forest	Unknown	Unknown
0324601ES	5	1	2	30	3	Forest	Unknown	Unknown
0324602ES	5	-1	2	50	2	Forest	Unknown	Unknown
0324603ES	5	-1	3	75	3	Forest	Headcutting	Unknown
0403201ES	5	2	1	5	2	Forest	Headcutting	Landuse Change
0220202ES	5	3	3	18	5	Forest	Unknown	Unknown
0223201ES	5	3	5	75	3	Forest	Headcutting	Unknown

Table B.5 SCA - Pipe Outfall Characteristics

Site ID	Severity	Correctability	Accessibility	Type	Material	Location	Pipe Diameter (in.)	Channel Width (ft.)	Discharge	Color	Comments
0419501PO	3	5	1	Other	Corrugated Metal	Head of Stream	48	50	Yes	Clear	
0327601PO	3	-1	1	Stormwater	Corrugated Metal	Right Bank	30	60	No	Other	
0224601PO	4	5	2	Unknown	Corrugated Metal	Left Bank	24	24	No		
0327602PO	4	-1	2	Stormwater	Plastic	Left Bank	24	4	No		
0419502PO	5	5	1	Stormwater	Corrugated Metal	Right Bank	48	300	No		downstream of gravel pit
0419503PO	5	5	1	Stormwater	Corrugated Metal	Right Bank	48	200	No		across streaan down from gravel pit
0213201PO	5	3	1	Stormwater	Corrugated Metal	Head of Stream	12	0	No		
0213202PO	5	4	4	Stormwater	Corrugated Metal	Right Bank	24	0	No		
0226201PO	5	3	1	Stormwater	Corrugated Metal	Head of Stream	32	24	No	Clear	

Table B.6 SCA - Trash Dump Site Characteristics							
Site ID	Severity	Correctability	Accessibility	Type	Estimated Amt. (pick-up truck loads)	Volunteer Opp.	Ownership
0219202TD	2	2	2	Mixed Types	10	Yes	Private
0323602TD	3	4	3	Residential	1	No	Unknown
0213201TD	4	1	1	Industrial	2	No	Private
0213202TD	4	1	1	Industrial	3	No	Private
0219201TD	4	2	1	Residential	1	No	Private
0226201TD	4	1	1	Residential	2	No	Private
0323601TD	4	4	3	Residential	1	No	Unknown
0324601TD	4	1	4	Tires	2	Yes	Private
0419501TD	5	1	1	Tires	0.3	Yes	Private
0419502TD	5	1	1	Floatables	0.3	Yes	Private
0216201TD	5	5	4	Other	0.5	No	Private

Table B.7 SLA – Bank, Buffer, and erosion characteristics																			
		BANK (bank height and erosion status - miles of shore)												BANK COVER (miles)			BUFFER CONDITION			
		0-5 ft			5-10ft			10-30ft			>30ft						BEACH (miles)		MARSH (miles)	
Plate Number	Total Miles Surveyed	low	high	undercut	low	high	undercut	low	high	undercut	low	high	undercut	bare	partial	full	eroding	stable	eroding	stable
1	4.37	0.63	0.11	0.00	0.36	0.13	0.00	1.50	0.22	0.00	0.74	0.68	0.00	0.00	2.21	2.16	0.00	0.10	0.00	0.17
2	7.34	1.24	0.05	0.00	1.16	0.14	0.00	2.47	0.59	0.00	1.51	0.13	0.00	0.03	4.00	3.32	0.03	0.08	0.00	1.07
3	7.22	3.01	0.80	0.00	1.41	0.88	0.00	0.19	0.61	0.00	0.00	0.00	0.00	0.25	3.57	3.40	1.01	0.31	0.00	2.17
4	5.53	4.22	0.00	0.00	1.04	0.11	0.00	0.12	0.02	0.00	0.00	0.00	0.00	0.17	0.47	4.90	0.00	0.90	0.00	1.74
5	5.63	2.98	0.00	0.00	1.04	0.31	0.00	1.05	0.06	0.00	0.07	0.12	0.00	0.46	0.72	4.45	0.00	1.82	0.00	2.45
6	3.72	2.53	0.00	0.00	0.07	0.24	0.00	0.41	0.30	0.00	0.17	0.00	0.00	0.54	0.67	2.52	0.00	2.16	0.16	0.70
7	2.62	0.77	0.00	0.00	0.25	0.15	0.00	0.65	0.23	0.00	0.05	0.53	0.00	0.81	0.32	1.49	0.00	0.69	0.00	0.03
8	3.08	1.50	0.02	0.00	0.07	0.03	0.00	1.05	0.03	0.00	0.33	0.06	0.00	0.16	0.92	2.00	0.00	1.63	0.00	0.00
26	3.98	1.67	0.00	0.00	0.30	0.12	0.00	0.06	1.12	0.00	0.12	0.59	0.00	1.39	0.38	2.21	1.67	1.83	0.00	0.00
27	4.69	2.68	0.00	0.00	0.34	0.41	0.00	0.31	0.41	0.00	0.12	0.40	0.00	0.29	0.66	3.73	0.92	1.95	0.00	0.49
28	6.40	3.22	0.05	0.00	1.00	0.55	0.00	0.50	0.77	0.00	0.09	0.23	0.00	0.86	0.78	4.76	0.48	2.21	0.00	1.53
29	8.95	5.86	0.24	0.02	0.43	0.35	0.15	0.75	0.40	0.00	0.70	0.05	0.00	0.58	1.04	7.32	0.18	1.48	0.10	5.11
30	5.60	2.22	0.13	0.00	0.53	0.35	0.10	1.17	0.48	0.04	0.50	0.09	0.00	0.02	1.85	3.73	0.00	0.00	0.00	1.11
31	4.95	0.79	0.14	0.00	0.40	0.56	0.04	1.52	0.38	0.00	0.50	0.63	0.00	0.00	4.17	0.79	0.00	0.00	0.00	1.50
Total	**74.08**	**33.32**	**1.54**	**0.02**	**8.40**	**4.33**	**0.29**	**11.75**	**5.62**	**0.04**	**4.90**	**3.51**	**0.00**	**5.56**	**21.76**	**46.78**	**4.29**	**15.16**	**0.26**	**18.07**

Table B.8 SLA - Land cover characteristics									
		LAND COVER (landcover - miles of shore)							
Plate Number	Total Miles Surveyed	agriculture	bare	commercial	forest	grass	paved	residential	scrub-shrub
1	4.37	0.02	0.00	0.12	1.90	0.72	0.02	1.60	0.00
2	7.34	0.15	0.00	0.65	2.51	0.06	0.03	3.95	0.00
3	7.22	3.32	0.06	0.00	3.35	0.00	0.00	0.41	0.08
4	5.53	1.25	0.15	0.00	0.87	0.08	0.00	2.98	0.20
5	5.63	0.58	0.00	0.00	2.44	0.21	0.08	1.57	0.74
6	3.72	0.71	0.00	0.00	1.70	0.00	0.00	0.12	1.19
7	2.62	0.19	0.20	0.00	0.84	0.09	0.00	0.87	0.42
8	3.08	0.00	0.00	0.00	0.66	1.27	0.00	0.38	0.77
26	3.98	0.00	0.00	0.00	1.29	0.73	0.00	1.15	0.81
27	4.69	0.61	0.00	0.00	2.04	0.35	0.00	0.04	1.65
28	6.40	1.63	0.00	0.00	2.06	1.26	0.03	0.57	0.85
29	8.95	2.82	0.00	0.00	3.89	0.31	0.01	1.61	0.30
30	5.60	0.00	0.00	1.44	2.22	0.88	0.20	0.70	0.18
31	4.95	1.58	0.00	0.00	1.62	1.05	0.00	0.59	0.11
Total	**74.08**	**12.86**	**0.41**	**2.21**	**27.39**	**7.01**	**0.37**	**16.54**	**7.30**

Table B.9 SLA - Shoreline Features

Plate Number	Total Miles Surveyed	Shoreline Features																
		Number of											Miles of					
		docks	dilapidated docks	boathouses	private	public	outfalls	groinfields	<50 slips	>50 slips	jetties	breakwater	debris	unconventional	bulkhead	dilapidated bulkhead	riprap	wharf
1	4.37	40	2	1	4	0	0	0	0	1	0	0	0.00	0.03	0.40	0.01	0.51	0.00
2	7.34	94	1	3	7	0	7	0	0	2	0	0	0.00	0.03	1.07	0.03	0.65	0.00
3	7.22	1	0	0	1	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.26	0.00
4	5.53	51	1	1	8	0	2	3	0	0	3	0	0.00	0.00	1.34	0.00	0.74	0.00
5	5.63	28	0	2	7	1	0	0	0	0	0	1	0.00	0.06	0.50	0.00	0.26	0.00
6	3.72	2	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.02	0.00
7	2.62	7	0	0	2	1	1	2	0	0	1	0	0.14	0.04	0.21	0.04	0.60	0.00
8	3.08	1	0	0	0	0	0	0	0	0	0	0	0.13	0.00	0.01	0.00	0.04	0.00
26	3.98	21	2	0	17	0	14	3	0	0	0	0	0.07	0.00	0.66	0.13	0.24	0.00
27	4.69	0	0	0	0	0	0	0	0	0	0	0	0.29	0.00	0.00	0.00	0.14	0.00
28	6.40	4	1	0	0	0	0	0	0	0	0	0	0.53	0.00	0.05	0.00	0.49	0.07
29	8.95	20	2	0	5	0	0	1	0	0	0	0	0.00	0.02	0.03	0.00	0.16	0.00
30	5.60	12	0	2	0	1	2	0	0	3	0	0	0.03	0.00	0.28	0.05	0.22	0.00
31	4.95	5	1	0	0	0	0	0	1	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Total	**74.08**	**286**	**10**	**9**	**51**	**3**	**26**	**9**	**1**	**6**	**4**	**1**	**1.19**	**0.18**	**4.55**	**0.26**	**4.33**	**0.07**

Table B.10 MDE Sassafras Synoptic Nutrient Monitoring Program						
Responsible Party	**Frequency**	**Parameters**	**Station**	**Latitude**	**Longitude**	**ADC**
Maryland Department of the Environment	Fall 2006/Spring 2007/Spring 2009	total nitrogen, total phosphorus, phosphate, nitrate, dissolved oxygen, pH, conductivity	US43	39.352180	-75.823240	Kent 5 K 6
	Fall 2006/Spring 2007/Spring 2009		US33	39.340722	-76.007003	Kent 3 C 8
	Fall 2006/Spring 2007/Spring 2009		US35	39.339890	-75.889270	Kent 4 K 8
	Fall 2006/Spring 2007/Spring 2009		US36	39.339990	-75.868480	Kent 5 D 8
	Fall 2006/Spring 2007/Spring 2009		US37	39.342240	-75.867160	Kent 5 D 8
	Fall 2006/Spring 2007/Spring 2009		US40	39.340790	-75.832370	Kent 5 J 8
	Fall 2006/Spring 2007/Spring 2009		US41	39.337840	-75.834750	Kent 5 J 8
	Fall 2006/Spring 2007/Spring 2009		US52	39.389840	-75.779670	Cecil 26 k 9
	Fall 2006/Spring 2007/Spring 2009		US54	39.390610	-75.792420	Cecil 26 H 9
	Fall 2006/Spring 2007/Spring 2009		US55	39.395750	-75.824460	Cecil 26 C 8
	Spring 2007/Spring 2009		US135	39.371861	-75.803783	Kent 6 C 2
	Spring 2007/Spring 2009		US136	39.34753	-75.841386	Kent 5 H 7
	Spring 2007/Spring 2009		US138	39.336253	-75.912881	Kent 4 G 9
	Spring 2007/Spring 2009		US42	39.331533	-75.833194	Kent 5 J 10
	Spring 2007/Spring 2009		US44	39.348494	-75.809781	Kent 6 B 7
	Spring 2007/Spring 2009		US47	39.335628	-75.791528	Kent 6 E 9
	Spring 2007/Spring 2009		US49	39.360567	-75.817831	Kent 6 A 4
	Spring 2007/Spring 2009		US56	39.411694	-75.833608	Cecil 26 B 8
	Fall 2009		US140			Cecil 23, K9

Table B.10 MDE Sassafras Synoptic Nutrient Monitoring Program						
Responsible Party	**Frequency**	**Parameters**	**Station**	**Latitude**	**Longitude**	**ADC**
	Fall 2009		US141			Cecil 24, G8
	Fall 2009		US142			Cecil 25, A8
	Fall 2009		US143	39.394467	-75.894372	Cecil 25, C9
	Fall 2009		US144			Kent 4, D7
	Fall 2009		US145			Kent 3, H9
	Fall 2009		US146			Kent 2, J8

Table B.11 - Selected Synoptic Nutrient Data

	September 2006 (mg/L)				April 2007 (mg/L)				May/June 2009 (mg/L)			
Station	PO_4	NO_2/NO_3	TP	TN	PO_4	NO_2/NO_3	TP	TN	PO_4	NO_2/NO_3	TP	TN
US134					0.007	1.646	0.038	2.240				
US135					0.013	3.167	0.078	4.270	0.008	3.100	0.245	4.520
US137					0.004	2.901	0.039	3.500				
US138					0.009	5.944	0.040	6.310	0.018	5.260	0.063	5.500
US31					0.002	2.404	0.025	2.820				
US32					0.002	2.896	0.017	3.200				
US33					0.006	2.951	0.100	4.420	0.006	1.700	0.047	2.880
US35	0.071	4.780	0.239	4.860	0.070	4.974	0.220	6.130	0.043	3.740	0.228	5.300
US36	0.004	3.900	0.046	5.680	0.005	4.169	0.033	4.880	0.003	2.850	0.048	3.130
US37	0.012	2.110	0.052	2.410	0.008	2.482	0.036	3.000	0.015	2.260	0.083	2.550
US38	0.005	1.360	0.024	1.750	0.001	1.256	0.035	1.810				
US40	0.003	12.260	0.005	12.240	0.002	9.404	0.022	10.250	0.001	10.570	0.014	10.280
US41	0.007	9.340	0.025	10.050	0.005	8.896	0.020	9.810	0.005	9.520	0.040	9.840
US42					0.005	8.132	0.031	9.160	0.004	5.500	0.092	5.990
US43	0.006	4.130	0.094	4.900	0.003	3.794	0.049	4.720	0.003	4.180	0.080	4.900
US44					0.004	2.560	0.097	4.170	0.001	1.720	0.071	4.290
US46					0.004	1.537	0.055	2.560				
US47					0.003	0.071	0.016	0.590	0.009	0.120	0.063	0.960
US49					0.009	8.745	0.042	9.260	0.020	8.640	0.036	8.810
US51	0.005	3.650	0.037	3.850	0.006	4.905	0.036	5.410				
US52	0.013	3.650	0.063	3.940	0.022	3.252	0.086	4.230	0.013	2.370	0.123	3.120
US53	0.012	5.040	0.070	5.430								
US54	0.017	10.800	0.043	11.780	0.002	1.884	0.060	8.510	0.475	9.430	0.616	10.260
US55	0.006	1.190	0.133	1.540	0.003	2.607	0.120	3.640	0.007	1.400	0.256	2.650
US56					0.025	8.010	0.034	2.780	0.003	0.560	0.057	2.280
US58	0.005	0.170	0.126	1.250	0.003	1.567	0.042	2.380				
US59					0.005	5.870	0.036	6.300				

Appendix C. Upper Eastern Shore Tributary Strategy BMPs

Table C.1 Upper Eastern Shore Tributary Strategies BMPs				
Practice	**Units**	**Strategy**	**Progress 2004**	**Remaining Goal**
Agriculture				
Soil Conservation and Water Quality Plans	acres/yr	252,862	113,654	139,208
Conservation Tillage	acres	151,587	174,726	0
Cover Crops, Small Grains, Alternative Crops				
Cover Crops	acres/yr	124,659	13,220	111,439
Small Grains	acres	31,165	0	31,165
Alternative Crops	acres	10,561	0	10,561
Animal Waste Management Systems				
Livestock	systems	342	132	210
Poultry	systems	80	69	11
Runoff Control	systems	148	37	111
Pasture BMPs				
Off-Stream Watering w/Fencing	acres	2,290	42	2,248
Off-Stream Watering w/o Fencing	acres	1,411	225	1,186
Nutrient Management	acres	252,862	389,919	0
Precision Agriculture	acres	97,701	0	97,701
Retirement Programs				
Forest Buffers	acres	4,029	1,652	2,377
Grass Buffers	acres	14,162	6,475	7,687
Wetland Restoration	acres	3,414	1,681	1,733
Retirement of Highly Erodible Land	acres	6,407	3,412	2,995
Tree Planting - Agriculture	acres	2,365	1,701	665
Ammonia Emmissions Reduction	houses	20	0	20
Phytase Feed Additive (% reduction)	%	32	16	16
Manure Transport (tons)	tons	7,297	1,220	6,077
Horse Pasture Management	operations	285	0	285
Urban				
Nutrient Management				
Urban Land	acres	30,404	0	30,404
Mixed Open Land	acres	90,409	0	90,409
Tree Planting				
Mixed Open Land	acres	58	60	-3
Urban Land	acres	2,291	0	2,291
Forest Buffers	acres	184	33	151
Sprawl Reduction	acres	1,396	0	1,396
Erosion & Sediment Control	acres/yr	2,349	184	2,165
Stormwater Management	acres	22,404	4,173	18,231

Table C.1 Upper Eastern Shore Tributary Strategies BMPs				
Practice	**Units**	**Strategy**	**Progress 2004**	**Remaining Goal**
Agriculture				
Stream Restoration	linear ft	0	3,497	-3,497
Septics				
Septic Connections	systems	3,797	4,461	-664
Septic Denitrification	systems	25,203	1	25,202

Table C.2 Upper Eastern Shore Tributary Strategies						
	NITROGEN LOADS (million pounds per year)			PHOSPHORUS LOADS (million pounds per year)		
Category	1985	2004	Strategy	1985	2004	Strategy
Agriculture	6.55	4.68	2.29	0.51	0.37	0.24
Resource Land	0.68	0.79	0.62	0.06	0.08	0.01
Urban Point Source	0.22	0.39	0.19	0.05	0.04	0.02
Urban Nonpoint Source	0.62	0.62	0.41	0.06	0.04	0.03
Septic	*0.24*	*0.27*	*0.15*	*0.00*	*0.00*	*0.00*
Stormwater	*0.38*	*0.35*	*0.26*	*0.06*	*0.04*	*0.03*
Total	8.06	6.48	3.52	0.69	0.53	0.30

Appendix D. Stakeholder Meeting Minutes 2009

D.1 February 12, 2009, 6:30 PM

Galena Fire Hall

Kim Kohl, Executive Director, opened, welcoming the crowd of more than 160 and providing a brief background on the Sassafras River Association (SRA). SRA is a not for profit, watershed organization, formed in 2004 whose mission is to advocate for and protect the Sassafras River. The Board made a decision in 2007 that the best way to do this was to undertake a Sassafras Watershed Action Plan (SWAP) and raised private funding, from both foundations and memberships, to support this effort. SRA has two paid staff, nine Board members, dozens of volunteers and over 500 members. The SWAP has been underway for the past six months and will continue through 2009. SRA is partnering with more than 30 state and local agencies, academic institutions and private business to complete this plan. Stakeholders play a critical role and as such, SRA will host quarterly meetings to both educate and gather input on problems and concerns.

Charlotte Staelin, SRA Vice President and owner of Colchester Farms which hosts a community supported agriculture program, recalled playing in the River as a child and the changes she has observed over the past 60 some years. Charlotte spoke of her fear of allowing her grandchildren to play in waters no longer clear and often covered in algae. Charlotte encouraged all present to accept responsibility for these changes and to join together to find the most effective solutions to restore the River's health.

Jeff Cornwell, Associate Professor at University of Maryland Center for the Environment and a member of the SWAP Core Team, presented the State of the Sassafras. Jeff provided basic characteristics of the River and the watershed and spoke of the primary issues confronting the river: phosphorous, nitrogen and sediments. Jeff demonstrated the effects of excess nutrients in the River and the resulting algae blooms that pose threats to both the watershed and the surrounding population. Jeff noted some of the key sources of pollution: waste water treatment plants, agricultural run-off, aging septics, and atmospheric deposition. Jeff also spoke of the specific research UMCES is undertaking on algae blooms. (To view Jeff's presentation in full please go to *Presentations* on this page.)

Kascie Herron, Sassafras RIVERKEEPER and principle researcher on SWAP, presented an overview of SRA's approach to the watershed plan. Kascie laid out the steps involved in the process (desktop assessment and field assessments), the timeline (through December 2009) and the various levels of participation (Core Team, Partners and Stakeholders). Kascie highlighted the work that is already underway (the characterization and the stream corridor assessment) and the work that is still to be done. (To view Kascie's presentation in full please go to *Presentations* on this page.)

Joanne Throwe, Associate Director of University of Maryland's Center for Environmental Finance and SWAP partner, facilitated an hour long discussion with stakeholders. Joanne began by asking for a show of hands by profession. The crowd included farmers, educators, numerous scientists, lawyers, artists and business owners -- many who live in the watershed and others, who have an interest in protecting the waters of the Chesapeake Bay. Joanne solicited input in the form of problems and causes which are summarized below with responses in italics. Additional questions raised by the crowd during the session have also been answered here for your review.

Problems in the Watershed

Impact of development
Cecil county development, commissioners allow anything
Homeowners using fertilizer and not realizing what impact that has on the River
Agriculture
SRA should considering the source of the water – surface vs ground vs aquifers. *Jeff Cornwell responded that Phosphorous is not really a ground water issue.*
Closed Beaches
Are farmers being singled out as the main problem*? Farmers are not being singled out. We know that agriculture contributes to nutrient loading in the River; however, we are investigating all sources of pollution to identify the most effective solutions for restoring water quality.*
Algal Blooms

Causes

Consider the impact of weather, wildlife, boaters on the river. *Jeff Cornwell explained that the best water quality tends to be in dry years. We'd like to make the dry years the equivalent of our "worst" years.*
Phosphorus loading from past activities

Solutions

Value of denitrifying systems vs. connection to community systems
Ensure the best "bang for the buck" in all potential/recommended solutions
Public outreach
Preservation of agriculture in the watershed
Involve schools in solutions
Adopt a stream
Do something - no more studies. *The SWAP is not a study but a scientific assessment. It will provide a blueprint for all future restoration strategies.*
Need to get people from New Castle County more involved. *SRA has engaged state and local agencies in NCC to participate on Core Team and has invited all stakeholders through mailed invitation to participate in SWAP.*
Consider long-range planning, openness, transparency, property rights

Other:

What is a stream? *For purposes of the Stream Corridor Assessment (a protocol developed by the Department of Natural Resources) a stream is a channel that has perennial flow.*

How were parcels identified for Stream Corridor Assessment? *Using Geographic Information System (GIS) software provided by DNR, SRA identified all parcels that were situated on stream channels. This amounted to approximately 400 parcels in Kent, Cecil and New Castle counties. Letters were sent to property owners requesting permission to walk across their property to access the stream channel. Out of 400 more than ¾'s of the letters went to homeowners and about ¼ to farmers. Although farmers own large tracts of land the number of actual farmers is small compared to home owners.*

Who is liable for the crew walking the streams? *Maryland Conservation Core is insured by the State of Maryland and SRA employees are covered under worker's comp and the organization's liability policy.*

Who will pay for implementation projects? *SRA's goal is to develop restoration strategies complete with cost estimates and potential funding opportunities. The restoration work will be undertaken by those groups with the appropriate expertise: county agencies, state agencies, academic institutions, SRA, etc. Everyone involved in the planning process will have a role to play in the restoration. One of the roles of the U of MD Environmental Finance Center is to helps communities figure out how to pay for it.*

Projects should be coordinated with similar groups, collaborate with Sultana Projects, schools. *SRA has partnered with more than 30 agencies, academic institutions, not for profit organizations and private businesses to ensure the most effective collaboration.*

Add USGS, sociologist, urban anthropologist to core team. *Core Team includes an anthropologist, John Seidel, Associate Professor of Anthropology and Environmental Studies, at Washington College. SRA will investigate partnering with USGS as well.*

Why is nitrogen a problem but not phosphorus in the Sassafras? *Both are a problem in the River; however, the State of Maryland has issued a Total Maximum Daily Load (TMDL) for the amount of Phosphorous which can be dumped into the River and therefore, pollutant reductions are calculable.*

Who are the stakeholders and what are their concerns? *Stakeholders are anyone living, working or recreating in the watershed as well as anyone who has an interest in protecting the Chesapeake Bay. Stakeholder concerns are your concerns. 2007 census data is available by county (not by watershed) and shows total population at 19, 987 (Kent) and 99,965 (Cecil); median household income $ 46,693 (Kent) and $ 62,489 (Cecil); and % of persons age 25+ with Bachelor's degree 21.7% (Kent) and 16.4% (Cecil).*

Who knows the science behind these issues? *The characterization pulls together all data that has been compiled to date on the Sassafras River. The SWAP Core Team includes 24 individuals who represent agencies or other organizations that have produced this data. The Core Team has* *extensive experience in watershed planning. For a complete list of members please see Core Team on this page.*

Who should people call when they see a problem? *Call the Sassafras RIVERKEEPER at 410-708-3303 or go to www.sassafrasriver.org and report an issue or concern on line.*

How do we get boaters, out-of-towners involved (they're dumping in the water)? *SRA is hosting a panel discussion on March 10th with marina owners/managers and the public to discuss Maryland Clean Marina program and clean boating practices. SRA is trying to foster working relationships with all marinas in the watershed in an effort to reach the more than 1800 boaters who rent slips here. In addition, the Sassafras RIVERKEEPER patrols the River from April to October, engaging boaters in dialog and handing out materials for involvement.*

What is the role of the Waterkeeper Alliance in SWAP? *SRA is a member of the Waterkeeper Alliance. The Alliance plays no direct role in nor provides any funding to SWAP. The Alliance does provide support to SRA in the form of creating a coalition of all RIVERKEEPERS, nationally and regionally, to share best practices and identify policy issues. SRA is an independent organization with its own voice and mission led by an Executive Director and Board who make all decisions for the organization.*

Kim Kohl thanked the presenters, participants, volunteers and donations for refreshments and door prize. Kim encouraged anyone interested in direct involvement to sign up on one of the many volunteer sheets or on line at www.sassafrasriver.org. Kim announced the next Stakeholder Meeting will be held April 14th, 6:30 pm at Galena Fire Hall. All are welcome.

John Burke, SRA president, mentioned SRA's need for new members and invited all interested parties to pick up a brochure or visit the website. The meeting was then adjourned.

D.2 April 14, 2009, 6:30 Pm
Galena Fire Hall

Kim Kohl, Executive Director, opened, welcoming the crowd of approximately 100 and provided a brief history of the Sassafras River Association (SRA). SRA is a not for profit, 501 (c) (3) watershed organization, incorporated in 2004. SRA's mission is to advocate for and protect the Sassafras River. The Board made a decision in 2007 that the best way to advance the mission was to undertake a Sassafras Watershed Action Plan (SWAP) and raised private funding, from both foundations and memberships, to support this effort. Foundation funders include Chesapeake Bay Trust, Rauch Foundation, Town Creek, Shared Earth and Munson to name a few. SRA hired its first staff, the Sassafras RIVERKEEPER, in June 2008 and an Executive Director in October of the same year. SRA currently has two paid staff, nine Board members, three consultants, 100 volunteers and over 500 members. The SWAP has been underway for the past six months and will continue through 2009. SRA is partnering with more than 40 state and local agencies, academic institutions and private business to complete this plan. Stakeholders play a critical role and, to this end SRA will continue to host quarterly meetings to share findings and gather input on problems and solutions.

Kim recalled that in the last meeting stakeholders voiced concern over issues in the watershed: development, run-off, erosion and excessive nutrients. Tonight's meeting will show how SWAP assessments are addressing those concerns and share some of the preliminary findings.

Former Congressman and SRA Board Member, Wayne Gilchrest, spoke on what the Sassafras River means to him and why it's important to save the River. Wayne spoke of the Watershed and how it is each of us, working together, that make this Watershed a unique and wonderful place – farmers, watermen, residents, catfish, bass, crab, fox, deer, beaver, sorghum, corn and soy. Wayne urged stakeholders to remain engaged in the process as each has a role to play in restoring the water quality in this place we love.

Paul Sturm, Program Director for Center for Watershed Protection, consultant to SRA and a member of the Core Team, presented preliminary findings from the stream corridor and upland assessments. Paul guided stakeholders through pie charts showing land use and correlated impacts. Paul summarized, the biggest issue confronting the River is run off from both agricultural and urban sources which contribute to excessive nutrient loading. Paul noted that farmers have made great strides with nutrient management plans and putting best management practices into place to reduce phosphorous. He emphasized the use of cover crops and buffers to further reduce phosphorus. In contrast, waste water treatment plants in Betterton and Galena operate with outdated technology from the 1960's. Aerial photographs demonstrated excessive use of fertilizers by watershed homeowners, further increasing phosphorous loads in the River. Paul showed examples of solutions from other watersheds.

Joanne Throwe, from the University of Maryland Center for Environmental Finance, broke the crowd into small groups of 8 – 10 participants and asked each group to answer the following questions: what are your goals for the Sassafras restoration effort and what are the restoration strategies that you think would work in the sassafras watershed? Groups reported back with much insight and innovation. Stakeholder goals and strategies, cover a wide spectrum of issues in the watershed (see list at end of minutes) and will be considered when identifying potential projects.

Kascie Herron, Sassafras RIVERKEEPER, closed the meeting, thanking all for their outstanding input and inviting all to the next SWAP meeting, Tuesday, July 21st , 6:30 pm at Turner's Creek Pavilion.

Stakeholder Goals

Fishable/swimmable
Clear
Safe for swimming
Developers use BMPs
Make sure public knows BMPs
Campaign against excess fertilizer

Education about proper fertilization
Healthy environment with native grasses v. phragmites
Introduce BMPs to Children
Cleaner River
More fish and crabs in the water
Identify leaky septics
Use this group as a model for other watersheds in area
Increase forest buffers
More/better enforcement
Meet the TMDLs, then go home
Quantify problem so we can see measurable progress
Quantify acreage that's not currently eligible for conservation practice funding
More people would recognize that there's a problem
See that measured results get better
Remove river from impaired waters list
Understand causes of erosion
Decrease impervious surfaces
Increase fish population – menhaden/algae eaters
Understand phosphorus better. (UMCES issues)

<u>Stakeholder Strategies</u>
Proper fertilization
Local legislation (QA – septic pump out)
Mandatory septic pump out
Galena and Betterton to improve sewage treatment plants
Grants for living shorelines to NOAA and
Funding to focus on NPDES
Greater attention on smaller/older communities – Gregg Neck, Indian Acre – need community sewage treatment. Proximity to river – nutrients feeding directly into River
Educate individuals on lawn care
Educate public on upgrading septic systems; tap into funds to assist people in critical area to make themselves ready for upgrade
Peer groups – peer to peer contact. Better than government coming on the land. One farmer
Forest buffers increase
County septic pump-out ordinance
More package plants
Address homeowner lawn care
Mobile boat pump-out
NPDES upgrades
Use algae for fuel
Make all programs available to all lands in the watershed (income
Protect shorelines by reducing boat wakes
BMPs in
Incentivize tire disposal

Farmland protection for all land
Measure effectiveness of septic systems – soil differences, etc. One size may not fit all.
Stabilize erosion channels
Encourage responsible recreation; publicize public landings so more people will use the river.
Have our meetings at public landings.
100-foot buffers for homeowners
Funding for septics
Educate homeowners on alternative landscaping, fertilizer use
Continue sassafras as priority funding area for cover crops.
Soil testing for homeowners
Stimulus money to correct State Highway erosion problems.

D. 3 July 21, 2009, 6:30 pm
SWAP Stakeholder/SRA Annual Meeting Minutes
Turner's Creek Pavilion

Kim Kohl, Executive Director, opened, welcoming the crowd of approximately 110 and provided a brief history of the Sassafras River Association (SRA), including highlights of the past 12 months which included hiring staff, purchasing a vessel, establishing an office, advocacy efforts, and securing funding and gathering a Core Team for the development of the Sassafras Watershed Action Plan. The Plan is expected to be completed by December 2009 and presented to the public in early 2010. Kim mentioned that SRA had already begun seeking funding to implement restoration recommendations.

Chesapeake environmentalist and author Tom Horton spoke next, delivering a message of optimism through regeneration and restoration. Tom recalled Henry David Thoreau's alarm at the decline of Concord's forests in the 19th Century as a result of human impact through cultivation. By 1975 those same forests resurged, and covered 50% of the land, as agriculture decreased and conservation increased. Tom praised the beaver in its role of creating ponds and wetlands that increase biodiversity while filtering silt and nutrients that would otherwise enter the waterways. Tom also referenced the impressive success of oyster restoration in the 64 square mile Lynnhaven River Watershed in Virginia — 1/1000th the size of the Chesapeake Bay's 64,000 square mile watershed. Lynnhaven's success has led to the creation of an 80-acre oyster bar in the Little Wicomico River that currently produces approximately 20% of all the oysters in Maryland's waters.

Paul Sturm, biologist with Center for Watershed Protection and a key member of the Sassafras Watershed Action Plan (SWAP) Core Team, presented 28 restoration strategies for the Sassafras which would result in significant reductions of nitrogen, phosphorus and sediments. Top priorities include the upgrade of Galena and Betterton's Waste Water Treatment Plants to ENR (enhanced nutrient reduction), implementation of 100 denitrifying home owner septics and an increase of 5,000 acres in cover crop on current ag lands. Stakeholders were receptive to the strategies and appreciated the comprehensive approach. Paul remarked that SRA will continue working with the Core Team to prioritize and identify funding opportunities for project implementation.

Joanne Throwe, Associate Director of University of Maryland's Center for Environmental Finance and SWAP partner, facilitated a short Q & A session. In addition to clarifying SWAP recommendations, stakeholders addressed individual concerns such as failing septics, increased development and zoning violations at Indian Acres.

