River Raisin Watershed Management Plan

River Raisin Watershed Council

Project Partners:
Lenawee Conservation District
University of Michigan School of Natural Resources and the Environment
Stantec
JFNew

Submitted June 25, 2008
Re-submitted June 5, 2009
Final submission September 30, 2009

Partially funded by Clean Water Act Section 319 Grant administered by the MDEQ
MDEQ Tracking Code 2005-0117

Cover Art by Tom Thiery

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

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY 9
1.1 Water Quality Concerns 11
1.2 Goals and Objectives 13
1.3 Recommendations 14
1.4 Adaptive Planning 15
2.0 Introduction 16
2.1 The Great Lakes and the River Raisin Watershed 16
2.1.1 The Bad News 18
2.1.2 The Good News 20
2.2 Purpose of the Watershed Plan 21
2.3 Stakeholder Participation 22
3.0 Characteristics of the River Raisin Watershed 24
3.1 Geology and Soils 24
3.2 History 26
3.3 Climate and Global Warming Implications 29
3.4 Land Use and Growth Trends 31
3.5 Hydrology 33
3.5.1 Flooding and Drainage 37
3.5.2 Flashiness 38
3.6 Channel Morphology 40
3.6.1 Headwaters to Tecumseh 42
3.6.2 Tecumseh to Dundee 42
3.6.3 Dundee to Lake Erie 43
3.7 Water Quality and Quantity Impacts 43
3.7.1 TMDLs/303d Listings 44
3.7.2 AOC 44
3.7.3 Agriculture 48
3.7.4 Point Sources, including CAFOs 49
3.7.5 Consumptive Water Use 52
3.7.6 On-site wastewater treatment 54
3.7.7 Underground Storage Tanks 54
3.8 Watershed Fauna 55
3.8.1 Fish 55
3.8.2 Mussels 56
3.8.3 Amphibians 56
3.8.4 Reptiles 57
3.8.5 Mammals 57
3.8.6 Birds 57
3.9 Invasives 58
3.9.1 Aquatic nuisance species 58
3.9.2 Terrestrial and wetland plants 58
3.9.3 Pests and pathogens 59
3.10 Regionally Significant Ecological Systems and Species 59
3.10.1 Aquatic Ecological Systems 59
3.10.2 Terrestrial Natural Communities 60
4.0 Current Conditions of the River Raisin Watershed 62
4.1 Heidelberg College National Center for Water Quality Research 62
4.2 Regional - USGS Lake Erie Tributary & Michigan Chemistry Water Quality Monitoring Project 65
4.3 UM Water Quality Surveys 66

