River Raisin Watershed Management Plan

River Raisin Watershed Council

Project Partners:
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This plan is dedicated to the memory of

Kara Suzanne Tecco (1982 – 2007)

who worked tirelessly and gave selflessly
to this plan and to the River Raisin Watershed Council

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ACH – Automotive Components Holding
AFO – Animal Feeding Operation
AOC – Area of Concern
BMP – Best Management Practice
BCC – Bioaccumulative Chemicals of Concern
BUIs – Beneficial Use Impairments
CAFO – Confined Animal Feeding Operation
CCRP – Continuous Conservation Reserve Program
CDM – Clean Development Mechanism
CFU – Colony Forming Unit
CREP – Conservation Reserve Enhancement Program
CRP – Conservation Reserve Program
CSOs – Combined Sewer Overflows
CSP – Conservation Security Program
CWA – Clean Water Act
CWP – Center for Watershed Protection
DDT – Dichloro-Diphenyl-Trichloroethane
DO – Dissolved Oxygen
DRP – Dissolved Reactive Phosphorus
DSS – Decision Support System
EAB – Emerald Ash Borer
EC – Conductivity
EQIP – Environmental Quality Incentives Program
FC – Fecal Coliforms
FEMA – Federal Emergency Management Association
FIRM – Flood Insurance Rate Map
FPP – Farmland Protection Program
FRED – Flowering Rush Eradication Demonstration
FSA – Farm Service Agency
FSEP – Food System Economic Partnership
GIS – Geographic Information Systems
GLO – General Land Office
GPD – Gallons Per Day
Hg – Mercury
HIT – High Impact Targeting for Managing Sediment Loading
HPE – Heptachlor Epoxide

I&E – Information and Education
IPCC – Intergovernmental Panel on Climate Change
LAMP – Lakewide Management Plan
LCD – Lenawee Conservation District
LID – Low Impact Development
LUGs – Local Units of Government
LUSTs – Leaking Underground Storage Tanks
LWD – Large woody debris
MAEAP – Michigan Agricultural Environmental Assurance Program
MCCI – Michigan Conservation and Climate Initiative
MDA – Michigan Department of Agriculture
MDEQ – Michigan Department of Environmental Quality
MDNR – Michigan Department of Natural Resources
MEC – Michigan Environmental Council
MiCorps – Michigan Clean Water Corps
MLULC – Michigan Land Use Leadership Council
MNA – Michigan Nature Association
MNFI – Michigan Natural Features Inventory
N – Nitrogen
NASS – National Agricultural Statistics Service
NCWQR – National Center for Water Quality Research
NGOs – Non-governmental Organizations
NHD – National Hydrography Dataset
NO3 – Nitrate-nitrogen
NOAA – National Oceanic and Atmospheric Association
NPDES – National Pollution Discharge Elimination System
NPS – Nonpoint Source Pollution
NRCS – Natural Resources Conservation Service
NWI – National Wetlands Inventory
P – Phosphorus
PAC – Public Advisory Council
PAH – Polycyclic Aromatic Hydrocarbons
PCBs – Polychlorinated Biphenyls
PCS – Permit Compliance System
PSC – Public Sector Consultants
POCSS – Privately Owned Community Sewage Systems
POTW – Publicly Owned Treatment Works
PUDs – Planned Unit Developments
QAPP – Quality Assurance Project Plan
RAP – Remedial Action Plan
RRI – River Raisin Institute
RRWC – River Raisin Watershed Council
RRWMP – River Raisin Watershed Management Plan
RVLT – Raisin Valley Land Trust
SCS – Soil Conservation Service
SEDMOD – Spatially Explicit Delivery Model
SEMCOG – Southeastern Michigan Council of Governments

SSCM – Site-Specific Crop Management
SSOs – Sanitary Sewer Overflows
SWAT – Soil and Water Assessment Tool
TMDL – Total Maximum Daily Load
TN – Total Nitrogen
TNC – The Nature Conservancy
TP – Total Phosphorus
TSM – Total Suspended Matter
TSS – Total Suspended Solids
UM – University of Michigan
USDA – United States Department of Agriculture
USEPA – United States Environmental Protection Agency
USFW – United States Fish and Wildlife Service
USGS – United States Geological Service
WASCOB – Water and Sediment Control Basin
WCMP – Water Chemistry Monitoring Project
WQS – Water Quality Standards
WRP – Wetland Reserve Program
WRSIS – Wetland Reservoir Sub-Irrigation System
WTM – Watershed Treatment Model

1.0 EXECUTIVE SUMMARY

The River Raisin just upstream of Monroe; courtesy Robert Burns – June, 2007

The River Raisin (Riviere Aux Raisin – River of Grapes), known as "Nummasepee" (River of Sturgeon) by its American Indian inhabitants, drains to the western Lake Erie basin. The watershed (United States Geological Hydrologic Unit Code: 04100002) covers most of Lenawee County and smaller portions of Monroe, Washtenaw, Jackson and Hillsdale counties in Michigan along with a piece of Fulton County in northeastern Ohio. Cities in the watershed include Saline, Adrian, Tecumseh, Petersburg and Monroe, and villages include Brooklyn, Cement City, Manchester, Blissfield, Britton, Clayton, Clinton, Deerfield, Onsted and Dundee (see **Figure 1-1**). The northwestern headwaters are on the rim of the Defiance moraine and mark the most easterly advance of ancient glacial ice sheets in southeastern Michigan. The Irish Hills area, a unique local high point in Hillsdale County is the headwaters for the Raisin, Grand, Kalamazoo, St. Joseph and Maumee rivers (Refer to **Figure 3-1**).

The River Raisin watershed is a major producer of corn and soybeans in the state of Michigan. Over 75% of the watershed is in agricultural production. But the River Raisin is caught in the middle of the great dilemma of modern, industrialized agriculture. Just by proportion of land use, agriculture is the biggest threat to ecological sustainability in the Raisin. The Renewable Fuel Standard outlined in the US Federal Energy Independence and Security Act of 2007 is creating a rapidly expanding market for biofuels with an emphasis on corn-based ethanol. Unfortunately, corn is probably the least ecologically sustainable biofuel, requiring significant annual nitrogen inputs, pesticide application and water. Its use as a biofuel could also lead to grain scarcity on the world food market.

The watershed covers about 1,059 square miles (677,800 acres) and drains from the north and west, entering Lake Erie at Monroe Harbor. The River Raisin is 540 feet above sea level at its mouth and rises to about 1,200 feet in the Irish Hills area (USDA, Local Coordinating Committee, circa 1996). The mainstem of the river is 149 miles long. Major tributaries include Goose Creek, Evans Creek, Iron Creek, Wolf Creek, Black Creek, Macon Creek, and the Saline River. There are some 429 lakes in the basin and more than 3,000 miles of artificial drainage systems, including drain tile, ditches, storm sewer along with more than 60 dams. Several earthen dams constructed in the 1800's are still maintained today, located at Brooklyn, Norvell, Loch Erin, Sharon Hollow, Ford, Clinton, Globe Mill, Saline, Milan, Blissfield, Dundee, Grape and Waterloo (USDA, Local Coordinating Committee, circa 1996).

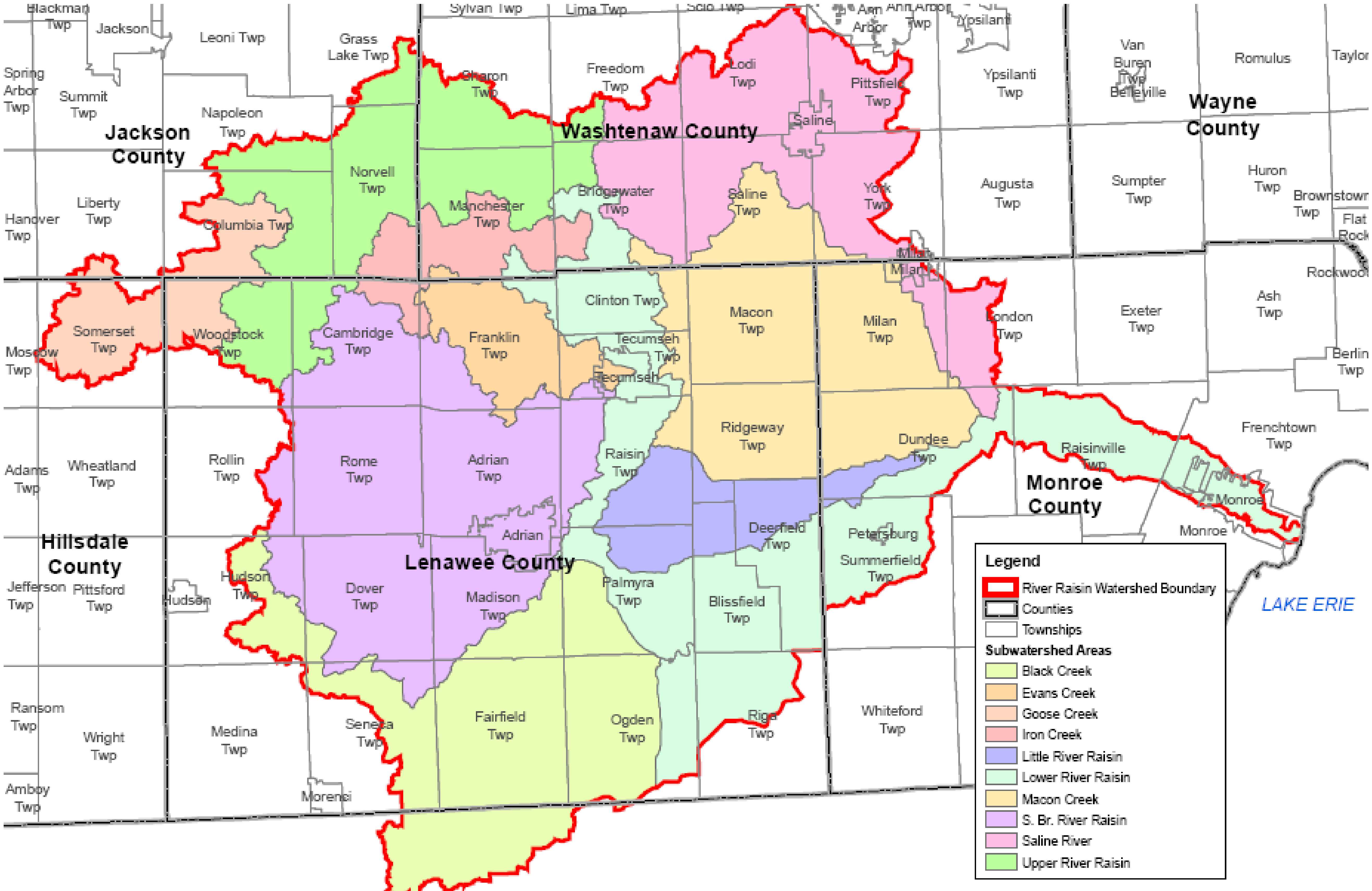


Figure 1-1 Major Subwatersheds and Jurisdictional Boundaries of the River Raisin

Several natural areas on the Raisin deserve broader attention. The mainstem of the river above Adrian has some of the richest mussel beds in the state of Michigan. Twenty-one species of mussels have been identified along with eighty species of fish – most of the original fishery. There are also several high quality, mesic hardwood forests, riparian and floodplain forests, prairie fens and remnant oak barrens in the upper watershed that support rare species such as the eastern massassauga rattlesnake, Blanchard's cricket frog, Indiana bat, spotted turtle and the Karner Blue butterfly. These same upper watershed areas are also among the most significant inland migratory bird stopover areas in the western Lake Erie watershed (Ewert et al., 2005).

This document summarizes water quality-related issues and problems confronting the River Raisin and all its inhabitants – human and otherwise. Over a two-year period (2006-2008) a committed group of volunteers spearheaded a steering committee to develop this plan. The over-arching theme of this effort is achieving sustainability by fostering sustainable ecological, economic and social systems. Not only do we believe these three aims are non-exclusive, we hold that all three must mesh in order to develop truly sustainable solutions. The vision for the watershed is spelled out in the vision statement developed by the steering committee:

River Raisin watershed residents recognize and celebrate their reliance on the river, the surrounding land and its interconnectedness with the Great Lakes and the global ecosystem. Working together communities, organizations and individuals will educate, understand and actively participate in the sustainable stewardship, conservation and preservation of the River Raisin and its cultural, ecological and economic resources.

1.1 Water Quality Concerns

Restoring impaired designated uses to the River Raisin is the key driving force behind the development of the River Raisin Watershed Management Plan (RRWMP). Currently there are sixteen separate 303(d) water-quality impaired reaches and lakes along the Raisin River, its tributaries and into Lake Erie. Six reaches have Total Maximum Daily Loads (TMDLs) for untreated sewage discharge, pathogens, and nitrates. These reaches are found on the mainstem of the River Raisin, Saline River and Lenawee County Drain 70 affecting 43 total miles of river. Five reaches are awaiting TMDLs for habitat modification, sewage discharge, pathogens, total dissolved solids, chlorides, siltation, PCBs and mercury. These include portions of the Little River Raisin, Black Creek, the South Branch and mainstem of the River Raisin affecting a total stream length of 106 miles. Three lakes (Clark, Sand and Wamplers) are awaiting TMDLs for mercury in fish tissue and the entire River Raisin watershed is awaiting a TMDL for PCBs. Lake Erie waters under Michigan's jurisdiction at the mouth of the River Raisin near Monroe are also awaiting a TMDL for PCBs and TCDD Dioxin.

The most significant disruption in watershed hydrology and river geomorphology occurred over a hundred years ago during a roughly 70-year period (1830-1900) when the entire state of Michigan was deforested and the draining and ditching of agricultural lands with tiles and ditches began in earnest. The Raisin went from land covered with oak-hickory, beech-maple forests and mixed hardwood swamps to one covered in agricultural fields.

River power was harnessed with dams for mills, along with other uses during the twentieth century. Dams completely changed the river sediment balance. Alluvial rivers (rivers that transport the same kind of sediment that makes up its bed and banks) move water and sediment. They have a varying capacity to move sediment. Dams are sediment traps on one side, and potentially a force for erosion on the other. In areas without sediment in the water column, the sediment transport capacity increases in relation to reaches that have an upstream sediment source. In this "clear water" condition the capacity of the river to provoke sediment transport via erosion goes up.

In 2000, agriculture accounted for 75% of the watershed's land use; urbanized areas represented 6%, forests 10%, open grassland areas 5% and open water and wetland areas 1% each (Gothie et al., 2007). Two hundred years ago the watershed was almost completely covered in forest and forested wetlands. Now there are 49 National Pollutant Discharge Elimination System (NPDES) point-source dischargers, including 4 concentrated area feeding operations (CAFO) in the watershed. There are 13 public water suppliers in the Raisin, with two of Michigan's eight surface water intakes for drinking water located on the River Raisin. During low flow periods most of the river and its tributary flow can be removed for consumptive uses. Before the recent national economic downturn, some urbanizing areas were experiencing strong growth pressures. Massive 1,000+ unit single-family housing developments had been proposed for Milan and Saline. These watershed issues have created nutrient, pathogen, sediment flow instability and habitat impairments.

The lower 2.6 miles of the River Raisin has been identified under the Great Lakes Water Quality Agreement as one of Michigan's fourteen Areas of Concern (AOC) due to PCB and heavy metal contamination of fish and sediments. In addition, the second largest coal-fired power plant---the Detroit Edison plant in Monroe, sits at the mouth of the River using the entire river's flow and some of Lake Erie for cooling during peak power demands.

The Monroe DTE Plant with the mouth of River Raisin to the right of the plant (Robert Burns, 2007).

Agriculture is the heart of the economy for the Raisin. However, detailed, long-term data for western Lake Erie tributaries like the Raisin, Maumee, Sandusky and Cuyahoga rivers shows very clearly that despite the best efforts of conservation agricultural practices over the last ten to fifteen years, dissolved reactive phosphorus (DRP) and nitrate concentrations and loads from these primarily agricultural watersheds are going up. The increase in DRP loads and the invasion of zebra mussels also appears to be fueling algae blooms, a growing anoxic zone (no water column oxygen) and mid-basin "desertification" (lack of primary production) in Lake Erie.

Not only does it appear that current agricultural conservation practices are not working for these kinds of dissolved pollutants, they may actually be helping to fuel these increases. There is a growing movement that is actively questioning whether the current relationships between farm-related conservation agencies such as the Natural Resources Conservation Service (NRCS) and the Farm Service Agency (FSA) and the farmer are the most cost-effective. Current programs for controlling agricultural non-point source pollution exist as cost-sharing best management practices and compensation to farmers for idling land. While these are important tools, the concern is that they do not always encourage the farmer to make the most cost-effective choices or inspire new and innovative approaches to dealing with problems on the farm. These programs also tend to not fully exploit the farmer's understanding of his/her land (other than for purposes of setting aside the least productive land), nor their capacities and experience for solving problems.

1.2 Goals and Objectives

The overall goal of this project is to create a "living" document that promotes broad cooperation, provides ideas and momentum, prioritizes problems and opportunities, helps achieve the Total Maximum Daily Loads (TMDLs) and improves water-quality impairments. One challenge during the planning process was to identify specific project opportunities. Therefore, this document lays out a set of general priorities that allow for on-going evaluation and prioritization of new specific projects within the framework of general improvement priorities.

The planning effort engaged a broad and diverse group of stakeholders over its two-year+ period. River Raisin watershed advocacy has now matured to the extent that stakeholders are clearly poised to move towards implementation. This project has worked in conjunction with several parallel improvement activities, such as the hydrologic studies of Dave Fongers and others at the Water Bureau, the wetlands work by Rob Zbiciak of the Wetlands group, the Lenawee Conservation District, the Nature Conservancy conservation planning, delisting target setting for the AOC, the River Raisin Stewardship groups, the NRCS and USDA, just to name a few. Field trips, assessment training, and stream evaluations have gotten volunteers to stand knee deep in water. Plan development was led by a stakeholder steering committee comprised of the major stakeholders, including federal, state, county and local government organizations, non-profit groups, development interests, citizen watershed representatives and technical experts.

The two primary goals of this plan are 1) to achieve all designated uses in the river and 2) help to promote a lifestyle and commerce that achieves the triple top line – environmental and economic sustainability and social equity. Other aims of the plan are to help foster better stakeholder coordination and dissemination of information, qualify the watershed for additional funding sources and create an implementable and sustainable plan.

The connection between the land and the river has to be understood not only in ecological terms but also in terms of economic and social impact. There is no turning back to some pre-development condition. Some notion of ecological integrity can only be achieved, in a sense granted, by the stakeholders in the watershed. Therefore, the economic livelihood and social well-being of residents has to be sustained so that interest and resources can be directed towards ecological restoration. Again and again, during steering committee meetings and at public meetings around the watershed, stakeholders voiced unwavering support for agriculture. There is support for agriculture both as a livelihood and as the backbone of a rural landscape that attracted residents to this area in the first place. The key here is to achieve the triple top line – economic and ecological sustainability as well as social equity – by making agricultural viability and ecological integrity simultaneous and inter-related goals.

The architect William McDonough has described the triple top line as a design perspective. As he says:

> This new design perspective creates triple top line growth: products that enhance the well being of nature and culture while generating economic value. Design for the triple top line follows the laws of nature to give industry the tools to develop systems that safely generate prosperity. In these new human systems, materials become food for the soil or flow back to industry forever. Value and quality are embodied in products, processes and facilities so intelligently designed, they leave footprints to delight in rather than lament. When the principles of ecologically intelligent design are widely applied, both nature and commerce can thrive and grow. (McDonough and Braungart, 2002)

The major assumption in this plan is that a healthy local economy will create the opportunity to achieve a healthier ecology. This plan therefore includes some suggestions and recommendations that fall outside of typical explicit Best Management Practices (BMPs) for water quality in order to help build more local economic resources to support more local ecological restoration.

1.3 Recommendations

The vision of this plan is one of sustainable development that fosters a healthy agricultural economy driven by diverse, local businesses that help drive ecological sustainability. The local agricultural businesses diversify crops, develop shorter supply chains by supplying food and products direct to local government institutions, restaurants, farmers markets and so on. Farmers apply precision agricultural tools and methods to achieve higher yields at significantly lower environmental impacts. Farmers finance sustainable projects, such as bioreactors, wind turbines, solar panels and a switch to native prairie plants for biofuels and along with new forests tap into the growing carbon emissions trading market.

One over-riding theme for this plan is that land development honors the continuum from urban to rural life. Residential growth follows conservation design and low impact development techniques to protect sensitive and critical natural resources. Residents grow to understand and cherish the river with the help of a networked group of non-profit organizations, local primary and secondary schools, colleges and universities that stitch together messages and curriculums that foster on the ground improvements and teaching opportunities. Recreational opportunities in the watershed continue to grow and natural area preservation and restoration connect critical wildlife corridors and extend riparian buffers along most of the river and its tributaries. As much as possible, all the designated uses of the river are attained. This sustainable development model driven by local action supports watershed and global sustainability goals: improved water and air quality, a lower carbon footprint, and a better quality of life.

The River Raisin Action Plan includes the following implementation strategies:

1. Achieve Nitrate TMDL & Reduce DRP Loads
2. Achieve Pathogen Target concentrations
3. Remove/Reduce Bioaccumulative Chemicals of Concern
4. Reduce Sedimentation, Total Phosphorus and Hydrologic Variability
5. Build River Raisin Watershed Council Capacity
6. Increase Public Awareness and Involvement
7. Conserve and Restore Natural Features
8. Increase Recreational Opportunities

This plan essentially breaks the implementation process into two broad periods. The first, implementation and demonstration, is aimed at developing a set of projects and initiatives that broaden and deepen stakeholder commitment to watershed restoration and "road-tests" ideas to determine which will lead the way to the second period of the plan - widespread adoption of effective best management practices.

Meeting the objectives of the first period of the plan will be the true test for meeting overall plan objectives, not just because it's the first phase, but rather because the first phase is the period over which attitudes are (hopefully) changed. Changing some longstanding attitudes will be the key hurdle to achieving the objectives of this plan. Some exciting and bold initiatives are recommended for implementation of this plan. A sampling of these initiatives includes:

1. Create a voluntary farm program in the South Branch of the Raisin or in Black Creek that uses a performance-based approach to environmental control, modeled after the Performance-Based Environmental Policies for Agriculture (PEPA) initiative.
2. Create a farm equipment grant/loan program that trades government funding for advanced agricultural monitoring and application equipment that improves productivity and environmental benefit for riparian buffer conservation and restoration

3. Install, monitor and advertise the use of two-stage ditches and constructed wetlands for drained cropland.
4. Create a community program to establish at least 100 rain gardens in five years in the urbanized areas of the Raisin.
5. Hold a bi-annual River Raisin conference that brings together farmers, watershed practitioners, planners, developers, students, researchers, regulators, homeowners, and outside experts to discuss and debate successes and failures, monitoring results, education initiatives, etc.
6. Hold an annual River Raisin film festival, with films solicited from all ages and backgrounds that focus on the River Raisin and the human connection to the river
7. Apply for natural rivers status for the Upper River Raisin between Goose Lake and Tecumseh
8. Accelerate greenway/trail establishment near Manchester, in the Saline area, between the River Raisin 1812 battlefield in Monroe, and the International Wildlife Refuge at Sterling State Park
9. Conserve an additional 10,000 acres in the watershed, with a focus on riparian zones
10. Restore 5,000 acres of wetland, particularly in the lower watershed
11. Perform streambank stabilization and stream restoration (including two-stage ditch projects) on 50 miles of mainstem and major channels

1.4 Adaptive Planning

This plan emphasizes meeting designated and desired uses. This will require raising stakeholder awareness and appreciation as well as capitol. Our planning process goals include raising awareness, building relationships, generating action, and identifying and fostering new community leaders and potential funding opportunities.

The plan has to have a set of metrics to measure performance goals, but has to be flexible enough to change or adapt any component – planning, goals, objectives, monitoring and improvement actions. The one constant will be trying to attain designated and desired uses. Overall implementation should rely on the following principles (partially based on the Gulf of Mexico Hypoxia Action Plan 2008, Mississippi River/Gulf of Mexico Watershed Nutrient Task Force):

1. Always look for the most effective and most cost-effective strategies for improvements (they may not always be one in the same)
2. Encourage actions that are voluntary and practical
3. Utilize existing programs to the extent possible
4. Identify opportunities for and potential barriers to innovative and market-based approaches
5. Follow adaptive management principles

2.0 INTRODUCTION

The River Raisin faces many challenges. The Raisin's watershed is predominantly agricultural and is dotted with a few cities and a number of small villages and towns. During the writing of this plan, the State of Michigan was grappling with its fifth, sixth and seventh straight years of state budget deficits. These deficits are partly a result of a restructuring domestic automobile industry and a new global recession. One consequence of a shrinking state budget has been the decline in state aid to local units of government (LUGs). During the planning period for this watershed plan, Federal support for watershed efforts was also stagnating or declining. LUGs are being asked to do more with less. The River Raisin is a watershed composed of small LUGs. The largest cities in the watershed, Adrian and Monroe, have a population of over 20,000 each while the total watershed population is approximately 189,000. Over the last few years there has been little to no population growth. Unfortunately, ethanol production, the one bright spot of growth for the region, is fraught with environmental issues.

Nationally, the country just recently passed a new Farm Bill. Globally, it looks increasingly clear that the world is facing a climate crisis. Unfortunately, the hoped-for close correspondence between Farm Bill funding and helpful global warming actions has not prevailed. For instance, the Farm Bill continues to push a build-up in ethanol infrastructure when, scientifically, all evidence points to a need for diversifying biofuel crops away from corn.

The current push for increased ethanol production is resulting in conversion of more and more acres to corn. An alternative biofuel option would be to grow native prairie plants. For example, prairie cordgrass (*Spartina pectinata*) is a tall robust perennial grass native to the prairies of North America. It grows well in a wide range of conditions, including wet and dry marginal lands, as well as salty soils. Prairie cordgrass is especially acclimated to low temperatures that allow early growth in the spring. This ability to initiate vegetative growth in early April represents a physiological advantage over other species such as corn (*Zea mays*) and switchgrass (*Panicum virgatum*), contributing to a longer growing season, and therefore producing more biomass per hectare.

Using native prairie plants as biofuel would allow farmers to harvest the shoots for fuel, while decreasing irrigation, fertilizer, and pesticide needs. They/we would also receive the benefits of carbon sequestration, soil erosion and sediment control, restored native habitat, improved stream hydrology and a long pollinator/pollination period. Science and politics are at odds over this issue right now. It will be unfortunate if the divergence between policy and science continues to grow. What the River Raisin needs is a close correspondence between the two.

2.1 The Great Lakes and the River Raisin Watershed

The Great Lakes contain 20% of the world's fresh surface water and are a unique natural resource. Michigan lies almost entirely within the watersheds of Lakes Superior, Michigan, Huron, and Erie. The state maintains jurisdiction over approximately 45% (by surface area) of the four bordering Great Lakes (38,865 of a total area of 86,910 square miles). As Howard Tanner, former director of the Michigan Department of Natural Resources said, "Michigan is the principal area responsible for water quality of the Great Lakes. Therefore, we must be careful about what we put in and keep on our rivers" (Michigan Land Use Institute, Undated).

The River Raisin basin economy is closely tied to its land use. As the top economic sector in the watershed, agriculture is a key component of the basin's future, along with other land-based industries such as tourism, science-based industries, education and services. The integrity of agriculture and farmland is also very important to establishing the quality of life that is necessary to attract and retain residents and skilled workers.

The Michigan Land Resource Project estimates that Michigan agriculture production and processing contribute $37 billion annually to Michigan's economy, making agriculture the second largest industry in the state. Farms and processing operations employ nearly 100,000 workers directly, and an additional 400,000 jobs in retailing and wholesaling (PSC, 2001). Other benefits of farmland include preservation of natural scenic and recreational open space, protection of habitat corridors, access to fresh produce through local markets, agri-tourism opportunities and links to rural lifestyles.

In most watersheds in the United States, agriculture is the greatest contributor of NPS pollution, responsible for 70 percent of the degradation in the United States' impaired waters (Cunningham, 2003). Common agricultural NPS pollutants can reduce water quality to a level below that required for designated uses such as agriculture, aquatic life and wildlife, and fisheries (MDEQ, 2000). Pollutants typically associated with agricultural land use include nutrients (phosphorus and nitrogen), sediment, salts, and pesticides (USEPA, 2003); generated by soil disturbance, alteration of natural vegetation, commercial fertilizer and animal waste application, pesticide application, and irrigation.

Sedimentation of water bodies in many catchments results from tillage practices in agricultural areas. Eroded soil and sediments from fields enter into streams and rivers and increase sediment loads in these systems. Adverse effects of the high sediment load include increased turbidity, loss of fish and invertebrate habitat, decreases in primary productivity and food sources thus altering food web interactions, and declines in species diversity within the stream ecosystem (Allan, 2004).

Nutrient enrichment of water bodies also often results from traditional agricultural practices, including the usage of fertilizers to maximize crop productivity. Phosphorus (P) and nitrogen (N) are common nutrients found in fertilizers. Excess P and N are transferred to streams via runoff following storm events, spring snowmelt, and general precipitation. High nutrient levels accelerate algal growth and organic matter breakdown, and can result in lowered dissolved oxygen levels, especially in slower moving, waters (Allan, 2004). Furthermore, traditional agricultural practices tend to change the hydrologic regime of aquatic systems by various methods, including tiling-and-drain systems, ditching, and differences in water uptake volume by crops versus natural flora (Poff et al., 1997). Allan (2004) describes how clearing of riparian forest canopy can exacerbate primary productivity in aquatic systems and decrease the occurrence of large woody debris found in healthy riverine systems.

In the River Raisin watershed like much of the upper Midwest, agricultural changes over the last few decades have drastically changed N management. These changes include the use of less diversified crop rotations, separation of crop production and animal enterprises, changes in tillage intensity, drainage of agricultural fields and increased use of manufactured N fertilizers (Dinnes et al., 2002).

The installation of subsurface drainage (tile) lines and the increased availability of N fertilizers are two of the most substantial practices that facilitated a tremendous jump in agricultural production throughout the Midwestern US. However, throughout the Midwest and in the River Raisin watershed, the soils have developed under a sub-humid climate in areas of low relief and poor surface drainage, resulting in high organic matter content (> 5% -6%). With subsurface drainage, tillage to prepare the seedbed and the change from perennial to seasonal vegetation, the potential for mineralization (conversion from soil/plant residue to plant-available, soluble form) of N from stored organic matter and N loading to surface water has increased dramatically (Dinnes et al., 2002).

The intensification of row crop production and increased use of N fertilizers have been identified as the primary cause of NO_3 contamination of surface waters over the past several decades. Continuous corn production has repeatedly been identified as providing the greatest amount of NO_3 to streams through subsurface drainage (Kanwar et al., 1993; Reed et al., 2001). Baker (1975) found the average NO_3 concentrations in subsurface drainage water from corn-soybean and corn-oat rotations to be 21 mg/L. Jaynes et al., (1999) reported that flow-weighted NO_3 concentrations were often greater than 10 mg/L and that on a mass basis, NO_3 losses ranged between 4 to 66 kg/ha/yr. The variation in NO_3 among years was directly linked to variation in annual precipitation.

2.1.1 The Bad News

The River Raisin is a major tributary of Lake Erie (**Figure 2-1)** and the fate of the Raisin impacts the fate of the Lake. The Lake Erie Lakewide Management Plan Report (LAMP) is charged with measuring ecosystem health, identifying the stressors responsible for impairments and evaluating the effectiveness of existing programs in resolving the stress by continuing to monitor the ecosystem response. The Lake faces impacts from high levels of trace elements and polycyclic aromatic hydrocarbons (PAHs) in bed sediments. Most of these impacts are in localized areas, like the twelve where Remedial Action Plans (RAPs) have been developed, including the RAP on the River Raisin in the Monroe harbor. Significant annual amounts of mercury and polychlorinated biphenyls (PCBs) (over 151,800 pounds mercury and 1.7 million pounds of PCBs) are released into the watershed, primarily to landfills.

Figure 2-1 River Raisin Location Map (Source: Fongers, 2006)

Over the last decade, major tributary and in-lake concentrations of dissolved reactive phosphorus (DRP) have been on the rise. Hypoxia and anoxia in the central basin are more extensive and occurring earlier in the summer. Microcystis blooms and Cladophora growth have been observed recently to rival those of the 1970s (See **Figure 2-2** below). These signs suggest that Lake Erie is out of trophic control again (Lake Erie LAMP, 2006).

Figure 2-2 LANDSAT image of phytoplankton bloom in western Lake Erie, August 18, 2003 (image from LANDSAT 7 server courtesy of OhioView)

The National Center for Water Quality (NCWQ) Research at Heidelberg University has been conducting daily water quality sampling of the major Ohio tributaries to Lake Erie, including the River Raisin for more than twenty years. The sampling is analyzed for total suspended solids and nutrients and is conducted at USGS stream gages so daily concentrations and loads are chronicled. In the predominantly agricultural watersheds, like the Maumee River, TP and DRP showed significant declines till the mid-1990's. After that period, while total phosphorus held steady or even continued to show declines, DRP concentrations and loads have been going up and are now starting to exceed 1970s levels.

The Lake Erie Ohio Task Force (http://www.epa.state.oh.us/dsw/lakeerie/ptaskforce/index.html) began meeting in Spring 2007 to look at these issues. They have highlighted the apparent relationship between zebra mussels, increasing DRP loads, and the rise of Microcystis and Cladophora. The zebra mussels, with their amazing capacity to clarify the water column, have changed the nearshore algae and primary production balance from pelagic (open water) to benthic. The zebra mussels are reducing the primary production potential of offshore waters in the lake by trapping phosphorus in the near shore areas. Phosphorus load analyses also show the bulk of the load affecting all of Lake Erie is the western basin, including the River Raisin drainage.

In that same late 1990's period, many cropland BMPs were implemented to manage sediment and phosphorus. While it appears that these BMPs have been providing real reductions in sediment and sediment-associated loads like total phosphorus, the concentrations of the dissolved component of phosphorus is going up. The dissolved component is also much more bioavailable than particulate phosphorus. The NCWQ has done some research that shows some of the BMPs implemented to fight solids, may be part of the culprit of the rise of DRP loads. Surface applied fertilizers and manures, along with no-till and other forms of conservation agricultural practices are increasing concentrations of phosphorus at or near the soil surface. When the surface levels exceed crop needs, phosphorus field losses go up, both from runoff as well as from drain tile flows.

The unintended consequence of focusing agricultural BMPs on retaining soil has been a lack of focus for dealing with dissolved constituents like DRP, nitrate and pathogens. We believe this means that BMPs must target a broader list of BMP attributes, and emphasize the need to manage dissolved pollutants more effectively. We suggest that it may also be time to change the relationship between environmental control, farmers and the federal government and move to a more performance-oriented agricultural management and one where more of the environmental management decision-making is returned to the farmer.

2.1.2 The Good News

The River Raisin is uniquely positioned to take advantage of some its unique landscape characteristics. The Raisin lies directly in the path of two major migratory bird routes (see **Figure 2-3** below). The Nature Conservancy and others have identified the upper watershed as an area having the most value of inland bird habitat in the western Lake Erie watershed. The Detroit River International Wildlife Refuge, a concerted agency effort spearheaded by the US Fish and Wildlife Service, is poised to create a unique attraction for birds, area residents and visitors. The refuge is the only international wildlife refuge of its kind in North America. It includes islands, coastal wetlands, marshes, shoals and waterfront lands along 48 miles of the Detroit River and Lake Erie western shoreline. The Eagle Island Unit at the mouth of the Raisin is part of this refuge (**Figure 2-4**). There is a unique opportunity here to capitalize on regional geography and concerted conservation, restoration and recreational opportunities in this region.

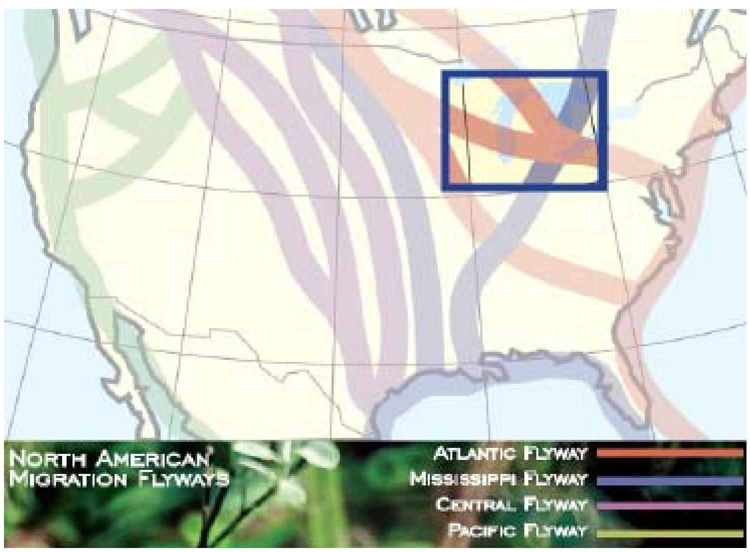


Figure 2-3 Major Bird Migration Paths through the United States (from: Byways to Flyways – A Driving Tour of Featured Birding Locations in the Windsor-Detroit Metropolitan Region. Prepared for the International Wildlife Refuge)

Figure 2-4 Detroit River International Wildlife Refuge Map
(http://www.fws.gov/midwest/detroitriver/)

2.2 Purpose of the Watershed Plan

The purpose of the watershed plan is first and foremost to eradicate water quality impairments throughout the River Raisin watershed. If improvements are to be identified, designed, implemented and maintained, the residents of the watershed are going to have to lead the way. The River Raisin is a sparsely populated watershed with a limited set of financial resources. If we are to rely on residents to do the bulk of the work to improve the local ecology, this plan has to also contribute to improving the lives of residents.

2.3 Stakeholder Participation

A Steering Committee composed of River Raisin Watershed stakeholders was formed in 2006. Steering Committee meetings were held at Tecumseh Public Library to develop the plan of action for brainstorming and layout of the River Raisin Watershed Management Plan. Nine steering committee meetings and approximately two dozen or more project team meetings were held during the watershed management plan development period. A series of teleconference meetings were also set in place as plan development checkpoints.

Public informational meetings were held in River Raisin Watershed sub-basin areas to bring on-board support from stakeholders within the watershed. Public meetings, where the plan goals and objectives and watershed problems were discussed in an open forum, were held in Pittsfield Township, Manchester, Blissfield, and Adrian. Additional public meetings planned for Dundee and/or Monroe were cancelled due to funding constraints.

Three River Raisin watershed annual meetings were occasions for presentations and discussion of the plan. A field trip to the Ives Road Fen (hosted by The Nature Conservancy) and a River Raisin Restoration Tour and Plant Sale (hosted by the RRWC, the Raisin Land Conservancy and the Stewardship Network), held during the planning process, introduced many individuals to some of the conservation and restoration efforts in the watershed.

Over the life of the planning period, many organizations and individuals contributed to this document. Some of the organizations which contributed time or resources to this document include:

Adrian College
Adrian Dominican Sisters
Adrian Township
Bridgewater Township
Cambridge Township
City of Adrian
City of Adrian Parks & Recreation Department
City of Adrian Water Treatment Plant
City of Milan Parks & Recreation Department
City of Monroe
City of Saline
City of Tecumseh
City of Tecumseh Parks & Recreation Department
City of Tecumseh Planning Commission
Clinton Township
Clinton Township
Detroit Riverkeeper
Frenchtown Township
Herpetological Resource and Management
Jackson Community College
JFNew
Lenawee Conservation District
Lenawee County Drain Commission
Lodi Township
Manchester Township
Michigan Department of Environmental Quality
Michigan Department of Natural Resources – Fisheries Division
Michigan State University Extension
Monroe County Drain Commission
Natural Resources Conservation Service
Pittsfield Charter Township
Raisin Valley Land Trust
Raisinville Township
River Raisin Institute
Rollin Township
Saline River Greenway Alliance
Seneca Township
Sharon Township
Somerset Township
Stantec
The Nature Conservancy
United States Department of Agriculture
University of Michigan
Village of Blissfield
Village of Manchester
Washtenaw County Drain Commission
Washtenaw County Planning & Environment Commission
Washtenaw County Road Commission
Washtenaw County Technical Department
Water Quality Investigators
Western Lake Erie Waterkeeper
York Township
York Township Parks Committee

On-the-ground efforts included installation of a staff gage by volunteers on Evans Creek and an expansion of the Adopt-A-Stream program. The Adopt-A-Stream program was expanded from 12 sites to 20 sites and from only a spring sampling to a spring and fall sampling. Other field efforts, such as habitat and road crossing surveys, that would have incorporated volunteers, also had to be cancelled due to funding constraints.

A social survey was conducted at the first steering committee meeting and at the public meetings. A total of 34 individuals responded. Most of the respondents have lived in the watershed at least 10 years and were between the ages of 50-80. Residents were from Ann Arbor, Ypsilanti, Pittsfield, Chelsea, Lenawee, Manchester, Milan, Saline, Tecumseh, Washtenaw and York. Respondents were almost evenly split in the belief that water quality in their streams was either getting better or worse. Most survey respondents felt water quality problems were predominately caused by systems, runoff from impervious surfaces and agricultural land and sewage overflows. All but one individual was very strongly concerned about environmental quality in the Raisin, while most people felt their individual property has some impact on stream water quality. All respondents noted that they had engaged in outdoor activities in the watershed with the top activities listed as hiking/walking, bird/nature watching, biking and picnicking. About a quarter of the respondents noted that they had participated in a volunteer watershed council meeting, while about half of those who had not participated said they were interested in participating in future council volunteer activities.

3.0 CHARACTERISTICS OF THE RIVER RAISIN WATERSHED

The River Raisin Watershed is located in Southeast Michigan and includes parts of Hillsdale, Jackson, Lenawee, Monroe and Washtenaw Counties. The watershed drains from the north and west and enters Lake Erie at the Monroe Harbor. The River Raisin is 540 feet above sea level at its mouth and rises to about 1,200 feet in the Irish Hills area (USDA, local Coordinating Committee, undated). The Irish Hills area in Hillsdale County is also home to headwaters of the St. Joseph, Kalamazoo, Grand and Huron rivers (See **Figure 3-1** below).

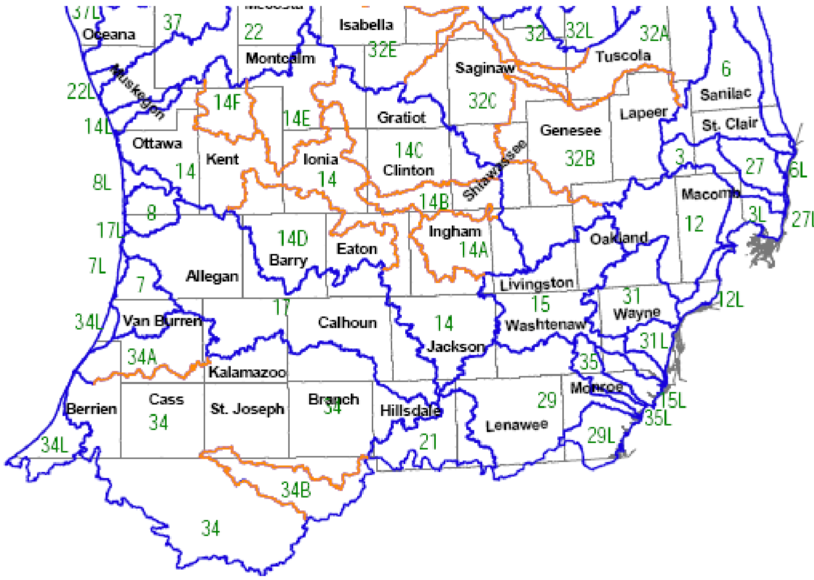


Figure 3-1 Headwaters intersection of the Raisin (watershed #29), St. Joseph (#34), Grand (#14), Kalamazoo (#17) and Maumee (#21) rivers (Clark, 1999)

3.1 Geology and Soils

The River Raisin watershed is primarily a glacial feature. The River Raisin was once covered with mile-high glaciers that pushed and pulled everything in their path, dropped sediment and then retreated. The formation of the Raisin watershed actually dates back to before the formation of modern Lake Erie.

At around 15,000 years ago, a series of glacial lakes were formed from what was known as the Wisconsin ice sheet or Pleistocene Glacier. The drainage of water eastward did not occur at first. What is presently called Lake Erie used to comprise many smaller lakes such as Maumee, Arkona, Whittlesey, Warren, Wayne, Grassmere, and Lundy. Drainage started westward from Lake Maumee (at an elevation of 800 ft. above sea level) towards Fort Wayne, Indiana into the Wabash River. The drainage of waters eastward started 12,000 years ago and resulted in a low lake level stage for 8,000 years. During that low lake stage the River Raisin was born. Gradually, the Lake Erie water level rose from 470 feet above sea level to its current elevation of 570 feet above sea level after the Niagaran escarpment rebounded from the loss of the glaciers' weight.

The parent material of the soils of the River Raisin area was deposited about 10,000 years ago during the Wisconsin stage of Pleistocene glaciations and the lacustrine deposits of the ancestral Great Lakes. The soils in the River Raisin Watershed are highly variable and the topography is split between rolling hills to the northwest and low-lying, flat old lake plain to the southeast. Within the hills to the northwest, well drained loamy sands and sandy soils, and very poorly drained loamy-muck soils that formed in glaciofluvial deposits or in organic matter, are found on the kames, end moraines, and ground moraines (USDA, SCS, 1961). The central area contains large areas of gently rolling soils comprised of silty clay loams and limey clays along with nearly level poorly drained soils developed from clay loams and clays found on end moraines and ground moraines. This central region also includes long narrow areas of level to nearly level, poorly drained loam, sandy loam and loamy sand overlying limey sand and gravel in the south central area with level to gently rolling well drained sandy loam and loamy sand overlying sand and gravel in the north central area (USDA, SCS, 1961). Nearly level, very poorly drained, silty soils are located along the Lake Erie Shoreline. Level, poorly drained soils developed from silty clays, and clays developed in deltaic and lacustrine deposits are located in the eastern watershed (USDA, SCS, 1961).

Surficial geology in the Raisin Basin transitions from coarse and medium textured glacial till and moraine deposits in the northwest, to fine sediments in the central portion of the watershed, to very fine lacustrine deposits in the Lake Erie lakeplain (see **Figure 3-2**). The thickness of glacial deposits ranges from 50 to 300 feet, with the thickest portions occurring in the northeastern and southwestern portions of the watershed. Thicker deposits generally provide more storage and thus increase the percentage of flow of a river that has a subsurface rather than a overland (Knutilla and Allen 1975) source. Lake bed deposits consist principally of clays and sands which were deposited in former glacial lakes (van Wagner et al., 1998). In general, the coarse sand and gravel of moraines promote groundwater retention and flow, whereas silt, clay, fine sand, and till favor surface drainage (Knutilla and Allen 1975).

Landforms in the area generally northwest of Adrian consist of kames, end moraines and ground moraines. The kames are formed by unsorted glacial till deposited directly from ancient mile-high sheets of ice. The end moraines and ground moraines are generally stratified gravel, sand, silt, and clay deposited from streams flowing from the retreating glacier. These deposits produce a hilly to gently rolling topography (USDA, SCS, 1961). Many of the lakes in the Irish Hills area were formed in kettles, or depressions formed when blocks of ice broke off from the glacier and were subsequently buried in debris and later melted leaving holes in which the lakes formed.

Southeast of a line generally connecting Morenci, Adrian, and Tecumseh is an area once covered by the glacier and by glacial lakes that were part of the predecessor to Lake Erie. This Lake Bed Plain contains a series of narrow, low beaches, bars and deltas formed by streams flowing into the lake. These lake bed deposits are moderately fine to fine grained materials covered by deltaic deposits up to 20 feet thick. Lacustrine or lake deposits of sand, silt, and clay are common in the southeastern part of the watershed. These deposits produce the flat topography dissected by entrenched drainage with steep sides (USDA, SCS, 1961).

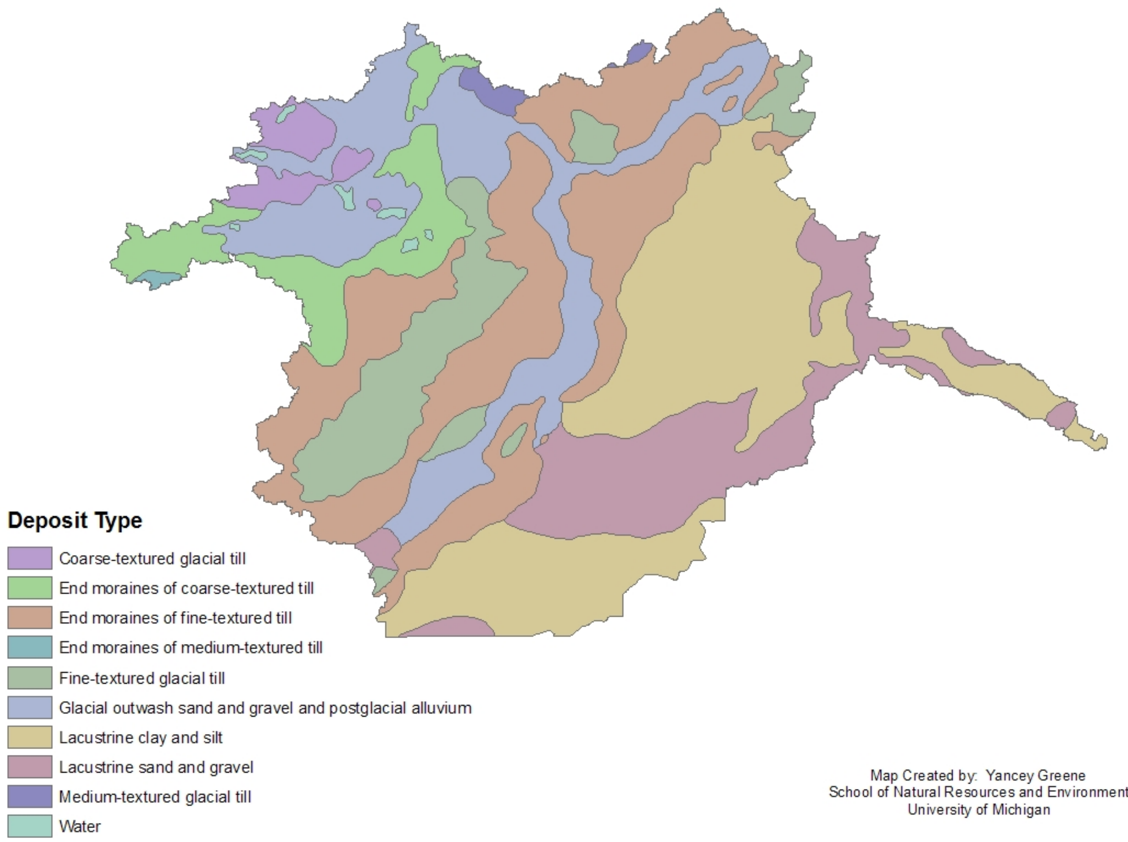


Figure 3-2 River Raisin Watershed surficial geology map (Michigan Center for Geographic Information)

3.2 History

The Michigan Natural Features Inventory has mapped Michigan pre-settlement vegetation (circa 1800) using land surveyor notes from the Federal General Land Office (GLO) surveys of the state between 1816 and 1856 (see **Figure 3-3** below) and soils-plant association maps of the Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service. Based on this data, pre-settlement vegetation in the River Raisin consisted primarily of oak-hickory and beech-maple forests and mixed hardwood swamps.

Before contact with Europeans, much of the River Raisin watershed was inhabited by the Kickapoo Indians who lived in northwest Ohio and southern Michigan, occupying most of the area between Lake Erie and Lake Michigan. Seeking new hunting territory for fur to trade with the French, Tionontati, Ottawa and Neutrals warriors attacked the Kickapoo and their neighbors the Fox and Sauk to the north. A full-scale invasion by the Iroquois followed during the 1650s, which forced the Kickapoo to abandon their lands and retreat west around the south end of Lake Michigan to the Mississippi River in southwestern Wisconsin. There were other tribes in this region who vanished long ago taking their history with them. Today, there are eleven federally recognized Indian tribes in Michigan, none of which have a reservation within the River Raisin watershed. Lack of recognition and legislation to protect archeological sites in Michigan has forced some American Indians to keep references to their ancestral sites off any maps. Without protection, the chances that recovered artifacts fall under the control of someone other than an American Indian, rises considerably. It is unfortunate that more of the Raisin's rich and living American Indian heritage cannot be shared as a collective resource.

The famous French explorer LaSalle passed by the River in 1679 and was astounded by its bounty and stated that "Groves of black walnut and wild plum trees and oaks festooned with grapevines stood like islands on the fine prairies." The French settlers were also impressed with the grapevines that grew along its bank and called it "Riviere Aux Raisin" or River of Grapes. The American Indians called the River "Nummasepee" which translates to River of Sturgeon. The first American settlement was established in 1793 at Frenchtown and then in 1796 the first American flag on Michigan soil was raised by Captain Porter. On July 14th, 1817 Monroe County was established. This land included all of present day Lenawee County and a portion of Washtenaw and Wayne counties. Frenchtown was located on the north bank of the River Raisin and the town of Monroe on the south side of the river.

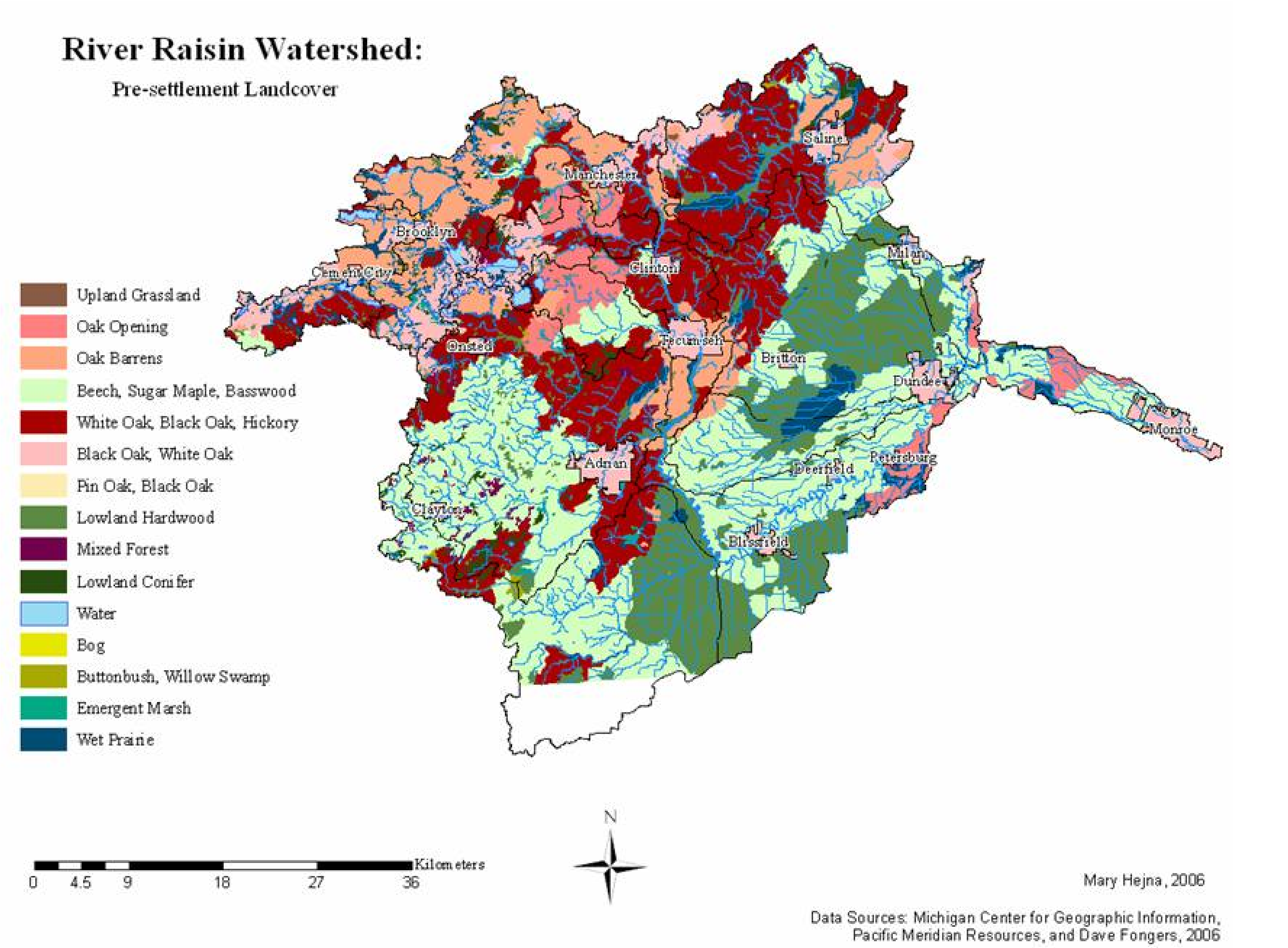


Figure 3-3 River Raisin Watershed Pre-settlement Vegetation (circa 1800)

After Frenchtown became a settlement, it became a site for one of the largest military battles during the War of 1812. This one battle resulted in more causalities than any other battle during that war. On August 16, 1812 General Hull in Detroit and the local militia in Frenchtown surrendered. The British then occupied the area, burned the fortified blockhouse and left. A small militia of Canadians was stationed at Frenchtown to track the movements of the American army that had been recruited in Kentucky. In August of 1812 the American army routed 200 Potawatomi Indians and the Canadian militia and in January of 1813 reoccupied Frenchtown. Once the areas were reoccupied 600 British and Canadian soldiers and 800 Native Americans counterattacked with 6 cannons. The American force numbered 1,000 troops and militia. A portion of the American force was flanked by Canadians and Native Americans. The Americans retreated and were pushed into a disastrous route. Over half of the 400 Americans who ran were killed, and another 150 were captured. The remaining Kentucky militia surrendered on orders by their captured general. The British withdrew promptly and the pro-British Native Americans returned and plundered settler's homes where the Americans who were wounded had been left behind. These unarmed and wounded Americans were murdered and their bodies tossed into burning houses. The Americans who could walk were taken to Detroit and held for ransom. Over 60 unarmed Americans were killed in this action that came to be known as the "Massacre of the River Raisin". 'Remember the Raisin' became a battle cry of the American troops and militia for the rest of the War of 1812. After all the hostilities, white settlers started moving back into southern Michigan. Native American lands were taken by the government (refer to **Figure 3-4)** and reservations established.

Figure 3-4 Excerpt from the Royce Indian Treaty (1807) Map (Produced by the Smithsonian Institution. Refer to http:en.wilkipedia.org/wiki/image: Royce-areas-michigan.jpg)

The watershed underwent its major land use change between 1830 and 1900. The Raisin watershed was either covered by wetland, grassland or forest before the forests and grasslands were burned and cut down and the wetlands drained. Clearing for agriculture in the southeastern area of the Lower Peninsula was slow and laborious. Clearing was mainly accomplished by logging and burning the remaining slash. At times the fires in Michigan were enormous, with some mammoth fires in the state consuming well over 1 million acres. In these 70 years, logging and clearing destroyed most of the original pine and hardwood forests in Michigan.

Drainage throughout Michigan is mainly handled by County Drain Commissioners. The Drain Commissioners are bound by the Drain Code, a document that has not been substantively updated since 1959. The role of the drain commissioners is to practice and improve drainage engineering and soil erosion and sediment control to help drain land and keep it drained. Much of Raisin requires engineered drainage systems to keep the land arable or available for development.

Monroe Pier, circa 1915. Monroe Historical Society

In 1832, the U.S. Army Corps of Engineers changed the course of the River Raisin by dredging a navigation channel through a barrier beach that protected the Monroe Marshes. Since that time dredging and filling has continued unabated. I-75 truncated Plum Creek Bay and the upper reaches of the River Raisin estuary. The City of Monroe used this area for a sanitary landfill, the Consolidated Paper Company disposed of lead and PCBs in lagoons and Detroit Edison built one of the world's largest fossil fuel electricity generating plants on Guyor's Island adjacent to the Federal Navigation Channel. The Power Plant also changed the flow of the River and can withdraw so much water for non-contact cooling that the entire flow of the Raisin and part of Lake Erie are drawn into the intake at the same time.

Henry Ford had a grand scheme to make auto parts in small water-powered rural plants around Dearborn that would supply the Ford Rouge industrial complex, including several in the Raisin. He built up these village industries to 19 plants and acquired sites for 10 more. These included plants in Brooklyn, Sharon Mills, Manchester, Saline and Milan that turned out gauges, lights, starters, generators, lighters, horn buttons and ammeters. Wellers Complete Banquet Facilities in Saline was a grist mill that Ford converted to a water-powered auto plant that operated from 1938 to 1947. Workers processed soybeans there to be converted into plastics and paint; at one point Ford had roughly 7,300 acres of land in Lenawee County for growing soybeans. Ford thought soybeans would turn farmers into industrial suppliers. He experimented with 300 soybean varieties to find new uses and used soybean meal to make plastics for horn buttons, light switches and gearshift knobs. Soy oil was used in auto plants. However, soy could not compete with other more industrial plastics.

In recent years, industry in the watershed has increased its recognition of the area's natural resources. On December 21, 2001, President Bush signed legislation (Public Law 107-91) establishing the first International Wildlife Refuge in North America. The refuge, which includes islands, coastal wetlands, marshes, shoals, and riverfront lands along 48 miles of the Detroit River and western Lake Erie, will protect and restore habitat for 29 species of waterfowl, 65 kinds of fish, and 300 species of migratory birds in Michigan and Ontario, Canada. This area includes the mouth of the River Raisin, including Sterling State Park and Eagle Island.

The purpose of the refuge is to protect the remaining fish and wildlife habitats of the Detroit River and western Lake Erie before they are lost to further development and to restore and enhance degraded wildlife habitats; to assist in international efforts to conserve, enhance, and restore the native aquatic and terrestrial community characteristics of the Detroit River and western Lake Erie both in the United States and Canada; and to facilitate partnerships among the United States Fish and Wildlife Service, Canadian national and provincial authorities, State and local governments, local communities in the United States and in Canada, conservation organizations, and other non-Federal entities to promote public awareness of the resources of the Detroit River and western Lake Erie (USFW, 2005). In the first five years, the Detroit River International Refuge has grown from 304 acres to 4,982 acres which have all been set aside as a conservation region.

In 2005, Automotive Components Holdings (ACH) and the U.S. Fish and Wildlife Service announced an agreement bringing 240 acres of coastal wetlands into the Detroit River International Wildlife Refuge. Located near ACH's Monroe Plant, these wetlands, adjacent to Lake Erie, are bordered by Sterling State Park on the north and the River Raisin on the south. The area has since been named Eagle Island Marsh as a tribute to bald eagles that have returned to the coastal marshes. The nation's largest aquatic wildflower, the threatened American Lotus, is also found in this area.

3.3 Climate and Global Warming Implications

The River Raisin watershed is in the warmest and driest portion of Michigan, with a mean annual temperature between 47 °F and 49 °F and mean annual precipitation of 32 – 34 inches. The average annual snowfall ranges from 32 to 38 inches. Average annual groundwater recharge is 5 – 12 inches. Runoff is roughly 8 inches annually. The remainder of the precipitation, 12 – 21 inches is lost via evapotranspiration. The watershed has low levels of warm season surface runoff due to high average air temperatures and high evapotranspiration rates. Evapotranspiration exceeds precipitation by more than 80% during the growing season, and total annual surface runoff in the watershed is lower than in most of the rest of the state (Dodge 1998).

Warming of the global climate system appears to be occurring, as confirmed by observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (IPCC, 2007a) (See **Figure 3-5**). Higher temperatures can impact microorganisms and benthic invertebrates as well as the distribution of many species of fish, invertebrates and waterfowl. In some areas of the planet major changes are likely to occur in the species composition, seasonality and production of planktonic communities and their food web interactions with consequent changes in water quality (IPCC, 2007b).

The Great Lakes region is predicted to experience a warmer future and more chaotic precipitation patterns. We may be simultaneously experiencing hotter and longer droughts but more unpredictable and extreme rain events. Summer temperatures are changing quickly, and within the next 25 years summers in Southeast Michigan are predicted to feel like Kentucky does today (See **Figure 3-6** below) and by 2095 will feel like Arkansas today (Kling et al., 2003). Winters will warm as well, resulting in less ice cover on the Great Lakes and inland lakes. Coupled with increased evaporation, an overall drying trend may result in lower water levels in the Great Lakes and inland lakes and streams. Our winters are already getting shorter and extreme heat and precipitation events are occurring more commonly than in the past (Kling et al., 2003). The Union of Concerned Scientists' report "Confronting Climate Change in the Great Lakes Region" (Kling et al., 2003) predicts that native species ranges (including fish and other aquatic species) will shift northward, and that invasive species problems will likely get worse as native species in the southern limits of their ranges die off, leaving unfilled niches that non-natives can occupy. Plant hardiness zones have already shifted so that more southern plants can now survive Michigan winters. Plant hardiness zones are categorized according to the mean of the lowest temperature recorded each winter. According to the National Arbor Day Foundation (2006), southern Michigan warmed from Zone 5 (-29 °C to -23 °C) to Zone 6 (-23 °C to -17 °C) between 1990 and 2006.