John Burke presented an award to SRA co-founder and first Board President, John Vail. Vail's four years of service as President were acknowledged as well as his ongoing commitment to the organization.

The meeting was adjourned at sunset.

Appendix E. Zoning

Appendix F. Sassafras River Watershed Characterization

Sassafras River
Watershed Characterization

In support of the Sassafras Watershed Action Plan

Product of joint partnership between:

Sassafras River Association
Center for Watershed Protection
Cecil County Planning and Zoning
Cecil Soil Conservation District
Delaware Department of Natural Resources and Environmental Control
Kent County Planning, Housing, and Zoning
Kent Soil and Water Conservation District
Maryland Department of the Environment
Maryland Department of Natural Resources
McCrone Inc.
University of Maryland Center for Environmental Science
University of Maryland Environmental Finance Center
University of Maryland SeaGrant Extension
Upper Eastern Shore Tributary Strategy Team
Washington College Center for Environment and Society

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES AND MAPS

LIST OF ABBREVIATIONS

BIBI	Benthic Index of Biotic Integrity
BMP	Best Management Practice
CHLA	Chlorophyll a
COMAR	Code of Maryland Regulation
CWA	Clean Water Act
DHMH	Department of Health and Mental Hygiene
DIN	Dissolved Inorganic Nitrogen
DNREC	Department of Natural Resources and Environmental Control
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIBI	Fish Index of Biotic Integrity
HAB	Harmful Algal Bloom
HIBI	Habitat Index of Biotic Integrity
MBSS	Maryland Biological Stream Survey
MDE	Maryland Department of the Environment
MDNR	Maryland Department of Natural Resources
NMP	Nutrient Management Plan
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resource Conservation Service
NRDC	Natural Resource Defense Council
NSSP	National Shellfish Sanitation Program
PCB	Polychlorinated Biphenyls
PO4	Dissolved Inorganic Phosphorus
SAV	Submerged Aquatic Vegetation
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UMCES	University of Maryland Center for Environmental Science
USGS	Unites States Geological Survey
WSSC	Wetland of Special State Concern
WWTP	Waste Water Treatment Plan

1.0 INTRODUCTION

The Sassafras River watershed is located in the Lower Elk River Basin, with its headwaters in Delaware and the mouth at the Chesapeake Bay. Its geographic location lies across three counties: Cecil and Kent Counties in Maryland, and New Castle County in Delaware. The Sassafras River itself is roughly 20 miles long and the watershed covers approximately 94 square miles (Map 1). There are two municipalities within the boundaries of the Sassafras Watershed: Betterton and Galena in Kent County, MD, and one municipality partially within the watershed: Cecilton in Cecil County, MD (Map 1). The Maryland Department of Natural Resources (MDNR) as well as the Delaware Department of Natural Resources and Environmental Control (DNREC), designate watershed codes across each state. Table 1-1 summarizes these codes for the Sassafras watershed and its respective smaller subwatersheds (Map 1).

Table 1.1 Subwatersheds in the Sassafras River Watershed

Subwatershed Number	Subwatershed Name
Delaware Basin 21	Sassafras River
021306100353	Tuners Creek/Lloyds Creek
021306100354	Money Creek
021306100355	Woodland Creek/Dyer Creek
021306100356	Back Creek
021306100357	Swantown Creek
021306100358	Herring Branch

An area rich in history, the Sassafras was sailed by John Smith and his crew in 1607 as a part of their exploration of the Chesapeake Bay. At this time, “fish were everywhere so plentiful that Smith and his men jokingly attempted to catch them with frying pans” (Wennerstein 2001, 23). Smith documented his journey on the Sassafras and on August 1st, 1607, “the party was surrounded but taken peaceably to the Tockwogh chief’s town” (Barry 2005, 1). The exact location of this tribe on the Sassafras is unknown, but historical accounts and artifacts show how humans have been shaping the Sassafras watershed for quite some time.

1.1 Purpose of the Characterization

The intention of this document is to characterize the Sassafras as it is today, using readily available information to report on the current health and physical components of the watershed. This characterization is also the first step in devising the Sassafras Watershed Action Plan which will guide future restoration projects. Specifically, the Watershed Characterization is intended to meet several objectives:

- briefly summarize the most important or relevant information and issues;

- provide preliminary findings based on this information;
- identify any gaps or discrepancies for further research or analysis;
- suggest opportunities for additional characterization and restoration work; and
- provide a common base of knowledge about the Sassafras River Watershed for local governments, citizens, businesses and other organizations.

1.2 Identifying Gaps in Information

It is important to identify gaps in available watershed knowledge and gauge the importance of these gaps. In assessing data gaps, there are three areas into which the information has been divided.

- Water Quality: water chemistry, biology, physical, pollution sources
- Landscape: land use, soils, wetlands, lands of natural resource value, human population
- Living Resources and Habitat: submerged aquatic vegetation (SAV) abundance, fish species, sensitive species, invasive species and habitat conservation.

1.3 Additional Work Post the Characterization

The Watershed Characterization is intended to be one starting point that can be updated as needed. It is part of a framework for a more thorough assessment involving additional input from various core team members and partners. Several of the items below have either been completed, are in process, or are considered potential future actions as of December 2009.

Completed:

- A stream corridor assessment, in which Maryland Conservation Corp. personnel physically walked the streams and catalogued important issues. The training for this section was given by MDNR and the results are reported in the Appendix Section of the Sassafras Watershed Action Plan (SWAP).
- A synoptic water quality survey, i.e. a program of water sample analysis that can be used to focus on local issues like nutrient hot spots, point source discharges or other selected issues. A synoptic survey was completed in Fall 2006, Spring 2007 and Spring 2009 by MDE. Findings of the synoptic survey of the streams in the Sassafras River Watershed are also be reported in the Appendix Section of the SWAP.
- A tidal shoreline assessment where observations were made along the tidal shorelines of the Sassafras River, noting areas of severe erosion, inadequate buffers and bank characteristics

such as dilapidated bulk heads and hardened shorelines. This assessment was conducted by the Sassafras River Association (SRA) and restoration engineers.

- An upland assessment conducted by Center for Watershed Protection which included written observations of the developed areas of the watershed and potential pollution sources in these areas.

In process and continuing into the future:

- Input from local citizens
- Self-investigation by Cecil, Kent and New Castle Counties
- Targeted technical assistance and assessment by partner agencies or contractors gathering additional support data and documentation.

Ultimately SRA will continue to gather relevant data in one location. For the purpose of this initial characterization the goal was to gather relevant background and physical characteristics of the watershed as well as information on water quality and land use being sure to identify any pertinent gaps. There are many documents that will be referenced throughout this report, however it is important to note that many were written over ten years ago, and changes have occurred to the landscape, management of natural resources, and overall water quality. Many indicators that were historically used to assess the health of the Sassafras watershed are mentioned, but more importance is placed on prioritizing problems in the watershed and solutions or restoration projects to address those problems.

- Maryland's 1998 Clean Water Action Plan, Unified Watershed Assessment was written to prioritize watersheds throughout the state in four categories: Restoration Watersheds, Preventative Action Watersheds, Protection Watersheds, and Watersheds with insufficient data. Many different data sets were examined as possible natural resource indicators that together would determine in which category a certain watershed belonged. The indicators selected were grouped into four major "clusters" that focused on the key areas of watershed condition. These groups were: water chemistry, aquatic living resources, instream physical habitat, and landscape. These were used as the basis for comparison of the state's 138 "8-digit" watersheds, although not all watersheds had enough information to complete each indicator. Once information was collected, each watershed was prioritized and placed in one of the four categories. The Sassafras River was put into Category 1 which means in need of Restoration.
- Assessment Report of Delaware's Chesapeake Basin written in 2001 was the state of Delaware's approach, developed by the Department of Natural Resources and Environmental Control (DNREC) to coordinate between all divisions (air and waste management, fish and wildlife, parks and recreation, soil and water conservation and water resources) a comprehensive management plan in protecting Delaware's Chesapeake Basin. The Sassafras watershed makes up roughly 20 square miles of the

Chesapeake Basin in Delaware, and while this assessment does not make individual watershed based recommendations, it does highlight the major issues contributing to the Chesapeake Bay from Delaware, and management strategies to address those.

- Total Maximum Daily Load for Phosphorus was written by the Maryland Department of the Environment (MDE) and was approved by the Environmental Protection Agency (EPA) in 2002. This document was written to address one of the use impairments on the Sassafras: nutrients. Because phosphorus was determined through sampling as the nutrient that limits algal growth, a daily maximum was determined for the input of phosphorus on the Sassafras.
- Total Maximum Daily Loads for Pholychlorinated Biophenyls (PCB's) in the Sassafras River, Oligohaline Segment, drafted by MDE in 2009 and submitted to EPA for approval. This document addressed the impairment of PCB's on the Sassafras.

Because restoration is an active evolving process, the Watershed Characterization and the resulting Watershed Action Plan will be maintained as living documents within an active evolving restoration process. These documents will need to be updated periodically as new, more relevant information becomes available and as the watershed is monitored and reassessed.

2.0 WATER QUALITY

Many factors are considered when evaluating the water quality of a given water body. Acknowledging the affect the landscape, and human interaction or manipulation on the land and water has on its quality is critical. Assessing the overall water quality of the Sassafras requires a combination of data collected from past and present monitoring from both the tidal mainstem of the river and nontidal creeks and streams across the watershed. As well as the investigation of pollution sources from both on the water and upstream on the land. Modeling is another tool that watershed scientists can use to estimate fairly accurately where the majority of certain pollutants are coming from and therefore the total loading into the waterbody.

2.1 Designated Uses and Water Quality Standards

Across the country, every state is required to designate its waterbodies for particular uses, which are associated with a set of water quality criteria necessary to support that use. In the state of Maryland there is a Code of Maryland Regulation (COMAR) that cites the various uses for each specific water body and what standards must be achieved in that waterbody in order to fulfill that use. The Maryland surface water use designation states that all surface waters of Maryland shall be protected for water contact recreation, fishing and protection of aquatic life and wildlife (MDDS, 2008). The Sassafras is designated as a Use 1 and Use II waterbody. Use I designation includes waters that are suitable for: water contact sports; play and leisure time activities where individuals may come in direct contact with the surface water; fishing; the growth and propagation of fish (other than trout), other aquatic life, and wildlife; agricultural water supply; and industrial water supply. (MDDS, 2008). Only in its Oligohaline segment (also referred to as the Sassafras River embayment) it is designated as Use II which means support of estuarine and marine aquatic life and shellfish harvesting (MDDS, 2008).

Delaware also designates surface water quality standards to the various stream basins across the state. These standards are separated into different categories of beneficial use of waters of the state which must be maintained and protected through application of appropriate criteria. The Sassafras River Basin is designated as an industrial water supply, primary and secondary contact recreation, fish, aquatic life and wildlife, as well as an agricultural water supply (DNREC, 2008).

2.2 Use Impairments and Restrictions

Some streams or water bodies cannot be used to the full extent envisioned by their designated use due to some impairment. This is why Section 303(d) of the Federal Clean Water Act requires states to identify these water bodies in a list called the "303(d) list." Each identified impairment may require preparation of a Total Maximum Daily Load (TMDL) to address the water quality and/or habitat impairment in the affected water body. The TMDL puts a limit on how much of a certain pollutant a water body can likely tolerate and still meet its designated use. Maryland's list of impaired waters cites the Sassafras River as being impaired for nutrients, sediment, biological impairments (poor or very poor fish and benthic organism populations, and toxics (PCB's and fish consumption advisory) (MDE 1996; MDE 2002; MDE 2004; MDE 2008). In addition to these official state impairments, there are issues that affect not only the health of the river but impair its designated use such as shellfish harvesting restrictions and toxic algal blooms.

According to the Delaware 2008 Combined Watershed Assessment Report (305 (b)) and Determination for the Clean Water Act Section 303 (d) List of Waters Needing TMDL's, the Sassafras River is impaired for biological and habitat pollution stressors (DNREC, 2008).

2.2.1 Nutrients

The tidal portion of the Sassafras River was listed as impaired by nutrients in the 1996 303(d) list. The origins of these nutrients were listed as natural and nonpoint sources. This impairment was given low priority, although a TMDL was submitted in 2001 and approved by the EPA in 2002. According to the April 2002 report Total Maximum Daily Loads of Phosphorus for the Sassafras River, impairment by both nitrogen and phosphorus contribute to excessive algal blooms and concentrations of dissolved oxygen below the minimum State standard of 5.0 milligrams per liter (mg/l). The algae and dissolved oxygen problems impair local conditions preventing designated uses of the Sassafras River (MDE, 2002b).

2.2.2 Sediment

The tidal portion of the Sassafras River is listed for impairment due to sediments on the 1996 303(d) list. The potential sources of these suspended sediments were listed as natural and nonpoint sources. This impairment was given low priority but was also cited as a problem that would be addressed in two years. This impairment was later changed to a total suspended solids (TSS) listing and was moved from Category 5 of the Maryland Integrated Assessment of Water Quality (waterbody is impaired, does not attain the water quality standard, and a TMDL is required), to a Category 2 (waterbodies meeting some water quality standards, but with insufficient data to assess all impairments) in the 2008 Integrated Report (MDE, 2008).

2.2.3 Biological Impairment

The non-tidal portion of the Sassafras River is listed as impaired for biological degradation or limitations in the 2004 303(d) list. In selected stream segments statewide, populations of benthic macroinvertebrates and fish and their associated physical habitat have been assessed by the Maryland Biological Stream Survey (MBSS). Based on criteria developed for each physiographic/ecological zone in Maryland, each stream segment is rated as good, fair, poor or very poor. Ratings of poor and very poor were listed as biological impairment for the first time in Maryland in the draft 2002 303(d) list of impaired waters. In the Sassafras River watershed, one stream site appears on the list because of biological impairment. Swantown Creek is listed based on 2001 sampling of the stream. Refer to section 2.4.3 on Biological Monitoring for a reference table and the data in reference to the Sassafras River.

The tributaries of the Sassafras River were listed on the Delaware 303 (d) list in 1998 due to impairments for biology and habitat. The Sassafras was also given a “5” listing which indicates that a TMDL is needed in order to address the impairment. A target date of 2010 was set for the Sassafras to complete a TMDL for biological impairment. Refer to section 2.3.4 on Delaware Monitoring for an explanation of this score and the factors analyzed.

2.2.4 Toxics—PCB’s and Fish Consumption Advisory

MDE monitors and evaluates contaminant levels in fish, shellfish and crabs in Maryland waters. This monitoring allows MDE to determine whether the specific contaminant levels in these species are within safe limits for human consumption. One such contaminant which has been found in the Sassafras is polychlorinated biphenyl, or PCB’s. The tidal portion of the Sassafras River is listed as impaired for toxic compounds on the 2002 303(d) list. PCB’s are listed for the cause of this toxic impairment and a TMDL has been drafted by MDE and submitted to EPA for final approval. PCB’s belong to a family of man-made organic chemicals known as chlorinated hydrocarbons. They were domestically manufactured from 1929 until their ban in 1979 (USEPA, 2008b).

Although PCB’s are no longer produced in the U.S. their past use and improper disposal has resulted in elevated levels in the Sassafras. Certain fish, such as channel cat and white perch in the Sassafras can accumulate this substance to levels which are harmful to human consumption. Current advisories are the result of contamination due to this past use of PCB’s, and are summarized in Table 2-1 (MDE, 2009). For more information on the fish consumption advisory see www.mde.state.md.us/CitizensInfoCenter/FishandShellfish.

Table 2.1 Maryland Department of the Environment 2009 Advisory on Fish Consumption for Sassafras River Area Recommended Maximum Allowable Meals Per Year

Species	Area	General Population 8oz meal	Women 6oz meal	Children 3oz. meal	Contaminant

Channel Catfish	Sassafras River	9	6	AVOID	PCBs – risk driver & pesticides
White Perch	Sassafras River	24	18	14	PCBs – risk driver & pesticides

2.2.5 Shellfish Harvesting Restrictions

Map 2 Designated Use and Use Restrictions, shows that portions of Sassafras River are affected by shellfish harvesting restrictions. For MDE Designated Use purposes, shellfish include clams, oysters, and mussels. Tidal waters from the mouth of the river to Ordinary Point are "restricted" which "means that no harvesting of oysters and clams is allowed at any time." The remainder of the river and its tributaries are non-shellfish harvesting waters. This may seem contradictory considering the Sassafras has a use II designation, which means support of estuarine and marine aquatic life and shellfish harvesting. However, the upper Chesapeake Bay is restricted to shellfish harvesting for "administrative reasons and is not listed. This area is designated as Use II waters; however there is insufficient shellfish resource for harvesting due to the fresh water input from the Susquehanna River. Since there are no oysters or clams to harvest and the NSSP requirements for sanitary survey is not met, the area is classified as restricted. In order to protect shellfish waters directly below this area, the shellfish harvesting water designation is a valuable protective measure" (MDE, 2008).

2.2.6 Toxic Algae Blooms

Algae are a natural and critical part of the Chesapeake Bay Ecosystem. Algae are like any other land plant in that they photosynthesize, capturing sunlight and converting it to food. They occur in a size range from tiny microscopic cells floating in the water column (phytoplankton) to large mats of visible macroalgae that grow on bottom sediments.

Algae may become harmful if they occur in an unnaturally high abundance or if they produce a toxin. A high abundance of algae can block sunlight to underwater bay grasses, consume oxygen in the water leading to fish kills, produce surface scum and odors, and interfere with the feeding of shellfish and other organisms that filter water to obtain their food. Some algal species can also produce chemicals that are toxic to humans and aquatic life (MDNR, 2008c).

The Sassafras River has consistently been subject to various algal blooms over the years. MDNR has studied populations of algae on the Sassafras since 1995, and in many instances Microcystis (a toxic algal species) has been observed. MDNR's website includes a note that states "Illness associated with harmful algal blooms is now a reportable illness so physicians should be reporting these to local health departments. The MDNR in coordination and cooperation with the Department of Health and Mental Hygiene (DHMH) and MDE will continue to monitor algal blooms throughout the state. For up to date information on all of Maryland's harmful algal blooms and water quality, please visit Eyes on the Bay at www.eyesonthebay.net" (MDNR, 2008b; MDNR, 2008c).

The University of Maryland Center for Environmental Science (UMCES) is currently funded by Maryland Sea Grant until January 2011 to assess algal population on the upper Sassafras and research environmental conditions that promote the development of nuisance blooms and that result in the demise of such blooms. Algal blooms in the Sassafras are a product of the biogeochemical conditions (or abiotic factors of ecosystems such as water, land and air) in the upper river. However such blooms have also been found to have self-sustaining biological feedback mechanisms which allow them to survive without additional inputs from their surrounding environment. High pH is evident when algal blooms remove an excessive amount of carbon dioxide, and in turn the high pH's can result in the release of phosphorus that's bound to the sediment, back up into the water column. This mechanism may sustain the bloom for extended periods of time by providing phosphorus for growth. In addition, nitrogen fixation from some cyanobacteria may also help to sustain high algal biomass by providing nitrogen (Cornwell, 2009).

The key objectives of the Sea Grant project include 1) a strong spatial/temporal monitoring of water column and sediment biogeochemical processes at the most HAB-prone site in the Sassafras River and 2) an effort to understand the mechanisms leading to the excessive growth of algae. High pH's have been observed in the upper river and this impact will be explored. In particular, the objectives will be addressed by a seasonal study of sediment biogeochemistry, pH effects on benthic nutrient cycling, and pH impacts on algal dynamics in the upper Sassafras River. Sediment flux experiments in the upper Sassafras River during spring-summer 2009 indicate that P and N stored in sediments can be a source of soluble reactive phosphate (SRP) and ammonium (NH_4^+) that can help support phytoplankton growth during the summer. Flux rates were compared before and after the summer "bloom" period: with temperature increase and cyanobacterial decomposition, the efflux of SRP and NH_4^+ elevated from sediment into water column.

According to MDNR data, water column pH was surprisingly high for considerable periods of 2007 and 2008 and elevated pH was observed for a shorter period in 2009. Lab experiment showed that increases in pH resulted in enhancement of benthic N and P release. The nitrogen release rate was almost doubled and P release increased by an order of magnitude when pH was increased from 7 to 9.5. High pH favored P release because pH (>9 or 9.2) increases the desorption of Fe-P or Al-P in sediment. In addition, pH can directly affect the sediment surface and convert ammonium (NH_4^+) to ammonia (NH_3). The relative increase of NH_3 concentration changes the pore water profile, and promotes nitrogen. Elevated pH inhibited N losses via dentrification, which is a microbially facilitated process of nitrate reduction that may ultimately produce gaseous products such as nitrous oxides (N_2O) and dinitrogen (N_2). This result indicated that dense phytoplankton blooms, by increasing pH, can facilitate release of nutrients from shallow water sediments in the upper Sassafras.

Diel elevation of pH by dense blooms may also facilitate daytime N-fixation by cyanobacterial blooms in water samples, which would add new N derived from atmospheric N_2 into the system and help maintain blooms. In co-operation with Dr. Judy O'Neill (UMCES), primary production (light mediated ^{14}C uptake) and nitrogen fixation (acetylene reduction) were measured in order to investigate the effects of dissolved inorganic carbon (DIC) availability and pH on both photosynthesis and N fixation. In the light, CO_2 uptake by phytoplankton resulted in an increase of pH from 8 to ~9.6 in the "natural" treatment. Controls were maintained at neutral pH by air bubbling to provide enough CO_2 for photosynthesis. We observed dramatic effects on nitrogen fixation during the light phase of the incubation. In high pH conditions, the N-fixation rate increased for nine hours, whereas in the low pH treatments, nitrogen fixation decreased dramatically after 6 hours incubation in the light. Nitrogenase, the enzyme complex performing nitrogen fixation, is extremely oxygen sensitive. Nitrogen fixation can be inhibited by the O_2 evolved through photosynthesis. DIC limitation of photosynthesis (high pH) during dense blooms may favor increased N-fixation by cyanobacteria, which relieves N-limitation, adds more N to the ecosystem and helps to perpetuate blooms (Cornwell, 2009).

2.3 Water Quality Monitoring

In order to investigate and determine the impairments observed in the Sassafras watershed, monitoring of the tidal mainstem as well as all the creeks and streams is necessary. Both Maryland and Delaware as a part of their statewide natural resource programs are required to give reports on the state of their rivers. MDNR as part of that requirement have had a long term monitoring station on the Sassafras River since 1986 sampling once a month various parameters. MDNR also runs a near to real time continuous monitoring program designed to collect water quality data while also drawing links between water quality and events such as harmful algal blooms and fish kills. MDNR is currently in the third year of a shallow water monitoring program that assesses the same parameters at five sites once per month between April and October. In the nontidal regions, MDNR has taken benthic and fish samples to monitor the health of the state's streams. Delaware has also monitored two locations in the Sassafras as a component to their Chesapeake Basin Assessment, and the Sassafras River Association has even been monitoring on a volunteer basis for the past four years. In addition, both the Cecil County and Kent County Health Departments routinely monitor for bacteria levels in the water at select community beaches along the shores of the Sassafras River.

2.3.1 Maryland Department of Natural Resources Monitoring in Tidal Waters

There is one long-term monitoring station (ET3.1) in the Sassafras watershed located on the 213 bridge crossing the Sassafras River, in approximately 5 meters of water (Map 3). This station is monitored once a month throughout the entire year. This long-term ambient water quality monitoring program, which has data from 1986 to present, assesses nutrients, chlorophyll, total suspended solids and physical parameters such as pH, salinity, dissolved oxygen, and water clarity via secchi depth.

Data for this station is assessed in part using a nutrient limitation model, which seasonally predicts whether algae growth is limited by light (nutrient saturated), nitrogen, or phosphorus. The model was developed by Tom Fisher and Anne Gustafson of the UMCES Horn Point Laboratory. Based on data collected between 2005 and 2007 the model predicts that in the winter months, algae growth at ET3.1 is limited only by light, i.e., nitrogen and phosphorus are present in abundance. Algae growth in the spring is also primarily light limited, with slight phosphorus limitation (excess nitrogen). The dynamics shift in the summer months as the system becomes nitrogen limited (excess phosphorus) as the available nitrogen is used up by the growing phytoplankton population. The fall dynamics change again, when the station becomes primarily light limited again, with partial nitrogen and phosphorus limitation (MDNR, 2009).

Dissolved oxygen (DO) is one parameter measured that has a state standard in both Maryland and Delaware. 5 mg/L is considered the level at which DO must meet in order to sustain aquatic life. Falling below 5 mg/L indicates a possible life threat to fish and other organisms. Low DO can also indicate that there are other factors at play such as high nutrients. At station ET3.1 samples were taken every month from 1986 to 2008, one and a half meter from the surface and another one meter from the bottom. Dissolved oxygen remained high most months out of the year with lower levels between June and August each year. In July of 1986-1988 DO reached a low of 3.7 mg/L and in August of 1991 and 1992 DO was also seen at 3.5 mg/L. These were lowest historic readings of DO on the Sassafras, and in recent years (since 2003) there have been no readings below 5 mg/L at the ET3.1 station according to MDNR.

Maryland DNR also has two continuous monitoring stations that operate in near real time 24 hours a day year round. This program is funded in part by a grant from National Oceanic Atmospheric Administration (NOAA), and has been monitoring water quality since 2006. In 2006 there were two continuous stations: one at Betterton Beach and one at Georgetown Yacht Basin. In 2007 an additional station was installed at Budd's Landing and in 2008 the station at Georgetown Yacht Basin was removed (Map 3). All data for both the long term monitoring station as well as the continuous monitoring stations in near real time can be viewed by navigating to the Eyes on the Bay website:
http://mddnr.chespeakebay.net/sim/dataflow_data.cfm#sassafras (MDNR, 2009).

MDNR is currently in the second year of a three year shallow water monitoring program that assesses the same parameters at five sites once per month between April and October (Shallow water monitoring program data are not available for June 2008.) Two of the sites are part of the continuous monitoring project and three sites are part of the data-flow monitoring project (Map 4). In addition to data being collected every four seconds, biologists also stop at 5 stations along the river and take samples that are later processed for nutrients (nitrogen and phosphorus), chlorophyll, and total suspended solids. Light penetration is also calculated at these stations. Currently, the State of Maryland does not have nutrient, chlorophyll, or total suspended solids standards available for the estuarine waters of the Chesapeake Bay. However some indication of water quality condition can be obtained for concentrations of total suspended solids (TSS), chlorophyll-*a*, dissolved inorganic nitrogen (DIN), and dissolved inorganic phosphorus (PO4), and water column light through comparisons to the recommended habitat requirements for submerged aquatic vegetation (SAV) (USEPA-CBP, 2000).

Thirty samples are available for 2008 from the five shallow water monitoring program stations (no samples were collected in June). In terms of light requirement it is recommended that 13% of ambient surface light penetrates the water column in order to support the growth and propagation of SAV. Of those 30 samples, the recommended light requirement of greater than 13% for oligohaline waters (salinity between 0.5 and 5 practical salinity units) was met or exceeded only four times. The recommended requirement was met three times at the lower most station (XJH2362) located at the mouth of the river and once at XJI2112, which is the next up-river station. These results indicate that water clarity throughout most of the Sassafras River is inadequate to support the growth and propagation of SAV (MDNR, 2009).

The recommended SAV habitat requirement for sediment of less than 15 mg/L (TSS) was met for 18 of the 30 samples that were collected. Fewer samples met the requirement in April, May, and September than other months of the SAV growing season. The TSS requirement was met for 13 of the 15 samples collected in July, August, and October.

The 2007 chlorophyll concentrations shown in Figure 2.1 indicate that from late July to nearly mid-October, chlorophyll concentrations far exceeded the SAV habitat requirement of, less than 15 ug/L. This data was recorded with a Yellow Springs Instrument data sonde which was deployed at Betterton Beach in 2007 (MDNR, 2009).

All but one PO4 sample met the SAV growing season requirement of less than 0.02 mg/L; however, given the high fluorescence-chlorophyll values observed in the continuous monitoring data sondes, the PO4 may be low, because PO4 was used in the production of algae.

Current data (as of 2008) from the shallow water monitoring program can also be viewed at http://mddnr.chesapeakebay.net/sim/dataflow_data.cfm#sassafras.

The available data for the Sassafras River indicates that the system is currently nutrient rich with poor water clarity, particularly after heavy rain, and has an excess amount of algae. In general, the SAV habitat requirements are not met. It is anticipated that water quality in the Sassafras River will improve following the aggressive implementation of best management practices that target the reduction of nutrients and suspended sediments (MDNR, 2009).

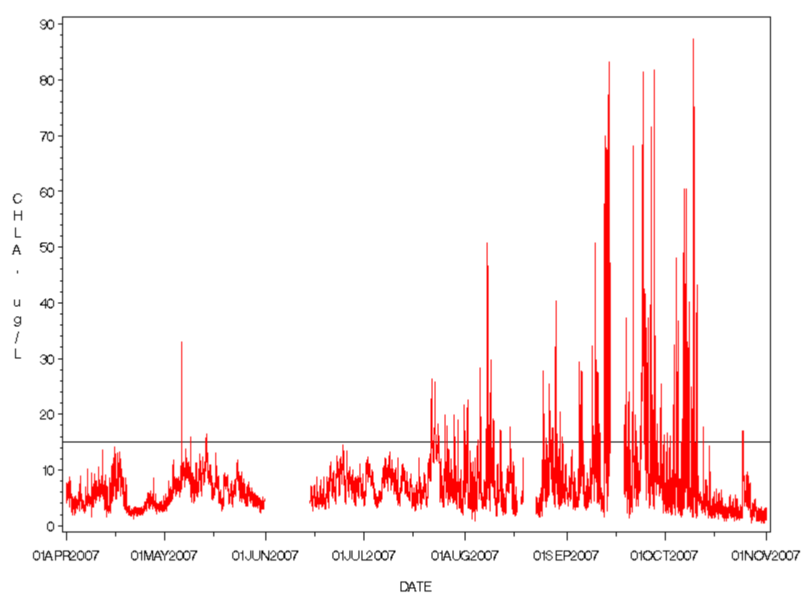

Figure 2.1 CHLA levels at Betterton Beach in 2007

2.3.2 TMDL Monitoring

Data was collected by MDE at 20 water quality stations in the Sassafras River and its branches during 1999 in order to do analysis for the TMDL for Phosphorus (Map 5). Three sets of samples were collected during seasonal low flow periods in the summer and three high flow periods in the winter. Problems associated with eutrophication, which is when excess nutrient input leads to growth of algae and vegetation, were seen more frequently in the summer season (low flow period) which is when there is typically less stream flow available to flush the system, higher temperature and more sunlight available for aquatic plant growth including algae. Refer to the TMDL for more details.

As a follow up for the TMDL, a Nutrient Synoptic Survey was conducted in the Fall of 2006 and Spring of 2007 for the Sassafras watershed (Map 6). Samples were analyzed for total nitrogen (TN), total phosphorus (TP), orthophosphate (PO_4) and Nitrate/Nitrite ($NO_2 + NO_3$). There are no water quality standards for nutrients in Maryland but for the purpose of this analysis, nitrate levels above 1 mg/L were considered anthropogenic. Nitrate/Nitrite levels between 3 and 5 mg/L were considered high and those over 5 mg/L were considered excessive. For phosphates, levels of 0.01 to 0.015 mg/L were considered high and those above 0.015 mg/L were considered excessive.

A total of 30 sites were chosen based on access, therefore mainly consisting of road crossings. Sampling during the spring and fall allows for the capture of high and low flows. Many stations during the fall of 2006 were dry leading to the gaps in the data string. Mean phosphorus concentrations for the spring and fall were 0.011 mg/L and 0.001 mg/L respectively. Nitrate/Nitrite mean concentrations were 4.25 mg/L in the fall of 2006 and 3.99 mg/L in the spring of 2007. The fall 2006 survey indicated five sites with high orthophosphate levels and ten sites with elevated nitrate/nitrite levels in the high category. Four sites were deemed high for orthophosphate during the spring 2007 survey while 14 sites tested high or in excess for nitrate/nitrite (Spotts, 2009). Refer to figures 2.2 and 2.3 for the varying phosphate and nitrate levels across the watershed.