4.3.1 Total Nitrogen 68
4.3.2 Total Phosphorus 70
4.3.3 Total Suspended Matter 71
4.3.4 Conductivity 73
4.3.5 Water Temperature, Dissolved Oxygen & pH 74
4.3.6 E. Coli 75
4.3.7 UM Water Quality Summary 75
4.4 Macroinvertebrates 76
5.0 PRIORITIZING Challenges and Goals in the River Raisin Watershed 79
5.1 Designated Uses 80
5.1.1 Status of Designated Uses 81
5.2 Prioritization of Pollutants and Sources 82
5.2.1 Prioritization of Pollutants and Sources for Impaired Uses 82
5.2.2 Prioritization of Sources and Causes for Threatened Uses 88
5.3 Pollutant Load Estimation 88
5.3.1 SWAT Model Calibration and Evaluation 89
5.3.2 NPDES Point Source and Septic Field Loads 92
5.4 Geographic Water Quality Priorities 94
5.4.1 Highest Priority Water Quality Subwatersheds: S. Branch RR and Black Creek 95
5.4.2 High Priority Water Quality: Lower River Raisin, Macon Creek, Evans Creek, Saline River, & Little River Raisin 95
5.4.3 High Priority Conservation: Goose Creek, Iron Creek, Upper RR 95
5.5 Watershed Goals and Objectives 98
5.5.1 Watershed Goals 98
5.5.2 Water Quality Goals 100
6.0 Proposed Implementation Activities 101
6.1 Achieve Nitrate TMDL (and Reduce Dissolved Reactive Phosphorus Loading) 102
6.1.1 Source Control Strategies for Reducing Nitrate and DRP Losses from Farm land 103
6.1.2 Post-Fertilizer/Manure Application Strategies for Reducing Nitrate and DRP Losses from Farm Land 107
6.1.3 Post-Fertilizer/Manure Application Strategies for Reducing Solids and TP Losses from Farm Land 109
6.2 Achieve Target Pathogen Concentrations 111
6.3 Reduce Sedimentation, Total Phosphorus & Hydrologic Variability 114
6.3.1 Planning 116
6.3.2 Urban and Suburban Best Management Practices 118
6.3.3 Non-Structural BMPs 119
6.3.4 Stuctural BMPs: Runoff Volume/Infiltration-Oriented 119
6.3.5 Structural BMPs: Runoff Volume/Non-Infiltration-Oriented 123
6.3.6 Structural BMPs: Runoff Quality/Non-Infiltration 123
6.4 Reduce/Remove Bioaccumulative Chemicals of Concern 125
6.5 Build RRWC Capacity 127
6.6 Public Information and Education Plan 128
6.6.1 Goals and Objectives of the Plan 129
6.6.2 Target Audiences 129
6.6.3 Target Messages and Public Communication Strategies 129
6.7 Conserve and Restore Natural Features 144
6.8 Increase Recreational Opportunities 149
6.9 General Economic Recommendations 152
7.0 Watershed Action Plan 156
7.1 Phase 1 Tasks: Initiate Implementation and Perform Additional Watershed Assessment 156
7.1.1 Phase 1 Task 1: Create Implementation Committee 157

7.1.2 Phase 1 Task 2 – Build Organizational Capacity 157
7.1.3 Phase 1 Task 3: Watershed Assessment 157
7.2 Phase 2: Demonstration Projects 158
7.2.1 Achieve Nitrate TMDL and Reduce Dissolved Reactive Phosphorus Loads 158
7.2.2 Lift Pathogen Impairments 159
7.2.3 Sediment, Total Phosphorus (TP), and Hydrologic Variability 159
7.2.4 Remove/Reduce Bioaccumulative Chemicals of Concern 160
7.2.5 Public Involvement and Education 161
7.2.6 Conservation/Restoration 162
7.2.7 Recreation 162
7.3 Phases 3 and 4: Interim Evaluation and Widespread Implementation 163
7.4 Anticipated Water Quality Improvements 163
7.4.1 SWAT Model Results 164
7.5 Estimated Costs and Schedule 169
8.0 Evaluation Methods for Measuring Success 179
8.1 Phase 1: Implementation Initiation and Watershed Assessment 180
8.2 Phase 2: Demonstration Projects 180
8.3 Phases 3 & 4: Interim Evaluation/Action Plan Refinement 180
8.4 Phase 5: Widespread Adoption 181
9.0 Long-term Sustainability 184
9.1 Steering Group for Implementation 184
9.2 Subwatershed Groups 184
10.0 REFERENCES 185
11.0 APPENDICES 193