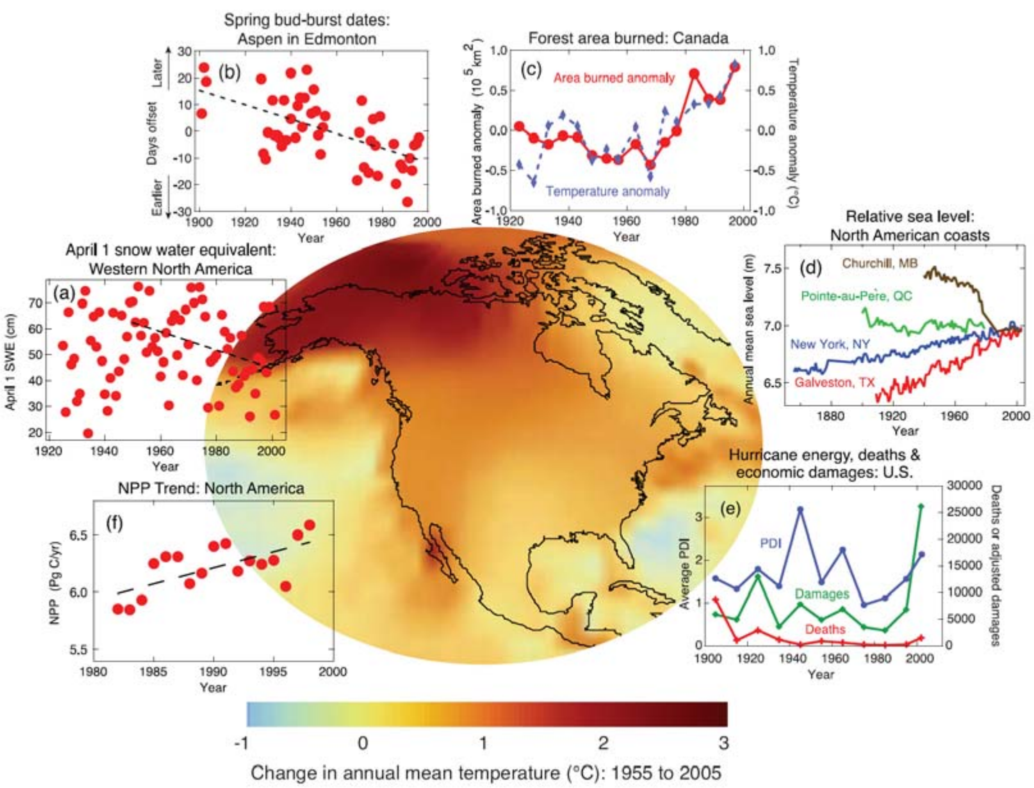


Figure 3-5 Change in North American Mean Temperature (and other parameters) since 1955

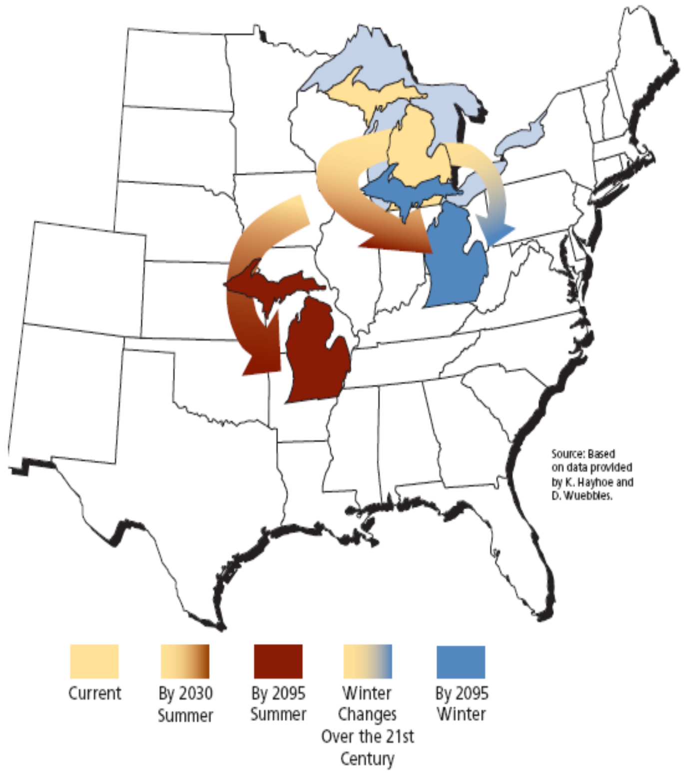


Figure 3-6 Potential Climate Change Impact on Michigan

3.4 Land Use and Growth Trends

The River Raisin is primarily composed of agricultural land use (~75% areal coverage), much of it consisting of corn, some soybean and wheat, very small percentages of other crops such as organic produce along with some dairy and horse farms (See **Figure 3-7** and **Table 3-1**). Only 6% of the watershed is in residential land use. Ten percent of the watershed still retains forest cover and about 5% of open field areas. Wetlands, with the exception of some of the upper areas of the watershed are almost entirely extinct. While some communities in the watershed, like Saline and Adrian, were experiencing significant residential growth pressures before the Global recession began late in 2008, the recession has essentially shut down the residential market in the Raisin, statewide and beyond. In fact, this watershed is experiencing a population contraction and will continue to contract until employment in the state of Michigan, and in particular, in Southeast Michigan begins to stabilize. The Southeast Michigan Council of Governments (SEMCOG) does not predict an employment rebound in this region until after 2012 (SEMCOG, 2009).

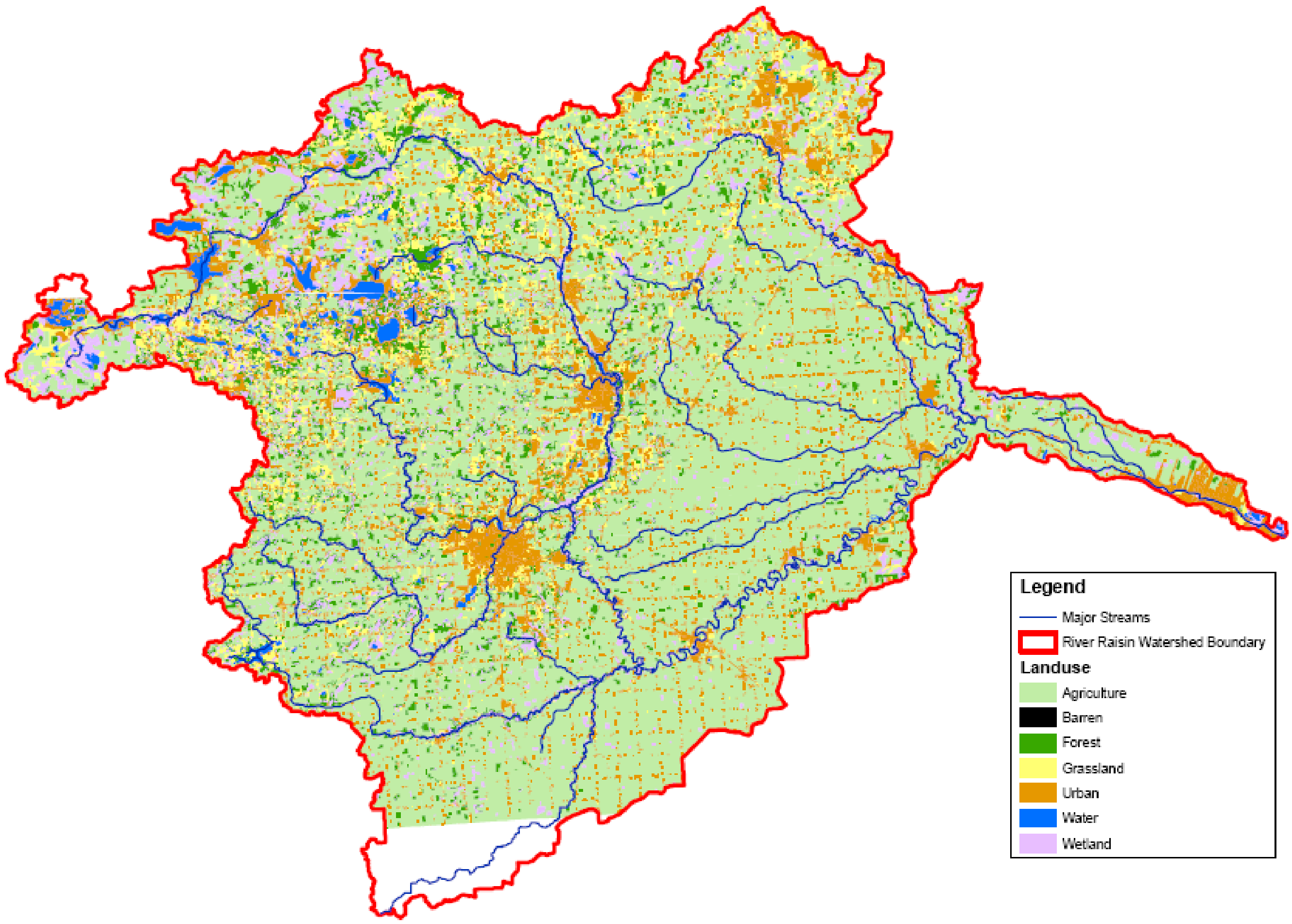


Figure 3-7 Current River Raisin Land Use (Bennett et al., 2006)

When land cover in the River Raisin is broken out by subwatershed, clear trends emerge. The Raisin's major subwatersheds can be aggregated into 3 levels of agricultural land conversion, from low to high percentages of conversion. The watersheds with the least amount of agricultural land include Goose Creek (44%) and Iron Creek (40%). The group with a medium amount of agricultural land conversion (67% - 72%) includes the Upper River Raisin, Evans Creek, South Branch of the River Raisin, and the Saline River. The last group, with the highest percentage of agricultural land conversion (78% - 95%) includes Black Creek, Macon Creek, the Little River Raisin and the Lower River Raisin (refer to
Table 3-2).

For the Goose and Iron creeks, only 42% of their watershed area has been converted to agriculture. Forest, wetlands and grasslands still comprise 18%, 9% and 11%, respectively. The middle group of subwatersheds has an average agriculture coverage of 69%, with 12%, 1% and 7% of forest, wetland and grassland coverage. The third has an average agriculture coverage of 85%, with Macon Creek and the Little River Raisin with agricultural coverages of 90% and 95%, respectively. On average forest coverage is 7%, with wetlands and grasslands accounting for no more than 3% of the total area in these subwatersheds.

Table 3-1 Current Land Use in the River Raisin Watershed (from: Gothie et al., 2007)

Subwatershed	Area (mi^2)	Percent of Total by Subwatershed: Residential	Cropland	Pasture	Herbaceous Open Land	Forest	Wetland	Open Water
Black	150	1	86	0	2	8	<1	1
Evans	29	4	72	2	4	12	1	1
Goose	40	12	44	0	9	15	9	9
Iron	32	5	40	2	14	21	10	6
Little RR	43	0	95	0	1	3	<1	<1
Lower RR	181	10	78	0	2	9	1	1
Macon	142	1	90	0	2	5	<1	<1
South Branch RR	189	7	69	2	5	13	1	2
Saline	129	8	67	0	11	13	1	<1
Upper RR	124	6	72	1	6	11	1	2
Overall	**1,059**	**6**	**75**	**1**	**5**	**10**	**1**	**1**

Table 3-2 Subwatershed Grouping By Agricultural Land Coverage

Grouping by Extent of Ag Coverage	Area (mi^2)	Percent of Total (Weighted Average): Residential	Cropland	Pasture	Herbaceous Open Land	Forest	Wetland	Open Water
Low (Goose, Iron)	72	9	42	1	11	18	9	8
Medium (Evans, South Branch RR, Saline, Upper RR)	471	7	69	1	7	12	1	1
High (Black, Little RR, Lower RR, Macon)	516	4	85	0	2	7	1	1
Overall	**1,059**	**6**	**75**	**1**	**5**	**10**	**1**	**1**

3.5 Hydrology

River Raisin hydrology has changed dramatically over the last century. The change is substantially due to the conversion of forest, grassland and wetland to drained agricultural fields. Any increase in impervious area in the Raisin over time cannot explain the hydrologic and water quality changes the Raisin has experienced over the last two hundred years. In fact, urban/suburban land only covers six percent in the watershed. The rough threshold for habitat and environmental impact due to conversion of pervious area to impervious area is ten percent (Schueler,1995).

The loss of forest cover, wetland storage along with drain tiling have likely increased baseflows, baseflow as a percentage of total flow and total annual flow. For example, in a six year study in Minnesota, Randall (2004) found that drainage from row crops exceeded drainage from perennial crops by a factor of 1.1 to 5.3 times during wet years. Subsurface drainage reduces soil moisture content, evapotranspiration, surface storage and runoff, and increases infiltration and subsurface flows. Furthermore, these subsurface flows are delivered to receiving waters via an artificial system of drains that could be thought of as engineered preferential flow paths.

The hydrologic impacts of converting natural land to drained cropland may not be as distinct as the impacts of covering aboriginal land with impervious surfaces. The flashiness of streams dominated by drained cropland tends not to be as high as that of urbanized streams. The difference can be visualized as the contrast between water running over asphalt or concrete to a street inlet, through a pipe to a stream as opposed to rainfall infiltrating two to three feet into the ground to an underdrain, out a ditch to a stream. The conversion of natural land to agriculture is nearly ubiquitous in some of the major subwatersheds of the Raisin. This conversion has had significant hydrologic and water quality impacts. Some of the impacts, including land clearing and conversion and dam building, the river may still be reacting against.

The United States Geological Survey (USGS) operates three gaging stations on the mainstem of the River Raisin, one just upstream of Manchester; one just downstream of the Raisin's confluence with the South Branch of the Raisin (near Adrian) and one just upstream of Monroe (see **Table 3-3** below). The USGS used to also maintain gages on the mainstem near Tecumseh (Period of Record: 156-1980) and on the Saline River near Saline (Period of Record: 1965-1977); (See **Figure 3-8** below for reference). The typical annual flow pattern of these gages shows seasonal high flows in March and April and base flows during July through October (**Figure 3-9**). The gaging stations all show a similar annual flow pattern. The table below shows the mean annual flow rates at each of the USGS gage locations in cubic feet per second (cfs).

Table 3-3 USGS Flow Gaging Stations in the River Raisin

USGS Gage Location	**Mean Annual Flow (cfs)**
Mainstem (#4175600) 2 miles upstream from Manchester at Sharon Valley Road	107
Mainstem (#4176000) below confluence with South Branch, 3 miles east of Adrian at Academy Road	340
Mainstem (#4176500) ½ mile upstream from mouth at Lake Erie, 1 mile below bridge on Ida-Maybee Road	741

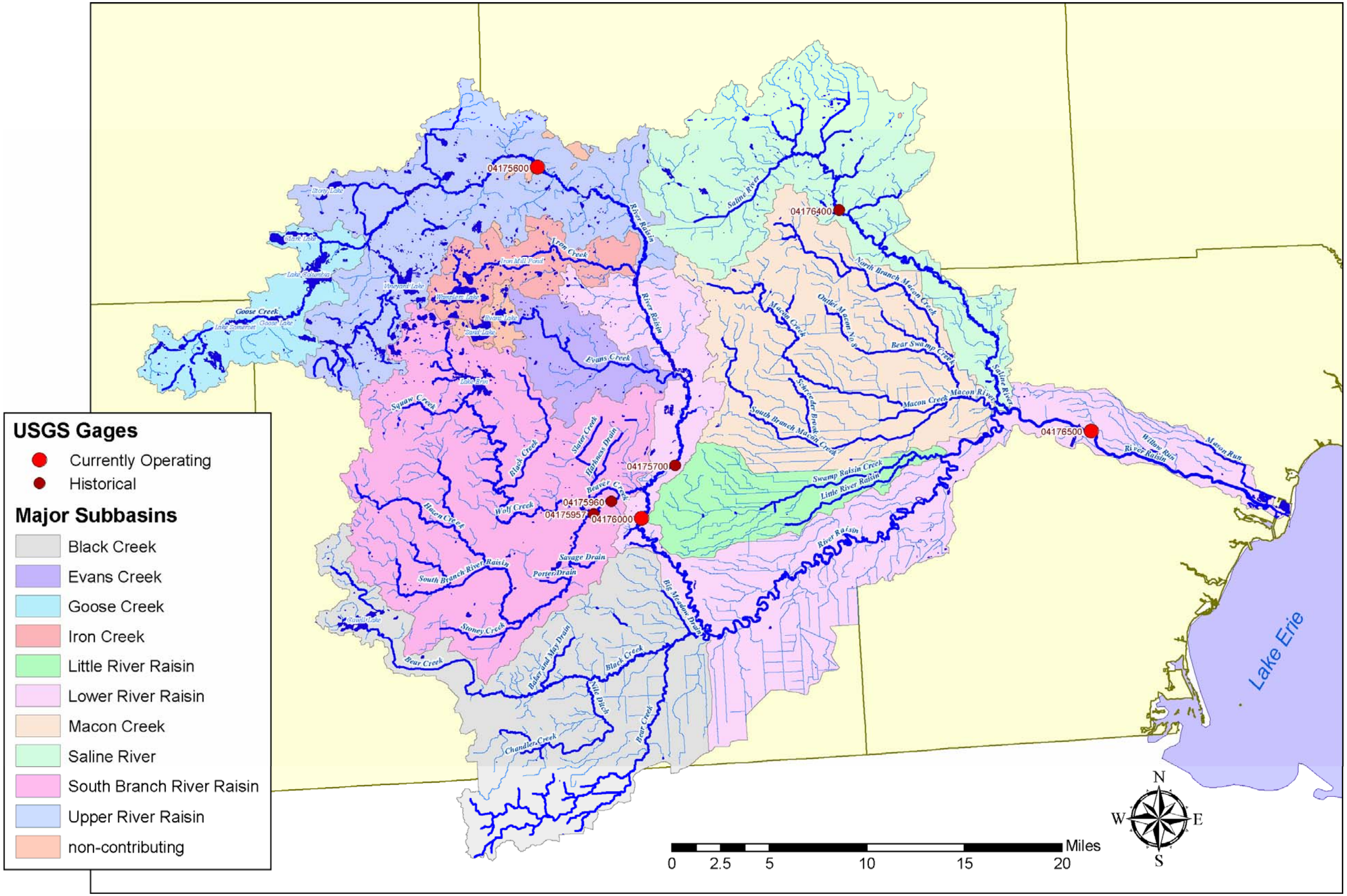


Figure 3-8 Major Subbasins of the River Raisin (Fongers, 2008)

Flow-duration curves are developed for a given location on a stream or river by arranging the observed flow rates in order of descending magnitude. From this, the percentage of time for each flow magnitude to be equaled over the period of record can be computed. This percentage of time of exceedance is plotted against the flow magnitude to define the flow-duration relationship. For instance, the 5% exceedance value is the discharge that has been exceeded 5% of the time during the given period. The flow duration curves for the mainstream near Manchester, Tecumseh, Adrian, and Monroe, as well as for the Saline River near Saline show a similar pattern (see **Figure 3-10**).

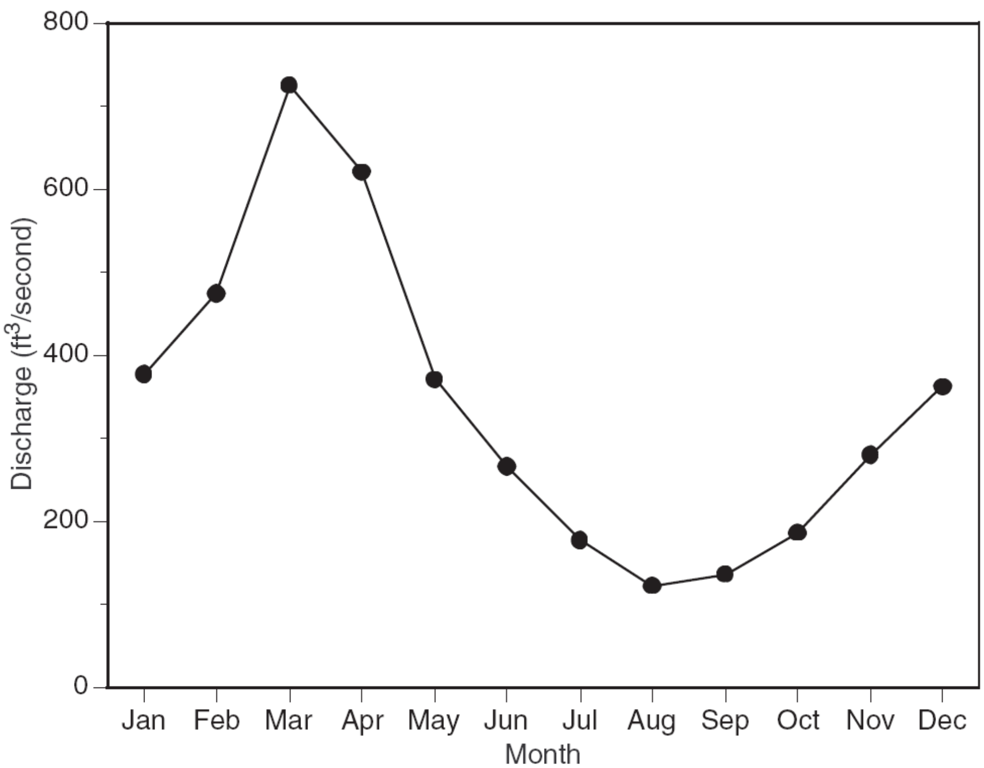


Figure 3-9 Annual Hydrograph for River Raisin mainstem east of Adrian period of record 1954 – 1994 (from Dodge 1998)

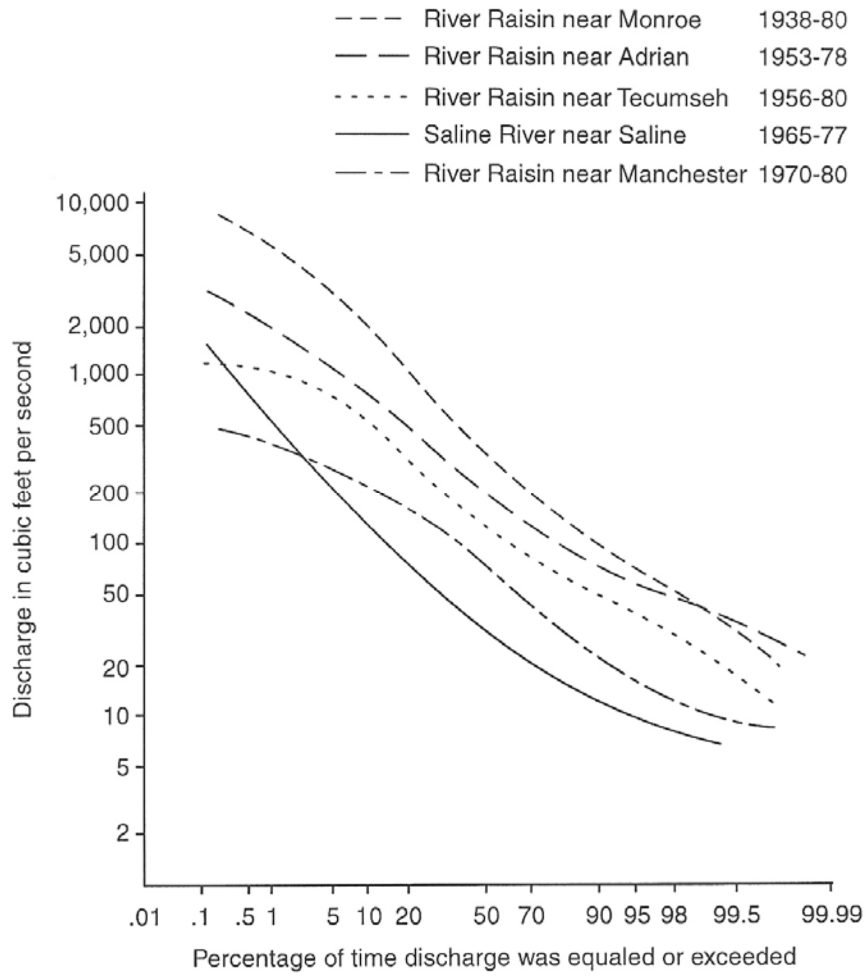


Figure 3-10 Flow duration curves for USGS gaging stations on the River Raisin (from: Dodge, 1998)

3.5.1 Flooding and Drainage

The Federal Emergency Management Agency (FEMA) administers the National Flood Insurance Program, which publishes Flood Insurance Rate Maps (FIRMs). The FIRMs identify areas within the 100-year floodplain, or areas that have a 1% chance of flooding in any given year. Areas within the 100-year floodplain are subject to more stringent regulations for development and provide an opportunity to maintain open space buffers to improve water quality.

It is impractical to attempt to completely prevent flooding or any damage due to flooding. It is estimated that inland flooding claims 133 lives and causes property losses that exceed four billion dollars in an average year in the U.S. (NOAA, 2008a). The National Weather Service's Advanced Hydrologic Prediction Service has developed a web-based suite of flood forecasting products that display the magnitude and uncertainty of the occurrence of floods from hours to months in advance. This is accomplished using computer models and various data sources such as super computers, automated gages, satellites, radars, and weather observation stations from which predictive information is presented graphically in numerous ways.

The Detroit/Pontiac National Weather Service office provides forecasting information for the River Raisin Basin from currently operating automatic gages near Manchester, Adrian and Monroe as well as from manual flow readings recorded near Dundee, Blissfield and Tecumseh. Information varies from each site depending on availability of data but can include: current flood-stage and flows, historical flood-crests, flood impacts at the site for specific flood heights, recently observed and forecasted flood-stage/flows and weekly exceedance probabilities for flows and river stage that are updated throughout the year. For instance, at the Monroe gage site a flood crest of 9 feet will begin to flood the Monroe YMCA and a flood crest of 9.5 feet will flood homes on the western edge of Monroe; historical floods at this site reached 12.10 ft on December 27, 1977 and a maximum record peak of 13.40 ft on February 14, 1984 (NOAA, 2008b).

3.5.2 Flashiness

Flow stability is vital for maintaining suitable fish and macroinvertebrate habitat in a riverine system. In the 1998 River Raisin Assessment, it was noted that flow in the Raisin becomes less stable proceeding downstream on the mainstem. This finding is also confirmed in the River Raisin Hydrologic Study by the MDEQ (Fongers, 2006). This study includes HEC-HMS modeling of subwatershed runoff for predevelopment conditions (circa 1800) and circa 1978 land use. The two most useful metrics for looking at the Raisin are yield – peak flow divided by watershed area and flashiness. Flashiness reflects the frequency and rapidity of short term changes in stream flow. The flashiness analysis was conducted using data from United States Geological Survey (USGS) stream gages on the Saline River near Saline, and Raisin River gages near Manchester, Tecumseh, Adrian and Monroe.

The HEC-HMS modeling simulated the impact of runoff changes due to changes in land use and loss of surface storage for the 2-year (bankfull) 24-hour (2.26 inches) Soil Conservation Service (SCS) Type II design storm event. The runoff modeling is based on the curve number method, an empirical relationship between rainfall, runoff and land use, soil types and antecedent moisture condition (soil wetness) developed by the former SCS (now NRCS). This modeling is essentially an analysis of land use change (refer to **Figure 3-11**).

The yield analysis results, shown in **Figure 3-12** below, clearly show that there are increases in yields even without any real increase in impervious surfaces. With the exception of the Monroe area there is an increase in yield moving downstream. The subwatersheds showing only a 0-100% increase in yield are in the Irish Hills area, including portions of Goose Creek, Iron Creek, Evans Creek and the Upper River Raisin. These are the areas with the lowest percentage loss of forest, wetland and grassland.

The flashiness analysis was calculated using the Richards – Baker Flashiness Index (Baker et al., 2004) and flow records from the three existing (Manchester, Adrian and Monroe) and the two retired USGS stream gages (Saline and Tecumseh). This index substantiates the increasing peak flow trend downstream identified by HEC-HMS and the impact of agriculture on flow regime. The index is calculated by dividing the sum of the absolute value of changes in day to day flow by the annual median daily flow. This index compares oscillations of flow relative to total flow. Values for this index can range from zero to two where zero represents constant flow and two represents high variability. The index value decreases with increase in watershed size. Baker et al., (2004) have computed the index values for 510 stream gages in Michigan, Ohio, Indiana, Illinois, Minnesota and Iowa and grouped index values by watershed size and index value. The lower quartiles represent stable and fairly stable streams, while the upper two quartiles represent somewhat and very flashy streams. The results of the flashiness analysis are shown in **Figure 3-13**.

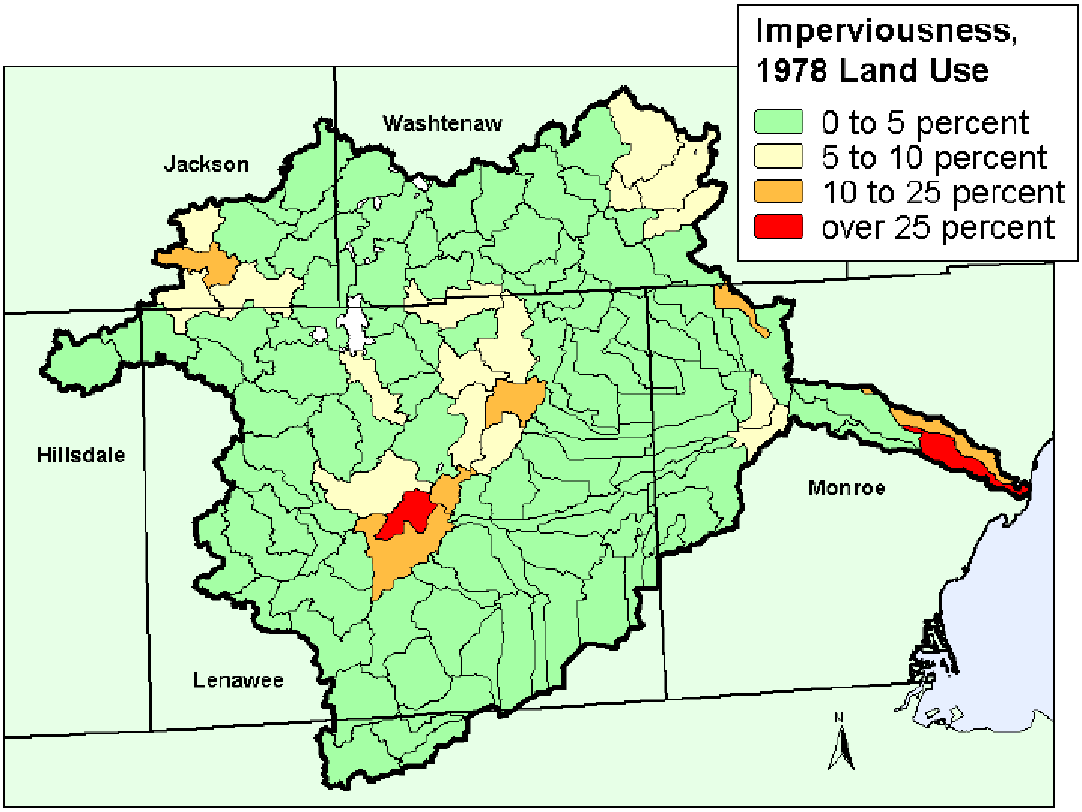


Figure 3-11 Impervious area fractions for 1978 land use (Fongers, 2006)

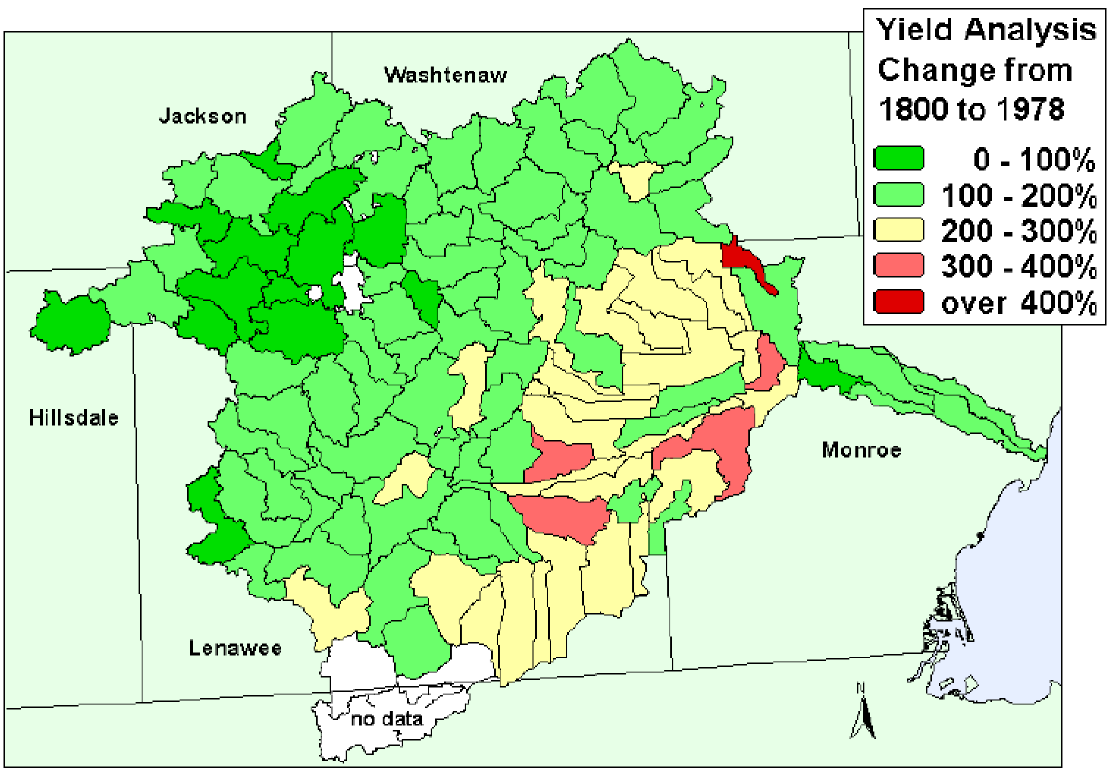


Figure 3-12 Estimated change in runoff yield from 1800 to 1978 (Fongers, 2006)

The flashiness trends and the ranking of the gage results within its watershed size category show a strong correlation with average agricultural land cover. This correlation is summarized in **Table 3-4** below. The upper watershed with the least conversion of natural cover into agriculture shows no or lowered flashiness trending and ranks in the lowest quartile for its watershed size class. For gages with a higher agricultural land use, the flashiness trends upwards and for the Monroe gage, ranks in the upper middle quartile of size class. Agricultural land kept dry with drain tiles and ditches clearly has an impact on stream hydrology.

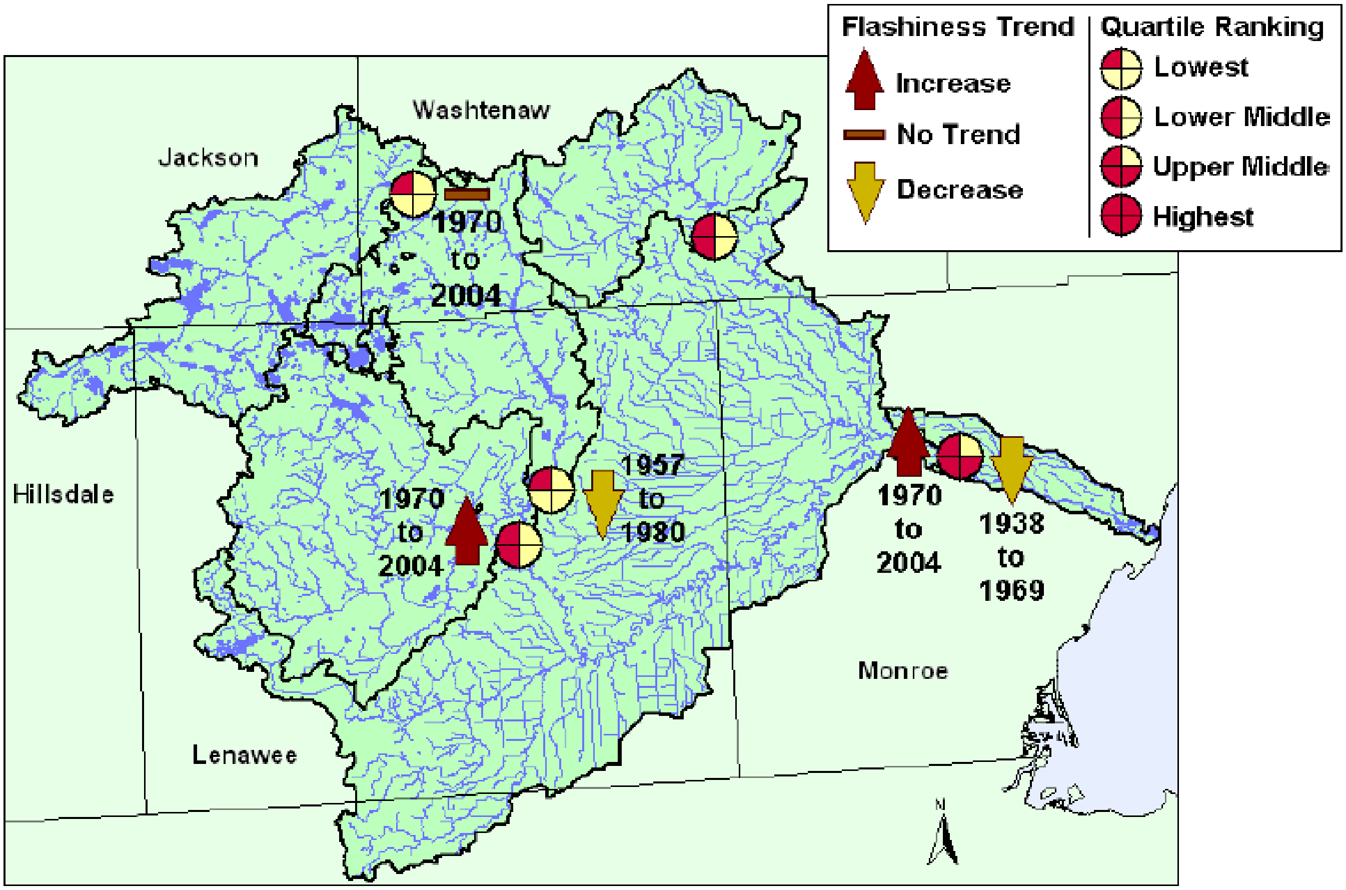


Figure 3-13 Stream flashiness index trends for River Raisin USGS gages (Fongers, 2006). Note: Quartile ranking based on Baker et al., (2004) analysis of 510 sites throughout Great Lakes states.

Table 3-4 Flashiness Trend Comparison with Agricultural Land Use Cover

USGS Gage	Period of Record for Analysis	Contributing Subwatersheds	Average Agricultural Land Coverage†			Trend in Flashiness	Quartile Ranking
			LOW	MED	HIGH		
Manchester	1970-2004	Goose Creek, Upper RR*	Goose Creek	Upper RR		Flat	Lowest
Tecumseh	1956-1980	Evans Creek, Iron Creek, Upper RR*, Lower RR*	Iron Creek	Evans Creek		↓	Lowest
Saline	1965-1977	Saline River*		Saline River		NA	Lower Middle
Adrian	1970-2004	South Branch RR		South Branch RR		↑	Lower Middle
Monroe	1970-2004	Black Creek, Little RR, Macon Creek, Saline River*, Lower RR*			Black Creek , Little RR, Lower RR, Macon Creek	↑	Upper Middle

* = partial subwatershed contributes to gage
† Average Ag Land Categories: LOW = 42%, MED = 69%, HIGH = 85%; River Raisin Watershed average = 75%

3.6 Channel Morphology

The shape of a stream or river is a complex result of many interacting factors of which there are two general classes: factors related to the debris load: its volume, particle sizes, lithology, amount, and depositional forms; and factors related to water flow (hydraulic factors). The water and debris carried within the channel carve the conduit in which they are contained. The channel is also self-adjusting, for if the timing and volume characteristics of its water or debris flows are altered by man, climate change, or by alteration of the protective vegetative land cover, the channel system will adjust to the new set of conditions (Dunne and Leopold, 1978).

Land cover on the River Raisin watershed has changed dramatically from a mostly forested to a mostly agricultural land use and this has affected the channel and its tributaries. Roads, bridges, culverts, and other channel modifications have also caused the channel to deviate from its pre-settlement form. Many of the highest gradient portions of the stream have been inundated by dams (**Figure 3-14**).

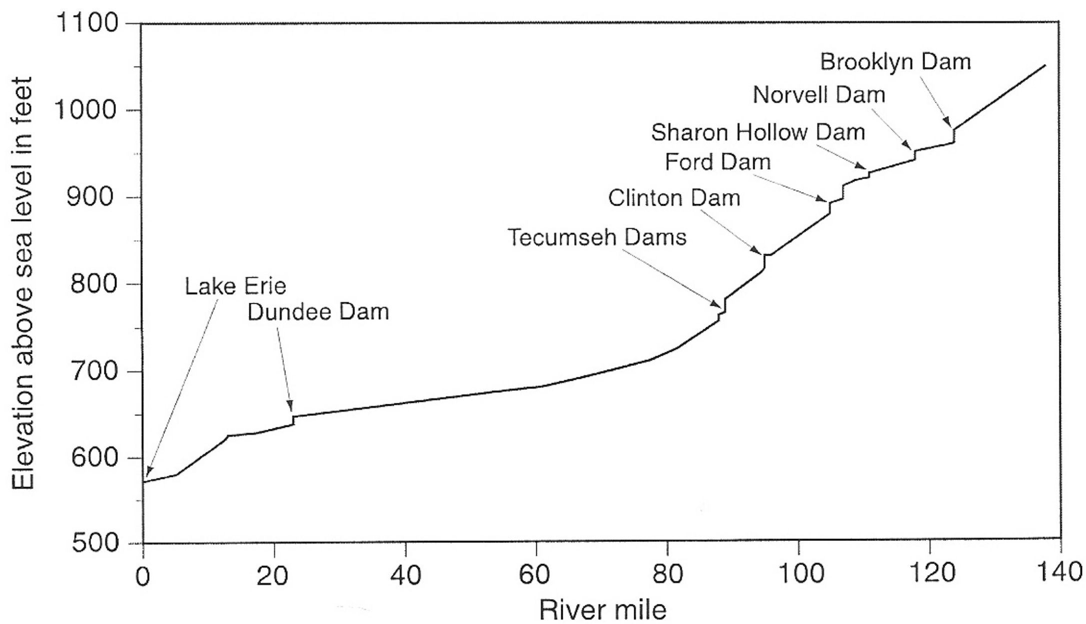


Figure 3-14 Elevation drop along the mainstem of the River Raisin (from Dodge, 1998)

The total drop of the mainstem River Raisin from the headwaters to the mouth at Lake Erie is about 475 feet, yet these gradients are not uniformly distributed (**Figure 3-15**). The average gradient of the mainstem is 3.2 feet per mile (ft/mi) with the highest gradient sections located in the headwaters and near Tecumseh and the lowest gradients between Tecumseh and Dundee.

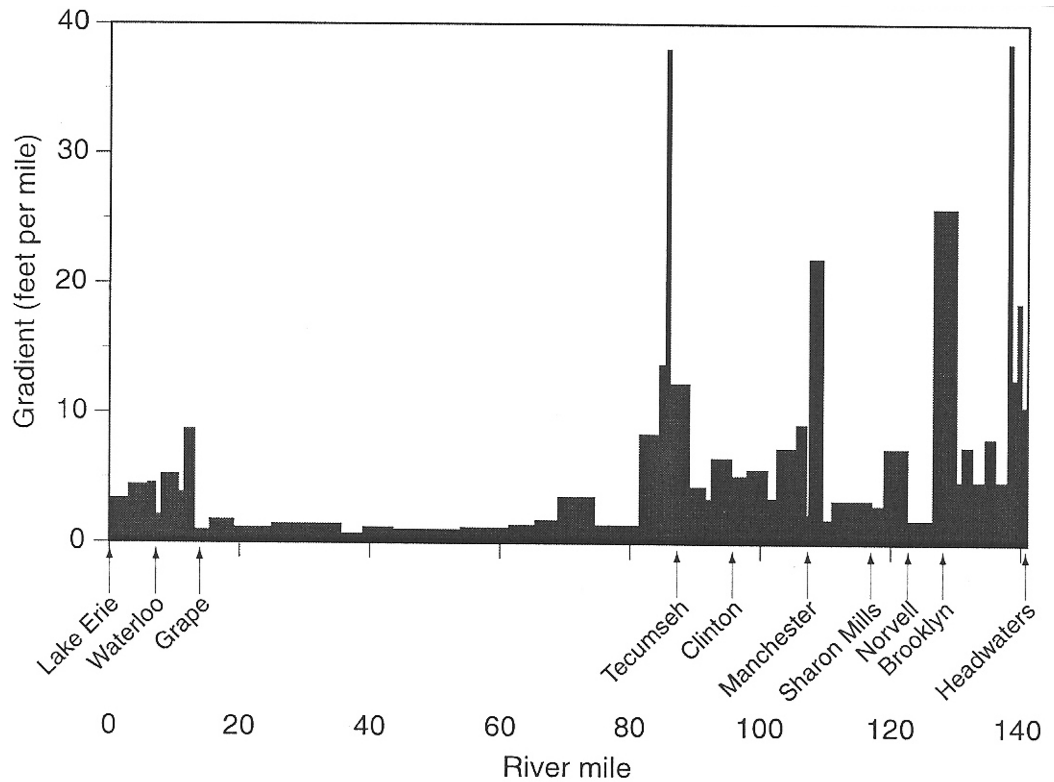


Figure 3-15 Gradient along the mainstem of the River Raisin (from Dodge, 1998)

Channel morphology of the River Raisin can be broken into three distinct sections moving from the headwaters to Tecumseh, from Tecumseh to Dundee, and from Dundee to Lake Erie. The following sections are derived from Dodge (1998) who used cross sections, topographic maps, aerial photographs, data from a Michigan DNR survey (1984) and his general knowledge of the stream to develop these reach descriptions.

3.6.1 Headwaters to Tecumseh

This 54-mile portion contains most of the highest gradient class habitat on the mainstem. This high gradient habitat is concentrated in the extreme headwaters and in relatively short stream stretches near Brooklyn, Manchester, and Tecumseh. Gradients of 3.0 - 9.9 ft/mi characterize 33.5 miles (62%) of this stream segment while gradients less than 3.0 ft/mi are found on only 14 miles (26%).

The extreme headwater segment upstream from Mercury Lake is narrow and channelized running through a heavily wooded corridor until entering Mercury Lake. The River Raisin then flows through a series of small lakes and wetlands at low gradients where banks are less well defined and covered with emergent vegetation. Below US-12 the mainstem has a short portion of higher gradient before entering another wetland area connected to Vineyard Lake. Impoundments in Brooklyn and Norvell Lake Dam slow the river into a flowing wetland with dense aquatic vegetation. The river meanders through bottomland hardwoods with increased gradients from Norvell Lake Dam to Tecumseh with some shallow, sediment laden impoundments in Sharon Hollow, Clinton, and Manchester.

3.6.2 Tecumseh to Dundee

This 69-mile middle portion of the river endures a very shallow nearly constant grade of less than 3.0 ft/mi. The 2-mile section of higher gradient is located immediately below the most downstream of the three impoundments in Tecumseh (Globe Mill Pond). The three dams at Tecumseh mark generally where the river drops from the morainal, northwest portion of the watershed to the old lake plain southeast portion. Stream flow is sluggish due to the low gradients, particularly during normal and low flow periods. From Tecumseh to Dundee the average gradient is only 1.3 ft/mi. This low gradient forms a meandering channel through bottomland hardwoods and farm fields with old oxbows cut-off by the river.

3.6.3 Dundee to Lake Erie

Gradient increases in this 25-mile lower portion of the river. Most of the gradient in this reach ranges between 3.0 and 9.9 ft/mi with the highest gradient near the mouth. The stream bed in most of this downstream section is composed of limestone bedrock. This rock bottom in combination with increased gradient produces improved game fish habitat compared to the low-gradient middle section.

At the confluence of the mainstem and Saline River, the channel of the mainstem meanders less and becomes excessively wide due to a change in bedrock composition from clay sand and silts, to gravel bedrock. This change in stream bottom combined with an increase in gradient creates excellent habitat for smallmouth bass which are abundant in the lower river. Near Monroe a portion of the river is lined with concrete retaining walls with small islands covered with grasses and marsh vegetation.

3.7 Water Quality and Quantity Impacts

The biggest change to impact water quantity and quality in the Raisin is the original conversion of forest, grassland and wetland to agriculture. The loss of canopy, understory and duff layer interception along with evapotranspiration, micro surface storage, and shallow and deep infiltration, irrevocably changed the land’s hydrologic cycle. Where the land once made the most efficient use of the water with little to no runoff, the land is now manipulated hydrologically to suit our needs. Where the land once seasonally flooded providing all of flooding’s benefits, such as peak flow shaving, vernal pool habitat, sediment and nutrient storage and conversion, etc., we now drain with subsurface drain tile and swale systems, also draining out nutrients, manure leachate, sediment and pesticides. These drainage systems, on a localized basis, can also draw down the groundwater table. All the effort put into controlling conditions in the fields has been at the expense of the waterways receiving field runoff and drain tile flows.

Much of the river began reacting to these massive hydrologic changes long ago in a variety of ways – some areas became sediment sinks (like dam impoundments) while other reaches are actively eroding, in some cases incising and acting as sediment sources in the river.

The Raisin was also impacted by point sources before passage of the Clean Water Act in 1973 and during the two-decade period following passage and implementation of the National Pollutant Discharge Elimination System (NPDES). NPDES helped create, manage and enforce water quality standards that profoundly cleaned up many point sources and receiving waters across the country. Other legacies, such as dam building, river re-routing and withdrawal, along with massive pollutant leaks and dumping have taken their toll on the Raisin.

The Raisin is now facing the new leading cause of pollution nationally: non-point pollution. The diffuse nature of the non-point sources is a barrier to reacting to them. They are harder and more expensive to manage when they are essentially everywhere, rather than conveniently located in a few pipes. Now every septic system, every drain tile, every yard is a potential culprit.

Three watershed communities, Adrian, Blissfield, and Deerfield (via Blissfield), get their drinking water from surface water intakes on the Raisin even though 49 NPDES point-source dischargers have been identified in the watershed. Source water protection plans have been completed for Blissfield and Deerfield. Basically, the source water protection areas cover the entire upstream contributing areas.

3.7.1 TMDLs/303d Listings

The TMDL/303(d) listed waterbodies are central to the development of the River Raisin Watershed Management Plan (RR WMP). Lifting the TMDL/303(d) impairments is the primary goal of this plan. The Section 303(d) list includes Michigan water bodies that are not attaining one or more designated uses and require the establishment of Total Maximum Daily Loads (TMDLs) to meet and maintain Water Quality Standards (WQS).

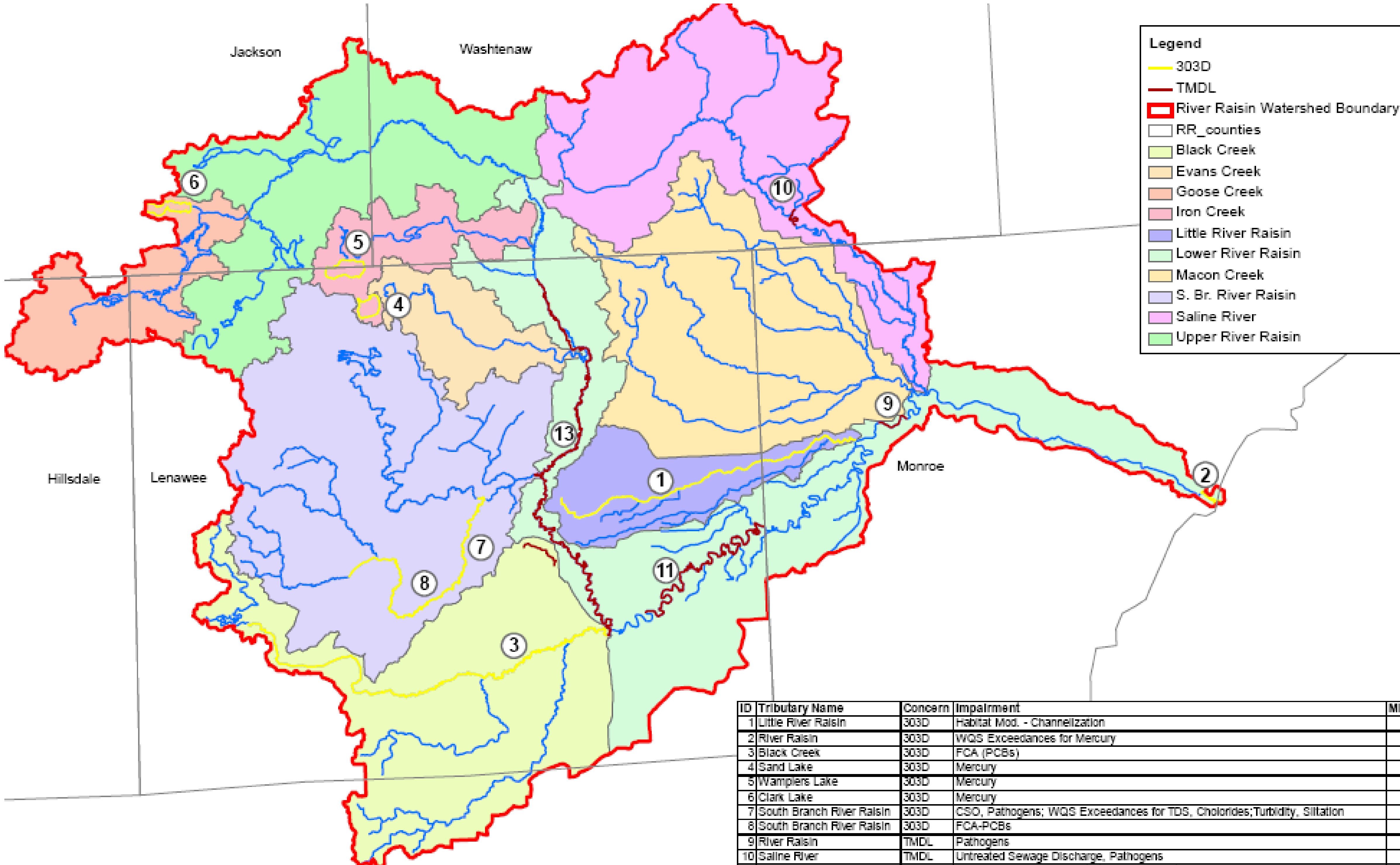
When a lake or stream does not meet WQS, a study must be completed to determine the amount of a pollutant that can be put in a waterbody from point sources and nonpoint sources and still meet WQS, including a margin of safety. The TMDL acronym is a short hand description of the process used to determine how much pollutant load a lake or stream can assimilate. WQS are state rules established to protect the Great Lakes, connecting waters, and all other surface waters of the state. These rules define the water quality goals for a lake or stream. TMDLs are required by the federal Clean Water Act for waterbodies that do not meet WQS. The maximum daily load of a pollutant is allocated to point source discharges and non-point source discharges, along with a margin of safety reserve to account for uncertainties. **Table 3-5** below summarizes the waterbodies within the River Raisin watershed that are on the 303(d) list and **Figure 3-16** shows their location.

3.7.2 AOC

In 1987, amendments to the Great Lakes Water Quality Agreement were adopted by the federal governments of the US and Canada. The amendments included 14 Areas of Concern (AOC) in Michigan that do not meet the objectives of the Agreement. The River Raisin AOC has been defined as the lower (2.6 miles) portion of the river, downstream from the low head dam at Winchester Bridge in the City of Monroe, extending one-half mile out into Lake Erie. The River Raisin has nine of the 14 possible Beneficial Use Impairments (BUIs), including:

- Restrictions on fish and wildlife consumption
- Degradation of fish and wildlife populations
- Bird or animal deformities or reproductive problems
- Degradation of benthos
- Restrictions on dredging activities
- Eutrophication or undesirable algae
- Beach closings
- Degradation of aesthetics
- Loss of fish and wildlife habitat

These impairments have been primarily caused by historical discharges of oils and grease, heavy metals, and polychlorinated biphenyls (PCBs) to the river from industrial facilities in the area. Additionally, industrial and municipal waste disposal sites adjacent to the river are suspected of contaminating the river and have caused significant loss of fish and wildlife habitat (**Figure 3-17**). The BUIs provide a tool for describing effects of the contamination and for focusing remedial actions. The priority remedial actions include remediation of PCB-contaminated sediments, upstream non-point source pollution control, and elimination of upstream combined sewer overflows (CSOs).



ID	Tributary Name	Concern	Impairment	Miles
1	Little River Raisin	303D	Habitat Mod. - Channelization	64
2	River Raisin	303D	WQS Exceedances for Mercury	1
3	Black Creek	303D	FCA (PCBs)	27
4	Sand Lake	303D	Mercury	2
5	Wamplers Lake	303D	Mercury	2
6	Clark Lake	303D	Mercury	2
7	South Branch River Raisin	303D	CSO, Pathogens; WQS Exceedances for TDS, Cholorides;Turbidity, Siltation	4
8	South Branch River Raisin	303D	FCA-PCBs	10
9	River Raisin	TMDL	Pathogens	1
10	Saline River	TMDL	Untreated Sewage Discharge, Pathogens	1
11	River Raisin	TMDL	WQS Exceedances for Nitrates & CSO, Pathogens	16
12	Lenawee County Drain #70	TMDL	Untreated Sewage Discharge, Pathogens	1
13	River Raisin	TMDL	Untreated Sewage Discharge, Pathogens	8

Figure 3-16 Map of River Raisin 303(d) and TMDL Areas (figure by Stantec)

Table 3-5 River Raisin TMDLs and 303D-Listed Segments

Waterbody	County	Location	Problem Summary	Impaired Use	Miles Affected
TMDLs					
River Raisin	Lenawee	Lenawee County Line upstrm to Blissfield	Nitrate WQS exceedances, CSO, pathogens	Public Water Supply, Partial and total body contact recreation	16
River Raisin	Lenawee	Tecumseh, upstrm to Clinton	Untreated Sewage, pathogens	Partial and total body contact recreation	8
River Raisin South Branch	Lenawee	River Raisin confluence upstrm to Adrian WWTP	CSO, pathogens	Partial and total body contact recreation	4
River Raisin	Monroe	Dundee, dwnstrm 1 mile	Pathogens	Partial and total body contact recreation	1
Saline River	Washtenaw	Near Mooreville, Sec. 28 York Twp.	Untreated Sewage, pathogens	Partial and total body contact recreation	1
Lenawee County Drain 70	Lenawee	Trib. to Big Meadow Creek, w. of Palmyra Twp., upstrm to Manor Farms	Untreated Sewage, pathogens	Partial and total body contact recreation	1
AWAITING TMDLs					
Little River Raisin	Monroe	River Raisin confluence, upstrm to headwaters, includes tribs	Habitat modification - channelization	Other indigenous aquatic life & Wildlife/aquatic habitat	64
River Raisin South Branch	Lenawee	River Raisin confluence, upstrm to Adrian WWTP	siltation, WQS exceedances for TDS, turbidity	Aquatic life & Wildlife/aquatic habitat	4
Black Creek	Lenawee	River Raisin confluence to Lake Hudson outlet	Fish consumption advisory - PCBs	Fish consumption	27
River Raisin Watershed	Monroe	Entire Watershed, including tributaries	PCB WQS exceedances	Fish consumption	692
River Raisin South Branch	Lenawee	River Raisin confluence upstrm to Carlton Rd. near Adrian	Fish consumption advisory - PCBs	Fish consumption	10
Clark Lake	Jackson	NW of Brooklyn	Fish Tissue - Mercury	Fish consumption	580
River Raisin	Monroe	Monroe, near mouth ERA dock and 1 mile upstrm	Fish Tissue - Mercury	Fish consumption	1
Sand Lake	Lenawee	8 mi. w. of Clinton	Fish Tissue - Mercury	Fish consumption	440
Wamplers Lake	Jackson/Lenawee	Near Oak Shade Park	Fish Tissue - Mercury	Fish consumption	780
Lake Erie (Michgan Jurisdiction)	Monroe/Wayne	Lake Erie waters under Michigan jurisdiction	Fish consumption advisory - PCBs, TCDD Dioxin	Fish consumption	115

(Shaded) Requires follow-up sampling to determine if reach can be de-listed

Figure 3-17 River Raisin Area of Concern (USEPA, 2008a)

As of June 2007, over $154,000,000 has been invested in remediation and restoration projects in the River Raisin AOC. The primary remediation work was completed in 1997. Fish cage studies, where fish in open cages are anchored in-stream for 28 days, have shown a decreasing trend in fish tissue update of PCBs (See **Figure 3-18** below) at the mouth. Low level uptake of chlordane, dichloro-diphenyl-trichloroethane (DDT) and heptachlor epoxide (HPE) was measured at some sites suggesting some remnant sediments are still contributing low concentrations of these banned and discontinued pesticides.

It is worth noting that the most recent fish uptake studies (2004) showed higher uptake of PCBs at the mouth of the River Raisin than in the Kalamazoo and Saginaw Rivers, other PCB-polluted rivers in Michigan. In addition, the Michigan Department of Environmental Quality Water Chemistry Monitoring Project (WCMP) showed that the highest PCB concentrations of the 31 Michigan sites were found in the Raisin AOC. For more information on the River Raisin AOC see: **[**http://www.epa.gov/glnpo/aoc/rvraisin.html] .

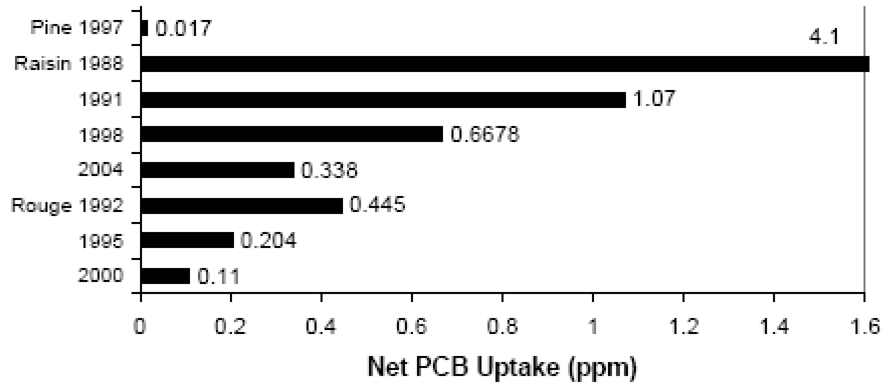


Figure 3-18 PCB Uptake in Caged Fish Studies at the mouth of the River Raisin (excerpted table from MDEQ, 2005)

The River Raisin Public Advisory Council (PAC), a standing sub-committee under the City of Monroe Commission on the Environment and Water Quality has developed delisting targets for the Loss of Fish and Wildlife Habitat and the Degradation of Fish and Wildlife Populations BUIs. For more information on the targets refer to the document: “Delisting Targets for Fish/Wildlife Habitat & Population Related Beneficial Use Impairments for the River Raisin Area of Concern,” (ECT, 2008) in the **Water Quality (MDEQ Folder) Appendix**

3.7.3 Agriculture

The most commonly grown crops in the River Raisin watershed are corn, soybeans, wheat, and vegetables. Lenawee County ranks first in Michigan for corn (for grain) production, second for soybeans, and third for wheat (NASS, 2005). Lenawee County farmers typically practice one of three main types of crop rotation according to soil type and access to markets. In the Macon Creek and Black Creek sub-watersheds, a three-year rotation of corn, soybeans and then wheat is practiced. The typical strategy in the South Branch sub-watershed is a five-year rotation of corn, soybeans, corn, soybeans, then wheat. Most common in the flatter lakeplain portions of the watershed (including the Little and Lower River Raisin sub-watersheds), is a three year rotation of one year each of corn, soybeans, and wheat.

Corn requires a high concentration of fertilizer (both nitrogen and phosphorous) and so is relatively expensive to grow. The Lenawee Conservation District (LCD) recommends using just the amount of fertilizer that the crop will actually take up (about 1.2 pounds of nitrogen per bushel of corn, or about 156-216 pounds per acre) because they have not seen much increase in production with an increase in fertilizer use.

Soybeans are slightly cheaper to produce than corn because they require fewer inputs, and they are also important for fixing nitrogen in the soil. Vegetable farms are less common because they require highly productive alluvial soil found mainly in the Lower River Raisin sub-watershed around the city of Blissfield in the eastern part of Lenawee County. This soil is very wet and requires intensive tiling every 30-50 feet.

Soil erosion is one of the top concerns for farmers in Lenawee County. The most erosive soils for the county are located in the South Branch and Black Creek sub-watersheds where the slope is 3-7%. This silty-clay soil requires more tiling to enhance production. In row cropping agriculture, riparian areas are often cleared to remove sources of weeds, reduce competition with crops for resources, allow easy operation of farm equipment and remove habitat suitable for wildlife that may damage crops. Once cleared, these areas generally have reduced infiltration caused by decreases in evapotranspiration and the destruction of soil pore openings due to rain drop impact. This affects the way water moves into the stream with less water moving through the soil profile and more flowing overland directly into the river. Removal of riparian vegetation also increases sunlight entering the channel resulting in increased water temperatures and aquatic plant growth.

In the River Raisin watershed like much of the upper Midwest, agricultural changes over the last few decades have drastically changed nitrogen management. These changes include the use of less diversified crop rotations, separation of crop production and animal enterprises, changes in tillage intensity, drainage of agricultural fields and increased use of manufactured nitrogen fertilizers (Dinnes et al., 2002). The bulk of the agricultural nitrogen problem can be traced to the over-application or ill-timed application of animal manure or commercial fertilizer. The over-application provides too much plant available nitrogen and increases the potential for nitrogen leaching. Most nitrogen that leaches from agricultural fields is in the form of nitrate (NO_3). With subsurface drainage, tillage to prepare the seedbed and the change from perennial to seasonal vegetation, the potential for mineralization (conversion from soil/plant residue to plant-available, soluble form) of nitrogen from stored organic matter and nitrogen loading to surface water has increased dramatically (Dinnes et al., 2002).

Continuous corn production has repeatedly been identified as providing the greatest amount of NO_3 to streams through subsurface drainage (Kanwar et al., 1993; Reed et al., 2001). Baker (1975) found the average NO_3 concentrations in subsurface drainage water from corn-soybean and corn-oat rotations to be 21 mg/L. Jaynes et al., (1999) reported that flow-weighted NO_3 concentrations were often greater than 10 mg/L and that on a mass basis, NO_3 losses ranged between 4 to 66 kg/ha/yr. The variation in NO_3 among years was directly linked to variation in annual precipitation.

3.7.4 Point Sources, including CAFOs

The Michigan Department of Environmental Quality (MDEQ) regulates point source discharges through the National Pollutant Discharge Elimination System (NPDES) permit program. The NPDES permit process was initiated by the Federal Water Pollution Control Act amendments of 1972. The purpose of the program is to control the discharge of pollutants into surface waters by imposing effluent limitations to protect the environment. Point source discharges are typically from publicly owned treatment works (POTWs), Concentrated Animal Feeding Operations (CAFOs), or industrial discharges. There are currently 49 NPDES discharge permits including CAFOs issued in the River Raisin watershed as shown in **Figure 3-19**.

The issuance of an NPDES permit or certificate of coverage does not authorize violation of any federal, state or local laws or regulations, nor does it obviate the necessity of obtaining such permits, including any other MDEQ permits, or approvals from other units of government as may be required by law. An NPDES permit requires that management practices be implemented at the site and that water quality be monitored on an ongoing basis. For example, CAFOs are required to have a manure management plan and POTWs are required to perform ongoing water quality monitoring.

In June 2004, the MDEQ began issuing general and individual NPDES permits to regulate new, large CAFOs in Michigan. CAFO rules were enacted in 2005, and a new revised CAFO general permit was developed by the MDEQ in November 2005 with input from a stakeholder group. A CAFO can choose to operate under an individual permit or the general permit. In either case, a Nutrient Management Plan must be developed for each facility.

A CAFO is an Animal Feeding Operation (AFO) that meets a threshold number of animals to be defined as a large CAFO (see **Agriculture Appendix**) or meets the method of discharge criteria by either: 1) discharging manure or wastewater directly to surface water through a pipe or ditch, or 2) allowing animals to come into contact with surface water that flows through the area where they are confined. In addition, even if an AFO does not meet these criteria, it may still be designated a CAFO by the regulatory authority if it is determined to be a significant contributor of pollutants. An operation must meet the definition of an AFO before it can be defined or designated as a concentrated animal feeding operation (CAFO). The State of Michigan implements and enforces the CAFO requirements to minimize impacts on water quality.

An AFO is an agricultural operation where animals are kept and raised in confined situations. AFOs generally congregate animals, feed, manure, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures. Animal waste and wastewater can enter water bodies from spills or breaks of waste storage structures (due to accidents or excessive rain), and non-agricultural application of manure to crop land. AFOs that meet the regulatory definition of a concentrated animal feeding operation (CAFO) have the potential of being regulated under the NPDES permitting program (See **Figure 3-20**).

To evaluate the overall effectiveness of the MDEQ's NPDES permit for new, large CAFOs in protecting the designated uses of adjacent surface waters, the MDEQ Water Bureau designed and began implementing a comprehensive water quality project that involves monitoring a suite of biological, chemical, and physical indicators at multiple sites. As part of this project, monitoring studies are currently underway at two new, large CAFOs that meet the project's monitoring candidate selection criteria. (MDEQ 2006d.).