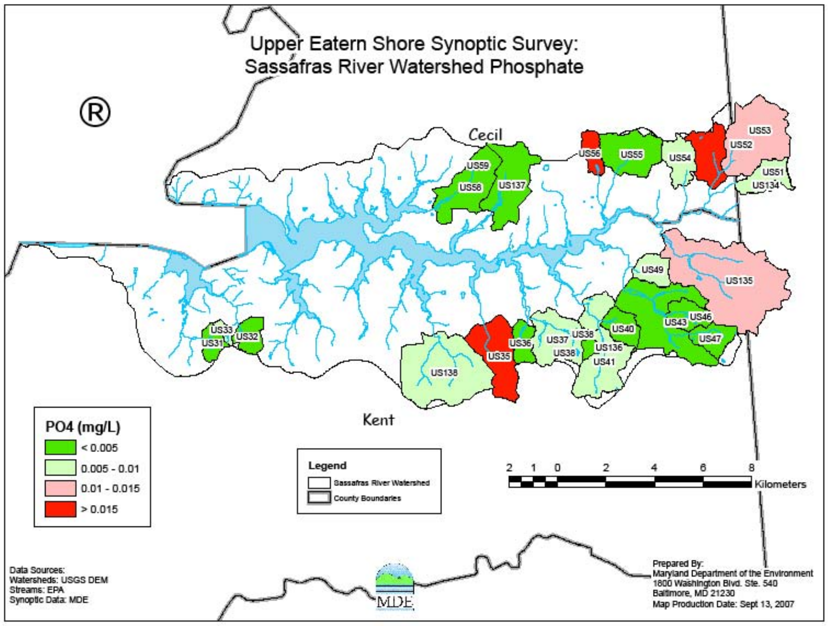

Figure 2.2. Phosphate levels in the Sassafras Watershed

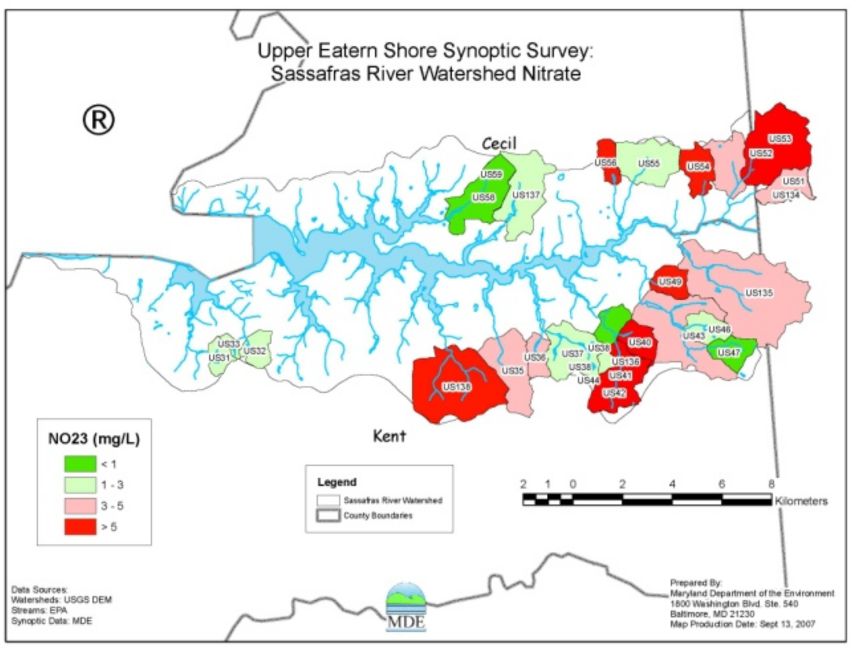

Figure 2.3. Nitrate Levels in the Sassafras Watershed

In September 2000, fish tissue samples were collected by MDE in the Sassafras River embayment. Because the total PCB (tPCB) levels in the fish tissue sampled exceeded the state threshold of 39 ng/g, the Sassafras River was 303 (d) listed as impaired for PCB's. Beginning in 2006, water column samples were taken throughout the embayment and in 2006 water column samples were collected in two nontidal sites of the Sassafras watershed in order to complete a TMDL for PCB's. The state of Maryland adopted three separate ambient water quality/water column criteria for PCB levels: a human health criterion for protection of human health associated with consumption of PCB contaminated fish, as well as freshwater and salt water chronic criteria for protection of aquatic life. The tPCB human health criterion is set at 0.64 nanograms/liter (ng/L). This criterion is based on a cancer slope factor, bioconcentration factor, a lifetime risk level and exposure duration of 70 years and a fish intake of 17.5 g grams/day. A cancer risk level provides an estimate of the additional incidence of cancer that may be expected in an exposed population. The Maryland aquatic life freshwater chronic tPCB criterion is 14 ng/L and the saltwater chronic tPCB criterion is 30 ng/L. While none of the total average water column tPCB concentrations in the Sassafras embayment exceeded the Maryland 30 ng/L, aquatic life saltwater chronic criterion, all of them exceeded the 0.64 ng/L ambient water quality and water column human health criterion (MDE 2002). Based upon this information a draft TMDL for PCB's in the Sassafras River has been completed by MDE and submitted to EPA for final approval. This draft summarizes the baselines and allowable annual loads of total PCB's and the required load reductions in order to meet the state health criterion. Refer to section 2.4 Total Maximum Daily Loads for additional information.

2.3.3 Maryland DNR Non-Tidal Monitoring

MDNR's Maryland Biological Stream Survey (MBSS) began in 1993 as a pilot program to study three select watersheds. In 1994 the program expanded statewide and was the first random stream sampling program, as its intention was to generate neutral results of stream conditions from across the state. These streams ranged in size from large river basins to medium sized watersheds. The Sassafras watershed was one of these to be sampled in 2001 and in 2007. Samples were taken in Swantown Creek, Woodland Creek, Duffy Creek and Herring Branch. A non-tidal benthic index of biotic integrity (BIBI) is one score generated from work done by MBSS sampling. This score is based on species diversity, species composition and productivity. These parameters are scored and summed to calculate a BIBI for a given site (Map 7). Another score that is generated from MBSS sampling in non-tidal streams is the non-tidal fish index of biotic integrity (FIBI). This score is measured much the same as a BIBI, but includes several different parameters pertaining to fish species, such as: the number of native species, percentage of dominant species, and if there is a presence of tolerant species, what percentage that is. The scores for these sites can be seen on Map 8.

Physical habitat is another indicator that was used in Maryland's Unified Watershed Assessment and was historically calculated from MBSS sampling (Map 9). The physical habitat index (PHI) score is based on several different observational measurements such as channel erosion, alteration, land use, in-stream habitat condition, etc. Habitat measures the quantity and quality of physical habitat available in the stream for fish and benthic macroinvertebrates and the rate or degree to which the stream channel may have been altered due to landscape changes.
MDNR's volunteer monitoring program "Stream Waders" is another non-tidal sampling program in which BIBI scores are generated to evaluate level of stream health. MBSS protocols are used in this monitoring program, and results of these tests as well as the MBSS samplings can be accessed online at http://mddnr.chesapeakebay.net.

Table 2-2 gives the reference levels for the BIBI, FIBI and PHI scores, which range from "good" to "very poor." Table 2-3 shows the MBSS findings for the five sampling locations in the Sassafras Watershed, and Table 2-4 shows the volunteer monitoring data from 2001. MBSS scores show mostly poor to fair conditions in the benthic communities. Based on MBSS sampling and FIBI scores, for the most part, the fish communities ranked "good."

Table 2.2 Key for MBSS Data

Index of Biotic Integrity	Ranges for Index	Very Poor	Poor	Fair	Good
Fish and Benthic	1.0 (worst) to 5.0 (best)	1.0-1.9	2.0-2.9	3.0-3.9	4.0-5.0
Physical Habitat	0.0 (worst) to 100 (best)	0.0-11.9	12-41.9	42-71.9	72-100

Table 2.3 MBSS Findings for 2001 and 2007

Stream Name	Station #	Score		
		Fish	Benthos	Physical
Swantown Creek	SASS-102-R-2001	1.6	3	79.23
Woodland Creek	SASS-104-R-2001	4.3	2.7	64.8
Herring Branch	SASS-205-R-2001	4.3	3.5	65.94
Duffy Creek	SASS-120-R-2001	4.3	2.1	68.25
Sassafras River	SASS-105-R-2007	4.0	3.2	(no longer calculated)

Table 2.4 Stream Waders Findings from 2001 Benthic Sampling

Station Number	Stream Name	BIBI Score
357-5-2001	Duffy Creek	Poor
357-4-2001	Jacobs Creek	Poor
357-3-2001	Jacobs Creek	Poor
357-2-2001	Swantown Creek UT	Poor
357-1-2001	Mill Pond Creek UT	Poor
356-4-2001	Cox Creek	Poor
356-3-2001	Cox Creek	Poor
356-1-2001	Hall Creek	Poor
355-2-2001	Woodland Creek	Poor
355-1-2001	Dyer Creek	Poor
353-1-2001	Lloyds Creek UT	Poor

2.3.4 Delaware DNREC Non-Tidal Monitoring

In Delaware's 2008 Combined Watershed Assessment Report (305 (b)) and Determination for the Clean Water Act Section 303 (d) List, watersheds across the state are analyzed under various parameters and then rated based on the severity of degradation. Two sites were selected in the

Sassafras portion in Delaware and were visited on two occasions (Map 3). Various factors such as channel modification, instream habitat, bank stability, bank vegetation type, shading and riparian zone width were observed and rated on a scale from either zero to 10 for certain parameters or zero to 20 for others. These scores were calculated and a habitat index was generated. Benthic samples were also collected and based on the number of organisms and types found in the sample, a benthic index score was assigned. If this score was less than a 66 (degraded) then the water body was assigned a number "5" which on the Delaware 303 (d) list means a TMDL is needed. The "5" is essentially an arbitrary number which the state uses to categorize watersheds (DNREC, 2004). At site 11011, the first sampling scored a 30% in the biology class, which means "severely degraded," and scored a 73% which is "good condition." However, it is conservatively listed on the 303 (d) for biology as severely degraded because this was the worst condition observed. The second site 11012 scored a 10% from the one sampling instance, placing it in the "severely degraded" category. With regards to habitat class scores, site 11011 scored a 92% and 95% in its respective samplings giving it a "good condition" score, however site 11012 scored a 52%, listing it as severely degraded on the 303 (d) list for habitat. Due to the severely degraded listings for both sites, the Sassafras River is listed on Delaware's 303 (d) list for habitat and biological impairments (DNREC 2008).

2.3.5 SRA Water Quality Monitoring

Tidal Monitoring

Water quality testing was conducted three times a year from October 2005 to October 2008 at the same 20 sites along the tidal mainstem of the Sassafras River (Map 10). Although sampling protocol and units differed from MDE and MDNR monitoring programs, volunteer results showed similar results. PO4 was greater than 0.1 parts per million (ppm) approximately 100 percent of the time, with Turbidity less than 40 JTU's at only 80 out of 200 samples. These results also indicate that phosphate levels are consistently high, and water clarity is also poor.

Using the volunteer data from 2005-2008, a smaller subset of tidal sites was selected and monitored once a week from May to October by the Sassafras Riverkeeper. Dissolved oxygen, pH, salinity, conductivity and temperature were measured at each of the seven sites in half meter intervals from the bottom of the water column to the top using a hand held YSI multi-probe instrument. In addition, two samples were collected at each site: one at the surface and the second, one meter from the bottom. These samples were brought back to the lab and analyzed for turbidity using an instrument called a turbidimeter. Much like a colorimeter, a turbidimeter uses light to determine the amount of suspended solids within a sample. More light reaches the detector if there are lots of small particles scattering the source beam. The units of turbidity from a turbidimeter are called Nephelometric Turbidity Units (NTU). Turbidity was also measured at each site using a secchi disk. Tidal results in terms of water clarity are fairly consistent to past monitoring results. Sites located farther up river display higher turbidity readings than those sites located towards the mouth of the river. Dissolved oxygen was generally higher at the surface of the water column and lower at the bottom at almost every site.

Non-tidal Monitoring

Beginning in Spring 2009, the SRA volunteer water quality monitoring program extended into the non-tidal streams of the Sassafras watershed. Volunteers collected samples from 16 sites at road crossings and bridges, once a month from April to October. Samples were analyzed for nitrite-nitrate, phosphate, ammonium, pH, copper and dissolved oxygen by using colorimeters from LaMotte chemical company. A colorimeter is a device that determines the concentration of a known solute (like phosphate or ammonium) in a given solution by measuring the absorbance of wavelengths of light by that solution. 2009 data will primarily serve as a first year baseline from which to direct future restoration efforts or targeted monitoring.

2.3.6 Beach Monitoring

In 2003, Maryland began designating public beaches as high, medium or low priority based on the risk of disease to swimmers. This was required of all coastal counties in the state as they were recipients of a federal grant called the BEACH Act grant. The EPA allowed individual states to select the criteria that would be used to rank the beaches, which in most cases included "number of users, known pollution sources, past monitoring results, and 'best professional judgement"(NRDC, 2008). If a standard is exceeded, the issuance of a beach advisory is required. The indicator organism for testing has been Enterococcus, or E. Coli. The BEACH Act required standards for marine waters is 104 enterococcus colony forming units per 100 millimeters (ml) and for freshwater the standard is 235 E. Coli colony forming units per 100 ml. Table 2-5 lists the years and percent of the samples taken that exceeded these required standards.

Table 2.5 Natural Resource Defense Council's Annual Report "Testing Our Waters" from 2005-2009

Year	Beach	Total Samples	Percent Exceedance
2005	Betterton Beach and Public Landing	21	24%
2005	Greg Neck Beach	18	17%
2005	Kentmore Park Beach	17	6%
2006	Betterton Beach and Public Landing	14	40%
2007	Gregg Neck Beach	33	18%
2007	Grove Point Camp	18	17%
2008	Grove Point Camp	18	11%

In 2004 Betterton Beach and Public Landing was closed from August 12th to August 29th due to algae and bacteria. The cause or source of pollution was not identified. In 2006 Betterton Beach was again closed from June 30th to July 20th as a result of exceeded bacteria counts. In 2007

Grove Point Camp was closed from June 8th to June 14th and in 2008 was closed from August 5th to August 12th for unknown sources.

2.4 Total Maximum Daily Loads

MDE uses the 303(d) list to determine whether a certain water body needs a Total Maximum Daily Load (TMDL) written to address a certain pollutant. A TMDL is the total maximum amount of a given pollutant that a waterbody can have discharged to it while still meeting its designated uses. TMDLs are established to achieve and maintain water quality standards so that a waterbody can meet its designated uses. A waterbody may have multiple impairments with TMDLs to address each; and MDE is responsible for establishing TMDLs for impaired waterbodies in the state of Maryland. TMDLs include two key components: one, maximum pollutant load that the water can accept while still allowing the water body to meet its intended use; and two, allocation of the maximum pollutant load to specific pollutant sources.
As of April 2002, only one approved TMDL for the Sassafras River watershed existed. The report Total *Maximum Daily Loads of Phosphorus for Sassafras River* was completed by MDE in December of 2001 and was approved by US EPA in April 2002. This document addressed the impairment of nutrients only, establishing a Sassafras River TMDL for Phosphorus. Table 2-6 shows current loads as of 1997 from both point and nonpoint sources in the watershed. Table 2-7 consists of allocated loadings given by MDE to point sources and nonpoint sources after TMDL implementation, as well as total pounds and percentage reduction needed in order to meet those allocated limits for both the point sources and nonpoint sources in the watershed. A TMDL for PCB's is currently under development and a public draft has been released for review as of September 2009. Table 2-8 shows a summary of baseline and allowable annual loads of total PCB and the required load reductions to meet the Sassafras River's designated uses.

Table 2.6 Phosphorus and Nitrogen Loading from Point and Non-point sources based on 1997 land use data

Nutrient	Point Sources	Non-point Sources	Total Loading
	(lbs/yr)		
Phosphorus	6,824	13,494	20,318
Nitrogen	16,877	176,553	193,430

Table 2.7 TMDL Allocated Loads for Phosphorus and the percent reduction needed to meet the TMDL allocation

	Load Allocation	Reduction needed to meet TMDL	Phosphorus Reduction Needed to meet TMDL
	(lbs/yr)		%
Phosphorus	13,875	6,443	31.7

TMDL			

Table 2-8 Summary of Baseline and Allowable Annual Loads of tPCB and the Required Load Reduction				
Source	**Baseline (g/year)**	**Baseline (%)**	**TMDL (g/year)**	**Load Reduction**
Bottom Sediment (resuspension/diffusion)	4,496.1	45.99	463.2	89.7
Chesapeake Bay (tidal influence)	5,133.2	52.50	390.1	92.4
Atmos. Deposition (to embayment surface)	117.9	1.21	117.9	0.0
Maryland Watershed and Nonpoint Sources*	25.0	0.26	25.0	0.0
Delaware Upstream	2.6	0.03	2.6	0.0
Nonpoint Sources/Load Allocations	***9,774.9***	***99.97***	***998.8***	***89.8***
WWTP *	2.0	0.02	2.0	0.0
NPDES Regulated Stormwater*	0.5	0.01	0.5	0.0
Point Source/Waste Load Allocations*	***2.5***	***0.03***	***2.5***	***0.0***
MOS			***111.3***	
Total	**9,777.3**	**100**	**1,112.6**	**88.6**

Notes: *These sources were characterized only for the Maryland portion of the watershed. Waste Water Treatment Plant loads were considered to be *de minimis* and at this point will not be subject to the traditional waste load allocation requirements. (TMDL for PCB's)

2.5 Sources of Pollution

There are two different types of water pollution: Point Source and Non Point Source. Both kinds of pollution degrade the quality of surface and ground water making them unsafe for drinking, fishing, swimming and aquatic life.

2.5.1 Point Sources

In 1972, as a component of the Clean Water Act, a permit program, the National Pollutant Discharge Elimination System (NPDES), was established to control point sources of water pollution. Point sources are defined as any kind of conveyance such as a pipe or a man-made ditch that eventually discharges directly into the surface water. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge, do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters (USEPA, 2008). Waste Water Treatment Plants (WWTP) are an example of a point source pollutant as the discharge from a plant can contribute nutrients into the water that consume oxygen upon which aquatic life depends for survival. Industrial point source is another example of a contributor of various forms of pollution. The NPDES program was created to regulate any type of point source pollution. Table 2-9 lists NPDES permitted facilities as well as any MDE permitted facility whether it has a surface water, groundwater or industrial stormwater discharge (Map 11). Table 2-10 gives the discharge numbers as well as the effluent limits for the WWTP's.

Characteristics of permitted discharges (volume, temperature, pollutants, etc.) are tracked by MDE through the permit system. This information is accessible to the public and can be obtained from MDE through filing a Public Information Act request www.mde.state.md.us/pia.

Table 2.9 MDE Permits -- Surface and Ground Water Discharge

Facility Type / Name		MD Permit / NPDES Permit	Receiving Stream / Street / Description
Surface Water Discharge	Betterton Wastewater Treatment Plant	01DP0591/ MD0020575	Sassafras River/Third Ave/surface municipal discharge for treated sewage effluent
	Galena Wastewater Treatment Plant	01DP0528/ MD0020605	Dyer Creek/MD Rt.213/surface municipal discharge for treated sewage effluent
	Georgetown Yacht Basin, Inc.	07SI6024/ MDG766024	Sassafras River/Augustine Herman Highway/general permit
	Georgetown Yacht Basin, Inc.	08DP3610/ MD0070033	Sassafras River/Augustine Herman Highway/surface industrial discharge for painting, maintenance and ice machines
	Indian Acres Campground	07SI6035/ MDG766035	Back or Dowdel Creek/Knight Island Rd.
	Kent Sand and Gravel – Alexander Pit	00MM9896/ MDG499896	Jacobs Creek/Alexander Rd. and Massey Rd./general permit for a borrow pit
Ground Water Discharge	ISE America, Inc.	01DP3134	Duffy Creek/Sassafras Rd./groundwater industrial discharge for egg processing lagoon
	ISE America, Inc.	01DP2593	Duffy Creek/Cecilton-Warwick Rd./groundwater industrial discharge
	Sassafras Harbor Marina	01SI6124/ MDG766124	Sassafras River/George St./general permit for pool -- discharging into groundwater

Table 2.9 MDE Permits -- Surface and Ground Water Discharge			
Facility Type / Name		**MD Permit / NPDES Permit**	**Receiving Stream / Street / Description**
	Skipjack Cove Yachting Resort	02SI6130/ MDG766730	Sassafras River/Skipjack Rd./general permit for pool – discharge to groundwater
Industrial Stormwater Discharge	David A. Bramble, INC.	02SW1670	Bramble Way/For Asphalt Plant

Waste Water Treatment Plants in the Sassafras watershed are located in Galena and Betterton. Galena's plant was built in 1962, and currently receives 60,000 gallons of wastewater per day and treats it using a lagoon system. Although this system has been used to treat wastewater for many years, in small communities like Galena it is not capable of matching the pollutant removal efficiencies provided by new wastewater treatment technologies. Both nitrogen and phosphorus have caused water quality degradation in the Sassafras River and lagoons do not provide the environment needed to remove significant amounts of nutrients like nitrogen and phosphorus from wastewater streams. Betterton's plant was built in 1969, and although it is permitted to discharge 200,000 gallons of treated wastewater per day, the plant receives and treats an average of 12,000 gallons of sewage per day. Raw wastewater is mechanically screened and treated in an aeration tank and clarifier-digester that is housed in a single tank. While this method has been maintained for many years, like the lagoon system, it is an outdated facility that is not capable of removing nitrogen and phosphorus to the extent of enhanced nutrient removal and biological nitrogen removal systems.

Table 2.10 Discharge and Effluent Limitations for Galena and Betterton WWTP's						
Waste Water Treatment Plant	**Effluent Characteristics**	**Monthly Loading Rate (lbs/d)**	**Weekly Loading Rate (lbs/d)**	**Monthly Average (mg/l)**	**Weekly Average (mg/l)**	**Sampling Frequency**
	Biochemical Oxygen Demand (BOD)	23 (50)	34 (75)	30	45	One per week – 8 hour composite

Table 2.10 Discharge and Effluent Limitations for Galena and Betterton WWTP's						
Betterton WWTP	Total Suspended Solids (TSS)	23 (50)	34 (75)	30	45	One per week – 8 hour composite
		Maximum		Minimum		
	Fecal Coliform	14 MPN/100 ml monthly median concentration		Not applicable		One per week – Grab
	Total Residual Chlorine	Not Applicable				One per day – Grab
	Dissolved Oxygen	Not Applicable		5.0 mg/l at anytime		One per day – Grab
	pH	8.5		6.5		One per day – Grab
	Flow	A maximum of 0.2 million gallons per day (mgd) is the permitted effluent amount.				Continuously recorded
Galena WWTP	BOD	6.8 (15)	10 (23)	30	45	One per week – Grab
	TSS	20 (45)	N/A	90	N/A	One per week – Grab
	Ammonia-N (5/1-10/31) (11/1-4/30)	1.1 (2.5) 2.5 (5.5)	N/A	4.7 11.0	N/A	One per week – Grab
	Total Phosphorus (TP) (5/1-10/31)	2.4 (5.4)	3.6 (8.1)	10.7	16.1	One per week – Grab
		Maximum		Minimum		
	Fecal Coliform	200 MPN/100 ml maximum monthly log mean		N/A		One per week – Grab
	Total Residual Chlorine	0.028 mg/l		N/A		One per day – Grab
	Dissolved Oxygen	N/A		5.0 mg/l at any time		One per day – Grab
	pH	8.5		6.5		One per day – Grab
	Flow	0.060 mgd is the permitted effluent amount.				Continuously recorded

2.5.2 Diffuse or Nonpoint Sources

Any source of pollution that does not have a specific origin or conveyance into the surface or ground water is referred to as a nonpoint source of pollution. Nutrients and sediment are the most common types of pollution to result from nonpoint sources as they can travel from surfaces into nearby waters. Rain water that runs off of the land, roads, buildings and any other surface can pick up nutrients and sediment and carry those pollutants into the surface and ground water.

Nonpoint pollution is the most difficult type of pollution to address because it does not have an exact origin. Best management practices for land use and land cover are the most effective ways of addressing this type of pollution, but are difficult to implement and enforce. Some facilities are permitted for industrial stormwater pollution (refer to Table 2-9). These facilities are required to install best management practices to prevent pollution to nearby surface and ground water due to stormwater runoff.

Another type of nonpoint source pollution is atmospheric deposition, which occurs when pollutants are transferred from the air to the earth's surface through rain, snow, or absorption of pollutant particles from gas form into the water. Ground water contamination from failing septic systems serve as yet another nonpoint pollution source that makes significant nutrient contributions to the overall system.

Woodland Gullies

Woodland Gullies are a natural landform feature common to the Sassafras River. These gullies are difficult to access as they are located predominantly in upper tributaries of the River in intermittent areas that do not always have perennially flowing streams. However, in storm events these areas experience the effects of heavy water exposure; which eventually sends sediment and its binding nutrients down to non-tidal streams. These gullies form in wooded ravines that head cut once meeting other land use forms such as agricultural fields, impervious surfaces, or areas generally affected by human development. The erosion coupled with stormwater runoff, creates large plumes where sediment collects and severely clouds sections of the River. This large contributor of sediment to the River serves as a difficult problem to assess due to the inaccessibility and large cliffs. Mapping out the presence and persistence of these woodland gullies should be taken into consideration in order to develop a definition of the Sassafras watershed. Observing aerial photographs during the leaf off season as well as topographic maps could be a way of identifying some of these areas. Anecdotal accounts could also serve as a source of information to locate problem areas. Once these areas are flagged, they can be ground truthed to validate the severity of the problem and assess the possible solutions. The issue of headcutting erosion can be reduced through the installation of drop structures and Kent and Cecil Soil Conservation Districts should be consulted for potential project areas and solutions for headcutting erosion.

Shoreline Erosion

Erosion of shorelines can be a significant source of pollution as sediment and soil break off and enter into the water column. Erosion can occur from many different sources such as critical area development or destruction, major storm events and wakes from recreational boating. As discussed earlier, nutrients cling to soil particles and travel with sediment as it runs off the land and into the water. Shoreline erosion inadvertently results in pollution of sediment and nutrients into local waterbodies. In 1998, Kent County implemented a living shorelines policy which prioritizes the implementation of nonstructural shoreline protection based on very specific criteria. Structural measures are permitted only in areas where nonstructural practices are impractical or ineffective. Resources are available to all county residents through MD Coastal Zone Management and Resources Conservation and Development (a branch of NRCS). In 2000, MDNR put together the Erosion Task Force Report, which identified and analyzed areas that were highly susceptible to shoreline erosion, and recommended strategies to manage them. Since the Erosion Task Force Report was written, DNR has worked to improve the state's ability to predict areas that are at a higher risk of shoreline erosion. This is possible by examining historic erosion rates as well as the effects of land use and sea level rise. Table 2-11 gives a summary of Kent and Cecil County since those are the two Maryland counties with tidal shorelines in the Sassafras River Watershed. Using Maryland Geological Survey Maps historic shoreline changes from 1895 to 2004 can be tracked. Map 21 shows changes in the shoreline of Lloyd's Creek, a tributary near the mouth of the Sassafras River on the Kent County side. Through further examination of these maps, calculation of acreage or miles of shoreline lost to erosion is possible, as well as the total volume of sediment pollution to the Sassafras River from the shoreline erosion.

Table 2.11 Cecil and Kent County Shore Erosion Rate Summary

County	Total Shoreline	Total Eroding Shoreline	Erosion Rate		
			0 to 2 feet / year	2 to 4 feet / year	4 or more feet / year
	(miles)				
Cecil	200	44 (22%)	39	5	0
Kent	268	78 (29%)	64	12	2

Source:2000 Shoreline Erosion Task Force Final Report

Septic Systems

Twenty percent of property owners in Maryland use septic systems for treatment of their wastewater. The average person contributes approximately 9.5 lbs of nitrogen each year to the groundwater through septic use. In Maryland there are over 51,000 properties in the critical area, which is the land within 1000 feet of tidal waters (Map 12). Using spatial data from Maryland Department of the Environment which identifies points on a map of every septic system in the state, the number of septics in the Sassafras was calculated. In the Sassafras River watershed there are approximately 1718 homes that use septics as their source for wastewater treatment. Approximately 824 of these homes are located in the critical area. In addition to individual on site homeowner septic systems, the Sassafras watershed has community shared septic systems. Nine of these are located at a campground in Earlville, MD in Cecil County called Indian Acres. On the campground there are approximately 2150 parcels: roughly 1700 privately owned and 450 owned by the management company that maintains the property. At the individual campsites, residents have holding tanks where waste and grey water is collected. When these tanks are full, they are pumped out and the waste is transported to one of nine large community septics, where the waste settles out in the larger drain field. This campground was originally established as a part time residency but over the years, more residents began living at the campground on a full time basis. The infrastructure for handling waste was not adequately upgraded to account for this increase in waste flow and septic usage. Another community septic system is located at a Girl Scout Camp also in Earlville, MD in Cecil County. These shared septics are used seasonally and by hundreds of people at a time (URS Corporation, 2004).

It is estimated that almost 80 percent of nitrogen from conventional septic systems reach a local waterways (Boris, 2009). Septic systems along the water are not the only problem as all septic systems discharge some nitrogen to groundwater. While some of this groundwater is consumed as drinking water, much of the groundwater is eventually discharge to surface waters. This means that ALL septic systems are contributors of nitrogen pollution to the Sassafras River. State funding is available to Maryland Residents who are interested in upgrading their septics to a system the removes nitrogen before discharging to groundwater. In 1998, Kent County implemented a nitrogen removing septic system requirement on all septic systems which require buffer variances (Moredock, 2009). In 2006, both Kent and Cecil Counties began implementing a local Bay Restoration Fund Program which assists property owners to install a nitrogen removing/best available technology component to their existing systems or to defer that cost in a case of complete replacement systems (Boris, 2009).

Water Resource Based Industry

In the Sassafras River watershed there are seven marinas and two boat yards. The predominance of these water based businesses draws a large recreational boating community in the summer season. This boating population serves as a potential source of pollution as some boaters are not aware of certain best management practices (BMPs) while recreating on the river. For example, discharges of sewage from boats compromises water quality since various nutrients and pathogens are released in the sewage. This contributes to the Sassafras River's identified impairment of nutrients. However, there are opportunities for the boating population to participate in BMPs through pumping out boat sewage at a pump out station versus dumping sewage overboard. The Clean Marina program is another way for marina owners to be certified in voluntary maintenance of their facilities in order to manage water resources more consciously. This can help to promote an environmental ethic and stewardship among boaters in the watershed. Table 2-12 shows all Clean Marinas, Clean Marina Pledges, as well as pumpout facilities on the Sassafras River. According to individual correspondence with marina owners on the Sassafras River, there are approximately 1,800 boat slips occupied at various times throughout the year. All marinas on the Sassafras River are using individual septic systems, which in the summer months can experience a surge in use from boat slip occupants.

Table 2.12 Clean Marinas, Clean Marina Pledges, and Pump-out Facilities

Marina	Certified Clean Marina	Clean Marina Pledges	Pump out Available
Duffy Creek Marina	X		X
Georgetown Yacht Basin		X (3/3/03)	
Gregg Neck Marina			

Sailing Associates Marina		X (4/24/03)	X
Sassafras Harbor Marina		X (1/26/99)	X
Skipjack Cove Yachting Resort	X		X
Granary Marina			

Source: http://www.dnr.state.md.us/boating/cleanmarina/cleanmarinas.html

2.5.3 External Nonpoint Sources

A United State Environmental Protection Agency study from 1982 stated that "nutrients and suspended solids (SS) entering the Chesapeake Bay from the Susquehanna River Basin contribute to nutrient enrichment problems in the Bay." A USGS water resource investigation report from 1995 stated that the Susquehanna River contributed nearly 50% of the freshwater discharge to the Chesapeake Bay in a year of normal or average streamflow. However, the river also transported the greatest amount of nutrients, at approximately 66% of the nitrogen, 40% of the phosphorus and 25% of the sediment loads from all non-tidal areas in the Chesapeake Bay Basin (Langland, 1997).

An additional study was conducted through a partnership with the Pennsylvania Department of Environmental Protection, USEPA, and the Susquehanna River Basin Commission, at twelve sites from 1984 to 1989 to quantify nutrient and SS transported to the Bay. In 1990 this was reduced to five sites, and in 1994 one more long term monitoring site was added. As a part of the Chesapeake Bay Program's Non-tidal Water Quality Monitoring Network, 13 sites were added in 2004, and in 2005 four more sites were added. This project involves monitoring efforts conducted by all six Bay states in order to create a uniform monitoring network for the entire Bay watershed.

In 2007, a report using this long term data was conducted by the Susquehanna River Basin Commission in cooperation with Pennsylvania Department of Environmental Protection, Bureau of Water Quality Protection, and Division of Conservation Districts and Nutrient Management, to present basic information on annual and seasonal loads and yields of nutrients and SS measured during 2007 and compare these to the long term mean (LTM) from 1985 to 2007. There was below average rainfall (except in January, March, April and December) that led to a below average LTM annual flows. But a connection between nutrient loads and flow showed that total nitrogen (TN) and suspended sediments (SS) were below the LTM. The report also documented that despite the decrease in TN and SS loads, there was a dramatic increase in Total Phosphorus (TP), and Dissolved orthophosphate (DOP), indicating the DOP may be the nutrient of most concern or in need of additional attention and management (McGonigal, 2008).

The Susquehanna could be a significant nutrient source, especially for the lower portion of the river toward the mouth. "In such a case, load reductions from the Susquehanna, as part of the Chesapeake Bay Agreement, could have a significant positive effect on the Sassafras River quality" (MDE, 2002b 25). Tom Fisher (2009) from University of Maryland Center for Environmental Science, remarked that "quality near the mouth of the Sassafras has to be strongly influenced by Susquehanna River discharge due to tidal exchange and the large difference in basin sizes. Nonetheless, the net flow is out of the Sassafras, and water quality in the upper Sassafras (upstream of the mouth) will be largely determined by local inputs."

2.6 Groundwater and Water Supply

The sole source of domestic water supply in the Sassafras River Watershed is ground water. Surface water is used for irrigation and livestock watering only. Ground water in this area comes from a series of aquifer layers that are formed by sand and gravel deposits. The aquifers are separated by confining beds that are composed of clay and silt. This aquifer system can be visualized as a "tilted layer cake" that gets deeper to the southeast, and rests on a "basement" surface composed of crystalline bedrock (Drummond, 2008). From shallow to deep, the aquifers in the Sassafras area are the Columbia, Aquia, Monmouth, Magothy, Patapsco, and Patuxent aquifers. Generally, the shallowest aquifer in a given area is used for smaller water supplies, whereas larger supplies (like industries and public suppliers) go to deeper aquifers (Drummond, 2008).

The layers of sediment underlying the watershed, contain plenty of water for wells, although a groundwater study will be necessary in order to confirm this. However, in some wells the water is hard and in others there are problems with contamination from nearby septic systems. A characteristic on the Sassafras is older homes with outdated, shallow and either hand dug or driven wells. New wells are drilled to anywhere between 60 and 200 feet. Homes with failing septics, serve as a source of pollution to groundwater sources, as nitrogen and other contaminants are no longer filtered (Kent County, 2008b). Well testing would be beneficial to determine possible contamination sites from septics, and whether this is affecting drinking water quality.