TABLE OF FIGURES

Figure 1-1 Major Subwatersheds and Jurisdictional Boundaries of the River Raisin 10
Figure 2-1 River Raisin Location Map (Source: Fongers, 2006) 18
Figure 2-2 LANDSAT image of phytoplankton bloom in western Lake Erie, August 18, 2003 (image from LANDSAT 7 server courtesy of OhioView) 19
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) 20
Figure 2-4 Detroit River International Wildlife Refuge Map 21
Figure 3-1 Headwaters intersection of the Raisin (watershed #29), St. Joseph (#34), Grand (#14), Kalamazoo (#17) and Maumee (#21) rivers (Clark, 1999) 24
Figure 3-2 River Raisin Watershed surficial geology map 26
Figure 3-3 River Raisin Watershed Pre-settlement Vegetation (circa 1800) 27
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) 28
Figure 3-5 Change in North American Mean Temperature (and other parameters) since 1955 30
Figure 3-6 Potential Climate Change Impact on Michigan 31
Figure 3-7 Current River Raisin Land Use (Bennett et al., 2006) 32
Figure 3-8 Major Subbasins of the River Raisin (Fongers, 2008) 35
Figure 3-9 Annual Hydrograph for River Raisin mainstem east of Adrian period of record 1954 – 1994 36
Figure 3-10 Flow duration curves for USGS gaging stations on the River Raisin (from: Dodge, 1998) 37
Figure 3-11 Impervious area fractions for 1978 land use (Fongers, 2006) 39
Figure 3-12 Estimated change in runoff yield from 1800 to 1978 (Fongers, 2006) 39
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 40

Figure 3-14 Elevation drop along the mainstem of the River Raisin (from Dodge, 1998) 41
Figure 3-15 Gradient along the mainstem of the River Raisin (from Dodge, 1998) 42
Figure 3-16 Map of River Raisin 303(d) and TMDL Areas (figure by Stantec) 45
Figure 3-17 River Raisin Area of Concern (USEPA, 2008a) 47
Figure 3-18 PCB Uptake in Caged Fish Studies at the mouth of the River Raisin (excerpted table from MDEQ, 2005).....48
Figure 3-19 NPDES Point Source Permit Map.....51
Figure 3-20 Concentrated Animal Feeding Operations Map 52
Figure 3-21 Average Annual Daily Reported Water Consumption (total surface water and groundwater withdrawals) in the River Raisin Watershed (MDEQ, 2007b).....53
Figure 3-22 Schematic of Detroit Edison's Monroe Power Plant cooling water intake and aerial photograph of plant (circa 1981) (Dodge, 1998) 54
Figure 3-23 Sewer and Water Service Areas in the River Raisin Watershed 55
Figure 3-24 Michigan Department of Natural Resources Stream Ratings (from Dodge, 1998) 60
Figure 4-1 Cumulative Histogram of Total Suspended Solids Concentrations at Heidelberg College River Raisin Station at Monroe (1982-2007).....63
Figure 4-2 Cumulative Histogram of Total Phosphorus Concentrations at Heidelberg College River Raisin Station at Monroe (1982-2007).....64
Figure 4-3 Cumulative Histogram of Nitrate Concentrations at Heidelberg College River Raisin Station at Monroe (1982-2007). 64
Figure 4-4 Average annual, flow-corrected Suspended Solids and Nitrate concentrations at Heidelberg College River Raisin station at Monroe (Suppnick, 2008).....65
Figure 4-5 Average annual, flow-corrected Total Phosphorus and Dissolved Reactive Phosphorus at Heidelberg College River Raisin station at Monroe (Suppnick, 2008) 65
Figure 4-6 Water Quality Sampling Dates and Flow at Adrian USGS Gage.....67
Figure 4-7 Location of Water Quality Sampling Sites 68
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. 69
Figure 4-9 Range of concentrations of TN from synoptic surveys in the River 69
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. 70
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).....71
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. 72
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). 72
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. 73
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).....74
Figure 4-16 Marcoinvertebrate sampling sites in the River Raisin 77
Figure 4-17 Macroinvertebrate sampling summary using the MI Corps Index (type and diversity quality). From: Adopt-A-Stream program sampling from 2002-2007.....78
Figure 5-1 SWAT-Identified Sub-Basins of the River Raisin 90
Figure 5-2 SWAT Model Hydrologic Calibration Comparison with USGS Gage on the River Raisin near Monroe (1998-2001). 91
Figure 6-1 Habitat Restoration Areas for the River Raisin AOC (ECT, 2008) 126
Figure 6-2 Low-Head Dams and Waterloo Dam on the River Raisin in Monroe 126