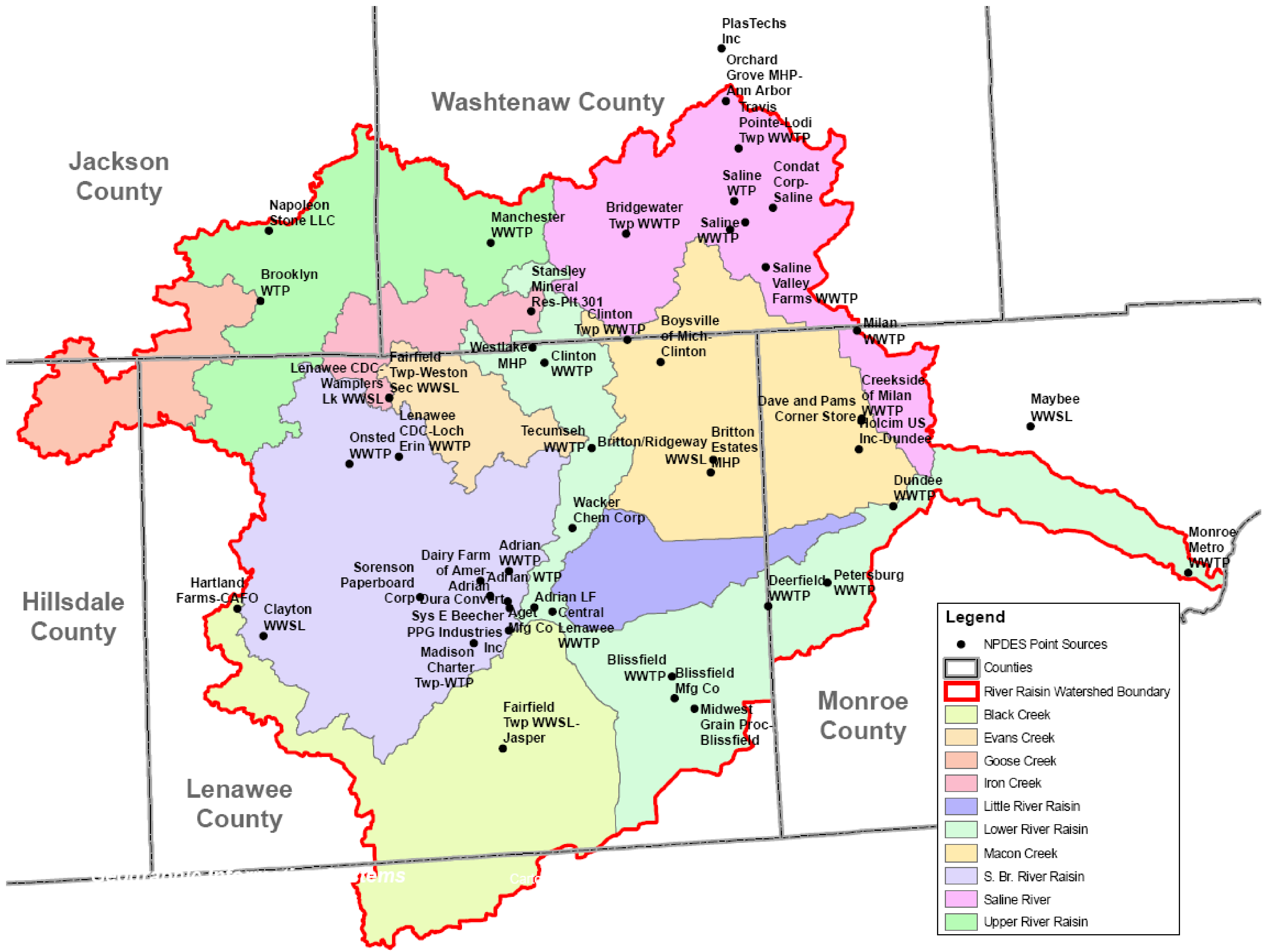


Figure 3-19 NPDES Point Source Permit Map

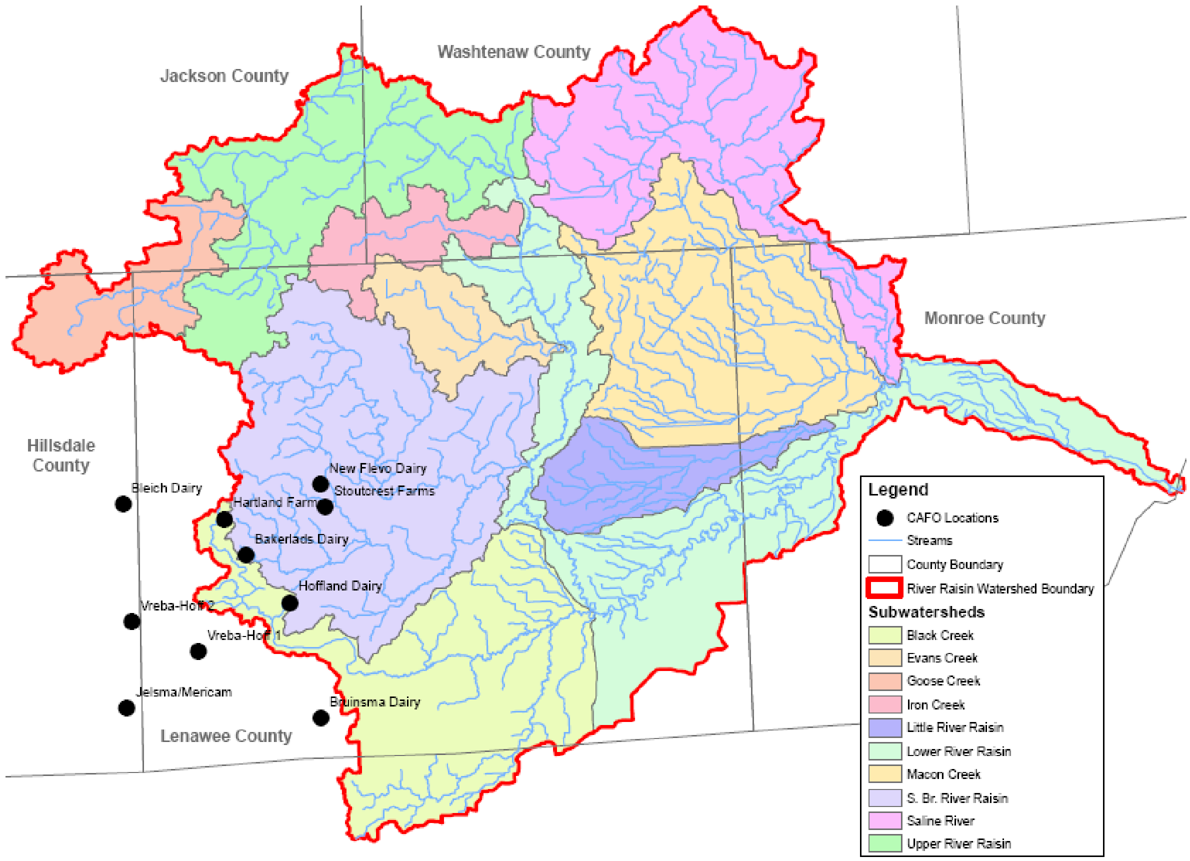


Figure 3-20 Concentrated Animal Feeding Operations Map

3.7.5 Consumptive Water Use

Fulcher et al., (1986) prepared a study on the effects of consumptive uses on drought flows in the River Raisin. Fulcher noted that since 1971 significant increases in irrigation had occurred in the watershed. In 1984 agricultural and golf course irrigation needs together required an average daily withdrawal rate of 9.16 cfs. Annual irrigation consumption for agricultural and golf courses has averaged a fairly constant daily rate from 1991-2004 of 4.8 cfs (see **Figure 3-21** below). Withdrawals for public water supplies rose from an average daily rate of 13.4 cfs in 1984 to an average of 28.8 cfs over the period from 1997 to 2004. Industrial uses rose from a daily average of 11.3 cfs in 1984 to an average of 16.7 from 1997 to 2002 and then abruptly dropped to a daily average of 3.4 cfs in 2003-2004. The total daily average withdrawal in 1984 of 33.9 cfs rose to a peak withdrawal of 53 cfs in 1998-1999 and has since fallen back to 38 cfs in 2006 (MDEQ, 2007b).

While these total consumptive withdrawals can exceed low flows almost all the public and industrial water withdrawals are returned to the river, albeit as wastewater. Except for the Detroit Edison power plant at the mouth (see next section), total net water loss is less than the lowest recorded flows in the Raisin (refer to **Section 3.5**). With the threat of global warming this may not always be the case.

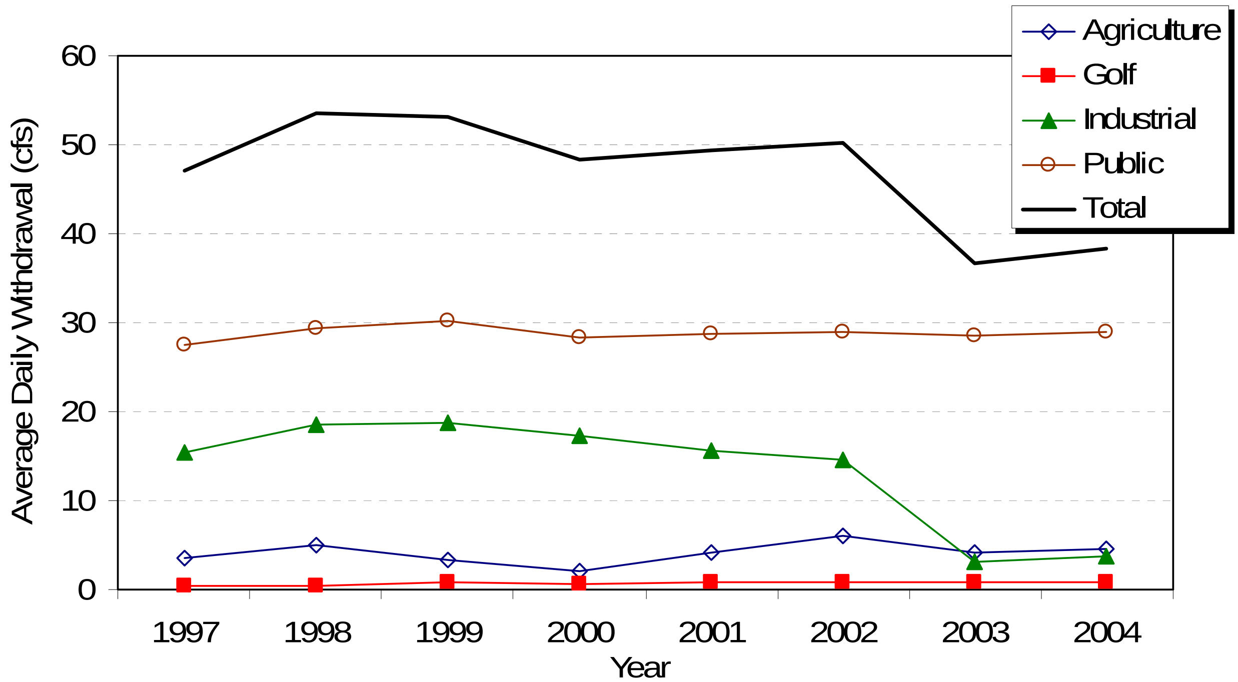


Figure 3-21 Average Annual Daily Reported Water Consumption (total surface water and groundwater withdrawals) in the River Raisin Watershed (MDEQ, 2007b)

Detroit Edison (DTE)

The Monroe Power Plant is DTE's largest producer of electricity and the second largest coal-fired plant in the Midwest. The plant can produce 3,200 Megawatts of electricity a day which is equal to about 40 to 45% of DTE's total power generation for its 1.8 million customers in Southeast Michigan. The Monroe plant is also the largest source of emissions among all of DTE's fossil-fueled power plants. In advance of requirements set in the 2005 Clean Air Interstate Rule and Clean Air Mercury Rule, DTE installed two flue gas desulphurization units (scrubbers) and one selective catalytic reduction unit that controls 97% of sulfur emissions and 80% of mercury emissions.

The enormous amount of energy produced in the plant requires large amounts of water for steam, as a cooling medium and for cleaning. The plant's peak cooling requirement of up to 3,000 cfs greatly exceeds the annual mean flow of the River Raisin of 741 cfs (Blumer et al., 1996). For withdrawals that exceed the Raisin's flow, Lake Erie water is drawn upstream to the plant essentially reversing the flow of the river (Dodge, 1998) (see **Figure 3-22**). Water withdrawn that is used for cooling is then returned to receiving waters near the plant. The Monroe Power Plant does have one of its discharge outputs flowing directly into the River Raisin yet these flows do not require a mixing zone because the quality of the discharge itself is equal to or better than WQS.

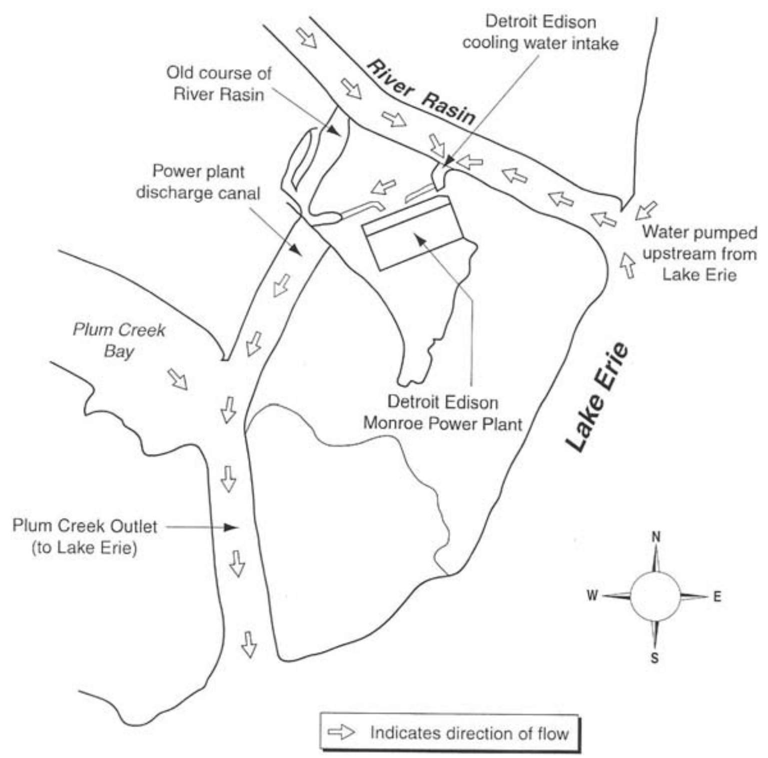


Figure 3-22 Schematic of Detroit Edison's Monroe Power Plant cooling water intake and aerial photograph of plant (circa 1981) (Dodge, 1998)

3.7.6 On-site wastewater treatment

Septic systems are waste water treatment systems that use septic tanks and drain fields to dispose of sewage in soil. They are typically used in rural or large lot settings where a sanitary sewer is not available. It is important to maintain and inspect septic systems. A failure of a septic system can cause serious problems for both humans and animals. Pollution from failing septic systems can contaminate ditches, creeks and shallow drinking water supplies. In addition to public health concerns, there are costly repair bills to fix or replace the system. Normal use of the system is interrupted while the system is uncovered for repairs or replacement. **Figure 3-23** shows the locations of existing sewer and water service areas. It is safe to assume that all development outside of these areas is served by wells for drinking water and septic systems for wastewater management.

3.7.7 Underground Storage Tanks

Leaking underground storage tanks (LUSTs) can always pose a threat to water quality. Typically, LUSTs are a result of resource management practices before the USEPA outlined regulations for constructing, inspecting, and maintaining underground storage tanks. There are 55 environmental contamination sites and 142 LUST sites in the River Raisin watershed. However, none of these sites are listed on the USEPA's list of superfund sites (**see MDEQ LUST website: http://www.deq.state.mi.us/sid-web/**). As feasible, these sites should be managed and ultimately cleaned up.

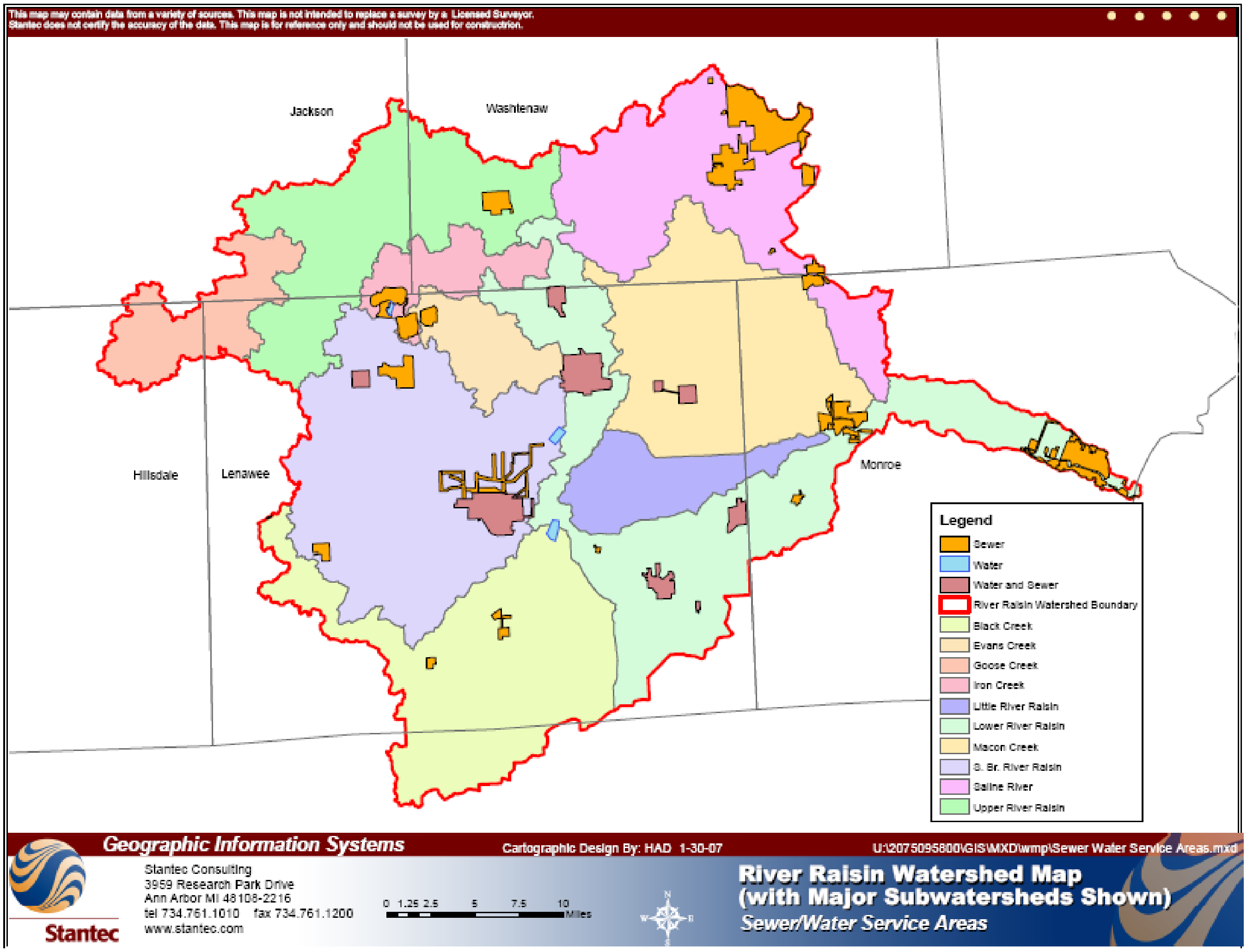


Figure 3-23 Sewer and Water Service Areas in the River Raisin Watershed

3.8 Watershed Fauna

3.8.1 Fish

The River Raisin historically contained several potamodromous fish species that migrated from Lake Erie into the river including sturgeon, muskellunge, walleye, pike, white bass, mullet, and possibly whitefish and lake trout (Dodge, 1998). During the mid to late 1800's and early 1900's paper mills and other industrial and municipal sources discharges affected local fish populations. This effluent combined with dam construction, intense agriculture, urban land use, and municipal and agricultural withdrawal also affected local fish populations. Dams were especially harmful, altering stream temperature patterns and flow regimes while also blocking access of potamodromous fish to spawning habitat and concentrating subsequent runs below the dams increasing their vulnerability to harvest. Before implementation of the Federal Clean Water Act in the 1970's point discharges in the River Raisin were at least partly responsible for the elimination of one-third of the fish species below Clinton and Tecumseh and about one-half the fish species immediately below Adrian (Dodge, 1998).

Smallmouth bass

At least 90 fish species are now found in the River Raisin watershed, distributions of which range from basin wide to localized populations;

eleven non-indigenous fish species have been introduced in the watershed (Dodge, 1998). Common species in the basin include sunfishes, darters, catfishes, suckers, pike, carp and smallmouth bass. Researchers from the University of Michigan collected over 3000 fish from 18 sites in the River Raisin watershed in the late 1990's. 75% percent of the individuals captured were made up of six species with the creek chub being the most abundant, captured at 17 of 18 sites. Twenty-eight species in total were collected, half of which were species that made up less than 1% of the catch (Lammert and Allan, 1999). Results of a 1984 MDNR survey found smallmouth bass populations were highest in the higher gradient river segments near Manchester and near Monroe and lowest in the low-gradient mid-section near Blissfield (Dodge, 1998).

3.8.2 Mussels

Mussels are used as indicators of aquatic environmental quality because they are immobile and are especially sensitive to pesticides, metals, and other contaminants. Additionally, declines in mussel populations can reveal declines in fish populations because mussels depend on host fish species during their larval stage. Historical records dating to the 1920s indicate 29 known species of mussels throughout the River Raisin watershed (Strayer, 1979); the current state of mussel species is fairly good given the alterations that have occurred in the watershed. In the summers of 2000 and 2001, Kopplin (2002) searched forty sites across the watershed and found 21 mussel species, with two species showing expansion of their historical ranges and five species showing significant range declines. Additionally, mussel abundance, richness, and diversity were all greater in the upper- and mid-portions of the basin than in the lakeplain region. The mussel declines that have occurred are attributed to increased instream sediment loading from agriculture and urban development.

Freshwater mussels

3.8.3 Amphibians

The class Amphibia includes frogs, toads, salamanders, newts and caecilians. They are cold-blooded, using the environment to regulate their body temperature and most are bound to fresh water for reproduction. Many amphibians begin life with gills developing lungs as they age, have glandular skin without external scales and have eggs that develop without formation of extra-embryonic membranes. Dramatic declines in amphibian populations, some in areas where they were recently abundant, have been noted in the past two decades from locations all over the world. This includes relatively pristine, undisturbed habitat. A number of causes may be involved including: habitat destruction, over-exploitation, pollution, introduced species, climate change and diseases like chytridiomycosis (an infectious disease caused by the chytrid fungus). At the same time, amphibian populations are stable and growing in other regions leading to continued research to determine why some populations are declining while others are not.

Twenty amphibian species are found in the River Raisin Watershed including eight species of salamander and twelve species of frogs and toads. The smallmouth salamander (*Ambystoma texanum*), is listed as endangered in Michigan, and The Michigan Natural Features Inventory lists the Blanchard's cricket frog (*Acris crepitans blanchardi*) as a species of special concern (Dodge, 1998). The distribution of the smallmouth salamander ranges from Ohio west through eastern Nebraska and as far south as Texas. They exist in lowland floodplain woodlands and can breed in woodland vernal ponds, runoff ponds, flooded areas, river backwaters, and roadside ditches. Blanchard's cricket frog is found from Southwestern Ontario, Michigan, and Ohio west to Nebraska and

Blanchard's cricket frog

south to include most of Texas, yet has almost disappeared from much of the Northern portion of its range. They prefer water sources with an open canopy that have plenty of low emergent vegetation and may inhabit ponds, ditches, wet prairies, marshes and fens in close proximity to permanent or flowing water with soft muddy bottoms to hibernate in through the winter. Random events such as droughts, floods or wetland contamination can place local populations in jeopardy.

3.8.4 Reptiles

Reptiles are air-breathing, cold-blooded vertebrates that have skin covered in scales and most lay amniotic eggs covered with calcareous or leathery shells. Modern reptiles inhabit every continent with the exception of Antarctica and their habitat varies greatly from one species to the next. Like amphibians, reptiles often make their home around water and lay eggs, yet reptiles tend to lay their eggs on land whereas amphibians generally lay their eggs in water.

Blanding's turtle

Twenty-seven reptile species are found in the River Raisin Watershed, five of which are listed by the Michigan Natural Features Inventory as species of special concern including: the Blanding's turtle (*Emydoidea blandingii*), eastern box turtle (*Terrapene carolina*), spotted turtle (*Clemmys guttata*), black rat snake (*Elaphe obsoleta obsolete*) and eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*) (Dodge, 1998). The spotted turtle and Blanding's turtle are semi-aquatic turtles found in marshes, the shallow bays of lakes and reservoirs, slow moving streams, backwater sloughs and along the water's edge in brush piles, overhanging vegetation and sphagnum; while the eastern box turtle is found in a wide variety of habitats from wooded swamps to dry, grassy fields preferring moist forested areas with plenty of underbrush. Black rat snakes and the eastern massasauga rattler are usually found in river bottoms, swamp margins, hardwood forests and in nearby fields.

The River Raisin Watershed also contains the eastern fox snake (*Elaphe vulpina gloydi*), listed as threatened in Michigan as well as the Kirtland's snake (*Clonophis kirtlandii*) which is listed as endangered (Dodge, 1998). The Eastern fox snake inhabits marshland bordering western Lake Erie and the rocky shores of Lake Erie islands. The Kirtland's snake shows a preference for wet meadows, and is also found in open swampy woodlands spending much of the time underground, frequently using other animal burrows.

3.8.5 Mammals

There are very few rare mammals in Michigan — the Michigan Natural Features Inventory only lists ten, one of which (eastern cougar) is listed as extirpated (Michigan Natural Features Inventory, 1999). The only species listed as Federally Endangered is the Indiana bat (*Myotis sodalis*). Indiana bats spend their winters in caves of southern Indiana and Ohio and northern Kentucky and summer mostly in riparian and wetland forests scattered around the upper Midwest. Maternal colonies have been confirmed in at least two places along the River Raisin within the last ten years, highlighting the importance of intact riparian forest for this very rare species.

Another bat species that is common in North America but reaches its northern limit in Michigan is the evening bat (*Nycticeius humeralis*). Until recently, this species was only known from a few individuals collected in southeastern Michigan, and these were assumed to be vagrants that had lost their way. In 2004, a maternal colony was discovered along a small tributary of the River Raisin near Palmyra (Kurta, 2005).

3.8.6 Birds

The headwaters of the River Raisin has been identified as a high-priority conservation target for its prime stopover habitat for migratory birds. An analysis of the Western Lake Erie basin by Ewert et al., (2005) investigated habitat characteristics of portions of 32 counties in Michigan and Ohio and ranked land area according to its value as a stopover site for migratory waterfowl, shorebirds, raptors, landbirds and waterbirds. The Upper River Raisin contained the highest quality and most abundant habitat patches of any inland area suitable for birds in all of the above categories. This habitat is especially important for Michigan's threatened and endangered species such as the short-eared owl (*Asio flammeus*), red-shouldered hawk (*Buteo lineatus*), osprey (*Pandion haliaetus*), common loon (*Gavia immer*) and trumpeter swan (*Cygnus buccinator*). This high-priority area is concentrated in the portion of the watershed contained by Jackson County, but includes smaller contiguous areas of Hillsdale, Lenawee, and Washtenaw Counties.

3.9 Invasives

A prominent cause of contraction or loss of preferred habitat within a species range is invasion by non-native species. Fluctuation in resource availability, which can be driven by climate, has been identified as the key factor controlling invasibility (IPCC, 2007a). Invasive species are one of the biggest threats to the significant natural features of the River Raisin Watershed, and the streams, lakes, wetlands, and uplands have all been affected by invasive species. Changes in land use and natural processes including stream flow, groundwater and surface water hydrology, and fire regimes have all contributed to the susceptibility of ecosystems to invasion by species that will harm the ecology, economy, or human health within the watershed.

3.9.1 Aquatic nuisance species

Introduced species including zebra mussels (*Dreissena polymorpha*), rusty crayfish (*Orconectes rusticus*), Eurasian water-milfoil (*Myriophyllum spicatum*), curly-leaf pondweed (*Potamogeton crispus*), flowering rush (*Butomus umbellatus*) and purple loosestrife (*Lythrum salicaria*) have had negative effects on native fishes and macroinvertebrates (Kopplin, 2002). These effects include displacement of native species through direct competition for food or space, disruption of food webs, and changes in habitat quality. Another species that has become a problem in inland lakes is water celery (*Vallisneria aquatica*). This is a native species, but strains from southern states have been promoted for their greater seed production and have become a nuisance to boaters.

3.9.2 Terrestrial and wetland plants

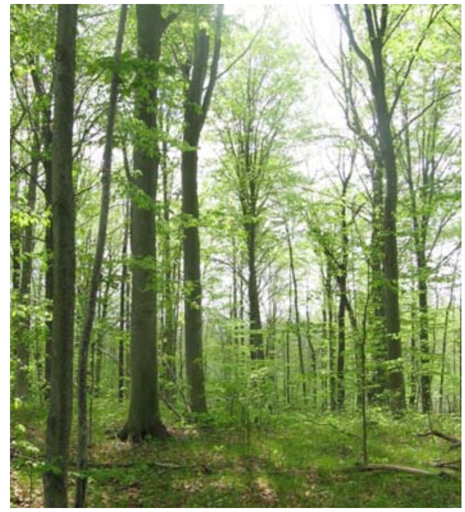
It is a safe assumption that all wetlands and uplands in the River Raisin watershed have been invaded by some non-native plants, and many natural areas have been heavily degraded by some of the worst invaders. Many wetlands have been invaded by non-native plants including reed-canary grass (*Phalaris arundinacea*), common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), flowering rush (*Butomus umbellatus*) and glossy buckthorn (*Rhamnus frangula*) – these are some of the most problematic invasive plants in the watershed. Common reed is particularly a problem in wetlands on or near the shore of Lake Erie, where it has become the dominant species in most coastal marshes. Flowering rush is becoming more of a problem in these same wetlands, especially as water levels in Lake Erie have become lower. It is particularly a problem in Ohio and becoming more so in Michigan. Inland of Lake Erie, some wetlands have been so invaded that native wetland species can no longer be found. These species severely degrade habitat quality but can also change wetland hydrology. Monitoring of water levels before and after removal of glossy buckthorn from Ives Road Fen Preserve showed that water levels in the soil rose in response to invasive species removal (P. Marangelo, pers. comm.).

The worst invasive species in upland forests and barrens of the watershed include garlic mustard (*Alliaria petiolata*), autumn olive (*Elaeagnus umbellata*), Asian shrub honeysuckles (*Lonicera* spp.), spotted knapweed (*Centaurea maculaat*) and others. Invasive shrubs are typically spread by birds and can leaf out earlier than natives and shade them out before they can establish; whereas other invasives (garlic mustard and spotted knapweed), can change soil chemistry to inhibit the growth of other species. Control of these invasive species is very costly and can be a never-ending task, but it is critical to the maintenance of habitat for native species.

3.9.3 Pests and pathogens

Emerald ash borer (EAB) has had a dramatic effect on forests of southeast Michigan. EAB is well established in the watershed and, if present trends continue, will end up killing all ash trees in the watershed within the next few years. The ecological effects of this rapid die-off are not well understood, but riparian forests are likely to be among the hardest hit. This rapid die-off is likely contributing to increased levels of large woody debris in the river. A dramatic increase in light to the forest floor may result in increased presence of invasive plants and will ultimately lead to a change in the composition of local forests.

3.10 Regionally Significant Ecological Systems and Species



Second growth Beech stand – Nan Weston Preserve. S. Dierks, 2007

Through a regional assessment of conservation priority areas, The Nature Conservancy has identified the headwaters of the River Raisin as critical for the conservation of upland, wetland, and aquatic systems and the many species they support. In particular, the mainstem of the river, several tributaries, and several kettle lakes are recognized as the best examples of several stream types in the western Lake Erie basin and contain the most intact assemblage of mussels and other aquatic species of any river in southern Michigan (DePhilip, 2001). Additionally, many areas in the watershed contain high-quality or restorable remnants of terrestrial and wetland natural communities, and the upper portion of the watershed has been identified as an area well suited for restoration of a large, connected landscape representative of the North Central Tillplain ecoregion (TNC 2003).

3.10.1 Aquatic Ecological Systems

An assessment of aquatic ecological systems throughout the Great Lakes Basin identified several examples in the River Raisin watershed that are of basin-wide conservation significance (DePhilip, 2001). The mainstem of the river from Norville Dam to the confluence of the mainstem with the South Branch (south of Adrian) is known to have some of the most productive mussel beds in southern Michigan (Paul Marangelo, pers. comm.) Additionally, sections upstream of the Norville dam could be considered important should opportunity arise for dam removal, as the backwaters presently inundate high gradient habitats, which are otherwise lacking in the river. Along with the upper mainstem, several tributaries are important examples of interlobate headwater streams including Iron Creek, Marsh Creek (aka Fay Lake outlet), and Goose Creek. Although the upper Raisin does not contain any globally rare species, there are a number of state listed fish and mussels: silver shiner (*Notropis photogenis*; E), brindled madtom (*Noturus miurus*; SC), purple wartyback (*Cyclonaias tuberculata*; SC), rainbow (*Villosa iris*; SC), round pigtoe (*Pleurobema coccineum*; SC), elktoe (*Alasmidonta marginata*; SC), slippershell (*Alasmidonta viridis*; SC), and wavy-rayed lampmussel (*Lampsilis fasciola*; T).

The MDNR have specified their rankings for the main channels of the River Raisin and its tributaries (see **Figure 3-24**). Reaches specified or recommended as top warmwater reaches include the mainstem of the Raisin downstream of Lake Norvell to just upstream of the confluence of Evans Creek, the mainstem from downstream of Dundee to just upstream of Monroe, and Beaver Creek, a tributary of the South Branch of the River Raisin.

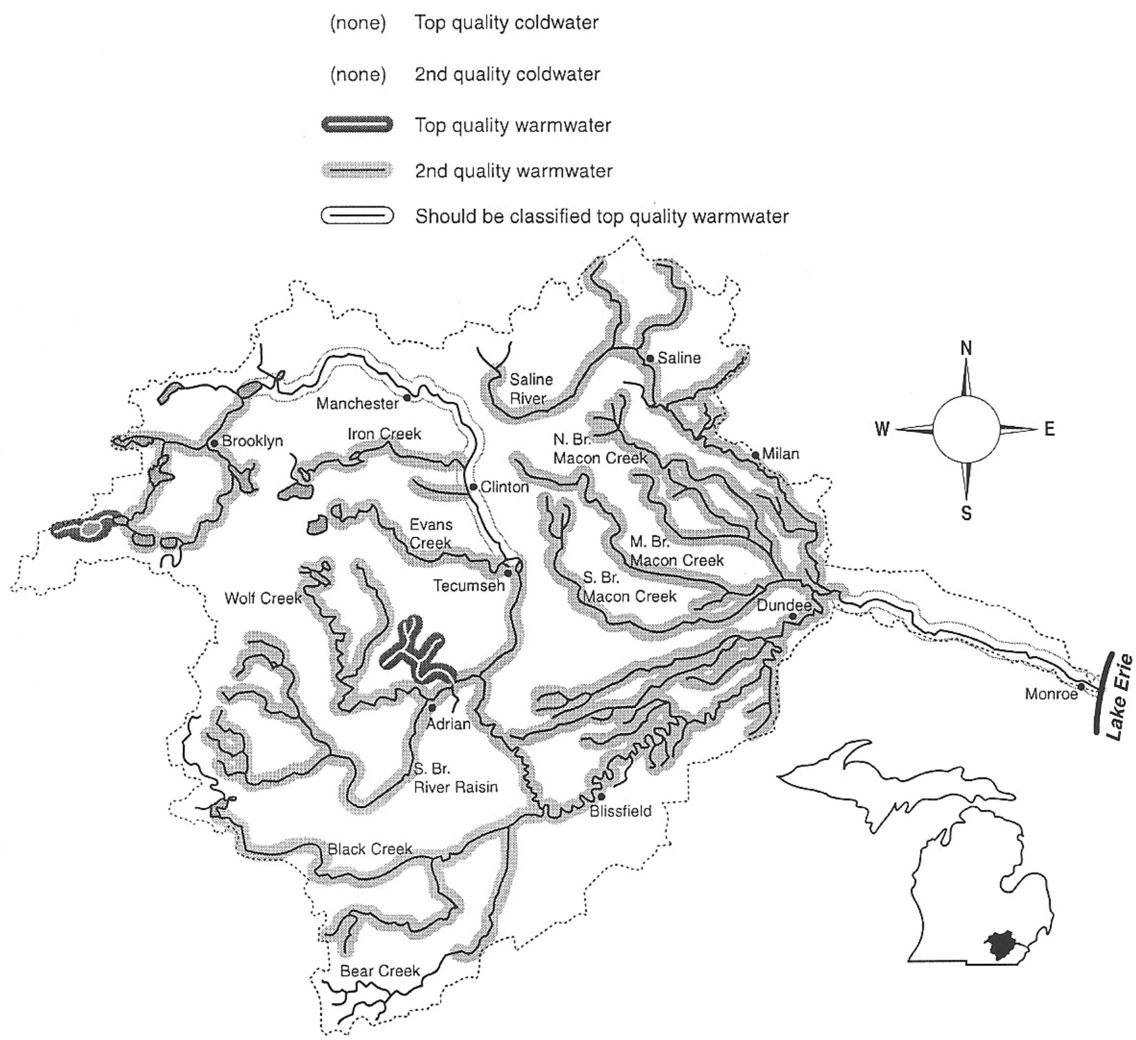


Figure 3-24 Michigan Department of Natural Resources Stream Ratings (from Dodge, 1998)

Several high quality, mostly undeveloped kettle lakes occur in the upper watershed: the Onstead Game area lake complex (One-mile and Cleveland Lakes), Whelan Lake and Fay Lake. While little is known about the biota of these lakes, their very good condition and relatively low amount of shoreline development, as well as proximity to other high quality wetlands and uplands, warrant conservation. One-Mile Lake has an unusual population of *Villosa iris* (Special Concern) (Paul Marangelo, personal observation), a mussel that usually occurs only in creeks and rivers.

3.10.2 Terrestrial Natural Communities

When viewed at the scale of the western Lake Erie basin or the North Central Tillplain ecoregion, the upper portions of the River Raisin watershed contain a relatively high proportion of remnant natural vegetation. Many natural communities in this part of the watershed are of regional significance and are the objects of conservation interest including riparian forests, southern mesic forests, prairie fens, and oak savannas and barrens. Occurrences of the natural communities persist in several areas, often in association with headwater streams or the river mainstem and around kettle lakes. Conservation of these systems thus contributes to conservation of the aquatic ecological systems described in the section above.

A Phase 1 assessment of the watershed (Bennett et al., 2006) revealed several mostly intact riparian forests along the mainstem above Adrian, and also along tributaries such as Iron Creek. These areas serve to buffer the river from surrounding land uses, and undoubtedly are an important factor in the maintenance of the high quality nature of the aquatic system in the mainstem and in Iron Creek. High-quality examples of riparian forest remain, especially between Tecumseh and Adrian, and several rare species are known to occur in this system. Two riparian sites are known to support the federally endangered Indiana bat (*Myotis sodalis*), at Sharonville State Game Area and Ives Road Fen.

Southern mesic forest was the predominant natural committee on mesic to wet mesic soils in the watershed (MNFI Circa 1800 vegetation map), but has largely been lost due to historic conversion to agriculture. At least one high quality remnant occurs at the Nan Weston Preserve at Sharon Hollow and Sharonville State Game Area. Other smaller remnants undoubtedly occur, one example being at the Leonard Preserve just west of Manchester.

Table 3-6 Globally Imperiled or Declining Species

Scientific Name	Common Name
Acer saccharinum - Ulmus americana - (Populus deltoides) Forest	silver maple – elm – (cottonwood) forest
Acris crepitans blanchardi	Blanchard’s cricket frog
Besseya bullii	kitten tails (rare plant)
Clemmys guttata	spotted turtle
Fagus grandifolia - Acer saccharum - (Liriodendron tulipifera) Glaciated Midwest Forest	beech – maple glaciated forest
Fraxinus pennsylvanica - Ulmus spp. - Celtis occidentalis Forest	central green ash – elm – hackberry forest
Lepyronia angulifera	angular spittlebug
Myotis sodalis	Indiana bat
Oarisma powesheik	powesheik skipperling (rare butterfly)
Pentaphylloides floribunda / Carex sterilis - Andropogon gerardii - Cacalia plantaginea Shrub Herbaceous Vegetation	cinquefoil – sedge prairie fen
Sistrurus catenatus catenatus	eastern massasauga rattlesnake

4.0 CURRENT CONDITIONS OF THE RIVER RAISIN WATERSHED

Current water quality conditions in the River Raisin Watershed reflect the legacy of land conversion to agriculture, as well as industrial pollution. The loss of wetlands and conversion to intensive agriculture has resulted in extreme non-point source contributions that have degraded water quality and biological health in the River Raisin. The River Raisin watershed has the highest percentage of agricultural land use in the state of Michigan (Dodge 1998). As a result, water quality is expected to reflect high concentrations of total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), and conductivity (EC), pollutants typically associated with agricultural areas.

Several sources of water quality data were used to assess river conditions and health of the River Raisin watershed. The River Raisin is fortunate to have a long-term data record (over 30 years) of water quality samples near the mouth collected by the Heidelberg College National Center for Water Quality Research. However, because these samples are taken near the mouth at Monroe, they represent an aggregation of inputs from the entire watershed. In order to flesh out relative inputs from the major subwatersheds and prioritize corrective actions, additional data was collected. In 2006, the University of Michigan collected synoptic (nearly) samples (collected during same short time interval) at the mouth of each major subwatershed on four occasions. Because samples were taken at roughly the same time using the same methods, they provide representative samples of each subwatershed that can be directly compared. Macroinvertebrate index scores from the Adopt-a-Stream sampling program were used as a bio-indicator of water quality and compared for each subwatershed. While other small data sets are available, they are not reported here as they are limited in geographic coverage and difficult to compare due to temporal, climatic, or flow-dependent variables.

In order to assess water quality on a larger regional scale, the River Raisin data were compared to USEPA's recommendations for nutrients in streams of the glaciated upper Midwest and Northeast (which includes Ecoregion VI), as well as to background nutrient concentrations for U.S. streams and rivers reported in Smith et al., (2003). The Smith, et al. study found that background TP concentrations for this region are just above the USEPA's 25th percentile recommendations (greater than 10 µg /L) (USEPA, 2000). Background TN concentrations from the study indicate USEPA 25th percentile concentrations are at or above the background concentrations found in U.S. streams and rivers (0.2 mg/L). Nutrient concentrations in the headwaters of the River Raisin are just above those identified as regional background concentrations, but in the priority water quality subwatersheds and the mainstem, concentrations of TP and TN are well above these background levels. Regional water quality data collected by the USGS and MDEQ are summarized here as well.

When all of these water quality data sources are considered together, the major subwatersheds fall out into groups associated with land use. The South Branch RR, Black Creek, Macon Creek and the Lower RR had very high N concentrations as well as high to very high P and fair to poor macroinvertebrate ratings. Evans Creek and Saline River had high N and high P and fair to poor macroinvertebrate ratings. Little RR had low P but had poor to fair macroinvertebrate ratings. Goose Creek, Iron Creek, and the Upper RR watersheds had low N and P and fair to good macroinvertebrate ratings. The water quality assessment shows a relationship between poor water quality and a high percentage of land in agriculture and a high percentage of wetlands lost (see Chapter 5).

4.1 Heidelberg College National Center for Water Quality Research

Since 1974, the Heidelberg College National Center for Water Quality Research (NCWQR) has collected more than 90,000 water samples as part of its Ohio Tributary Monitoring Program. The sampling program has been designed to provide accurate and long-term pollutant loading data for Ohio's major tributaries to Lake Erie, including the River Raisin in Michigan. Samples from all stations have been collected at USGS stream gaging stations and have been analyzed for major nutrients and suspended solids. The data provide uniquely detailed data sets on ambient water quality in the streams and support investigations on pollutant sources and transport (see: http://wql-data.heidelberg.edu/index_files/slide0001.html). These data sets are available for public use in the form of Excel files. A “users guide” for the data sets along with an “analysis template” (also an Excel file) to help users analyze the data with graphs and common calculations are included on the website cited above.

The data for the Raisin summarized below represents daily grab samples six days a week beginning in 1982 and reported through September, 2007. Roughly 7,600 measurements are summarized in the plots (see **Figure 4-1** through **Figure 4-3** below) for Total Suspended Solids (TSS), Total Phosphorus (TP) and Nitrate (NO3). TSS concentrations ranged between 0 and 1,918 mg/L, with a median concentration of 28 mg/L. TP concentrations ranged between 0.007 and 1.827 mg/L with a median of approximately of 0.104 mg/L. NO3 concentrations ranged between 0 and 16.55 mg/L, with a median concentration of 2.4 mg/L.

Based on conversations with Dr. David Baker, the Project Director, it should be noted that the water quality samples on the Raisin, until very recently, were grabbed by a volunteer sampler. Dr. Baker noted that in the mid to late 90’s the lab had some questionable sample grabs with exceptionally high TSS concentrations. These high TSS samples may have been contaminated by bottom sediment re-suspended at the time of the sampling. At this point it is very difficult to tell to what extent the results may be biased. For now, these results will be relied upon until demonstrated otherwise.

Nitrogen, phosphorus and suspended solids loads at Monroe were calculated from the Heidelberg College flow and concentration data. The average annual loads for nitrogen, phosphorus and total suspended solids are 8,934,573, 303,180 and 127,061,642 pounds, respectively. Unit area loads for the watershed, calculated from the entire data set, are 198 lbs/acre/year for TSS; 0.47 lbs/acre/year for total phosphorus; 10.8 lbs/acre/year for nitrate, 2.8 lbs/acre/year for TKN, and 14-15 lbs/acre/year for TN.

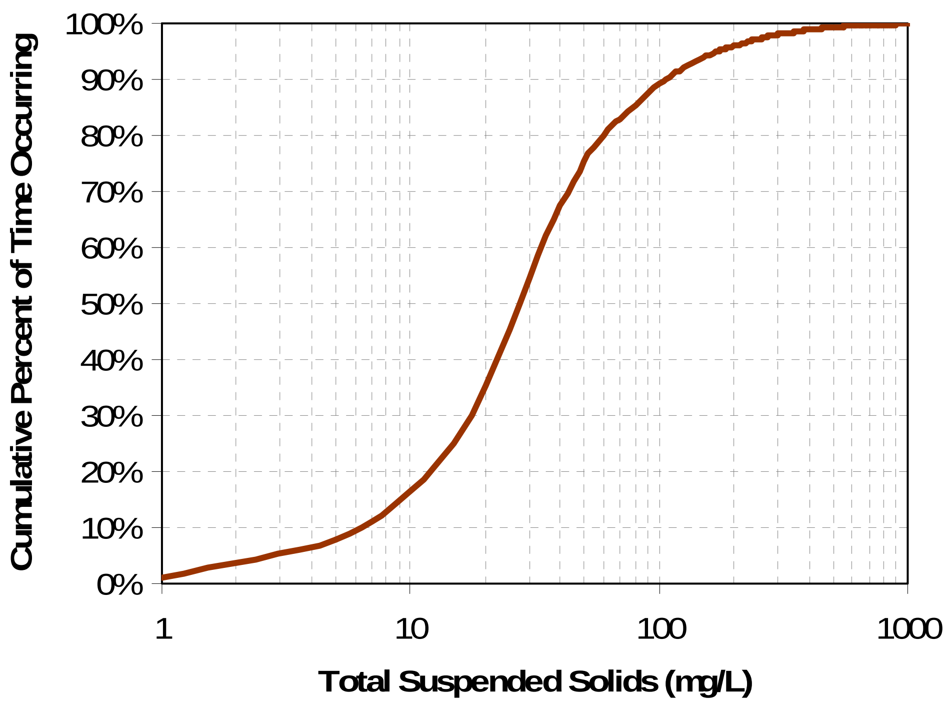


Figure 4-1 Cumulative Histogram of Total Suspended Solids Concentrations at Heidelberg College River Raisin Station at Monroe (1982-2007).

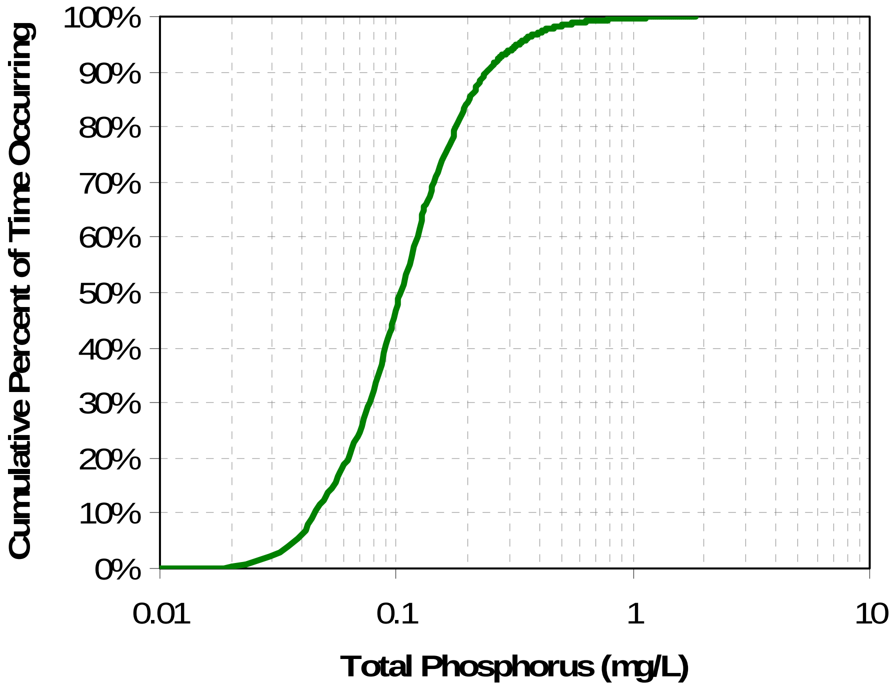


Figure 4-2 Cumulative Histogram of Total Phosphorus Concentrations at Heidelberg College River Raisin Station at Monroe (1982-2007).

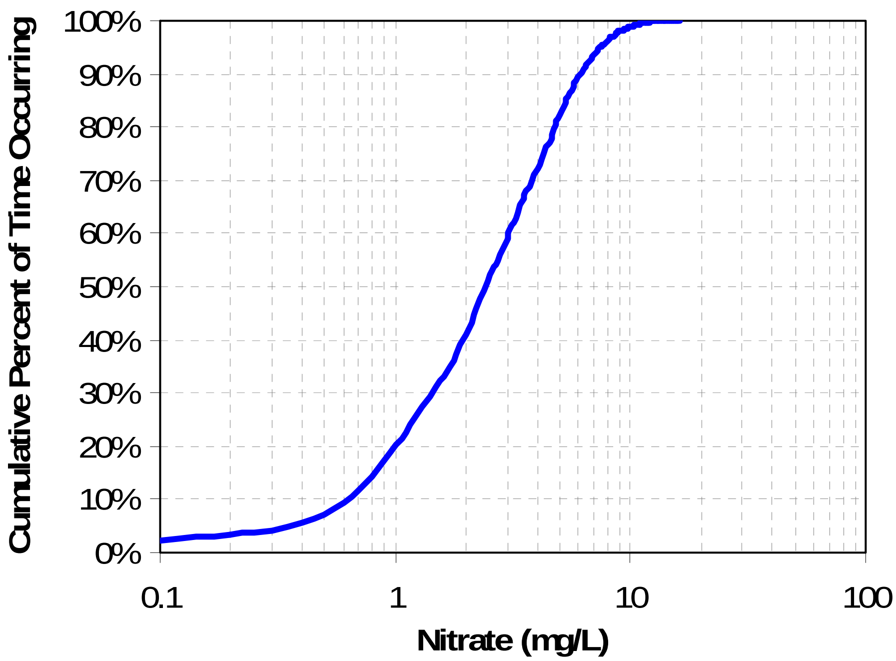


Figure 4-3 Cumulative Histogram of Nitrate Concentrations at Heidelberg College River Raisin Station at Monroe (1982-2007).

Heidelberg College has statistically analyzed the entire record of concentration data at the Raisin station in Monroe. They have developed average annual, flow-corrected and statistically-smoothed concentration plots for all the parameters sampled. The plots in **Figure 4-4** and **Figure 4-5** below show the results of this analysis for

Total Suspended Solids (TSS), Nitrate (NO3), Total Phosphorus (TP) and Dissolved Reactive Phosphorus (DRP). Some of these parameters showed decreases in the 1982-1995 timeframe, but heading into 2006 all are showing an upward trend. TSS and nitrate concentrations are now higher than ever. Note the flow-correction step takes any concentrating effect due to lower flows out of the equation. These results suggest that the steps currently being taken to address these water quality issues in the Raisin are not having the intended effect.

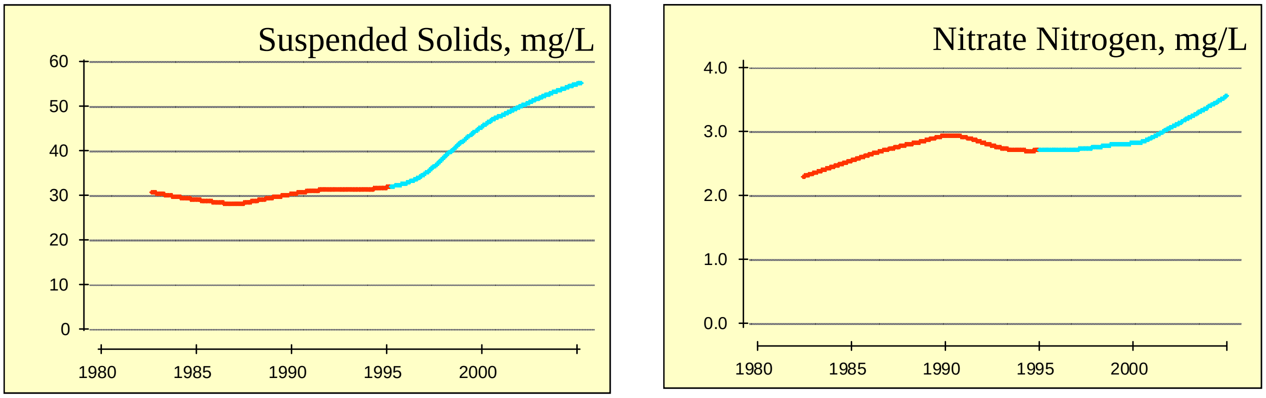


Figure 4-4 Average annual, flow-corrected Suspended Solids and Nitrate concentrations at Heidelberg College River Raisin station at Monroe (Suppnick, 2008).

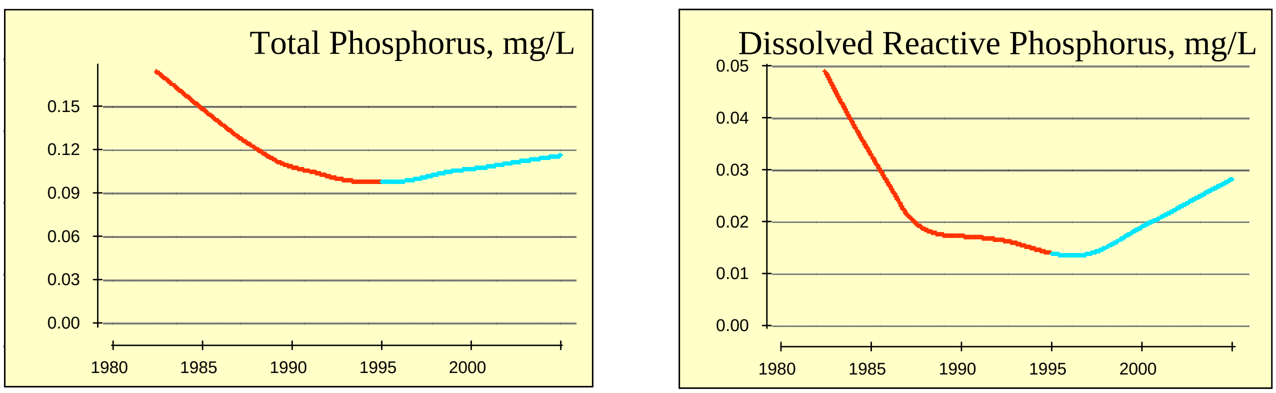


Figure 4-5 Average annual, flow-corrected Total Phosphorus and Dissolved Reactive Phosphorus at Heidelberg College River Raisin station at Monroe (Suppnick, 2008)

4.2 Regional - USGS Lake Erie Tributary & Michigan Chemistry Water Quality Monitoring Project

A regional water quality study in the Lake Erie basin was conducted by the United States Geological Survey (USGS) from 1996-1998. The report is included as PDF in the **Water Quality Appendix** for this plan and can be found on the web at: http://pubs.usgs.gov/circ/circ1203/ . The MDEQ has been conducting the Michigan Water Chemistry Monitoring Project (WCMP) since 1998. The most recent report of the MDEQ project is posted at: http://www.michigan.gov/documents/deq/wb-swas-9805tribreport_222804_7.pdf and is also included as a PDF in the **Water Quality Appendix**. Very brief summaries of these efforts are offered here.

The USGS study quantified several different water quality parameters in 10 watersheds within the Lake Erie basin, including the River Raisin at Manchester. Watersheds were compared on the basis of pesticide concentration exceedances, TN and TP inputs and outputs. Within the Lake Erie basin, the Manchester site on the River Raisin ranked moderate to low in TN inputs and very low in TP outputs (USGS, 2000). In the context of a general evaluation of water quality in the River Raisin, it is important to note that the pesticide exceedance measure from this study indicates that the Raisin at Manchester is just 1 of 2 watersheds sampled that showed no pesticide levels in exceedance of aquatic-life guidelines (USGS 2000). By the standards and sites measured in this study, the water quality of the River Raisin at Manchester ranks among the highest for the Lake Erie basin.

The WCMP is an on-going effort by the MDEQ to provide annual water chemistry monitoring at selected Michigan streams tributary to the Great Lakes and the Great Lakes connecting waters. Monitoring includes Total Suspended Solids (TSS), Total Phosphorus (TP) and bioaccumulative pollutants of concern, including mercury (Hg) and PCBs. The results of the WCMP provide a snapshot comparison of water quality in the monitored watersheds. The monitoring station on the River Raisin is in Monroe near the mouth of the river.

By way of quick comparison, the Raisin had the 7th highest median TP concentration, the 16th highest median TSS concentration, the 15th highest median mercury concentration and the highest median and measured PCB concentrations of the 31 stations summarized in the WCMP (MDEQ, 2008).

4.3 UM Water Quality Surveys

Four synoptic surveys were conducted to assess water quality at or near the mouths of each of the Raisin's ten major subwatersheds. Water chemistry samples were grabbed between May and October, 2006, and included two wet-weather and two dry-weather periods (refer to **Figure 4-6**). The water quality sampling was planned and conducted according to a MDEQ-approved Quality Assurance Project Plan (QAPP) (refer to **Water Quality Appendix**). Sampling sites included at least one station for each major subwatershed (see **Figure 4-7**), including Goose Creek, Iron Creek, Evans Creek, South Branch River Raisin, Black Creek, Saline River, Macon Creek, and Little River Raisin. In addition, eight sites on the mainstem of the River were sampled, extending along the entire reach of the Raisin from the upper headwaters in the northwest to the city of Monroe on Lake Erie.

Water samples were collected mid-channel with a chemically clean bucket and immediately processed into designated tubes for nutrient analyses and total suspended matter (TSM). Samples for dissolved nutrients (nitrate and phosphate) were filtered through a 0.2 micron nylon filter into polypropylene tubes and later frozen until analyzed. Samples for total phosphorus and total nitrogen were measured out in a clean plastic syringe and dispensed into acid-cleaned Pyrex™ tubes. The remaining water was returned to the UM laboratory in clean polypropylene bottles for TSM determination.

Additionally, water temperature, dissolved oxygen (DO), pH and conductivity were measured in the field directly. A YSI™ dissolved oxygen meter was used to measure both temperature and DO and a Hanna probe was used to measure pH and conductivity. *E. coli* samples were taken by plunging the sample bottle neck down below the water surface and then turning it upright into the flow and transported to a laboratory for analysis within 24 hours on ice in coolers.

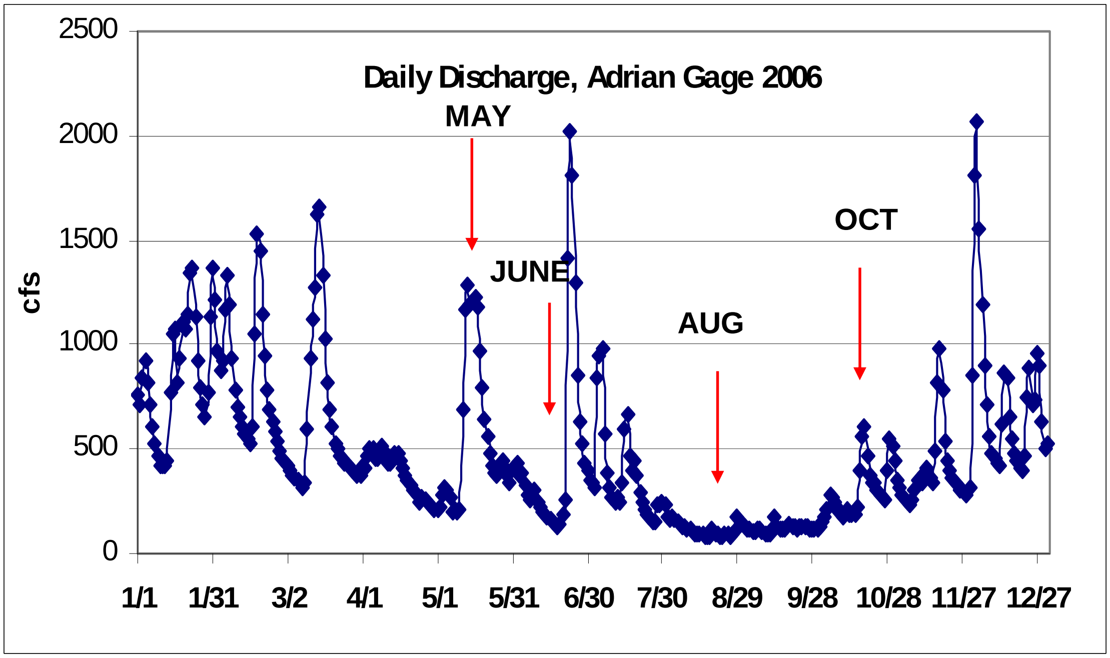
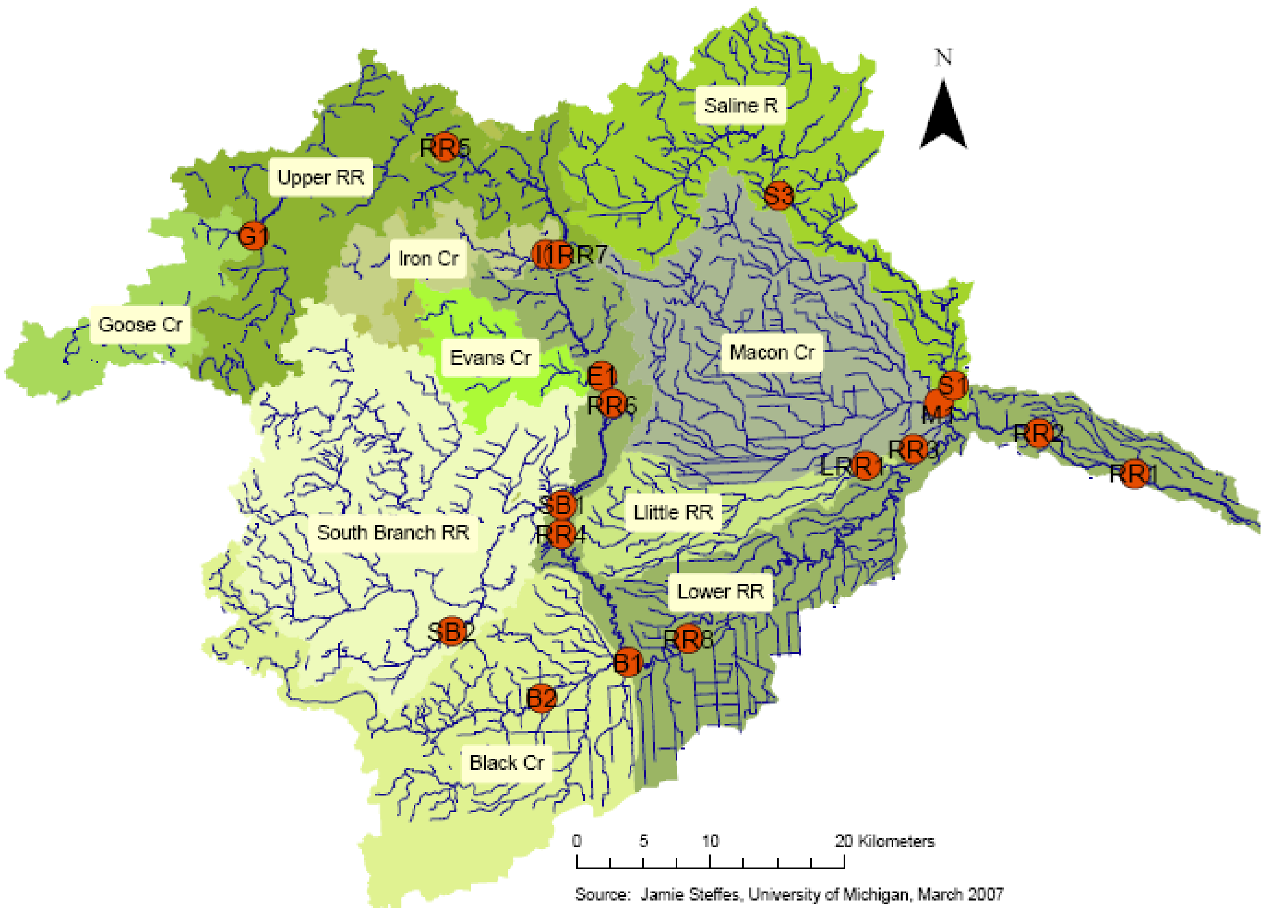


Figure 4-6 Water Quality Sampling Dates and Flow at Adrian USGS Gage

To assist in prioritizing subwatershed problems, water quality categories were created. **Table 4-1** shows the categories and designated cut-offs for water quality to establish four concentration categories referred to as very low, low, high and very high concentrations. Due to the lack of comprehensive water quality criteria set by the State of Michigan DEQ, impairment categories were calculated using cumulative frequencies of nutrients in the Raisin, supplemented with reference data from states, federal agencies and other researchers. These concentration categories were developed to reflect thresholds, existing water quality standards, and the distribution of our data.

Table 4-1 Water quality concentration categories

Report Card Score	Conductivity (uS/cm)	Total Suspended Matter (g/L)	Total Phosphorous (ug/L)	Total Nitrogen (mg/L)
Very low	<300	<10	<25	<0.70
Low	300-500	10-40	25-75	0.70-1.50
High	500-700	40-80	75-150	1.50-6
Very high	>700	>80	>150	>6



Site Code & Tributary

RR5	River Raisin	RR6	River Raisin	RR2	River Raisin	RR8	River Raisin
G1	Goose Creek	W3	Wolf Creek	S1	Saline River	B1	Black Creek
I1	Iron Creek	SB2	S. Branch Raisin	M1	Macon Creek	RR4	River Raisin
RR7	River Raisin	B2	Black Creek	RR3	River Raisin	SB1	S. Branch Raisin
E1	Evans Creek	RR1	River Raisin	LRR1	Little River Raisin	S3	Saline River

Figure 4-7 Location of Water Quality Sampling Sites

4.3.1 Total Nitrogen

Total nitrogen (TN) concentrations ranged from 0.52 mg/L (Site I10) to 13.04 mg/L (Site LRR10) with a mean of 3.67 mg/L and median of 2.16 mg/L. **Figure 4-8** and **Figure 4-9** show that TN concentrations were generally higher in the May and June events and lower during the August and October events. This may be from runoff, spring snowmelt and flooding carrying some of the applied fertilizer into the river. In addition, there is a general downstream increase in TN, and certain subwatersheds (South Branch, Black, Saline, Macon, Little Raisin, and Lower Raisin) presented consistently high concentrations. Relatively low TN concentrations in the headwater streams are consistent with the relatively high incidence of remaining natural land use in headwater regions.