Various state and federal agencies are in the process of developing a Science Plan for a Comprehensive Regional Assessment of the Atlantic Coastal Plain Aquifer System in Maryland (Aquifer Assessment Plan). The Aquifer Assessment Plan addresses the Coastal Plain area which includes most of Southern Maryland, nearly all of the Eastern Shore (including all of Kent County), all of Delaware south of Wilmington, and the northeast corner of Virginia. The Aquifer Assessment Plan will address significant declines in water levels and water-quality problems in parts of the aquifer system that may be exacerbated by increased withdrawals. When the assessment is completed, Kent County will incorporate applicable parts of the assessment into its Plan (Kent County, 2008b).

In the Sassafras River watershed there are three municipalities which operate community water supply systems to homes within those municipalities. All other homes obtain water from their own wells. In addition to the municipalities there are many other permits for water appropriation in the watershed. Some of these are for irrigation of crop fields, chicken and cattle watering, and commercial purposes such as marinas, restaurants, sand and gravel operations and nurseries. Table 2-13 gives the average annual use of each category of water appropriation, and the allotted annual use from MDE. Figure 2.4 shows the percentage of each type of water use in the Sassafras Watershed.

Table 2.13 MDE permitted water appropriation		
Type of Use	**Maximum Annual Use (gallons)**	**Average Annual Use (gallons)**
Irrigation and Cattle/Poultry	10,596,000	3,003,500
Residential	3,946,800	399,700
Commercial and Industrial	1,906,200	860,800

Source: Gary Kelman from MDE Water Management Administration 2009.

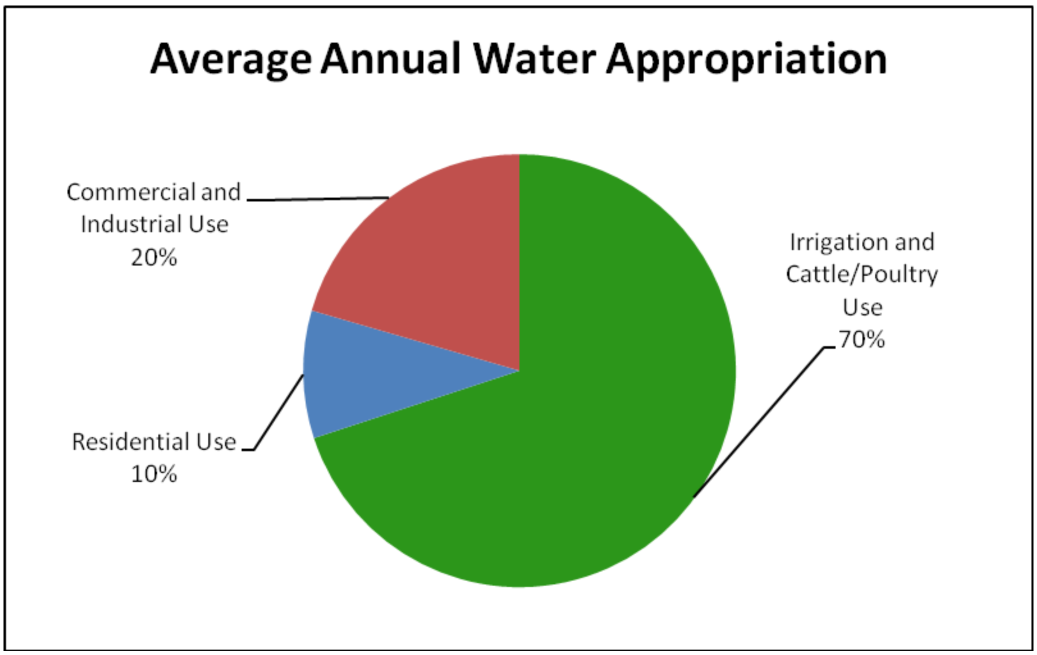

Figure 2.4 Average Annual Water Appropriation in the Sassafras Watershed

3.0 LANDSCAPE

A watershed is the area of land where all of the water that is under it or drains off of it goes into the same river system. As explorer, John Wesley Powell expressed, a watershed is: "that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community." (EPA, 2008c).

What this means is that drop by drop, all water, from streams, creeks, groundwater, or channeled from the soil, eventually makes its way to a larger river, in this case the Sassafras River. Water is a universal solvent, and is affected by everything that comes into contact with it. The most important aspect to remember is that even if someone is not living on the water, he or she is living in a watershed and everything that is done on the land affects the water quality in its given watershed.

A watershed landscape type and how land is used within a watershed can affect water quality. Either by riparian zones, soils, and vegetative cover, water quality is affected. In order to gauge the affects of land on water quality, there are a series of indicators used to identify and assess landscape conditions that affect overall watershed health.

3.1 Land Use and Landscape

Figure 3-1 shows land use summaries from 2002 Maryland and Delaware Departments of Planning data. If surface water is included in land use percentages, then approximately 57% of the land use is agriculture. A quarter of the landscape is forest, and 4% is developed (residential or commercial) land. Table 3-1 shows land use by subwatershed, and Map 13 outlines each of these land use areas in the watershed.

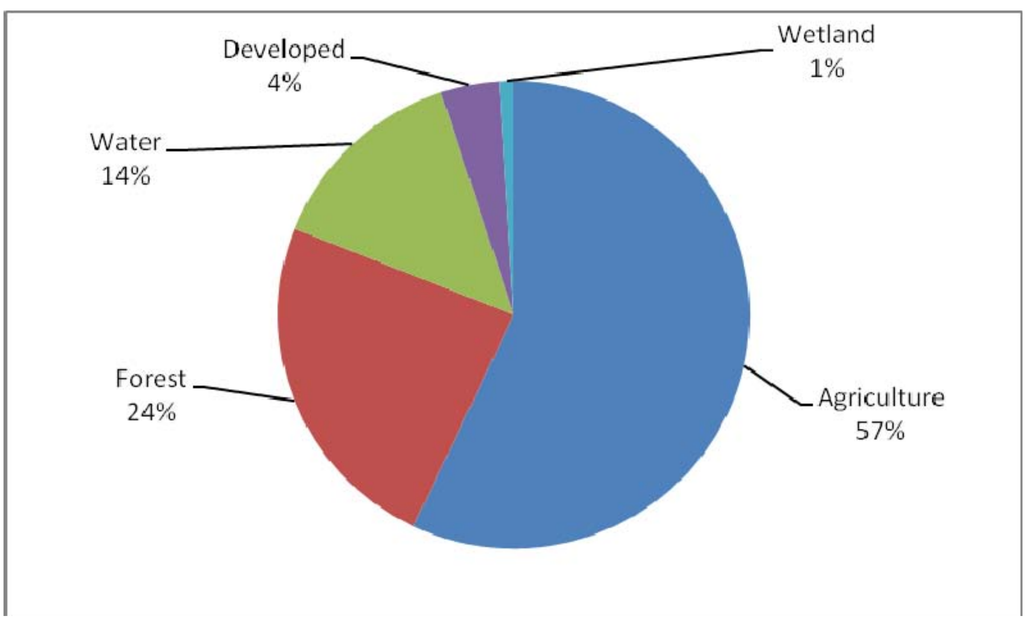

Figure 3.1 Land use in the Sassafras Watershed

Table 3.1 2002 Maryland and Delaware Departments of Planning Land Use Data							
Subwatershed	**Agriculture**	**Forest**	**Developed**	**Wetland**	**Land only (acres)**	**Water only (acres)**	**Total acres**
	(%)				(acres) (%)		
Lloyd's /Turners Creek	45%	23%	4%	2%	9471 (74%)	3375 (26%)	12846
Money Creek	23%	25%	3%	4%	2299 (55%)	1869 (45%)	4168
Woodland/Dyer	62%	23%	3%	1%	8638 (89%)	1078 (11%)	9716
Back Creek	55%	23%	5%	1%	7136 (84%)	1349 (16%)	8485
Swantown/Jacobs Creek	64%	22%	7%	0.5%	15047 (93%)	867 (7%)	15914
Herring Branch	70%	27%	3%	0.3%	11010 (99%)	5 (1%)	11015
Total Watershed					53701 (86%)	8443 (14%)	62144

Acknowledging the methods of determining land use percentages is important as some of these numbers can contradict other sources. When Maryland Department of Planning calculates land use, the numbers are based on a level two United States Geological Survey classification scheme. These schemes are developed from high altitude aerial photography and satellite imagery, and where possible Property View information at a scale of 1:63,360. This is considered a more generalized data set and differing pockets of data are often combined with a larger surrounding land use. (MDP, 2002).

3.1.1 Agricultural Significance

Recognizing the predominantly agricultural land use in the Sassafras Watershed is important in its characterization. More than half of watershed area is comprised of a working landscape which connects the people who live in the watershed directly to the land. Since Europeans first settled on the Eastern Shore of the Chesapeake, this region has been agricultural based. From tobacco production to potatoes and corn, agriculture has changed and shaped the identity of the watershed. Agricultural practices of the first colonists did not address problems of erosion and sedimentation. There were many historic problems with flooding and soil loss. But between 1750 and 1820 there was a transition in farming methods that revolutionized the way agriculture affected the landscape. Crop rotation was introduced as a way to replenish the soil, and the shift from deep plowing to conservation tillage helped prevent soil loss and movement.

Today agriculture types in both Kent and Cecil County are comprised predominantly of row crops: corn, soy beans and wheat. There are various animal operations such as dairy, horses and poultry, as well as nurseries (tree and shrub). The agricultural types in the New Castle County portion of the Sassafras landscape consists of primarily the same as those in Kent and Cecil: corn, soy beans and wheat. Best Management Practices (BMP's) with regards to agriculture have come even farther in technology and practice. Nutrient Management Plans (NMP) for example, are required by both the state and federal government for all farms. The purpose of NMPs is to conserve the use of fertilizer and regulate its application, as to prevent excess fertilizer from absorbing into groundwater or running off to nearby surface water. In 1997 Governor Paris Glendening of Maryland appointed an action commission to study events surrounding *Pfiesteria* outbreaks on the Lower Eastern Shore, and then recommend policy actions to the Governor. *Pfiesteria piscicida*, a tiny marine organism identified in the last decade in estuaries in North Carolina and Delaware and in the Chesapeake Bay and its tributaries, has been blamed for killing fish and causing health problems in humans. A consensus by a group of agricultural scientists concluded that dissolved phosphorus in runoff increased at excessive levels of soil test phosphorus even when erosion was minimal. The main focus of the commission's report placed emphasis on phosphorus in nutrient management planning. On January 21, 1998, the Governor introduced the Water Quality Improvement Act of 1998 in the Senate, which included mandatory nitrogen and phosphorus based nutrient management plans to be developed by 2000 and implemented by 2002. The bill was amended by the Senate and passed with the requirements that all farm have nitrogen based plans by 2003 and nitrogen and phosphorus based plans by 2006 (University of Maryland, 2009). Other active BMP's in the Sassafras Watershed include conservation tillage, cover crops, grassed waterways, agricultural waste storage, filter strips, and vegetation buffers. Definitions of some of these can be found on EPA's website http://www.chesapeakebay.net/agriculture.aspx?menuitem=14745 as well the soil conservation district offices in Kent, Cecil and New Castle counties. For cover crops, in the Cecil County portion of the Sassafras Watershed, the total acre in traditional non manure is 1735.8, manure is 135.2, and commodity is 1291.03. In the Kent County portion of the Sassafras, the total acre in traditional non manure is 2,892, manure is 193.6 and commodity is 1377.6 (Littleton-Bradley, 2009).

3.1.2 The Zoning Approach

Although zoning ordinances are considered living documents, it is imperative to monitor changes as they have implications for water quality. Each county in the watershed has its own unique approach to zoning and should be considered when targeting areas for restoration or protection.

Kent County, Maryland

The Land Use Ordinance for Kent County, Maryland serves to provide a unified, comprehensive approach to regulations that affect land use including Zoning, Subdivision, Forest Conservation, Floodplain Management, Sediment and Erosion Control, Stormwater management and the Chesapeake Bay Critical Area. The purpose of the Ordinance is to implement the Kent County Comprehensive Plan and to promote the health, safety, general welfare, and prosperity of the present and future inhabitants of Kent County by: giving effect to policies and proposals of the Kent County Comprehensive plan; reducing financial burdens imposed on the community by preventing unwise land use that requires costly infrastructure, harms existing communities , or is in areas of natural hazards such as floodplains, shoreline cliffs, steep slopes, and areas subject to erosion; minimizing damage to public and private property; providing for the preservation and enhancement of the attractiveness of Kent County through good design and arrangement, and the provision of adequate public utilities, open space, services, and facilities; enhancing the County's employment base; protecting and preserving Kent County's agricultural industry and the prime agricultural soils essential to the conduct of this industry; providing efficiency in the process of development; protecting Kent County's significant historic structures and areas from destruction or encroachment; protecting the biological and environmental quality of Kent County, including forest, water quality, habitat and wetlands; reducing the effects of land use on land erosion or stream channel erosion; dividing the territory of Kent County, into zoning districts; governing the use of the land and the intensity of such use, including bulk and height. The purposes of the Floodplain Management provisions are to provide public awareness for flooding prevention; to protect individuals from unknowingly buying land and structures subject to flood hazard; and to encourage appropriate construction practices in order to prevent or minimize future flood damage. The purposes of the Stormwater Management provisions are to reduce local flooding, to control adverse impacts associated with increased stormwater; and to improve or substantially maintain after development the pre-development runoff characteristics of the site (Kent County, 2008a).

Cecil County, Maryland

The Cecil County zoning Ordinance serves to promote the orderly development of Cecil County, Maryland, in accordance with the Cecil County Comprehensive Plan. The objective is to provide the means to implement the Comprehensive Plan of Cecil County with the following purpose: to make the most appropriate and balanced use of land throughout the County to the extent that both economic development and the conservation of natural resources and the environment is encouraged; to preserve the character and appearance of neighborhoods and to maintain property values generally throughout the County; to preserve the agricultural economy of the County by discouraging conversion of cropland, pastureland, and woodlands to urbans uses, and to maintain farming activities without interference from other land uses; to conserve natural resources; to secure safety from fire, panic, flood, and other dangers; to minimize traffic congestion on streets and roads, and to provide adequate off-street parking and loading facilities' to provide adequate light, air, and open space, to insure adequate recreation opportunities, and to provide convenience of access to property; to concentrate development in areas suitable for growth as designated in the Cecil County Comprehensive Plan, as amended; to create and preserve an environment conducive to healthful and safe living conditions' to make adequate provision for transportation, water and sewer, schools, police and fire protection, and other public facilities, and to economize on the costs of such public facilities by a careful phasing of development with efficient provision of public improvements; to regulate the intensity of land use; to fix reasonable standards to which structures and uses shall conform; and to prohibit uses and structures incompatible with the character of development of the permitted uses within specified zones; to protect sensitive areas, to control erosion of the land and to protect the waters in and adjacent to the County from excessive sedimentation and from pollution by pesticides, fertilizers, and liquid or solid effluent; to define the powers and duties of administrative officials and bodies in the administration and enforcement of this Ordinance, to establish penalties for violations and to provide for amendments; to protect environmentally sensitive areas from unnecessary disturbance (Cecil County, 2008).

New Castle County, Delaware

The New Castle County Unified Development Code (UDC) establishes standards, procedures and requirements, consistent with the Comprehensive Development Plan which regulates and controls the planning and subdivision of lands; the use bulk design and location of land and building; the creation and administration of zoning districts and the general develop of real estate in the unincorporated areas of New Castle County, Delaware. The UDC protects the interests of current and future residents and neighbors from potential adverse impacts of land use. The code is intended to promote and protect the health, safety, prosperity, convenience, general welfare and quality of life for all present and future citizens of the County.

In additional to preservation of lifestyles, encouragement of desirable growth and employment, maintenance of public facilities and services, orderly growth and development and adequate affordable housing; the UDC strives to protect the natural resource base of the County and to assure long-term economic viability and welfare of the County. The code is intended to: control density, open space and regulate the disturbance of natural features to protect the watershed and surface water resources; protect life and property by mitigating against the hazards of flooding, stormwater accumulation, runoff or destabilization of soils; avoid or lessen erosion hazards; preserve and protect areas with limited development potential due to topography, hydrology, soils or other natural conditions a habitats for wildlife; preservation of archeological, historic and architectural sites; prevention against the destruction or impairment of the floodplains which adversely aft the public health, safety and general welfare (NCCDP, 2002).

3.1.3 Impervious Surface

Impervious surface refers to anything that blocks rainwater from naturally seeping into the ground. This includes roads, parking lots, roofs, sidewalks, driveways, decks or other construction. Lot coverage and impervious surface allow stormwater runoff to flow at an accelerated pace because it usually directs it downward towards the nearest stream or waterway. Less water is able to infiltrate into the soil and more water is directly entering the stream before naturally filtering through vegetation. Watersheds that have relatively little impervious surface usually have better water quality in local streams than watersheds with greater urbanization or development. This is because storm water runoff from lot coverage and impervious surfaces is a non-point source of pollution that can input chemicals, nutrients, sediment and contribute to erosion of streambanks.
Table 3-2, Upstream Impervious Cover Thresholds, shows the relationship between impervious surface and stream quality. These thresholds are determined by the Maryland Biological Stream Survey and are based on extensive biological monitoring.

Table 3.2 Upstream Impervious Cover Thresholds

Percent Impervious Cover	Affects on Stream Quality

< 2 %	Imperviousness is relatively insignificant compared to other factors affecting habitat quality. In cold-water habitats, brook trout may be found.
> 2 %	Negative impacts to stream health begin. Brook trout are never found in streams with watershed imperviousness above this threshold.
> 15 %	Stream health is never rated good, based on a combined fish and benthic macroinvertebrate Index of Biotic Integrity.
> 25 %	Only hardy, pollution-tolerant fish, macroinvertebrates, amphibians and reptiles can thrive, while more pollution-sensitive species are eliminated.

Source: Maryland DNR

Based on land use data from the 1998 Unified Watershed Assessment, impervious surface made up 1.2% of the watershed. More recent legislation passed by the Critical Area Commission changed the way local jurisdictions in the state of Maryland calculated impervious surfaces. In July 2008, for properties located within the Critical Area, lot coverage limits have been established replacing previously determined impervious surface requirements. The limits remain similar; however, the calculation of lot coverage has been significantly altered (Moredock, 2009). By digitizing high resolution aerial photos from 2007, GIS students from Washington College were able to capture and detail out all the most recent impervious surfaces in the watershed (Map 14). According to these calculations there is a total of 1195.5 acres of impervious surface which makes up 2.2% of the land area in the Sassafras watershed. Any impacts from impervious surface that might affect water quality are concentrated in and surrounding the municipalities of Galena, Betterton and Cecilton. Not only town centers, but neighborhoods, marinas and major roads are included in the assessment of impervious surfaces in the Sassafras. These concentrations may be appropriate sites for stormwater management retrofits including bioretention, rain gardens, rain barrels and other filtering measures.

3.1.4 Buffered Waterways

The presence of vegetation along tidal waterways and streams is essential to the health and function of habitat. Vegetation provides shade which helps keep water temperature lower, the roots of tress and grasses help to stabilize banks, and serve as a source of food for wildlife. In most places where there is a loss or reduction in stream buffer, there is also a degradation of stream habitat. Therefore, a strategy to improve stream habitat and health is to replace and enhance stream buffers. McCrone, Inc. analyzed the stream buffer totals in the watershed, using current land use data and imagery. Analyzing a stream layer from the Maryland and Delaware State Highway Administrations, the 1000 foot area bordering all “blue line streams” was considered. This included both the tidal and non-tidal stream portions of the watershed including and extending beyond the critical areas. The areas located beyond the critical area in the non-tidal streams although smaller in size, are crucial to the biological integrity of the watershed. This 1000 foot area was then analyzed for any type of natural vegetation that had not been heavily isolated by development. Any area with this vegetation buffer that comprised of at least 50 feet was counted in the vegetated acreage totals. Refer to Table 3-3.

The critical area refers to the 1000 foot buffer between tidal segments of a waterway and its upland land use (agricultural, residential, etc.). Any area with a vegetation buffer that comprised of at least 50 feet was counted as critical area buffer and this came to a total of 6,024 acres. Map 15 highlights the critical area, and Map 18 shows all vegetation buffers present in the entire watershed whether along tidal portions or in the 1000 foot area bordering the blue line streams (non-tidal waters).

Table 3.3 Buffered Streams

	Acres in this area	Acres Vegetated	% of total acres vegetated
Critical Area	11,567	5,663	49%
Non-tidal Streams outside of the critical area	16,369	4,484	27%
Watershed Totals	17,236	10,147	76%

3.2 Lands with Significant Natural Resource Value

3.2.1 Green Infrastructure

The state of Maryland's Department of Natural Resources has mapped greenways across the state which identifies a network of ecologically important lands. These hubs and linking corridors of greenways are called "Green Infrastructure;" and must contain one of the following:

- Large blocks of contiguous interior forest (containing at least 250 acres, plus a transition one of 300 feet) ;
- Large wetland complexes, with at least 250 acres of unmodified wetlands;
- Important animal and plant habitats of at least 100 acres, including rare, threatened, and endangered species locations; unique ecological communities; and migratory bird habitats;
- Relatively pristine stream and river segments (which, when considered with adjacent forests and wetlands, are at least 100 acres) that support trout, mussels, and other sensitive aquatic organisms.

Existing protected natural resource lands contain one or more of the above (for example, state parks and forests, National Wildlife Refuges, locally owned reservoir properties, major stream valley parks, and Nature Conservancy preserves). Green Infrastructure is important to protect as it provides a “natural support system” cleaning the air, filtering water, storing and cycling nutrients, conserving soils, regulating climate, and protecting sensitive areas from storm damage. Many municipalities such as Betterton have designated Green Belts in accordance with state Green Infrastructure maps. These Green Belts are meant to act as green growth boundaries (MDNR, 2006).

There are various programs that aim to protect green infrastructure hubs. These include Rural Legacy, Program Open Space, and Conservation Easement among many others. Ultimately any agricultural land that is well managed in terms of nutrient balances and minimized sediment and nutrient loss should be considered as part of the green infrastructure of the Sassafras watershed. Map 17, Green Infrastructure, shows that there are 13 Green Infrastructure hubs identified in the Sassafras River watershed.

3.2.2 Large Forest Blocks

Large forest blocks differ from green infrastructure in that green infrastructure must cover at least 250 adjoining acres, whereas large forest blocks include any block of contiguous forest that are least 50 acres in size with at least 10 acres of forest interior (which means forest edge is at least 300 feet away). These blocks of forest are just as important as green infrastructure hubs because they provide habitat for species that cannot withstand influence from open area habitats or humans. This specific amount of forest acreage was determined as a threshold that could provide significantly large enough habitat for sensitive forest dwelling species.

Forest Interior Dwelling Birds are species of birds which require relatively large forested tracts in order to breed successfully (for example, various species of flycatchers, warblers, vireos, and woodpeckers. Existing riparian forest of 300 x 300 feet or more and forest areas used by forest interior dwelling birds and other wildlife species must be managed according to the guidelines developed by the Maryland Department of Natural Resources and the Chesapeake Bay Critical Area Commission. A site survey for forest interior dwelling birds shall be conducted prior to any development or agricultural expansion on deciduous forest of at least 50 acres or 300 x 300 foot riparian deciduous forest. The Planning Director may waive a site survey for forest interior dwelling birds provided the forest is managed for all forest interior dwelling bird species. Cutting and building shall be restricted to safe times (not during nesting season) (37). Map 18 shows all forest cover in the Sassafras watershed.

3.2.3 Protected Lands

Map 19 Protected Lands shows the distribution of all protected lands in the Sassafras River watershed. Protected land refers to any land with some type of long term limitation on conversion to urban or developed land use. Protected land can either be publicly owned for a natural resource or recreational purpose, or privately owned with some third party acquired development rights.

Table 3.4 Protected Land Summary for the Sassafras River Watershed		
	Acres	**%**
MET / ESLC Easements	4273	8.0
Agricultural Easements	2518	4.6
Rural Legacy Areas	4110	7.7
County Parks, Open Space	182	3.4
DNR Lands	1547	2.8
Protected Land Total	12630	23.5
Watershed Land Total	53701	

Source: MDNR GIS mapping data

3.2.4 Archeological Presence and Absence

Archeological presence and absence in the Sassafras watershed can be viewed on Map 20 which highlights areas that have a very high, high or moderate probability of an archeological presence. Maryland Historical Trust Data also shows generalized site locations of past archaeological finds. These are segmented by grids to protect exact locations, but to highlight general locations of significant finds. In terms of watershed management, knowledge of these sites is important when selecting areas for restoration projects or areas to target for preservation or protection.

3.3 Wetlands

3.3.1 Wetland Categories

The Sassafras River is located on the Eastern Shore of the Chesapeake Bay which is within the Coastal Plain Province. The Coastal Plain has overall low topography accompanied by a high ground water table. These characteristics allow for a high diversity of both emergent estuarine and palustrine, or freshwater, wetland communities unlike any other region in the Chesapeake Bay watershed. Wetlands in the Sassafras watershed occur along the shoreline as tidal wetlands, in floodplains of streams, at the heads of drainageways, and in isolated depressions. Characteristic of the Sassafras River are the steep slopes, meandering shorelines and alluvial deposits along these shores. Wetlands often extend until reaching one of these slopes, but will sometimes transition into other types of wetlands along the shoreline's twists and turns. In these areas extensive freshwater tidal marches can also be found (Tiner, 1995). Using DNR wetland mapping data each wetland type found in the Sassafras watershed, the associated vegetation type for each, and the acreage totals can be determined. In the Sassafras Watershed there are estuarine, palustrine and lacrustine wetlands.

Estuarine wetlands consist of salt and brackish water, as their vegetation is dependent upon salinity, but have been found to stretch up into the nontidal/freshwater areas of the watershed. Despite its presence in both salt and fresh waters, estuarine wetland distribution is sensitive to changes in salinity and tidal flooding (Tiner, 1995). Brackish marshes are the most predominant wetland type in Maryland, stretching along the shoreline of the Chesapeake Bay and for most of the Eastern Shore. According to DNR mapping, the subclasses of estuarine wetlands found in the Sassafras are tidal emergent, scrub-shrub, and unconsolidated shore. Emergent wetlands are dominated by erect rooted herbaceous plants, such as lotus, water lily, and cattail. Scrub-shrub wetlands are dominated by shrubs and tree saplings less than twenty feet in height. Unconsolidated shore wetlands exhibit three characteristics: 1)less than 75% coverage by bedrock, boulders or stones; 2) less than 30% coverage by persistent vegetation and 3)alternately exposed and flooded (Cowardin *et al*, 1979).

Palustrine wetlands are all non-tidal freshwater wetlands dominated mostly by trees, shrubs and persistent emergent vegetation (Tiner, 1995). This wetland type is associated with high water tables or intermittent ponding on land (Tiner, 1995). They are located in floodplains, depressions in upland areas, drainage divides, and in broad flat areas between watersheds. The most abundant type of palustrine wetland in the Coastal Plain region is forested wetlands. Tidal freshwater swamps can also be found along coastal rivers in areas that are tidally influenced. The subclasses of palustrine wetlands that are found in the Sassafras are aquatic bed, emergent, scrub shrub, forested and unconsolidated bottom. Aquatic beds include small ponds that are dominated with vegetation on or below the surface of the water (Tiner1995).

Lacustrine wetlands are the third category of wetlands found in the Sassafras, and are associated with deepwater habitats such as freshwater lakes, deep ponds or reservoirs. They are classified into either lacustrine aquatic beds which are wetlands in shallow water, or lacustrine emergent wetlands which are located along the shoreline (Tiner1995). The subclass of lacustrine wetlands found in the Sassafras are unconsolidated bottom wetlands which have at least 25% cover of particles smaller than stones, and vegetation cover of less than 30% (Tiner 1995).

Wetlands of Special State Concern (WSSC) are selected wetlands that represent the best examples of Maryland's nontidal wetland habitats. Because of their representative status they are given additional protection in state law beyond the permitting requirements that generally apply to wetlands. There are 276 total acres of WSSC in the Sassafras watershed.

Using MDNR spatial information, there are approximately 4,026 total acres of wetlands currently in the Sassafras River watershed. It is also important to note that the methodology used by MDNR to calculate wetland totals is very different from the methods utilized by MDP. MDNR mapping layers are created by collecting data from aerial and remote sensing imagery as well as ground truthing. When MDP analyzes low resolution imagery for land use data collection, small pockets of wetlands can often be considered water or forests because wetlands are not distinguishable at the altitude the imagery was taken. This is why MDP wetland acreage totals in the Sassafras watershed (approximately 700) is much less than the totals produced by MDNR.

In the 1998 Unified Watershed Assessment an estimate of historic wetland loss was also conducted. This determination is based upon the assumption that all the hydric soils in the watershed were all at one time wetlands. If all the acres of nonwetland hyric soil in the Sassafras watershed are assumed to be historic wetlands, than the estimated loss of wetlands is 11,651 acres. Selecting locations for wetland restoration is an effective strategy that can be implemented to improve water quality. There are many cases in which historic wetland areas have been drained or filled for other uses. Restoring these areas would bring back the natural functions of wetlands as filters and habitat. There are regulations set forth by the State of Maryland, Army Corp. of Engineers, US Fish and Wildlife, and EPA to protect wetlands, and currently Kent County Maryland has a no net loss policy regarding wetlands.

Map 25 Wetlands and Table 3-5, Wetland Acreage Totals, summarizes distribution and categories of wetlands in the Sassafras River watershed.

Table 3.5 Wetland Acreage Summary Table Sassafras River Watershed

Wetland Class		Acres
Estuarine	Tidal Emergent	451
	Scrub Shrub	49
	Unconsolidated Shore	397
Palustrine	Emergent	271
	Aquatic Bed	4
	Forested	1,942
	Scrub Shrub	261
	Unconsolidated Bottom	429
Lacustrine	Unconsolidated Bottom	222
Wetlands of Special State Concern		276
Total Wetlands (DNR mapped wetlands)		4,026
Estimated Wetland Loss		11,651

Source: 2009 DNR Wetlands GIS layer

3.3.2 Tracking Wetlands

In a cooperative effort between MDNR and the Army Corps of Engineers, MDE is the lead agency overseeing activities that affect wetlands with regulatory authority. A responsibility of MDE is to track state permitting and the net gain or loss of wetlands over time. According to the latest MDE report "Prioritizing Sites for Wetland Restoration, Mitigation and Preservation in Maryland," (2006) there was only one instance of recorded wetland loss of 0.33 acres and this loss was offset by a gain of 0.36 acres.

3.4 Soils and Watershed Planning

3.4.1 Soil Types and Classes

Soil types are an important determining factor in ecological systems. They affect the kinds of plants that can grow, forming different wildlife habitats, and affecting water quality in both surface water and ground water systems. Soil properties vary considerably from site to site, but soil survey maps (National Cooperative Soil Survey SSURGO data) provide the location and distribution of soil types that are important in watershed and land use planning (Refer to Map 22).

The soils in the Sassafras River watershed have formed in unconsolidated sediments of the Coastal Plain. In general there are sandy and gravelly layers deep under the surface, with varying layers of silts on the surface that were brought in with the wind over the Chesapeake Bay and river beds, when water levels were much lower. A few areas have layers of heavier clay materials that were deposited under shallow or still water. Very few rocks are found near the surface of the soil, and depth to bedrock is very deep. With the temperate, humid climate, and level to gently sloping topography, the soils are extremely productive for agriculture and forestry. Soil types are divided into groups A-D (Table 3-6). Group A soils have a high infiltration rate or low runoff potential when thoroughly wet. These consist mainly of deep, well drained sands or gravelly sands. Group B soils have moderate infiltration when wet and consist chiefly of moderately deep or moderately well drained soils. Group C soils have a slow infiltration rate when thoroughly wet and consist of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. Group D soils have a very slow infiltration rate and high runoff potential when thoroughly wet. These consist of chiefly clays that have a high shrink-swell potential, and a permanent high water table (White, 1979).

Table 3.6 Soil Types of the Sassafras Watershed

Hydrologic Soil Group	Acres	% of watershed	% of watershed excl. water
(water)	8795.2	14.18%	

A	277.7	0.45%	0.5%
A/D	46.9	0.08%	0.1%
B	35559.3	57.32%	66.8%
B/D	688.8	1.11%	1.3%
C	12422.1	20.02%	23.3%
C/D	1205.4	1.94%	2.3%
D	3042.6	4.90%	5.7%
	62038.1	**100.00%**	**100.0%**

Approximately 60 percent of the watershed is considered “Prime Farmland”; these soils can be farmed sustainably with few major inputs. Another 20 percent of the area is considered “Farmland of Statewide Importance” – these soils may be equivalent to Prime Farmland if drainage, irrigation, or erosion control practices are used (Shields, 2009).

Soils with ground water at or very near to the surface during the growing season are found in about 13% of the watershed. These soils are “hydric”, and are either currently functioning as wetlands, or have been drained for agriculture or other land uses. Restoring the hydrology and vegetation of the drained areas can increase the beneficial functions of wetlands, water quality, and wetland wildlife habitat.

The use of soil maps can help target areas for conservation or water quality practices that would be the most beneficial. Land Capability Classes and subclasses can be used as a quick method to assess major soil properties for agriculture. There are eight classes, with Class 1 soils being ‘best suited’, through Class 8 soils that are not suitable for agriculture. The subclasses “e” for erodibility, “w” for wetness, or “s” for sand or low water holding capacity, are the primary agricultural limitations for soils in the Sassafras R watershed (Table 3-7) (Shields, 2009).