Figure 6-3 Remaining River Raisin PCB Hot Spots in the AOC (ECT, 2008) 127
Figure 6-4 Potential Restoration Areas for Habitat Opportunities....147
Figure 6-5 Potential Wetland Restoration Areas for Habitat and Water Quality Improvements....148
Figure 6-6 Proposed Southeastern Michigan Greenway Plan (Greenway Collaborative, Inc., 1999). 152
Figure 7-1 SWAT Model Nitrate Yield Results 167
Figure 7-2 SWAT Model Phosphorus Yield Results 168
Figure 7-3 SWAT Model Sediment Yield Results....168

TABLE OF TABLES

Table 3-1 Current Land Use in the River Raisin Watershed (from: Gothie et al., 2007)....33
Table 3-2 Subwatershed Grouping By Agricultural Land Coverage....33
Table 3-3 USGS Flow Gaging Stations in the River Raisin 34
Table 3-4 Flashiness Trend Comparison with Agricultural Land Use Cover....40
Table 3-5 River Raisin TMDLs and 303D-Listed Segments 46
Table 3-6 Globally Imperiled or Declining Species 61
Table 4-1 Water quality concentration categories 67
Table 4-2 Water Temperature, Dissolved Oxygen & pH....75
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....76
Table 4-4 Concentration of TP and TN at sites at the mouth of priority subwatersheds. 76
Table 5-1 Annual Nitrogen Load Estimates by Source in the River Raisin Nitrate TMDL 83
Table 5-2 Nitrate Loss Intensity for Subwatersheds based on River Raisin GeoBook Analysis 83
Table 5-3 Prioritized River Raisin Impaired Use and Threatened Use Pollutants....85
Table 5-4 River Raisin Prioritized Pollutants and Prioritized Sources 86
Table 5-5 Prioritization of Causes of Impairments....87
Table 5-6 Average Unit Area Loads for Rural and Residential Land Uses, lbs/ac/year 88
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....89
Table 5-8 Calibrated SWAT Model Subwatershed Unit Area Pollutant Loads 91
Table 5-9 Calibrated SWAT Model Subwatershed Pollutant Loads and Percent Total Load 92
Table 5-10 Example Septic System Effluent Water Quality....93
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....93
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 94
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 94
Table 5-14 Summary of River Raisin Geobook Water Quality Impact Analyses....95
Table 5-15 Water Quality Summary by Subwatershed in the Raisin River....97
Table 5-16 River Raisin Watershed Goals and Objectives....99
Table 5-17 Quantitative Water Quality Goals 100
Table 6-1 Strategic and Geographic Prioritization of Nitrate and Dissolved Reactive Phosphorus Management Practices....104
Table 6-2 Summary of federal cost-share programs available to landowners in the River Raisin watershed. ...109
Table 6-3 Prioritization of Sources and Management Practices to Address Pathogens 113
Table 6-4 Prioritization of Sources and Management Practices to Reduce Sedimentation, TP and Hydrologic Variability 115
Table 6-5 Information and Education Plan 136
Table 6-6 Acreage of conservation and recreation lands in the River 149

Table 7-1 Summary of Sensitivity Models for Evans Creek 165
Table 7-2 Summary of BMPs in Each Subwatershed 166
Table 7-3 Summary of SWAT Model Results at Outlet of River Raisin Watershed.....167
Table 7-4 River Raisin Watershed Action Plan.....170
Table 7-5 Implementation Schedule 178
Table 8-1 Interim Measurable Milestones..... 182
Table 8-2 Quantitative Monitoring Metrics 183

LIST OF ACRONYMS

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).