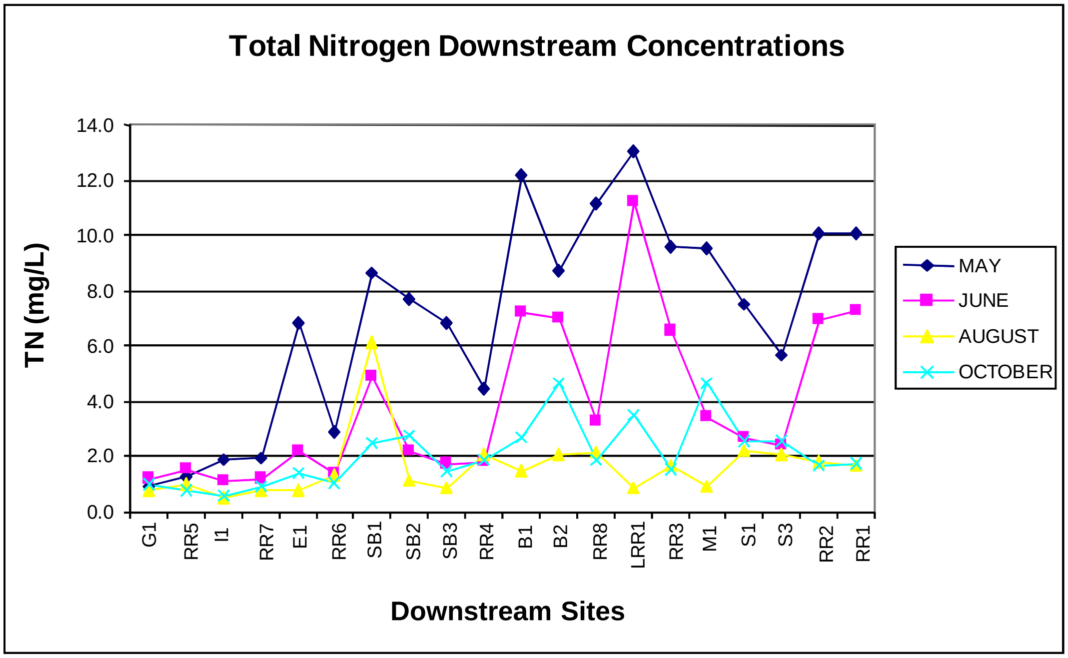


Figure 4-8 Concentrations of TN measured during May, June, August, and October sampling events. Sites are arranged from left to right in an approximate upstream-downstream pattern.

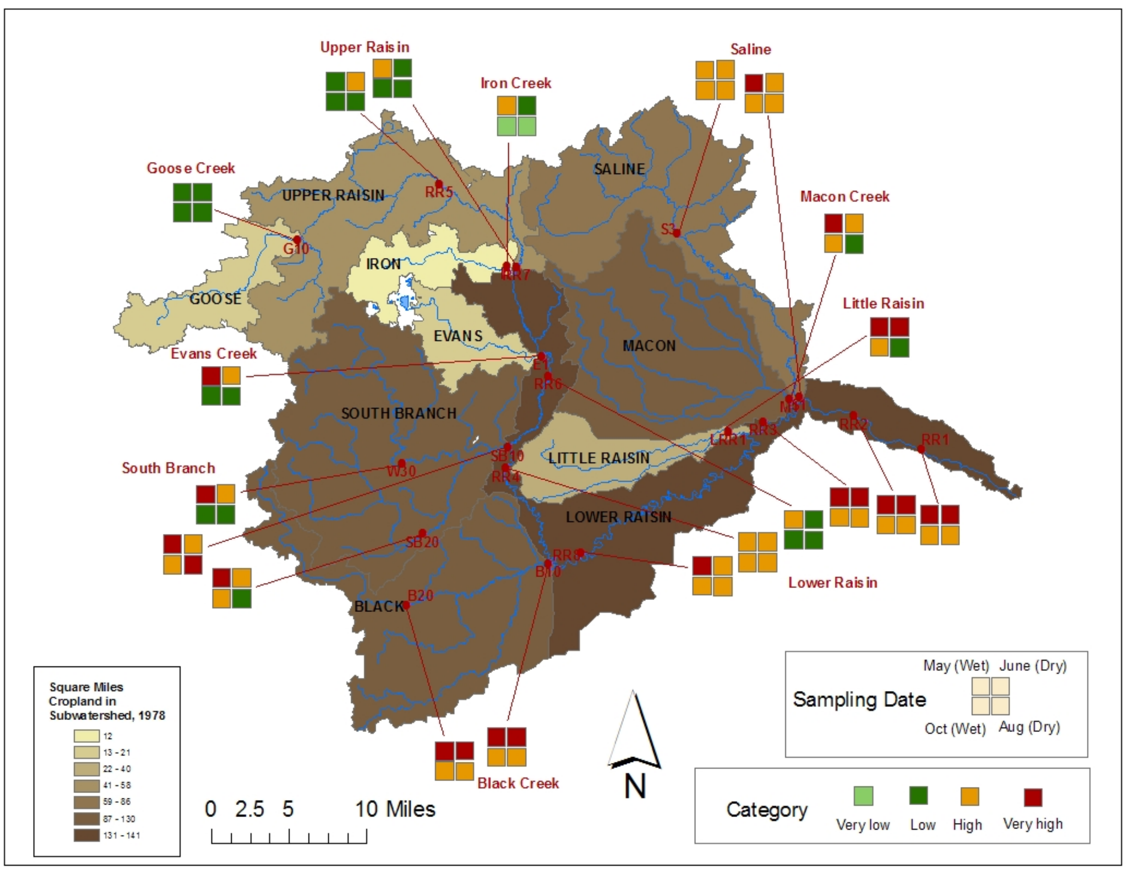


Figure 4-9 Range of concentrations of TN from synoptic surveys in the River Raisin watershed. Concentration categories (mg/L) are very low (less than 0.70), low (0.70-1.50), high (1.50-6), and very high (greater than 6)

4.3.2 Total Phosphorus

Total phosphorus (TP) concentrations ranged from 21.2 µg/L (Site I10) to 412.9 µg/L (Site M10) with a mean of 98.6 µg/L and median of 94.9 µg/L. TP concentrations showed a general downstream increase throughout the watershed. Headwater streams in Goose Creek and the Upper Raisin had some of the lowest TP concentrations (**Figure 4-10**) during all sampling events. Concentrations of TP were consistently higher downstream where the South Branch River Raisin, Black Creek, Macon Creek, and Saline sub-watersheds empty into the Lower Raisin. TP was higher in August and October, presumably because low flows in the late summer and autumn resulted in less dilution.

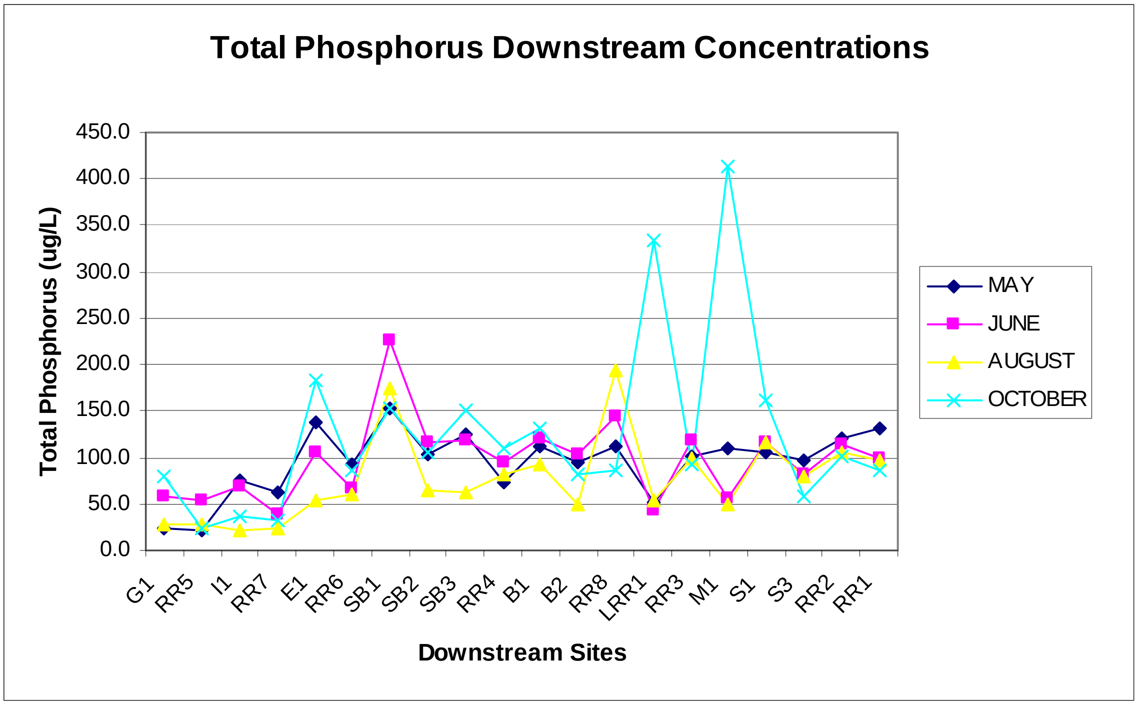


Figure 4-10 Concentrations of TP measured during May, June, August, and October sampling events. Sites are arranged from left to right in an approximate upstream-downstream pattern.

TP concentrations were highest during October. Values were generally lower along the upper mainstem and greater along the lower mainstem. South Branch, Black, Saline, Macon, Little Raisin, and Lower Raisin sub-watersheds presented consistently high concentrations (**Figure 4-11**).

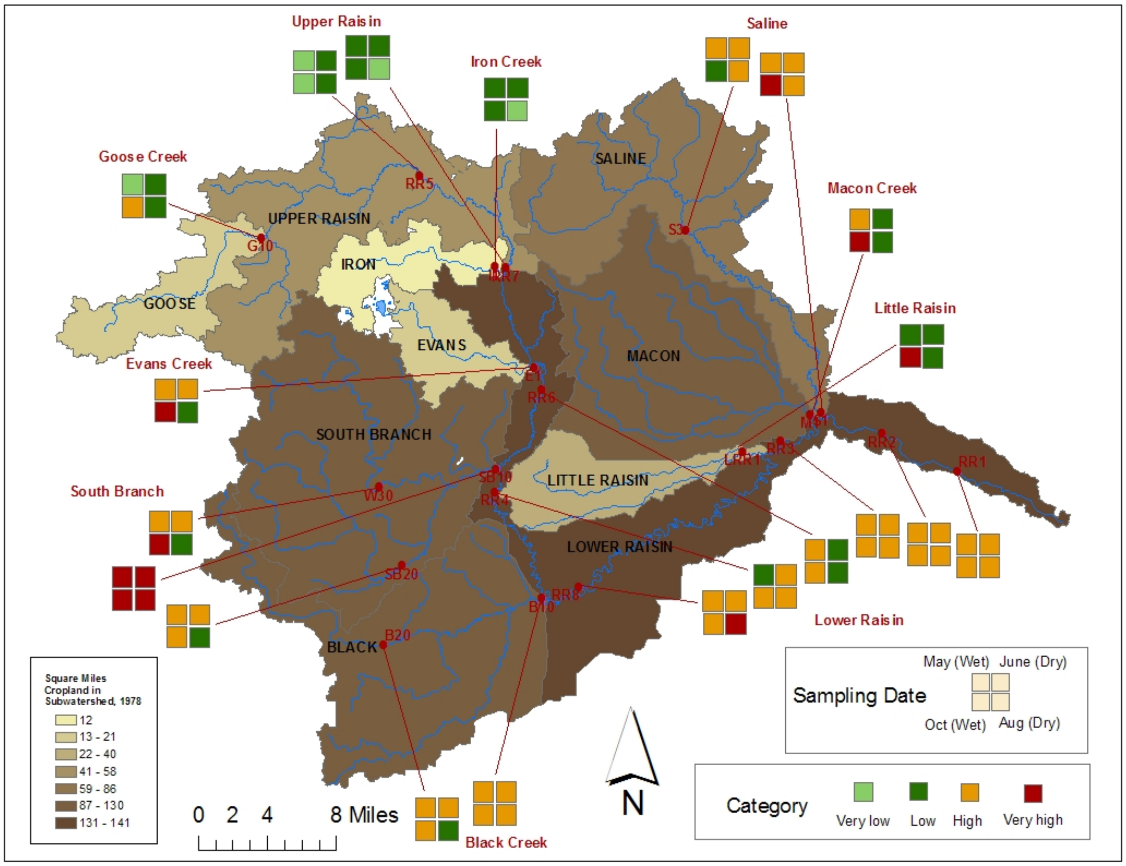


Figure 4-11 Range of concentrations of TP on four sampling dates in the River Raisin watershed. Concentration categories (µg/L) are very low (less than 25), low (25-75), high (75-150), and very high (greater than 150).

4.3.3 Total Suspended Matter

Total suspended matter (TSM) concentrations ranged from 2.3 mg/L (Site RR5) to 122.2 mg/L (Site M10) with a mean of 22.3 mg/L and median of 19.5 mg/L. TSM concentrations were generally low across sampling dates and sub-watersheds, though South Branch and Macon basins had slightly higher values. **Figure 4-12** shows the general downstream increase in TSM values. The October sampling from Site M1 generated an outlier (extreme value), which was likely due to a difficulty in sampling leading to a sediment-contaminated sample. Highly agricultural sub-watersheds, such as South Branch Raisin, Black Creek, Macon Creek, and Saline, exhibited higher TSM concentrations during wet-weather samplings (May and October), likely due to increased overland runoff and erosion. In addition, high flows during storm events increases the erosive capacity of stream systems, causing down-cutting of stream beds and undercutting of banks (**Figure 4-13**).

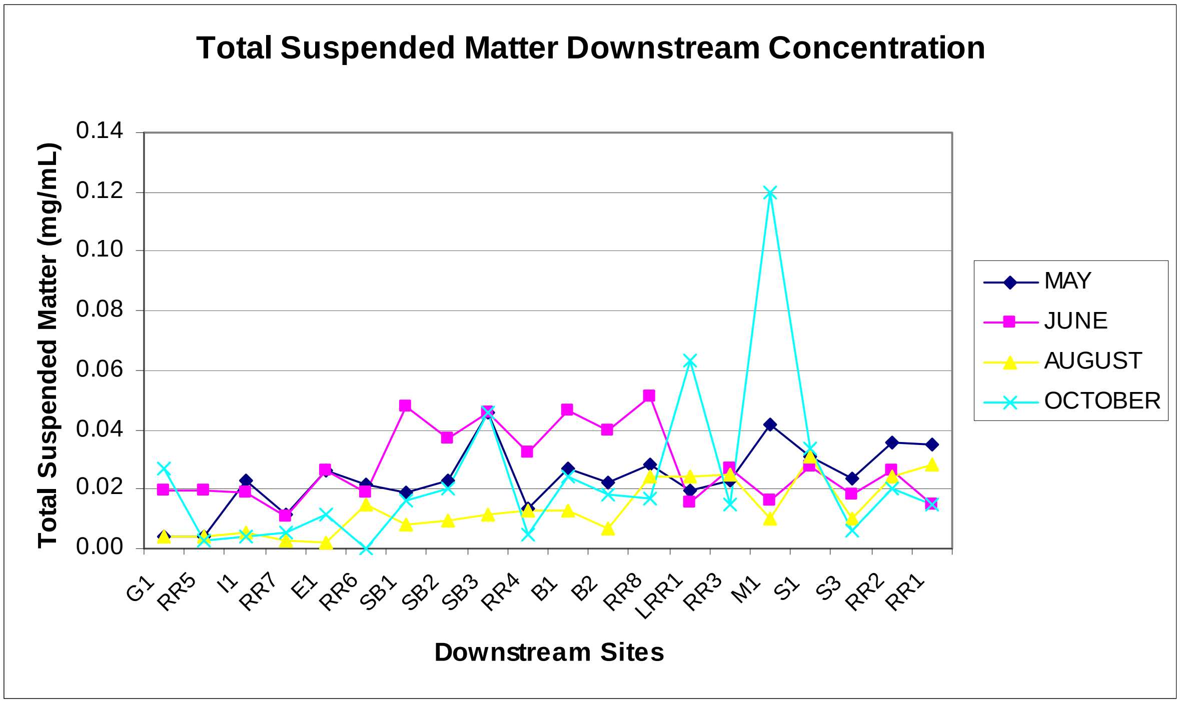


Figure 4-12 Concentrations of TSM measured during May, June, August, and October sampling events. Sites are arranged from left to right in an approximate upstream-downstream pattern.

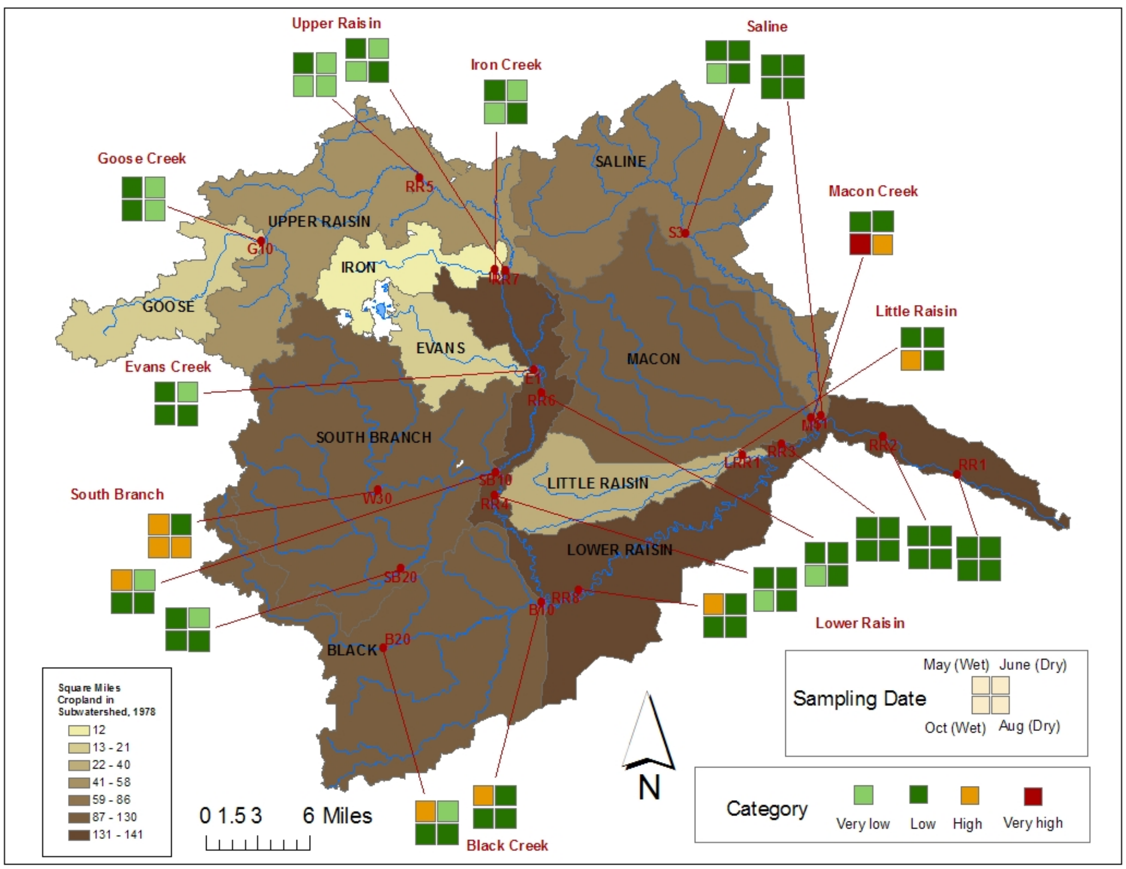


Figure 4-13 Range of concentrations of TSM on four sampling dates in the River Raisin watershed. Concentration categories (g/L) are very low (less than 10), low (10-40), high (40-80), and very high (greater than 80).

4.3.4 Conductivity

Conductivity values ranged from 204 µS/cm (Site RR50) to 1010 µS/cm (Site M10) with a mean of 445 µS/cm and median of 392 µS/cm (**Figure 4-14**). Conductivity values were highest during May and August. Scores increased downstream along the mainstem, and South Branch, Black, Saline, Macon, and Lower Raisin sub-watersheds presented consistently higher values (**Figure 4-15**). Conductivity is an indirect measure of the dissolved ion content of a waterbody. This metric is directly influenced by the geology and soils of the area through which water flows, as well as various human influences such as fertilizers and road salts.

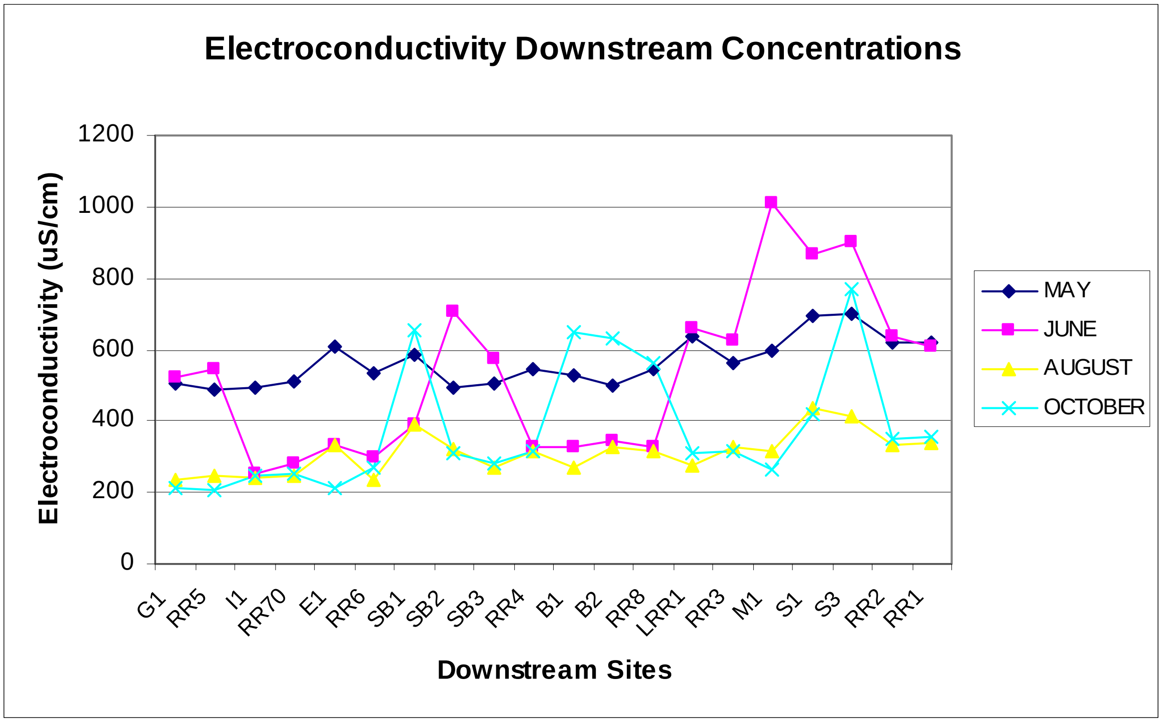


Figure 4-14 Conductivity values measured during May, June, August, and October sampling events. Sites are arranged from left to right in an approximate upstream-downstream pattern.

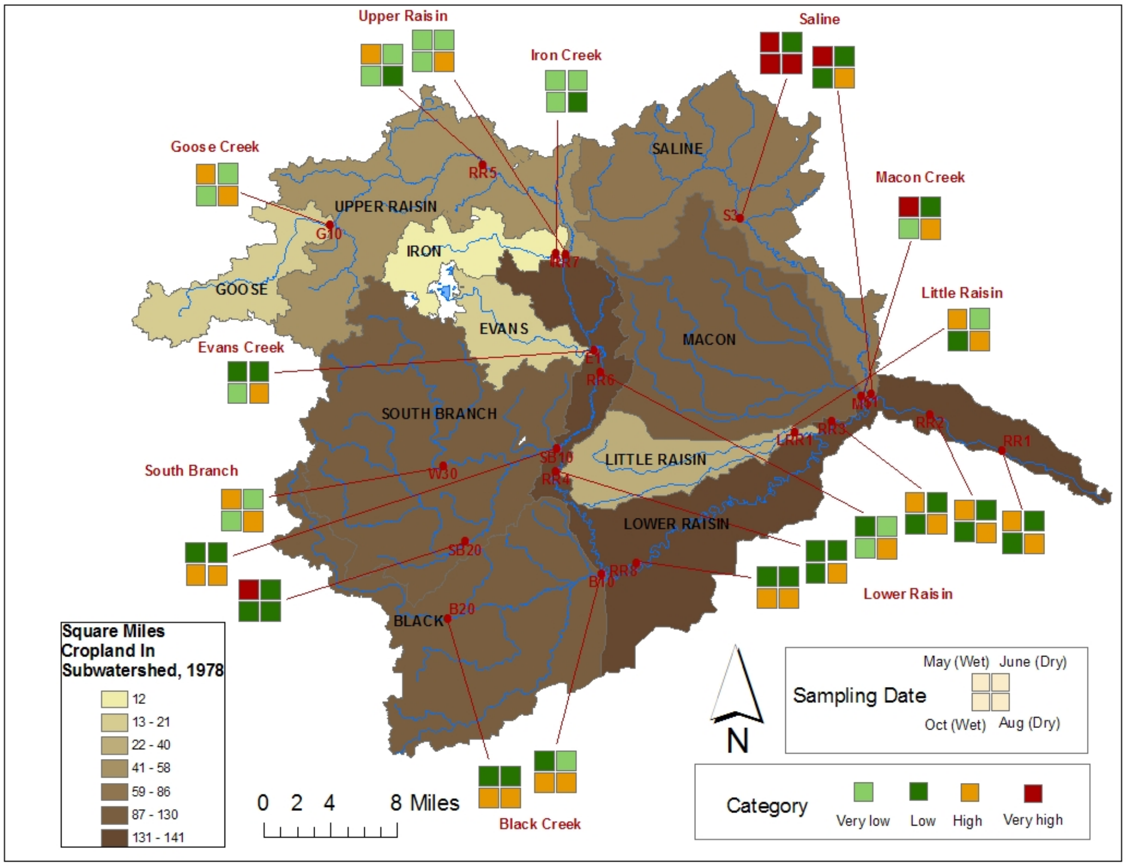


Figure 4-15 Range of conductivity values on four sampling dates in the River Raisin watershed. Value categories (µS/cm) are very low (less than 300), low (300-500), high (500-700), and very high (greater than 700).

4.3.5 Water Temperature, Dissolved Oxygen & pH

Average water temperatures from the sites ranged from 11.9 °C in May and October (Site M1) to 22.8 °C in August (Site RR2). Dissolved Oxygen (DO) ranged from 6.6 mg/L in June (Site RR3) to 13.5 mg/L in August, with pH samples consistently averaging between 7.8 and 7.9 for each of the four sampling periods (**Table 4-2**). The high dissolved oxygen temperatures recorded during June and August are intriguing considering water temperature helps determine the maximum amount of oxygen gas that water can dissolve and generally as water temperatures increases, dissolved oxygen levels decrease. Dissolved oxygen concentration is important because it helps determine the water's ability to support oxygen-consuming creatures. As water temperatures rise many chemical reactions in the water environment are accelerated, including the consumption of oxygen.

Table 4-2 Water Temperature, Dissolved Oxygen & pH

May Wet Weather Sampling

	Mean	Maximum	Max. Site	Minimum	Min. Site
Air Temperature (°C)	20.6	30	B2	11	RR1
Water Temperature (°C)	13.9	16.2	RR7	11.9	M1
Dissolved Oxygen (mg/L)	8.52	9.8	I1	7.4	RR3
pH	7.81	8	RR7	7.6	B1

June Dry Weather Sampling

	Mean	Maximum	Max. Site	Minimum	Min. Site
Air Temperature (°C)	27.7	30	B1,2,RR6,8	23	I1
Water Temperature (°C)	18.7	22	RR6	16.2	E1
Dissolved Oxygen (mg/L)	9.45	12.1	I1	6.6	RR3
pH	7.97	8.2	RR6	7.7	RR5

August Dry Weather Sampling

	Mean	Maximum	Max. Site	Minimum	Min. Site
Air Temperature (°C)	30.2	38	I1	23	RR5
Water Temperature (°C)	20.2	22.8	RR2	15.6	G10
Dissolved Oxygen (mg/L)	10.2	13.5	RR7	8.5	RR1, 3,8
pH	7.89	8.2	I1, RR2,7, S1,3	7.5	E1

October Wet Weather Sampling

	Mean	Maximum	Max. Site	Minimum	Min. Site
Air Temperature (°C)	20.6	30	M1	11	RR1
Water Temperature (°C)	13.9	16.2	RR7	11.9	M1
Dissolved Oxygen (mg/L)	8.52	9.8	I1	7.4	RR3
pH	7.81	8	RR7	7.6	B1

4.3.6 E. Coli

The USEPA recommends *Escherichia coli* (*E. coli*) bacteria as one of the best indicators of human health risk from water contact in recreational waters. Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Therefore, their presence in streams suggests that pathogenic microorganisms might also be present and that swimming and eating shellfish might be a health risk.

Samples from 24 sites in the River Raisin basin were tested for *E. coli* concentrations with numerous sites reporting concentrations of over 2,000 colony forming units (cfu)/100 ml, multiple times during the year. The data, collected sporadically, does show elevated levels of *E. coli* that warrant further investigation.

4.3.7 UM Water Quality Summary

Benchmarks in the literature offer a context for overall performance of the River Raisin watershed. USEPA has developed a draft set of background nutrient concentrations for Ecoregion VI in an effort to assist state and tribal groups in setting standards consistent with section 303(c) of the Clean Water Act (USEPA 2000). The range of TP measured in the River Raisin was within the reference values found by the USEPA (**Table 4-3**). The range of measured TN values for the River Raisin was reasonably close to the USEPA's reference range, with the maximum value in the River slightly higher than the reference range.

Table 4-3 A comparison of TP and TN ranges set by the USEPA's ambient water quality criteria recommendations and the actual ranges measured in the River Raisin.

Constituent	USEPA Reference		Raisin Data	
	Min	**Max**	**Min**	**Max**
TP (ug/L)	10	1,225	21.2	412.9
TN (ug/L)	0.4	11.97	0.52	13.04

In addition to the USEPA recommendations, a study by Dodds et al., (1998) suggested reasonable distributions of TN and TP for a large number of temperate streams. Dodds suggested that the lower third of the distribution (which he called the oligotrophic-mesotrophic boundary) includes values at or below 25 µg/L, and the upper third of the distribution (called the mesotrophic-eutrophic boundary) includes values at or above 75 µg/L. For TN the boundaries were 0.7 and 1.5 mg/L, respectively. In comparison to the divisions chosen by Dodds et al., (1998), the River Raisin data had minimums for both TP and TN below the lower third of the distribution, with some sites having less than 25 µg/L of TP and less than 0.7 mg/L of TN. However, some sites are of concern due to values of TP and TN in the upper third from the Dodds distribution; these values are listed in **Table 4-4**.

Table 4-4 Concentration of TP and TN at sites at the mouth of priority subwatersheds.

	Total Phosphorus (µg/L)			
	May	Jun	Aug	Oct
South Branch	152	226	175	153
Black Creek	112	121	92	132
Saline River	105	115	116	162
Macon Creek	110	56	50	116
Lower Raisin	131	100	98	87

	Total Nitrogen (mg/L)			
	May	Jun	Aug	Oct
South Branch	8.7	4.9	6.1	2.5
Black Creek	12.2	7.2	1.5	2.7
Saline River	7.5	2.7	2.2	1.8
Macon Creek	9.5	3.4	0.9	4.6
Lower Raisin	10.1	7.3	1.7	1.7

4.4 Macroinvertebrates

The year 2007 was the sixth year of the River Raisin Watershed's Adopt-A-Stream Program. This program was designed and implemented to assess the health of River Raisin watershed streams and rivers by looking at the aquatic invertebrates that are found during organized searches. Some aquatic invertebrates are extremely susceptible to pollutants and low oxygen levels – finding them indicates good water quality. Other aquatic invertebrates are very tolerant of pollutants and/or low oxygen levels. The presence of pollution-tolerant species combined with the absence of sensitive species indicates poor water quality.

There are now six years of data for the spring collection (always sampling on the last Saturday of April) and two years of data for the fall collection (always sampling on the last Saturday of September). There were originally 13 sites chosen along the mainstem and its tributaries. To be inclusive of all the major sub-basins in the watershed the number was increased to 20 sites by fall of 2006 (See **Figure 4-16**).

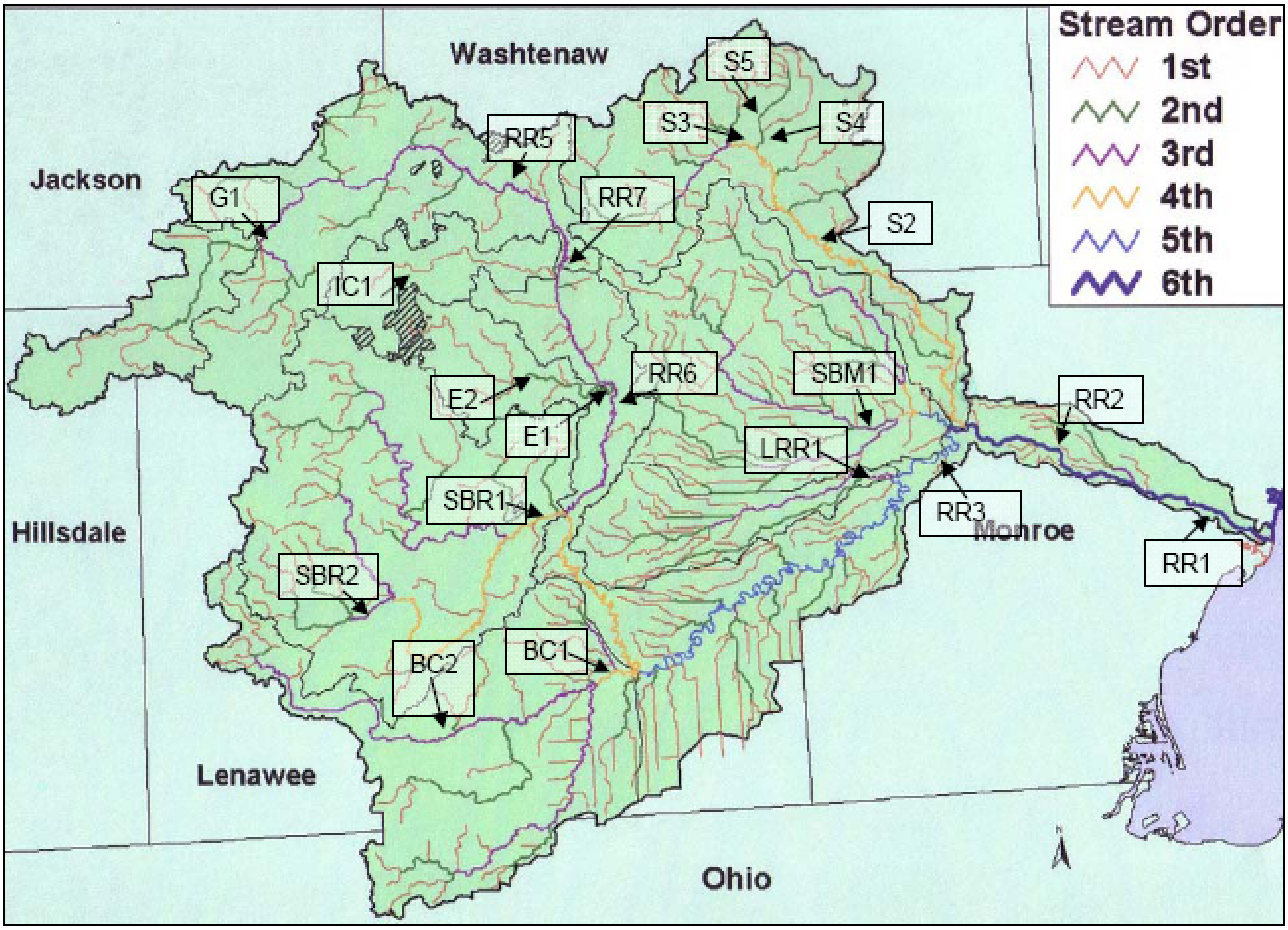


Figure 4-16 Marcoinvertebrate sampling sites in the River Raisin

Figure 4-17 presents a summary of all collected adopt-a-stream program data up to fall of 2007. The figure includes Michigan Clean Water Corp Index quarterly thresholds (MiCorps: http://www.micorps.net/). The index compares invertebrate recoveries through the years as well as with points within the watershed and against other watersheds. The MiCorp Index (an example data form is provided in the **Macroinvertebrates and Mussels Appendix**) classifies the sample into one of four categories according to the type and diversity of stream invertebrates recovered during a stream search (poor, fair, good or excellent).

Looking at the data for the individual sites through the years, four different patterns emerge: stable, erratic, declining, and improving. The Upper Raisin has been relatively stable through the sampling, even showing an uptick in the rating scale the last several stream searches. The Lower Raisin (Dundee, Monroe, and a site in-between) started with ratings in the 'good' category, though by 2005 and 2006 these sites had declined into the 'fair' to 'poor' category. It is unclear why this decline has occurred, though variance in sample size is very likely to be at least partly responsible. It is encouraging that in the fall 2007 sampling, the site closest to the mouth of the river edged into the 'good' range, and the other two sites just up river were well into the 'fair' range. An erratic (up and down) pattern is observed at some of the other sites through time and often linked to low sample size as well.

Summarizing the preceding maps into a figure can allow us to compare all sites through the years. The following summary (**Figure 4-17**) shows all the collection sites for all the years, plotted against their MiCorp Index. Note that the blue line connecting the boxplots is running through the average value for that year, while the median value is represented by the center line in the box. Black Creek is, so far, reporting the most consistently poor invertebrate fauna populations while Iron Creek, Goose Creek, and the River Raisin above Clinton (RR5) have shown consistently healthy macroinvertebrate populations with MiCorp Index ratings of mostly good, including one excellent rating each for Goose Creek and RR5.

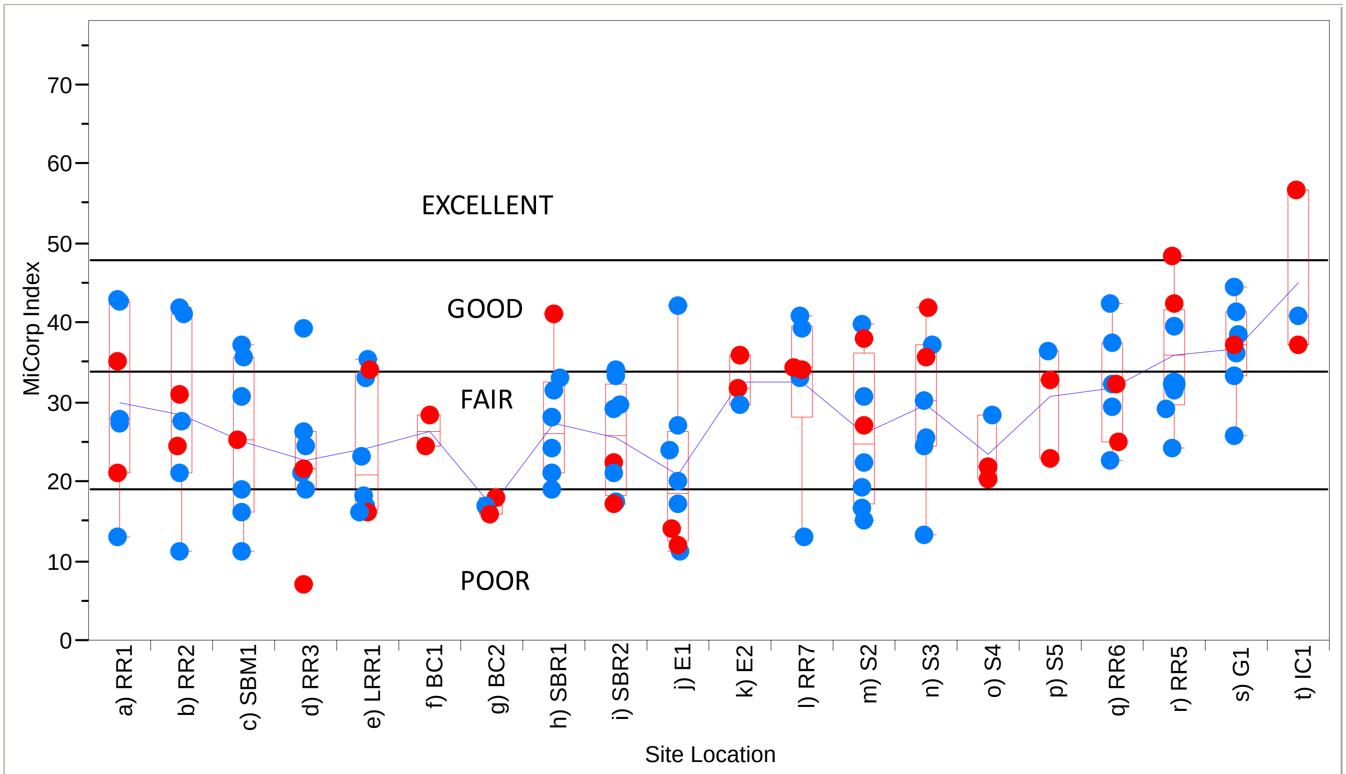


Figure 4-17 Macroinvertebrate sampling summary using the MI Corps Index (type and diversity quality). From: Adopt-A-Stream program sampling from 2002-2007.

5.0 PRIORITIZING CHALLENGES AND GOALS IN THE RIVER RAISIN WATERSHED

Based on their various water quality, sediment, fish and macroinvertebrate evaluations, the MDEQ and USEPA have identified impaired uses and the sources and causes of these impairments on the River Raisin. As part of compiling this plan, stakeholders also took the opportunity to identify for themselves use impairments and possible sources and causes of those impairments. Over the two year planning period for this plan, stakeholders found that the set of federal and state impairments for the river were consistent with their list, but represented only a subset of the river's problems. The stakeholders identified secondary sources and causes of the listed impairments and created their own set of "threatened" uses. The stakeholders held that all uses in the river are either impaired or threatened (refer to **Table 5-3** below).

The first set of priorities in this plan are lifting the impairments of the TMDLs; the second set of priorities is to address impairments of waters of the Raisin that do not have TMDLs yet but are on the state's 303(d) Impaired Waters List; the third priority is to address stakeholder-identified threats. Fortunately, addressing many of the sources and causes of designated impairments will also go a long way to addressing the identified sources and causes for the threatened uses.

This plan has a set of strategies that address the nitrate and *E.coli* TMDLs. These TMDL strategies contain the most thorough process described in this plan for dealing with their associated pollutants, sources and causes. This set of TMDL strategies is also sufficiently broad that implementing the suite of recommendations would have an impact on more than half the remaining impairments.

Recovering the beneficial use impairments (BUI) of the Raisin Area of Concern (RR AOC) in Monroe is also a priority on par with recovering the uses identified on the 303d impaired Water List. The Raisin AOC already has its own Public Advisory Council (PAC), Remedial Action Plan (RAP), and for the fish and wildlife habitat and population impairments, delisting targets and a restoration plan. For more detail refer to: "Delisting Targets for Fish/Wildlife Habitat & Population Related Beneficial Use Impairments for the River Raisin Area of Concern," (ECT, 2008) in the **Water Quality (MDEQ Folder) Appendix**. This delisting plan addresses these two BUIs with actions for recovering habitat, addressing flow instability and upstream nutrient loads.

The impairments for the AOC that remain to be addressed include:

- restrictions on fish and wildlife consumption
- Bird or animal deformities or reproductive problems
- Degradation of benthos
- Restrictions on dredging activities
- Eutrophication or undesirable algae
- Beach closings
- Degradation of aesthetics

The AOC/PAC process along with implementation of this plan will work to address these impairments. Many of the impairments within the AOC area have been primarily caused by historical discharges of oils and grease, heavy metals and polychlorinated biphenyls (PCBs) to the river from industrial facilities. Industrial and municipal waste disposal sites adjacent to the river are also suspected of contaminating the river and causing significant loss of fish and wildlife habitat. Priority remedial actions to address these other impairments include remediation of PCB contaminated sediments, improvement of upstream non-point source pollution control and elimination of upstream sanitary sewer and combined sewer overflows.

5.1 Designated Uses

The primary goal for meeting water quality criteria is to attain the designated uses for a given waterbody. In the state of Michigan all water bodies are to meet the criteria for the same minimum, nine designated uses below. This is the same list of uses the Raisin must attain.

Agriculture
Navigation
Warm water fishery
Indigenous aquatic life and other wildlife
Partial body contact recreation
Total body contact recreation between May 1 and October 31
Public water supply at point of intake
Industrial water supply
Fish Consumption

The definition of each designated use is given below.

Agriculture – Surface waters must be a consistent and safe source for irrigation and livestock watering. Irrigation is a critical water use in the River Raisin watershed.

Navigation – Reaches of waterways that are large enough for canoes and kayaks must maintain navigable conditions.

Warmwater fishery – A warmwater fishery is generally considered to have summer temperatures between 60 – 70 degrees Fahrenheit and is capable of supporting water species, such as largemouth and smallmouth bass on a year-round basis.

Other Indigenous Aquatic Life and Wildlife – Aquatic plants and animals and other wildlife in the ecosystem should be considered in all management strategies. A stable and sustainable habitat supports populations of wildlife that support a healthy ecosystem.

Partial body contact recreation – All waterbodies must meet water quality standards of less than 1,000 count/100 ml of *E. coli* for recreational uses of boating and fishing to be considered safe.

Total body contact recreation – All waterbodies must meet water quality standards of less than 130 count/100 ml of *E. coli* as a 30-day geometric mean for areas to be considered safe for swimming between May 1 and October 31. Other impediments to total body contact recreation include nuisance aquatic vegetation and algae blooms from excessive nutrients loadings.

Public water supply at Point of Intake – Municipal water supplies must have safe and adequate amounts of surface water. Groundwater and the River Raisin are the primary sources of drinking water in the watershed.

Industrial water supply – Water supply must be adequate for industrial water use.

Fish consumption – Consumption of fish must be safe. The MDEQ uses a number of assessments to determine if fish consumption exceeds threshold levels. These assessments include water and fish tissue concentrations of bioaccumulative compounds, such as PCBs, mercury and Dioxin, and state health advisories.

5.1.1 Status of Designated Uses

When various water quality standards are exceeded on a regular basis, such as average and maximum *E. coli* concentrations, these conditions warrant eliminating the use and result in MDEQ declaring the specific sampling reach of a water body as "impaired". In the *E. coli* example, the standards are set as statistically reasonable risk estimates above which the chances for bacterial river concentrations to cause sickness or death are deemed to be unreasonable. Impaired uses have been identified both by the MDEQ, EPA and watershed stakeholders. The five impaired uses of the River Raisin in order of importance include: 1) public water supply, 2&3) total and partial body contact recreation, 4) aquatic life and wildlife and 5) fish consumption. The first three impairments on this list have TMDLs, the latter two impairments are due for TMDLs over the next three years.

Public water supply between Blissfield and the Lenawee County line is impaired due to nitrate concentrations that exceed the USEPA drinking water standard of 10 mg/L. Partial and full body contact recreational uses for several locations on the lower River Raisin, the South Branch of the Raisin near Adrian, on the Saline River in York Township, and the Lenawee County Drain 70 are impaired due to raw sewage discharges and *E. coli* concentrations that exceed the daily maximum (1,000 colonies per 100 ml) and the 30-day average (130 colonies per 100 ml). *E. coli* is also the pollutant of concern for the beach closings BUI in the Raisin AOC.

The Little River Raisin and the South Branch of the Raisin have been listed as impaired for Aquatic Life and Wildlife due to habitat modification and channelization, although a date for their TMDLs has not been set. Listings for fish consumption impairments exist on Black Creek downstream of Lake Hudson, on the South Branch of the Raisin downstream from Adrian, Clark Lake, Sand Lake, Wamplers Lake, the mouth of the Raisin as well as the entire watershed, including tributaries. The pollutants for these impairments are PCBs, mercury and Dioxin and they originate from legacy sediments and atmospheric deposition. TMDLs are planned for these listings sometime between 2010 and 2012. These same pollutants are also the source of many of the BUIs in the Raisin AOC, including bird/animal deformities or reproductive problems, degradation of the benthos and restrictions on dredging activities. Another set of Raisin AOC BUIs, include eutrophication and/or undesirable algae. The source of these problems could be phosphorus from the Raisin watershed as well as phosphorus coming into Monroe Harbor from Lake Erie.

For the Lenawee County Drain #70 and the Saline River TMDLs, remedial projects have been completed that may address some or most of the pollutant sources. For the Lenawee County Drain #70, construction of a regional wastewater treatment plant (WWTP), the Central Lenawee County Sewer Disposal System, may be enough to address the source of the problem. Follow-up monitoring needs to be done to see if this reach can be de-listed. For the Saline River, some of the un-sewered homes on the TMDL reach were hooked into sewer after the reach was listed. While sampling done in 2004 appeared to show significant improvements, exceedances were still found. This reach and other potential sources upstream need to be sampled again to assess any possible changes in their status.

Impairments due to pollutants like PCB, mercury and Dioxin (bioaccumulative pollutants of concern) derive from sources that are either inordinately expensive to remediate (legacy sediments) or are global in nature, such as atmospheric deposition. This plan includes some ideas and direction for addressing these sources; however, remediation of legacy sediments will require significant federal and state agency response as well as significant financial investment. Addressing regional, national and global causes of atmospheric pollutants in detail is beyond the scope of this plan. Some information on regional atmospheric mercury reduction initiatives is included as part of this plan (see **Water Quality Appendix)**. If stakeholders are committed to addressing these problems, they will require participation in regional and national initiatives and raising the political stakes. The new Obama administration has proposed significant Great Lakes restoration funding for 2010. If that or other funding sources like it arise, they should be at least be partially exploited for dealing with this class of pollutants.

5.2 Prioritization of Pollutants and Sources

Prioritization of pollutants and sources starts with the list of pollutants and sources that are impairing designated uses. The top priority starts with TMDL reaches, while the second priority is for impaired reaches that do not yet have a TMDL, including BUIs in the Raisin AOC. The third general priority is to address the sources and causes of threatened uses. We would also suggest setting aside the TMDLs for the Lenawee County Drain 70 and the Saline River. Significant projects have been completed in these TMDL areas and the first task for these areas is to conduct more bacteria sampling to either de-list these reaches or re-prioritize sources. Impaired uses and their prioritized pollutants as well as stakeholder-identified threats and their prioritized pollutants are summarized in **Table 5-3**.

The list of all prioritized pollutants is then aggregated and prioritized sources of those pollutants assigned in **Table 5-4**. In **Table 5-5** the sources are aggregated and assigned their prioritized causes. Additional rationale for this prioritization process is given in the next two sections below.

5.2.1 Prioritization of Pollutants and Sources for Impaired Uses

The top three TMDLs that likely require the most work to remediate are in order of importance:

1) Nitrate on the River Raisin between Blissfield and the Lenawee County line
2) *E. coli* on the same reach and a one mile reach also on the mainstem, near Dundee
3) *E. coli* on the River Raisin between Clinton and Tecumseh

The next priority (#4) is to help address the River Raisin AOC BUIs for eutrophication and undesirable algae. The fifth priority is the four-mile reach on the South Branch of the River Raisin, downstream of the Adrian Wastewater Treatment Plant (WWTP) to the confluence of the South Branch with the mainstem of the Raisin. Adrian has made big strides the last few years to address the City's CSO and SSO issues. The City has an on-going program of sanitary and storm sewer rehabilitation to continue to improve performance. The MDEQ has only sampled this reach in 2006. Improvements should be assessed by another round of sampling for *E. coli*.

The last TMDL priorities are the Lenawee County Drain #70 and the Saline River. A new treatment plant and new sanitary sewer may have substantially controlled the identified sources. Follow-up sampling for *E. coli* needs to be conducted to assess the potential improvements and possibly de-listing.

A description of possible sources and causes of these TMDLs as described in the MDEQ TMDL documents follows below.

TMDL Priority 1: Nitrate – River Raisin This TMDL covers the sixteen-mile long reach of the River Raisin from Blissfield downstream to the Lenawee County line (near Deerfield). This reach is listed as impaired for public water supply use due to high nitrate concentrations.

MDEQ used the Sparrow model to assess sources of nitrogen in the River Raisin watershed. Point sources were shown to contribute only 4 percent of the annual nitrogen load. Because agricultural fertilizer and livestock waste (manure) contributed almost 70% of the annual nitrogen load (see **Table 5-1**), these constituents are targeted for reduction in this TMDL. The TMDL calls for a 57% reduction in fertilizer and manure loads. This would reduce the total annual load from 5,510,000 lbs/yr to 3,134,000 lbs/yr. A sub-watershed prioritization may also be useful to consider, based on the nitrogen loss intensity rating (see **Table 5-2**) and spatial location of the subwatershed in relation to the TMDL reach.

Table 5-1 Annual Nitrogen Load Estimates by Source in the River Raisin Nitrate TMDL

Nitrogen Source	Mean Load (lbs/yr)	Percent of Total Load
Nonpoint Sources		
Fertilizer	3,273,000	59.4
Atmospheric Deposition	1,157,000	21.0
Livestock Waste	603,000	10.9
Nonagricultural Lands	243,000	4.4
Point Sources	234,000	4.2
TOTAL ANNUAL LOAD	5,510,000	100.0

Table 5-2 Nitrate Loss Intensity for Subwatersheds based on River Raisin GeoBook Analysis

VERY HIGH:	LOW (cont.):
East Bear Creek	Lower River Raisin 3
Lower Black Creek 2	South Br River Raisin 2
Upper Br Nile Ditch	South Br River Raisin 3
	South Br River Raisin 4
HIGH:	Stoney Lk Drain
Lower River Raisin 4	Upper Beaver Creek
Nile Ditch	Upper Goose Creek
Upper Black Creek 2	Upper River Raisin 2
	Upper River Raisin 3
MODERATE:	Upper River Raisin 4
Black Creek	Upper West Bear Creek
Lower Black Creek 1	Wolf Creek
Lower River Raisin 5	
South Br River Raisin 1	VERY LOW:
Upper Black Creek 1	Dillingham Creek
West Bear Creek	Iron Creek
	Kedron Drain
LOW:	Lower Goose Creek
Beaver Creek	Lower River Raisin 2
Evans Creek	Norvell-Manchester Drain
Hazen Creek	Sweezy Lake Drain
Lower River Raisin 1	Upper River Raisin 1

TMDL Priority 2: *E. coli* – River Raisin

This TMDL covers two reaches of the mainstem of the River Raisin : 1) a sixteen-mile long reach from Blissfield downstream to the Lenawee County line (near Deerfield) and 2) a one-mile long reach near Dundee in Monroe County. These reaches are listed for impairment of full body contact recreational use due to pathogens. Although there are 23 point-source NPDES permits (including 4 WWTP outfalls - Blissfield WWTP, Deerfield WWTP, Dundee WWTP, and Petersburg WWTP) in these reaches, they are not believed to be the sources of the pathogens, as they have generally been in compliance with their permits. The townships comprising the largest portion of this TMDL area are: Deerfield Township (17.2%), Summerfield Township (14.8%), and Blissfield Township (14.3%). The Village of Blissfield has eliminated their CSO's and the Village of Deerfield has completed an evaluation and rehabilitation study of their sanitary wastewater system. It is believed that the primary sources of pathogens are agricultural runoff and to a lesser degree, suburban land uses including urban runoff and failing septic systems. Specific pathways from agricultural land uses could be through runoff from pastureland or land applications of manure via field drainage systems, such as tiles.

TMDL Priority 3: *E. coli* – River Raisin

This TMDL covers an eight-mile long reach from the village of Clinton downstream to the city of Tecumseh (primarily upstream of the impoundment). This reach is impaired for full body contact recreational uses due to excessive pathogens measured as *E. coli*. Although there are two permitted NPDES wastewater treatment plant outfalls (Clinton WWTP and Tecumseh WWTP) within the TMDL reach, these are not expected to be major pathogen sources as they have been in compliance with their permits. It is expected that elevated *E. coli* concentrations are the result primarily of urban and suburban land use including stormwater runoff, and secondarily of agricultural land uses in the watershed.

TMDL Priority 4: *E. coli* – South Branch River Raisin

This TMDL covers a four-mile long reach of the South Branch River Raisin near Adrian (from Adrian WWTP downstream to confluence with main branch). The reach is impaired for both fully body contact recreation and partial body contact recreation due to pathogens (*E. coli*). Load duration curves were developed to help identify pathogen sources contributing to the high concentrations of *E. coli*. The load duration curves indicate that there are both wet and dry weather sources contributing to the high *E. coli* concentrations. Wet weather sources include CSOs/SSOs in the City of Adrian (regulated under the Adrian WWTP NPDES permit) and runoff from agricultural land in the watershed (including regulated CAFOs). The most likely dry weather sources of *E. coli* are a constant source, such as failing septic systems and illicit connections of sewage sources to surface water bodies throughout the watershed.

TMDL Priority 5: *E. coli* – Saline River, near Mooreville & Lenawee County Drain #70

These two TMDLs cover 1) a one-mile long reach of the Saline River near Mooreville, from Maple Road downstream to Platt Road; and 2) a one mile reach of the Lenawee County Drain #70 in Palmyra Township. The Saline River reach is impaired for full body contact recreational uses due to high pathogen (*E. coli*) concentrations. Sampling in 2001 indicated highest exceedances near Dennison Road where homes are located. Illicit discharges, agricultural inputs and to a lesser degree, storm water inputs, are likely the dominant source of E. coli to the Saline River. Additional sampling aimed at identifying upstream sources revealed additional exceedances at Maple Road as well as upstream of the City of Saline at Dell Road.

The Lenawee County Drain #70 is listed for impairment of recreational uses due to pathogens and is primarily associated with illicit discharges and inadequately treated wastewater from the Manor Farms Subdivision. A regional WWTP (Central Lenawee Sewer Disposal System) was constructed to serve this area after the TMDL was issued.

Table 5-3 Prioritized River Raisin Impaired Use and Threatened Use Pollutants

IMPAIRED USE	POLLUTANTS
Public Water Supply	1. Nitrate *2. Dissolved Reactive Phosphorus* *3. Pesticides* *4. Sediment* 5. BOD 6. Hydrocarbons *7. Mercury* 8. E.coli
Full/Partial Body Contact Recreation	1. E.coli *2. Sediment* *3. Dissolved Reactive Phosphorus* 4. Large woody debris *5. Pesticides* 6. Hydrocarbons
Fish Consumption Advisory	*1. PCBs* *1. Mercury* *1. TCDD Dioxin*
Aquatic & wildlife habitat	*1. Sediment* *2. Flow alteration* 2. Nutrients 3. BOD 4. Trash 5.Temperature 6. Exotic species
AOC BUI - Eutrophication/ Nusiance Algae	*1. Dissolved Reactive Phosphorus* 1. Impoundments

THREATENED USE	POLLUTANTS
Warmwater Fishery	*1. Sediment* 2. Invasive species 3. Mercury *4. Pesticides* *5. Flow alteration* 6. Temperature 7. Hydrocarbons 8. E.coli 9. BOD *2. Dissolved Reactive Phosphorus* 11. Large woody debris/trash
Navigation	*1. Sediment* 2. Large woody debris/trash *3. Flow alteration* 4. Impoundments
Agriculture	*1. Sediment/Turbidity* *2. Flow alteration*
Industrial Use	*1. Sediment/Turbidity*

Red font: MDEQ-Listed Impairments and Pollutants for existing TMDLs

Italics: MDEQ-Listed Impairments and Pollutants for future TMDLs

Plain font: Stakeholder-identified threats and pollutants for water quality threats

Table 5-4 River Raisin Prioritized Pollutants and Prioritized Sources

POLLUTANTS	SOURCE
1. Nitrate	1. Ag Fertilizers
	2. Livestock waste
	3. Improperly treated wastewater
	4. Cropland Drainage
	5. Urban Fertilizers
2. E.coli	1. Improperly treated wastewater
	2. Livestock waste
	3. Ag runoff
	4. Cropland Drainage
	5. Urban runoff
	6. Wildlife
3. Sediment	1. Ag runoff
	2. Stream erosion
	3. Urban runoff
4. Phosphorus	1. Ag Fertilizers
	2. Improperly treated wastewater
	3. Stream erosion
	4. Urban fertilizers
5. Flow alteration	1. Conversion of natural land cover
	2. Cropland Drainage
	3. Urban runoff
	4. Impoundments
6. PCBs	*1. Legacy sediments*
	2. Atmospheric Deposition
7. Mercury	*1. Atmospheric Deposition*
	2. Legacy sediments
8. TCDD Dioxin	*1. Legacy sediments*
	2. Atmospheric Deposition

POLLUTANTS	SOURCE
9. Pesticides	*1. Pesticides*
	2. Cropland Drainage
	3. Ag Runoff
	4. Urban Runoff
10. Invasive species	1. Human introduction
	2. Natural transport
11. Large woody debris	1. Conversion of natural land cover
	2. Cropland Drainage
	3. Stream erosion
	4. Tree mortality
	5. Urban Runoff
12. Hydrocarbons	1. Urban runoff
	2. Ag runoff
13.Temperature	1. Conversion of natural land cover
	2. Impoundments
	3. Urban runoff
14. Impoundments	1. Mill Power
	2. Electric Power
	3. Recreation
15. Biological Oxygen Demand	1. Ag Fertilizers
	2. Urban Fertilizers
	3. Improperly treated wastewater
	4. Ag Runoff
	5. Ag drain tile
	6. Urban runoff
16. Trash	1. Dumping

Red font: MDEQ-Listed Pollutants and sources for existing TMDLs

Italics: MDEQ-Listed Pollutants and Sources for future TMDLs

Plain font: Stakeholder-identified pollutants and sources for water quality threats

Table 5-5 Prioritization of Causes of Impairments

SOURCE	CAUSES
Ag Fertilizers	1. Imprecision, over-use, poor timing
Livestock waste	1. Lack of effective livestock management plan
	2. Poor land application practices
	3. Improper feedlot management
Improperly treated wastewater	1. CSO, SSO
	2. Failing or impropery sited septic systems
	3. Un-treated wastewater
Cropland Drainage	1. Lack of proper drain tile and swale management
Urban Fertilizers	1. Over-use
Ag runoff	1. Lack of effective storm water management plan
Urban runoff	1. Impervious & compacted pervious surfaces
	2. Inadequate stormwater management
Wildlife	1. Turf grass riparian buffers
	2. Urban habitat shelters, e.g., manholes
Stream erosion	1. Conversion of natural land cover
	2. Cropland drainage
	3. Ag runoff
	4. Urban runoff
	5. Large woody debris
Conversion of natural land cover	1. Clearing and draining for development
Impervious surfaces	1. Development
Legacy sediments	*1. Historic dumping*
Atmospheric Deposition	*1. Smokestack emissions*
Pesticides	1. Imprecision, over-use, poor timing
Human introduction	1. Lack of understanding
Natural transport	1. Wind, water, animals
Tree mortality	1. Tree disease & pests
	2. Development
Built for Mill Power	1. Former Mills
Built for Electric Power	1. Former Power Companies
Built for Recreation/aesthetics	1. Lakeside owners
Dumping	1&2. Ignorance & arrogance

Red font: MDEQ-Listed Sources and Causes for existing TMDLs

Italics: MDEQ-Listed Sources and Causes for future TMDLs

Plain font: Stakeholder-identified Sources and Causes for water quality threats

5.2.2 Prioritization of Sources and Causes for Threatened Uses

The highest priority threatened uses are 1) warmwater fishery and 2) navigation. For stakeholders, the barriers to navigation included barriers to canoeing the river. In this sense, both threatened uses are barriers to recreation on and access to the river and are deemed critical for first-hand experience of the resource and development of understanding, sensitivity and stewardship.

The next highest priority threatened use is agriculture. This use was deemed threatened by stakeholders, including local farmers, by barriers to water withdrawal for irrigation. Farmers noted that while flow variability and erosion and sedimentation issues may complicate withdrawal, they do not usually incapacitate it. This same rationale holds for industrial uses. Because there is so little industry in the watershed relying on water withdrawals, this threatened use was made the last priority.

The steering committee listed flow variability and sediment as pollutants for almost all impaired and threatened uses. Flow variability is defined as smaller low flows or larger high flows. Sediment is listed as a pollutant due to its excess, defined in terms of suspended solids or turbidity as well as excess sedimentation along the river and its tributaries. Flow variability and sediment are clearly the other top two pollutant priorities in the watershed. Other committee priorities not already included in the impaired list are large woody debris, invasive species, temperature, phosphorus, hydrocarbons and industrial/agricultural process-specific pollutants, including pesticides.

5.3 Pollutant Load Estimation

Total watershed pollutant load estimates were derived for agriculture, NPDES point sources, septic systems and bank erosion. Although this group of loads neglects the contribution of suburban/urban land uses, total suburban/urban land use constitutes roughly 6% of the watershed. Because literature unit area loadings for TSS, TN and TP are not that dissimilar from agriculture, agriculture acts as a default load source for any suburban/urban loads (see **Table 5-6** below).

Table 5-6 Average Unit Area Loads for Rural and Residential Land Uses, lbs/ac/year (from Caraco, 2002)

LAND USE	TSS	TN	TP
Rural	100	5	0.75
Residential – 1 acre lots	57	1.9	0.1
Multi-Family	160	5.8	0.8

Estimates of non-point source agriculture loads were estimated with the Soil Water Assessment Tool (SWAT). NPDES point source loads were calculated using reported NPDES data, estimates of properly functioning and failing septic systems and non-point source agricultural and urban, and suburban runoff volumes and pollutant loads. SWAT was also used to estimate the loss or conversion of runoff-generated pollutants in the river. The SWAT model and accompanying documentation are included in the **Water Quality Appendix**. Additional detail on SWAT and other load estimates are provided below.

NPDES point source loads were estimated both from reported monitoring data and from permit limits. Permitted flows and pollutant concentrations were used in the final watershed loading estimate. Typically, flows are lower than permitted, so using permit numbers makes for a conservative load estimate. Septic system loads were estimated from septic system data from county health departments. Very limited data on local failure rates was available. Literature values for failure rates and pollutant concentrations from properly functioning and failing septic systems were used to estimate septic system loads. NDPES load and septic system load estimates are covered in more detail below.

The Watershed Treatment Model (WTM) compiled by the Center for Watershed Protection cites a model-default value for streambank erosion in urbanizing areas of 500 lbs/ac/year (Caraco, 2002). We feel this number over-estimates the bank erosion in the Raisin because 1) it is a predominantly agricultural watershed and as mentioned in **sections 3.5** and **3.6**, 2) the major hydrologic and geomorphic destabilization of the watershed occurred during the initial land clearing and draining of the middle of the nineteenth and twentieth centuries.

The summary load table (**Table 5-7**) below compares the total annual average TSS, TN and TP loads estimated from the Heidelberg College water quality station and USGS Monroe gage data, SWAT model output, and NPDES, septic systems and bank erosion load estimates. Bank erosion estimates are from the Watershed Treatment Model (WTM). By comparision the WTM default sediment load is 500 lbs/ac/yr for urban streams. Even assuming the TSS & TN load estimates are potentially off by 100%, the SWAT model load estimates of agricultural loads show that they will still be the majority load in the watershed. For phosphorus, however, any of the estimated source loads could be the majority load.