<table>
<tr><th colspan="4">Table 3.7 Soil Summary for the Sassafras River Watershed</th></tr>
<tr><th>Land Classification Capabilities</th><th>Subclass Descriptions</th><th colspan="2">Total Acres</th></tr>
<tr><td>Class 1 – Soils may have slight limitations that restrict use.</td><td>There are no subclasses for class 1. The class is characterized primarily by well drained, silty loam, moderately eroding soils</td><td colspan="2">5,295</td></tr>
<tr><td rowspan="2">Class 2 – Soils have moderate limitations that restrict the choice of plants or that require moderate conservation practices.</td><td>2e – well to moderately well drained, silty/sandy loam, moderate erodibility</td><td>23, 102</td><td rowspan="2">26,616</td></tr>
<tr><td>2w – moderately well drained, silty/sandy loam</td><td>3,514</td></tr>
<tr><td rowspan="2">Class 3 – Soils have severe limitations that restrict the choice of plants or that require special conservation practices or both.</td><td>3e – well to moderately well drained, silty loam, moderate erodibility</td><td>4,966</td><td rowspan="2">8,547</td></tr>
<tr><td>3s – somewhat excessively drained, loamy sand, moderate erodibility</td><td>103</td></tr>
</table>

Table 3.7 Soil Summary for the Sassafras River Watershed

Land Classification Capabilities	Subclass Descriptions	Total Acres	
	3w – poorly drained, silty/sandy loam, moderate erodibility	3,478	
Class 4 – Soils have very severe limitations that restrict the choice of plants or that require very careful management, or both.	4e – well to moderately well drained, silty gravelly loam, moderate to severe erodibility	3,152	
	4s – well drained, loamy sand, moderate erodibility	26	
	4w – poorly drained, sandy/silty loam	1650	4,828
Class 5 – Soils are subject to little or no erosion but have other limitations (ex. Impractical to remove) that restrict their use mainly to pasture, rangeland, forestland or wildlife habitat.	5w—poor to very poor drained, sandy loam, frequently flooded		1,713
Class 6 – Soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland or wildlife habitat.	6e – well drained, sandy gravelly loam, moderate to severe erodibility		2,108
Class 7 – Soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland or wildlife habitat.	7e – well drained	3,153	
	7s – somewhat excessively drained, loamy sand	314	
	7w – very poorly drained, silty loam, muck peat, frequently flooded	530	3,997
Class 8 – Soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes.	There are also no subclasses for class 8. This class is characterized by very poorly drained and very frequently flooded soils.		410
Total Soil/Land Acreage			53,514
Prime Farmland	32,237		
Statewide Important Farmland	10,229		
Hydric Soils	6,894		
Not Prime Farmland (*this includes Hydric Soils)	11,048 *		
Total Soil/Land Acreage	53,514		53,514

Source: Compiled by Diane Shields from NRCS.

3.4.2 Soil Erodibility

Watersheds with highly erodible soils are going to be more vulnerable to surface erosion and sedimentation. The soil erodibility indicator calculated in the 1998 Unified Watershed Assessment, considered different soil conditions, but not the management of the surrounding land. For instance, cropland management is not a factor. Soil erosion can be managed through best practices that are commonly used in the watershed. Cover crops, no-till or reduced till cropping are examples of best management practices (BMP's) that can reduce the threat of erosion and movement of sediment to nearby streams and eventually the river.

Soil erodibility is an indicator based on an area's slope, soil erodibility factor (also known as the "K factor"), distance to nearest stream and land use type. In the Unified Watershed Assessment, the Sassafras River watershed, was given a soil erodibility of 0.28. If a watershed scored in the high (score between 0.275 and 0.314) or very high (score between 0.314 and 0.37) classification, it received a Category 1 rating for this indicator. The Sassafras's soil erodibility ranked high among other watersheds in the state and did not meet the state benchmark.

3.5 Floodplains and Low Elevation Areas

Because the Eastern Shore of the Chesapeake Bay is located in the coastal plain region, much of it is low-lying and therefore more susceptible to floods associated with storm events and rising sea level. Located on the Eastern Shore, the Sassafras River is positioned in the low-lying coastal plain region of the Chesapeake Bay Watershed. Map 16: Floodplains, shows the 100-year floodplain of the Sassafras River watershed. Floodplains are relatively flat or low areas adjoining rivers, streams, watercourses, or drainageways which are subject to partial or complete inundation. Floodways are the channels and adjacent land areas required to discharge the waters of the 100-year flood of a watercourse without increasing the water surface elevations more than a specified height. Flooding is a common problem in areas of development and extensive impervious surface. Public roads, neighborhoods and parking lots can flood during storm events and can contribute to degradation of local stream health. Since the late 1990's modern stormwater management techniques have been required and generally put in place in the region and when constructed properly have helped to limit the impact of stormwater pollution. Modern retrofits can control the amount of stormwater runoff, enhancing water quality and limiting other adverse affects of stormwater such as erosion.

According to the National Flood Insurance Program: Flood Insurance Rate Maps, compiled by FEMA, much of the Sassafras River Watershed is located within Flood Zone A11, Elevation Eleven (FEMA, 1985). The upper reaches of the watersheds tributaries are also mapped and anecdotal floodways. The actual elevations in the watershed vary greatly; as a result, this area of Kent County contains a high number of mapping errors and subsequent FEMA map amendments. It is important to note that these maps did not always account for cliffs or high slopes towards the River edge.

Another important factor to consider is the average rate of sea level rise in the state of Maryland, especially along coastlines. The average rate has so far been 3-4mm/yr or approximately one foot per century. This is nearly double the global average which is about 1.8mm/yr. According to Maryland's Sea Level Rise Strategy of 2000, the rate of sea level rise is expected to increase to 2-3 feet by 2100 in response to global warming (Johnson, 2000).

3.6 Human Population

Population dynamics are important when characterizing a watershed. The physical characteristics of the Sassafras are necessary to determine its problems and restoration strategies, but understanding the people that live and identify themselves with the Sassafras watershed is just as critical in developing a restoration plan. Population demographics as well as density are important factors when analyzing pollutant contributors to a watershed system as well as where to focus restoration. Human activity can degrade natural habitats especially when land use is manipulated to fulfill human needs. Watersheds with high populations can make a big impact on waterways, but can also be planned using best management practices reducing the negative impacts. Based on the 1990 U.S. Census, the population density in the Sassafras River watershed was 0.17 people per acre of land. Using 2000 U.S. Census data for both Maryland and Delaware the population density in the Sassafras watershed is 0.08 people/acre and 52 people per square mile of land.

3.6.1 Demographics of Sassafras Watershed

Maryland Department of Planning organizes census data in two forms: census blocks and census block groups. Census blocks (2000) include broad information but are smaller and clip more easily to the boundary of the watershed. May 24 includes both the Maryland Delaware census blocks. The following characteristics in the census blocks of the Sassafras watershed have been identified: The total population is 4,318, where 2,166 are male and 2,152 are female. Of the 4,318, 90% are white, 7.2% are African American, 2.5% are Hispanic or Latino, and less than one percent is comprised of Asian, American Indian or Native Hawaiian decent. Housing units (vacant or occupied) in the census blocks of the Sassafras watershed total 2,818, with 2,156 occupied. (Baldwin, 2009; Mahaffie, 2009).

Census block groups hold more data than census blocks but cannot be clipped to the watershed boundary (Map 24B). For this reason, the total population is higher than the total population of the census blocks. Because of the level of detail the data in the census block groups give, the information is useful in characterizing the Sassafras watershed and its surrounding area. The following characteristics in the census block groups including and surrounding the Sassafras watershed in the Maryland portion have been identified: The total population is 7,986 with 95% born in the United States and 47% born in the state of residence. Of the 295 or 4% of the population that is foreign born, 1.5% are naturalized citizens. 7,019 or 93% of the population have English only speaking households. 521 or 7% speak a language other than English including 5% Spanish, 1% other Indo-European and .38% Asian and Pacific Island.

The total population 16 years and over is 6,426; of this 4,116 or 64% comprise the labor force. Of the 3,842 working, 955 commute to work with a mean travel time of 31 minutes. Occupations include management (31%), sales and office occupations (22%), service occupations (16%), construction and maintenance (14%), production and transportation (12%)

and farming, fishing and forestry (5%). Total households number 3,167, with a mean household income of $ 57,217 (median not available). Mean family income is $ 65,103 (median not available). Of total persons 18 – 65 years 12% live in poverty. Of total persons 65 years and over 5% live in poverty.

The total population 25 years and over is 5,665. Of this number 2,193 or 39% have attained a high school degree; 1,052 or 19% have attained some college, no degree; 670 or 12% have attained a Bachelor’s degree; and, 453 or 8% have attained a graduate degree. In summary 81% have graduated high school or higher and 19% have graduated with a bachelor’s degree or higher (Baldwin, 2009).

4.0 LIVING RESOURCES AND HABITAT

Living resources are another indicator of the health of a given watershed. Aquatic organisms like fish, benthic aquatic insects, as well as submerged aquatic vegetation are sensitive to changes in their environments. They serve as a gauge to measure the affects of human interaction and use on the environment. The decline of certain species of plants and animals over time, suggests that stress on these living resources because of alterations and destruction of habitat can also lead to excessive sediment and nutrients in our waterways.

In determining the status of living resources in the Sassafras watershed the following factors were considered: changes in submerged aquatic vegetation from 1984 to 2006, benthic and fish communities in the non-tidal areas, instream physical habitat, migratory fish spawning areas, as well as the presence of imperiled (rare, threatened or endangered). All of these conditions play a role when it comes to evaluating the issues in the watershed and prioritizing those issues for restoration work. There are often times when stakeholders in the watershed can identify living resources that state agencies are not able to monitor or record. These will be included and added as further assessments and observations are made.

4.1 Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV) distribution and abundance is one way of assessing the health in an estuary or estuarine river system. It serves as an indicator of water quality as well as habitat for aquatic life such as fish and benthic organisms.
SAV abundance was determined in the 1998 Unified Watershed Assessment by using 1996 aerial survey results. The extent of areas with SAV growth was measured and this number was divided by the Unified Watershed Assessment restoration goal of two meters. This number was then multiplied by 10 to yield a value between one and ten (one being most degraded and ten being the best conditions). Watersheds with a resulting score of one means that SAV covered 10% or less of potential SAV habitat, and that those watersheds are in need of restoration. The Sassafras River received a score of one meaning that SAV restoration in this watershed is a priority. The purpose of this indicator is to allow for comparisons between watersheds based on actual SAV acreage versus the potential SAV acreage.

Maps 26, 27 and 28 as well as Table 4-1 depict the changes in SAV presence from 1984 to 2007 using aerial imagery and GIS software.

Table 4.1 SAV Presence in the Sassafras River By Year

Year(s)	Description of SAV
1984	Near mouth on southern coast
1985	In Lloyds Creek and mouth of Turners Creek
1986	In Lloyds Creek, mouth of Turners Creek and east of Freeman Creek on south bank
1987	In Lloyds Creek and mouth of Turners Creek

Table 4.1 SAV Presence in the Sassafras River By Year	
1989	Trace amounts west of Lloyds Creek and west of Turners Creek
1990	Trace amounts west of and in Lloyds Creek and west of Turners Creek
1991	Trace amounts west of Lloyds Creek and west of Turners Creek
1992	Trace amounts west of an in Lloyds Creek and west of Turners Creek
1993	In Lloyds Creek and Turners Creek
1994-1996	In Lloyds Creek, Turners Creek and Freeman Creek
1997	In Lloyds Creek, Turners Creek, Freeman Creek and Money Creek
1998	In Lloyds Creek and Turners Creek
1999	In Lloyds Creek, along southern bank at mouth of Turners Creek and on the northern bank at mouth
2000	Along both banks of mouth of Sassafras River and in downstream tributaries to Cox Creek
2001	Along both banks of mouth of Sassafras River and in downstream tributaries to Foreman Creek
2002-2004	Along both banks of mouth of Sassafras River and in downstream tributaries to Woodland Creek
2005	Along both banks of mouth of Sassafras River and in downstream tributaries to Woodland Creek, and in upstream tributaries of Mill Creek, Swantown Creek and Duffy Creek
2006	Along both banks of mouth of Sassafras River and in downstream tributaries to Cox Creek, spots on the southern bank and in Woodland Creek

More detailed information and data tables from 1971 to 2007 are available from Virginia Institute of Marine Science. More analysis and translation is needed, but acreage counts for different sections of the Sassafras are on record from 1971.

Another indicator that was taken into account is SAV Habitat Index. The purpose of this score was to allow for comparisons between watersheds based on various measurements of habitat conditions such as: water clarity measured by secchi depth, dissolved inorganic nitrogen, dissolved inorganic phosphorus, abundance of algae measured by chlorophyll a, and total suspended solids. The index was then determined by using 1994 to 1996 Chesapeake Bay Program segments of passing, failing and borderline habitat requirements for SAV. Scores were adjusted to range between one and ten (one being most degraded and ten being best condition). Watersheds that scored less than seven were placed in Category 1 (in need of restoration). The Sassafras Watershed scored a seven for this indicator and was therefore placed in Category 1.

4.2 Fish Species

4.2.1 Tidal Areas

Map 31, with data from DNR fisheries April 2009, shows four different types of anadromous fish species that are known to spawn in several tidal streams in the Sassafras watershed. The species noted here are Alosid, White Perch, Yellow Perch and Striped Bass. Anadromous fish species are important indicators because they migrate each year to the same location to spawn and therefore are very sensitive to changes or degradation in water quality. Drops in dissolved oxygen and reduced water clarity can affect their ability to navigate and survive in areas where they may have previously spawned. Tracking and monitoring of these species is important to consider when determining areas for restoration targeting.

4.2.2 Non-Tidal Areas

As a part of the Maryland Biological Stream Survey, crews from the MDNR visit streams across the state in both spring and summer assessing biological and physical health. The spring visit consists of benthic sampling, and the summer visit includes a procedure whereby fish are netted off for a 100 foot segment of stream, shocked momentarily so they can float to the surface long enough for biologists to count and identify the different species found in that segment. From visits in 2001 and 2007, Table 4-2 includes a list of the different species and totals of each identified at various sites in the Sassafras watershed.

Table 4.2 MBSS of Fish in Non-tidal Streams of the Sassafras Watershed

Site	Species	Total
Swantown Creek 2001	Eastern Mudminnow	838
	Bluegill	8
Woodland Creek 2001	Largemouth Bass	1
	Eastern Mudminnow	23
	American Eel	84
	Creek Chubsucker	33
	Golden Shiner	96
	Creek Chub	12
	Eastern Mosquitofish	22
	Brown Bullhead	4
	Bluegill	118
	Pumpkinsead	31
	Tessellated Darter	87
	Least Brook Lamprey	18
Sassafras River Unnamed Tributary 2007	Eastern Mosquitofish	848
	American Eel	14
	Tessellated Darter	3
	Creek Chubsucker	3
	Largemouth Bass	4
	Pumpkinseed	234

Table 4.2 MBSS of Fish in Non-tidal Streams of the Sassafras Watershed		
Site	**Species**	**Total**
	Green Sunfish	26
	Bluegill	110
	Eastern Mudminnow	100
	Golden Shiner	1190
	American Eel	14
Duffy Creek 2001	Brown Bullhead	74
	Bluegill	8
	Eastern Mudminnow	30
	Tessellated Darter	124
	Golden Shiner	209
	Redfin Pickerel	12
	Green Sunfish	23
	Creek Chubsucker	530
	Pumpkinseed	13
Herring Branch 2001	Bluegill	39
	American Eel	63
	Pumpkinseed	6
	Eastern Mudminnow	8
	Largemouth Bass	2
	Golden Shiner	2
	Brown Bullhead	1
	Tessellated Darter	61
	Least Brook Lamprey	57

4.2.3 DNR 5 year Eel Study

There have been many other studies conducted over the years on the state level to monitor and assess the health of fish species throughout the Chesapeake Bay Watershed. Maryland DNR conducted an eel study from 2003 to 2008 on select rivers on the Eastern Shore of the Chesapeake. One of the locations for this study was the Sassafras River. The purpose of the study from 2003 to 2008 was to characterize Maryland's commercial American eel fishery in the Nanticoke River and at least one other Maryland Chesapeake Bay tributary: (Patuxent, Choptank, Fishing Bay and Sassafras were the others). Another objective of the study was to collect biological data to describe American eel populations on the Sassafras River through a fishery independent survey, as a follow up to a previous study done on the Sassafras from 1998-2000. And finally the study was to serve as participation in a multi-state management effort of American eels through Atlantic States Marine Fisheries Commission. In the main study, growth rates varied considerably among systems and among years within the same system. In fact the eels on the Sassafras were much smaller than any other tributary sampled, with average annual growth approximately 15mm less than the others. The independent study on the Sassafras was designed to provide size and age structure data, parasite infestation rates, and sex composition of eels in the Sassafras River, as well as a fishery independent relative abundance index. Copies of this study can be obtained from MDNR Fisheries Service (Whiteford, 2009).

4.3 Sensitive Species

Sensitive species are plant and animal species recognized by the state or federal government to be most vulnerable to environmental change and therefore not as capable of maintaining viable or sustainable population levels. Some of these species are classified as rare, threatened or endangered. From a watershed restoration and management perspective, it is important to identify locations where these species inhabit, and consider those areas for habitat protection or habitat restoration where sensitive species were known to once inhabit. In addition to fish, benthic organisms and aquatic plants, sensitive species are considered indicators of the negative affects degradation to the environment can have on survival. Refer to section 3.2.1 Green Infrastructure for more information on sensitive species.

4.3.1 Shellfish in the Sassafras

According to shellfish biologists from the Maryland Department of Natural Resources, salinity levels in the Sassafras can reach near zero for extended periods of time. This means that any significant oyster presence in the river is highly unlikely. According to records from the early 1900's, the closest oyster bar to the Sassafras River was near Poole's Island. Salinity is definitely a limiting factor for other commercial shellfish species in the Sassafras. In addition to the absence of oysters, the salinity is generally too low for softshell clams *Mya arenaria* and razor clams *Tagelus plebeius*. Non-commercial species that you can expect to find, sometimes in large numbers include the brackish-water clam *Rangia cuneata*, and in the fresher reaches of the river, the non-native Asian freshwater clam *Corbicula fluminea* (Tarnowski, 2008).

4.3.1 Rare, Threatened and Endangered Species List

In the Sassafras River watershed there are quite a few rare, threatened or endangered plants and animals. State endangered species include the eastern tiger salamander, puritan tiger beetle, and barking treefrog, while state threatened species include the Bald Eagle. There are various listed endangered plants in the Sassafras which include: Velvety Sedge, Standley's Goosefoot, Parker's Pipewort, Harper's Fimbristylis, Featherfoil, Mudwort, Clammyweed, Flatstem Pondweed and Spongy Lophotocarpus (Davidson, 2008). Although most sensitive species tend to collect in ecologically or targeted sensitive species areas, many of these species can be found throughout the watershed. While prioritization of restoration or protection might be in these areas, there are many areas of the watershed that these species call "home." All projects located within these sensitive areas, must be reviewed by the MDNR Wildlife and Heritage Service Environmental Review Coordinator. This review results in a variety of best management practices which may include stormwater management, setback, or time of year requirements (Moredock, 2009).

4.4 Invasive Species

4.4.1 Water Chestnut

The first records of water chestnut in North America were near Concord Massachusetts in 1859. In 1955, water chestnuts were observed in Maryland in the Bird River in Baltimore County. At this time, the Maryland Departments of Game and Inland Fish and Tidewater Fisheries used mechanical removal and chemicals (herbicide 2,4-D) to eradicate. However, despite those efforts, in 1964, water chestnut reappeared in the Bird River and an additional 100 acres were discovered in the Sassafras River in Kent County. Mechanical removal was used to eradicate thirty acres of water chestnut from the Sassafras River in 1964, and a combination of removal techniques were used in 1965 to eradicate 200 acres from the Sassafras (MDNR, 2008d). These efforts were thought successful as nothing was observed for the next 30 years. However, in the summer of 1997, reports were received from Lloyd's Creek on the Sassafras, the same location of the 1960's populations. From 1999 to 2008, DNR has led volunteers on kayaks, canoes, and personal watercrafts, in an effort to mechanically and physically remove water chestnuts from the Sassafras River. In 1999, 260,000 pounds were removed from the Bird and Sassafras Rivers combined. In 2000 that number dropped to 1,000 pounds on each river. This led volunteers and MDNR staff to believe that handheld removal was an effective approach; however, there is also a strong resurge in populations of the invasive species that is unpredictable from year to year. In 2007, SRA assisted MDNR with volunteer coordination, meeting staff and surveying landowners who observed water chestnuts in their farm ponds. In 2008, there was a large area of water chestnut discovered in "Swan Pond" (tidal pond west of the mouth of Turner's Creek) increasing the total pounds of eradicated species to 2,800. In 2009 there was an enormous decrease in water chestnut found in the Sassafras River. MDNR staff surveyed all navigable sections of the River over two days and eradicated only two bushels of water chestnut, however they were unable to navigate into "Swan Pond." (MDNR, 2008d).

4.4.2 Landscape Vegetation

There are many invasive species that have been observed over the Sassafras watershed landscape. Some of these include garlic mustard, purple loosestrife, Italian ryegrass and phragmites. However, because there are two species of phragmites (invasive and native-aggressive) determining which is present in the Sassafras watershed would be necessary before taking eradicative action. In North America phragmites (*Trapa Natans*) has often been misunderstood and commonly considered an exotic species not native and introduced from Europe. However there is evidence of the existence of phragmites native in North America long before European colonization. The native forms of phragmites have been observed as less aggressive than European forms, but are almost indistinguishable from the European form of the species. The invasive form of the species can cause serious problems for other wetland plants including the native phragmites (ISSG, 2006). Genetic analysis would be necessary to determine which species is present in the watershed. In addition to state listed invasives, there are some "noxious weeds" that also tend to take over native vegetative species. Some of these include: Multi Flora Rose, Johnson Grass, and Canada Thistle (Batchelor, 2008).

4.5 Habitat Conservation

Through mapping of DNR's targeted ecological areas and potential habitats, it is possible to locate areas in the Sassafras watershed where prioritization of habitat restoration projects or protection of certain areas might be focused. Map 30 Ecologically Significant Areas of the Sassafras Watershed, includes: targeted ecological areas, potential habitats and wetlands of special state concern (WSSC).

4.5.1 Hardwood in the Sassafras

There have historically been important products in the forests of the Chesapeake watershed. One of these was "sassafras," widely used in Europe for various human ailments from "gout to liver complaints to venereal diseases." Sassafras was a popular Chesapeake export in the seventeenth and eighteenth centuries, from which it was sold and boiled into teas that were thought to be good for "purifying the blood." The Sassafras River owes its name to "colonial root grubbers who believed they had found the magic cure all for disease" (Wennerstein, 2001, 53).

The forest types or hardwood seen the Sassafras today is important in characterizing the watershed and the available habitat for sensitive species. According to MDNR foresters, the trees in the Kent County portion of the watershed have been mixed oak/American Beech/Tulip Poplar with introduced Paulownia in some deep ravines. There are blocks that have been planted with Loblolly pine in fields here with some strips of White Pine. There are sections of sweet gum and red maple but their numbers increase greatly towards Rt. 299/Massey Rd. In some instances where lands are left fallow from agricultural use, pioneer species such as Virginia pine and black locust return. Other species that have emerged in these areas include: black cherry, sweet gum and red maple.

Distribution of oaks has varied depending on soil types present. White oak, northern red oak, black oak, and chestnut oak have been found on rockier steeper ravine areas, whereas swamp white oak, swamp chestnut oak, willow oak and pin oak, which are wet tolerant, are found in more hydric soils. In the early 1980's, Gypsy moths did significant damage to most tree species in the Sassafras watershed, especially white oaks, however, according to MDNR observations, many landowners were able to salvage cut and save their trees from this harm.

Loblolly pines have been planted in previous years as they will grow easily on a variety of soil types, wet and dry and are more tolerant of deer browsing in comparison to other species (Batchelor, 2009). There has also been some discussion with individual landowners who noticed native hemlocks in wooded ravines being lost to hemlock woolly adelgid. Woolly adelgid was originally introduced from Japan and can be found in both Eastern and Western North America.

It is not considered a pest in Japan, but this tiny aphid-like insect is a serious pest of hemlock in Maryland. It is found primarily on the young branches of hemlock at the bases of the needles and sucks sap from branches. It may also inject a toxin into the tree during feeding. The feeding can result in rapid desiccation and discoloration of the foliage. A heavily infested tree may die within four years (Malinowski, 2009).

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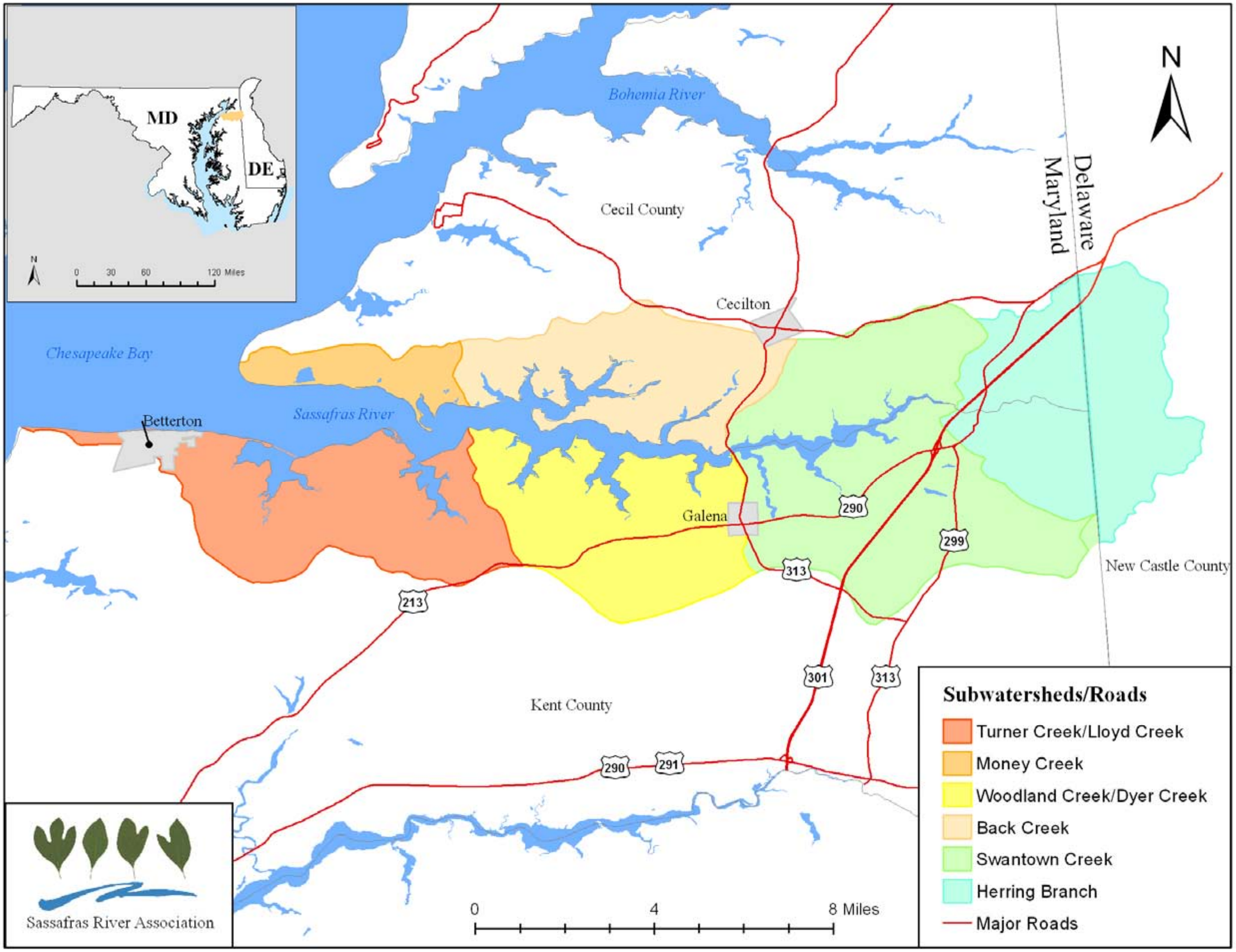
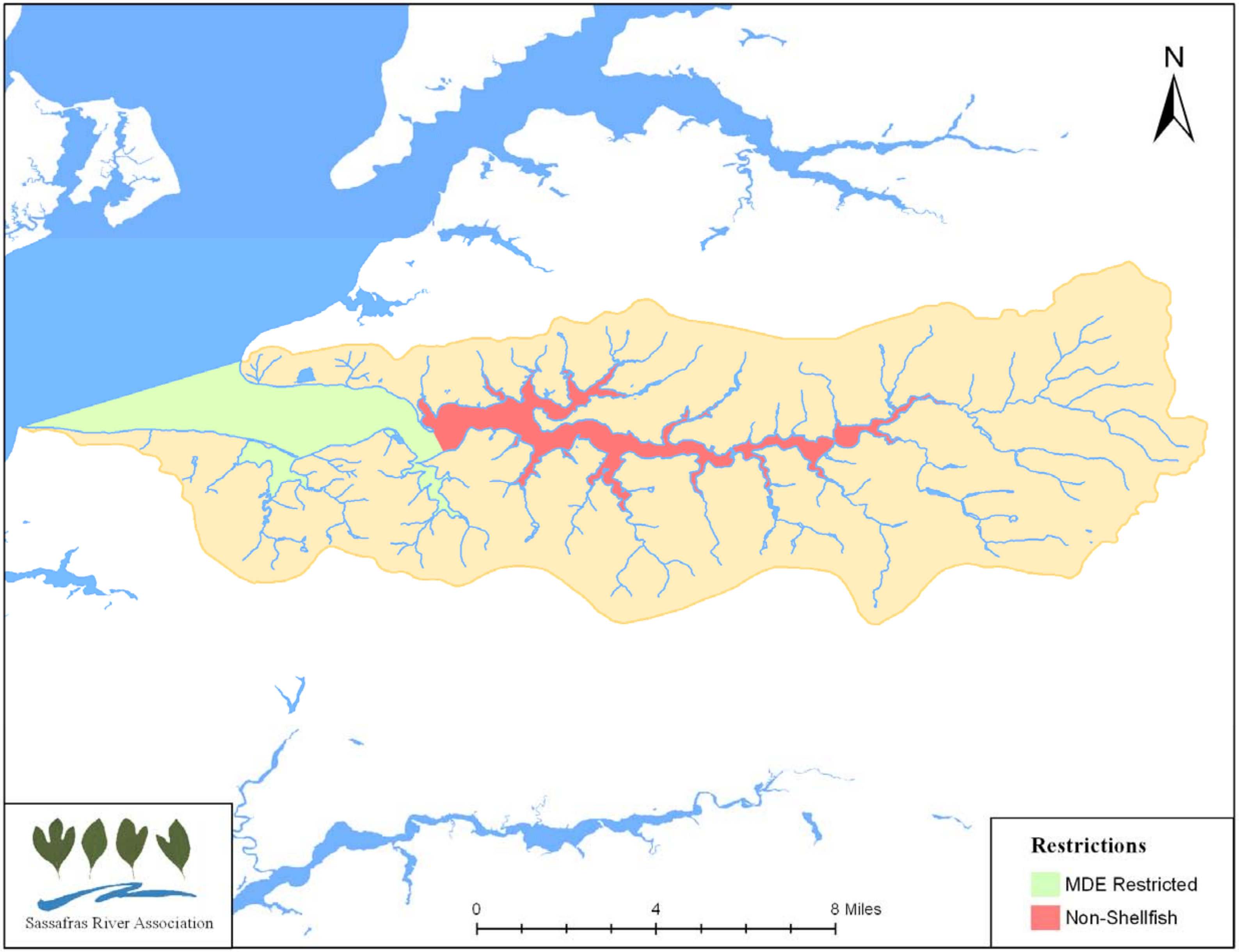
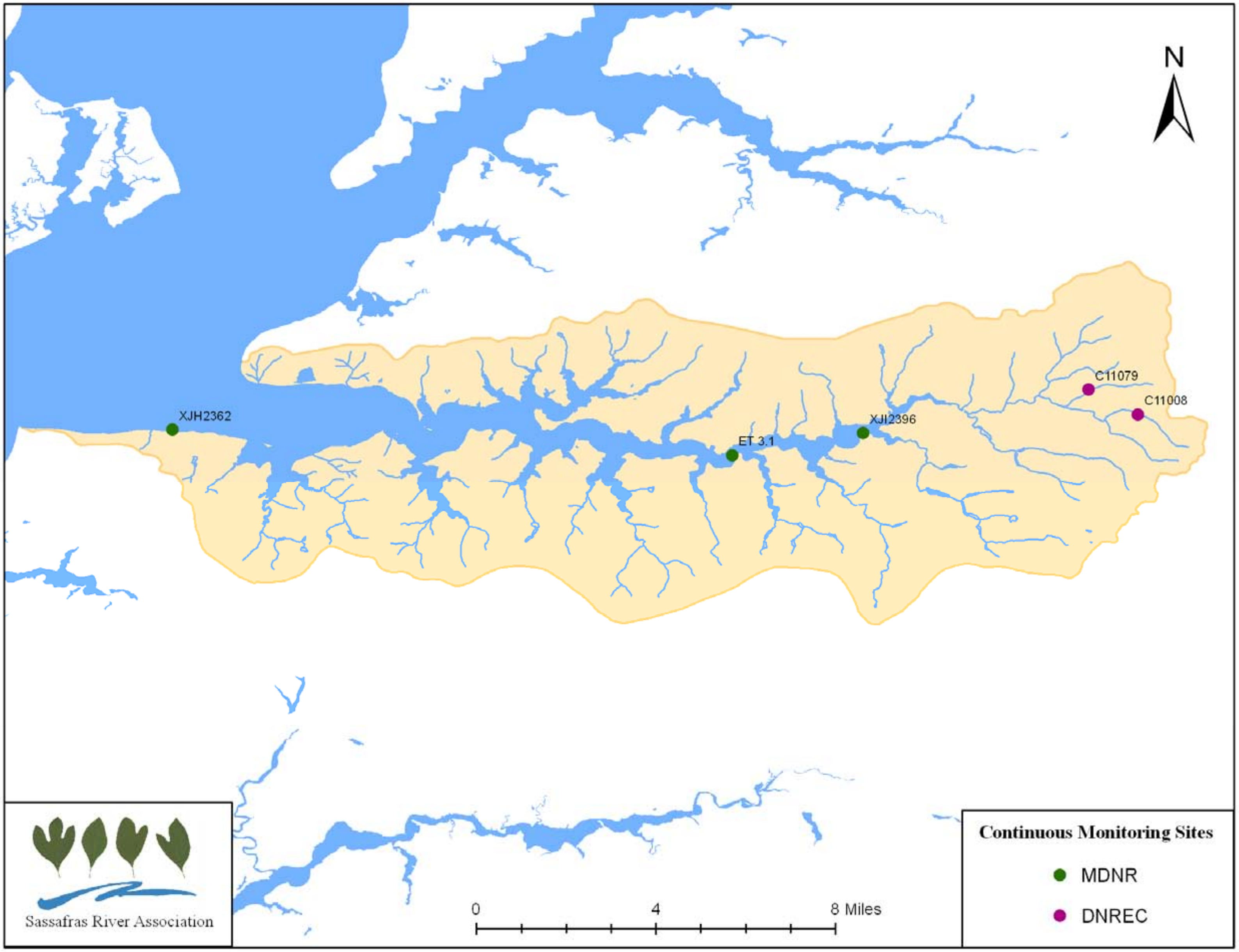
MAPS



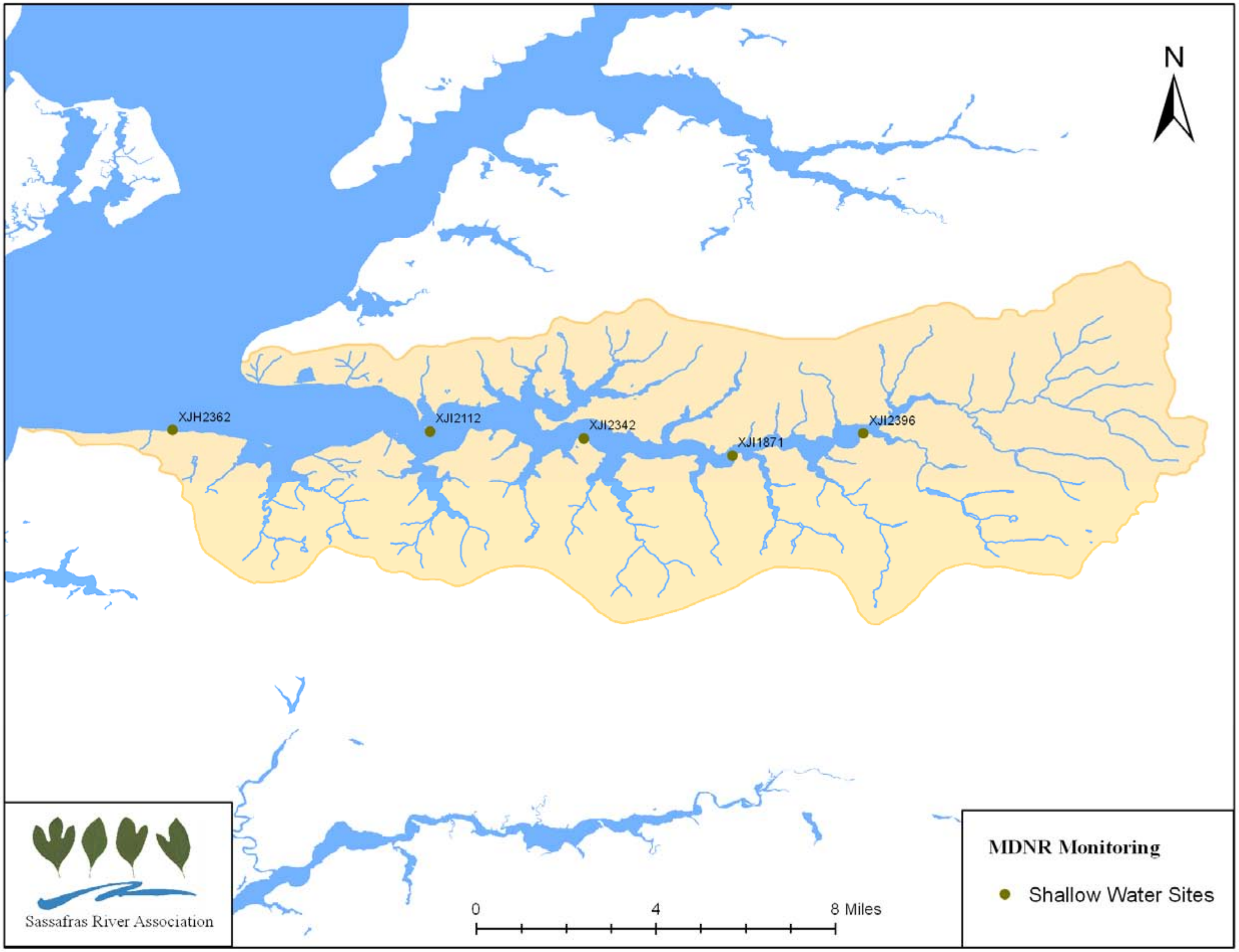
Map 1. Sassafras River Area Map (Map: SRA, Data Source: MD-DNR)



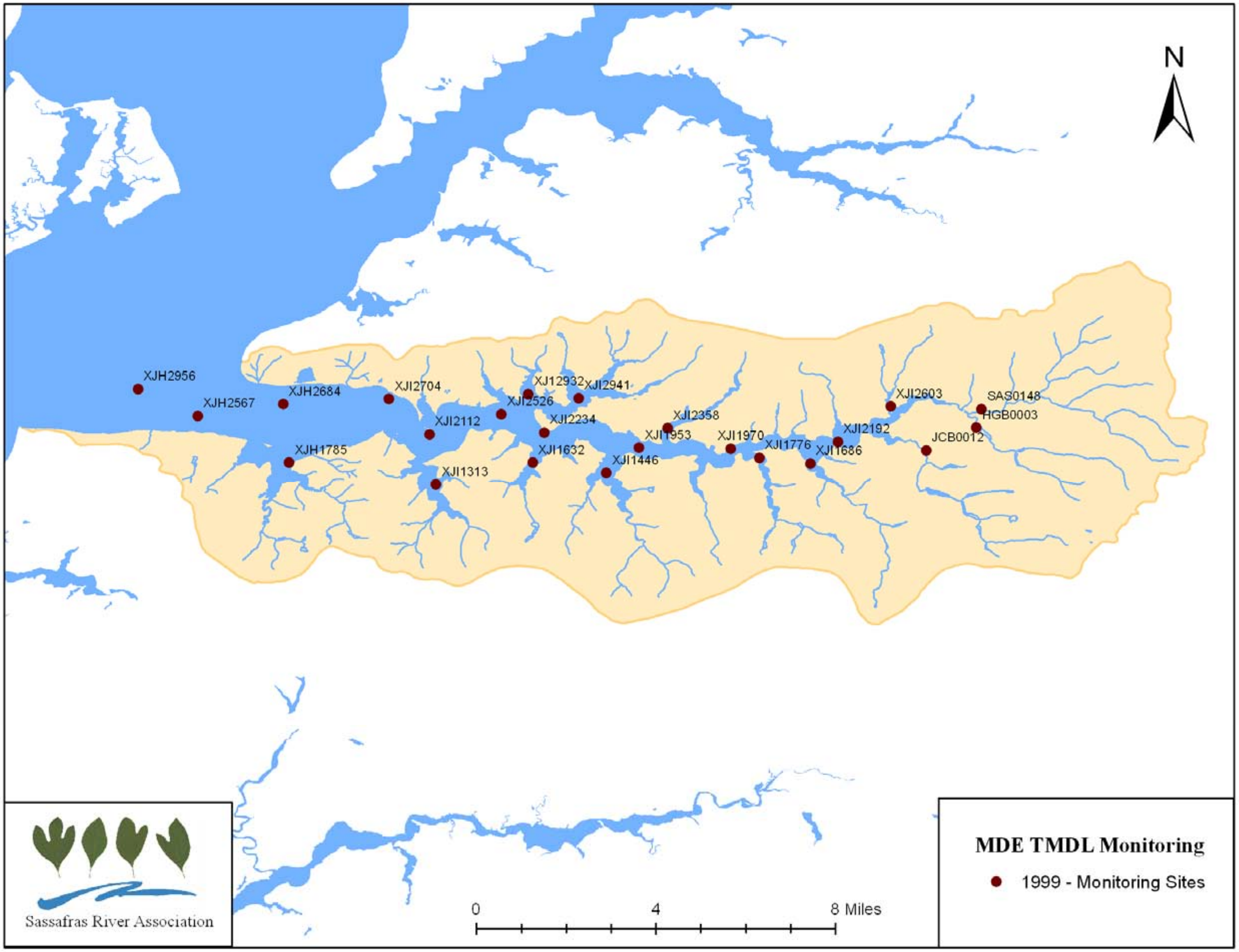
Map 2. Designated Use and Use Restrictions – Sassafras River Watershed (Map: SRA, Data Source: MDE)



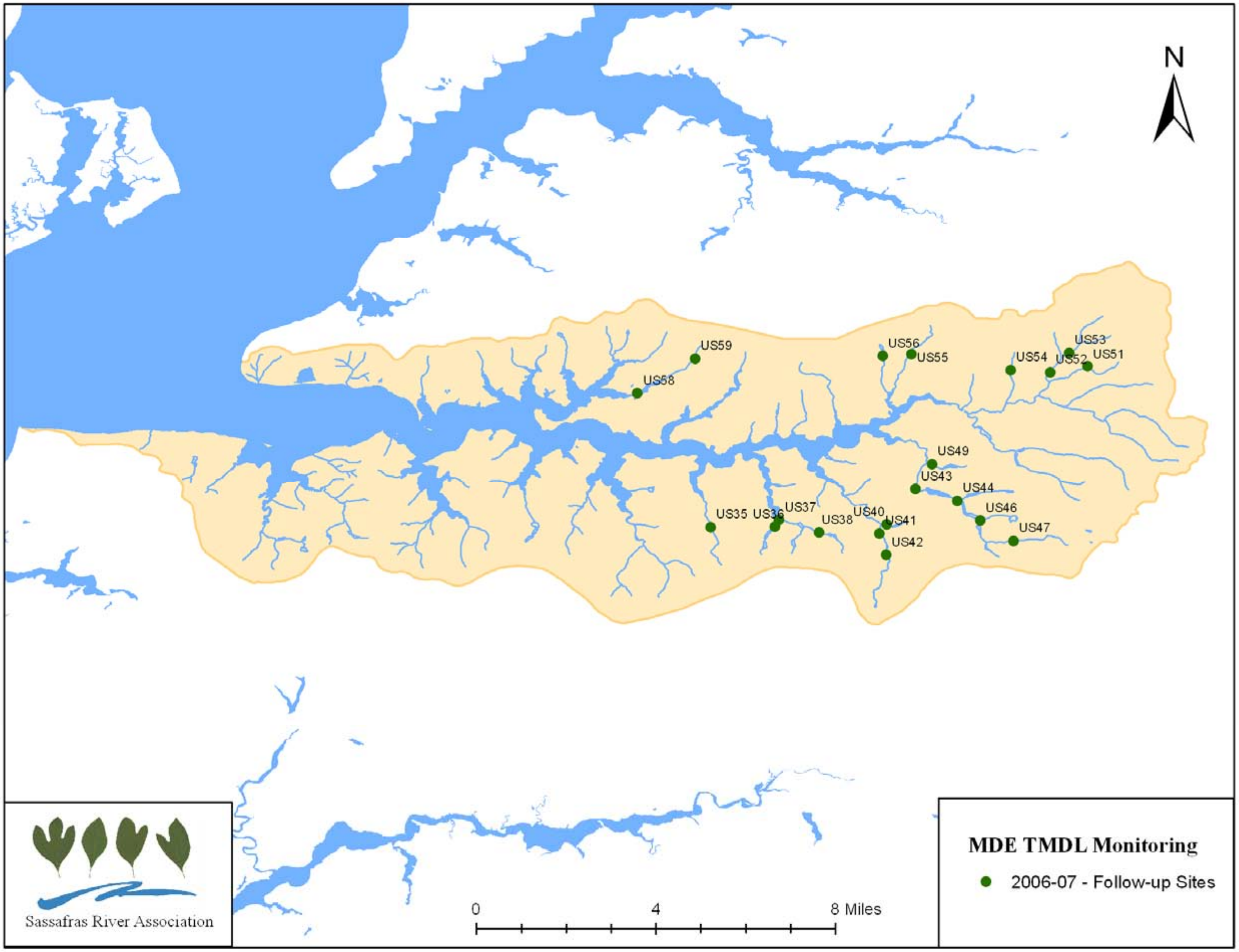
Map 3. Continuous Monitoring Sites – Sassafras River Watershed (Map: SRA, Data Source: MD-DNR, DNREC)



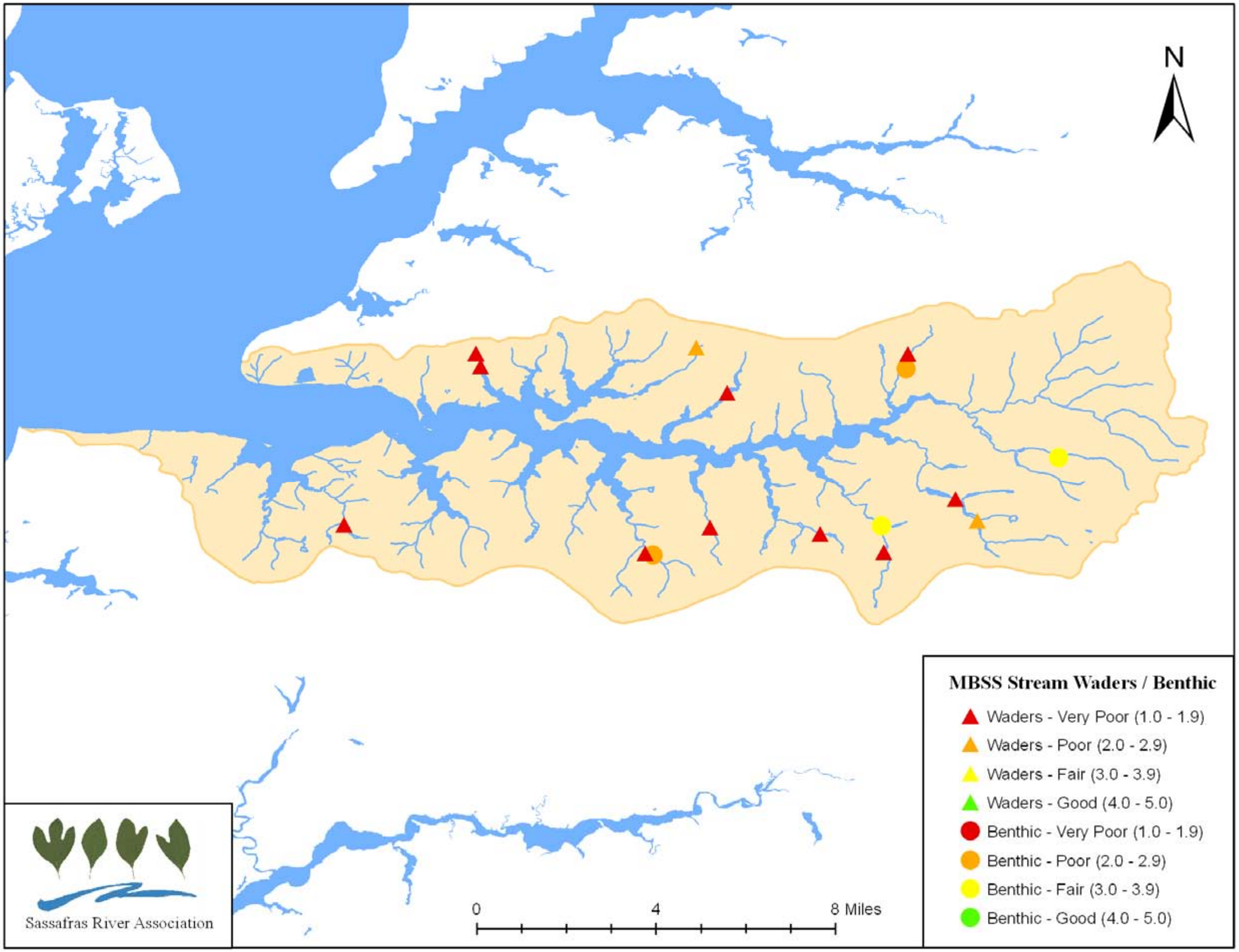
Map 4. MD-DNR Shallow Water Monitoring Sites – Sassafras River Watershed (Map: SRA, Data Source: MD-DNR)



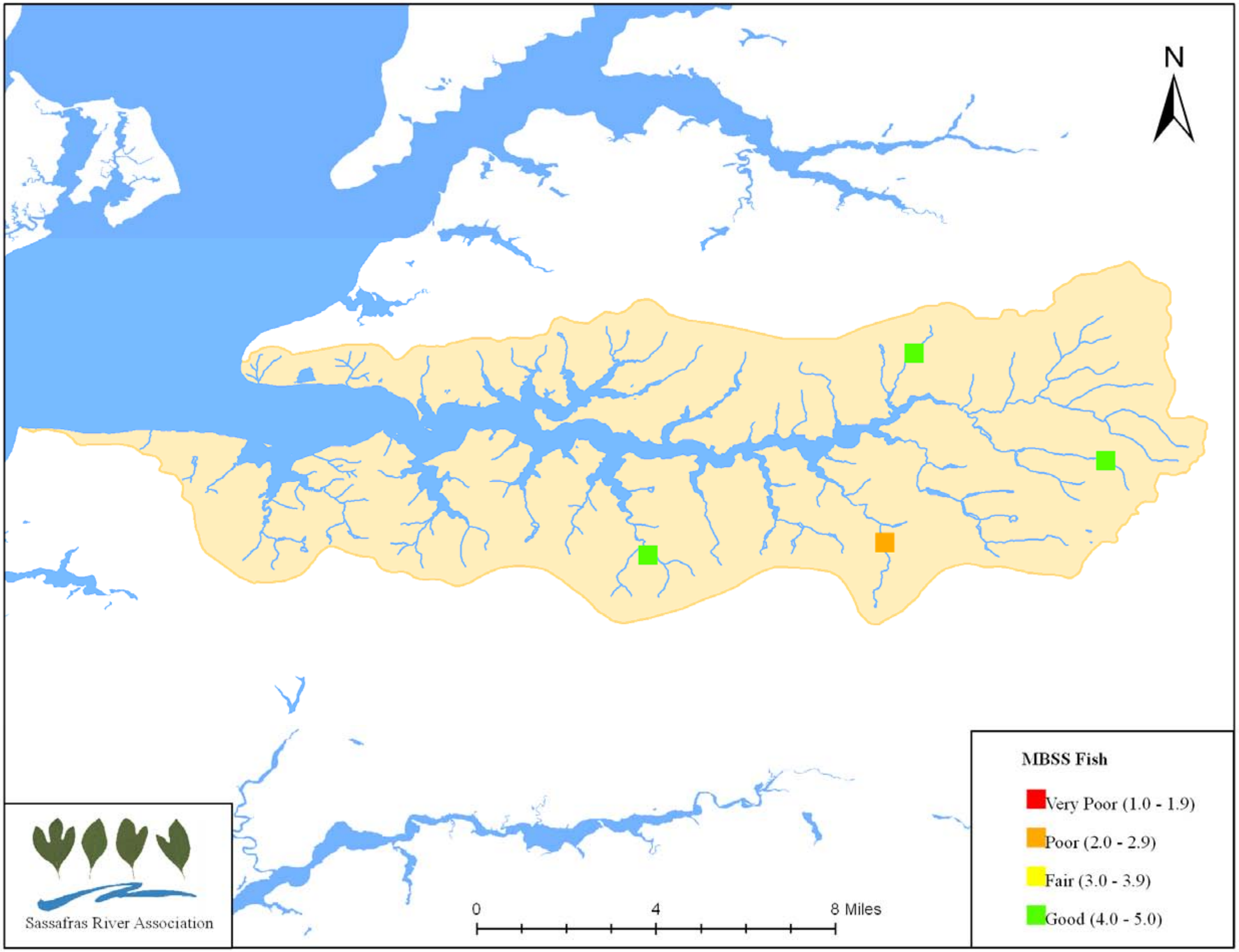
Map 5. TMDL Monitoring Sites - 1999 – Sassafras River Watershed (Map: SRA, Data Source: MDE)



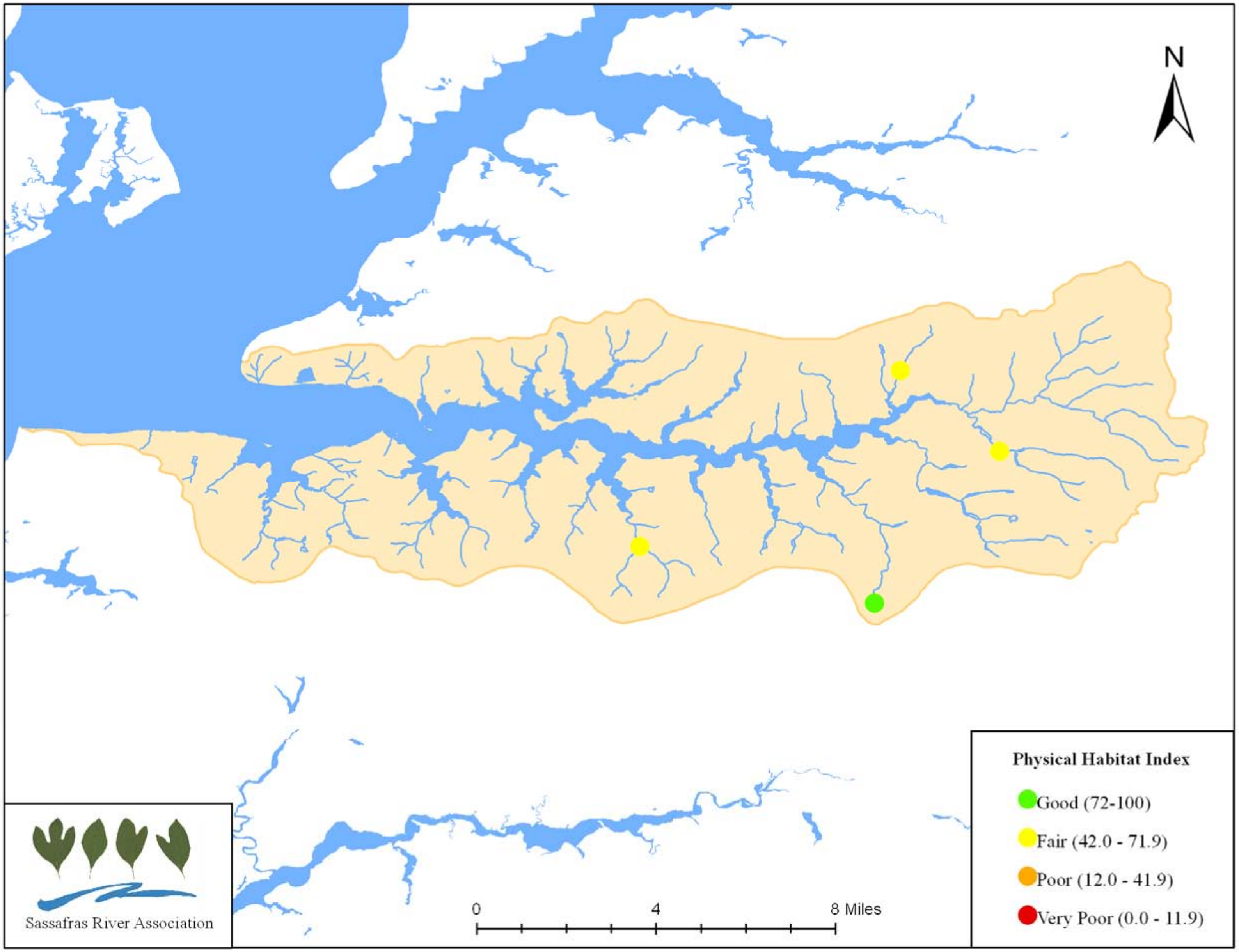
Map 6. TMDL Monitoring Site – 2006-07 – Sassafras River Watershed (Map: SRA, Data Source: MDE)



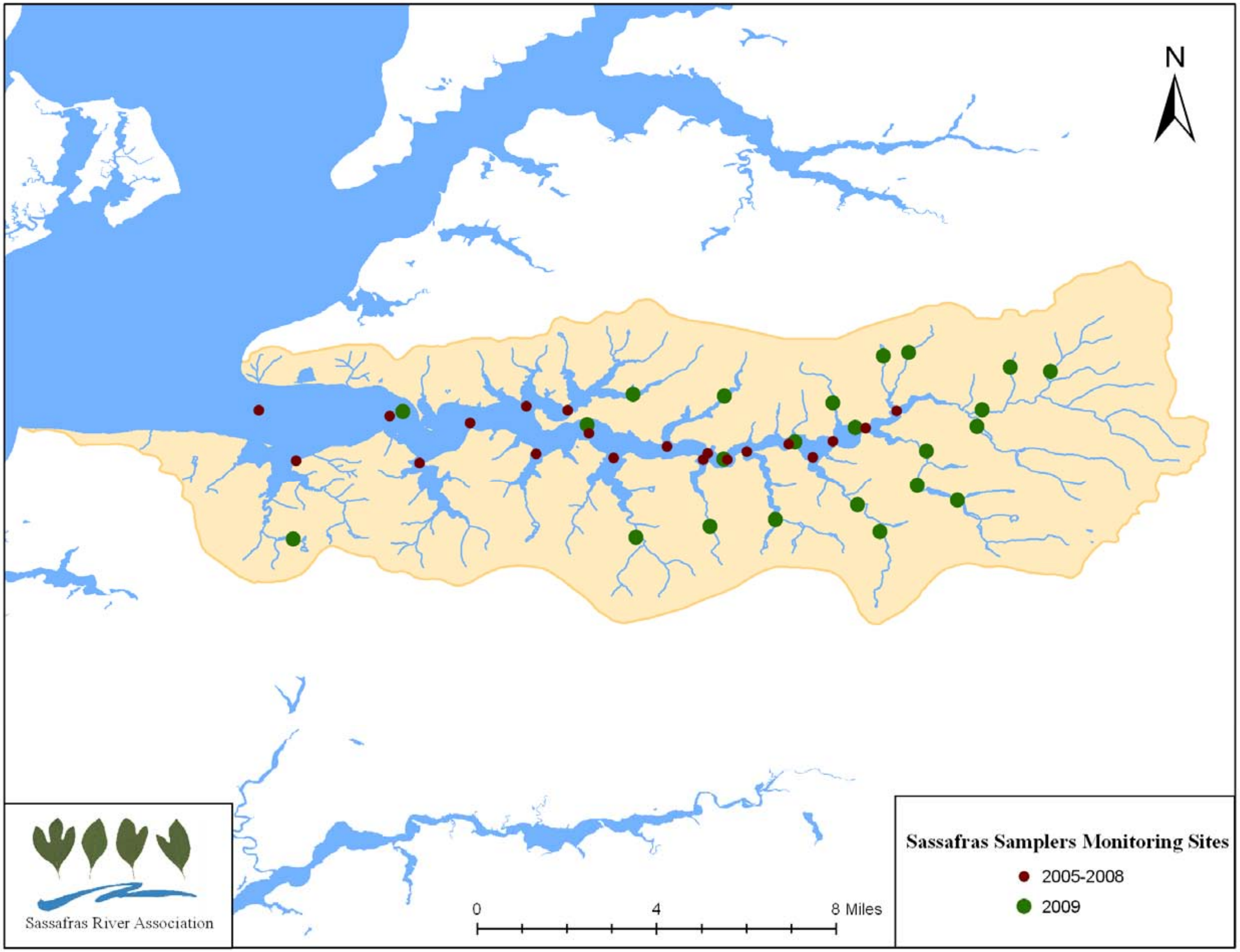
Map 7. Benthic Index of Biotic Integrity – Sassafras River Watershed (Map: SRA, Data Source: MD-DNR)



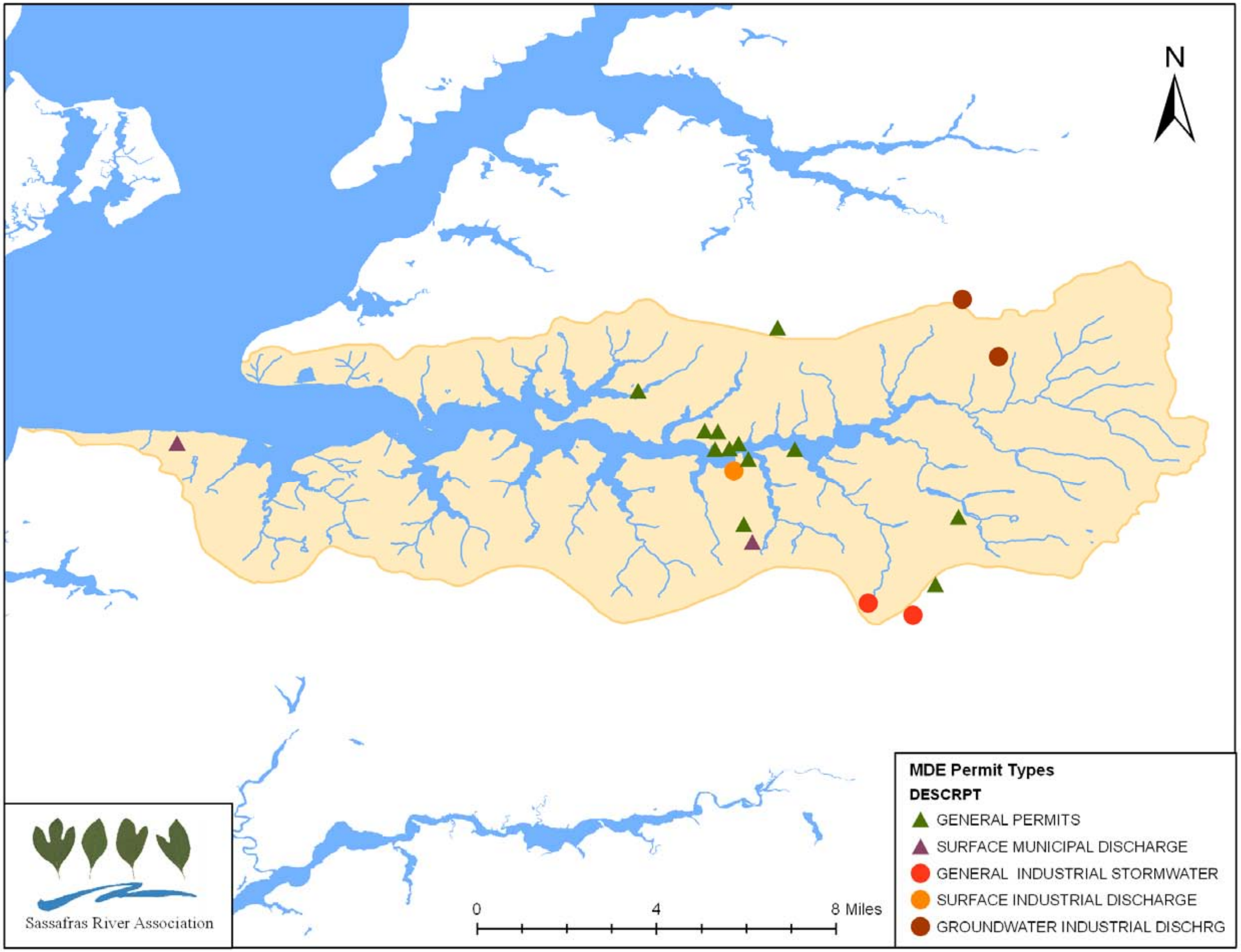
Map 8. Fish Index of Biotic Integrity – Sassafras River Watershed (Map: SRA, Data Source: MD-DNR)