Table 5-7 Comparison of Total Annual Average Loads (in tons/year) at River Raisin mouth from Data (Heidelberg Station), SWAT Model (watershed runoff loads and in-river load at mouth), NPDES Point Sources, Septic Systems and Bank Erosion

Pollutant	Heidelberg Monroe Station	SWAT		NPDES	Septic Systems	Bank Erosion
		Watershed Load	Delivered to Mouth			
TSS	140,691	621,266	139,252	3,933	651	21,198
TN	5,360	4,675	4,751	44	112	3
TP	187	110	193	181	218	81
Pollutant		**Percent of Load Measured at Heidelberg Monroe Station**				
TSS		441.6%	99.0%	2.8%	0.5%	15.1%
TN		87.2%	88.6%	0.8%	2.1%	0.1%
TP		58.6%	102.9%	96.5%	116.6%	43.0%

5.3.1 SWAT Model Calibration and Evaluation

The Soil and Water Assessment Tool (SWAT) is a sophisticated GIS-based model. SWAT was developed in the 1990's by Dr. Jeff Arnold for the USDA to predict the long-term effects of land management practices in large watersheds containing varying soils and land use types. Because it is a long-term model, SWAT is not designed to predict individual flood events or estimate the effects of large, accidental spills. Rather, SWAT is designed to predict the yields of water, sediment, and agricultural chemicals in a river for multi-year, continuous simulations. Model algorithms are based on physical principles and empirical correlations. Examples of physical input data for SWAT include weather conditions, soil properties, vegetation, topography, and land/agricultural management conditions in the watershed.

In a watershed the size of the Raisin, a GIS-based model helps efficiently estimate existing non-point source loads, project the impacts of watershed land use changes and recommended improvements. We used the GIS-based Soil and Water Assessment Tool (SWAT) to model existing and projected conditions in the watershed. SWAT works with topographic data in ArcView or ArcGIS to divide watersheds into subbasins. Within each subbasin, SWAT identifies hydrologic response units, or HRUs, that have unique land cover, soil types, and management conditions. In addition to HRUs, each subbasin is assigned information about its climate, groundwater, ponds, wetlands, and its streams.

For the River Raisin SWAT model, elevation data was acquired from the USGS National Elevation Dataset. Rivers, lakes, and streams information was provided by the USGS National Hydrography Dataset (NHD), and supplemented by the EPA Basins website. Minor errors in both datasets were manually corrected prior to integration into the model. SWAT identified 35 different subbasins within the River Raisin watershed (**Figure 5-1**).

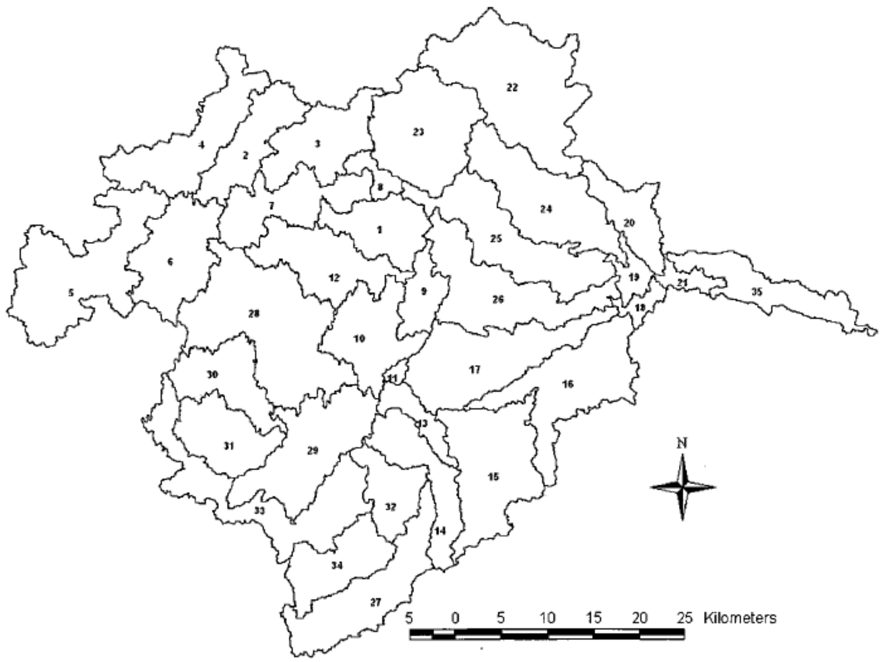


Figure 5-1 SWAT-Identified Sub-Basins of the River Raisin

The following datasets were then incorporated into the model:

- Data for dams and reservoirs was collected from the Great Lakes Fishery Commission, the Michigan Department of Natural Resources, and from local officials in the watershed.
- Land Use data for the entire watershed was found at the NOAA Coastal Change Analysis Program website
- Soils data was provided by the USEPA State Soil Geographic Database.
- Daily precipitation, temperature, wind speed, dew point, and cloud cover for 1995 through 2005 were provided by the NOAA Climatic Data Center.
- The MSU Michigan Climatological Resources Program was the source of daily solar radiation data.
- The USEPA Permit Compliance System database offered a wide variety of chemical and physical data pertaining to point source dischargers in the watershed (USEPA 2008b). This data was supplemented through direct contact with dischargers, including many wastewater treatment plant officials.
- Agricultural management practices were also considered when assessing the water quality in a watershed. Three generalized crop rotation schedules were used based upon data collected from the USDA's National Agricultural Statistics Service and through conversations with officials at the Lenawee Soil Conservation District.

Agricultural management practices are also model inputs. Three generalized crop rotation schedules were used based upon data collected from the USDA's National Agricultural Statistics Service and through conversations with the Natural Resources Conservation Service and Lenawee Soil Conservation District.

The accumulation of all collected data was integrated into the SWAT model, and the calibration phase was initiated. The SWAT model interpreted the input data, and the predicted results were compared to actual long-term data collected by USGS monitoring stations and water chemistry data from the Heidelberg College National Center for Water Quality Research. Locations included sites near Monroe, Manchester and Adrian. The calibration process for the River Raisin SWAT model was modified and repeated dozens of times until the results of the model closely resembled the actual conditions that occurred at the known locations and times (**Figure 5-2**).

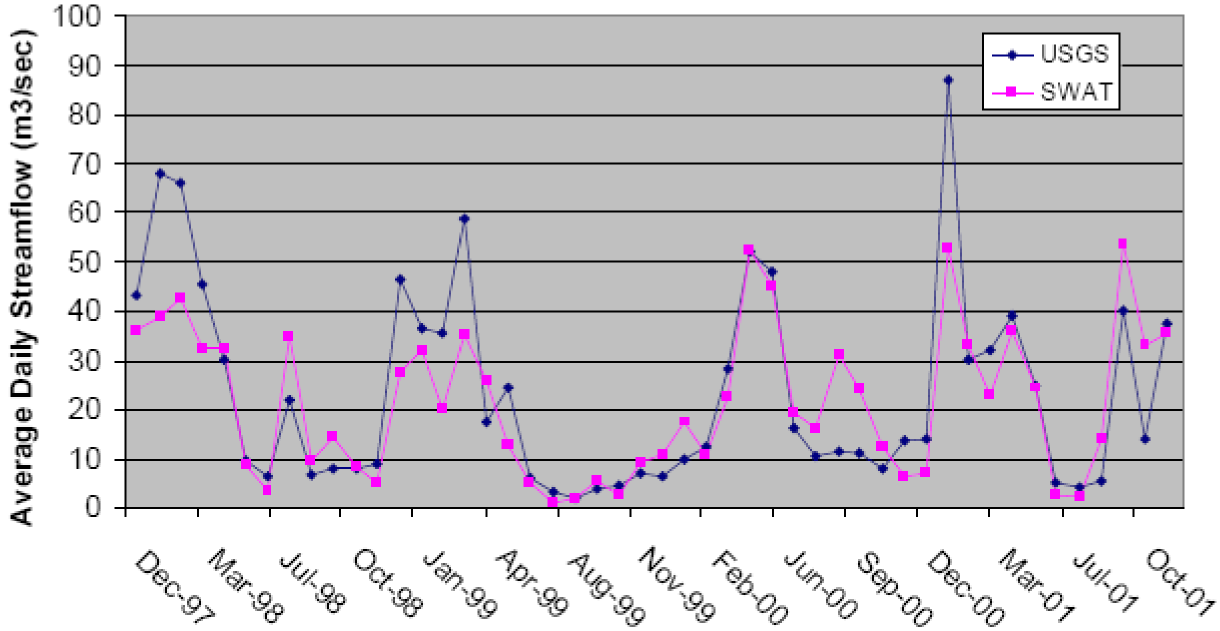


Figure 5-2 SWAT Model Hydrologic Calibration Comparison with USGS Gage on the River Raisin near Monroe (1998-2001).

Table 5-8 Calibrated SWAT Model Subwatershed Unit Area Pollutant Loads

Subwatershed	Area (mi^2)	Unit Area Loads		
		TSS (metric tons/ha)	TP (kg/ha)	TN (kg/ha)
Black Creek	150	3.479	0.09	15.61
Evans Creek	29	2.816	0.072	12.35
Goose Creek	40	0.809	0.019	7.15
Iron Creek	31	1.616	0.039	7.41
Little River Raisin	43	3.166	0.079	14.57
Lower River Raisin	181	1.629	0.044	6.52
Macon Creek	142	1.953	0.056	9.91
Saline River	129	1.796	0.048	6.12
South Branch River Raisin	189	2.454	1.796	25.10
Upper River Raisin	124	0.701	0.018	5.20
Average Watershed Unit Load		**2.057**	**0.364**	**11.92**

Table 5-9 Calibrated SWAT Model Subwatershed Pollutant Loads and Percent Total Load

Subwatershed	Area (mi^2)	Total Load			% Total Loads		
		TSS (metric tons)	TP (kg)	TN (kg)	TSS	TP	TN
Black Creek	150	135,159	3,496	606,360	24.0	3.5	18.6
Evans Creek	29	21,151	541	92,795	3.8	0.5	2.8
Goose Creek	40	8,381	197	74,094	1.5	0.2	2.3
Iron Creek	31	12,975	313	59,519	2.3	0.3	1.8
Little River Raisin	43	35,260	880	162,252	6.3	0.9	5.0
Lower River Raisin	181	76,366	2,063	305,443	13.5	2.1	9.4
Macon Creek	142	71,827	2,060	364,483	12.7	2.1	11.2
Saline River	129	60,006	1,604	204,370	10.6	1.6	6.3
South Branch River Raisin	189	120,125	87,916	1,228,856	21.3	88.2	37.6
Upper River Raisin	124	22,513	578	167,086	4.0	0.6	5.1
TOTAL	**1058**	**563,762**	**99,647**	**3,265,257**			

5.3.2 NPDES Point Source and Septic Field Loads

Nutrients and suspended solids loads (in lb/day) were calculated for NPDES point sources and septic systems and compared to the loads measured at the Heidelberg station near the mouth of the River Raisin at Monroe, MI.

NPDES Loads

Loads contributed from the 49 NPDES point sources in the watershed were estimated from data and permit limits. The NPDES point sources were identified using the MDEQ active permit list (MDEQ 2007a) and the USEPA's Permit Compliance System (PCS) database (USEPA 2008b). Each permit was accessed in the PCS database to find permitted limits and monitoring data. When permitted limits were available, the maximum concentrations or loads were used. When permitted limits were not available, monitoring data for flows and concentrations were used to calculate average loads. Loads were calculated by subwatershed and summed to get the total load for the entire River Raisin watershed.

Septic Loads

Loads contributed by septic systems were approximated by multiplying the estimated number of septic systems by an average flow value per system and by literature values for concentrations of nitrogen, phosphorus, and suspended solids. The number of septic systems for each township or municipality came from 1990 Census data (American FactFinder) and from the County Health Department surveys. These numbers were pro-rated by the area of communities within the watershed boundary. Data were not readily available for the number of new systems installed since 1990, or for the number of recent replacements for failed systems, so the adjusted 1990 data was used to represent operational systems, and an additional 5% of total systems were considered failed, based on DeWalle (1981). Data on replacement systems in Jackson County confirmed the failure rate of 4-8% of total systems per year. We estimated a population in the watershed of approximately 186,000. The total number of septic systems in the River Raisin watershed is estimated to be roughly 26,300, with approximately 1,400 failures. The number of households/facilities on sewer is estimated to be 37,650. In total this represents 63,950 households in the watershed with an average household size of almost 3 people.

An average flow of 500 gallons per day (GPD) per system was assumed per household. This represents a 2 bedroom house with 250 GPD of wastewater per bedroom. Literature values for operational septic system concentrations came from Canter and Knox (1985), while values for typical household wastewater influent concentrations, which were used to represent failed systems, came from Iowa DNR (2007). These concentrations are shown in **Table 5-10**.

Table 5-10 Example Septic System Effluent Water Quality

Example Septic System Water Quality		
	Failed	Operational
Constituent	Influent to Septic	Post - Drainage Field
(mg/L)		
N	50	10
P	12	5
TSS	250	20
BOD	220	30

The point source loads and the on-site system pollutant loads were compared to the Heidelberg College Monroe station average loads over the entire sampling period (**Table 5-11, Table 5-12, Table 5-13**).

Table 5-11 Total Suspended Solids (TSS) Loads from NPDES Point Sources and Septic Systems as a Percentage of Total River Raisin Loads Calculated at Monroe, MI

Subwatershed	**NPDES (lb/yr)**	**Septic (lb/yr)**		**Annual % Contributing to RR Outlet**	
		Normal	Failed	NPDES	Septic
Saline River Subwatershed	616,961	91,096	56,935	0.5%	0.1%
Macon Creek Subwatershed	1,300,239	59,369	37,106	1.0%	0.1%
Lower River Raisin Subwatershed	4,887,654	117,375	73,359	3.8%	0.2%
Black Creek Subwatershed	94,251	46,493	29,058	0.1%	0.1%
South Branch RR Subwatershed	866,784	129,433	80,895	0.7%	0.2%
Upper RR Subwatershed	63,300	166,549	104,093	0.0%	0.2%
Iron Creek Subwatershed	36,126	65,539	40,962	0.0%	0.1%
Evans Creek Subwatershed	0	37,440	23,400	0.0%	0.0%
Goose Creek Subwatershed	0	60,079	37,549	0.0%	0.1%
Little River Raisin Subwatershed	0	28,274	17,671	0.0%	0.0%
Total Annual Loads	**7,865,316**	**801,646**	**501,029**	**6.19%**	**1.03%**

Table 5-12 Total Nitrogen Loads from NPDES Point Sources and Septic Systems as a Percentage of Total River Raisin Loads Calculated at Monroe, MI

Subwatershed	NPDES (lb/yr)	Septic (lb/yr)		Annual % Contributing to RR Outlet	
		Normal	Failed	NPDES	Septic
Saline River Subwatershed	31,216	45,548	11,387	0.3%	0.6%
Macon Creek Subwatershed	15,828	29,685	7,421	0.2%	0.4%
Lower River Raisin Subwatershed	52,302	58,687	14,672	0.6%	0.8%
Black Creek Subwatershed	4,977	23,247	5,812	0.1%	0.3%
South Branch RR Subwatershed	246,285	64,716	16,179	2.8%	0.9%
Upper RR Subwatershed	3,358	83,275	20,819	0.0%	1.2%
Iron Creek Subwatershed	0	90	22	0.0%	0.0%
Evans Creek Subwatershed	7,636	51	13	0.1%	0.0%
Goose Creek Subwatershed	0	30,039	7,510	0.0%	0.4%
Little River Raisin Subwatershed	0	14,137	3,534	0.0%	0.2%
Total Annual Loads	**361,602**	**349,475**	**87,369**	**4.0%**	**4.9%**

Table 5-13 Total Phosphorus Loads from NPDES Point Sources and Septic Systems as a Percentage of Total River Raisin Loads Calculated at Monroe, MI

Subwatershed	NPDES (lb/yr)	Septic (lb/yr)		Annual % Contributing to RR Outlet	
		Normal	Failed	NPDES	Septic
Saline River Subwatershed	14,914	22,774	2,733	4.9%	0.3%
Macon Creek Subwatershed	27,132	14,842	1,781	8.9%	0.2%
Lower River Raisin Subwatershed	12,582	29,344	3,521	4.2%	0.4%
Black Creek Subwatershed	5,640	11,623	1,395	1.9%	0.1%
South Branch RR Subwatershed	26,006	32,358	3,883	8.6%	0.4%
Upper RR Subwatershed	1,679	41,637	4,996	0.6%	0.5%
Iron Creek Subwatershed	0	16,385	1,966	0.0%	0.2%
Evans Creek Subwatershed	743	9,360	1,123	0.2%	0.1%
Goose Creek Subwatershed	0	15,020	1,802	0.0%	0.2%
Little River Raisin Subwatershed	0	7,068	848	0.0%	0.1%
Total Annual Loads	**88,696**	**200,411**	**24,049**	**29.26%**	**2.51%**

5.4 Geographic Water Quality Priorities

In this section we summarize the previous sections on land use, habitat and water quality in terms of prioritizing subareas and establish two kinds of geographic priorities: 1) those subwatersheds and areas most responsible for TMDL impairments and 2) those subwatersheds or areas that have few or no impairments, but most deserve protection from further degradation. We have also briefly summarized potential water quality issues analyzed in the River Raisin Geobook in **Table 5-14**. The results of the Geobook analyses on a finer subwatershed scale can be found in the **Water Quality Appendix**.

The preceding sections have summarized a lot of data from a number of sources. But as this data demonstrates, it is a mixed blessing to have so much data. The greater the amount and variety of data sources, the more likely there will be contradictions between data sets. This is certainly true in the Raisin. Where contradictions exist it can be difficult to establish primacy among data. We have tried as much as possible to base priorities on the largest sets of correspondence and most conspicuous set of problems and/or opportunities. For instance, one glaring omission in the Geobook analyses is a low priority ranking for nitrogen loads from the South Branch of the River Raisin. By other accounts – water quality data and SWAT analyses, South Branch is the main contributor of nitrate to the downstream TMDL. **Table 5-14** summarizes the geographic priorities and impairments, along with characteristics of each subwatershed that are likely impacting its water quality.

Table 5-14 Summary of River Raisin Geobook Water Quality Impact Analyses

Metric	Highest Priority	High Priority
Nitrogen Loss Potential	MIddle Black	Lower Black, Lower RR and Macon
Septic Failure Rank	Upper Saline River	Evans, lower Iron Creek, Upper S.Branch, Black, lower Lower RR, and Macon
Manure Contamination Rank	Upper S. Branch	Lower S. Branch, Evans, middle Macon
Phosphorus Loading	Middle S. Branch	upper Lower RR, Monroe area
Surface Runoff Potential	Monroe area	Reaches in S. Branch, Black, Lower RR and Macon
Off-Field Soil Loss Potential	S. Branch	Evans, Upper RR, upper Lower RR
Streambank Erosion Potential	Reaches in S. Branch, Black, Lower RR and Macon	S. Branch, Black, Lower RR & Macon

5.4.1 Highest Priority Water Quality Subwatersheds: S. Branch RR and Black Creek

These subwatersheds have been selected as the top geographical priorities because together they account for 92%, 56%, and 45% of the SWAT-estimated phosphorus, nitrogen, and sediment loads for the watershed and are the top contributors of nitrogen to the nitrate TMDL for the Blissfield-Dundee reach. These also happen to be the only subwatersheds in the Raisin with CAFOs. The South Branch also includes Adrian, one of the two largest communities in the Raisin (in addition to Monroe) still experiencing on-going CSO and/or SSO problems contributing to the *E. coli* impairment on the South Branch of the Raisin.

5.4.2 High Priority Water Quality: Lower River Raisin, Macon Creek, Evans Creek, Saline River, & Little River Raisin

While it is difficult to draw a distinction between medium and high subwatershed water quality priorities in the River Raisin, distinctions must be drawn in order to focus resources where the most bang for the buck can potentially be realized. These five subwatersheds are prioritized below the top two either because they have one low priority impairment (channel modification in the Little River Raisin), and have two localized impairments (Saline). This rating does not disqualify them for attention, it just places them one notch below the top priorities. Evans is included because it appears to be contributing both to nitrate problems, sediment and bacteria problems downstream. The Lower River Raisin may be a questionable addition to the high priority subwatersheds and may simply be the recipient of upstream problems.

5.4.3 High Priority Conservation: Goose Creek, Iron Creek, Upper RR

There is at least one clear distinction to be made up front from water quality and habitat quality data: the upper River Raisin, including Goose Creek, Iron Creek and Upper River Raisin subwatersheds are of distinctly better quality in all categories than the remaining subwatersheds in the Raisin. This division in water quality between the upper watershed and the remainder of subwatersheds appears to be related to land use changes: the three highest quality subwatersheds have the lowest wetland loss and agricultural land use. The upper watershed has, on average, lost 43 percent of pre-settlement wetlands and is 47 percent agriculture, while the remaining watershed has lost on average 86 percent of pre-settlement wetlands and is 73 percent agriculture.

The three upper subwatersheds have no impairments other than mercury in the fish tissue of Clark Lake, Sand Lake and Wamplers Lake. However, the mercury in the fish tissue probably originated from atmospheric deposition and can be traced to sources well outside the watershed. Dealing with this impairment means dealing with forces much, much larger than the watershed. These three subwatersheds are high priority for protecting and conserving existing quality. They can also be thought of as low priority for implementing specific water quality improvement projects. However, a component of the highest priority protection and conservation projects include policy and ordinance changes that put in place new measures for assessing and regulating land protection, conservation and development.

Table 5-15 Water Quality Summary by Subwatershed in the Raisin River

Subwatershed	Land Use Comments	Listed Impairments	Water Quality & Macroinvertebrate Sampling	SWAT Model Output Subwatershed Percent of Total Load		
				TSS	TN	TP
S. Branch RR (189 mi^2)	10 NPDES permits (36 MGD) 1 CAFO CREP 73% wetlands lost 60% agriculture City of Adrian urban area	CSO, Pathogens, Siltation TDS, chlorides, turbidity FCA-PCBs	Very High N Mod. TSS High P Fair Macroinv. Rating (Beaver Ck)	21.3	37.6	88.2
Black Creek (150 mi^2)	1 NPDES permit (0.7 MGD) 2 CAFOs CREP 92% wetlands lost 80% agriculture	FCA - PCBs Fish community rated poor Untreated sewage discharge Pathogens	Very High N Mod. TSS Mod. P Poor to Fair Macroinv.	24	18.6	3.5
Macon Creek (142 mi^2)	7 NPDES permit (8 MGD) Mod. CREP 96% wetlands lost 80% agriculture	None listed	Very High N, TSS, P Poor to Fair Macroinv.	12.7	11.2	2.1
Lower RR (181 mi^2)	Receives RO from Upper RR, Iron Ck, Evans Ck, S. Branch, Goose Ck, & Black Ck 13 NPDES permits (14.3 MGD) CREP 93% wetlands lost 70% agriculture	FCA - PCBs Pathogens Nitrate Pesticides CSO, Untreated Sewage	Very High N Low TSS Very High P Poor to Fair Macroinv.	13.5	9.4	2.1
Saline River (129 mi^2)	8 NPDES permit (3.2 MGD) Small CREP 78% wetlands lost	Untreated sewage discharge Pathogens	High N and P Low TSS Poor to Good Macroinv.	10.6	6.3	1.6
Little RR (43 mi^2)	Small CREP 98% wetlands lost 90% agriculture	Habitat Modification - channelization	Low P Poor to Fair Macroinv.	6.3	5	0.9
Evans Creek (29 mi^2)	CREP 1 NPDES Permit (1.4 MGD) 72% wetlands lost 70% agriculture	None listed	High N & P Poor to Fair Macroinv.	3.8	2.8	0.5
Upper RR (124 mi^2)	Receives RO from Goose Ck. 2 NPDES permits (0.5 MGD) 39% wetlands lost 50% agriculture	None listed	Low N and P, Fair to Good Macroinv.	4	5.1	0.6
Iron Creek (31 mi^2)	1 NPDES permit (1.5 MGD) Small CREP 48% wetlands lost 40% agriculture	Wamplers Lake & Sand Lake (fish tissue - mercury)	Low N & P Mod. TSS Good Macroinv.	2.3	1.8	0.3
Goose Creek (40 mi^2)	Upper watershed CREP 42% wetlands lost 50% agriculture	Clark Lake (fish tissue - mercury)	Low N, TSS, P Good Macroinv.	1.5	2.3	0.2

5.5 Watershed Goals and Objectives

The two primary improvement themes for this plan are 1) achieving all designated uses and 2) achieving the triple top line – economic and environmental sustainability and social equity. At the outset of the planning process, the steering committee, along with input from the public meetings developed a vision statement, and a set of guiding principles for improving the watershed's future outcomes. This vision statement and guiding principles establish the guidepost for looking forward and focusing action and involvement.

Vision Statement

River Raisin watershed residents recognize and celebrate their reliance on the river, the surrounding land and its interconnectedness with the Great Lakes and the global ecosystem. Together, communities, organizations and individuals will educate, understand and actively participate in the stewardship, conservation and preservation of the River Raisin and its cultural, ecological, and economic resources.

Guiding Principles

1. The planning process should ensure that all interests are heard and should also capitalize on the use of existing planning, education and informational resources as much as possible.
2. Create/provide/promote new and existing educational and information sources on natural resources, resource planning, land development, agriculture, and BMPs for local units of government, non-governmental organizations, educational institutions and individuals.
3. Create networking and synergistic collaborative efforts between local units of government, non-governmental organizations, schools, churches and so on. Encourage the alignment of agency/organizational goals.
4. Improve the image of the River Raisin. Create/understand the "story" of the river by creating/promoting its identity, distinguishing characteristics and rallying points.
5. Develop an implementable plan along with smaller, short-term projects to create implementation momentum and participation. Identify/establish local volunteer groups and leaders committed to the watershed improvement process.
6. Preserve and protect the River Raisin's valuable cultural and ecological treasures, including farmland, historical sites, groundwater recharge areas and critical/sensitive natural lands.
7. Increase and improve opportunities to interact and enjoy the river, including improved recreational access, river monitoring and clean-ups.
8. Promote active participation in watershed improvement by creating diverse opportunities for participation; educating residents on individual impacts and improvement activities.
9. Acknowledge the differences between urban and rural development. Work to define development that provides housing, transportation and economic activity while preserving ecological benefits. Balance development with the need for green space and coordinate and provide uniformity between planning efforts and land use ordinances while at the same time respecting private property rights.

5.5.1 Watershed Goals

The steering committee has established a set of goals and objectives that are consistent with the themes of use attainment and the triple top line and will help provide realistic direction for implementing this plan (**Table 5-16**). Watershed goals have been grouped into the following categories:

1. Lift Nitrate Impairment
2. Lift pathogen impairments
3. Reduce sedimentation
4. Reduce available phosphorus loading
5. Reduce hydrologic variability
6. Lift Bioaccumulative Chemicals of Concern

7. Build River Raisin Watershed Council capacity
8. Increase public awareness and involvement
9. Conserve and restore important natural features
10. Promote economic and environmental sustainability

Table 5-16 River Raisin Watershed Goals and Objectives

Goal	Cause of Pollutant Impairing and/or Threatening Use	Objectives	Geographic Priorities
1. Lift Nitrate Impairment	Poor fertilizer useage Lack of proper drain tile & swale management Poor manure application practices Failing or improperly sited septic systems Untreated sanitary, CSO, SSO Urban fertilizers	Improve fertilization practices Improve drain tile & swale management Improve manure spreading practices Develop better regulation & Management Improve treatment of sanitary, CSO, SSO Reduce urban fertilizer use	South Branch of River Raisin Black Creek Lower River Raisin
2. Lift Pathogen Impairments	Untreated sanitary, CSO, SSO Poor manure application practices Failing or improperly sited septic systems	Fully treat sanitary, CSO & SSO Improve manure spreading practices Develop better septic system regulation & Management	South Branch of River Raisin Black Creek Evans Creek Lower River Raisin Macon Creek
3. Reduce Sedimentation	Conversion of natural land cover Lack of effective farm storm water management Cropland Drainage Impervious & compacted surface Large woody debris (LWD) Impoundments Inadequate storm water management	Conserve and/or restore natural land cover Create more effective farm storm water management systems Improve drain tile & swale management Reduce impacts of impervious/compacted surfaces LWD Management Dam Removal Develop more comprehensive storm water management ordinances, design and maintenance	South Branch of River Raisin Macon Creek Saline River Evans Creek Upper River Raisin Lower River Raisin
4. Reduce Phosphorus (Total & DRP) Loading	Same causes as Goal #'s 1 & 4	Same objectives as Goal #'s 1 & 4	South Branch of River Raisin Black Creek
5. Reduce Hydrologic Variability	Conversion of natural land cover Ag runoff Cropland Drainage Urban runoff	Decrease flashiness Increase base flow	Monroe area South Branch of River Raisin Black Creek Lower River Raisin Macon Creek
6. Remove Bioaccumulative Chemicals of Concern Impairments	Historic dumping Smokestack emissions	Removal and remediation of sediments Join/advocate for regional, national, global initiatives	Monroe area Goose Creek Iron Creek South Branch of River Raisin Black Creek Lower River Raisin
7. Build RRWC Capacity		Increase public visibility Increase educational capacity	Throughout Watershed
8. Increase Public Awareness and Involvement	Clearing and draining for development Lack of understanding Ignorance & Arrogance	Build public involvement Assist with school programs	South Branch of River Raisin Black Creek All other subwatersheds
9. Conserve and restore natural features	Conversion of natural land cover	Identify critical areas Identify partnerships/funding opps Undertake projects	Goose Creek Iron Creek Upper River Raisin Lower River Raisin
10. Increase recreational opportunities	Clearing and draining for development Lack of understanding Ignorance & Arrogance	Increase public awareness	Goose Creek Iron Creek Upper River Raisin Lower River Raisin Saline River

5.5.2 Water Quality Goals

The plan water quality goals are summarized in **Table 5-17** below. The major goals include reducing nutrient and pathogen loadings, hydrologic variability, and sedimentation. Specific metrics to measure each goal are also included in the table. Some of the water quality goals or targets are based on MDEQ-specified water quality standards for use attainments. These include standards for drinking water (nitrate < 10 mg/L) and partial and full body contact standards for *E. coli* concentrations.

We have also specified water quality goals that we believe will help the Raisin lift impairments specified by stakeholders in the watershed. These include an annual average Total Suspended Solids (TSS) concentration that more closely resembles pre-1995 TSS concentrations at the mouth of the river (< 30 mg/L). Also, we have specified total and dissolved phosphorus concentrations to levels we believe will help reduce the likelihood of eutrophication behind impoundments and in Lake Erie.

We have also specified goals for macroinvertebrate scores at all sites, including an ambitious goal of all sites meeting a MiCorps rating of "good" by the end of the implementation period.

Table 5-17 Quantitative Water Quality Goals

Goal	Target	Measurement Location
Reduce Nitrogen Loading	99th%tile < 10 mg/L Average < 2 mg/L Reduce fertilizer and animal waste loadings by 57%	River Raisin mainstem concentrations @ Blissfield
Reduce Pathogen Loading	<130 cfu/100 ml 30 day average <1,000 cfu/100 ml maximum	Confluence of South Branch & mainstem River Raisin Mainstem at Blissfield Saline River Lenawee County Drain #70
Reduce Sedimentation	Avg TSS < 30 mg/L (pre-1995 conc.s) Improvement in macroinvertebrate scores	River Raisin at Monroe (NCWQR Site) All Adopt-A-Stream sites achieve MiCorps rating ≥ "Good" Goose Creek, Iron Creek & Upper River Raisin achieve "Excellent"
Reduce Phosphorus Loading	Avg Total P < 0.100 mg/L Avg Dissolved P < 0.015 mg/L	River Raisin at Monroe (NCWQR Site)
Reduce Hydrologic Variability	Flashiness Index Metrics: - Keep or achieve flat trend at all sites - Keep lowest quartile for Upper RR - Achieve lowest quartile for Adrian - Achieve lower middle quartile for Monroe Improvement in macroinvertebrate scores	Measured at USGS gages All Adopt-A-Stream sites achieve MiCorps rating ≥ "Good" Goose Creek, Iron Creek & Upper River Raisin achieve "Excellent"
Remove/Reduce Bioaccumulative Chemicals of Concern	Below limits to de-list impairments	Monroe - mouth of River Raisin South Branch River Raisin Black Creek Wamplers Lake Sand Lake Clark Lake

6.0 PROPOSED IMPLEMENTATION ACTIVITIES

Long-term success for this plan will require a very broad set of changes, activities, regulatory structures, partnerships and on-the-ground implementation of best management practices (BMPs). Proposed activities include the typical watershed improvements such as installation of BMPs, creation/upgrading of local ordinances and improving local organizational strength. The plan alludes to and makes some suggestions to accomplish these goals while also helping to grow the local economy. Typical watershed improvement activities have a direct bearing on improving and eventually eliminating impairments. But the River Raisin still needs significantly more local support of watershed advocacy and the water quality aims of this plan. This can only come from parallel and connected growth of local watershed advocacy groups and the local economy. While this separate implementation track of economic and advocacy growth may appear to have an indirect tie to water quality improvements, we would contend it is more important than simply implementing watershed BMPs, new ordinances and planning activities. Cost is almost always commensurate with effort; finding the money to pay for improvements will be one of the main impediments to implementation. Growing watershed economic value should also help increase the chances that watershed ecological value will grow as well.

This plan also proposes an agriculture pilot project that aims to change the relationship between the Federal institutions supporting the farm, including the National Resources Conservation Service (NRCS) and Farm Services Agency (FSA), and the farmer. There is a growing movement that characterizes the current relationship between these support agencies and the farm as one based more on the administrative details of conservation rather than field efficacy. This is not to say these agencies or their farm support mechanisms should go away. Rather that the emphasis on managing the environmental impact of farms should be more performance-based rather than based on indirect performance metrics, such as the number of acres in a certain Best Management Practice (BMP). Unfortunately, the NCWQR data from Monroe appears to vividly underscore this issue, with pollutant concentrations still going up after more than a decade of installing agricultural conservation practices in the watershed.

The RR WMP breaks the implementation process into two broad periods. The first period - implementation and demonstration, is aimed at developing a set of projects and initiatives that broaden and deepen stakeholder commitment to watershed restoration and “road-tests” ideas to navigate the way to the second period of the plan - widespread adoption of effective best management practices. Achieving the objectives of the demonstration period will require some changing of long-standing attitudes and practices. Acceptance of change can be a difficult hurdle to overcome, even when change is needed. This changing of attitudes or at least a hardy dose of education and outreach are really the keys to achieving success for this plan: the more residents of the watershed share an ethic of stewardship the more the goals of this plan will be realized.

This chapter is divided into the following sections on recommended implementation strategies:

6.1 Achieve Nitrate TMDL & Reduce Dissolved Reactive Phosphorus Loads
6.2 Achieve Pathogen Target Concentrations
6.3 Reduce Sedimentation, Total Phosphorus & Hydrologic Variability
6.4 Remove/Reduce Bioaccumulative Chemicals of Concern (BCC)
6.5 Build RRWC Capacity
6.6 Increase Public Awareness and Involvement
6.7 Conserve and Restore Natural Features
6.8 Increase Recreational Opportunities

The strategies laid out here to achieve the Nitrate TMDL are also many of the strategies that will directly reduce phosphorus loading, particularly dissolved reactive phosphorus (DRP). Targeting all the causes of river sedimentation also addresses many of the same causes of total phosphorus and hydrologic variability. The bulk of the strategies address farm practices and the sources and causes of pathogens in the river. The plan also lays out a schematic for removing BCCs, but again most of the effort for pursuing their removal either derives as part of the AOC/PAC process or as part of much larger regional, national and global reduction efforts.

The poor perception of the river needs to be improved by developing an understanding of the connection between watershed residents and the river. This understanding derives from experiencing the river. There are also features of the river and its watershed that are regionally unique and deserve conservation. Also, in a sense, any land that is restored to its predevelopment land cover helps accomplish all the plan objectives.

The public education component is also directly tied to recreational and stewardship activities in the watershed. The greater the number and variety of recreational and stewardship activities in the watershed, the more likely watershed residents and visitors will spend time seeing and appreciating the value of this landscape. The more residents see the tie between their actions and consequences in the watershed, the more likely they are to become river stewards.

6.1 Achieve Nitrate TMDL (and Reduce Dissolved Reactive Phosphorus Loading)

The strategy for lifting the nitrate TMDL is nearly the same strategy needed to address the reduction of dissolved reactive phosphorus (DRP) loading in the River Raisin. The priority subwatersheds for nitrate (South Branch of the River Raisin and Black Creek) are also the critical subwatersheds for DRP, total suspended solids (TSS) and total phosphorus (TP). However, addressing DRP, TP and TSS at the mouth of the Raisin will require a broader geographic reach than addressing Nitrate at Blissfield. The breadth of the DRP, TP and TSS geographic priorities are covered in this section too.

Local and national investigation into the nitrogen and phosphorus non-point source pollution problem, particularly in agricultural watersheds, has traced the problem to losses of fertilizer nitrogen and phosphorus. Whether the application is animal manure or commercial nitrogen and/or phosphorus fertilizer, over-application or ill-timed application of either source can provide too much plant available N and P and increase the potential for nitrogen leaching and phosphorus losses. Most nitrogen that leaches from agricultural fields is in the form of nitrate (NO_3). The highest percentage of bioavailable phosphorus leaves as dissolved reactive phosphorus (DRP). Untreated wastewater and urban runoff are also implicated as sources of nitrate and phosphorus, although to a lesser extent.

The first priority action for the nitrate TMDL and DRP problem is source control. A pollutant is much easier to manage at the point of distribution rather than over the entire distribution area. Nitrate is a soluble pollutant that requires specific environmental conditions – no oxygen, abundant, available carbon and the right set of microorganisms----to be broken down and converted into harmless nitrogen gas. DRP needs to contact soil and plant surfaces so that it can either be sequestered or utilized by a plant.

Nitrate needs to be addressed with BMPs that hold water and create anaerobic (without oxygen) environments. DRP removal also favors water holding time. The agricultural piece of this strategy focuses first on nitrogen and phosphorus source control, then on BMPs that transform nitrate to nitrogen gas, and then on the other suite of existing agricultural conservation programs that favor solids and runoff control. Existing agricultural conservation programs mainly target solids and runoff and are described in **section 6.1.3**.

The next important sources addressed in this strategy are 1) untreated wastewater and 2) urban runoff. Rather than include a detailed description of managing untreated wastewater and urban runoff here, details are included in the Strategy to Achieve the Pathogen TMDLs (**Section 6.2**) and Strategy to Reduce Sedimentation

and Hydrologic Variability (**Section 6.3**), respectively. The general prioritization of sources, management actions and geographic priorities for the nitrate TMDL are summarized in
Table 6-1 below.

We have prioritized agricultural BMPs and proposed locations based on existing impairments and TMDLs, SWAT modeling, NRCS recommendations and best professional judgment (**Table 6-3**). The BMPs have been prioritized based on their capacity to manage nitrate/total nitrogen, bacteria, flow variation, total suspended solids and phosphorus. The priority subwatersheds were previously identified in **Section 5.4**. While the high priority conservation subwatersheds are not on
Table 6-1, they are also candidates for application of these BMPs. They are simply low priority subwatersheds for these kinds of improvements at this time.

As noted previously, NCWQR water quality data appear to indicate that the suite of existing agricultural management practices in the Raisin are not keeping pace with rising TSS, TP, DRP, Nitrate, and TN in the Raisin. All pollutant concentrations measured at the NCWQR Monroe station over the last 10-15 years are going up. This is particularly alarming for nitrate and drinking water use and for phosphorus that is feeding impairments at the mouth of the Raisin in Monroe and Lake Erie. The NCWQR data from the major Ohio tributaries to Lake Erie are also showing increases in nitrate and DRP loads in agricultural watersheds. It appears that this is a systemic agricultural problem. Nitrate and DRP are dissolved constituents and most of the agricultural conservation practices in the watershed and elsewhere are best suited for managing solids, and solids-associated pollutants. The first priority management practices must start addressing these dissolved constituents in a more systematic manner.

6.1.1 Source Control Strategies for Reducing Nitrate and DRP Losses from Farm land

Source control strategies for reducing farm NO_3 losses include improved rate and timing of fertilizers and manure, diversifying crop rotations corn-soybean (nitrogen fixer), using cover crops, and a set of measures known as precision agriculture, including soil testing and plant monitoring, combined with satellite imagery and geographic information systems to optimize fertilizer or pesticide application rates. While this section addresses N losses, many of the recommendations also apply to the issues of other fertilizers as well as to pesticides.

We strongly recommend creating a pilot project to incentivize performance-based, farm environmental control. To date in Michigan, a water quality-based farm discharge permit system has not withstood the pressure of farming advocates. The recommended pilot may or may not have a water quality-based performance metric, but would do well to follow the model created recently in Vermont. Led by a group at the University of Vermont, they are developing Performance-based Incentives for Agricultural Pollution Control as part of the Performance-Based Environmental Policies for Agriculture (PEPA) initiative funded partly by USDA. Their pilot incentives include: 1) payments for achieving specific environmental performance targets, often measured at the farm level; 2) allowing farmers to achieve the targets in any way they choose; 3) incentivizing farmer use of the most cost-effective actions to meet their targets. Some information on the initiative is included in the **Water Quality Appendix**. Also see their website: http://www.flexincentives.com . It may be that the answer to some of the apparently intractable problems of the Raisin, Lake Erie, and the Gulf hypoxia zone, lie in taking this next step in agricultural management.

Table 6-1 Strategic and Geographic Prioritization of Nitrate and Dissolved Reactive Phosphorus Management Practices
(1 = Critical Priority; 2= High Priority; 3=Medium Priority; Upper River Raisin, Iron Creek and Goose Creek are low priority areas)

Source	Type of Control	Recommended Management Practice	S. Branch River Raisin	Black Creek	Evans Creek	Lower River Raisin	Macon Creek	Saline River	Little River Raisin
Fertilizers & Manure	**Application**	Improve Fertilizer Application Rates Improve Fertilizer Timing Improve Manure application rates Improve Manure application timing Apply Precision Agriculture Apply Crop Rotation	1	1	2	2	3	3	3
	Post-Application (NO3 & DRP)	Apply Cover crops Improve Drain Tile Management Retrofit Two-Stage Ditches Build Constructed wetlands Build Wetland Subirrigation System	1	1	2	2	3	3	3
	Post-Application (TSS & TP)	Apply Riparian and in-field buffers Apply Conservation tillage Apply Contour cropping Apply Cover crops Create Critical area planting Create Conservation areas	1	1	3	2	2	2	3
Poorly Treated Wastewater	**Illicit connections** **SSO** **CSO** **Septic systems**	Disconnect illict connections Treat SSO Treat CSO Develop Better Septic System Practice	1	1	2	2	2	2	3
Poorly-Treated Runoff	**Development** **Storm Water Management**	Better planning tools Better ordinances Better design and construction	1	2	3	2	3	3	3

Fertilizer Application Rate and Timing
The challenge with N fertilization is to apply the fertilizer before, during and after peak crop demand. The risk of N losses to leaching and other biogeochemical cycling processes increases as the time between N application and crop uptake increases. This is true for existing soil N as well as applied N. Typical N fertilizer management for corn production in the Midwest consists of a single fall application. This practice is often promoted by agricultural experts because the potential for compaction following harvest is generally less, labor is often more available, weather and soil conditions are generally more favorable and fertilizer prices are generally lower than in the spring. However, fall application increases the changes of N soil leaching. Changing the timing of the fertilizer application from fall to spring can significantly decrease N loss. In southern Minnesota, annual NO3 losses from tile drainage were reduced by an average of 36% (Randall et al., 1992).

Despite the opportunities for increased efficiencies of fertilizer application in the spring, many farmers continue fall fertilization due to real and perceived risk. Spring rainfall can prevent or delay N fertilizer applications. This risk is real, because there are few options in most rain-fed farming operations to compensate the farmer for yield losses. Dinnes et al., (2002) recommends that in order to achieve farmer adoption of N management practices other than fall fertilization, concepts such as insurance policies against N deficiencies are needed along with more flexible and efficient application methods.

Manure Application Rate and Timing
Manure application challenges are much the same as those for commercial fertilizer discussed above, with the added complicating factor that manure is a waste product that is continually being produced by livestock. For livestock farms and particularly for AFOs, manure application is primarily a waste disposal method rather than purely a crop yield enhancement method. Because manure is produced year-round, storage facilities may be required in order to both maximize benefits of manure application and minimize detrimental water quality impacts.

Land application of manure should be carried out according to site-specific nutrient management plans, based on the NRCS conservation practice standard for nutrient management (Ribaudo et al., 2003). The NRCS policy allows manure application rates to be based on either a nitrogen standard or a phosphorus standard. Because application rates based on a nitrogen standard usually result in over-application of phosphorus, the nitrogen standard should only be used where a risk assessment tool, such as the Phosphorus Index, indicates an acceptable risk for offsite transport of phosphorus. The phosphorus standard allows only the amount of phosphorus needed based on soil tests or based on phosphorus removed in harvested biomass. Because it is often hard to apply manure at the P standard rate with available equipment, application to fields should be rotated on a multi-year basis. This standard practice, in contrast to the nitrogen standard, prevents build-up of P in soils.

Timing of manure application is critical for water quality protection. Nutrients should ideally be applied close to the time of crop utilization, to an actively growing crop or within 30 days of planting (Risse 2008). Although spring manure application is ideal for crop utilization, heavy rains and high water tables can increase the risk of runoff and leaching. Recent research at University of Wisconsin Discovery Farms has led to a recommendation that soil moisture content in the upper 4 inches of soil should not exceed 35 percent during manure application (Weisenberger and Madison 2007). This allows some capacity for infiltration so rainfall does not immediately runoff, carrying nutrients from the freshly applied manure with it. Farmers should likewise avoid manure application during and immediately prior to rainfall events. Proper manure storage techniques should be employed so that winter manure application, when the ground is frozen, can be avoided.

Precision Agriculture

Precision agriculture or site-specific crop management (SSCM) refers to a developing agricultural management system that promotes variable management practices within a field according to site conditions. Early American settlers were first introduced to Precision Farming by Native Americans who taught them corn production and soil fertility practices such as placing a fish (or two) under each hill of corn to supply a slow release nutrient source of N-P-K and trace elements. Notwithstanding the Native American version of precision agriculture, SSCM technology is only a few years old, and various names have been used to describe the concept: farming by soil; farming soil, not fields; farming by the foot; spatially prescriptive farming; computer aided farming; farming by computer; farming by satellite; high-tech sustainable agriculture; soil-specific crop management; site-specific farming; and precision farming (see: http://www.precisionag.org/).

SSCM is an information and technology based agricultural management system to identify, analyze, and manage site-soil spatial and temporal variability within fields for optimum profitability, sustainability, and protection of the environment. SSCM employs a system engineering approach to crop production where inputs are made on an "as needed basis," and was made possible by recent innovation in information and technology such as microcomputers, geographic information systems, positioning technologies (Global Positioning System), and automatic control of farm machinery. It is a holistic approach to micromanage spatial and temporal variability in agricultural landscapes based on integrated soil, plant, information, and engineering management technologies as well as economies.

Precision agriculture requires integration of three elements: 1) positioning capabilities (currently, global positioning system or GPS) to know where equipment is located; 2) real-time mechanisms for controlling nutrient, pesticide, seed, water, or other crop production inputs; and 3) databases or sensors that provide information needed to develop input response to site-specific conditions. The technologies associated with requirements 1 and 2 are advanced compared with the understanding necessary to meet requirement 3. Building databases to quantify yield variability will improve the understanding of how various stresses affect plant growth, development, or yield, and ultimately lead to optimum site-specific prescriptions.

There is evidence that variation in nutrient elements in the soil is not the foremost factor affecting crop yields. Precision farming advocates have devoted significant efforts to applying fertilizers more selectively to soils based on yield potential and soil test results. The goal is to obtain more efficient use of applied fertilizer, to reduce any excess application that might cause environmental insult, and to improve economics. It should be emphasized that soil fertility needs, particularly nitrogen, are dependent on yield level and/or the amount of rainfall that occurs during the growing season. Variable rate application of fertilizer is based on expected yield, a parameter that is often difficult to predict.

The ultimate goal of precision farming or site specific management is to manage the farm on a site-by-site basis. Knowledge of the soil and crop characteristics on a fine grid basis is therefore needed. Traditional soil and plant sampling and analysis methods are very expensive, tedious, and time consuming for obtaining soil and crop parameters on a fine grid and at a short time scale. Sensors capable of gathering information on-the-go are needed. They will be particularly useful to measure parameters that vary faster in time, such as nitrogen and soil water content.

In the not too distant future, probes mounted on tillage equipment will map entire fields for soil texture, pH, salinity or chemical parameters. Very often the new map becomes the basis for more complete soil testing by zone. Bringing the results of soil tests and yield monitoring together via map stacking and other data analysis tools has demonstrated that every field is not likely to present easy “textbook” answers. In the not too distant future, however, precision agriculture will be providing a wealth of information that will literally turn every field properly tested, harvested and analyzed into a multifaceted research plot. Many software packages have the capability to do multiple regression analysis of the stacked map data to help delineate the yield limiting factor. Variable rate application technology will then make possible tremendous crop yield increases while minimizing environmental impacts.

Crop Rotation/Diversification

Crop rotation could potentially improve the nutrient levels in the watershed. However, as described in the SWAT modeling section, the crop rotation management practice did not significantly decrease the overall nutrient levels within the River Raisin watershed.

Crop diversification can include a switch from continuous corn to corn and soybean and perennial legume and non-legume crops. A corn-soybean rotation has been shown to reduce nitrate leaching, though the reduction can be minimal depending on climactic conditions. N-fixing legumes can release large quantities of N to soils over time. Organic N derived from plant and microbial residues is not as rapidly available to plants as inorganic N provided by most commercial fertilizers. But the gradual release of organic N is often better synchronized with subsequent plant and microbial needs than point-in-time application of N fertilizers.

Cover Crops

Cover crops can reduce potential NO_3 leaching growing as natural ecosystems such as prairies where plants grown as long as the ground is not frozen. Meisinger et al., (1991) reviewed studies that demonstrated that cover crops reduced the mass of N leached and NO_3 concentration of leachate by 20% to 80%. The biggest impediment to using cover crops in the River Raisin is the short and generally cool season between harvest and planting of the subsequent row crop. Because rye overwinters, it must be killed or it can reduce the yield of the corn crop, use too much water or immobilize too much N. Oats show more promise as a cover crop because the seed is inexpensive, easy to obtain and it is killed in the winter.

6.1.2 Post-Fertilizer/Manure Application Strategies for Reducing Nitrate and DRP Losses from Farm Land

Subsurface drainage removes excess water from the soil profile, usually through a network of perforated tubes installed 2 to 4 feet below the soil surface. These tubes are commonly called "tiles" because they were originally made from short lengths of clay pipes known as tiles. Water would seep into the small spaces between the tiles and drain away. Nitrate loss is one of the biggest water quality concerns related to tile drainage. Several new technologies can reduce nitrate loss. Controlled drainage keeps the water table high during the off-season when crops are not growing. The high water table increases the rate of denitrification (a process that converts nitrate to harmless nitrogen gas (N_2) as soon as the saturated soil warms up in the spring) and reduces nitrate loss to the environment. Work in North Carolina along with preliminary research in the Midwest suggests that drain water management can lead to a 30% reduction in average annual nitrate levels where appreciable drainage occurs in the late fall and winter. This kind of reduction translates into load reductions of 24 to 35 kg/ha (Cooke et al., 1999).

Drain Tile Management

Drain tile management is best suited for relatively flat, uniform fields, generally in areas with slopes less than 1%. A control structure is recommended for every 30 cm to 45 cm in grade change. These systems are used to elevate the water table when fields are fallow. These systems could also be used to store water during the growing season and made available for crop consumption. Management of these systems during the growing season must be carefully done so that water tables do not get into the root zone and reduce yields. Existing drainage systems can be retrofitted with structures for a cost of approximately $50 to $100 per hectare (Cooke et al., 1999).

Two-Stage Ditches

The use of two-stage ditches by Michigan Drain Commissioners, the agricultural community, county road commissioners and the Michigan Department of Transportation deserves much wider application. Recent research and implementation strategies suggest that two-stage ditches offer equivalent or superior benefits over buffer strips, particularly for dissolved constituents like Nitrate and DRP (Bukaveckas 2007; Kaushal et al. 2008; Roley et al. 2008).

Two-stage ditches are an attempt to more closely emulate natural stream function than typical trapezoidal ditches that are carved clean every once in awhile. Natural streams and rivers not only transport water, but are also earth-moving machines. Alluvial channels, channels that transport the same material that composes their bed and banks (as opposed to bedrock-lined channels), convert the potential energy of elevation into the kinetic energy that moves water and sediment down gradient. In theory, channels that are “stable”, at least in terms of human time-scales, achieve a dynamic sediment equilibrium on an annual basis by conveying roughly the same amount of sediment downstream that entered the channel from upstream. This equilibrium equates to roughly stable channel dimensions. Another way to say this is a stable channel is neither incising/widening nor is it aggrading/narrowing.

One of the keys to single-thread (as opposed to braided) channel stability is maintaining an active connection between the channel and its floodplain. Increased sediment transport and sediment transport capacity generated during high flow events is mitigated by active floodplains. The floodplain helps reduce shear stress and velocity over the entire channel (defined now as both the single thread channel and floodplain) and as a consequence of reducing sediment transport capacity, enhances sedimentation on the floodplain. These channels, particularly when flooded also offer anoxic/anaerobic conditions and sufficient carbon to enhance denitrification. The channels quickly establish (or can be pushed) to establish a biological community that can act as both temporary and permanent sink of phosphorus.

Deisgn and construction of two-stage ditches is very straightforward. Drainage areas, flows, depths and velocities must be calculated, but the key design attributes are the dimensions of the floodplain benches. The NRCS has incorporated two-stage channel design into the National Engineering Handbook on Stream Restoration Design (see: http://policy.nrcs.usda.gov/OpenNonWebContent.aspx?content=17770.wba). The one impediment to more widespread application of this idea is the lack of conservation payment credits for the floodplain benches.

Currently, an odd administrative hurdle stands between this practice being paid for by the Farm Service Agency (FSA). For Conservation Reserve Enhancement Program (CREP) payments, the FSA values land based on soil type. For the two-stage ditch, the area to be occupied by the benches has to be excavated, thus getting “rid of” the soil the FSA needs to establish the land value. Agencies, organizations and individuals interested in seeing this practice treated in the same manner as buffer conservation or restoration need to talk to NRCS, conservation districts and their congressional representatives to change this unfortunate administrative blind-spot. This practice shows bright promise for a simple, cost-effective manner to treat a host of pollutants, while at the same time, providing consistent, nearly maintenance-free hydraulic performance for many decades.

Wetland Reservoir Subirrigation System

A wetland reservoir sub-irrigation system (WRSIS) is an innovative management system that includes a wetland, water storage reservoir and a network of subsurface pipes used at different times to either drain or irrigate crops through the root zone. One demonstration of the WRSIS has been installed in the River Raisin to date. This integration of components allows the WRSIS to operate in a closed loop most of the time, minimizing offsite water release. This kind of system can increase crop yields on irrigated land, reduce offsite delivery of nutrients, pesticides and sediment and increase wetland vegetation and wildlife habitat (Fausey et al., 2005).

6.1.3 Post-Fertilizer/Manure Application Strategies for Reducing Solids and TP Losses from Farm Land

The federal Farm Bill authorizes several cost-share programs relevant to the River Raisin that are primarily based around removing solids or particulates. Notwithstanding the lack of success in the Raisin for controlling pollutant concentrations, these are worthwhile programs. How they are implemented, how on-the-ground decisions get made, might be improved by putting the onus for performance back onto the farmer, the individual who usually knows his or her land best. The PEPA program or some similar performance-based program would be a different way of managing the environmental impacts of farms and by all accounts a different way of doing things appears warranted.

In general, farm conservation programs fall into one of two categories: those that work with farmers to improve management on land currently being cultivated (working lands programs), and those that retire cropland to protect soil, air, and water quality (land retirement programs). **Table 6-2** summarizes the eligibility requirements, associated best management practices, and funding for several Farm Bill programs. EQIP and CSP are working lands programs, while CRP, CREP, WRP, and FPP are land retirement programs. Further distinctions can be made as to agency responsibility for programs. For example, NRCS administers EQIP and WRP while the FSA administers CRP and CREP.

Table 6-2 Summary of federal cost-share programs available to landowners in the River Raisin watershed.

<table>
<tr><th>Farm Program</th><th>Eligibility Requirements</th><th>Types of BMPs Implemented</th><th>Amount/Type of Funding</th></tr>
<tr><td>Conservation Reserve Program (CRP)</td><td rowspan="2">• Land must be cropped for 2 of last 5 years
• Funds environmentally-sensitive land: eg. erodible land, cropped wetlands
• Allows managed haying and grazing</td><td>• Conservation cover for wildlife</td><td rowspan="2">• Per-acre rental payment and half the cost of establishing permanent land cover</td></tr>
<tr><td>Continuous Conservation Reserve Program (CCRP)</td><td>• Grass waterways
• Filter strips
• Erosion control structures
• Shallow wildlife ponds</td></tr>
<tr><td>Conservation Reserve Enhancement Program (CREP)</td><td>• Projects must address soil, water quality, or wildlife habitat issues of local or national significance (suggested by state, local, or tribal government or non-profit group)
• Cropland must have an environmentally-sensitive area</td><td>• Filter strips
• Riparian forest buffer
• Field windbreak
• Sediment retention control structure
• Wetland restoration
• Conservation cover on highly erodible land within 1000 feet of water</td><td>• State-federal partnership implemented in target watersheds
• 100% reimbursement
• Rental payments are 40% higher than CRP
• Funded by CCC</td></tr>
</table>

Conservation Security Program (CSP) A system for making payments to farmers for practices that have already been installed, plus additional incentive money to take it to the next level.	• Land must be cropped for 4 of last 6 years • Lands is not already enrolled in WRP or CRP • Focus is on land-based practices and animal waste handling facilities	• Land shaping • Permanent vegetative cover • Animal waste-management facilities • Terraces • Filterstrips • Grassed waterways • Tailwater pits • Historic practices like soil testing and satellite spraying	• Three tiers of land rental payments depending on level of conservation effort • Also cost-share payments for maintaining conservation practices
Environmental Quality Incentives Program (EQIP)	• Farmers must have an established conservation plan or nutrient management plan for CAFOs • 60% of funds targeted towards livestock producers	• Conservation tillage • Nutrient Management Plans • Wetland Restoration • Grassed Waterways • Buffers/filter strips • Streambank Protection • Irrigation efficiency	• Funded by CCC • 40-75% cost-share; up to 90% for low-income farmers • Payments to one farmer must not exceed $450,000 total between 2002-2007 • Funding increases from $400 million in 2002 to $1.3 billion in 2007
Farmland Protection Program (FPP)	• Land must have historical, archeological significance or unique soil • Priority is given to applications for permanent easements	Land is purchased to prevent development	• State, local, or tribal governments and non-profit conservation groups can apply for funding • Funded by CCC • Funding averages about $95 million/year 2002-2007

Wetland Reserve Program (WRP)	Wetlands must be restored through an easement (either permanent or 30-year)	Wetlands restored for wildlife habitat and water quality	• Funded by CCC • USDA pays 100% restoration costs for permanent easements and 75% of costs for 30-year easements

Sources: USDA ERS 2008; Tom Van Wagner, District Conservationist USDA Adrian, Michigan, personal communication

6.2 Achieve Target Pathogen Concentrations

Untreated or partially treated human sewage due to combined sewer overflows (CSOs), sanitary sewer overflows (SSOs) or illicit connections are obvious first targets to achieve in-river pathogen concentration thresholds for recreational uses. Improperly sited or installed septic systems are also potential sources to be addressed. Manure spreading and feedlot drainage also need to be addressed more systematically. Lastly, pet and wild animal wastes cannot be left out of this equation. Pets are a source that can be addressed by individual owner behaviors with some help from communities. Wild animal wastes are more problematic. Examples of problems are Canada geese occupation of grassed borders of water bodies and raccoons who take up residence in catch basins and manholes. In a City of Ann Arbor study, the source of *E. coli* in storm sewers was predominantly cats and raccoons (Turner, 2006).

A significant amount of work to address human sources of pathogens has occurred in the Raisin. In particular, the efforts to address sources for the Lenawee County Drain #70 and Saline River pathogen TMDLs, deserves follow-up monitoring to check progress and determine if more work needs to be done. The City of Adrian has eliminated CSOs and has dramatically decreased SSOs through its on-going system rehabilitation. They are currently working on removing sources of inflow and infiltration (I&I) to decrease wet weather influences on the system and completely eliminate SSOs. The improvements due to Adrian's efforts also deserves follow-up monitoring.

Several privately owned community sewage systems (POCSS) and on-site wastewater treatments systems, in general, have been judged to be sources of pollutants causing many of the current water quality impairments. For on-site treatment facilities and POCSS recommendations include:

1. Implement watershed-wide septic system inspection at point of sale and every five years and abandoned well closure in conjunction with local health departments.

2. Develop septic system/abandoned well closure ordinance. Require point of sale inspections and inspections every five years. Consider having septic haulers certified for inspections.

3. Develop local POCSS ordinance (see example in **Ordinance Appendix**).

4. Implement Lenawee county illicit discharge elimination program. Investigate cross-connections, leaking sanitary system, leaking septic systems and remove the source of the problem.

River and streamside communities should adopt pet waste ordinances and implement "Pick up Your Pet Waste" programs. The feral cat population should be reduced as well by spraying and neutering cats. Last, but not least river, stream and lake fringes should, as much as possible, be converted to high-growing, native Michigan plants. With better sight lines, geese feel more at ease in turf grass than in native vegetation. With this combination of grass at the water's edge, we create the perfect environment for geese to flourish. Anyone who walks along these edges knows the result – a very high concentration of goose droppings.

Table 6-3 Prioritization of Sources and Management Practices to Address Pathogens

Source	Management Practice	S. Branch River Raisin	Black Creek	Evans Creek	Lower River Raisin	Macon Creek	Saline River	Little River Raisin
Sanitary Sewer & Treatment	Evaluate and reduce Sanitary Sewer Overflows Create privately-owned community sewage system ord. Lobby for increased funding for advanced WWT upgrades	1			1		1	
Combined Sewer	Evaluate & Remediate Combined Sewer Overflows	1						
Illicit connections	Create city/county illicit discharge elimination program* Adopt Illicit Discharge Ordinance Identify and eliminate Illicit Discharges and Connections Dye test illicit connections for new construction Dye test whenever property changes ownership Dye test when inspection suggests illicit dischage	1	1		1			
Manure	Improve spreading practices Alternative manure treatment systems	1	1	3	1	3	2	3
Septic Systems	Septic system inspection at point of sale & every 5 years Private On-Site/WWTP Ordinance Create Special Assessment Districts for costs Develop certification program for hauler/installer	1	2	2	1	2	1	3
Pet & Wild Animal Wastes	Establish dog parks with appropriate BMPs Adopt Pet Waste Ordinanace Implement "Pick Up Your Pet Waste" program Spay and neuter cats to reduce feral population and decrease habitat for the Canada Goose population	1	2	2	1	2	1	2

6.3 Reduce Sedimentation, Total Phosphorus & Hydrologic Variability

Sedimentation in the River Raisin can be traced both to the source of the sediment – watershed and river/streambank erosion as well as the cause of settling – dams, large woody debris and other drainage and ditching practices that decrease water velocities enough to drop out suspended solids. Much of the total phosphorus load in the Raisin is associated/adsorbed onto these watershed and streambank sediment loads. These sediment and phosphorus loads are partially contributed to the river by natural causes. But the primary accelerator of this sediment load was the original conversion of the aboriginal land to agriculture in the nineteenth century. Today, this sediment load is exacerbated by farm storm water and tile drainage as well as runoff from impervious and compacted surfaces.

These sources and causes of sedimentation are either closely connected or create a cascade of effects – such as hydromodification accelerating both watershed and streambank erosion loads. Therefore, to address sedimentation and associated phosphorus, changes in watershed hydrology and river hydraulics must also be addressed.

The top priority for recovering pre-development hydrology and sediment loads is to re-capture or emulate the original land cover. This is the most effective way to recover the lost functions of a hydrologically efficient landscape. The top geographic priorities include saving as much natural land cover as possible in the upper watershed and addressing impairments in subwatersheds with identified sediment or hydromodification problems. In the upper watershed, land needs to be conserved to protect areas like Goose Creek and Iron Creek, where some landscape areas still resemble their pre-development conditions.

Impoundements are also identified as a top priority because they are the key factor for retaining sediment in the watershed. While dams serve to keep sediment and sediment-associated pollutants from moving downstream, they tend to degrade the water quality upstream of the dam. Dam removal is a difficult task to accomplish, either because the dam structure itself is integrated with a bridge crossing or politically, the idea cannot gain any traction.

The next priorities are the management of storm water and cropland drainage systems. Although as mentioned in Chapter 3, the impacts of farm land on flashiness are not as easy to discern as the impact of impervious surfaces, the flashiness index goes up in the Raisin as more and more farm land contributes to the river's flow.

Although low on the prioritization list, Large Woody Debris (LWD) can be a real problem on the Raisin for capturing sediment and trash, as well as creating obstacles to river access and navigation. Full consideration of problems on the Raisin has to include LWD. There is no organization or agency with responsibility for managing or removing LWD. LWD is also a component of a properly functioning river ecosystem; therefore LWD needs to be managed to address both flow and sediment issues as well as river ecology. A primer on developing a LWD management plan is included in the **LWD Appendix**.

Table 6-4 Prioritization of Sources and Management Practices to Reduce Sedimentation, TP and Hydrologic Variability

Source	Management Practice	Upper River Raisin, Iron Creek & Goose Creek	S. Branch River Raisin	Black Creek	Evans Creek	Lower River Raisin	Macon Creek	Saline River	Little River Raisin
Conversion of natural land cover	Conserve natural land cover Restore natural land cover Establish Master Plan & Conservation/Protection Ord.s Promote/require Smart Growth principles Lobby for dedicated state conserv./restoration fund	1	3	3	2	2	3	2	3
Impoundments	Dam Removal	1	3	3	2	1	3	2	3
Lack of effective farm storm water management	Construct/restore wetlands Retrofit Two-Stage Ditches Implement Riparian and Field Buffers	2	1	1	2	1	2	2	1
Cropland Drainage	Improve drain tile management	3	1	1	2	2	2	2	2
Impervious & compacted Surfaces	Adopt site design standards that reduce imp. surfaces Reduce impervious surfaces Retrofit impervious surfaces with LID BMPs Incorporate road & ROW BMPs in new & re-built roads Develop better gravel road design & maintenance std.s	1	1	2	1	1	2	1	2
Inadequate storm water management	Develop better storm water management ordinances Adopt Michigan LID Manual Design and std.s Create storm water utility Add SESC Ordinance Improve SESC enforcement Retrofit/create Two-Stage Ditches	1	1	2	1	1	2	1	2
Large woody debris (LWD)	LWD Management Program	1	2	2	2	1	2	1	2

6.3.1 Planning

Communities in the watershed are developing or are poised to develop in ways that may diminish their rural character and create or exacerbate water quality problems in the Raisin and its tributaries. Development often replaces natural porous surfaces that contain micro (leaf surfaces, microtopograhpy, etc.) or macro (ponds, lakes, wetlands) storage areas, with hard, flat impervious surfaces. These impervious surfaces change the local hydrology and act as efficient conduits for carrying accumulations of dust, dirt, fertilizers, pesticides, heavy metals, soaps, etc. into the waterways of the Raisin. These impervious surfaces cover natural groundwater recharge areas and convert more rainfall and snowfall from infiltrating water into runoff. This reduces groundwater recharge and increases the peak flow rates and total volume of runoff to receiving surface waters in the watershed.

Some local communities try to skirt the issues of development by specifying large minimum lot sizes. But large minimum lot sizes do not protect rural character. While large lots spread development over a larger area, they also make it harder to utilize existing infrastructure and fire and police resources or achieve compact designs that preserve natural features. Based on surveys by the Michigan Environmental Council (MEC) census data and farmland loss statistics, large lot zoning appears to promote the destruction of rural character by driving out the very farmers who provide the community its agricultural base (MEC, 2004).

Communities and counties should foster closer working relationships to see if there are ways to develop some efficiencies in services. Coordinated land use and infrastructure planning across jurisdictions not only integrates and broadens planning windows but also tends to be a more attractive arrangement for attracting outside funding. Neighboring units of governments would clearly benefit from working collaboratively to protect the variety of land-based industries and residential development needed to sustain the economy.

One way to help energize this effort would be to seek outside funding to develop a set of balanced growth tools for the communities in the River Raisin watershed. A set of model ordinances along with multi-jurisdictional development policy/guidance should be developed. Naturalized buffer zones around the River Raisin and its tributaries should be better integrated into existing and proposed development and for agriculture (see model buffer ordinance in **Riparian Buffer Appendix**).

These balanced growth tools should include urban service districts, with urban limit lines and/or urban growth boundaries. This would include boundaries for the provision of public services for a particular planning period (e.g., 20-30 years) and implementing transfer of development rights to preserve open space while increasing density in service areas. Agricultural/Residential and other ambiguous zoning districts need to be avoided. Communities should be zoned by desired density rather than by lot size. Higher density development can be enjoyable and profitable for everyone if it is well planned and includes open space, easy access to transportation with a variety of housing choices.

Capital improvement plans should require communities to plan for density. Land use planning and zoning decisions should be coordinated with water and sewer extensions. Houses are a one-time “crop” that alone will not sustain a community. Requiring multi-year capital improvement plans at the local level can help ensure cost-effective delivery of infrastructure and services to all communities. Communities should allow for and promote innovative designs for cohesive, environmentally-friendly neighborhoods, such as conservation design and low impact development techniques. Mixed land uses, a variety of transportation choices, and walkable neighborhoods fosters distinctive, attractive communities with a strong sense of place. New construction ordinances could potentially play a key role in the future water quality of the River Raisin. As shown in the SWAT modeling section, a vegetated buffer along the creeks/rivers improves water quality significantly. Therefore, new construction ordinances should require a setback from creeks/rivers. This BMP would improve sediment and nutrient control.

Recommendations for development in the watershed that protects rural character, allows for growth, while at the same time protecting water quality in the River Raisin includes:

1. Inventory and prioritize natural, agricultural and culturally significant resources and develop a preservation strategy.

2. Establish natural buffer zones around the River Raisin and its tributaries (see model buffer ordinance in the **Model Ordinance Appendix** *Retention of a wide, continuous riparian zone in forest cover or wetlands has shown to be the BMP of greatest potential and versatility among those in current use* (Horner and May, 1999).

3. Develop a storm water ordinance that requires no net runoff (no difference between pre-development and post-development conditions) for runoff from the 2-year, 24-hour storm (see model storm water ordinance in **the LID Manual Appendix**).

4. Create urban service districts, urban limit lines and/or urban growth boundaries. Establish boundaries for the provision of public services for a particular planning period (e.g., 20-30 years).

5. Implement transfer of development rights to preserve open space while increasing density in service areas.

6. Avoid Agricultural/Residential and other ambiguous zoning districts. Quasi-rural zoning districts such as A/R zones often result in increased loss of farmland and demand for costly infrastructure.

7. Zone communities by desired density rather than by lot size. Higher density development can be enjoyable and profitable for everyone if it is well planned and includes open space, easy access to transportation with a variety of housing choices.

8. Rely more frequently on cluster zoning and Planned Unit Developments (PUDs). Cluster zoning and PUDs are more effective than large minimum lot sizes in guiding future growth patterns and protecting agricultural land. These tools provide the opportunity to accommodate a diverse base of uses and a more economical use of land resources.

9. Coordinate land use and infrastructure planning across jurisdictions. Neighboring units of governments would clearly benefit from working collaboratively to protect the variety of land-based industries and residential development needed to sustain the economy across a broader geographic area that can accommodate both rural industry and residential development.

10. Require capital improvement plans to help communities plan for density. Coordinate land use planning and zoning decisions with water and sewer extensions. Houses are a one-time “crop” that alone will not sustain a community. Requiring multi-year capital improvement plans at the local level can help ensure cost-effective delivery of infrastructure and services to all communities.

11. Allow for and promote innovative designs for cohesive, environmentally-friendly neighborhoods, such as conservation design and low impact development techniques. Mix land uses, provide a variety of transportation choices, create walkable neighborhoods and foster distinctive, attractive communities with a strong sense of place.

12. Private wastewater treatment plant ordinances should require regular testing and inspection of systems so that failures could be identified prior to impacting water quality.

13. Similarly to private wastewater treatment plant ordinances, well and septic inspections would identify potential leaks and failures so that mitigation actions could be put in place to reduce negative impact on water quality.

14. New construction ordinances should require a setback from creeks/rivers. This BMP would reduce sediment and nutrient loads.

15. Woody debris provides valuable habitat along creeks and rivers. Woody debris management allows for protection of this habitat while reducing the potential for flooding and streambank erosion. The clean and open method for woody debris management is advocated by SEMCOG and includes removing trash and debris, removing floating debris to allow flow passage, placement of excess debris along streambanks and in the adjacent riparian corridor, and minimizing the overall impact to the area. Local agencies should consider adopting this method of woody debris management by using staff maintenance crews or volunteer efforts. Woody debris management will improve sediment loads.

6.3.2 Urban and Suburban Best Management Practices

The urban/suburban area BMPs highlighted in this manual and the philosophy underlying them is referred to as Low Impact Development (LID). Simply stated, LID is the practice of minimizing development's footprint and as much as possible emulating pre-development hydrology. This means designing a site so that peak and total runoff volumes for developed conditions matches, as closely as possible, pre-development conditions. Development is planned so that it works with a site rather than completely reshaping the site to some set of arbitrary design standards. On sites where water once infiltrated, the goal is to infiltrate the same amount of water. BMPs tend to be smaller than standard detention basins and are scattered across a site, managing storm water as close to the source of runoff as possible. This practice applies to all areas of the watershed, but is particularly relevant to proposed and existing urban and suburban areas of the watershed.

This practice of matching pre- and post-development hydrology is, at this time in Michigan, not completely consistent with existing and probable future Drain Code. Pre-existing hydrology for low-lying, poorly draining land, like much of the lower Raisin, would normally experience some flooding on an annual basis. County Drain Commissioners, who have made development and agriculture possible in poorly drained areas, are not ready to change some standards for complete adoption of LID standards that might relax their requirements. For instance, County Drain standards in these poorly drained areas often specify a drainage rate that results in less runoff and less flooding from a site than from pre-development conditions.

The compromise position adopted in this plan is to follow the LID design prescription and philosophy as much as possible. Much of LID, particularly, the non-structural BMPs that relate to planning and site design standards, can be adopted wholesale. Finding the right prescription for balancing site hydrology in low-lying, poorly draining areas will, however, be a process of implementing and refining site design so that it balances environmental and societal goals to the extent practicable.

The highest priority areas for application of new or retrofit urban/suburban BMPs are the largest communities with the highest proportion of impervious surface area and also the communities poised for the highest potential growth. The largest communities in the watershed are Adrian and Monroe, and these areas along with Saline and Milan are poised for the largest potential growth. Other secondary priority application areas include the villages of Manchester, Clinton, Tecumseh, Blissfield, and Dundee.

Non-structural and structural LID BMPs are listed below. Very brief descriptions of these BMPs follow.

6.3.3 Non-Structural BMPs

These non-structural BMPs reduce stormwater runoff by improving the ability of the vegetation or soil to intercept and infiltrate rainwater before it becomes runoff.

Restoration (Reforestation/Revegetation)

Restoration includes reforestation and revegetation of savannas and/or meadows and the conversion of turf to meadow outside of riparian (or other specially protected) buffer areas. The emphasis is on saving existing systems if possible and re-planting and re-vegetating with "natives" after disturbance has occurred. Native species are those existing in a given geographic area prior to European settlement that generally have the greatest tolerance and resistance to pests and do not typically require significant chemical maintenance by fertilizers, herbicides and pesticides.

As restored native landscapes grow and mature they become much more effective in reducing runoff volumes and controlling peak flow due to increases in infiltration, evapotranspiration and recharge. Native species are usually vigorous growers with stronger and denser root and stem systems than non-native ornamentals. The benefits of native plants are long term but not immediately forthcoming until the plants have had an opportunity to grow and mature. Restoration through use of natives improves water quality by reducing disturbance and maintenance and minimizing application of fertilizers, pesticides and herbicides.

Soils Amendment

Soil amendment is a technique that can be used to restore soil health and as a consequence enhance water cycling and water quality. Soil amendment is used to reestablish the soil's long term capacity for infiltration and pollutant removal. A healthy soil provides a number of vital functions including the ability to store water and nutrients, regulate the flow of water, and immobilize and degrade pollutants. Soil restoration is a critical BMP to combat erosion, sedimentation, and soil compaction. Amended soils can reduce compaction (increase pore space) and the need for irrigation by retaining water and slowly releasing moisture and increase infiltration therefore reducing the volume of stormwater runoff. Soils rich in amendments also improve water quality by increasing the soil's nutrient holding capacity while adding microorganisms that immobilize or degrade pollutants.

6.3.4 Stuctural BMPs: Runoff Volume/Infiltration-Oriented

This set of structural BMPs focus on reducing runoff volume through infiltration into the subsurface soils. Properly designed, constructed, and maintained BMPs can infiltrate a large percentage of the precipitation resulting in little to no runoff entering the storm sewer system. Infiltration BMPs should be sized according to site-specific soil infiltration rates. Generally, the BMP area should be 5-10% of the contributing watershed area.

Raingarden

Rain Gardens

Rain Gardens/Bioretention basins treat stormwater by pooling water on the surface and allowing filtering and settling of suspended sediment at the mulch layer, prior to entering the plant/soil/microbe complex media for infiltration and pollutant removal. These BMPs are sometimes underlain by a sand or gravel storage/infiltration bed. Plants take up pollutants while microbes associated with the plant roots break down and convert pollutants; the soil medium filters out pollutants and allows storage and infiltration of stormwater runoff. Rain Gardens/Bioretention basins can be expected to remove a high amount of total suspended solids (typically 70% to 90%), a medium amount of total phosphorus (approximately 60%), and a medium amount of total nitrogen (often 40% to 50%). Properly designed bioretention techniques mimic natural forest ecosystems through species diversity, density and distribution of vegetation, and the use of native species, resulting in a system that is resistant to insects, disease, pollution, and climatic stresses while providing habitat for wildlife and improving site aesthetics.

Vegetated Filter Strip

A vegetated filter strip is an area of perennial grasses or other dense vegetation designed to remove sediment and other pollutants from stormwater runoff flowing through as sheet flow. They are designed to remove sediment, organic material, nutrients, and chemicals carried in runoff or waste water. The vegetation and soils affect pollutant removal via filtration, infiltration, absorption, adsorption, and volatilization. Plant nutrients and pesticides that become trapped in a filter strip may be degraded or transformed by biological and chemical processes into other compounds that may be used by the vegetation growing in the filter. Vegetative filter strips can increase water quality by removing 50% - 90% of TSS, 40% – 80% of TN and 30% – 70% of TP. A 50-ft wide vegetative filter strip has value, however a 100-ft wide strip is recommended for maximizing water quality benefits.

Vegetated Swales

Vegetated swales are broad, shallow, densely planted earthen channels designed to slow runoff, promote infiltration, and filter pollutants and sediments in the process of conveying runoff. Vegetated Swales provide an excellent alternative to conventional curb and gutter conveyance systems, while providing partially treated (pretreatment) and partially distributed stormwater flows to subsequent BMPs. The various pollutant removal mechanisms of a swale include: physical filtering by the swale vegetation (both on side slopes and on bottom), filtration through the soil matrix, and/or infiltration into the underlying soils with the full array of infiltration-oriented pollutant removal mechanisms. A Vegetated Swale typically consists of a band of dense vegetation, underlain by at least 12 inches of permeable soil (> 0.5 inches/hour). Swales constructed with an underlying aggregate layer can provide significant volume and peak rate reductions. The permeable soil media should have a minimum infiltration rate of 0.5 inches per hour and contain a high level of organic material to enhance pollutant removal. Check dams can be used to improve performance and maximize infiltration, especially in steeper areas. Vegetated Swales can remove 70% - 90% of TSS, 10% - 50% TP and often 40% - 75% of TN.

Porous Pavement with Infiltration Beds

A pervious pavement system consists of a pervious surface course underlain by a storage reservoir placed on un-compacted sub-grade to facilitate stormwater infiltration. The pervious surface can be porous concrete, porous asphalt, or porous concrete pavers. The storage reservoir may consist of a stone bed of uniformly graded and clean-washed course aggregate, 1-1/2 to 2-1/2 inches in size, with a void space of at least 40% or other pre-manufactured structural storage units. Stormwater drains through the surface course, is temporarily held in the voids of the stone bed, and then slowly exfiltrates into the underlying, uncompacted soil mantle. The stone bed can be designed with an overflow control structure so that during large storm events peak rates are controlled, and at no time does the water level rise to the pavement level. A layer of nonwoven geotextile filter fabric separates the aggregate from the underlying soil, preventing the migration of fines into the bed. Many designs incorporate a riverstone/rock edge treatment or inlets which are

Porous Pavers along Residential Street directly tied to the bed so that the stormwater system will continue to function despite the performance of the pervious pavement surface.

Pervious pavement systems are effective in reducing such pollutants as total suspended solids, metals, and oil and grease. Both the pervious pavement surface and the underlying soils below the infiltration bed allow pollutant filtration. When pervious pavement systems are designed to capture and infiltrate runoff volumes from small storm events they provide very high pollutant reductions because there is little if any discharge of runoff. Because pervious pavement systems require pretreatment of TSS when adjacent areas drain to them, reduction of TSS and other particulates is typically high, however, pervious pavement systems can provide treatment of dissolved pollutants, such as nitrates.

Infiltration Basins

Infiltration basins are shallow, impounded areas designed to temporarily store and infiltrate stormwater runoff. The size and shape can vary from one large basin to multiple, smaller basins throughout a site. Infiltration Basins use the existing soil mantle to reduce the volume of stormwater runoff by infiltration and evapotranspiration. Therefore, the use of sediment pretreatment is imperative to prevent clogging of the infiltration surface area within the basin while providing enough surface area for the volume of runoff to be absorbed within a given time (typically 72 hours or less).

With the use of a properly designed outlet structure, infiltration basins can be designed to mitigate volume and water quality for small frequent storms, while managing peak rates for large design storms. During small storms, infiltration basins provide very high pollutant reductions because there is little if any discharge of runoff effectively reducing such pollutants as total suspended solids, metals, and oil and grease. Both the vegetative surface and the underlying soils allow pollutant filtration and studies have shown that pollutants typically are bound to the soils and do not migrate deeply below the surface. The basin acts as a storage reservoir during large storm events while runoff exfiltrates through the soil mantle through the process of infiltration. Outlet structures can be designed to manage peak rates with the use of weir and orifice controls and systems can be designed to manage peak rates for storms up to and including the 100-year storm. Because infiltration basins require pretreatment of TSS when adjacent areas drain to them, reduction of TSS and other particulates is typically high, however, infiltration basins can provide treatment of dissolved pollutants such as nitrates.

Infiltration Trenches

An infiltration trench is a linear subsurface infiltration structure consisting of a continuously perforated pipe at a minimal slope within a sub-surface stone-filled trench wrapped with geotextile. Usually an infiltration trench is part of a conveyance system and is designed so that large storm events are conveyed through the pipe with some runoff volume reduction. Although the width and depth can vary, it is recommended that infiltration trenches be limited in depth to not more than six (6) feet of stone due to both construction and loading rate issues. Sediment pretreatment of runoff from impervious areas should be considered to prevent clogging within the trench, particularly when conveying runoff from roadways and parking areas.

Infiltration trenches provide volume, peak rate and water quality functions. Because they are often used for conveyance as well as volume reduction, they function best in reducing runoff volumes generated by small storm events, and allow larger storms to pass through, reducing peak rates by contributing to an increase in stormwater travel time. Infiltration trenches are effective in reducing such pollutants as total suspended solids, metals, and oil and grease. When infiltration trenches are designed to capture and infiltrate runoff volumes from small storm events they provide high pollutant reductions because there is little if any discharge of runoff. Because infiltration trenches require pretreatment of TSS when adjacent areas drain to them, reduction of TSS and other particulates is typically high, however, infiltration trenches can provide treatment of dissolved pollutants, such as nitrates.

Dry Wells

A dry well, also referred to as a seepage pit, French drain or Dutch drain, is a subsurface storage facility that temporarily stores and infiltrates stormwater runoff from rooftop structures. Roof leaders usually connect directly into the dry well, which may be either an excavated pit filled with uniformly graded aggregate wrapped in geotextile, or a prefabricated storage chamber or pipe segment. Dry wells discharge the stored runoff via infiltration into the surrounding soils. In the event that the dry well is overwhelmed in an intense storm event, an overflow mechanism (surcharge pipe, connection to larger infiltration area, etc.) will ensure that additional runoff is safely conveyed downstream.

The dry well typically provides more peak rate benefit for small frequent storms, rather than large design storms. Because dry wells contribute to a decentralized approach to stormwater management, they benefit peak rate mitigation by reducing direct impervious area connections to storm sewer collection systems and contribute to increased stormwater travel time. Dry wells provide high pollutant reductions because there is little if any discharge of “first flush” runoff which carries the highest pollutant loads. Because dry wells may require pretreatment of TSS when adjacent areas, such as roads, walkways and patios drain to them, reduction of TSS and other particulates is typically high, however, dry wells usually capture rooftop runoff which typically contains smaller amounts of nonpoint source pollutants.

Level Spreaders

Level spreaders promote infiltration and improve water quality by evenly distributing flows over a stabilized vegetated surface. There are several different types of level spreaders including concrete sills, earthen berms and level perforated pipes; all of which are designed to prevent erosion at an outlet by increasing the interaction between stormwater, vegetation and soils in the BMP or filter strip.

The amount of volume reduction from a level spreader will depend on the length, the density of receiving vegetation, the downhill length and slope, the soil type of the receiving area, and the design runoff. Large areas with heavy, dense vegetation will absorb most flows, while barren or compacted areas will absorb limited runoff. The influent peak rate to a level spreader will be diffused over the length of the level spreader. The number of perforations in a level spreader pipe will essentially divide the concentrated flow into many smaller flows, yet spreaders will not substantially decrease the overall discharge rate from a site. Water quality improvements occur if the area down gradient of the level spreader is vegetated, stabilized, and minimally sloped. Level spreaders are not intended to reduce TSS, TP or TN alone, however, they may help other BMPs, such as vegetated filter strip, attain their full water quality improvement potential by distributing water evenly across the recipient BMP.

Retentive Grading Techniques

Infiltration berms and retentive grading techniques use a site’s topography to manage stormwater and prevent erosion. Infiltration berms are shallow depressions created by generally small earthen embankments that collect and temporarily store stormwater runoff allowing it to infiltrate and recharge groundwater. They may function independently in grassy areas or may be incorporated into the design of other stormwater control facilities such as bioretention and constructed wetlands. Berms may serve various stormwater drainage functions including: creating a barrier to flow, retaining flow for volume control, and directing flows.

There are two ways in which infiltration berms can help mitigate peak rates: providing storage for detention (and on-going infiltration) behind them and, in some cases, elongating the flow path through a site, thereby extending the time of concentration. The degree to which infiltration berms help control peak rate is a function of the storage volume provided (i.e. depth and area), the overflow configuration (adjacent to and around the end vs. over the berm crest), and the total length of the berm in the case of parallel flow situations. Infiltration berms improve runoff quality primarily through settling, filtration, and infiltration. They are capable of removing between 50% and 70% of TSS from runoff as well as between 30% and 50% of nitrate (NO3) and between 40% and 60% of TP.

6.3.5 Structural BMPs: Runoff Volume/Non-Infiltration-Oriented

This set of structural BMPs reduce runoff volume by using the stormwater for other purposes. The vegetated roofs reduce peak runoff by capturing rainwater before it becomes runoff. Vegetated roofs are often are combined with infiltration practices to further reduce runoff volumes. Capture/reuse systems utilize rainwater for irrigation or grey-water uses.

Vegetated roofs

An extensive vegetated roof cover is a veneer of vegetation that is grown on and covers an otherwise conventional flat or pitched roof, endowing the roof (< 30 degree slope) with hydrologic characteristics closely matching surface vegetation. The overall thickness may range from 2 to 6 inches and may contain multiple layers, consisting of waterproofing, synthetic insulation, non-soil engineered growth media, fabrics, and synthetic components. Vegetated roof covers can be optimized to achieve water quantity and water quality benefits by significant rainfall retention and detention functions.

Vegetated roof covers are an "at source" measure for reducing the rate and volume of runoff released during rainfall events and are frequently combined with ground infiltration measures. Vegetated roof covers improve the efficiency of infiltration devices by reducing the peak runoff rate, prolonging the runoff, filtering runoff to produce a cleaner effluent. Once the plant cover is established, fertilization should be suspended. Experience indicates that the efficiency of vegetated covers in reducing pollutant and nutrient releases from roofs will increase with time. The vegetated cover should reach its optimum performance after about five years.

Capture Reuse

Capture-reuse is a term that encompasses the practice of collecting rainwater in a container such as a rain barrel or cistern and reusing it to reduce potable water needs while simultaneously reducing stormwater discharges. Rain barrels are commonly connected to rooftop downspouts where water is reused for garden irrigation, including landscaped beds, trees, or other vegetated surfaces. Rain barrels can be used on residential properties, but also can be used at schools and campuses, commercial offices, and any other area where highly aesthetic landscaping features are important. Greater storage capacity can be accomplished through the use of cisterns which may be comprised of fiberglass, concrete, plastic, brick or other materials and can be stored underground or on the surface. Cisterns can be utilized with any land use where significant water need exists storing from 200 gallons to 10,000 gallons to be used to supplement greywater needs or for irrigation.

Overall, capture and reuse takes a volume of water out of site runoff and puts it back into the ground. This reduction in volume will translate to a lower overall peak rate and total runoff volume for the site. Pollutant removal takes place through filtration of recycled primary storage, and/or natural filtration through soil and vegetation for overflow discharge.

6.3.6 Structural BMPs: Runoff Quality/Non-Infiltration

This set of structural BMPs are essentially detention and/or filtration BMPs. The detention facilities store water until is displaced by additional incoming water. The storage time allows for settling of particulate pollutants, primarily sediment and associated phosphorus. The filtration BMPs utilize primarily physical or mechanical methods to filter stormwater runoff, however some also include plants which can assimilate a small portion of the dissolved pollutants.

Constructed Wetland

Constructed wetlands are shallow marsh systems planted with emergent vegetation that are designed to treat stormwater runoff through pollutant removal while also reducing peak rates and runoff volume to a certain degree. They also can provide considerable aesthetic and wildlife benefits but require relatively large amount of space and an adequate source of inflow to maintain the permanent water surface. Constructed wetlands can achieve some volume reduction through infiltration and evapotranspiration, especially during small storms and high temperature periods. Peak rate is primarily controlled through transient storage volume provided and the configuration of the outlet control structure.

Constructed wetlands improve runoff quality through settling, filtration, uptake, chemical and biological decomposition and transformation, volatilization, absorption and adsorption of many common stormwater pollutants including suspended solids, heavy metals, total phosphorus, total nitrogen, toxic organics, and petroleum products. The pollutant removal effectiveness varies by season and may be affected by the age of the wetland. Properly sized constructed wetlands can remove between 50% - 80% of TSS, 0-30% of TN and 15-70% of TP.

Wet Pond/Retention Basins

Wet ponds/retention basins are stormwater basins that include a substantial permanent pool for water quality treatment and additional capacity above the permanent pool for temporary runoff storage. The pond perimeter should generally be covered by a dense stand of emergent wetland vegetation and should include one or more forebays that trap course sediment, prevent short-circuiting, and facilitate maintenance (i.e. sediment removal). Wet Ponds do require an adequate source of inflow to maintain the permanent water surface. While they do not achieve significant groundwater recharge or volume reduction, wet ponds can be effective for peak rate mitigation and pollutant removal while providing aesthetic and wildlife benefits.

Wet ponds achieve some volume reduction through infiltration and evapotranspiration, especially during small storms. The degree to which peak rate is controlled is a function of the transient storage volume provided (i.e. depth and area) and the configuration of the outlet control structure. Wet ponds rely on physical, biological, and chemical processes to remove pollutants from influent stormwater runoff. The primary treatment mechanism is settling by gravity of particulates and their associated pollutants while stormwater is retained in the pond. Another mechanism for the removal of pollutants, especially nutrients, is uptake by algae and aquatic vegetation. Volatilization and chemical activity can also occur, breaking down and assimilating a number of other typical stormwater contaminants, such as hydrocarbons. Wet ponds are relatively effective at removing many common stormwater pollutants including suspended solids, heavy metals, total phosphorus, total nitrogen, and pathogens. Wet ponds are capable of removing 60% - 88% of TSS, 16% -41% of TN and 39% -76% of TP from runoff. The longer the runoff is allowed to remain in the wet pond, the greater the level of pollutant removal with removal effectiveness governed by season and the age of the wet pond.

Constructed Filters

Constructed filters are structures or excavated areas containing a layer of sand, compost, organic material, peat, or other filter media that reduce pollutant levels in stormwater runoff by filtering sediments, metals, hydrocarbons, and other pollutants. In some applications the stormwater runoff flows through an open air, “pretreatment” chamber to allow the large particles and debris to settle out. The runoff then passes through the filter media where additional pollutants are filtered out, and is collected in an underdrain and returned to the conveyance system, receiving waters or infiltrated into the soil mantle.

Constructed filters generally provide little, if any, peak rate reduction. However, if the filter is designed to infiltrate, then medium to high levels of peak rate attenuation can be expected. The extent to which Constructed filters remove pollutants in runoff is a function of their pretreatment, design, configuration, and filter media and can remove 80% - 92% of TSS, 30% -47% of TN and 41% - 66% of TP from runoff.

Water Quality Inserts

Water quality inserts are generally proprietary, commercially available units such as trays, bags, or baskets that utilize some form of filtration, settling, or hydrodynamic separation to remove pollutants including coarse sediment, oil and grease, litter, and debris to improve water quality as stormwater flows through the system. Water quality devices generally provide no peak rate reduction, yet the devices designed to reduce large suspended solids may also reduce co-pollutants such as phosphorus, nitrates, and metals by removing the sediment particles to which the co-pollutants adhere. Regular maintenance is critical for the continued proper functioning of water quality devices.

Extended Detention Basin

A dry extended detention basin is an earthen structure, constructed either by impoundment of a natural depression or excavation of existing soil, that provides temporary storage of runoff and releases the stored volume of water over time. Sediment forebays should be incorporated into the design to improve sediment removal with the basin outlet structure designed to detain runoff for extended periods with the primary purpose of attenuating stormwater runoff peaks.

Some volume reduction will be achieved by a dry basin through initial saturation of the soil mantle and some evaporation will also take place, however the net volume reduction is minimal. Detention basins should be designed to control runoff peak rates for rainfall events with return frequencies of 1 through 100 years. Water quality improvement is partially achieved by retaining the runoff volume with some studies reporting reduction in TSS from 40% - 60%, TN of 25% and TP of about 35%.

6.4 Reduce/Remove Bioaccumulative Chemicals of Concern

There are at least two sets of strategies to address the BCCs. One set of strategies has been developed for the fish and wildlife habitat and population beneficial use impairments as part of the Raisin AOC; the other set of strategies– to address longstanding contamination issues, particularly those caused by atmospheric deposition – is still in its infancy. The priorities for BCCs in this plan are:

1. Undertake the habitat restoration projects as outlined in River Raisin AOC Habitat and Population Delisting Targets (refer to **Figure 6-1** and **Figure 6-2** below). These include:
   a. North River Raisin Wetland Enhancements
   b. Sterling Island Improvements
   c. City of Monroe Low Head Dam Removals and fish ladder improvements at the Waterloo Dam
   d. River Raisin Habitat Evaluation
2. Remove and restore the five remaining PCB hot spots on the River Raisin as show in **Figure 6-3**Error! Reference source not found. below.
3. Become involved with larger regional efforts to control BCC atmospheric deposition, such as the Mercury Reduction Strategy (See MDEQ Mercury Strategy Staff Report). This problem is much bigger than the Raisin and will require large-scale efforts to mitigate.

Figure 6-1 Habitat Restoration Areas for the River Raisin AOC (ECT, 2008)

Figure 6-2 Low-Head Dams and Waterloo Dam on the River Raisin in Monroe

Figure 6-3 Remaining River Raisin PCB Hot Spots in the AOC (ECT, 2008)

6.5 Build RRWC Capacity

The RRWC needs to broaden and increase its diversity of revenue sources. Just like sound financial planning where diversification of investments is a key to potentially maximizing returns, sustainable non-governmental organizations have to rely on a diversified portfolio of funding sources.

The RRWC should broaden membership on its Executive Committee. Membership on the committee should be opened up to representatives from large organizations that have a stake in improving conditions in the watershed, such as representatives from the Port of Monroe, the Ford Motor Company, Detroit Edison, Adrian College, and so on.

In order to facilitate capacity building, a River Raisin Resource Development Committee should be formed. The committee should help develop a marketing plan/program with membership rewards, a press kit complete with communication themes and a DVD that traverses the entire Raisin and shows both the good and bad aspects and what people can do to help. The RRWC should also revise their by-laws to build the number and size of funding resources. Possible revenue sources include:

- Annual fundraising dinner
- Membership maintenance plan
- Mid-year and end-of-year membership drives for businesses, municipalities and associate members
- Fundraising events such as “Squish: A Wetland Walk”, River Fest, River Canoe Race, Walk/Run-A-Thon

- o Implement a program to solicit contributions from school districts to form a student monitoring program
- o Develop a plan to solicit funds from foundations and businesses
- o Target grants
- o Establish a tailored scope, services and member benefits for businesses, municipalities, individuals and associations
- o Develop membership outreach materials/brochure for each target audience
- o Committee Members should contact/court at least 4 businesses in calendar year for donations/sponsorships
- o Create Membership page on website with credit card acceptance capabilities
- o Public Forums/Speakers Bureaus/Lecture Series
- o Create professional quality calendar on an annual basis that can be sold at retail outlets throughout the River Raisin Watershed

Continued development and refinement of a sophisticated, content laden website will also be important to RRWC outreach. Refinement of the web page should be done with professional help. Opportunities should be provided for organizations to help sponsor the site, either with web hosting or selling of ad space. The site should contain NPDES and TMDL information, BMP manuals, model ordinances, results of on-going assessment efforts and related web links. Pages and on the site could include:

-Legislative update page
-volunteer page
-stormwater page
-Adopt-A-Stream Program page
-Education and Information pages
-sample ordinances page
-Promotional page that would sell RRWC shirts, t-shirts, travel mugs, videos, calendars
-Blog page
-Report watershed concerns page

6.6 Public Information and Education Plan

A critical component of the River Raisin Watershed Management Plan is public information and education (I&E). Primary support and involvement from watershed stakeholders is essential to identifying and supporting the action plan for addressing river impairments. Organizations in the Raisin have undertaken public education and involvement programs, some of which are on-going. For instance, the River Raisin Watershed Council has developed a school workbook, a detailed watershed map and a young, but on-going Adopt-A-Stream program. The River Raisin Institute has begun working with schools and helps oversee volunteer macroinvertebrate sampling and small scale restoration projects. Boy Scouts in the Monroe area undertake a very successful river clean-up every year. However, public understanding and support needs to be much broader, both to develop new river stewards and help build momentum and financial support for the goals of the overall watershed plan.

As part of the watershed planning process, an Information and Education sub-committee was formed to identify the target audiences and provide direction for the Information and Education strategy. Public information and education resources and activities currently available were identified and reviewed based on effectiveness. The committee then developed I&E goals and objectives, target audiences and messages and strategies for reaching these groups.

6.6.1 Goals and Objectives of the Plan

The overall goal of the I & E plan is to establish a platform of educational and public involvement components that incorporate the River Raisin Watershed planning objectives and tasks. The I&E plan will focus on establishing and increasing local awareness and educating target audiences, thereby serving as a catalyst to promote both individual and community-based aspirations for stewardship in the River Raisin Watershed. The prioritized objectives, based on the prioritized impairments and threats and their associated pollutants and sources, as established in **Chapter 5**, are the following:

1. Increase individual farm understanding of impacts and economics of environmental quality programs
2. Increase farmers' understanding and use of best management practices for nutrient management, livestock waste management, drain tile management, and vegetative buffers.
3. Increase local decision-makers' understanding of how on-site sewage ordinances and inspection/enforcement programs impact environmental quality
4. Increase individual residents' knowledge of septic system maintenance and how land use impacts water quality and watershed health in the River Raisin watershed
5. Increase awareness of stormwater runoff issues in urban/suburban areas

6.6.2 Target Audiences

A review of the diverse audiences within the River Raisin Watershed was studied and listed as key target groups for information and education strategy implementation. The target audiences have been divided into the following groups and prioritized based on the watershed priorities:

1. Farmers and Agricultural Support System
2. Municipalities/Counties
3. Individuals/Household
4. Students – Grades K through 12
4. Business/Industry
4. Recreation Industry/ Stakeholders

Farmers are the number one priority audience for education due to the agricultural causes associated with the two top priority pollutants, nitrate and *E. coli*. The current agricultural support system includes agencies such as NRCS, conservation districts, Michigan Department of Agriculture (MDA), and the MSU Extension (MSUE). While these organizations help to educate the farmers, there will be some need for "bottom up" education to implement new practices, such as the performance-based incentives pilot project. Municipalities and counties were identified through their influence in local ordinances and regulations for protection of natural areas and resources. Individuals/Household refers to the general public within the watershed, which includes riparian area landowners such as lake and river edge residents. Students ranging from kindergarten age through 12th grade were identified as particularly lacking in basic watershed information. Business/Industry was identified as a key player in supporting and promoting development and environmental impact. Recreation was identified as a tool to reach both residents and visitors that collectively can impact watershed resources.

6.6.3 Target Messages and Public Communication Strategies

The I&E strategy encompasses several avenues for disseminating information and fostering involvement in watershed activities. Several demonstration pilot projects are included in the Education Plan (see **Table 6-5**) and the Action Plan (see **Table 7-4**). These projects address some of the most important issues in the watershed, including the prioritized pollutants. We are recommending this first phase of implementation to disseminate information about river and watershed stewardship, trumpet early successes and establish broader and deeper participation in the entire suite of improvement activities. There are also more traditional education activities such as creation of brochures, and teaching materials that are direct public education activities. In addition, stewardship activities such as Adopt-a-Stream, river clean-up events, invasive species control, rain garden creation, bioengineered streambank stabilization, conversion of turf grass to native prairie, tree plantings, etc. that actively engage watershed residents are included. These activities not only improve the watershed but they are a direct hands-on educational and involvement opportunity as well.

Within the scope of the I&E plan is the necessity to identify behaviors/actions of target audiences that impact the water quality resources with the watershed. Communication strategies are outlined below for addressing target audiences: individuals/household, students (K-12), municipalities, business/industry, agriculture and recreation.

In the Action Plan (**Table 7-4**) we have divided up implementation of the plan into a demonstration phase and long-term implementation. For the demonstration phase we have suggested five separate I&E activities that we have prioritized for the first five years of implementation. These projects (described in more detail in **Chapter 7**) include a River Raisin Film Festival, an annual River Raisin conference, a watershed history book and full-scale implementation of the River Raisin Institute's "Connecting Schools to the Great Lakes" program.

On-going I&E activities should also include:

1) Agricultural

The River Raisin watershed has several impaired reaches that are not attaining designated water uses due to nitrate, *E. coli*, and sediment. Nitrate and *E. coli* TMDLs have been developed and approved. Agricultural sources are priority sources for both of these pollutants, and have been directly identified in several TMDLs. In addition, sediment and flow variability are secondary priorities, awaiting TMDL development. The major types of agricultural impacts in the River Raisin watershed are: 1) nutrient application (commercial fertilizer and manure) for row-crops, 2) inadequate livestock waste management (source of nutrients and pathogens), 3) drain tile management and 4) inadequate buffer strips. If Best Management Practices (BMPs) are used, the negative impacts from agricultural areas can be minimized. However, until these practices become common throughout the watershed, education focused on agricultural issues will be needed. Thus these educational activities and programs are priorities for the River Raisin watershed and in particular for the South Branch River Raisin, Black Creek, Macon Creek, Saline River and Lower River Raisin subwatersheds.

One important existing educational activity in the watershed is the Leneawee Conservation District's Center for Excellence annual field day. The Center for Excellence was started in the late 1980's by no-till farming supporters when other farmers in the area were switching back to conventional tillage practices. The Center for Excellence allows farmers to research and test new production methods and to share their results with area farmers. The Center for Excellence hosts an annual field day that includes presentations and farm visits to show off the latest conservation farming technology.

Watershed education goals relating to agriculture are focused on promoting conservation practices (BMPs) to reduce nutrient, pathogen, and sediment loads to drains, streams, and ultimately to the River Raisin. The target audiences include farmers as well as the agricultural support system (county, state, and federal agencies). Specific educational messages targeting farmers should stress the importance of source control for fertilizer and manure application, the value of precision agriculture to limit fertilizer use, the utility of developing a comprehensive nutrient management plan (CNMP), the importance of proper feedlot management, alternative options for drain tile management and swale design, and the importance of riparian buffers. Educational strategies should include encouraging voluntary participation in existing state and federal programs such as MAEAP and EQIP, as well as demonstration projects and seminars covering precision agriculture and drain tile/swale management. In addition, we are recommending a pilot project for a performance-based incentive program to improve water quality. The education portion of the performance-based pilot project will begin a year before the pilot project in order to raise awareness and build up farmer and agency participation.

MAEAP, the Michigan Agricultural Environmental Asssurance Program, is a voluntary program aimed at getting farmers to be proactive in reducing their environmental impact. The program has three steps: 1) education, 2) farm-specific risk assessment, and 3) on-farm verification that ensures the farmer has properly implemented environmentally sound practices. More information can be found at: http://www.maeap.org/maeap.

EQIP, the Environmental Quality Incentives Program, is a voluntary NRCS program authorized by the Farm Bill to promote agricultural production and environmental quality as compatible goals. The EQIP program offers landowners technical resources and financial incentives to implement structural BMPs and conservation management practices. For more information on EQIP, see: http://www.nrcs.usda.gov/PROGRAMS/EQIP/.

Demonstration projects involving precision agriculture and drain tile/swale management options (two-stage ditches, constructed wetlands, and water control structures) will serve as tangible examples of how these practices can be implemented to improve water quality. Classes and seminars will be held to disseminate the results of the demonstration projects. These may also be incorporated into future Center of Excellence field day activities.

2) Sewage Management

The River Raisin is a receptacle for both treated and sometimes untreated human and animal waste from the watershed. Munipalities and counties own and operate sewage collection and treatment systems throughout the watershed. Because the River Raisin watershed is a largely rural watershed, many residents have their own on-site wastewater treatment systems, often a septic tank and drainfield. In most areas where public sewerage systems are operated, NPDES regulations apply, and wastewater is treated to prevent degradation of the receiving waters. Where sewage treatment systems are not available, municipalities and counties regulate on-site systems through ordinances and inspections. Sewage management issues are priorities based on *E. coli* TMDLs for the River Raisin watershed. *E.coli* sources (in addition to the agricultural sources addressed above) include inadequately treated sewage from failing septic systems, untreated waste from illicit discharges, and occasional CSOs and SSOs during large precipitation events.

The target audiences for sewage management education will be municipalities/counties and individuals/households, with special emphasis on residents living near streams or drains and residents that are new owners of septic systems. The education goals for municipalities and counties are to raise decision-maker awareness of the importance of improving on-site wastewater ordinances as well as inspection and enforcement programs. This will be accomplished through presentations, disseminating example ordinances, and creating a public hotline to report illicit discharges.

The education goals related to individuals and households include improving understanding of how untreated sewage impacts waterways and groundwater, increasing understanding of proper septic system management, and increasing regular maintenance of septic systems (every 3-5 years). A variety of education methods will be employed to teach residents that regular septic system maintenance can help protect water quality and that maintenance is less expensive than replacing a system. The education strategies include mass media such as newspaper articles, utility bill inserts, and TV and radio spots, septic system replacement workshops, and encouraging participation in the Home*A*Syst program.

3) Planning

Where and how communities grow deeply affects water quality. The health of our water resources today depends on the sound management of where growth occurs. The goal of planning education is to inform local policy makers (municipalities/counties) of the connection between land use and water quality and begin to change local policies and implement ordinances to protect watershed health. This planning education will include the importance of riparian zones and riparian buffers, as well as concepts of Smart Growth, urban development issues, and habitat fragmentation.

In March 2008, the Citizen Planner co-sponsored six regional workshops titled, "Helping Communities Protect Water Resources." The five-hour workshop gave participants a better understanding of Michigan's water resources and how to protect them from the negative impacts of urbanization using watershed, community and site-level tools. See: http://www.citizenplanner.msu.edu/ProtectingWaterResourcesBrochure.SM.pdf

Proposed educational programs related to planning include creating a water quality primer for local government officials, creating an educational handbook containing example ordinances, educating the public about conservation easements, and educating public officials about habitat fragmentation and wildlife corridors through workshops, presentations, and demonstration tours.

4) Urban/Suburban

Watershed education goals relating to urban and suburban areas include increasing awareness of stormwater runoff, erosion and sedimentation and promoting low impact development (LID) and Smart Growth management techniques. Improving stormwater management is a priority based on the role that inadequate fertilizer management plays in nitrate pollution, a prioritized pollutant for the impaired Public Water Supply designated use. Stormwater management is also a secondary priority based on the role that urban runoff plays in sediment pollution and flow variability, which are prioritized pollutants for the Aquatic and Wildlife Habitat impaired use, currently awaiting development of TMDLs. Target audiences include municipalities/counties, individuals/households, students (K-12), and local businesses. The key educational message is that impervious surfaces create more runoff and that LID techniques and BMPs (vegetative buffers, raingardens, infiltration basins, etc) are key to mitigating the impacts of urban and suburban development. Other issues to be addressed also include residential fertilizer and pesticide use, residential car washing, pet waste management, and waterfowl management on lakefront and riparian properties.

Currently, stormwater education is limited in the River Raisin watershed. Recently, SEMCOG released the Michigan LID manual (see **LID Manual Appendix**). The Washtenaw County Drain Commissioner has published “The Homeowners Handbook: A Guide to Water Quality Protection for Homeowner Associations and Households”.

Proposed urban/suburban watershed education activities include general stormwater education through mass media including newspapers, radio, television, and door hangers. Presentations and workshops will be developed to provide more detail on specific practices that homeowners and businesses can implement on their properties, including fertilizer management and soil testing. A pet waste management program will be targeted at public parks and recreational areas. School curriculum on storm water will be developed to target students. Municipalities will be the target of a campaign to educate policy makers about creating guidelines and ordinances to reduce impervious surface area and implement LID and BMPs to improve stormwater retention and water quality.

Raingarden demonstration projects will also be implemented, with priority areas being Blissfield, Clinton and Tecumseh (which are near a TMDL reach), as well as the larger urban areas of Monroe and Adrian.

5) Conservation / Restoration

The focus of watershed education relating to conservation and restoration in the River Raisin will be on stream and wetland protection and restoration, streambank stabilization, invasive species control, and woody debris management for fish habitat. The goals of conservation/restoration education include protecting and restoring wetlands, stabilizing streambanks and restoring riparian habitat, reducing the introduction and presence of invasive species, restoring native plant populations, and maintaining woody debris for habitat while allowing river access for recreation. Watershed residents, students, recreational users, as well as municipalities will be the targeted audiences for conservation education.

There are several examples of restoration education currently happening in the River Raisin watershed. The River Raisin Institute (RRI) is working with students on several restoration projects including re-seeding native wild rice in wetland areas, removing the invasive Flowering Rush, restoring a wet prairie, and planting a rain garden and native plants. In 2008, the Monroe County Drain Commissioner has also led several volunteer Flowering Rush removal outings, as a part of the FRED (Flowering Rush Eradication Days) program. The Nature Conservancy has partnered with the Washtenaw County Parks and Recreation Commission and local land trusts to protect six miles of river and 1500 acres in the watershed. They are currently working, with volunteer help, to restore the Ives Road Fen property by removing invasive species and restoring hydrology. The Raisin Valley Land Trust (RVLT), a local non-profit dedicated to preserving natural areas and farmland in the River Raisin watershed, helps local residents set up conservation easements. The Stewardship Network, a relative newcomer to the area's non-profits, now has a Raisin Cluster and is establishing its own useful set of education and hands-on restoration activities in the upper watershed. The Raisin Cluster formed in 2003 and organizes annual workshops that provide hands-on stewardship opportunities and demonstrate land management practices.

Future education activities related to conservation and restoration include: presentations, workshops, and mass media publications on the important role of wetlands in the watershed and how they can be protected and restored; educating all audiences about streambank stabilization and the importance of buffers; getting residents involved in stream restoration activities through volunteer projects; educating residents and visitors of the negative impacts of aquatic and terrestrial invasive species; leading volunteer invasive species removal events to teach appropriate control strategies; developing a fact sheet about invasive species for local garden centers; presentations and workshops about native plant landscaping; and educating riparian landowners on woody debris management through mass media and workshops.

6) Recreation

There are two key goals of watershed education related to recreation for the River Raisin. The first goal is to educate the public that careful recreational use in combination with conservation land management can protect the watershed's natural resources and minimize negative environmental impacts. The second goal is to educate the public of the Native American culture within the River Raisin Watershed. Recreational watershed education will be targeted at recreational users including State Park visitors, boaters and river users, fisherman, and local sporting groups. It is also important to mention that recreation in itself is an important educational experience for residents. Getting out onto the river in a canoe or hiking alongside the river in a floodplain forest can often provide more effective education and awareness than printed media or PSAs. By continuing to provide opportunities for recreation in the watershed, we will increase awareness and active participation in protection of the watershed.

Some specific educational activities targeted at recreation include creating a geocaching treasure map, creating a canoe/fishing map, and distributing brochures about water quality at public beaches.

7) General Watershed Education

The goal of general watershed education is to increase public awareness and involvement within the River Raisin watershed. This includes helping landowners and residents gain an understanding of what effects pollutants have on the watershed, instilling personal interest in watershed health, and increasing local volunteer involvement to promote conservation, water quality protection and watershed improvement. The target audiences include: individuals/households, farmers, students (K-12), municipalities/counties, business/industry, and recreational users of the watershed.

Current educational programs/resources that address general watershed education include the River Raisin Watershed Council's website, RRWC's River Clean-Up Events, and the Washtenaw County Drain Commissioner's RiverSafe Home program. These existing educational programs are fairly skeletal and should be expanded in breadth and expanded to cover the entire geographic area of the watershed.

The River Raisin Adopt-a-Stream program began in 2002 and has since grown into a twice-a-year sampling event at 20 sites throughout the watershed. This is *the key* I&E and monitoring activity in the Raisin. Volunteer monitoring captures citizens' excitement and increases awareness of water quality issues for volunteers who in turn help educate the larger community. Many volunteers are actively involved in other decision-making bodies such as lake improvement boards or planning commissions, where they can help communities make informed decisions about issues affecting the watershed (CSREES 2002). Sampling done by volunteers also helps amass a long-term data set that may not otherwise be possible due to funding shortfalls. The Adopt-a-Stream program could be expanded by increasing the number of sampling sites as well as increasing the kinds of sampling done at each site. Currently macroinvertebrates are sampled and identified to family level. In the future, identification could be extended down to genus level. Additional water quality parameters could be sampled, such as temperature, pH, turbidity, and even *E. coli*.

The RRI in collaboration with eight local schools, collect macroinvertebrate samples and test for *E. coli* and total suspended solids in water samples, as a part of the River Raisin Watershed Monitoring Project. They are currently sampling at thirteen sites throughout the watershed and have already identified two future sampling locations. More information can be found at the RRI website: http://www.rriearth.org/rrwmrp.html. This effort should be coordinated more closely with the Adopt-a-Stream program, to increase spatial coverage, improve intra-program quality assurance and quality control, and cost-effectiveness. These sampling programs should be getting more publicity.

Educational campaigns to be implemented will focus on the following topics: general watershed concept and facts about the River Raisin watershed, problem areas/issues in the watershed, water quality and how pollutants are measured, designated uses and Total Maximum Daily Loads (TMDLs), Best Management Practices (BMPs) and how they can be used to correct watershed problems, individual landowner impacts, and landscaping to improve water quality. These general watershed education campaigns will be accomplished through a tiered strategy.

The educational strategy can apply to the various areas of concern that need to be addressed within the River Raisin Watershed. The information and education approaches below can each be tailored to individual sub-basin areas within the River Raisin Watershed. The information and education strategy will be a multi-pronged approach applied over a 10-year period, incorporating the items below to cover as many watershed issues as possible, the focus being to personalize watershed issues for individuals and foster awareness on a personal and community level. Once awareness and kinship to issues within the River Raisin Watershed are promoted, then positive action to conserve and protect the watershed will be generated on the part of individuals and the watershed communities

1. Identify priority areas in communities to personalize & use in education campaign

2. Educate the individual resident on homeowner issues that affect water quality that residents can identify with on a personal level such as septic system failure & maintenance
3. Train & use volunteers as presenters with local visuals for priority area communities
4. Create a website link to post local municipalities activities to access as “what’s happening in your community”, a local connection
5. Post websites for local links to environmental agencies, other local communities and environmental education organizations for the public
6. Create a number of publications (i.e. flyers, posters, brochures, booklets, CDs, etc.) over a 5-year period in partnership with other agencies as public education tools regarding River Raisin Watershed health and protection
7. Hold annual events such as the River Raisin Film Festival and River Raisin Watershed Conference to bring together residents, students, researchers, practitioners, Federal, State, County, and community representatives, businesses, farmers, to trade information and ideas, and highlight successes.

A few specific educational tools that are worthy of mention include: additional stream crossing signage, the RRWC quarterly newsletter, a watershed history guide, placemats with fun facts for local restaurants, a homeowner guide, and re-print of watershed maps. Students will be targeted through continuation/expansion of the Connecting Schools to the Great Lakes program, as well as through place-based outdoor education programs.

Table 6-5 Information and Education Plan

Project/Task	Estimated cost	Timeline	Pollutant Addressed	Critical Areas	Partners	Target Audience
A) Agricultural						
1) Educate farmers using manure about proper manure management for their fields. Stress the use of a) properly designed, constructed, and sited (including consideration of the proximity to surface waters) manure storage facilities, b) properly maintained and operated manure storage facilities to prevent leaks, overflows, and the need for untimely emptying, and c) applying manure to properly designated fields at appropriate times	$15,000	10 years	*E. coli* Nitrate Phopsphorus	South Branch RR Black Creek Evans Creek Lower RR	NRCS CDs Ag Advisory Comm MSU Extension	Farmers
2) Encourage participation in Michigan Agriculture Environmental Assurance Program (MAEAP). MAEAP is a comprehensive, voluntary, proactive program designed to reduce farmers' legal and environmental risks through a three-phase process: 1) education; 2) farm specific risk assessment; and 3) on-farm verification that ensures the farmer has implemented environmentally sound practices.	$100,000	Ongoing	*E. coli* Nitrate Phosphorus Sediment	South Branch RR Black Creek Evans Creek Lower RR	RRWC Cons. Districts NRCS MSU-E RRI JCC U of M	Farmers
3) Encourage development of Comprehensive Nutrient Management Programs. A Comprehensive Nutrient Management Plan (CNMP) is a total planning tool that details the animal production related activities for a specific farming operation. It combines conservation practices with management activities to create a system that addresses animal production operations, from feed inputs to the utilization of animal manure.	$100,000	Ongoing	Nitrate Phosphorus	South Branch RR Black Creek Evans Creek Lower RR	NRCS Cons. Districts RRWC U of M MSU-E RRI JCC	Farmers
4) Educate farmers about drain tile management - implement and monitor a pilot project	$50,000	2 years	Nitrate	South Branch RR Black Creek Evans Creek Lower RR	NRCS LCD - Center for Excellence Ohio State University Ohio EPA TNC County Drain Commissions	Farmers Ag Suport System
5) Educate farmers about drain tile management - hold two local seminars or classes	$2,000	1st 2010, 2 years	Nitrate	South Branch RR Black Creek Evans Creek Lower RR	NRCS LCD - Center for Excellence TNC Soil & Water Conservation Socie CDs MDA County Drain Commissions	Farmers Ag Support System
6) Educate farmers about precision agriculture through classes and demonstration project	$200,000	2 years	Nitrate Phosphorus Pesticides	South Branch RR Black Creek Evans Creek Lower RR	NRCS LCD - Center for Excellence CDs MSU - E MDA	Farmers
7) Public education for performance based environmental control pilot project	$15,000/yr	5 years, begin 1 year before pilot program	*E. coli* Nitrate	South Branch RR Black Creek Evans Creek Lower RR	PEPA NRCS participating farmers MSU-E	Farmers Ag Support System

KEY: HIGH PRIORITY | MEDIUM PRIORITY | LOW PRIORITY

Project/Task	Estimated cost	Timeline	Pollutant Addressed	Critical Areas	Partners	Target Audience
8) Identify existing farms with conservation practices to serve as positive role model demonstration sites. Invite the public for tours and workshops.	$20,000	10 years	Nitrate Phosphorus *E. coli* Pesticides	South Branch RR Black Creek Evans Creek Lower RR	NRCS CDs MSU-E Ag Advisory Comm. TNC	Farmers General Public
B) Sewage Management						
1) Develop comprehensive public education program regarding septic systems including: Using proper septic system design for the site conditions and considering the proximity to bodies of water when siting them, Properly maintain existing septic systems, and threats to groundwater, drinking water and wetlands from unmaintained septic systems, Providing education regarding the development of alternative onsite wastewater treatment systems. The following components will be used: door hangtags, utility bill inserts, workshops, brochures, newspaper articles, PSAs, radio & TV advertisement campaigns, radio talk shows, and print advertising.	$60,000/yr	5 years	*E. coli*	Lower RR South Branch RR Saline River	Health Depts. CDs RRWC MOWRA MSU - BAE	Rural Residents Lake Residents Lake Assns Riparian Landowners Subdivisions
2) Educate municpalities and governing bodies about importance of on-site wastewater ordinances, inspections, and enforcement programs (including illicit discharge elimination)	2000	3 years	*E. coli*	Lower RR South Branch RR Saline River	Health Depts. MSU- BAE SEMCOG	Municipalities Counties
3) Create and maintain a public hotline for reporting soil erosion, OSDS, illicit discharge and improper disposal of hazardous wastes	$100/hr municipal staff	On-going	*E. coli* Sediment hazardous chemicals	South Branch RR Lower RR Black Creek	county drain commissions health departments SESC local governments	All Audiences
4) Educate RV owners about proper disposal of waste to prevent illicit discharges	$2,000	5 years	*E. Coli*		county and local governments	RV Owners Tourists
5) Educate Boat Owners about proper waste disposal	$2,000	5 years	*E. Coli*	Monroe	marinas	Boaters
C) Planning						
1) Educate public officials through workshops, demonstration tours, and information packets regarding the impacts of increased land fragmentation and development on wildlife habitat and corridors.	$15,000	3 years			county planning depts CDs SEMCOG MI Land Use Institute	Local Government Relators Developers & Contractors
2) Water quality primer for local officials	$5,000	1 year			RRWC RRI Watershed colleges County Drain Commissions	Local Government
3) Distribute educational handbooks on municipal ordinances and citizen stewardship for local government and citizen groups	$30 per handbook	5 Years			local governments SEMCOG RRWC	Local Government Citizen Groups
4) Educate public about conservation easements	$2,000	5 Years		Goose Creek Iron Creek Upper RR	Land Conservancies CDs NRCS TNC Trout Unlimited Ducks Unlimited Pheasants Forever county and local governments	Residents Rural Landowners

KEY:	HIGH PRIORITY	MEDIUM PRIORITY	LOW PRIORITY

Project/Task	Estimated cost	Timeline	Pollutant Addressed	Critical Areas	Partners	Target Audience
D) Urban / Suburban						
1) Develop public education program regarding the control of storm water including the following components: door hangtags, utility bill inserts, workshops, brochures, newspaper articles, PSAs, radio and TV advertisement campaigns, radio talk shows, and print advertising.	$30,000/yr	Ongoing			RRWC	
				Village of Clinton	Local Government	Households
				City of Tecumseh	SEMCOG	Riparian Landowners
				City of Monroe	NRCS	Municipalities
				City of Adrian	CDs	Developers
					County Drain Commissions	
2) Provide general storm water education for local units of government that stresses the benefits of a) managing the amount of impervious surfaces in the watershed, b) reducing the filling and development of wetlands, which provide temporary holding of storm water, and c) implementing storm water BMPs and low-impact design practices to minimize storm water flows.	$25,000	5 years		Village of Clinton	NRCS	
				City of Tecumseh	CDs	
				City of Monroe	Local Government	Local Government
				City of Adrian	MI Land Use Institute	
					SEMCOG	
					TNC	
3) Raingarden pilot project education - create website and promotional pamphlets	$5,000	3 years		Village of Clinton	NRCS	Residents
				City of Tecumseh	CDs	Local Government
				City of Adrian	County Drain Comissions	Students
4) Partner with neighborhood associations to host presentations and workshops on controlling storm water on their properties, etc.	$8,000/yr	10 years			RRWC	
					Homeowner Assns	Households
					CDs	Riparian Landowners
					Lake Assns	
					NRCS	
					TNC	
5) Implement a geese/waterfowl campaign for lakefront/riparian landowners on how to control waterfowl numbers on the waterways that can impact water quality, which can include PSAs, signage, articles, brochures, etc.	$25,000	3 years			Lakefront Assns	
			E. coli		RRWC	Lakefront Landowners
			Phosphorus		CDs	Riparian Landowners
					Municipalities	Tourists
					Homeowner Assns	
					Ducks Unlimited	
6) Implement a 'Pick up Your Pet Waste' program in urban & park/public areas throughout the watershed.	$8,000	2 years			Municipalities	Households
			E. coli		Homeowner Assns	Tourists
			Phosphorus		Lake Assns	Riparian Landowners
					SEMCOG	
					Washtenaw County	
7) Develop school curriculum for storm water	$2,000 - $5,000	5 years			local governments	
					UM	Students (K-12)
					public and private schools	
					RRI	
8) Educate public about application and disposal of pesticides and fertilizers	$5,000	5 years	Nitrate		county and local governments	Households
			Phosphorus		UM	
					MDA - Groundwater	
9) Promote homeowner soil testing	$2,500	5 years			county and local governments	Households
			Phosphorus		MSU - Soil and Plant Nutrient	Riparian Landowners
					CDs	

KEY: HIGH PRIORITY | MEDIUM PRIORITY | LOW PRIORITY

Project/Task	Estimated cost	Timeline	Pollutant Addressed	Critical Areas	Partners	Target Audience
10) Educate public about management of riparian lands	$5,000	5 years	Sediment Phosphorus		county and local governments TNC NRCS Land Conservnacies Ducks Unlimited Trout Unlimited Pheasants Forever	Riparian Landowners
11) Educate the public regarding health risks associated with backyard trash burning and encourage alternative methods of disposal such as composting, recycling and utilizing hazardous materials disposal facilities and drop-off events.	$10,000	3 years			RRWC CDs Homeowner Assns Municipalities	Households Riparian Landowners Agriculture
12) Provide education regarding health risks to individuals and communities from improper disposal of hazardous wastes. Provide information regarding proper disposal and alternative products and methods and promote participation in household hazardous waste collection events.	$25,000	3 years			Municipalities RRWC CDs Homeowner Assns. County SWD	Households Riparian Landowners Agriculture
13) Educate public about residential and non-commercial car washing	$2,000	3 years			county and local governments SEMCOG	Residents
E) Conservation / Restoration						
1) Educate local governments, developers, contractors, and others through workshops and presentations, press releases, brochures, etc, regarding the ecological consequences of developing unregulated wetland areas, especially in recharge areas within the River Raisin Watershed.	$10,000	3 years		Goose Creek Iron Creek Upper RR	Land Stewardship Groups RVLT RRWC NRCS CDs TNC	Local Governments Builders/Developers/Realtors
2) Educate the public and public officials regarding the benefits of wetlands through workshops, demonstrative site tours, newspaper articles, PSAs, radio and TV advertisement campaigns, radio talk shows, print advertising, etc.	$75,000	3 years			RRWC CDs NRCS Land Stewardship Groups TNC RVLT	Households Riparian Landowners Local Governments Builders/Developers/Realtors
3) Educate local residents and visitors regarding the negative impacts of and appropriate control and eradication measures for both aquatic and terrestrial invasive species (including Eurasian water milfoil, purple loosestrife, zebra mussels, etc).	$25,000	3 years	Lower RR		RRWC CDs TNC Municipalities MSU-E RRI	Lake Assns Households Riparian Landowners Tourists
4) Provide education to the general public on wildlife species particular to the River Raisin Watershed and the importance of maintaining diverse wildlife habitats and developing wildlife corridors on their property in the form of printed brochures and booklets, and educational presentations.	$25,000	3 years			CDs MRCS TNC	Households Local Government Agriculture Developers
5) Broaden restoration resource network	$5,000	5 years			RRWC RRI Stewardship Network - Raisin Cluster	All Audiences

KEY: HIGH PRIORITY | MEDIUM PRIORITY | LOW PRIORITY

Project/Task	Estimated cost	Timeline	Pollutant Addressed	Critical Areas	Partners	Target Audience
6) Host a series of workshops and seminars throughout the watershed to educate public officials regarding appropriate and successful methods for restoring wetlands.	$10,000	3 years			RRWC RVLT Land Stewardship Groups NRCS CDs	Local Governments Landowners Developers Builders
7) Develop simple fact sheet or brochure to use as a handout at garden centers regarding terrestrial invasive species, including photos, drawings and eradication methods.	$10,000	1 year			RRWC MSU-E TNC CDs RRI	Households Riparian Landowners Lake Assns
8) Improve management of beneficial woody debris for fish habitat within watershed through landowner education.	$15,000	2 years			RRWC RRI NRCS US Fish & Wildlife CDs	Riparian Landowners Lake Assns Municipalities Public & Private Parks Canoe Liveeries
9) Create and distribute a resource list for native plant species.	$8,000	1 year			RRWC TNC MSU-E CDs	Households Garden Centers
F) Recreation						
1) Print and distribute brochures regarding beach monitoring and factors affecting public health at swimming beaches.	$10,000	3 years	*E. coli*		Lake Assns. Health Dept. Homeowner Assns Parks	Tourists Households Riparian Landowners Private Beaches
2) River Raisin Geocaching/Treasure Maps	$5,000	1 year			RRWC TNC MiGO (MI Geocaching Org)	Recreational Users Tourists
3) Create a canoe/fishing map to highlight canoable reaches and good fishing spots	$10,000	1 year			RRWC Watershed Colleges CRWC Trout Unlimited	Recreational Users Tourists
G) General Watershed Education						
1) Promote and increase local/community awareness of River Raisin Watershed issues and concerns by at least ten percent through PowerPoint presentations made to the communities throughout the watershed, and train volunteers who will serve as individual community watershed ambassadors to continue presentations (Train the Trainers).	$10,000/yr	Ongoing			RRWC LCD NRCS MSU-E RRI JCC U of M	Municipalities Households

KEY:	HIGH PRIORITY	MEDIUM PRIORITY	LOW PRIORITY

Project/Task	Estimated cost	Timeline	Pollutant Addressed	Critical Areas	Partners	Target Audience
2) Foster partnerships between schools and local conservation groups, businesses, & governmental agencies that will increase opportunities to engage rural and small town children within River Raisin Watershed in real world learning and community-based stewardship opportunities that generate local knowledge & local solutions to issues impacting the health of the Great Lakes and the River Raisin Watershed.	$20,000	3 years			NRCS RRI MSU-E Colleges RRWC CDs	School Students Grades 6-12
3) Create River Raisin Film Festival	$5,000/ yr	1st - 2010, Every other year			RRWC RRI Schools Community & business HRWC	All Audiences
4) Create Annual Watershed Conference	$5,000	1st - 2010, Every other year			RRWC RRI Schools Community & business partners	All Audiences
5) Inform the public about activities, study findings, successful example projects, and opportunities for contribution in the River Raisin watershed through a published newsletter to be distributed four times per year (quarterly).	$10,000 per newsletter	Four times per year- Ongoing			RRWC	All Audiences
6) Develop a watershed information and printed media campaign to the local newspapers and print publications in the form of feature stories, editorials and PSAs.	$15,000/yr	3 years			RRWC LCD Media Consultant	All Audiences
7) Set-up and maintain a comprehensive River Raisin Watershed Council website containing information about the watershed along with educational activities, events, ways to get involved, plan documents, links to relevant organizations and resources, etc.	$45,000 set-up $10,000 yearly maintenance	Ongoing			RRWC CDs NRCS U of M RRI Adrian College	All Audiences
8) Create "under one roof" watershed-wide website housing all the River Raisin Watershed municipality website links, serving as a local "go to" website for watershed residents to access information relevant to their locale. Each municipality updates their own link information on a continual basis for watershed residents.	$45,000 set-up $10,000 yearly maintenance	Ongoing			RRWC CDs RRI All Watershed Municipalities	All Audiences
9) Grow Adopt-A-Stream Program	$10,000	Ongoing			RRWC RRI Watershed colleges MI Corps	Residents Students
10) Conduct Social Surveys to measure public awareness	$50,000	Once every 5 years			RRWC	All audiences
11) Watershed Image Promotion	$1,200/yr	3 years			RRWC Chambers of Commerce Tourism Groups	All audiences

KEY:	HIGH PRIORITY	MEDIUM PRIORITY	LOW PRIORITY

Project/Task	Estimated cost	Timeline	Pollutant Addressed	Critical Areas	Partners	Target Audience
12) Outdoor/Environmental/Place-based Education (K-12)	$1,200/year	Ongoing			schools	Students (K-12)
13) Create Watershed History Guide	$5,000	1 year			RRWC RRI Historical Societies & Universities	All Audiences
14) Develop TV and radio spots and public service announcements focusing on relevant water quality issues and basic watershed messages.	$30,000- development $15,000/yr to maintain	3 years			RRWC LCD Municipalities Media Consultant	All Audiences
15) Develop a "Homeowner's Kit" containing variety of conservation and watershed tips & tools for promoting water quality awareness & green living within the River Raisin Watershed, and distribute to realtor offices, chamber of commerce, insurance offices, municipality clerk offices as handouts.	$15,000/yr	3 years			RRWC CDs RRI	Watershed Households New Residents
16) Educate general public awareness to the direct connection between groundwater and drinking water through educational brochure and insert brochure in community tax	$15,000	1 year			MGSP RRWC RRI CDs NRCS MDA - Groundwater Stewardship Program	All Audiences
17) Booth Displays and Field Days	$2,000 for booth display	Ongoing			RRWC	All Audiences
18) Increase watershed and stream crossing signage	$20 per 24"x30" sign, $23 per 24"x36" sign, plus cost of post and installation	3 Years			county and local governments corporate sponsorship	Residents
19) Initiate and develop a Waterway Stewardship Program for citizen participation	$10,000				local governments Stewardship Network volunteers Ducks Unlimited Trout Unlimted Pheasants Forever	All Audiences
20) Initiate Community Partners for Clean Streams Program for Pollution Prevention	$5,000				County Drain Commissions community & businesses partner	Businesses Municipalities
21) Organize, implement and expand Community/County clean-up programs and River Clean-up Events	$5,000	Ongoing			RRWC county and local governments	All Audiences
22) Collaborate with and provide technical assistance to sub-watershed groups	$5,000	Ongoing			RRWC	All Audiences
23) Design and print placemats for distribution to local eateries displaying the River Raisin Watershed map and special features, points of interest, water quality facts, wildlife profiles, etc.	$20,000	1 year			RRWC LCD	All Audiences
24) Reprint watershed maps and make available to general public, local governments and others.	$15,000	3 years			RRWC	All audiences

KEY:	HIGH PRIORITY	MEDIUM PRIORITY	LOW PRIORITY

Project/Task	Estimated cost	Timeline	Pollutant Addressed	Critical Areas	Partners	Target Audience
25) Intern program	$5,000	Ongoing			RRWC	Students (college)
					NRCS	
					LCD	
					Watershed Colleges	
26) Educate public about soil erosion and sedimentation control	$5,000	5 Years	Sediment		county and local governments	All Audiences
			Phosphorus		CDs	
					Drain Commissioners	
27) Educate public about citizen responsibility and stewardship practices	$5,000	5 Years			TNC	All Audiences
					Stewardship Network	
					Ducks Unlimited	
					Trout Unlimted	
					Pheasants Forever	
28) Use opportunities provided by public projects (sidewalk/street, sewer, and/or culvert repair) to provide public education	$150 per project	Ongoing			local governments	Residents
29) Educate local government staff to receive Pesticide Certification	$150 per staff person	Ongoing	pesticides		MSU- E	Municipalities
						Counties

KEY:	HIGH PRIORITY	MEDIUM PRIORITY	LOW PRIORITY

6.7 Conserve and Restore Natural Features

Critical conservation and restoration opportunities in the watershed have already been identified by several researchers and conservation groups. Bennett, et al. (2006) conducted a thorough analysis of habitat and conservation value of the River Raisin from the headwaters down to Adrian (See **UM Masters Projects Appendix**). Ewert, et al. (2005) evaluated migratory bird habitat value in the western Lake Erie basin. This work was compiled into a larger conservation/restoration plan by the Nature Conservancy and is summarized in **Figure 6-4**. The MDEQ also conducted a detailed GIS analysis of pre-development and existing wetlands and identified priority areas for wetland restoration, particularly for achieving water quality benefits (see **Figure 6-5**).