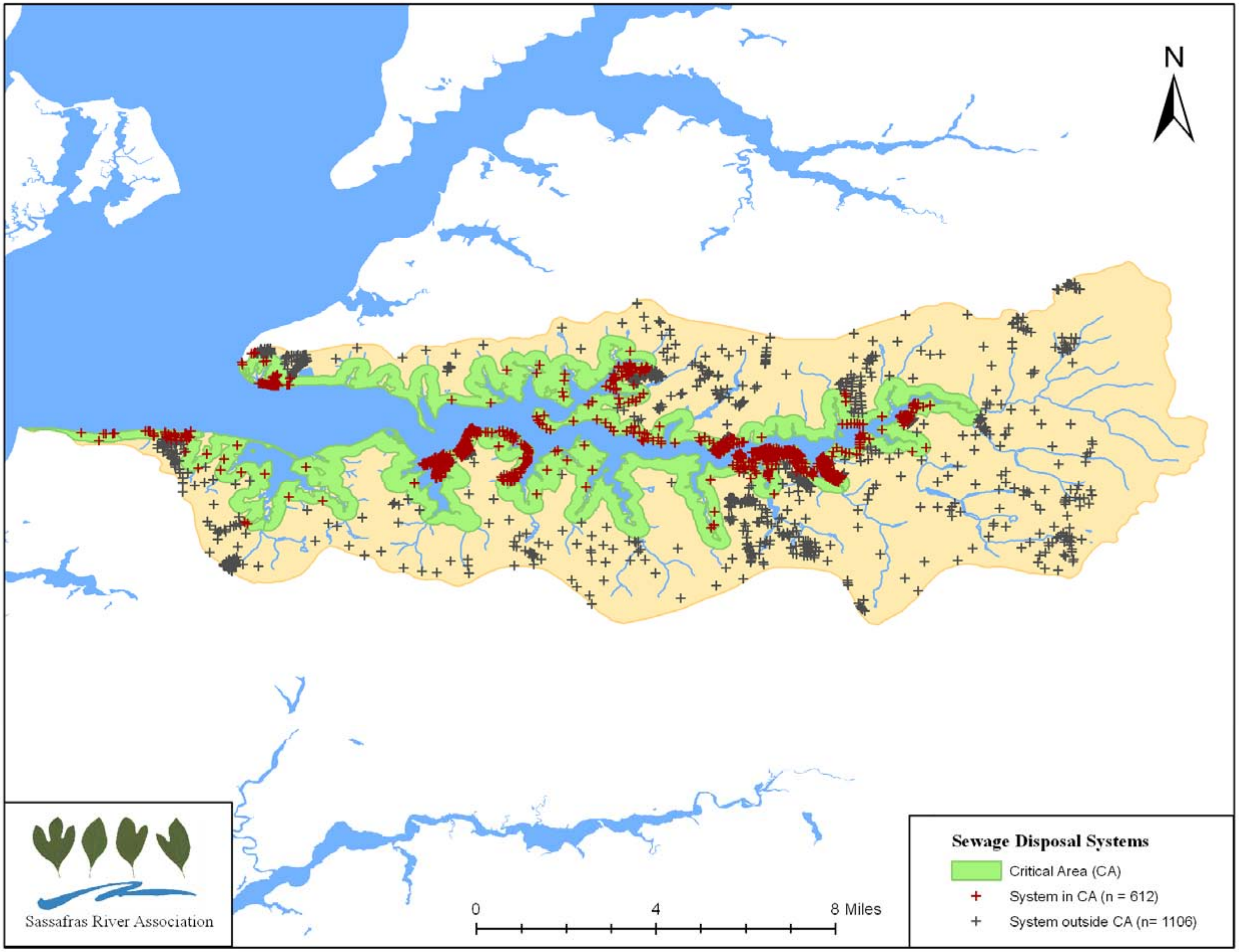
Map 9. Physical Habitat Index – Sassafras River Watershed (Map: SRA, Data Source: MD-DNR)



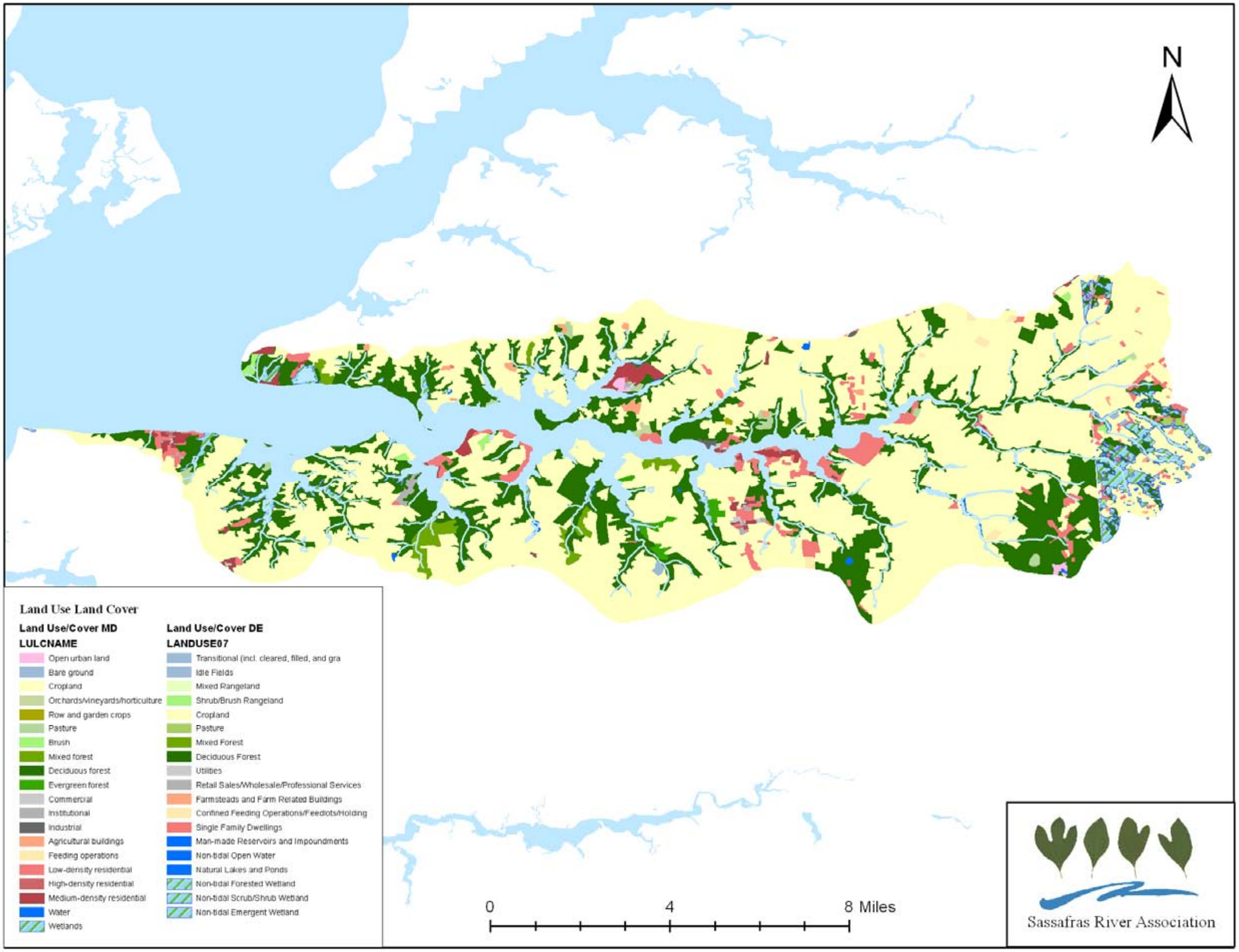
Map 10. Sassafras Samplers Monitoring Locations – Sassafras River Watershed (Map: SRA, Data Source: SRA)



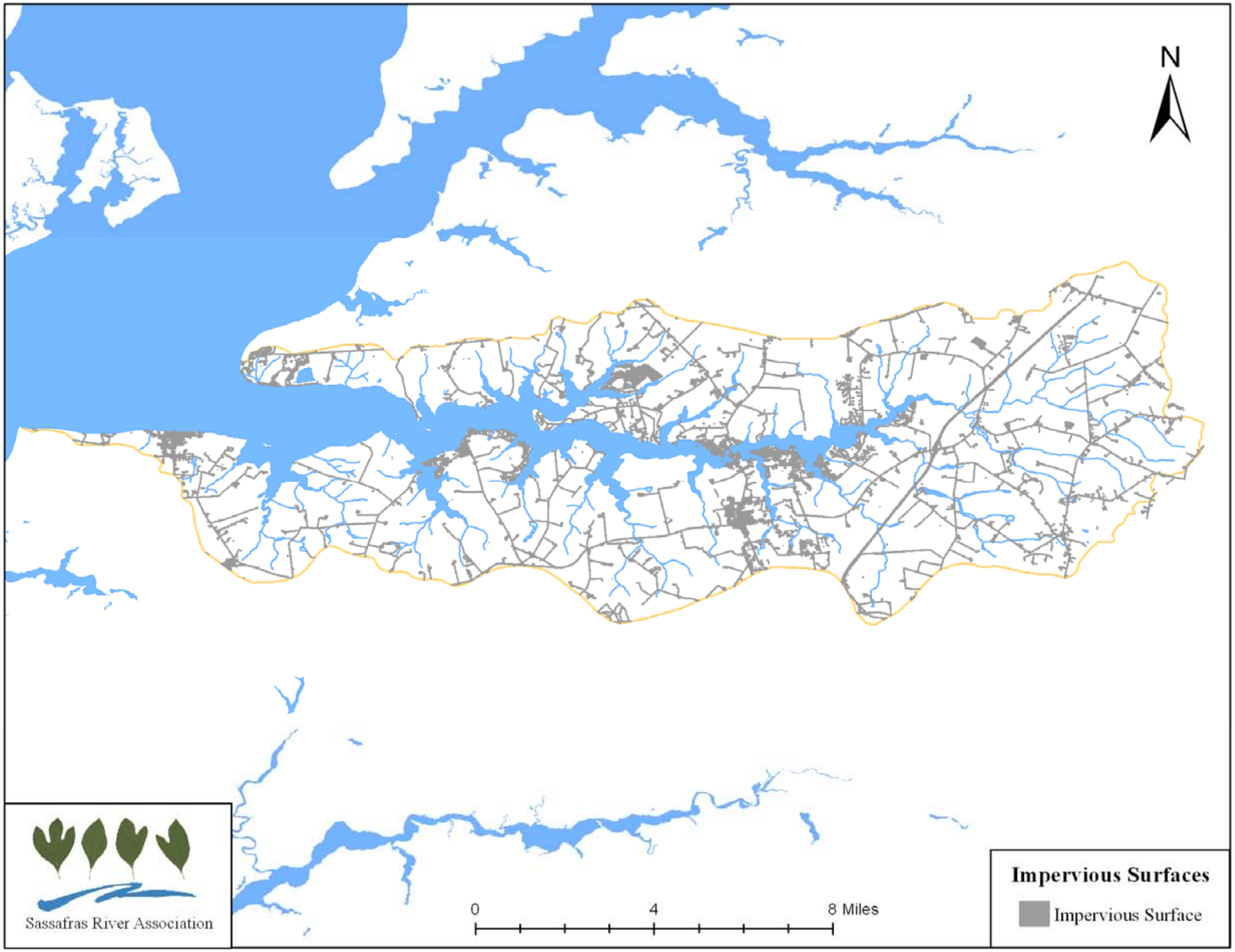
Map 11. MDE Permits – Sassafras River Watershed (Map: SRA, Data Source: MDE)



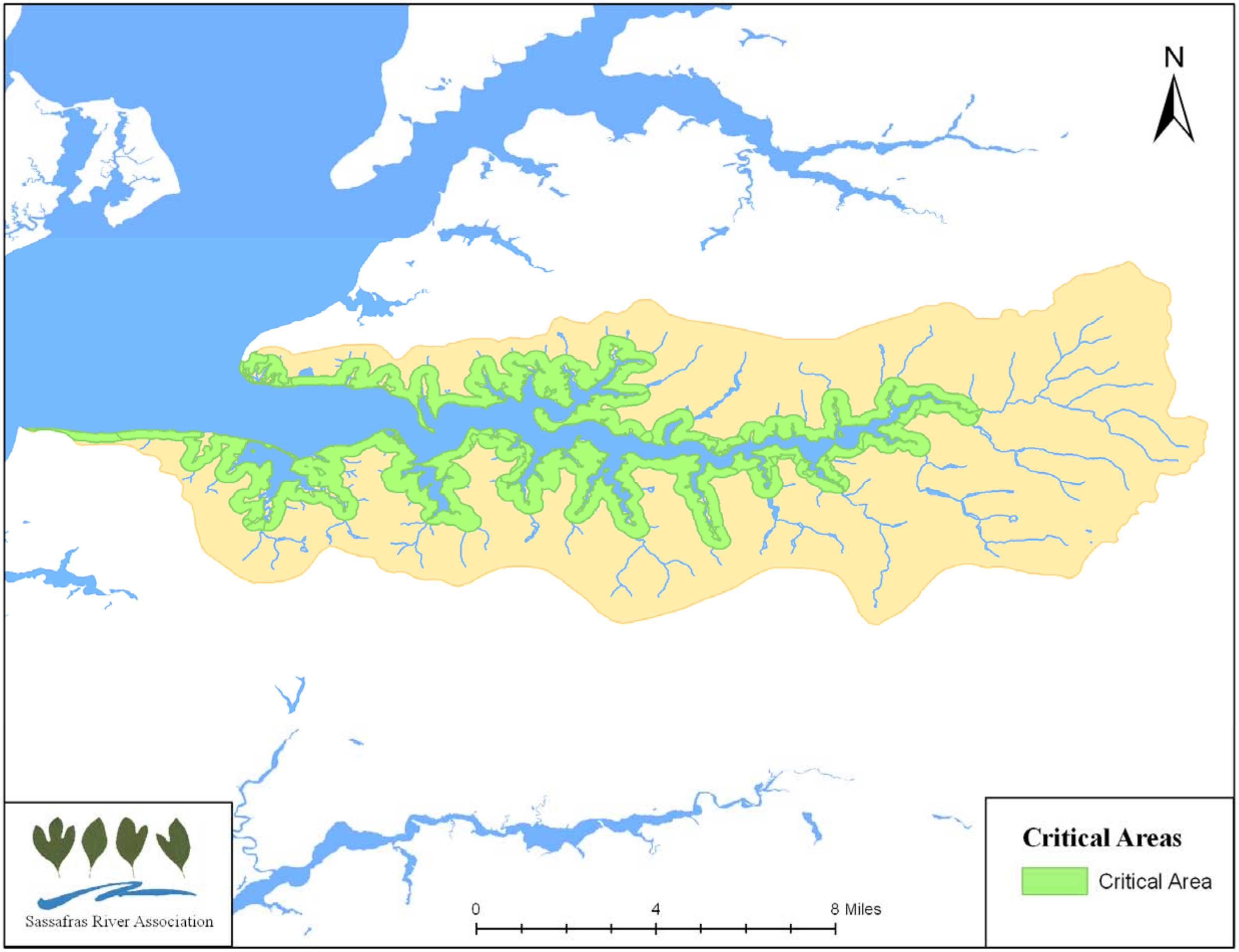
Map 12. Sewage Disposal Systems – Sassafras River Watershed (Map: SRA, Data Source: MDE)



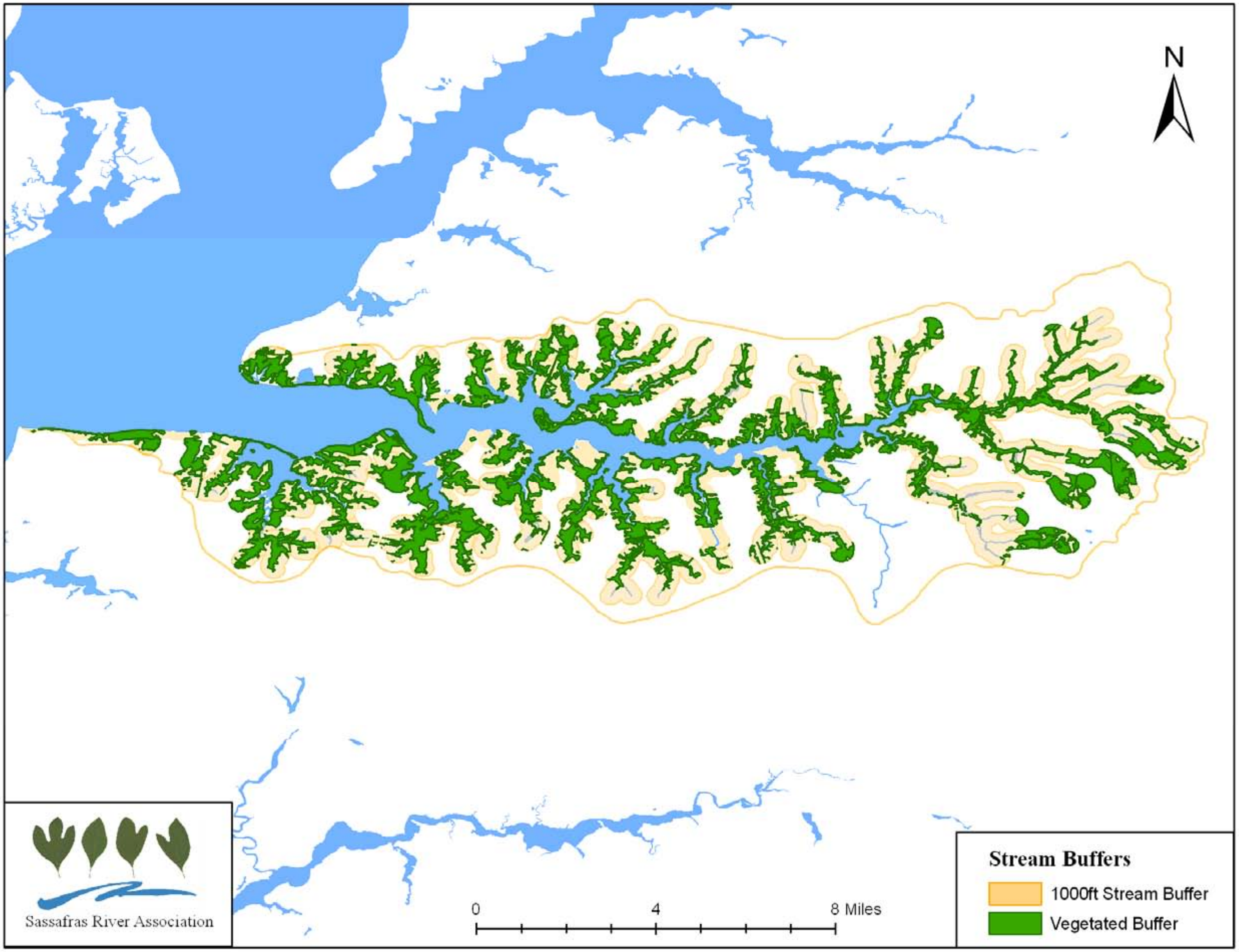
Map 13. Land Use and Cover – Sassafras River (Map: SRA, Data Source: 2000 MD and DE Land Use Data)



Map 14: Impervious Surfaces – Sassafras River Watershed (Map: SRA, Source: Washington College GIS Lab)

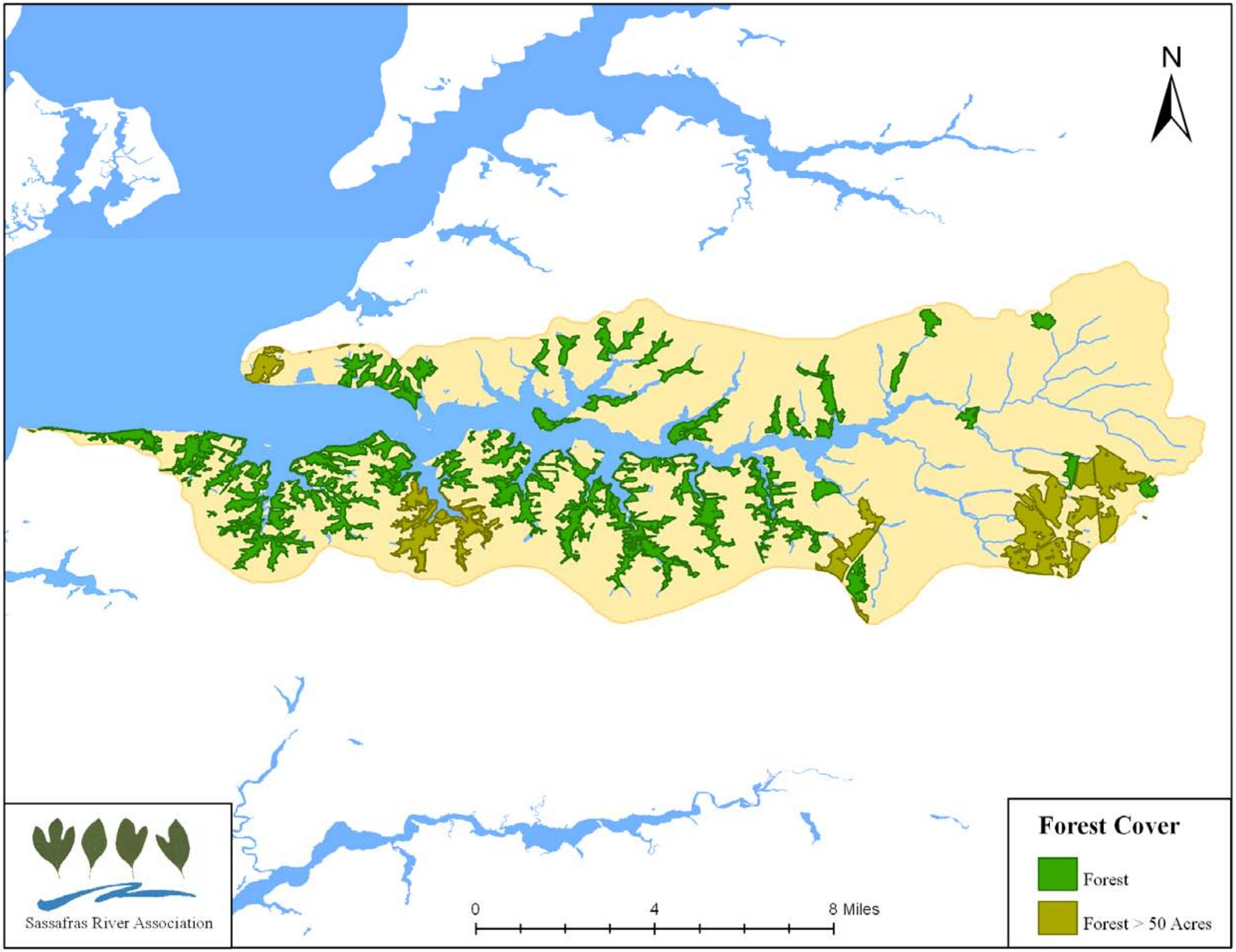


Map 15. Critical Areas – Sassafras River Watershed (Map: SRA, Data Source: MD-DNR)

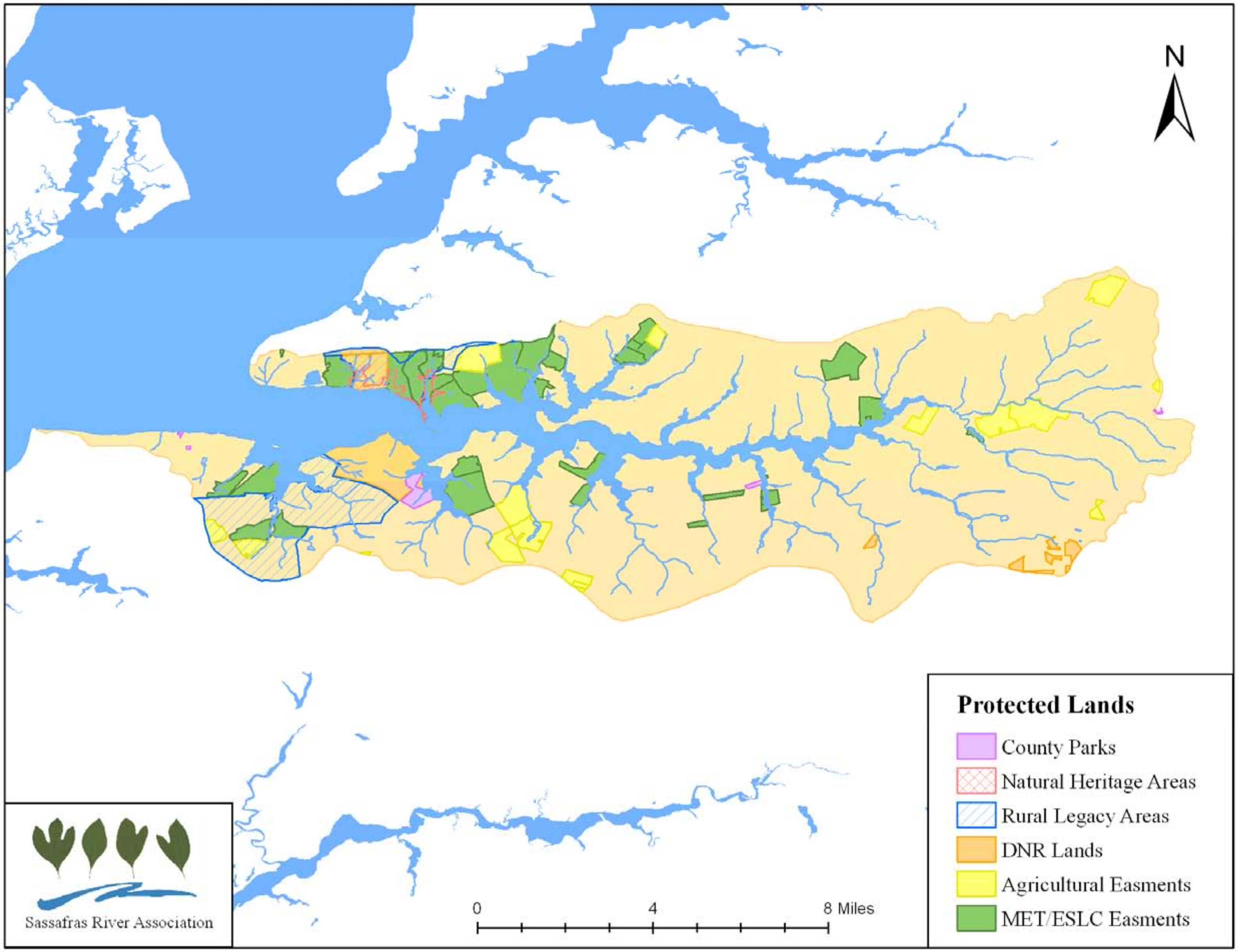


Map 16. Stream Buffer and Forests – Sassafras River Watershed (Map: SRA, Data Source: McCrone INC., MD-DNR)

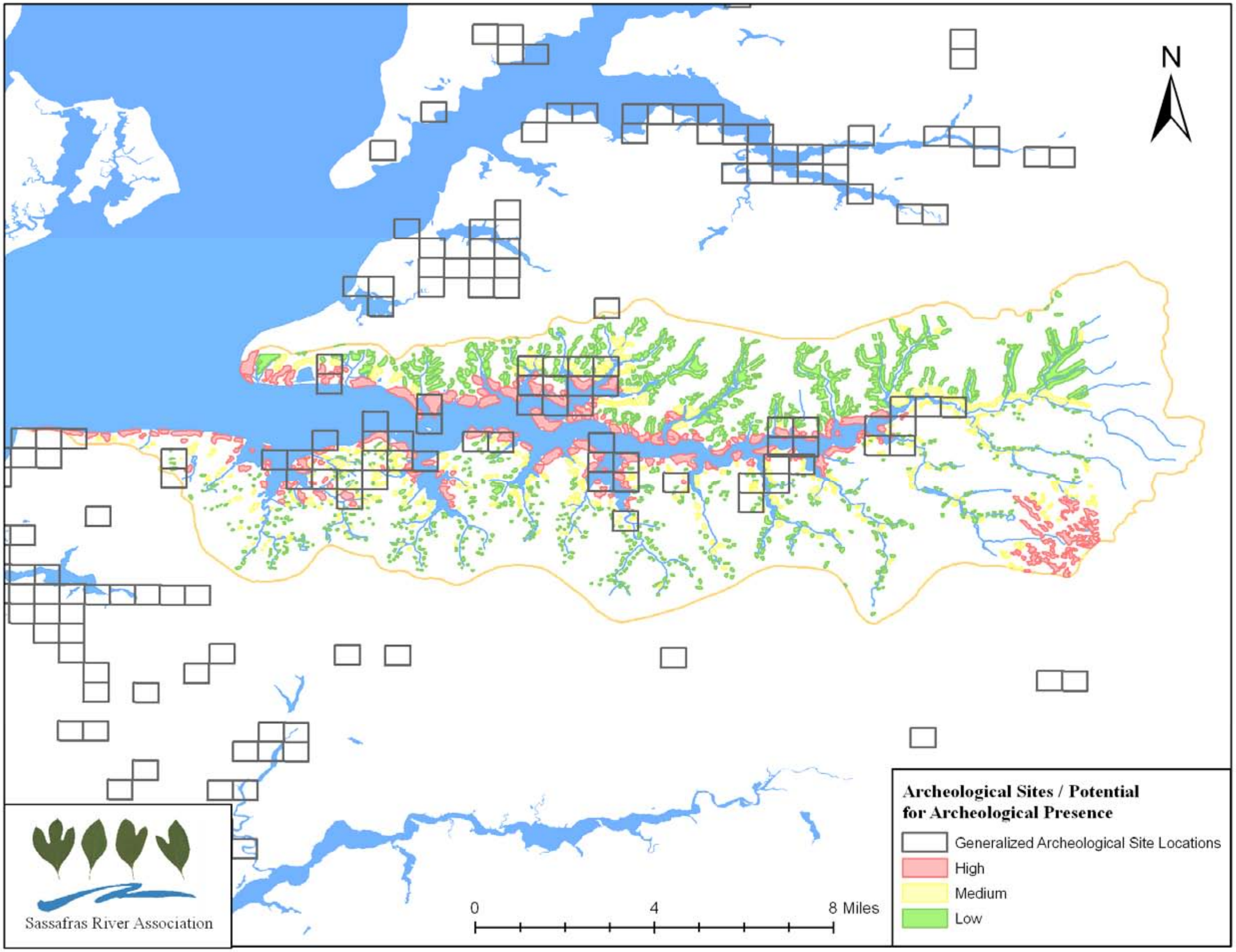
Map 17. Green Infrastructure – Sassafras River Watershed (Map: SRA, Data Source: McCrone Inc. , MD-DNR)



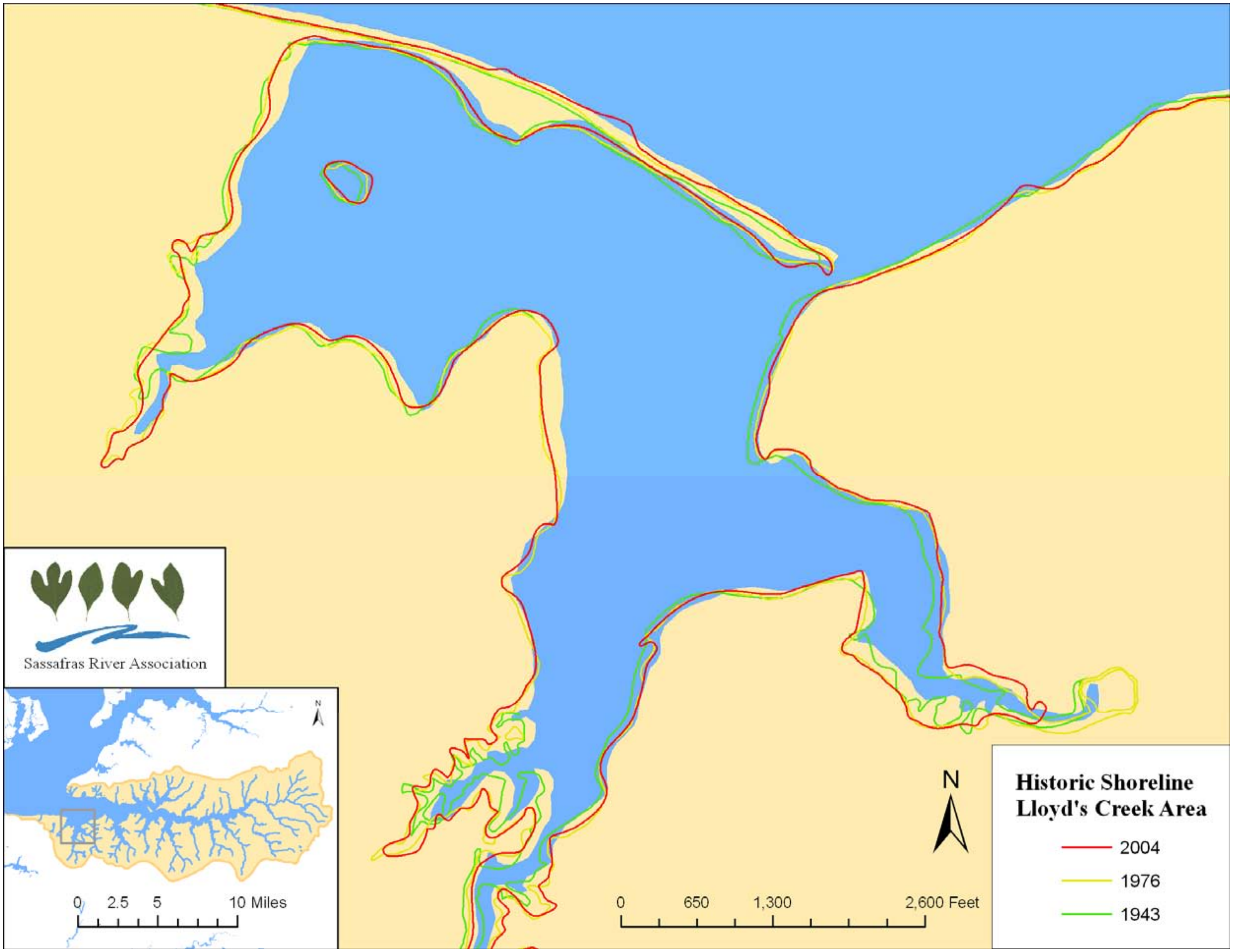
Map 18. Forest Cover – Sassafras River Watershed (Map: SRA, Data Source: McCrone INC., MD-DNR)