We have divided conservation and restoration efforts into projects that have predominantly habitat conservation or recreation value and those with predominantly water quality values. Most of the habitat and recreation opportunities prioritized in this plan are in the upper watershed, while most of the water quality conservation/restoration opportunities are in the lower watershed.

Conservation and restoration initiatives needed in the watershed include:

1. Protect and rehabilitate the function of wetlands and floodplains as water retention areas. Develop an inventory of existing wetlands and potential areas for the creation of wetlands with emphasis on riparian areas.

2. Wetland Restoration – Only 16% of original wetlands remain in the River Raisin Watershed (see for breakdown by subwatershed). Restoration of wetlands, riparian and otherwise, should be undertaken for protection of hydrology, water quality benefits and enhancement of wildlife habitat. Many hydrological processes within the watershed have been dramatically altered due to conversion of the land from natural systems to agricultural uses (Fongers 2006). Groundwater recharge has been reduced, runoff has increased, and stream flashiness has increased as well. Restoration of wetlands in areas that have high potential (see potential wetlands map) would mitigate some of these alterations and could create wildlife habitat or recreation opportunities as well.

3. Upland conservation/restoration - Restoration of natural ecological system on agricultural uplands could also benefit hydrology and wildlife, and provide recreation opportunities. In the upper watershed, especially in former gravel pits south of Tecumseh and the area between Iron Creek and Sharonville State Game Area (see map), such restoration could be accomplished through purchase or donation of land or easements and make use of CRP or CREP as a funding source. A conservation plan for the River Raisin Headwaters (TNC 2008) lists several long-term objectives and strategic actions directed towards conservation of aquatic and terrestrial ecological systems and species. Among these is a vision to restore uplands and wetlands to connect a landscape of 15,000 – 20,000 acres between the Iron Creek headwaters and Sharonville State Game Area (see **Figure 6-4**). Accomplishing this objective will require significant land protection and restoration activities and will result in protection of an important recharge area within the watershed as well as maintaining core wildlife habitat identified by student researchers from the University of Michigan (Bennett et al., 2006) and protect habitat for migrating waterfowl, shorebirds, and landbirds (Ewert et al., 2005). Much of the land that would be protected and restored would also be suited for compatible activities such as grazing or recreation.

4. Natural Area Stewardship - Ongoing activities include stewardship of existing managed natural areas as well as outreach to landowners and introducing stewardship practices to additional private lands. Organizations currently involved in natural areas stewardship within the watershed include The Nature Conservancy, Michigan Nature Association, Storer YMCA camp (in partnership with the Michigan DNR

Landowner Incentive Program), Washtenaw County Parks, Raisin Valley Land Trust, the River Raisin Institute, the Michigan DNR, Wildlife Division and Parks and Recreation Bureau, and The Stewardship Network – Raisin Cluster.

The Nature Conservancy (TNC) owns and manages two preserves—Ives Road Fen (700 acres) and Nan Weston (230 acres)—and holds conservation easements on an additional 40 acres. Stewardship activities focus on restoration of native vegetation, controlling invasive species, reintroducing fire as an ecological process, and restoring wetland hydrology. TNC also is implementing stewardship activities on other private lands in the watershed and will continue to reach out to additional private landowners in partnership with the RVLT and the MDNR Landowner Incentive Program (LIP).

The Michigan Nature Association (MNA) owns and manages the Goose Creek Grasslands Sanctuary (71 acres) and has undertaken restoration of the high quality wetlands there. MNA uses stewardship practices similar to The Nature Conservancy.

The Michigan Department of Natural Resources owns and manages over 14,000 acres in the watershed. Active restoration of grasslands and wetlands and control of invasive species is ongoing at Sterling State Park, Petersburg State Game Area, and Onsted State Game Area.

YMCA Storer Camps (796 acres) has developed a partnership with the MDNR LIP program to control invasive species in wetlands on the property. Washtenaw County Parks manages a remnant prairie and is restoring upland forest on their new 200 acre park in Manchester. Private easements held by the Raisin Valley Land Trust are being restored in partnership with the MDNR LIP program. Finally, the River Raisin Institute has created a native grassland on their property near the mouth of the river in Monroe.

Many of the groups and organizations listed above are also a part of the Stewardship Network – Raisin Cluster. In 2008, the Raisin Cluster chose two sites, the YMCA Storer Camps and a private site on Iron Creek, to partner with over a long-term period. At these sites, the Stewardship Network holds monthly work days and special events, which allows volunteers to visit the sites often and observe the long-term changes resulting from their work.

5. Rehabilitate rare high-gradient habitats by removing dams no longer used for their original purpose; e.g., retired hydroelectric facilities and dams that are a safety hazard. Dams that created small impoundments that are now shallow, silt-laden, and choked with aquatic vegetation could also be removed. Examples of these impoundments include Brooklyn, Sharon Hollow, upstream Manchester, Clinton, Red Mill, Standish, and Globe.

6. Rehabilitate populations of potamodromous fish by removing the gates of the six low-head dams in the City of Monroe and removal or installation of effective fish passage facilities at the Waterloo, Grape (Murciak), and Dundee dams.

7. If the cooling water intake at the power plant cannot be altered, it should be mitigated. Mitigation could involve measures taken to reduce impingement of adult and juvenile fish and entrainment of larval fish and fish eggs. A monetary agreement should be developed to compensate the people of Michigan for fish destroyed at the plant and the loss of recreational fishing opportunity created by the elimination of potamodromous fish runs. These funds could be used to enhance fisheries habitat and recreational benefits in the River Raisin watershed.

8. Rehabilitate headwater and tributary flow stability by working with county drain commissioners to incorporate natural channel template and two-stage ditch design into criteria for drain design and maintenance and storm water management.

9. Work closely with drain commissioners to protect tributaries from further channelization by developing alternatives to current detrimental drainage practices such as dredging, enclosure, and excessive removal of the tree canopy and bank vegetation (LID non-structural BMPs).

10. Rehabilitate designated county drains to natural stream status where designation as a drain is no longer appropriate. Encourage drain commissioners to use stream management practices that protect and rehabilitate natural processes rather than traditional practices of straightening, deepening, widening, and enclosing natural streams. Getting water off the land as quickly as possible by any means is no longer environmentally acceptable.

11. Protect remaining natural lake outlets by preventing the construction of new lake-level control structure, thereby allowing natural fluctuation of water levels needed to maintain wetlands. Operate existing lake-level control structures as fixed-crest structures rather than by opening or closing gates or removing stop-logs. Incorporate minimum flow requirements into the design of fixed-crest structures. Preserve vegetated headwater lake outlets by preventing dredging and construction of lake-level control structures at these areas.

12. Study effects of other pest species including rusty crayfish, Eurasian milfoil, purple loosestrife, etc. and develop biologically prudent and economically feasible methods of control.

13. Rehabilitate and improve smallmouth bass habitat in the mainstem above Tecumseh and below the confluence of the River Raisin and the Saline River. This work would include rehabilitation of instream woody cover and creation of additional channel diversity. Research from Michigan and other states should be used to design habitat improvement particularly for larger smallmouth bass.

14. Survey distribution and status of mussel populations and develop strategies for protection and recovery of these species. Study effects of zebra mussels on native mussel species.

15. Survey amphibian and reptile populations and develop protection and rehabilitation strategies for these species.

16. Continue to advocate and work toward legislative adoption of the recreational definition of navigability (a stream is legally navigable if it can be navigated by canoe or small boat).

17. Improve fish habitat in the River Raisin mainstem below Dundee by cracking spaces and holes in the limestone bedrock substrate or installing cover structures that are capable of withstanding large flow fluctuations.

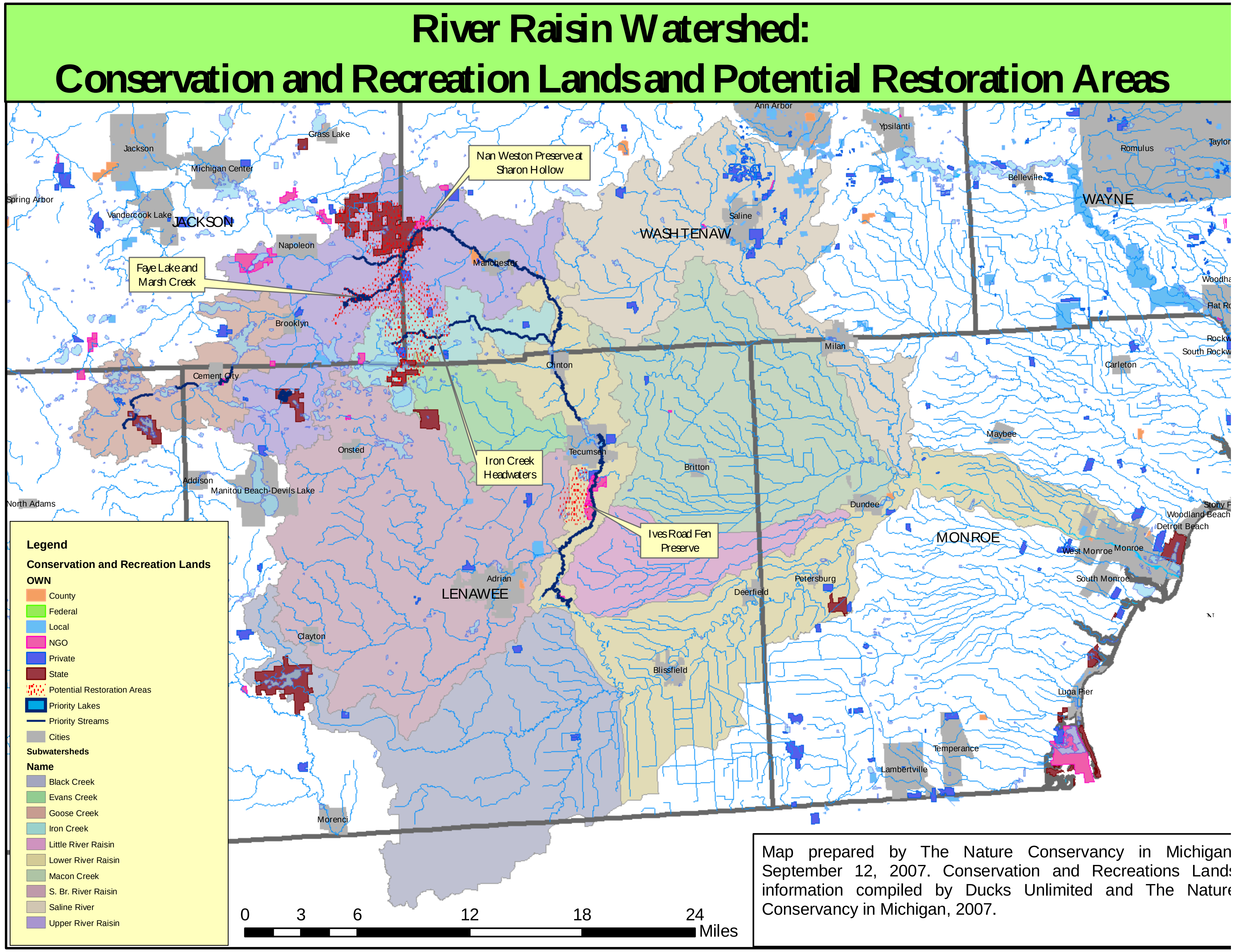


Figure 6-4 Potential Restoration Areas for Habitat Opportunities

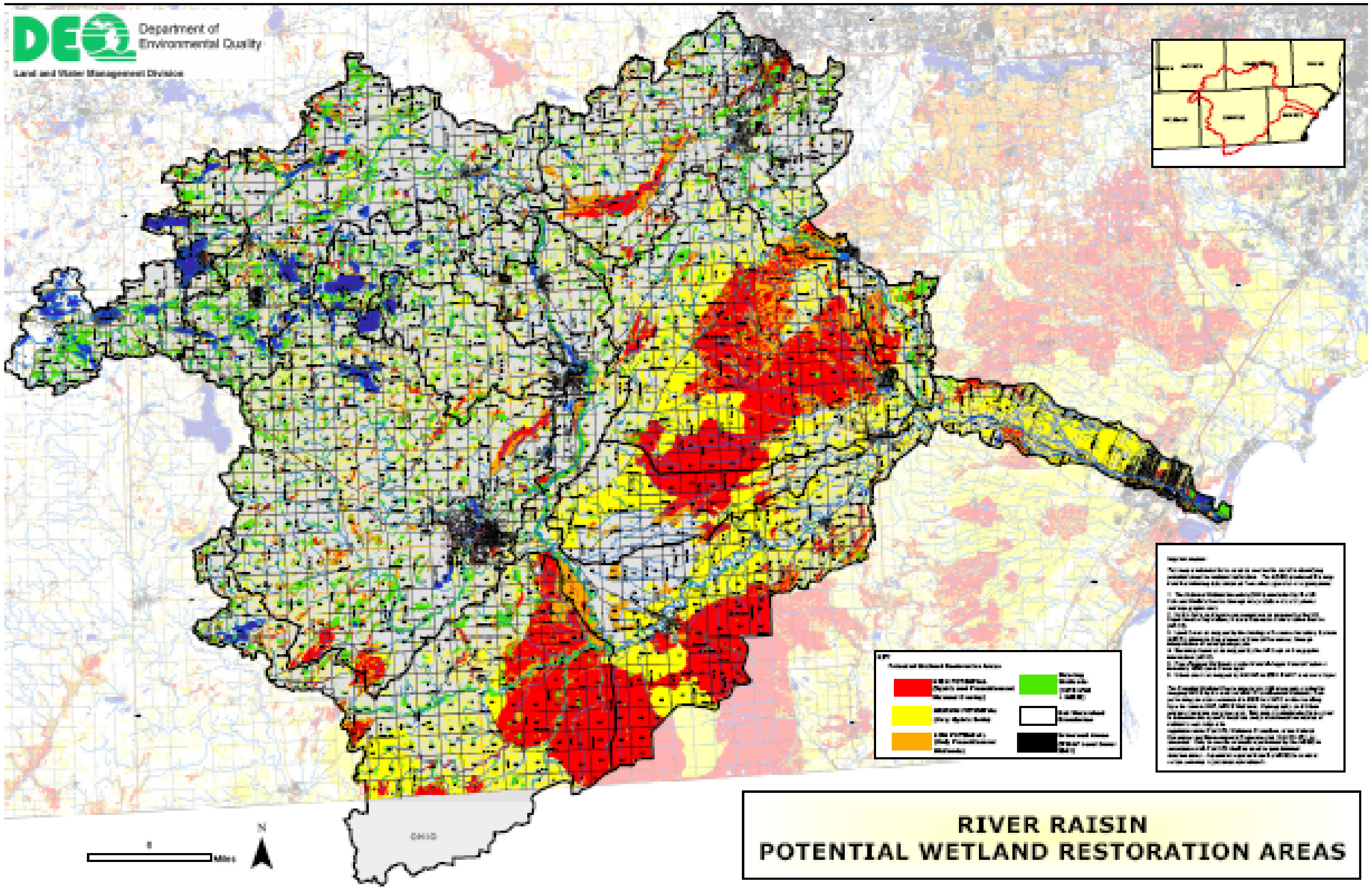


Figure 6-5 Potential Wetland Restoration Areas for Habitat and Water Quality Improvements

6.8 Increase Recreational Opportunities

Almost 24,000 acres of land in the River Raisin Watershed are owned and managed for conservation or recreation (**Table 6-6)**; Ducks Unlimited and The Nature Conservancy in Michigan 2007). Most of these lands (roughly 60%) are owned by the State of Michigan and managed as Game or Recreation area (e.g., Sharonville and Onsted) or State Parks (e.g., Walter J. Hayes). County and local government lands, including parks, comprise about ten percent of the total, and private recreational lands (including NGOs) make up about twelve percent. Most of these lands (61%) are managed primarily for conservation, whereas 26% are managed for recreation.

Among subwatersheds, the Upper River Raisin has the highest acreage in conserved lands, much of it located in the Sharonville and Ortonville State Game Areas (See **Natural Features Appendix** for more detail). In the Black Creek subwatershed, the only other one with more than 2,000 acres of conservation and recreation lands, the Lake Hudson State Recreation Area contributes over 2,800 acres of conservation ownership. Macon Creek has the least acreage in conservation ownership, at 118 acres.

Table 6-6 Acreage of conservation and recreation lands in the River Raisin watershed, by ownership type and management type (Ducks Unlimited and The Nature Conservancy in Michigan 2007).

Ownership Type	Acres		Management Type	Acres
County	439		Conservation	14,470
Federal	242		Recreation	6,277
Local	2,464		Other/Unknown	3,010
NGO	2,171			
Private	3,965			
State	14,350			
Other	126			
Grand Total	23,757			23,757

Many diverse recreational opportunities exist in the River Raisin Watershed including fishing, hunting, swimming, birding, sailing, motor boat use and canoeing. Furthermore its proximity to the major metropolitan centers of southeastern Michigan and northern Ohio make this region an attractive recreational area. This does not come without consequence, as some activities such as fishing and the use of ski-boats and jet skis come into conflict.

Most fishing in the River Raisin basin is in lakes and ponds in the northwestern portion of the basin; common sport fish species include: largemouth, smallmouth and rock bass, bluegill, black crappie, yellow perch, sunfish, pike, muskellunge, walleye and rainbow trout (Dodge, 1998). Excellent angling opportunities exist in areas of higher stream gradient and velocity leading to a substrate of cobble and gravel well-suited for smallmouth and rock bass. In many areas river fishing is not popular due to a lack of public access to streams and the general perception that the river is polluted.

The River Raisin watershed has a rich history and recreational opportunities exist in small artifact shops and museums throughout the area. For instance, historical enthusiasts could visit the River Raisin Battlefield visitor center, located in Monroe. In March 2009, the River Raisin Battlefield was authorized to become a national park. The battlefield is the site of one of the bloodiest battles in the War of 1812 (see **Section 3.2**). The park will commemorate the hundreds of lives lost and provide a historical account of the combat that took place there.

Public land available for hunting is limited. The largest block of state owned land for hunting is the Sharonville State Game Area which also has a supervised rifle, pistol, and shotgun range as well as an area for organized dog field trials (Dodge, 1998). Public hunting is also allowed on private lands leased by MDNR under the Hunting Access Program. Hunting in the basin is primarily for deer, turkey and small game along with duck and geese hunting near the rivers and Lake Erie.

There are many parks that have canoe access and/or shore-fishing in the River Raisin watershed. Some of these parks include: Swains Park in the Village of Brooklyn, Kirk Park in Manchester, Tate Park in Clinton, Kiwanis Memorial Park in Tecumseh, Trestle Park in Adrian, Clara Bachmayer Memorial Park in the Village of Blissfield, Wolverine, Ford, and West County Parks in Dundee as well as several parks located in the City of Monroe (Dodge, 1998). In addition to these parks there are numerous publicly owned parcels along the Raisin and its tributaries where access is available.

Access to Lake Erie from public and private marinas dominate motor boat use in the River Raisin basin; yet activities such as water and jet-skiing do occur in the upstream portions of the watershed. Lakes where these activities are popular exhibit excessive boating pressure, especially on weekends and holidays. Smaller lakes pose more of a problem for motorized boat users including limited public access, boat ramps, and insufficient parking area.

Much of the River Raisin is accessible by canoe providing exceptional opportunities for fishing and viewing wildlife. The Village of Blissfield Chamber of Commerce sponsors a canoe race in September where participants launch at Blissfield, paddle upstream a few miles, and return downstream to the finish line (Dodge, 1998). However logjams and heavily wooded areas can make canoe travel difficult. The Saline River, a tributary to the River Raisin, also provides canoeing during most of the year but the majority of other River Raisin tributaries are only accessible by canoe during spring run-off.

The residents of the River Raisin need more recreational opportunities for their own sake, and to help grow tourism opportunities as well. Many recreation opportunities are linked to land conservation. In the Raisin newly conserved land will be best obtained when multi-use objectives are identified for each opportunity. Greenways, in particular, meet many multi-objective needs such as habitat conservation, recreation and water quality protection. This plan adopts the Southeast Michigan greenway plan developed by the Greenway Collaborative in 1999 as a template for restoration, conservation and outright purchase of properties along the proposed greenway routes (see **Figure 6-6** and the **Recreation Appendix**). On-going efforts to create greenways by the Village of Manchester, the Saline River Greenway Alliance (SRGA) and the US Fish and Wildlife Service at the International Wildlife Refuge, in conjunction with the City of Monroe, are all consistent with the original regional plan. They all need technical and financial resources to start realizing their visions.

Recommended recreation opportunities include:

1. Lake Erie Access Project - Create access/greenway between the River Raisin battlefield site and the Sterling State Park and the US Fish and Wildlife Service International Wildlife Refuge. The River Raisin battlefield site is currently the object of a National Park Service to potentially create a new national park at and around the site. The Monroe County Historical Society has created a special committee to draft a nomination to recognize the battlefield site as a national historic monument.

2. Create greenways between Sharonville Game Area and Manchester and between between Saline and Milan.

3. Construct small public access sites particularly in the mainstem from Tecumseh to Dundee and on the lakes in the Irish Hills area. Adequate public access is an essential precursor to any activities aimed to foster pride and a feeling of stewardship toward the river by local citizens.

4. Encourage canoeing on the mainstem to promote public use and awareness of the river.

5. Develop LWD management plans (per **Section 6.3** recommendations) to improve river passage.

6. Encourage town festivals along the river to promote public awareness and a sense of stewardship for the river.

7. Protect existing public park systems in communities along the river and promote responsible management and provision of public access to the river and shore fishing facilities at these parks.

8. Continue to stock channel catfish and implement northern pike stocking in the mid-portion of the mainstem between Tecumseh and Dundee. Evaluate results of these stockings.

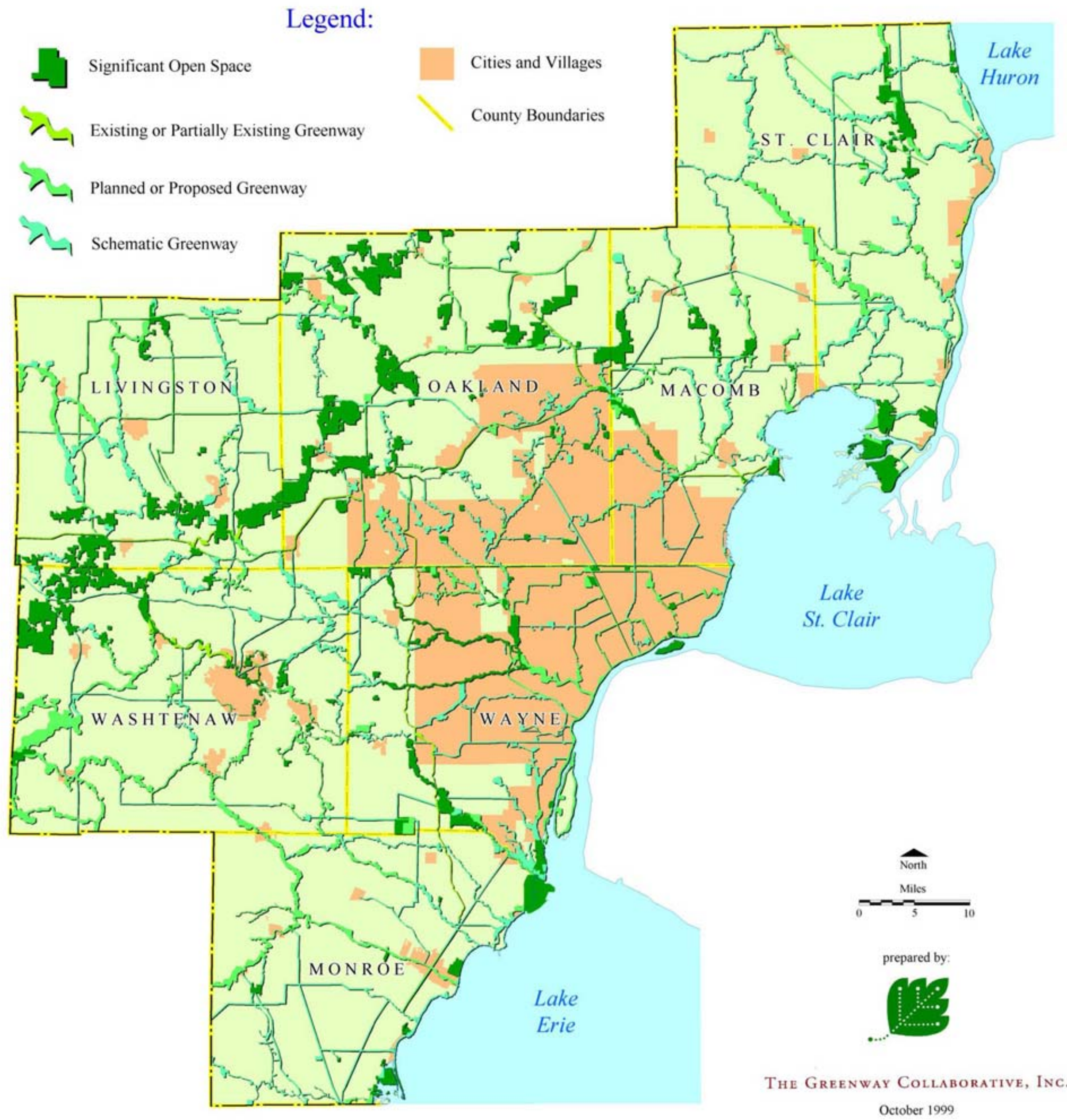


Figure 6-6 Proposed Southeastern Michigan Greenway Plan (Greenway Collaborative, Inc., 1999).

6.9 General Economic Recommendations

The thrust of the economic recommendations is to help point the way towards meeting the triple top line – economic and ecological sustainability and social equity- by focusing on local needs and capabilities. This philosophy has been recognized in southeast Michigan. For instance, Monroe County has created the Cultural Economic Development Committee. This committee was formed to help package community elements to turn the area into a tourist destination. These elements include cultural, historical and recreation attractions, among others.

The future of the agricultural industry in Michigan is uncertain due to the inability of many farmers to maintain an adequate level of profitability. The 2002 Census of Agriculture showed that 57% of Michigan farmers were losing money. In the last two years, however, there has been a reversal in this trend, as the demand for corn as the main component of ethanol has driven a resurgence in farm incomes. However, corn may not be a sustainable feedstock for ethanol. Corn-based ethanol is a relatively inefficient fuel. The use of corn as a fuel also reduces the global food supply. Farmers still struggle with in inability to compete in national and international markets, difficulties with environmental compliance issues, right to farm issues, lack of access to resources for agricultural innovation and fragmentation of farmland and resulting decreases in economies of scale (Adelaja, 2005).

Development pressures and lagging profitability are often responsible for farmers removing their land from production and selling to developers. The aging farm population, lack of intergenerational transfer and high value of farmland near urban areas are also contributing factors to loss of farmland.

Farms that have or can develop greater resiliency from an ecological, social and economic standpoint, and be compatible with other land uses should receive priority for preservation and sustainability. Farms should take advantage of opportunities to supplement farm income through eco-tourism and farm-based recreation. A diversity of farm sizes, farming methods and farm operators are needed in Michigan in order to respond to changes in consumer and market demands.

Clearly, the River Raisin watershed has the means to provide for much of its human needs locally. Food and water are or can be harvested locally. Energy needs are currently met by mostly non-local feed stocks, but that trend can be slowly reversed with a focus on renewables, including solar, wind, hydroelectric, biogas and cellulose-derived biofuels. The state of Michigan is looking to set ambitious alternative energy goals - produce 10 percent of our electrical energy from renewable sources by the year 2015 and a full 25 percent by the year 2025.

Energy needs and the threat of global warning are changing business in fundamental ways. Local farms and farmers, among other local individuals and institutions, can take advantage of this “greening trend” by providing carbon offsets. Carbon offsetting is the act of mitigating ("offsetting") greenhouse gas emissions. Carbon offsets generally refer to acts by individuals or companies that are arranged by commercial or not-for-profit carbon-offset providers. Formal standards and certifications for voluntary carbon offsets are starting to emerge to facilitate this process.

Farmland Preservation

The Michigan Land Use Leadership Council (MLULC) recommended that the state develop economic strategies that increase the profitability of farmers, including the encouragement of innovative ventures such as value added production and processing, direct farm marketing and agricultural tourism expansion, the pursuit of nonfood, bio-based industries, and the utilization of renewable energy sources, like wind energy (PSC, 2003) and anaerobic digesters. The MLULC recognized that increasing profitability of farmers will inevitably contribute to the preservation of farm land.

These strategies will require new business partnerships, new business practices, new markets, new technologies, new forms of entrepreneurship and new funding mechanisms to make it happen (Adelaja, 2001). Successful farmers of the future will need to be scientifically versed, with business savvy, and engaged in creative thinking. Farmers will have to branch into unique markets, such as agro-entertainment, bio-prospecting, nutraceutical crops, value-added products, service-oriented enterprises, on-farm processing, pick-your-own operations and creative land-related business ventures. Innovations in farming will also require innovation in agriculture’s financial support system (Adelaja, 2005).

A wide variety of offset methods are possible. While tree planting was initially a mainstay of carbon offsetting, renewable energy, energy conservation and methane capture offsets have become popular. The Kyoto Protocol has sanctioned offsets as a way for governments and private companies to earn carbon credits which can be traded on a marketplace. The protocol established the Clean Development Mechanism (CDM), which validates and measures projects to ensure they produce authentic benefits and are genuinely "additional" activities that would not otherwise have been undertaken. Organizations that have difficulty meeting their emissions quota are able to offset by buying CDM-approved Certified Emissions Reductions. The CDM encourages projects that involve, for example, sustainable power generation, changes in land use, and forestry, although not all trading countries allow their companies to buy all types of credit. A guide to retail carbon offset firms is included in the **Funding Appendix**. For more information also see: http://www.cleanair-coolplanet.org/ .

Anaerobic digestion decomposes manure, food processing waste, or any organic material in a process that produces biogas consisting of methane, carbon dioxide, and other trace gases. These biogases are utilized to produce heat, generate electricity, or as natural gas while the remaining materials coming out of the digester can used as high quality fertilizer, animal bedding, or composted and mixed with other recycled products to produce green building materials. Currently, Michigan has eight operational digester systems with several more in the planning phase. In addition to the production of renewable energy, there are many advantages to anaerobic digestion. Digesters can significantly reduce odor from livestock production, reduce greenhouse gas emissions, and protect our water resources. The renewable energy produced from 100 dairy cows could be used to power 15 homes per day.

The Michigan Department of Agriculture (MDA) has enhanced partnerships between the industry, other state agencies, and universities to explore this technology. In spring 2007, MDA launched an Anaerobic Digester Operator Certification Program to provide training and support to the operators of these systems. Additionally, MDA hosted a "Bio-Energy Production through Anaerobic Digester Technology" conference last month to provide information on the current technology and the real-life experiences of digester technology.

Additionally, MDA partnered with the Michigan Association of Conservation Districts and the Delta Institute to create the Michigan Conservation and Climate Initiative (MCCI). This project allows farmers and landowners the ability to earn greenhouse gas emissions credits when they use conservation tillage, plant grasses or trees, or capture methane with manure digesters. The "carbon credits" earned can then be sold on the Chicago Climate Exchange, a member-based market comprised of large companies, municipalities, and institutions. The landowner must sign a contract and commit to maintaining the conservation practices through 2010. As part of the MCCI, Michigan landowners implemented conservation practices on 36,601 acres sequestering approximately 27,000 metric tons of carbon dioxide. Depending on the market price, landowners will earn an additional $2 to $4 per acre just for implementing conservation practices and being good stewards of the land while saving money on farm energy costs (Michigan Department of Agriculture, See: http://www.michigan.gov/mda/0,1607,7-125--185322--,00.html).

As noted previously, the resounding stakeholder sentiment is that the watershed should remain fairly rural. However, there are signs that the ethanol surge may be a misguided effort. There are some efforts at the national level to look at other biofuel sources, such as sewage, garbage, manure and plant sources other than corn. Farmers have more options than ever to broaden their revenue streams and create more sustainable farming options. Options include:

-Agritourism
- On-Farm Direct Marketing
  - Pick-Your-Own Operations
  - Retail Farm Stands
  - Extend diversity of local produce/crops
- Educational Tourism

Farm Tours, School Tours
Work Days/Internships
Gardening Classes
Conservation Education
On-Farm Entertainment/Recreation
Hunting and fishing, hiking, camping, Horseback riding, bird watching
Petting zoo, Hayrides, Corn Mazes, Picnic areas
Festivals
Winery Tours
Bed and Breakfast

-Development of renewable energy sources
Anaerobic digester biogas
Solar power, Wind power, Hydroelectric power
Biofuels from sewage, garbage and other plant sources

-Development of new localized markets and products
Direct selling, Farmers Markets
Organic farming
Community Supported Agriculture
Local food processing facilities
Develop/strengthen local food distribution
Promotion of local foods through advertising and education
Cross-promotion with other local businesses/organizations such as restaurants, schools, colleges, nurseries, homeless shelters, Federal, state and local parks

-Carbon sequestration and carbon credit markets
Native plantings: Buffer strips/CREP program
Utilize carbon offset market for funding local renewable energy products

7.0 WATERSHED ACTION PLAN

The River Raisin watershed action plan must be driven by a committee of stakeholders committed to implementation. This committee would logically be an extension of the existing steering committee. This may be a challenge given that some members may be burned out by the long and arduous process to develop this plan. Formation of this committee along with a commitment from committee members to push implementation is the number one priority for initiating this plan. Someone has to “steer the bus”, so to speak.

This plan has identified the River Raisin Watershed Council as the prime non-governmental organization (NGO) suited to enabling this process. The plan has identified agriculture as the land use most responsible for water quality impairments and it has identified an unwillingness and/or apathy as the number one challenge facing stakeholders. Given the potentially large cost for significant improvements in water quality, it is critical to develop tools that can support cost-effective conservation policy and/or voluntary implementation of watershed plans focused on water quality (Helmers et al., 2007). Performance modeling of proposed improvements demonstrates that almost everyone in the watershed must participate to remove impairments and achieve designated and desired uses.

For planning purposes, the implementation schedule is broken up into four phases: 1) implementation initiation and additional watershed assessment, 2) demonstration projects, 3) implementation refinement, and 4) broad application. We have associated time periods with these phases but the demarcation between phases is not hard and fast. The intent is to help structure the large array of implementation activities. The Action Plan and implementation schedule are included in **Table 7-4** and **Table 7-5** at the end of this chapter.

The concept is to begin with assessment and implementation initiation activities and concurrently or following this phase initiate a varied set of demonstration projects that generate excitement and attract interest and additional funding. Gaining momentum during this phase will be critical to passing a key implementation threshold. These demonstration projects include public education and involvement activities, creation of local planning tools, implementation of innovative agricultural, urban/suburban BMPs, recreation improvements, conservation and restoration projects, as well as undertaking local economic initiatives. These first two phases occur roughly during the first five years of the implementation period. This period is followed by an evaluation of performance metrics and a refinement of activities going forward. This refinement may also include changes to the performance metrics themselves. Following this phase, a wide dissemination of the results of the assessment/planning and demonstration projects will be used to more broadly institute improvements throughout the watershed.

7.1 Phase 1 Tasks: Initiate Implementation and Perform Additional Watershed Assessment

Along with formation of a stakeholder committee, there are some key tasks that need to happen simultaneously for addressing the Raisin’s TMDLs: 1) strengthen organizational relationships amongst watershed advocates; 2) develop and implement prioritized plans for growing existing organizations including the River Raisin Watershed Council (RRWC), the Lenawee Conservation District (LCD), the River Raisin Institute (RRI), and primary, secondary, and post-secondary schools, among other deserving organizations in the watershed; and 3) finish the primary characterization of the watershed needed to refine the targeting of problems and solutions. These priorities make up the first phase of implementation, referred to as the assessment and implementation initiation phase.

Additional watershed assessment activities include: a) road crossing inventory; b) aquatic habitat and geomorphic stability inventory, c) targeted *E. coli* sampling, and d) targeted nitrate sampling. Secondary inventories include a large woody debris jam inventory, an aerial photography/Geographical Information System (GIS)-based inventory of existing riparian habitat as well as additional fish tissue studies of mercury, PCBs and dioxins.

7.1.1 Phase 1 Task 1: Create Implementation Committee

To borrow a phrase from the former Bush administration, implementation must be led by a "coalition of the willing": those who have a stake in the results and a desire to see those results through. This committee should at least be made up of like-minded groups already active in the watershed. This group includes the RRWC, the LCD and NRCS, the RRI, the Washtenaw, Monroe and Lenawee County Drain Commissioners, the Michigan Department of Environmental Quality, The Nature Conservancy and other land conservancies, the Stewardship Network, the cities of Adrian and Monroe, the villages of Saline, Clinton, Manchester and Blissfield, Monroe schools, among others. We hope and anticipate that as projects get implemented in the watershed, momentum will accrue, and the committee and its mission will grow.

7.1.2 Phase 1 Task 2 – Build Organizational Capacity

Working under the presumption that the RRWC is uniquely positioned to act as the central advocate for improving conditions and achieving designated uses in the watershed, adequate resources and staff are not currently available to the RRWC to fulfill this role. In order for plan implementation to be successful, the RRWC will have to continue to build internal capacity, while building new relationships and partnerships and strengthening existing ones. In a watershed like the Raisin River, with a relatively sparse population and limited resources, building and strengthening relationships will help achieve compatible goals more efficiently and more effectively too. Rather than compete for limited funding sources, the RRWC should focus on facilitation of parallel efforts, linking like-minded organizations together to increase the likelihood of securing funding and building capacity to undertake projects. The RRWC should also make more of an effort to support inter-related community economic goals.

RRWC growth will require board and staff to help with development support, programming, public education and involvement, and technical capacity. Internal development of staff and board members could be facilitated with annual retreats and workshops. Program development should also include volunteer education/training/development and recognition programs.

7.1.3 Phase 1 Task 3: Watershed Assessment

Proposed watershed assessment activities include efforts that were either identified by past watershed work or by this project. While this chapter summarizes activities that are recommended for on-going monitoring of plan implementation success, these activities are covered in more detail in Chapter 8. Inventorying and monitoring activities include more spatially and temporally detailed *E. coli* sampling, a road crossing survey that includes geomorphic stability and habitat evaluations of at least 10% of the length of the main channel and main tributaries, and initiation of a Large Woody Debris (LWD) monitoring program. Additional water quality and fish tissue monitoring should also be performed both for mercury, PCBs and dioxins.

A watershed-wide prioritized inventory of natural, agricultural and culturally significant resources and a preservation strategy should be developed. The preservation strategy can be linked to recreation improvements by way of greenways and parkland, among other linkages. This process has already begun in the upper watershed, driven in large part by The Nature Conservancy conservation and restoration plans and by the application of a Geographical Information System (GIS) Decision Support System (DSS) created by the University of Michigan School of Natural Resources and the Environment (refer to **Section 7.4** below). The inventory of these features could be driven locally, but the effort would reap economies of scale if conducted on a regional basis. One model for evaluating natural features in a cost effective manner comes from the Huron River Watershed Council's Bioreserve program. See: http://www.hrwc.org/text/bioreserve.htm for more information.

A critical improvement priority is the preservation, conservation and creation of riparian buffers. When we use the term buffers, we are referring to non-mowed/un-cleared areas of herbaceous and woody plants. along as many open water bodies, lakes, streams, rivers, drains and swales, as possible. An excellent model for a mixed woody and herbaceous species buffer - a mixed species buffer – has been well-studied and documented by Iowa State University (see the **Riparian Buffer Appendix** for more information). We believe the most cost-effective use of funding for creating and preserving critical riparian areas should be prioritized based on a watershed-wide inventory of riparian cover. This inventory should be done via a spatially-detailed analysis that includes evaluation of erodibility and aerial photography. This analysis should be conducted first in the top priority water quality subwatersheds, the South Branch of the River Raisin and Black Creek, and the priority conservation watersheds of Goose Creek, Iron Creek and the upper River Raisin and then extended to the secondary priority water quality subwatersheds: Lower River Raisin, Macon Creek, Evans Creek, Saline River, and Little River Raisin.

Woody debris provides valuable habitat along creeks and rivers. Woody debris management allows for protection of this habitat while reducing the potential for flooding and streambank erosion. A program for managing this debris can be started by communities or counties and distributed among parties. For instance, we recommend the RRWC develop its own inventory program and help communities, organizations and individuals find additional information on woody debris management. An example guide for identifying and categorizing woody debris for removal or partial removal along with removal and re-use techniques can be found in the **Large Woody Debris Appendix** of this plan.

7.2 Phase 2: Demonstration Projects

Over the first five years of implementation, along with the effort to foster and build organizational strength and partnerships, key projects – installation of agricultural/urban/suburban BMPs, planning efforts, public involvement and education activities, new conservation/restoration and economic development initiatives, along with the creation of new or enhanced recreational opportunities should serve to energize and demonstrate the power of this organized effort. Each new project will be an opportunity for education and promotion of the goals and objectives of this plan.

7.2.1 Achieve Nitrate TMDL and Reduce Dissolved Reactive Phosphorus Loads

There is a significant set of existing institutions for agricultural land management. The most notable and influential include the US Department of Agriculture, the Michigan Department of Agriculture, the Michigan Department of Environmental Quality, the Natural Resources Conservation Service, the county Conservation Districts and, to some extent, the county Drain Commissioners. These institutions have been helping manage agriculture and agricultural impacts for many years. However, as the evaluation of existing conditions has shown, water quality in the Raisin is not improving and to a significant extent, agriculture is the culprit.

Implementation of this plan must include coordination and action by, for and through these institutions. It clearly cannot be about 'business as usual'. Although there have been some very effective pilot programs implemented in the River Raisin, such as the Wolf Creek project, we would suggest a set of demonstration projects to both pilot appropriate management ideas and help spread the word about these ideas and technologies.

This effort will have to be driven by the local conservation districts and the Natural Resources Conservation Service, the Farm Service Agency, the Michigan Department of Agriculture, with assistance from Michigan State University, Farm Bureaus as well as non-governmental organizations (NGOs) that are trying to re-structure the business of agriculture in Michigan, such as the Food System Economic Partnership (FSEP).

The key demonstration project for the Raisin is the performance-based, environmental farm control pilot program based on the Performance-Based Environmental Policies for Agriculture (PEPA). Although as noted, there may be some resistance to the notion of performance metrics, the idea is to put more control in the hands of the farmer. In the work done by the coalition led by the University of Vermont, initial indications are that both higher levels of environmental control and better economic outcomes are achieveable.

Recommended agricultural demonstration programs include, in order or priority:

1. Performance-based environmental control program for nutrients and pathogen control

2. Set-up a system to front-end load money for new precision agricultural equipment and in return, require conservation practices. This equipment should include GPS units and GPS-activated spray shut-off, in-ground water and nutrient sensors, and side-dress applications, including manure spreaders

3. Provide demonstration plots via the NRCS Center for Excellence for new equipment for dealing with nutrients, and large animal farm waste

4. On-farm treatment of dairy manure for water reuse and anaerobic digesters for generating electricity.

5. Implement pilot drain tile and swale management systems, including water level control structures, two-stage ditches and constructed wetlands.

7.2.2 Lift Pathogen Impairments

The demonstration projects for lifting the pathogen impairments include projects recommended to lift the nitrate TMDL, as well as development of a Lenawee County illicit discharge elimination program like Monroe County has done. In addition, the recommended follow-up *E.coli* sampling should be conducted for the TMDLs on the Saline River, Lenawee County Drain #70 and on the River Raisin downstream from the Adrian WWTP.

7.2.3 Sediment, Total Phosphorus (TP), and Hydrologic Variability

The prioritization of sources identified conversion of natural land cover, impoundments, farm storm water and drain tile management as priorities for managing sediment, total phosphorus and hydrologic variability. However, the management actions and recommended demonstration projects for these priorities are identified in **Sections 7.2.6** (Conservation/Restoration), **7.2.4** (Remove/Reduce BCCs), **7.2.1** (Nitrate TMDL) and will not be repeated here. The bulk of the recommended demonstration activities include storm water management activities. Also, included is the initiation of a LWD pilot program in the reach of the mainstem downstream from Adrian to the Lenawee County line.

The recommended storm water management paradigm for the entire watershed is Low Impact Development (LID), a practice of mimicking pre-development hydrology and typically exchanging large, centralized detention ponds for small, decentralized green, vegetated BMPs. This management paradigm is just starting to catch on in Michigan. River Raisin stakeholders can help drive implementation by encouraging LID implementation through key demonstration projects. We would suggest the following set of projects to help drive LID application and recognition. This program of LID, in slightly altered form to account for poorly draining areas, can work in the old lake plain area of the Raisin. For instance, native Michigan plants, can improve infiltration and increase evapotranspiration everywhere in Michigan, even on tight soils.

1. Rain garden Initiative – With the help of an external funding source, such as Clean Water Act 319 funding for non-point source pollution control, a watershed wide rain garden program should be initiated. A program like this has been started in Toledo, as part of an initiative by the Maumee RAP, funded in part by a grant from the Joyce Foundation (See: http://www.raingardeninitiative.org/). A technical steering committee, made up of project partners such as the River Raisin Watershed Council, the River Raisin Institute, the NRCS, CDs, etc. should be formed to develop the program. A target acreage or number of rain gardens could be established and partial funding and technical support offered by the committee to homeowners and businesses in the watershed. Urbanized areas, such as Adrian, Monroe or Saline, are all priorities for this initiative.

2. LID Outreach - This same committee could establish an LID outreach program to deliver the LID "messsage" to local businesses, developers, contractors, engineers, architects, landscape architects, local governments, organizations such as churches, schools and universities and so on. The objectives of the committee would be to help initiate at least one new, large scale, LID development – large here meaning a built area of at least five to ten acres and one large scale LID BMP retrofit project in an urban/suburban area that mitigates at least five acres of existing development – residential or commercial.

3. LWD Management Plan Pilot – This project should start with an inventory of large woody debris jams on the reach between Adrian and the Lenawee County line. This is the area that anecdotal evidence suggests as the most acute problem with LWD. This inventory would characterize jams as either inconsequential, providing habitat or requiring partial or complete removal.

We think that three of the most important demonstration projects for the watershed would be to develop ordinances and standards that deal with development and post-development storm water control. This recommendation may best be adopted earliest by the more progressive communities in the watershed. The objective of the planning demonstration projects would be for at least two communities and/or county in the watershed to adopt:

1. A set of site design and road standards that minimizes natural system impacts and impervious surfaces;
2. A riparian buffer ordinance that creates reasonable river and stream setbacks (at least 50-ft) and minimizes channel crossings. A 50-ft buffer has value and a 100-ft buffer is a better minimum for water quality management.
3. A low-impact development (LID) stormwater ordinance that focuses on decentralizing storm water BMPs and mimicking pre-development hydrology.

7.2.4 Remove/Reduce Bioaccumulative Chemicals of Concern

The first priority for the Raisin AOC is to lift the habitat and population impairments. During the demonstration period of plan implementation, the five projects recommended in the delisting targets document, should be completed. These include:

1. North River Raisin Wetland Enhancements
2. Sterling Island Improvements
3. City of Monroe Low Head Dam Removals and fish ladder improvements at the Waterloo Dam
4. River Raisin Habitat Evaluation
5. Remove and restore the five remaining PCB hot spots on the River Raisin

7.2.5 Public Involvement and Education

We have identified four demonstration candidates with strong public involvement and education components. We have also identified these projects because they have the potential to capture public imagination and generate excitement about the Raisin and future outcomes. These four projects are:

1. Annual River Raisin Watershed Conference
2. Connecting Schools to the Great Lakes Program
3. River Raisin Watershed History Guide
4. River Raisin Film Festival

Annual River Raisin Watershed Conference

Another forum is needed to help bridge the individual and somewhat disparate efforts for understanding and improving conditions in the watershed. This could be a forum where everyone – students, researchers, practitioners, Federal, State, County, and community representatives, businesses, farmers, and others could use to trade and solicit information, pose new approaches to old problems and trumpet successes. The conference could include poster sessions, technical presentations, and a trade show, with the Film festival screening planned as part of the conference.

Connecting Schools to the Great Lakes

The guiding theme of the proposed work is building relationships that infuse a shared sense of responsibility and shared opportunities for improving the health of the Great Lakes. This program proposes to strengthen relationships between children and the land by involving students, grades 7-12 in an active, problem-solving process, and investigating real environmental problems in their own community as part of classroom-based education. Relationships between schools and local organizations are integral to integrating these opportunities into formal education content and to inspiring a culture of environmental stewardship in southeastern Michigan. The objectives of this program include:

1. Increase opportunities to engage rural and small town children in southeast Michigan in real world learning opportunities that generate local knowledge and local solutions to issues impacting the health of the Great Lakes

2. Build enduring partnerships between schools and local conservation groups, business, and governmental agencies that increase local capacity for maintaining and advancing opportunities for school-community collaboration in environmental stewardship

3. Inspire support of school administrators, teachers and the broader community for integrating local environmental stewardship into formal classes

River Raisin Film Festival

The Third Annual Millers Creek Film Festival recently attracted over 300 people to the screening of the amateur video entries at the Michigan Theater in Ann Arbor. Entries on the human connection to the Huron River or any one of its creeks or lakes were solicited from individuals of all ages. Films are separated between five minute and 30-second public service announcement entries. The best entries in school age children and adult categories won donated prizes that included cash, canoes, kayaks and more. This festival has become a source of annual creative excitement about the river and visual arts.

Winning 30-second Public Service Announcement in the 2007 Millers Creek Film Festival

River Raisin History Guide

The River Raisin watershed has a rich history that is treasured by many residents. A history guide, written from the perspective of human occupation, use, consumption and stewardship creates a wonderful opportunity for putting the present watershed condition into perspective and setting up the challenges we face today. This guide could integrate the human cultural elements with the natural history of place. The Raisin, particularly from the perspective of fluvial geomorphology, tells a story of clearcutting, draining, damming, dredging and industrial use. The largely silent history of Native American occupation in the Raisin still remains to be told for non-Native Americans. If it were not for the absence of legislation in the state of Michigan to protect archeological sites, these valuable locations could be identified and protected.

7.2.6 Conservation/Restoration

A number of conservation/restoration initiatives are currently underway in the River Raisin. These initiatives and new ones to come, need technical, labor and funding support. This plan should help facilitate accomplishing the creation of new conservation and restoration opportunities throughout the watershed. New and on-going demonstration efforts include:

1. Form a committee to submit Natural Rivers designation request for upper Raisin, encompassing all or part of the reach from Brooklyn to Ives Road Fen.

2. Initiate a program, in conjunction with the MDNR, TNC, RVLT, the Washtenaw Land Trust, Jackson, Hillsdale, Washtenaw, and Lenawee counties, the Villages of Manchester, Tecumseh, Brooklyn and Clinton to conserve and restore uplands and wetlands to connect a landscape of 15,000 – 20,000 acres between the Iron Creek headwaters and Sharonville State Game Area (see **Figure 6-4**). Refer to Bennett et al., (2006) in the **UM Report Appendix** for recommendations on high priority and medium priority sites (for reference: Patch numbers 26 (highest priority), 122, 166, 106, 98, 502, and 166 (medium priority).

3. Restore at least 1,000 acres of wetland area in lower River Raisin in the subwatersheds with the highest proportion of wetland loss – Macon Creek, Little River Raisin, Lower River Raisin and Black Creek (see **Figure 6-5**).

4. Initiate bank stabilization/stream restoration projects based on road inventory, geomorphic assessment and previously identified sites.

7.2.7 Recreation

Demonstration projects for recreation improvements in the River Raisin include:

1. Lake Erie Access Project - Create access/greenway between the River Raisin battlefield site and the Sterling State Park and the US Fish and Wildlife Service International Wildlife Refuge. The River Raisin battlefield site is currently the object of a National Park Service to potentially create a new national park at and around the site. The Monroe County Historical Society has created a special committee to draft a nomination to recognize the battlefield site as a national historic monument.

2. Develop at least two new boat/canoe access sites

3. Initiate creation of at least one new park in the upper watershed (above Adrian) and one new park in the lower watershed.

4. Initiate creation of at least one new greenway in the watershed. Three priority locations are 1) along the mainstem in Saline; 2) along the mainstem between Adrian, Tecumseh and Clinton Township and 3) along the mainstem between Sharonville Game Reserve and the Village of Manchester

5. Create a River Raisin fishing guide. The Clinton River Watershed Council recently completed a series of fishing maps. See www.crwc.org for more information.

7.3 Phases 3 and 4: Interim Evaluation and Widespread Implementation

The intent of the demonstration period is to develop a set of partnerships and initiatives that lay the groundwork for long-term, effective implementation. The problems plaguing the River Raisin have been on-going for decades. Past efforts to remediate watershed problems have met with limited success. More diverse partnerships are likely necessary to break out of the apparent stasis. Where resources are appropriated from the same funding sources, rather than from completely new sources of funding, the net effect may simply be a renaming of existing institutions, rather than the creation of new ones. When collaborative natural resource management programs simply remodel existing programs, they can be construed as merely symbolic policies (Bidwell and Ryan, 2006). The Raisin needs some new approaches to re-establishing designated and desired uses and the groundwork to accomplish a sound, sustainable approach will take some time and momentum to achieve.

The interim evaluation is based on achieving these demonstration and planning activities within five years of acceptance of this plan by MDEQ and USEPA (See **Chapter 8** for details). While there is a water quality monitoring component of the interim evaluation phase, except for achieving localized improvements we do not expect deep, widespread water quality improvements over this period. What we hope to achieve over this period is a broader, deeper, better funded stakeholder team with a message that is beginning to resonate with watershed residents.

7.4 Anticipated Water Quality Improvements

The projection of possible water quality improvements was done with SWAT and literature references. SWAT was used to analyze the possible benefits of a series of Agricultural Best Management Practices (BMPs). Unfortunately, SWAT has a limited repertoire of possible agricultural BMPs. In particular, the SWAT simulations showed that the model cannot simulate such things as constructed wetlands or two stage ditches. The literature demonstrates clearly that these kinds of BMPs are useful for managing dissolved constituents that riparian buffers often miss, such as nitrate and DRP.

In terms of context, we also need to touch on the issue of recommended but “un-quantifiable” watershed activities. These include such things as education activities not directly related to improvements, such as local ecology classes and recreational activities like new canoe liveries or launches and greenways. We have and continue to contend that while the benefits of these activities are nearly impossible to quantify, their implementation is critical to the success of this plan. Improvements to this watershed are not going to come without the concerted effort of watershed residents. Yet it still seems that a large number of these residents are going to have to be educated or shown the value of directing resources towards watershed improvement.

For direct water quality improvements that are quantifiable with SWAT, the most effective BMPs are riparian buffers and streambank stabilization. These BMPs can be effective throughout the watershed. Riparian buffers are also likely to be the most cost-effective agricultural BMP for solids and solids-associated pollutants. Drain tile management, two stage ditches and constructed wetlands are the most cost-effective means of control (beyond managing the source) for dissolved constituents like nitrate and DRP.

For any new development (which will likely result from the conversion of farm land), the most effective class of BMPs are Low Impact Development (LID) techniques. LID performance goals are to match pre- and post-development peak and total flows. These goals reduce hydraulic variability and tend to emphasize infiltration BMPs that are also highly effective for water quality improvements. We believe other critical improvements are possible by identifying and repairing failing septic systems, installing, operating and maintaining new on site wastewater management systems as well as upgrading and installing, maintaining and operating well-running private community wastewater systems.

7.4.1 SWAT Model Results

For the SWAT model it was assumed that the amount of existing agricultural land is currently at its peak coverage in the watershed. While we have repeatedly echoed the sentiment of watershed residents that farm land needs to stay farm land, the reality is, it is highly unlikely that all the land currently in agricultural production will remain in production twenty years from now. It is much more likely that some land currently in production will become residential land during the next twenty years.

The SWAT model has the capacity to quantify the benefit of implementing particular BMPs. However, the SWAT model is not capable of estimating pollutant load reductions for an infinite number of practices. It is possible to model the following BMPs with SWAT:

- Tillage operations
- Tile drain management
- Fertilizer application reduction
- Installing filter strips at edge of field
- Cover crop management

The capabilities of each of these BMPs are discussed below. It is important to note that several additional BMPs are proposed for the River Raisin watershed that cannot be quantitatively modeled within the SWAT model. These BMPs are discussed in other sections of the Watershed Management Plan.

Tillage Operations. The model parameters for tillage operations are tillage depth and mixing efficiency (fraction of nutrients on the soil surface that are mixed uniformly throughout the tillage depth). The three tillage options that were modeled include:

Method	Depth	Mixing Efficiency
Conservation	100 mm	25%
Field Cultivator	100 mm	30%
Deep Ripper	350 mm	25%

There is not a significant difference between the conservation tillage and field cultivator. The deep ripper also has a similar mixing efficiency, just to a deeper depth. From the model’s perspective, there is very little difference between these types of tillage operations. Conservation tillage was not used in the calibration model. Therefore, the only tillage operation that was run in the model was a “no till” scenario. This scenario was modeled in the South Branch, Black, Evans, and Lower River Raisin subwatersheds. The model showed only a modest reduction in the sediment yield for the “no till” scenario. This does not necessarily mean that tillage operations are not an effective BMP, just that quantifying a noticeable change is beyond the resolution of the model as currently calibrated. The model is also not sensitive to the combination of no-till with fertilizer or manure applications so the suggestion that nutrients may build up in the surface layers and be more susceptible to rainfall and runoff could not be tested. The NCWQR has hypothesized this may be one of the causes of rising DRP in western Lake Erie’s major tributaries.

Tile Drain Management. Tile drain management was applied to poorly drained soil types (C/D and D hydrologic groups) in agricultural and range lands in the calibration model. The depth to subsurface drain was set at 800 mm and the time to drain soil to field capacity was set at 24 hours. An alternative tile drain scenario with the time to drain increased to 72 hours was modeled for the South Branch, Black, and Lower River Raisin subwatersheds. Theoretically, the longer residence time of the water in the soil profile would allow for more plant uptake of nitrogen and phosphorus; however, the model was not sensitive to tile drain time. Again, this does not mean this may not be an effective strategy for treating nitrate, but rather that SWAT cannot resolve this question.

Fertilizer Application Reduction. The fertilizer application was reduced by 50% for the South Branch, Black, Evans, and Lower River Raisin subwatersheds in order to determine how effective this BMP would be. The fertilizer application in the calibration model includes two fertilizer applications (anhydrous ammonia and 10-34-00) for the corn crop, one (13-13-13) for the winter wheat, and none for the soybeans. Additionally, in subwatersheds with corn silage production, there is manure application. The results show approximately a 50% reduction in total phosphorus concentration, but a slight little to no reduction in all speciation of nitrogen (organic nitrogen, nitrate, nitrite, and ammonia). We speculate that the crop growth is phosphorus limited and the reduction in phosphorus results in an excess of nitrogen. After discussion with MDEQ, it was determined that the best approach for fertilizer application reduction is to work with the farmers to complete soil tests and talk with them about how they are applying nitrogen.

Filter Strip Implementation. Filter strips were not used in the calibration model. To determine the maximum benefit of implementing filter strips in the watershed, a simulation was done with 100 foot wide edge of field buffers in all of the subwatersheds. This results in a significant decrease in total suspended solids, total phosphorus, and nitrate concentrations.

Cover Crop Management. The crop rotation in the calibration model was corn, soybean, wheat every other year. However, no cover crops were included between the harvest crops. A scenario was simulated so that there was always either a cover crop or a harvest crop for the highest priority subwatersheds (South Branch, Black, Evans and Lower River Raisin). These simulations resulted in large reductions in both total phosphorus and nitrate concentrations, with minor reductions in total suspended solids.

Results Summary

The above BMPs were modeled in the SWAT model to estimate the pollutant load reductions for sediment (TSS), total phosphorus, and nitrate. The Evans Creek subwatershed was used to perform a sensitivity study to determine the potential benefit that could result from the various BMPs. The results for the Evans Creek subwatershed are summarized in **Table 7-1**.

Table 7-1 Summary of Sensitivity Models for Evans Creek

Scenario	TSS (metric tones/ha)	Total Phosphorus (kg P/ha)	Nitrate (kg N/ha)
Calibration model	2.816	0.072	0.013
No tillage operations	2.563	0.101	0.014
Tile drain management	2.816	0.072	0.013
Fertilizer application reduction by 50%	3.209	0.023	0.013
Cover crop management	1.060	0.009	0.014
100 ft wide filter strip	0.065	0.002	0.002

These model results indicate that the primary BMPs to implement in the River Raisin watershed are filter strips, cover crops, and fertilizer reduction. Therefore, these BMPs were simulated in other subwatersheds. Additional simulations were run with the following BMPs in the associated subwatersheds:

Table 7-2 Summary of BMPs in Each Subwatershed

Subwatershed	No Till	Fertilizer Reduction	Cover Crop Management	Filter Strip
Black Creek	X	X	X	X
Evans Creek	X	X	X	X
Goose Creek				
Iron Creek				
Little River Raisin				
Lower River Raisin	X	X	X	X
Macon Creek				X
Saline River				X
South Branch River Raisin	X	X	X	X
Upper River Raisin				

SWAT was used as a tool to predict whether or not the target water quality levels could be met on an average annual basis by implementation of vegetative buffers at the edge of fields within the high priority subwatersheds of the River Raisin (Black Creek, Evans Creek, Lower River Raisin, Macon Creek, Saline River, and South Branch River Raisin) and cover crop management in the Lower River Raisin, South Branch River Raisin, and Black Creek. The prioritization of the subwatersheds is discussed in detail in Chapter 5. The results are summarized in the sediment, total phosphorus, and nitrate figures below (see **Figures 7-1 to Figure 7-3**) and indicate that indeed the widespread implementation of 100 foot wide filter strips and cover crop management throughout the River Raisin will result in meeting the numeric water quality targets.

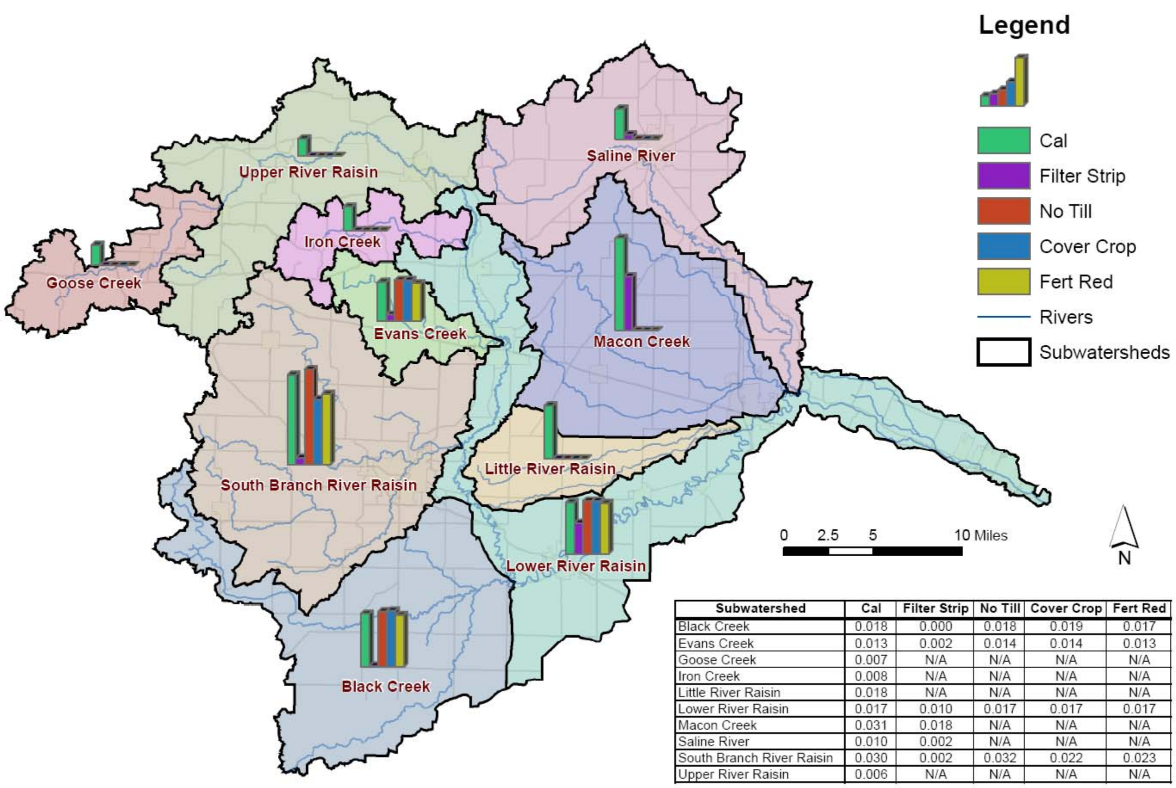
Additionally, water quality improvements can be achieved through use of other BMPs including proper fertilizer/manure application timing and constructed wetlands. In southern Minnesota, annual nitrate loss from tile drainages were reduced by an average of 36% when farmers switched from fall to spring application (Dinnes et al., 2002). Constructed wetlands have also been shown to remove nitrate through assimilation and denitrification. In a study of three Illinois wetlands, the ratio of denitrification capacity to mean nitrate load ranged from 19% to 59%, with an average of 33% (Dinnes et al., 2002).