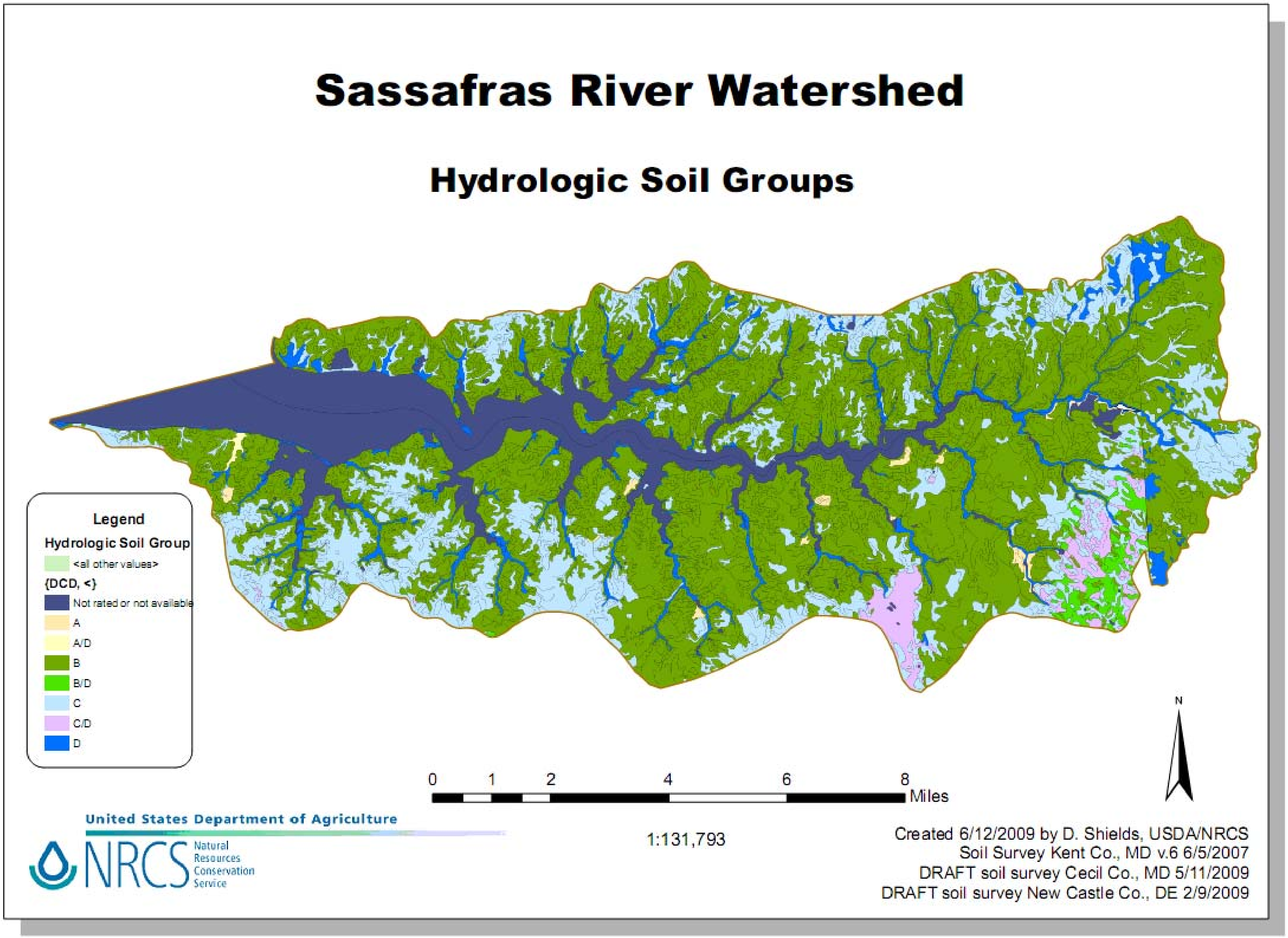
Map 19. Protected Lands – Sassafras River Watershed (Map: SRA, Data Source: MD-DNR)



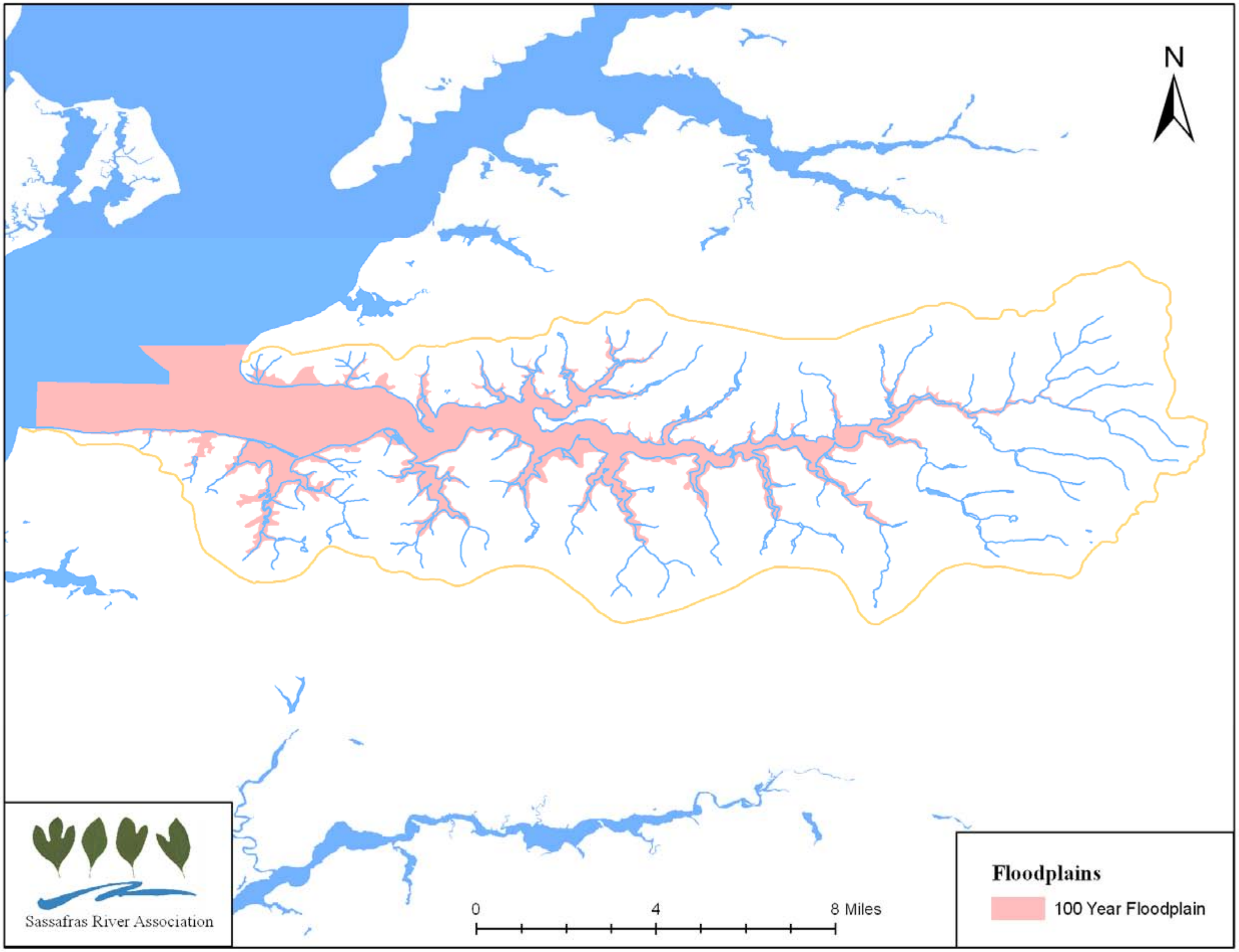
Map 20. Archaeology – Sassafras River Watershed (Map: SRA, Data Source: Maryland Historical Trust)



Map 21. Historic Shoreline (Lloyd's Creek Area) – Sassafras River (Map: SRA, Data Source: MD-DNR, MGS)

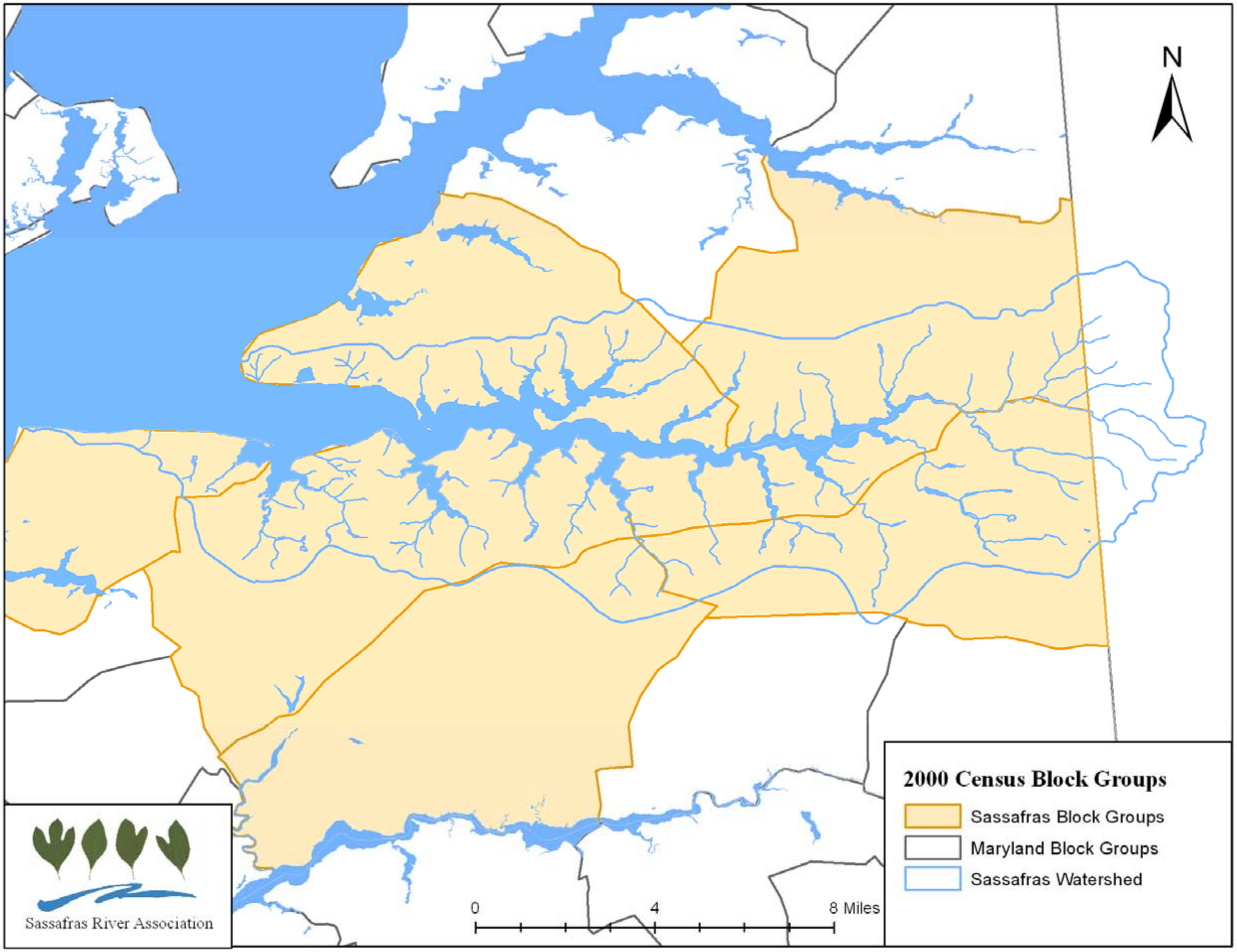


Map 22. Soil Groups – Sassafras River Watershed (Map: USDA-NRCS, Data Source: USDA-NRCS)

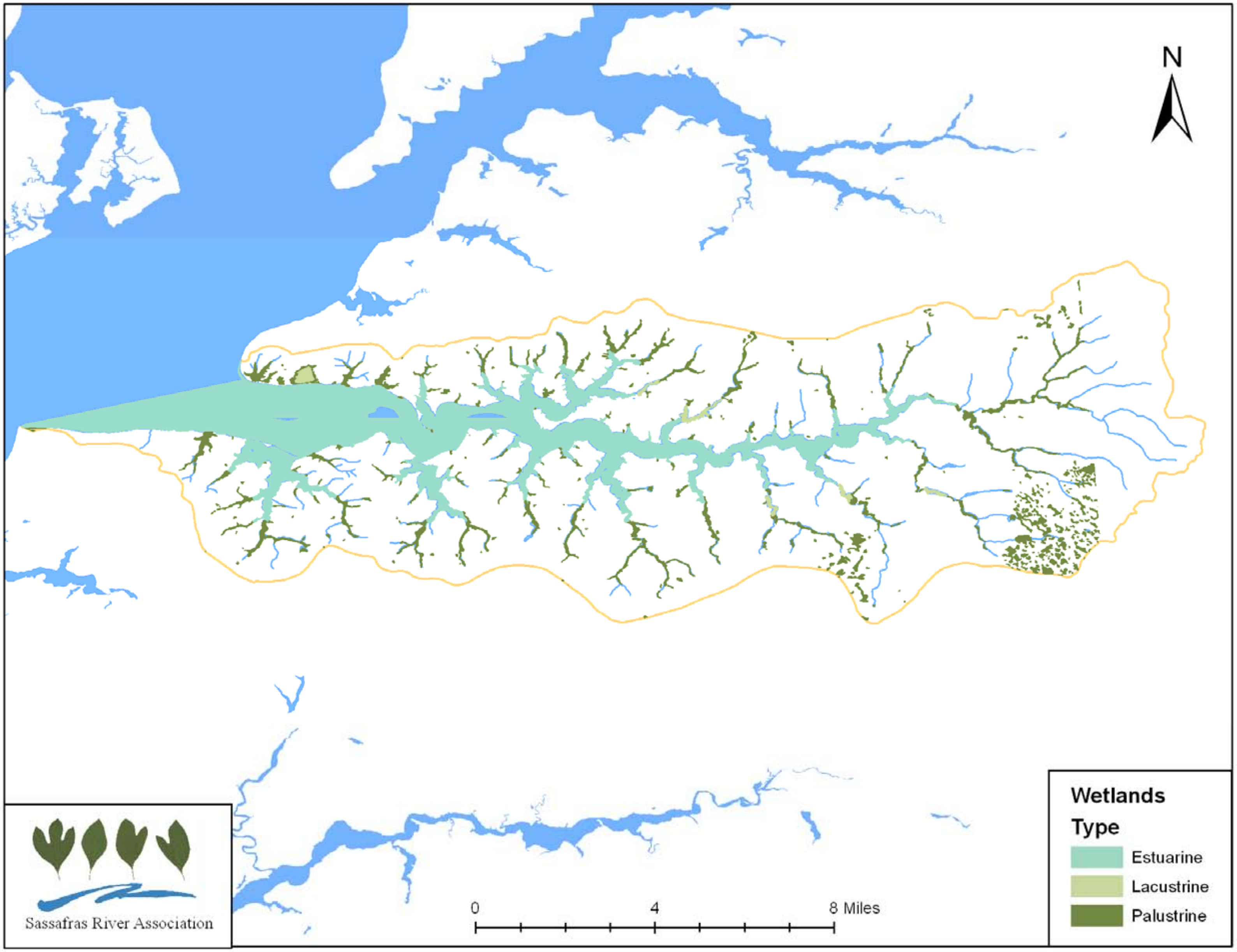


Map 23. Floodplain (100 year) – Sassafras River Watershed (Map: SRA, Data Source: MD-DNR)

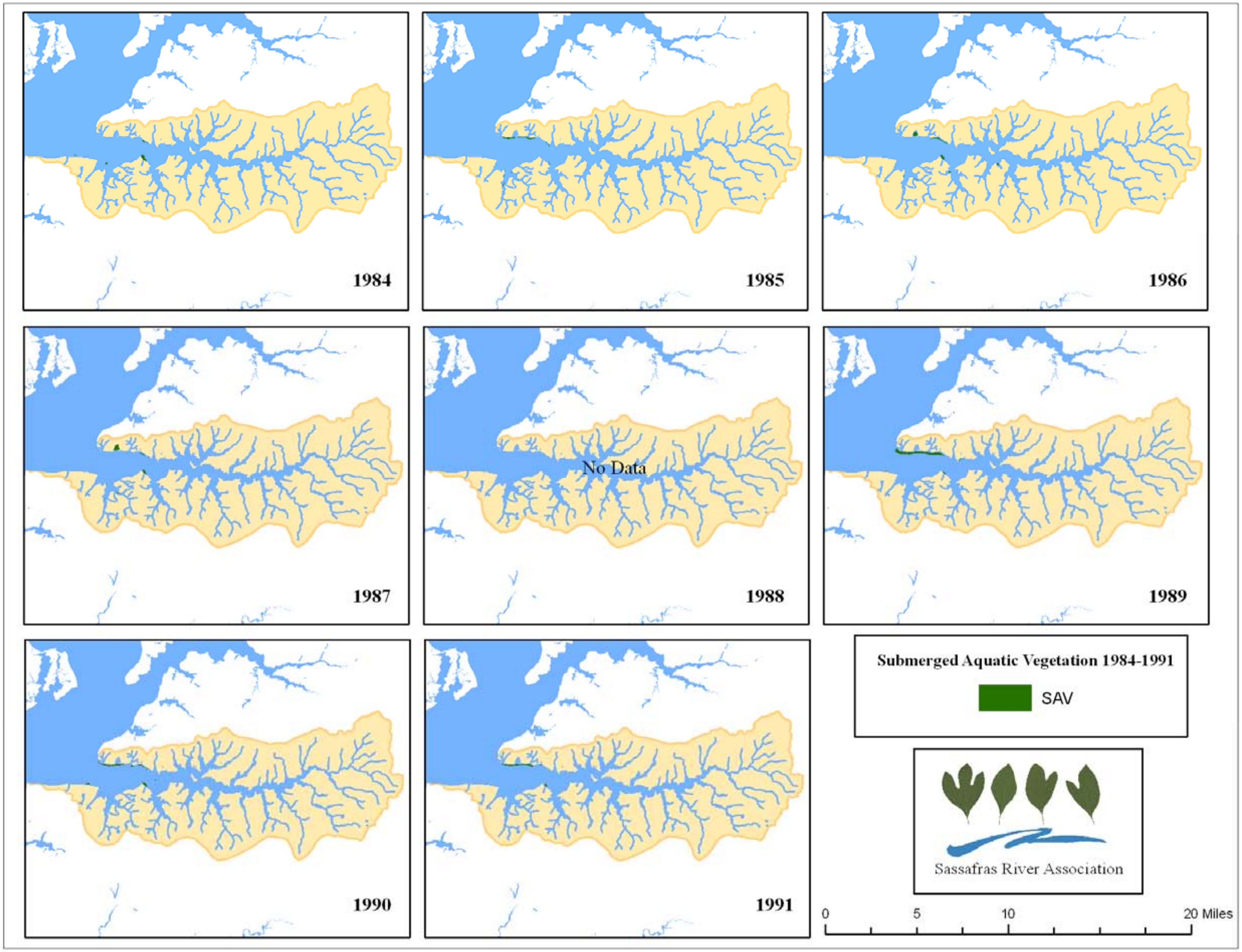
Map 24. Census Blocks (Source: MD of Planning and DE Office of State Planning Coordination)



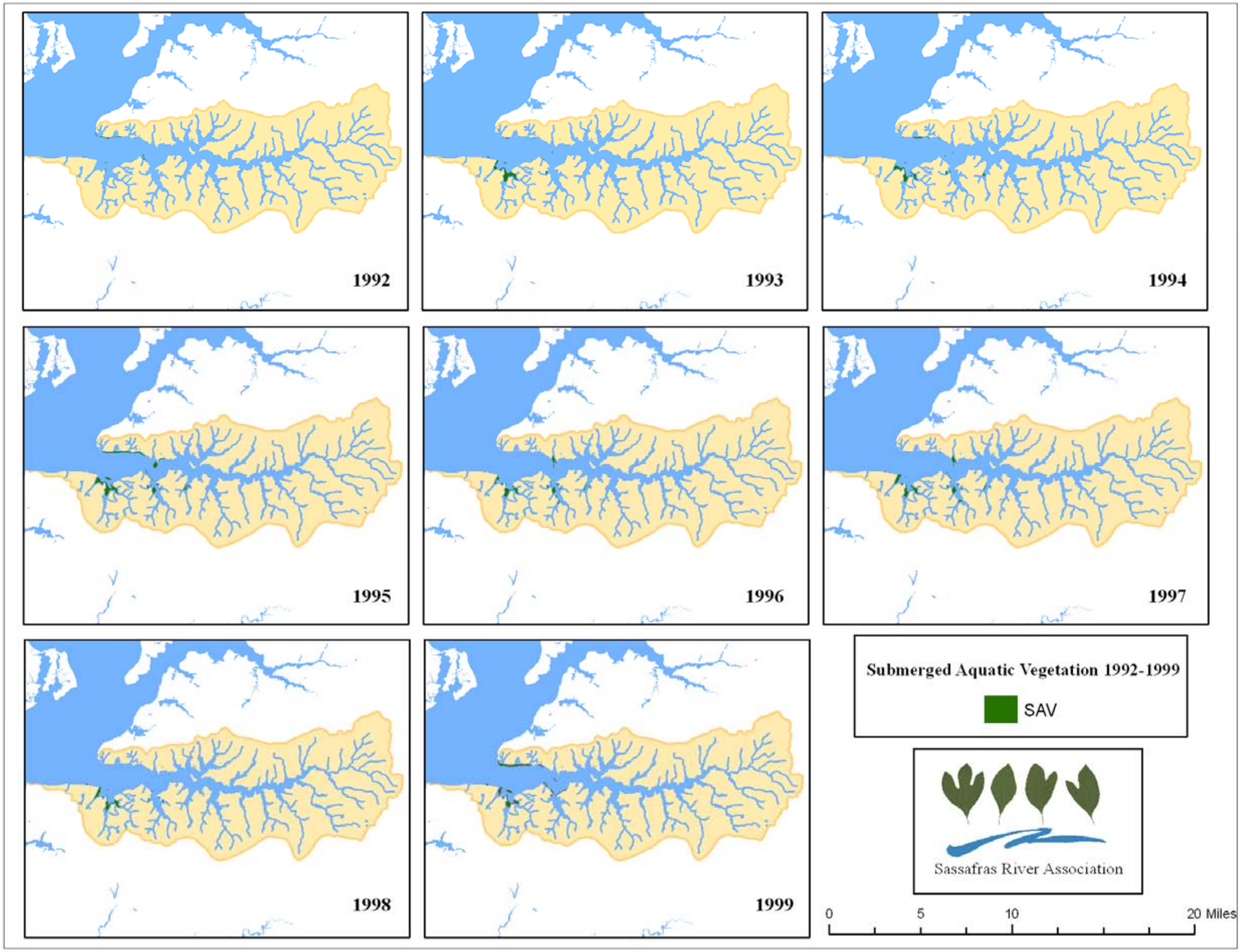
Map 24b. Census Block Groups (Map: SRA, Data Source: 2000 US Census, MD Dept. Planning)



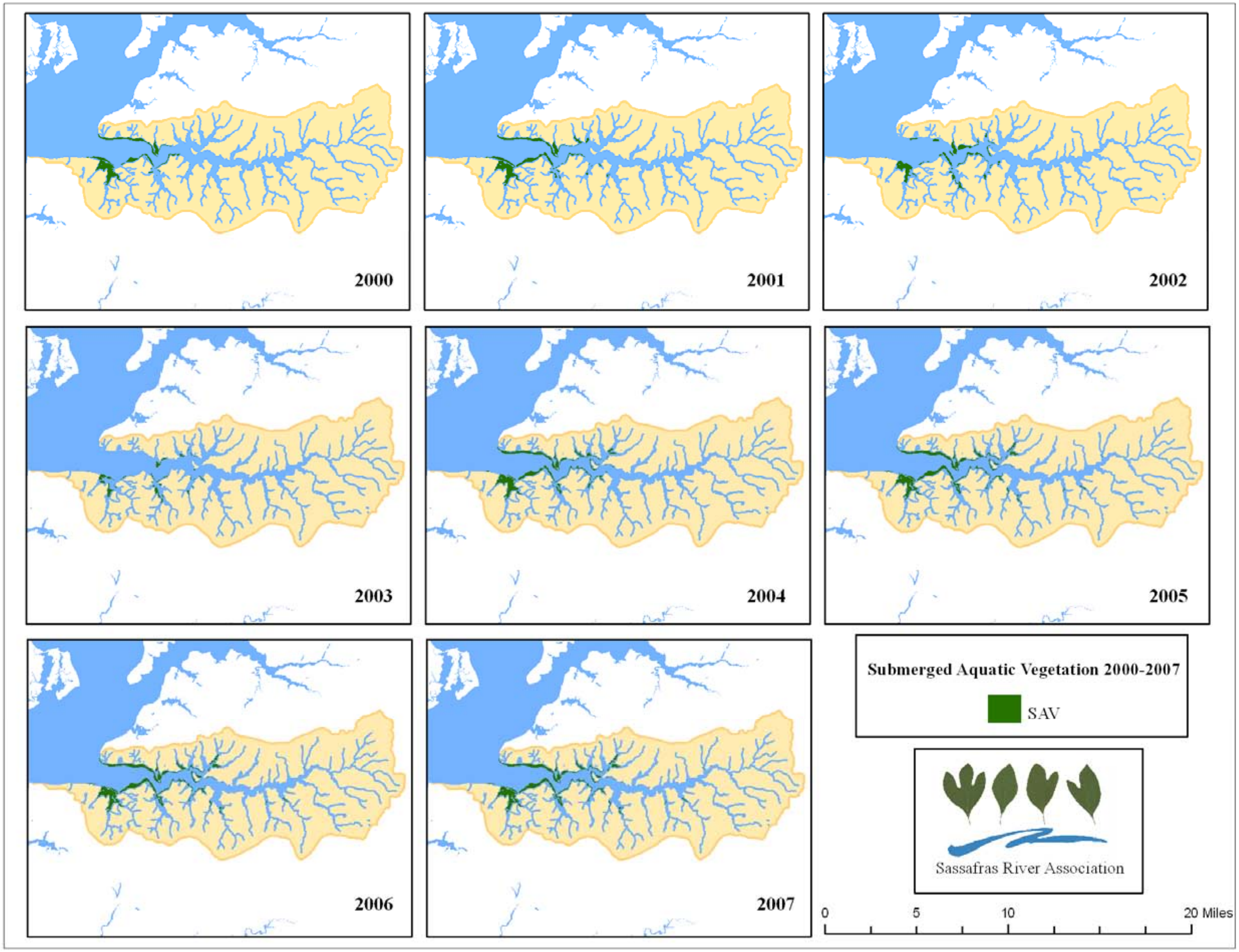
Map 25. Wetlands – Sassafras River Watershed (Map: SRA, Data Source: MD-DNR)



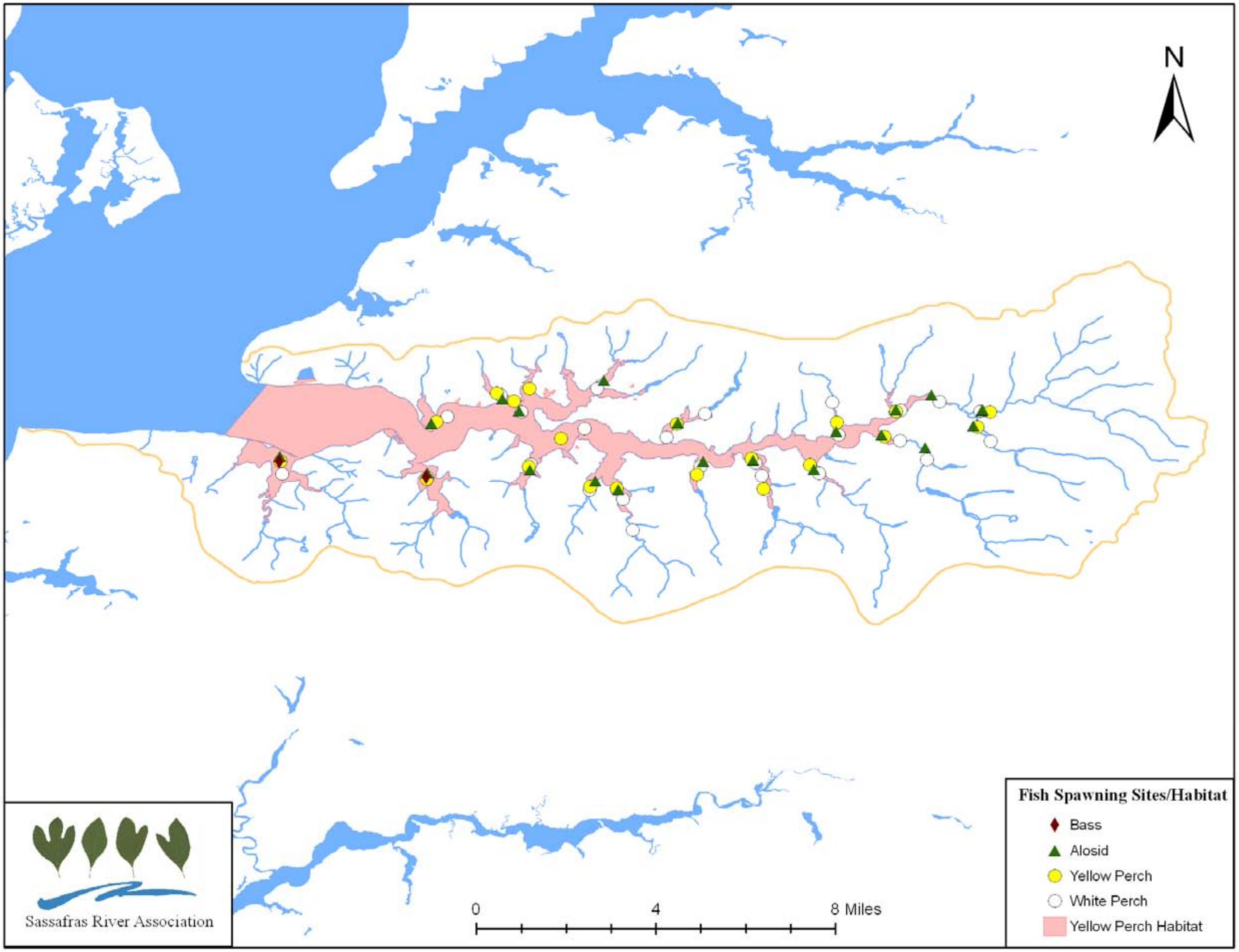
Map 26. Submerged Aquatic Vegetation (1984-1991) – Sassafras River Watershed (Map: SRA, Data Source: MD-DNR)


1992
1993
1994
1995
1996
1997
1998
1999
Submerged Aquatic Vegetation 1992-1999
SAV
Sassafras River Association
0
5
10
20 Miles

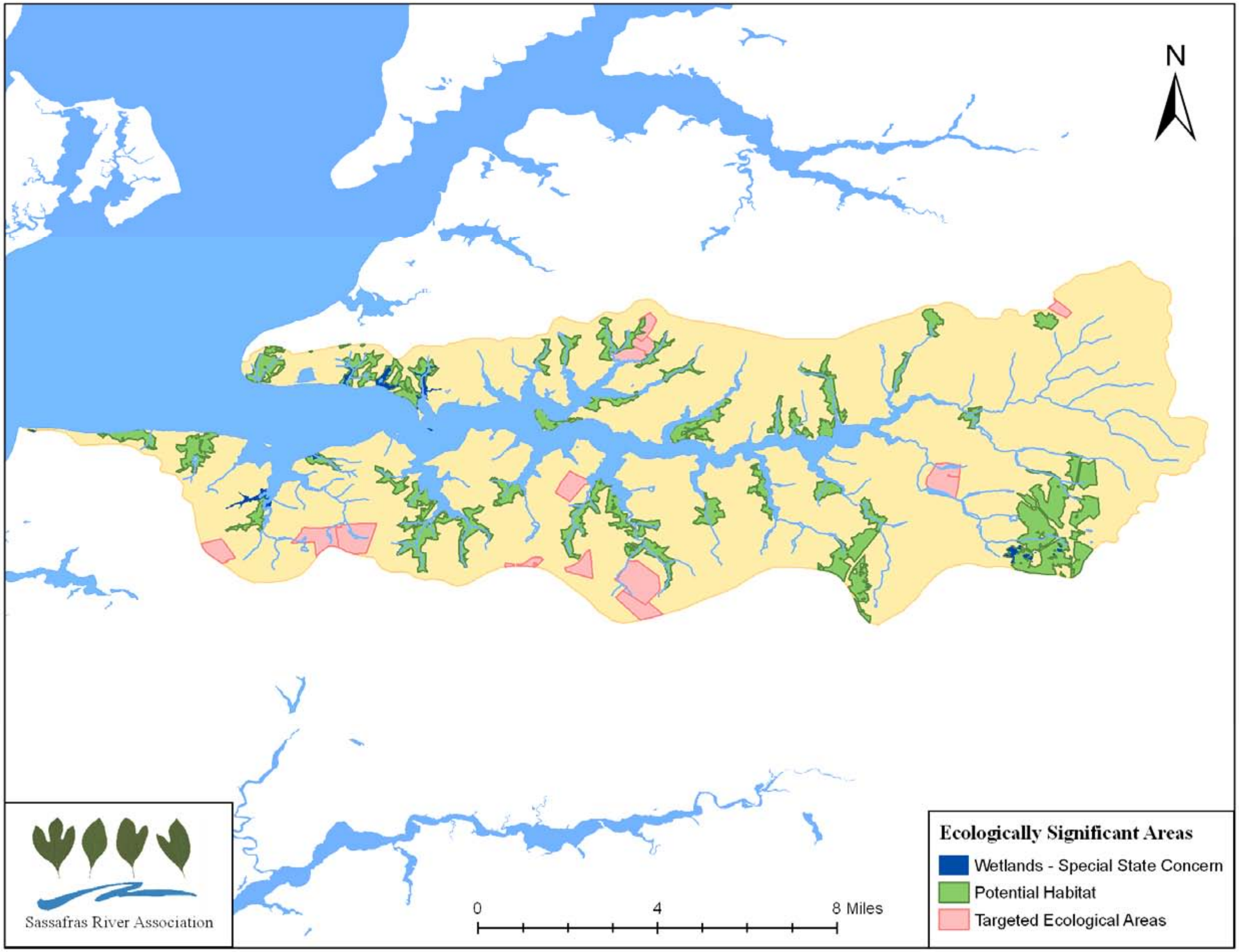
Map
M



2000
2001
2002
2003
2004
2005
2006
2007
Submerged Aquatic Vegetation 2000-2007
SAV
Sassafras River Association
0
5
10
20 Miles



Map 29. Fish Spawning Locations – Sassafras River Watershed (Map: SRA, Data Source: MD-DNR)



Map 30. Ecologically Significant Areas – Sassafras River Watershed (Map: SRA, Data Source: MD-DNR)