The following files are included in the **Water Quality Appendix**:

- Model set up description
- Calibration report
- Output file summaries
- Output file guidance from SWAT manual
- Output by HRU (on CD)

Table 7-3 Summary of SWAT Model Results at Outlet of River Raisin Watershed

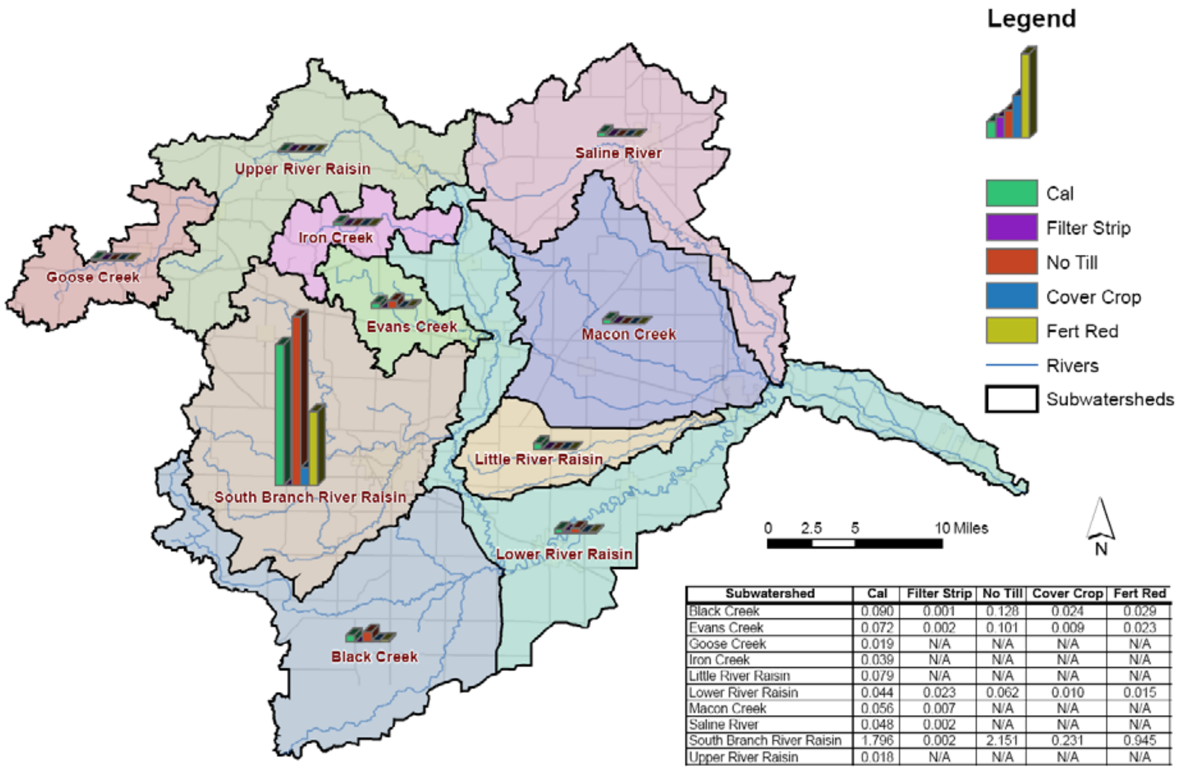
BMP Scenario	Total Suspended Sediment (mg/L)	Total Phosphorus (mg/L)	Nitrate (mg/L)
Annual Average Target Concentration	40	0.075-0.10	1.8
Calibration Model	52	0.206	4.282
No Till	51	0.231	4.295
Fertilizer Reduction, 50%	53	0.129	3.535
Cover Crop Management	44	0.090	2.583
100’ Filter Strip	24	0.069	0.986



Subwatershed	Cal	Filter Strip	No Till	Cover Crop	Fert Red
Black Creek	0.018	0.000	0.018	0.019	0.017
Evans Creek	0.013	0.002	0.014	0.014	0.013
Goose Creek	0.007	N/A	N/A	N/A	N/A
Iron Creek	0.008	N/A	N/A	N/A	N/A
Little River Raisin	0.018	N/A	N/A	N/A	N/A
Lower River Raisin	0.017	0.010	0.017	0.017	0.017
Macon Creek	0.031	0.018	N/A	N/A	N/A
Saline River	0.010	0.002	N/A	N/A	N/A
South Branch River Raisin	0.030	0.002	0.032	0.022	0.023
Upper River Raisin	0.006	N/A	N/A	N/A	N/A

NO3 in surface runoff (kg N/ha).
Nitrate transported by the surface runoff into the reach

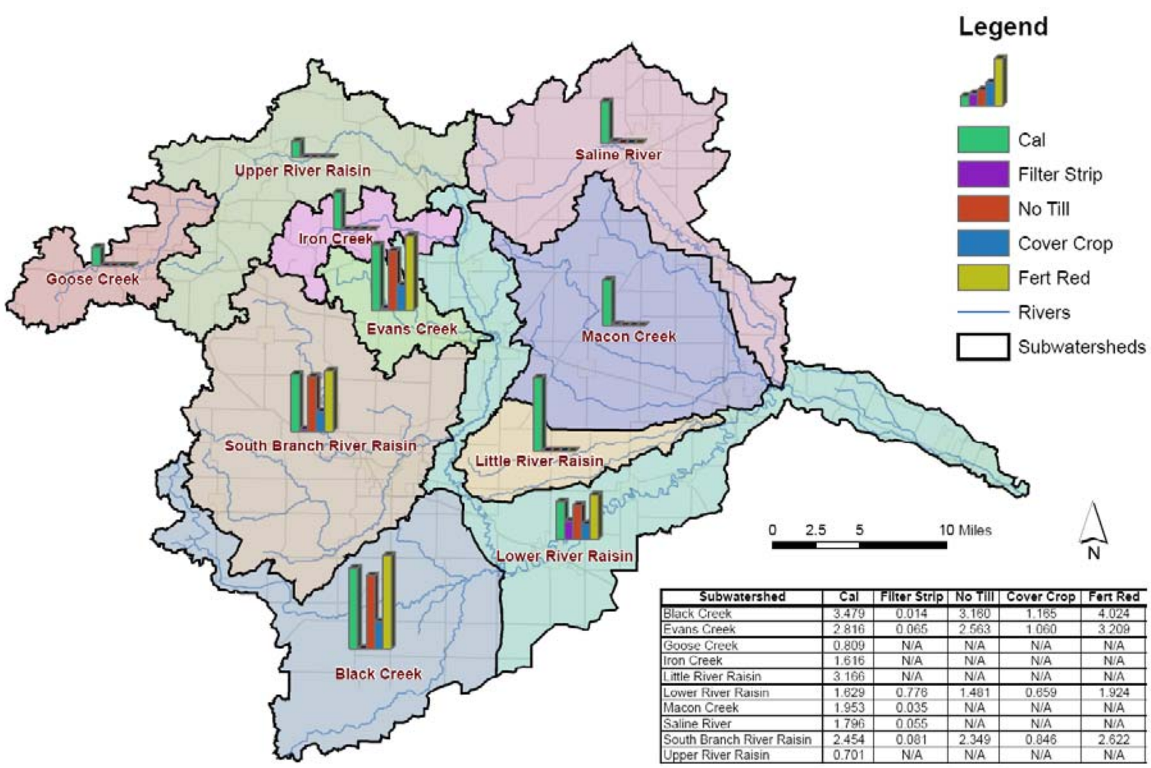
Figure 7-1 SWAT Model Nitrate Yield Results



Subwatershed	Cal	Filter Strip	No Till	Cover Crop	Fert Red
Black Creek	0.090	0.001	0.128	0.024	0.029
Evans Creek	0.072	0.002	0.101	0.009	0.023
Goose Creek	0.019	N/A	N/A	N/A	N/A
Iron Creek	0.039	N/A	N/A	N/A	N/A
Little River Raisin	0.079	N/A	N/A	N/A	N/A
Lower River Raisin	0.044	0.023	0.062	0.010	0.015
Macon Creek	0.056	0.007	N/A	N/A	N/A
Saline River	0.048	0.002	N/A	N/A	N/A
South Branch River Raisin	1.796	0.002	2.151	0.231	0.945
Upper River Raisin	0.018	N/A	N/A	N/A	N/A

Total phosphorus yield (kg P/ha).
Total phosphorus transported by surface runoff into the reach.

Figure 7-2 SWAT Model Phosphorus Yield Results



Subwatershed	Cal	Filter Strip	No Till	Cover Crop	Fert Red
Black Creek	3.479	0.014	3.160	1.165	4.024
Evans Creek	2.816	0.065	2.563	1.060	3.209
Goose Creek	0.809	N/A	N/A	N/A	N/A
Iron Creek	1.616	N/A	N/A	N/A	N/A
Little River Raisin	3.166	N/A	N/A	N/A	N/A
Lower River Raisin	1.629	0.776	1.481	0.659	1.924
Macon Creek	1.953	0.035	N/A	N/A	N/A
Saline River	1.796	0.055	N/A	N/A	N/A
South Branch River Raisin	2.454	0.081	2.349	0.846	2.622
Upper River Raisin	0.701	N/A	N/A	N/A	N/A

Sediment yield (metric tons/ha).
Sediment from the subbasin that is transported into the reach.

Figure 7-3 SWAT Model Sediment Yield Results

7.5 Estimated Costs and Schedule

The Action Plan, including estimated costs can be found in **Table 7-4** below. The schedule is delineated in **Table 7-5** below.

Table 7-4 River Raisin Watershed Action Plan

PHASE & PROJECT No.	Management Alternative	Goals Addressed: 1. Achieve Nitrate TMDL and Reduce Dissolve Reactive Phosphorus Loads	2.Achieve Pathogen Target Concentrations	3. Remove/Reduce Bioaccumulative Chemicals of Concern (BCCs)	4. Reduce Sedimentation, Total Phosphorus, and Hydrologic Variability	5. Build River Raisin Watershed Council Capacity	6. Increase Public Awareness and Involvement	7. Conserve and Restore Natural Features	8. Increase Recreation Opportunities	Responsible Party	Costs: Capital	Costs: Annual/Maintenance	Timeline/Duration	Reccomended Locations	Technical Resources
Implementation															
1 [Implementation]	Create Watershed Plan Implementation Committee					✓	✓			RRWC	$5,000	$1,000	Immediate/3 months, then on-going	RRWC	MDEQ
2 [Implementation]	Promote New Watershed Management Plan					✓	✓			RRWC	$5,000			throughout watershed	MDEQ, RRWC
3 [Demonstration]	RRWC Development Plan					✓	✓			RRWC and Stakeholders	$15,000		Demonstration	RRWC	Outside non-profit consultant
4 [Evaluation]	Interim Milestone Evaluation					✓	✓			RRWC, RRI, MDEQ, local communities & counties	$50,000	NA	2013 - 6 months	Same 20 sites as RRWMP	University Laboratory
5 [Refinement]	Action Plan Refinement					✓				RRWC, RRI, MDEQ, local communities & counties	100 hours	NA	3 months		MDEQ
Inventories / Data Collection and Analysis															
6 [Implementation]	Implement additional E.coli sampling and source characterization		✓				✓			RRWC/RRI/Watershed schools, colleges & universities & others	$25,000	$25,000 / Assessment	2011 - 3 months; once every 5 years	Priority: S. Branch, Black, Saline Lower RR, Evans, Macon	MDEQ
7 [Implementation]	Implement road crossing & rapid geomorphic assessment				✓		✓			RRWC/RRI/Watershed schools, colleges & universities & others	$15,000			Mainstem, main tributaries	MDEQ, MDNR, St. Joe River
8 [Implementation]	Identify and prioritize areas for new and/or improved riparian buffers				✓					NRCS/CD/MSU	$75,000		2010	Priority: S. Branch RR, Macon, Black, Saline & Lower RR	NRCS, MSU
9 [Implementation]	Conduct Natural Features Inventories						✓	✓	✓	local governments, UM	$3,000 per site		2010-2012	Priority: Upper RR, Goose, Iron	MNFI
10 [Demonstration]	Implement Large Woody Debris Inventory				✓		✓			RRWC/RRI/Watershed schools, colleges & universities	$15,000	$5,000	2010-2011	Priority: Upper RR, Goose, Iron, Lower RR, Saline	County Drain Commissions
11 [Widespread Adoption]	Identify and eliminate "Perched" culverts that fragment habitat and create fish barriers; , rennovate fish ladders							✓		MDNR, county drain commissions, local governments	varies with size of pipe, site constraints		on-going	Miller Road Lenawee County (T5S, R1E, Sec 13); fish ladder - Veterans Park	MDNR, USFWS
12 [Widespread Adoption]	Change intake structures or mitigate for impingement and entrainment of fish and fish eggs							✓		Detroit Edison Monroe Power Plant	?		depends on EPA	Detroit Edison Monroe Power Plant	MDNR, USFWS
13 [Widespread Adoption]	Develop GIS for Road Drainage Facilities				✓					county and local governments, UM	$100/hr for GIS	$100/hr for GIS		watershed-wide	County Road and Drain Commissions, WCDC, MDOT
14 [Widespread Adoption]	Establish and maintain GIS database to assist hydraulic, hydrologic, and water quality modeling	✓	✓		✓					county and local governments	$100/hr for GIS	$100/hr for GIS			MDEQ, MiCORPS, Kalamazoo River
15 [Widespread Adoption]	Construct and monitor strategic, innovative BMPs, including permeable pavements and vegetated roofs, and develop or refine standards accordingly	✓			✓					WCRC, local governments, private owners, commercial retailers	$12-$24 for vegetated roof	$100,000 permeable pavement	3 Years	All	SEMCOG, MI LID Manual
16 [Widespread Adoption]	Conduct Frog and Toad Survey						✓	✓		local governments		$2,000 + volunteer time	Annual	Priority: Upper RR, Iron, Goose	MDNR, MNFI, consultants
17 [Widespread Adoption]	Study effects of pest species and invasive species, and develop biologically prudent and economically feasible methods of control							✓		MDNR	?				MDNR, APHIS, TNC, consultants
18 [Widespread Adoption]	Inventory invasive and non-native species in riparian areas							✓		TNC, local governments	$100 - $500 / acre		periodic, every 3-5 years	watershed-wide	MDNR, TNC, consultants
19 [Widespread Adoption]	Study locations and identify properties to serve as overflow and diversion points during high water periods	✓			✓					county drain commissions, local governments					County Drain Commissions

KEY: Implementation | Demonstration | Evaluation | Refinement | Widespread Adoption

PHASE & PROJECT No.	Management Alternative	Goals Addressed								Responsible Party	Costs		Timeline/Duration	Reccomended Locations	Technical Resources
		1. Achieve Nitrate TMDL and Reduce Dissolve Reactive Phosphorus Loads	2.Achieve Pathogen Target Concentrations	3. Remove/Reduce Bioaccumulative Chemicals of Concern (BCCs)	4. Reduce Sedimentation, Total Phosphorus, and Hydrologic Variability	5. Build River Raisin Watershed Council Capacity	6. Increase Public Awareness and Involvement	7. Conserve and Restore Natural Features	8. Increase Recreation Opporrtunities		Capital	Annual/Maintenance			
Agricultural BMPs															
20	Create state/federal water quality (Nitrogen/bacteria) Advisory Committee(s)	✓	✓		✓			✓			$12,000	$5,000			Maryland SWQAC
21	Precision Agriculture Demonstration Program	✓			✓		✓			MDA, NRCS, CDs, MSU-E, Ag Advisory Comm.	$500,000	$100,000	5 Years	Priority: South Branch RR, Black Creek	MDA, NRCS, Lenawee County Center for Excellence
22	Renewable energy Farm Demonstration projects (wind, solar, etc.) & carbon offsets useage						✓	✓		MDA, NRCS, CDs, MSU-E, Ag Advisory Comm.	$250,000	$100,000	5 Years		MDA, NRCS, Lenawee County Center for Excellence
23	Provide demonstration plots for new technology for dealing with nutrients and large farm animal waste	✓	✓				✓			MDA, NRCS, CDs, MSU-E, Ag Advisory Comm.	$500,000	$100,000	5 Years	Priority: South Branch RR, Black Creek	MDA, NRCS, Lenawee County Center for Excellence
24	On-farm treatment of dairy waste demonstration	✓	✓				✓			MDA, NRCS, CDs, MSU-E, Ag Advisory Comm.	$250,000	$100,000	5 Years	Priority: South Branch RR, Black Creek	MDA, NRCS, Lenawee County Center for Excellence
25	Wetland restoration/creation for water quality control	✓			✓		✓	✓		MDA, NRCS, CDs, MSU-E, Ag Advisory Comm.	$250,000	$100,000	5 Years		MDNR
26	Performance- Based Environmental Control Pilot Project	✓	✓		✓		✓			MDA, NRCS, CDs, MSU-E, Ag Advisory Comm.	$500,000/yr includes up-front costs and incentive payments		3 Years	Priority: South Branch RR, Black Creek, Evans Creek, Lower RR	PEPA - Univ. of Vermont
27	Vocational training - continue/expand existing apprentice programs	✓	✓		✓		✓			MDA, NRCS, CDs, MSU-E, Ag Advisory Comm.	?		On-going	Priority: South Branch RR, Black Creek	WCDC, Lenawee ISD
28	Increase use of filter strips	✓	✓		✓					MDA, NRCS, CDs, MSU-E, Ag Advisory Comm.	$200 per acre	$4 per acre annually	On-going	Priority: South Branch RR, Black Creek	NRCS, MDA, Conservation Districts
29	Limit livestock direct access to streams	✓	✓		✓			✓		NRCS/County Conservation Districts	$1.50 per linear foot (exclusion fencing)		On-going	Priority: South Branch RR, Black Creek	NRCS, MDA, Conservation Districts
30	Promote rotaional grazing	✓	✓		✓					NRCS/County Conservation Districts	?		On-going	Priority: South Branch RR, Black Creek	NRCS, MDA, Conservation Districts
31	Increase use of In-field buffers	✓	✓		✓					NRCS/County Conservation Districts	$200 per acre		On-going	Priority: South Branch RR, Black Creek	NRCS, MDA, Conservation Districts
32	Increase Riparian buffer utilization	✓	✓		✓			✓		NRCS/County Conservation Districts	$350 per acre		On-going	Priority: South Branch RR, Black Creek	NRCS, MDA, Conservation Districts
33	Promote more fertilizer and pesticide source control	✓								NRCS/County Conservation Districts	$10,000	$5,000	On-going	Priority: South Branch RR, Black Creek	NRCS, MDA, Conservation Districts
34	Cover cropping	✓			✓					NRCS/County Conservation Districts	$170 per acre		On-going	Priority: South Branch RR, Black Creek	NRCS, MDA, Conservation Districts
35	Drain tile management	✓	✓		✓					NRCS/County Conservation Districts	?	$15 per tiled acre	On-going	Priority: South Branch RR, Black Creek; Feldkamp and Klager Drain, trib of Saline	NRCS, MDA, Conservation Districts
36	Service to inspect tiles, recommend improvements	✓	✓		✓					NRCS/County Conservation Districts	$100- $300 per inspection		On-going	Priority: South Branch RR, Black Creek	County Drain Commissions, NRCS, MDA
37	Map or record of where tiles are installed	✓	✓		✓					NRCS/County Conservation Districts	$10,000	$100/hr to create GIS map	On-going	Priority: South Branch RR, Black Creek	County Drain Commissions, NRCS, MDA
38	Local jurisdictions implement tile permit and inspection program	✓	✓		✓					NRCS/County Conservation Districts	$15,000	enforcement	On-going	Priority: South Branch RR, Black Creek	County Drain Commissions, NRCS, MDA
39	Remove or plug tiles that are no longer needed for land drainage as land is removed from agricultural use	✓	✓		✓					NRCS/County Conservation Districts			On-going	Priority: South Branch RR, Black Creek	NRCS, MDA

KEY: Implementation | Demonstration | Evaluation | Refinement | Widespread Adoption

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40	Encourage participation in NRCS and local Soil Conservation District incentive programs	✓	✓		✓		✓	✓		NRCS/County Conservation Districts			On-going	Priority: South Branch RR, Black Creek	NRCS, Conservation Districts
41	Manure management (CAFOs, other livestock operations, horse, cow, sheep)	✓	✓		✓		✓		✓	NRCS/County Conservation Districts	varies		On-going	Priority: South Branch RR, Black Creek	NRCS, MDA
42	Corrective actions at CAFOs	✓	✓		✓					MDEQ/NRCS/County Conservation Districts	varies depending on extent of problems		On-going	South Branch RR, Black Creek	MDEQ, NRCS
Sewage Mangement															
43	Develop County-wide Illicit Discharge Elimination Program	✓	✓		✓					Lenawee County	$300,000		3 Years 2010-2013	South Branch RR, Black Creek	Monroe County
44	Private On-Site/WWTP Ordinance (special assessment district?) Maintain GIS Maps	✓	✓		✓					Implementation Committee help disseminate, local governments	$5,000 to $10,000	enforcement	On-going	All, as appropriate	See Wash. Cty proposed On Site rules
45	Assistance with failed onsite septic - programs throughout the watershed	✓	✓		✓					County Health Depts	$10,000		On-going	Priority: South Branch RR, Lower RR, Saline	County Drain Commissions, MOWRA
46	Adopt Illicit Discharge Ordinance and include enforcement language	✓	✓		✓					local governments, Lenawee County	$5,000 to $10,000	enforcement	On-going	Priority: South Branch RR, Black Creek, Lower RR	SEMCOG, MI Land Use Institute
47	Adopt Pet Waste Ordinanace	✓	✓		✓		✓			local governments	$2,000 to $5,000 per ordinance	enforcement	On-going	Priority: South Branch RR, Lower RR, Saline	SEMCOG, MI Land Use Institute
48	Establish dog parks with appropriate BMPs	✓	✓		✓		✓		✓	county and local governments	$2,000 to $5,000 per dog park	$1,000 per dog park	On-going	Priority: South Branch RR, Lower RR, Saline	HRWC
49	Lobby for increased funding for advanced wastewater treatment upgrades	✓	✓		✓			✓		RRWC/LUGs	$10,000	$10,000	On-going	Priority: South Branch RR, Lower RR, Saline	MDEQ
50	Inspect Sanitary Sewer and Septic Systems for Elimination / Minimization of Infiltration	✓	✓		✓					county and local governments, private property	$100 to $300 per inspection		On-going	Priority: South Branch RR, Lower RR, Saline	MOWRA, MSU
51	Evaluate Sanitary Sewer and Combined Sewer Overflows	✓	✓		✓					Adrian	?		On-going	Adrian, Blissfield, and Dundee; South Branch at Clayton and at Mooreville on	County Drain Commissions, City of Adrian
52	Identify and eliminate Illicit Discharges and Connections	✓	✓		✓					county and local governments, Lenawee County	$100 / staff investigation per property	$600/dye test; $5,000 to $15,000 enforcement per property	On-going	Priority: South Branch RR, Lower RR, Black Creek; Manchester, Monroe	WCDC, MCDC, MDEQ
53	Conduct dye tests for illicit connections for all new construction, whenever property changes ownership, or when water quality sampling or inspection programs show evidence of illicit discharges	✓	✓		✓		✓			county and local governments	$600 / dye test		On-going	Priority: South Branch RR, Lower RR, Black Creek;	WCDC
54	Spay and neuter cats to reduce feral population and decrease habitat for the Canada Goose population	✓	✓		✓		✓			county and local governments, UM, private landowners	site specific		On-going	Priority: South Branch RR, Lower RR, Saline	MDNR
55	Implement "Pick Up Your Pet Waste" program, place dog bags in local parks	✓	✓		✓		✓		✓	municipalities, Parks and Recreation areas	$15,000 ($600 per park)		On-going	Priority: South Branch RR, Lower RR, Saline	WCDC
Remove/Reduce Bioaccumulative Chemicals of Concern (BCCs)															
56	Removal of 5 PCB Hot Spots at the mouth of River Raisin			✓				✓		River Raisin PAC, USACE, Port of Monroe	$20,000,000			Mouth of River Raisin at Lake Erie	USEPA, USACE, NOAA
57	North River Raisin Wetland Enhancements			✓	✓			✓		River Raisin PAC, USFWS, MDNR	$200,000		1 year for Feasibility Study, 2 years for Design and Construction	Sterling State Park and Eagle Island Marsh	USEPA, USACE, NOAA
58	Sterling Island Improvements			✓	✓			✓		River Raisin PAC, USFWS, MDNR, City of Monroe	$200,000		2 years for Design and Construction	Sterling Island near Monroe	USEPA, USACE, NOAA

KEY: Implementation | Demonstration | Evaluation | Refinement | Widespread Adoption

PHASE & PROJECT No.	Management Alternative	Goals Addressed								Responsible Party	Costs		Timeline/Duration	Reccomended Locations	Technical Resources
		1. Achieve Nitrate TMDL and Reduce Dissolve Reactive Phosphorus Loads	2.Achieve Pathogen Target Concentrations	3. Remove/Reduce Bioaccumulative Chemicals of Concern (BCCs)	4. Reduce Sedimentation, Total Phosphorus, and Hydrologic Variability	5. Build River Raisin Watershed Council Capacity	6. Increase Public Awareness and Involvement	7. Conserve and Restore Natural Features	8. Increase Recreation Opportunities		Capital	Annual/Maintenance			
59	Low Head Dam Improvements			✓	✓			✓		River Raisin PAC, City of Monroe	$1,800,000 - dam removal; $13,000,000 - includes sewer re-route		1 year for Feasibility, 2 years for Design and Construction	Monroe	USEPA, USACE, NOAA
60	River Raisin AOC Aquatic Habitat Evaluation			✓				✓		River Raisin PAC	$250,000		1 year	areas adjacent to RR AOC	USEPA, USACE, NOAA
Planning															
61	At least one community revise & adopt LID-based stormwater ordinance	✓	✓		✓		✓	✓		Local governments	$2,500 to $10,000 per ordinance	enforcement	New Ordinances: 1 Year, Enforcement: On-going	Cities, Towns, and Villages	SEMCOG, MI Land Use Institute
62	At least one community revise & adopt riparian buffer ordinance	✓	✓		✓		✓	✓		Local governments	$2,500 to $10,000 per ordinance	enforcement	New Ordinances: 1 Year, Enforcement: On-going	Cities, Towns, and Villages	SEMCOG, MI Land Use Institute
63	Adopt Site Design and Road Standards that reduce impervious surface	✓			✓					local governments	$3,000	enforcement		Cities, Towns, and Villages	SEMCOG, MI Land Use Institute
64	Establish Master Plans and Ordinances that protect natural features, such as a Natural Rivers Ordinance, Tree/Woodlands Protection Ordinance, Wetlands Ordinance, Riparian Buffer Ordinance, and Site Design Ordinance	✓			✓		✓	✓	✓	Local governments	$10,000 - $20,000 per ordinance	enforcement	New Ordinances: 1 Year, Enforcement: On-going	Cities, Towns, and Villages	SEMCOG, MI Land Use Institute
65	Examine existing Comprehensive Land Use Plans for all watershed communities; highlight good provisions, and make recommendations that will protect RR				✓		✓	✓		RRWC	$2,000 to $5,000 per ordinance	enforcement		Cities, Towns, and Villages	SEMCOG, MI Land Use Institute
66	Establish stormwater advisory committee and public involvement programs for creekshed communities	✓	✓		✓		✓	✓	✓	local governments, RRWC	$12,000	$5,000		Cities, Towns, and Villages	SEMCOG
67	Adopt new standards for lawn care such as Lawn Fertilizer Ordinance (phosphorus-free fertilizer), Native Landscaping Ordinance, Local Weed Ordinance	✓	✓		✓		✓			LUGs, local governments	$10,000 - $20,000 per ordinance	enforcement		Cities, Towns, and Villages	Pittsfield Twp., AA
68	Develop and Adopt Floodplain Ordinance	✓			✓		✓	✓		local governments	$50,000	enforcement	1 Year	Cities, Towns, and Villages	SEMCOG, MI Land Use Institute
69	Improve Soil Erosion and Sedimentation Control (SESC) by adopting Erosion and Sedimentation Ordinance, comply with practices and recommendations of a SESC Guide or Manual, and improve enforcement of SESC policies				✓		✓			local governments	$5,000 to $10,000; additional staffing costs for inspections, processingviolations	$40,000 to $50,000	On-going	Cities, Towns, and Villages	MDOT, MDEQ, MACDC, APA
70	Adopt Development Standards Zoning Ordinance for structural and non-structural BMPs	✓	✓		✓		✓	✓		local governments	$5,000 to $10,000	enforcement		Cities, Towns, and Villages	SEMCOG, MI Land Use Institute
71	Establish an Environmental Protection Overlay Zoning Ordinance	✓	✓		✓		✓	✓		local governments	$2,500 to $10,000 per ordinance	enforcement		Cities, Towns, and Villages	SEMCOG, MI Land Use Institute
72	Adopt Purchase of Development Rights Ordinance	✓			✓			✓		Countys, local governments	$5,000 to $10,000	variable, based on the availability of development right funds		Cities, Towns, and Villages	HCMA
73	Adopt a policy requiring any development which is financed or subsidized by local government, or receives a tax abatement, to meet or exceed LEED standards pertinaent to stormwater mangement	✓			✓					local governments	$2,000 to $5,000	enforcement		Cities, Towns, and Villages	MCA, MCCC
74	Continue to improve River/Groundwater withdrawal system (seek legislative authority to control ag irrigation withdrawl)				✓			✓		MDEQ				Cities, Towns, and Villages	MDEQ, MDA
75	Regulate maintenance of stormwater control facilities by requiring permits for their use and anniversary dates for inspections, maintenance, and permit renewals contingent on functional integrity	✓	✓		✓					County governments	$100,000	$50,000		All	MCA, MCCC
76	Incorporate methods for capturing and treating stormwater runoff within road construction and improvement projects				✓					local governments	$800/catch basin protection; $6000/sediment trap basin	$10/inspection, $25/basin cleaning	On-going		MDOT, County Road Comissions
77	Promote and Incorporate "Smart Growth" into community development plans	✓	✓		✓			✓	✓	local governments					MI Land Use Institute, MSU

KEY: Implementation | Demonstration | Evaluation | Refinement | Widespread Adoption

PHASE & PROJECT No.	Management Alternative	Goals Addressed: 1. Achieve Nitrate TMDL and Reduce Dissolve Reactive Phosphorus Loads	2.Achieve Pathogen Target Concentrations	3. Remove/Reduce Bioaccumulative Chemicals of Concern (BCCs)	4. Reduce Sedimentation, Total Phosphorus, and Hydrologic Variability	5. Build River Raisin Watershed Council Capacity	6. Increase Public Awareness and Involvement	7. Conserve and Restore Natural Features	8. Increase Recreation Opporrtunities	Responsible Party	Costs: Capital	Annual/Maintenance	Timeline/Duration	Reccomended Locations	Technical Resources
78	Lobby for dedicated statewide resource conservation/restoration fund	✓	✓	✓	✓	✓	✓	✓	✓	RRWC/LUGs					Ohio Lake Erie Commission - Lake Erie Protection Fund (license plate revenue). Indiana LARE program
Stormwater															
79	Rain Garden Initiative	✓	✓		✓		✓	✓		RRWC, local governments, homeowners, developers	$300,000	$25,000 - $50,000	1 Year Planning, 2 Years Implementation	Monroe, Adrian, Clinton, Tecumseh	Community Engineering, County Drain Commissions; Refer to: www.raingardeninitiative.org
80	LID Outreach Committee	✓	✓		✓		✓	✓			$100,000	$10,000	2 Years	Watershed-wide, focus on cities	SEMCOG
81	Identify and label catch basin / storm drain				✓		✓			local governments	$3.50 per storm drain		On-going	All	HRWC
82	Regularly inspect and maintain stormwater systems	✓	✓		✓					county and local governments		$25,000	On-going	Priority: Upper RR, Iron, Goose, South Branch RR, Evans, Lower RR, Saline	County Drain Comissions
83	Land acquisition for infrastructure improvements				✓		✓		✓	conservancies, local governments	$25,000-$250,000		One time event	Manchester riparian areas	RRWC, MDNR, TNC, NRCS, Ducks Unlimited
84	Review construction site plans for storm water enforcement and BMP recommendations	✓			✓			✓		local governments	$100 to $300 per inspection		On-going	All	MDEQ - Certified Stormwater Operators
85	Create catch basin Inspection / Maintenance programs	✓	✓		✓					county drain comissions	$100 to $300 per inspection		Yearly inspection, minimum	Priority: Upper RR, Iron, Goose, South Branch RR, Evans, Lower RR, Saline	County Drain Comissions
86	Comply with BMPs for landscaping on municipal properties (i.e. integrated pest management, soil testing, native plantings)	✓			✓			✓		local governments	$5,000-$10,000 per acre	$5,000-$10,000 per acre		Municipalities, Counties	MDEQ - Certified Stormwater Operators
87	Use stormwater in public art works such as fountains, sculptures, and landscaping water features	✓			✓		✓		✓	local governments	$5,000 - $50,000 each	$1,000 - $2,000 each			MCA, MCCC
88	Inspect facilties for pollution prevention	✓	✓	✓	✓					WCPE, local governments	$100 to $300 per inspection		On-going		MDEQ
89	Clean-up accident spills and establish communications to coordinate efforts	✓		✓	✓		✓			county and local governments	site/substance specific		On-going	All	MDEQ
90	Create and maintain street cleaning and roadside cleaning (Adopt-a-Road)	✓			✓		✓		✓	local governments	$100,000 to $200,000	$35 to $65 per curb mile	On-going	All	Community/ County Public Works
91	Comply with BMPs for fleet maintenance	✓		✓	✓					county and local governments	varies		On-going		Community/ County Public Works
92	Create and maintain yard waste/compost pick-up				✓					local governments, private landowners	recycling station expenses	$10 to $20 per cubic yard disposal	On-going	All	County Solid Waste Depts
93	Siena Heights underground storage				✓					Sienna Heights University	$400,000 +	$1,000 - $3,000	2 Years	Siena Heights University - Adrian	MDEQ, LCDC, Sienna Heights University
94	Plant and promote rain gardens	✓			✓		✓	✓	✓	county and local governments, private landowners	$500/ homesite, or $3-5/ sq ft up to $10-12/sq ft for professional work	4% construction costs	5 years	All; City of Monroe - Southworth Drain near Huber and Lorain south to River	SEMCOG, MI LID Manual
95	Plant vegetated swales	✓			✓			✓		county and local governments, private landowners	$0.50 / sq ft	$0.02 / sq ft	2 Years	All; Mason Run Drain at Calgary Park in Monroe	SEMCOG, MI LID Manual
96	Reduce turf by planting shrubs, trees, or native grasses	✓	✓		✓			✓		local governments, private landowners	$40/ tree; $5,000 per half acre of tree & shrub seedlings and groundcover; $3000 - $6000	$1000 - $2000 per year in maintenance costs	10 Years	All; City of Monroe: Southworth Drain	MDEQ, UM, MSU, consultants

KEY: Implementation | Demonstration | Evaluation | Refinement | Widespread Adoption

PHASE & PROJECT No.	Management Alternative	Goals Addressed								Responsible Party	Costs		Timeline/Duration	Reccomended Locations	Technical Resources
		1. Achieve Nitrate TMDL and Reduce Dissolve Reactive Phosphorus Loads	2.Achieve Pathogen Target Concentrations	3. Remove/Reduce Bioaccumulative Chemicals of Concern (BCCs)	4. Reduce Sedimentation, Total Phosphorus, and Hydrologic Variability	5. Build River Raisin Watershed Council Capacity	6. Increase Public Awareness and Involvement	7. Conserve and Restore Natural Features	8. Increase Recreation Opporrtunities		Capital	Annual/Maintenance			
97	Modify roof drain of directly connected impervious areas	✓			✓			✓		local governments	variable, depending on length of drain		5 Years	Priority: Upper RR, Iron, Goose, South Branch RR, Evans, Lower RR, Saline	MDEQ, UM, MSU, consultants
98	Install inlet filters	✓			✓					local governments, county drain commissions	$800. filter; $150,000 vactor truck	$3 per basin inspection; $25 per basin cleaning	On-going	Priority: Upper RR, Iron, Goose, South Branch RR, Evans, Lower RR, Saline	MDEQ, UM, MSU, consultants
99	Construct new stormwater facilities and retrofit existing facilities to detain first flush and bankfull storms and remove sediment.	✓			✓					county and local governments, institutions	Mobilization 3-5% of construction costs; site prep $3,000 to $6,000 for clearing; $2.50 - $6/ cu yd excavation; $3,000 - $7,000 each inlet/outlet. Design and contingencies 25-30%	2% of capital costs	On-going	Priority: Upper RR, Iron, Goose, South Branch RR, Evans, Lower RR, Saline	MDEQ, UM, MSU, consultants
100	Install / retrofit water quality sumps into catch basins, including regular maintenance and cleanout	✓			✓					county drain commissions, local governments	$5 per ft^3 treatment volume	$.54 per ft^3 per year	On-going	Priority: Upper RR, Iron, Goose, South Branch RR, Evans, Lower RR, Saline	MDEQ, UM, MSU, consultants
101	Local Government Stormwater Managers Directory						✓			RRWC	$2,000		On-going		MDEQ
102	River Friendly Home Program	✓	✓		✓		✓		✓	RRWC	$15,000	$5,000	On-going	All	WCDC
103	Stormwater Audits	✓			✓		✓			Local governments	$2,000 / audit		On-going	Priority: Upper RR, Iron, Goose, South Branch RR, Evans, Lower RR, Saline	USEPA
104	Clean-up trash, debris, and remove sediment that have accumulated in low-gradient areas				✓		✓	✓	✓	Local governments	$1,000 / day / site		On-going	Monroe: Mason Run culverts under Dixie Highway and Mason Run Cut-offs	RRWC
Conservation / Restoration															
105	Create committee and nominate upper Raisin for Natural and Scenic River Designation						✓	✓		Implementation Subcommittee	$5,000	$2,000	Within first 5 years of initiation	Upper RR	MDNR
106	Conserve/restore wetlands / natural areas in upper Watershed	✓			✓		✓	✓	✓	NRCS, CDs, TNC, Ducks Unlimited, Pheasants Forever, county and local governments, private landowners	$700 to $2,000+ / acre	2 -4 % construction costs	Within first 5 years of initiation	Cedar Hill in Walter J. Hayes State Park - riparian, invasives, outlook vista	MDNR, TNC, NRCS, Ducks Unlimited
107	Conserve/restore wetlands for water quality control in subwatersheds with highest wetland losses	✓			✓			✓		NRCS, CDs, TNC, Ducks Unlimited, Pheasants Forever, county and local governments, private landowners	$700 to $2,000+ / acre	2 -4 % construction costs	Within first 5 years of initiation	Macon, Little RR, Black, Lower RR	MDNR, TNC, NRCS, Ducks Unlimited
108	Bioengineered streambank stabilization	✓			✓		✓	✓		Drain Commissioners, local communities	Varies between $50/LF up to $500/LF of stabilization	2% of capital costs	First five years of initiation	Priority main stem locations between Adrian and Monroe	MDEQ, NRCS, County Drain Commissions, consultants
109	Restore wetlands / natural areas	✓			✓		✓	✓	✓	NRCS, CDs, TNC, Ducks Unlimited, Pheasants Forever, county and local governments, private landowners	$10 Million over 10 years	2 -4 % construction costs	On-going	Cedar Hill in Walter J. Hayes State Park - riparian, invasives, outlook vista	MDNR, , Conservation Districts, TNC, NRCS, Ducks Unlimited, Trout Unlimited
110	Land conservation				✓			✓		Conservancies, NRCS, sportsman clubs	$3,000 - $4,000 per acre			Priority: Upper RR, Goose, Iron; Pittsfield Charter Twp - Wood Outlet Subwatershed	MI Land Use Institute, Conservation Districts

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111	Prioritize areas/Idenfity natural features							✓			$8,000-$10,000	$4,000		Priority: Upper RR, Goose, Iron	TNC Conservation Planning
112	Plant Buffers along sensitive areas	✓			✓			✓		county and local governments, private landowners, land trust	$2 / LF 10 ft wide	$0.10 / LF		native plantings along riverbank in parks (Blissfield); buffers in Jackson and	NRCS, Conservation Districts
113	Land restoration	✓			✓			✓			$3,000 per acre	$500 per acre		Priority: Upper RR, Goose, Iron	MI Land Use Institute, MDNR, TNC, Pheasants Forever
114	Invasives Control						✓	✓	✓	Conservancies, NRCS, sportsman clubs	$1000 - $2000 for spraying	$2,500 for Manchester		City of Monroe; Tecumseh; area between Iron Creek and Sharonville SGA; Manchester	possibly partner with RRI, schools, Arthur Leslow Community Center; TNC,
115	Manage Roadside Vegetation	✓			✓					county road commissions, drain commissioners, local goverments		$2,000 per acre	On-going		MDOT, MDNR
116	Bioengineered streambank stabilization	✓			✓					county and local governments, private landowners	Varies between $50/LF up to $500/LF of stabilization	2% of capital costs	On-going	Priority: South Branch RR; Lane St in Blissfield	MDEQ, NRCS, County Drain Commissions, consultants
117	Pittsfield Twp drain rehabilitation	✓			✓			✓		Washtenaw County Drain Commissioner, Pittsfield Twp.	$100 - $300 / LF	2% of capital costs		Pittsfield Twp.	WCDC
118	Extend Evans Drain to lower 1.5 miles of Evan's Creek and facilitate suspended solids removal with riparian improvements	✓			✓		✓		✓	Lenawee County Drain Commission	$100 - $300 / LF	2% of capital costs		Evan's Creek, Tecumseh	LCDC
119	Streambank Stabilization with Educational Workshop	✓			✓		✓		✓	WCRC, local government	$1000 per workshop			Priority: South Branch RR; Dennison Road, Saline River	MDEQ, NRCS, consultants
120	In-stream planting of dense vegetation to narrow channel and focus flow	✓			✓					county and local governments, non-profits	$5 per plant			Monroe Street Crossing in Monroe	MDNR, TNC, NRCS, Ducks Unlimited, Trout Unlimited
121	Protect remaining natural lake outlets by preventing construction of new water level control structures				✓			✓			$5,000-$10,000	$5,000			MDEQ, USGS
122	Daylight streams where technically feasible and cost-effective	✓			✓			✓		county drain commissions, local governments	$500 - $1,000 /ft	2% of capital costs			MDEQ, MDNR, County Drain Commissions
123	Two-Stage Ditches				✓			✓		county drain commissions	$10- $20 / LF	$1 - $2 / LF	On-going	South Branch RR, BlackCreek, Evans Creek, Lower RR	MDEQ, MDNR, County Drain Commissions
124	Encourage dam removal where opportunities exist, especially where dams no longer fulfill the original purpose, or where impoundments are silted and choked by aquatic vegetation	✓			✓			✓			varies based on dam and impoundment		Monroe Dams during demonstration, others as feasible	Brooklyn, Sharon Hollow, upstream Manchester, Clinton, Red Mill, Standish, Globe; low head dams City of	MDEQ, MDNR, USFWS
125	Removal of Select Log Debris Jams				✓			✓		RRWC identifies private partners	$5,000-$20,000/jam depending on size/complexity		On-going	Macon-Raisin confluence; mainstem between Tecumseh and Dundee; Manchester	MDEQ, MDNR, County Drain Commissions
126	Wood Re-Use for Structures				✓			✓		County Drain Commissions, NRCS	$500 - $2,000 per structure		On-going		MDEQ, MDNR, County Drain Commissions, NRCS
127	Maintain wooded riparian areas for future LWD recruitment							✓		County Drain Commissions, NRCS			On-going		Conservation Districts, NRCS
128	Improve fish habitat by creating channel diversity and rehabilitating in-stream woody cover							✓		County Drain Commissions, NRCS			On-going	mainstem above Tecumseh; below confluence of Raisin and Saline River	MDEQ, MDNR, USFWS
129	Redevelopment of abandoned industrial and dump sites along river floodplain			✓			✓	✓	✓	Private and Public Partnerships	varies	varies	On-going	Clinton Woolen Mill and Atlas Feed&Grain; Blissfield public works parcel; Monroe Area	MDEQ - Brownfield Redevelopment Authorities
130	Natural Area Stewardship	✓			✓		✓	✓		TNC, MNA, YMCA Storer Camp, MDNR, RVLT, Washtenaw County		$500 - $1,000 / acre	On-going	Ives Road Fen, Nan Weston, Goose Creek Grasslands, state parks/game areas, YMCA Storer Camps, Washtenaw County	Stewardship Network - Raisin Cluster, TNC, MNA, MDNR, RVLT

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Recreation															
131	Lake Erie Access Project						✓		✓	US Fish and Wildlife Service, City of Monroe, MDOT	Planning, design, construction and perhaps most significantly $ per acre of easement		During Demonstration Period	Monroe at Lake Erie	US Fish and Wildlife Service, MDOT
132	Increase public access to River Raisin						✓		✓	Communities, Counties	varies by location		Establish 2 New Sites during Demonstration	RR between Tecumseh and Dundee; lakes in Irish Hills area; Blissfield; Manchester (Upstream of dam at Union; adjacent upstream of dam; adjacent downstream of dam; downstream at Furnace)	MI Trails & Greenway Alliance, Trout Unlimited, Ducks Unlimited, Metro/County/Local Parks and Rec
133	Increase number/ quality of parks along River Raisin						✓	✓	✓	local governments	varies		Establish 2 New Parks during Demonstration	Manchester (downstream of dam; Kirk Park; Village property @ Village Hall)	MI Trails & Greenway Alliance, Metro/County/Local Parks and Rec
134	Regional Greenway planning						✓	✓	✓		varies		Establish Plans for at least 1 new Greenway during Demonstration	1) Saline River in York Township & Milan; 2) RR btwn Sharonville Game Reserve and Manchester 3) RR btwn Clinton, Tecumseh & Adrian	MI Trails & Greenway Alliance, Metro/County/Local Parks and Rec
135	Create River Raisin Fishing Guide						✓		✓	RRWC/MDNR.Trout Unlimited	$10,000 per map design & printing	Re-print costs/distribution	1 Year		Trout Unlimited, Refer to Clinton River Fishing Guides (see www.crwc.org)
136	Construct access points in a manner to reduce erosion and protect banks and shorelines. Engage livery and marina operations to establish no wake zones and similar BMPs to control erosion				✓		✓	✓	✓	local governments, private businesses	$2,000 to $5,000 per access point		On-going	City of Monroe	MDNR, Trout Unlimited
137	Local Recreation Planning (riverwalks, bikeways, pedestrian bridges)						✓	✓	✓	local governments	$750,000 for Manchester ped bridge; $120,000 for trails; varies elsewhere	varies	On-going	Monroe; trail from Blissfield to Deerfield; Manchester ped bridge(connect ROW across Mill Pond u/s of Main St. Dam); Manchester boardwalk/trails	MI Trails & Greenway Alliance, Metro/County/Local Parks and Rec
138	Encourage Canoeing on the Mainstem						✓		✓	Communities, Volunteer Organizations			On-going	late spring canoe expedition from Brooklyn to Lake Erie	MDNR, Metro/County/Local Parks and Rec
139	Continue to stock Channel Catfish and implement Northern Pike stocking , Evaluate Results of stockings						✓		✓	MDNR, USFWS	?		On-going	mainstem between Tecumseh and Dundee	MDNR, USFWS

KEY: Implementation | Demonstration | Evaluation | Refinement | Widespread Adoption

Table 7-5 Implementation Schedule

INITIATION AND DEMONSTRATION

PHASE	PROJECT	2010 Jan - Jun	2010 Jul - Dec	2011 Jan - Jun	2011 Jul - Dec	2012 Jan - Jun	2012 Jul - Dec	2013 Jan - Jun	2013 Jul - Dec	2014 Jan - Jun	2014 Jul - Dec
INITIATION	Convene Implementation Committee	■									
	E.coli sampling		■	■	■	■	■				
	Natural system inventory		■	■	■	■	■				
	Significant cultural/agricultural site inventory		■	■	■	■	■				
	Develop large woody debris (LWD) inventory program		■	■	■	■	■				
	Road crossing & rapid geomorphic assessment		■	■	■	■	■				
	Identify & prioritize areas for new/improved riparian buffers	■	■			■	■				
DEMONSTRATION	**Public Education and Involvement**										
	River Raisin Watershed Conference				■		■		■		■
	Connecting Schools to Great Lakes Program	■	■	■	■	■	■	■	■	■	■
	River Raisin Watershed History Guide			■	■						
	River Raisin Film Festival				■		■		■		■
	Planning										
	Adoption of improved site design/road ordinance			■	■	■	■	■	■	■	■
	Adoption of riparian buffer ordinance			■	■	■	■	■	■	■	■
	Adoption of LID Stormwater ordinance			■	■	■	■	■	■	■	■
	Agricultural BMPs										
	Nitrogen Ag Committee			■	■	■	■	■	■	■	■
	Drain Tile and Two-Stage Ditch Demonstration Projects			■	■	■	■	■	■	■	■
	Precision Ag Equipment Demonstration Program			■	■	■	■	■	■	■	■
	Renewable energy Farm Demonstration projects			■	■	■	■	■	■	■	■
	New tech. for nutrients & large farm animal waste			■	■	■	■	■	■	■	■
	On-farm treatment of dairy waste demonstration			■	■	■	■	■	■	■	■
	Wetland restoration/creation for water quality			■	■	■	■	■	■	■	■
	Urban/Suburban BMPs										
	Rain Garden Initiative				■	■	■	■			
	LID Outreach				■	■					
	Recreation										
	Lake Erie Access	■	■	■	■	■	■	■	■	■	
	Two Boat Access Sites				■	■	■	■	■	■	■
	Greenway				■	■	■	■	■	■	■
	Lower Raisin Park				■	■	■	■	■	■	■
	Fishing Guide				■	■					
	Conservation/Restoration										
	Natural Rivers Committee			■	■	■	■	■	■	■	■
	Upper River Conservation/Restoration			■	■	■	■	■	■	■	■
	Lower Raisin Wetland Restoration			■	■	■	■	■	■	■	■
	FRED	■	■								
	Bank Stabilization/Stream Restoration	■	■	■	■	■	■	■	■	■	■

EVALUATION - REFINEMENT AND WIDESPREAD ADOPTION

PHASE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
INTERIM MILESTONE EVALUATION	■					■					■					■
ACTION PLAN REFINEMENT	■					■					■					■
WIDESPREAD ADOPTION	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

8.0 EVALUATION METHODS FOR MEASURING SUCCESS

In a watershed dominated by agricultural land-use, the use of a performance-based approach may make it difficult to consistently show improvements (Baker et al., 2005). Given that the outputs from this watershed will be driven mainly by the vagaries of climate, there are some outstanding issues that must be noted, and to the extent practicable, addressed. These issues include: 1) the number of legitimate choices of systems/practices available to farmers will be limited due to economic constraints; 2) ability to accurately predict nutrient reductions/outcomes for practices and systems under a standard or hypothetical set of homogeneous conditions is difficult; 3) the highly variable nature of weather both in time and space and the highly variable spatial nature of soils make predictions for realistic conditions very difficult and 4) the high cost and effort needed to accurately monitor the outcomes are a challenge. Baker et al., (2005) suggest that overcoming the first three issues can be accomplished by providing nutrient criteria based on a frequency analysis that allow for exceedances to occur.

We have divided up the implementation plan into five phases as noted in **Chapter 7**. The idea is that we develop a set of innovative and compelling projects at the outset to help broaden the watershed network and reach of the sustainability mantra. The phases are broken out into 1) implementation, 2) demonstration, 3) interim evaluation, 4) action plan refinement and 5) widespread adoption. Interim measurable milestones and measurement metrics are summarized in **Table 8-1** while the broader and longer term objectives and metrics are summarized in **Table 8-2**.

The modeling evaluation demonstrated that the suite of BMPs have to be applied widely, and intensively. This will take considerable time, effort and resources to accomplish. Further, stakeholders will have to be convinced both that the need is there and that it is to their benefit to pursue this set of actions. We believe that in order to initiate this process and generate excitement about the potential outcomes we have to bring people into the process with a set of exciting, challenging, but ultimately forward-looking projects that will not necessarily have immediate water quality impacts.

Our expectation is that substantive water quality accomplishments will be hard to discern during the implementation and demonstration phases of this project. Metrics for the first five years are almost exclusively devoted to the number and variety of implementation accomplishments and not to water quality improvements, per se. This may seem counterintuitive for a plan specifically focused on water quality; however, the magnitude and geographical extent of problems coupled with the relatively poor understanding of the problems and/or low motivation to change will likely mean significant water quality improvements will take more than five years to accomplish. That being said, we have still planned for the first watershed-wide water quality evaluation of plan performance to take place five years from now in 2014 and every five years thereafter for the entire twenty year planning period.

Water quality performance monitoring during this period, other than individual projects that may include site-specific monitoring to assess project performance, will be limited to the regular data collection at the Blissfield intake, the Heidelberg water quality station at Monroe and the Adopt-A-Stream macroinvertebrate collections in the Spring and Fall of each year.

8.1 Phase 1: Implementation Initiation and Watershed Assessment

Implementation activities include 1) convening an implementation committee and subcommittees, as necessary, to organize implementation activities, introducing communities and organizations in the watershed to the new watershed management plan, soliciting outside funding, monitoring and plan refinement going forward; 2) working to build RRWC capacity and 3) undertaking the additional watershed assessment activities that need to happen to help prioritize improvement activities in the watershed. Metrics for these activities are predominantly structured around confirmation that these activities have occurred (See **Table 8-1**). We have provided six months for the implementation committee to be formed and up to two years for all the watershed assessment projects to be completed (See attached Plan Implementation Schedule). This timetable assumes that adequate outside funding and outside technical support will be provided to undertake these activities. If adequate funding and/or technical support cannot be obtained within a year or so after implementation, these activities will probably take longer than two years to accomplish.

We envision formation of the implementation committee being driven by the RRWC. The RRWC will, of course, also drive the process to build capacity, although the RRWC may need outside technical assistance to develop a plan for building capacity. We have set interim measurable milestones for RRWC capacity building, including the addition of one additional full-time staff person by 2010 and one more additional full-time staff person and two part-time staff people by 2013.

8.2 Phase 2: Demonstration Projects

The demonstration projects and the period during which these projects are performed will be a big key to the success of this plan. The intent of these projects is to address, in some way shape or form, all the goals and objectives of the plan but not necessarily meet the ultimate measurement endpoints from the water quality perspective. We want to see the goals and objectives of this plan gain a foothold in public opinion, and see these demonstration projects capture the imagination and jump start ideas that will reach objective, water quality endpoints later. The metrics for these demonstration projects are quantified in terms of on the ground accomplishments, such as miles of streambank stabilized, acres of wetland restored, achievement of an annual watershed conference, and so on. The interim measurable milestones are structured around these demonstration projects and can be found in **Table 8-1** below

8.3 Phases 3 & 4: Interim Evaluation/Action Plan Refinement

We have specified interim evaluations at five year intervals during the entire 20-year implementation period of the plan (refer to **Table 7-5**). The first interim evaluation is of the degree of implementation of the demonstration projects. Success criteria are based on the actual carrying out of the specified demonstration activities. Water quality evaluations will be a part of the first interim evaluation; however, expectations for achieving significant water quality improvements at this juncture will be low. Following the first interim evaluation, assuming the goals are met, the succeeding interim evaluations will be judged solely on the goals that enumerated in **Table 8-2** below.

To put it in another way, the objective is to start looking for (expect) substantive water quality improvements ten years after implementation. The interim evaluations are tied to a continuous refinement process. The implementation committee, with help as needed by outside technical experts, will evaluate not only progress toward overall goals, but will also evaluate the appropriateness of the goals themselves. This refinement process occurs explicitly at these five year intervals when the plan metrics are evaluated and progress tallied up. If progress toward the goals is not being made then the implementation committee, subcommittees and allied groups will have to try and determine the underlying causes for the lack of progress and adjust the implementation plan and perhaps the monitoring plan to reflect this new understanding.

At the conclusion of the five year demonstration period, and in conjunction with the five-year river sampling cycle of the MDEQ, the twenty stations adopted by this plan will be sampled for the same suite of constituents, including temperature, pH, dissolved oxygen, conductivity, total suspended solids, total phosphorus, dissolved reactive phosphorus, nitrate, total kjeldahl nitrogen and *e. coli* (or other bacteria, e.g., see Layton, 2006). We also recommend that additional fish tissue sampling be conducted in areas identified with impairments for PCBs and mercury on a regular five-year cycle. We believe this effort should continue to be conducted by the MDEQ.

Ideally this sampling effort would be conducted over a spring and summer seasons, with at least one synoptic survey in the spring, preferably after thaw. Another synoptic survey, theoretically, should be conducted during a significant wet weather event (>0.5 inches of rainfall in 12 hours) and the last synoptic survey during a low flow period in mid to late summer. This is a major sampling effort that will require more resources than MDEQ currently devotes to sampling in the Raisin. Coupling this effort with local college/university help (e.g., University of Michigan, Adrian College, etc.) will help provide manpower and expertise for a reasonable cost, but clearly an additional source of funding will have to be identified to help pay for each watershed-wide sampling effort.

At a minimum, the data collected at the Blissfield intake and at the Heidelberg College sampling station can be used to assess annual trends for total suspended solids and for nutrients.

8.4 Phase 5: Widespread Adoption

By the end of the demonstration and first interim evaluation phases, a map for actions from that point forward should be drawn up. This map represents the combination of actions that have proven cost-effective during the demonstration phase or other ideas, actions and programs that have materialized in the meantime that help the plan reach its ultimate goal of lifting all water quality impairments in the watershed. Progress towards lifting impairments should always be the final metric actions are measured against.

With each five year cycle, it will be important to assess trends towards final implementation goals. We do not hold that with each five year cycle, 20% progress towards each objective should be achieved. This is an over-simplification of how these actions impact the watershed. The goal should be positive progress towards each end point at each five-year assessment point. If forward progress on the plan has not been made at each of the five year assessments, than the reasons for the lack of progress need to be understood. Either the goals and objectives were too ambitious, the management activities are not effective, or the goals themselves need to be re-assessed. This is part of the adaptive management process and the implementation committee must be prepared to potentially develop new approaches to addressing problems in the watershed mid-stream, so to speak.

Table 8-1 Interim Measurable Milestones

Activity	Description	Goal	Location	Time Frame* (Years)
Additional Watershed Assessment	E. coli Source Assessment	Identify/narrow sources for existing bacteria TMDLs	Adrian WWTP, Lenawee County Drain #70, Lower RR, Saline River	1-2
	Road Crossing Survey	Evaluate >10% of main stem and main tributary stream length	Watershed-wide	1-2
	Rapid Geomorphic Assessment	Evaluate >10% of main stem and main tributary stream length	Watershed-wide	1-2
	Lower Raisin buffer evaluation	Evaluate >50% of main stem and main tributary	SB,BC,LL,LR,M,S	1
	Natural system inventory	Evaluate entire lower Raisin	SB,BC,LL,LR,M,S	1-2
	Significant cultural/agricultural site inventory	Evaluate entire Raisin	Watershed-wide	1-2
	LWD Inventory program	Evaluate mainstem Raisin	Adrian to Dundee	1-2
Achieve Nitrate TMDL & Reduce Dissolved Reactive Phosphorus Loads	Pilot Performance-based Farm Environmental Control Program (PEPA)	Sign-up 5,000+ acres of contiguous farmland	South Branch or Black Creek	2 - 5
	Precision Agricultural Equipment Funding Demonstration Program	At least $3M in financial assistance provided/5,000 ac of buffers	S. Branch, Black, Lower, Evans	2 - 5
	Nutrient and manure control demonstration projects	At least 5 projects initiated/completed	S. Branch, Black, Lower, Evans	2 - 5
	Drain tile and 2-stage ditch demonstration projects	At least 5 projects initiated/completed	S. Branch, Black, Lower, Evans	2 - 5
	On-farm dairy manure re-use and anaerobic digestor demonstration	At least 5 projects initiated/completed	S. Branch, Black, Lower, Evans	2 - 5
	On-farm renewable energy demonstration projects	At least 5 projects initiated/completed	S. Branch, Black, Lower, Evans	2 - 5
Achieve Pathogen TMDLs	Create Illicit discharge elimination programs	Creation of county Illicit discharge elimination program	Lenawee County	2 - 5
	Improve private on-site sewage programs	Lenawee County & Monroe County	Lenawee & Monroe Counties	2 - 5
	Initiate point of sale septic system inspections	Double number of septic system inspections	Lenawee & Monroe Counties	2 - 5
	Remediate failing septic and private wastewater systems	Demonstrate compliance on at least 75% remediated systems	Lenawee & Monroe Counties	2 - 5
Reduce Bioaccumulative	Remove Raisin PCB Hotspots	Completion of removal	Monroe AOC	2 - 5
	Implement Habitat Improvement Projects	At least 2 AOC habitat projects implemented	Monroe AOC	2 - 5
Reduce Sedimentation, Total Phosphorus, and Hydrologic Variability	New site and road design standards	At least 2 communities/counties adopting	Adrian, Monroe, Saline	2 - 5
	riparian buffer ordinance	At least 2 communities/counties adopting	Upper RR, Goose, Iron	2 - 5
	LID ordinance	At least 2 communities/counties adopting	Upper RR, Goose, Iron	2 - 5
	Rain Garden Initiative	100 rain gardens installed	Adrian, Monroe, Saline	2 - 5
	Large-scale LID new development project	At least 2 > 5 acres of developed area	Watershed-wide	2 - 5
	Large-scale retrofit LID project	At least 2 > 5 acres of developed area	Watershed-wide	2 - 5
RRWC Development	Increase RRWC capacity	Add 1 FT staff in 2yrs\Add another 1 FT by 5 yrs Add 1 PT staff in 2yrs\Add another 1 PT by 5 yrs New board/Exec Committee Structure	Adrian	1
Public Education and Involvement Demonstration	Annual River Raisin Watershed Conference	Hold first conference by 2010	Watershed-wide	1
	Connecting Schools to the Great Lakes Program	Twenty schools - 200 students by 2013	Monroe County	1 - 4
	River Raisin Watershed History Guide	Finish guide by 2010		1
	River Raisin Film Festival	Hold first festival by 2010	Watershed-wide	1
Conservation & Restoration	Natural Rivers Designation for Upper Raisin	Committee formed and nomination submitted	Brooklyn to Manchester	2 - 5
	Upper Raisin conservation area	At least 1,000 acres of new conservation area committed	Upper RR, Goose, Iron	2 - 5
	Lower Raisin wetland restoration	1,000 ac of restored wetland areas committed/500 ac completed	S. Branch, Black, Lower, Evans	2 - 5
	Bank stabilization/stream restoration projects	At least 2 mi. of bank stabilization/stream restoration completed	S. Branch, Black, Lower, Evans	2 - 5
Recreation	Lake Erie access (RR Battlefield site to Sterling State Park)	Project initiated	Monroe	1
	Canoe/Fishing access	At least 2 new, improved access points	Watershed-wide	2 - 5
	River Raisin Fishing Guide	At least 1 print-ready guide (PDF format & printed version)	Watershed-wide	3
	New Upper Raisin Greenway	At least 1 in progress	Upper RR, Goose, Iron	2 - 5
	New Lower Raisin Park	At least 1 in progress	Monroe	2 - 5

* Time to accomplish milestone measured from the beginning of plan implementation

Table 8-2 Quantitative Monitoring Metrics

Goal	Target	Metric/Measurement Process	Location	Frequency
Achieve Nitrate TMDL & Reduce DRP	NO3 99th%tile < 10 mg/L	NCWQR water quality data	Monroe	Bi-Annually
	NO3 Avg < 2 mg/L	Water plant intake data	Blissfield & Deerfield	Bi-Annually
	Avg DRP < 0.015 mg/L	NCWQR water quality data	Monroe	Bi-Annually
		Interim watershed-wide WQ assessment	All WQ Monitoring Sites	1x every 5 years
Achieve Pathogen TMDLs	<130 cfu/100 ml 30 day average <1,000 cfu/100 ml maximum	RRWC supplemental EC sampling	Adrian WWTP, Lenawee County Drain #70, Lower RR, Saline River	One time in 2010-2011
	<130 cfu/100 ml 30 day average <1,000 cfu/100 ml maximum	Interim watershed-wide WQ assessment	All Pathogen impaired sites	1x every 5 years
Remove/Reduce BCCs	Reduce caged fish PCB uptake	Fish tissue samples meeting consumption criteria	Monroe AOC	1x every 5 years
Increase Public Awareness and Involvement	100% increase in Adopt A Stream volunteers	Annual volunteer count	Watershed-wide	Annually
	100% increase of public survey scores	Administer survey every 5 years	Watershed-wide	1x every 5 years
Build RRWC Capacity	2 additional FT/2 additional PT staff Triple existing RRWC Annual Budget New board/executive committee Add 3 new categories of funding	Staff count Annual budget Committee make-up Types of funding sources	Adrian	Assess 2011 & 2014
Reduce Sedimentation, TP and Hydrologic Variability	Avg TSS < 30 mg/L (pre-1995 conc.s)	Heidelberg water quality data	Monroe	Bi-Annually
		Water plant intake turbidity data	Adrian, Blissfield, Deerfield	Bi-Annually
	25% reduction in flashiness index	Apply Baker-Richards flashiness index to USGS gage data	Manchester, Adrian and Monroe	1x every 5 years
	All macroinvertebrate scores > MI Corps "Good" category	Adopt A Stream program	All WQ Sampling Sites	1x every 5 years
Conserve and restore natural features	10,000 additional acres conserved	# acres of conservation	Upper RR, Goose Creek, Iron Creek	1x every 5 years
	150 miles of bank stabilization/stream restoration	Miles of bank stabilization/stream restoration	S. Branch, Black Creek, Lower RR, Macon Creek	1x every 5 years
	325 miles of riparian buffers	Miles of riparian buffers > 50-ft wide	S. Branch, Black Creek, Lower RR, Macon Creek, Saline River	1x every 5 years
	5,000 acres of wetlands restored	# acres of wetland restoration	South Branch, Black Creek, Lower RR, Little RR & Macon Creek	1x every 5 years
Increase recreational opportunities	4 new river access points	Community feedback	Upper RR, Goose Creek, Iron Creek, Lower RR, Saline	1x every 5 years
	50 miles of new trails/greenways	Community feedback	Upper RR, Goose Creek, Iron Creek, Lower RR, Saline	1x every 5 years
	2 new parks	Community feedback	Upper RR, Goose Creek, Iron Creek, Lower RR, Saline	1x every 5 years

9.0 LONG-TERM SUSTAINABILITY

Carrying out this plan for the next twenty years or so will be a challenge from year one to year twenty. Clearly, the number one hope for implementing the greatest number of recommendations having the greatest impact, is that a growing group of individuals commit to improving the watershed. It is only by commitment that setbacks, slow progress or negating circumstances outside anyone's control can be worked through to find later success.

The other key factor for successful implementation in this watershed is attracting resources. The term 'resources' here means money, personnel, research, partnerships, etc. that accrue to the effort to improve the watershed. Support attracts other support. Stakeholder organizations in the watershed should be working to understand grant/resource opportunities and taking advantage of them as they arise.

9.1 Steering Group for Implementation

In the same manner that the RR WMP was led by a steering committee, plan implementation should also be driven by an oversight group that can help act as a clearing house for watershed-wide, local and regional initiatives. Consideration should be given to a name that attracts, action-oriented individuals, such as the River Raisin Watershed Action Team or Action Committee or Implementation Team or Implementation Committee.

9.2 Subwatershed Groups

Given the problems that already occur with the dilution of funds across the watershed, organizing subwatershed groups for the River Raisin should not be an immediate priority. River Raisin groups should partner together in the umbrella implementation committee to foster working relationships and make the most efficient use of group resources to attract outside assistance. This is not to preclude the creation of subwatershed groups that highlight and advocate for local problems and solutions. However, these groups should be represented by one or more stakeholders in the larger River Raisin Implementation Committee and continue to use the larger vehicle for educating their stakeholders, locating funding sources and technical groups that can help implement solutions.

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APPENDICES

Agriculture
- Agricultural Business
- Biofuels and Carbon
- BMPs
  - Two-Stage Channels
- Farm Policy

Example Ordinances

Funding Sources
- Carbon Offsets

Hydrology

Low Impact Development (LID) Manual

Large Woody Debris (LWD)

Macro Report

Macroinvertebrates and Mussels

Natural Features
- Wetlands

Public Education and Involvement
- Example Education Materials

Quality Assurance Project Plans (QAPPs)

Recreation
- Southeast Michigan Greenways

Riparian Buffers

River Raisin Assessment – Dodge

Social Survey

University of Michigan Masters Projects

Water Quality

- Geobook Water Quality Summary
- Heidelberg Data
- MDEQ Impairments and TMDLs
- Mercury
  - MDEQ Mercury Strategy
- SWAT
- Watershed Treatment Model