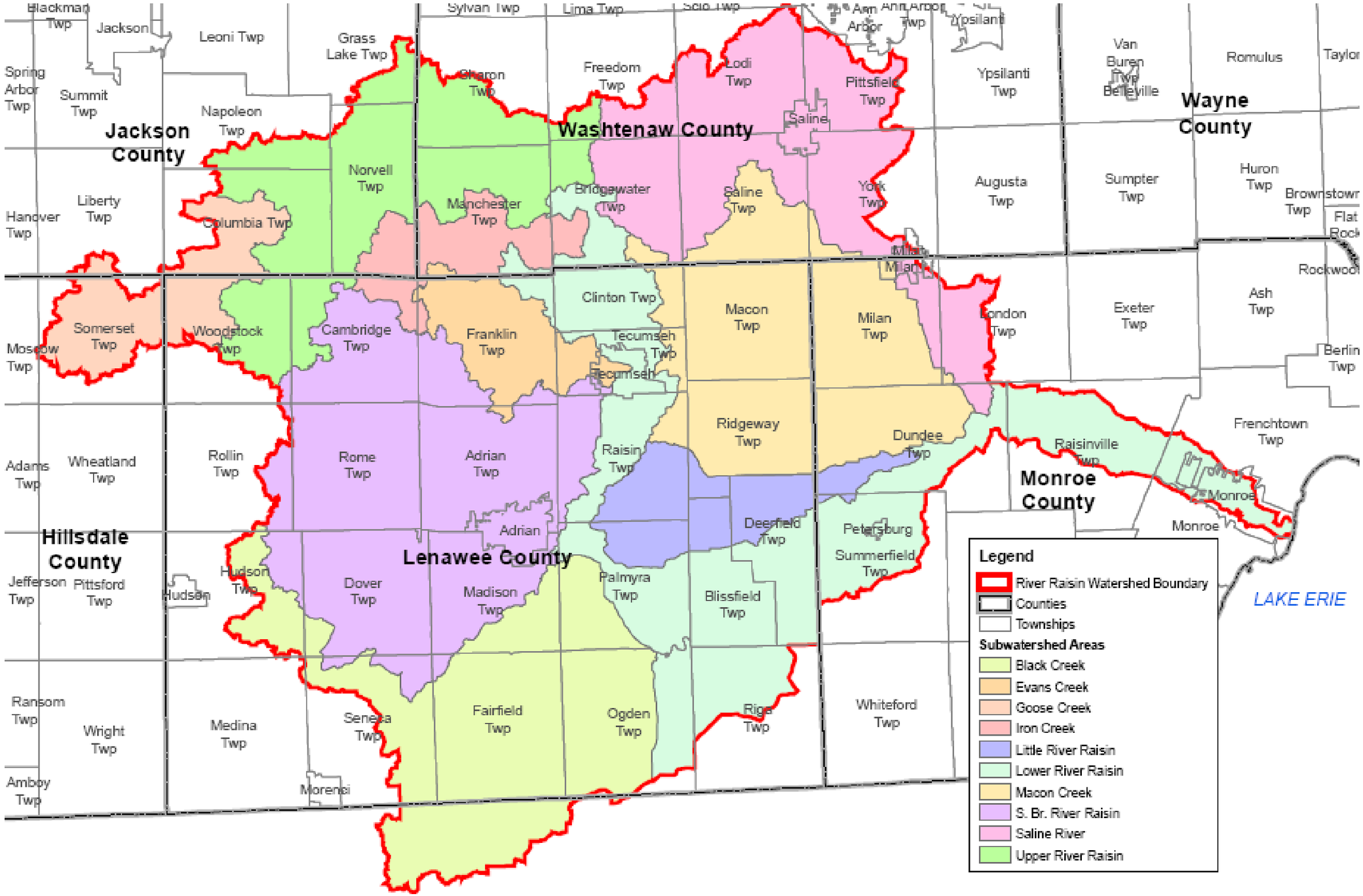


Figure 1-1 Major Subwatersheds and Jurisdictional Boundaries of the River Raisin

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.

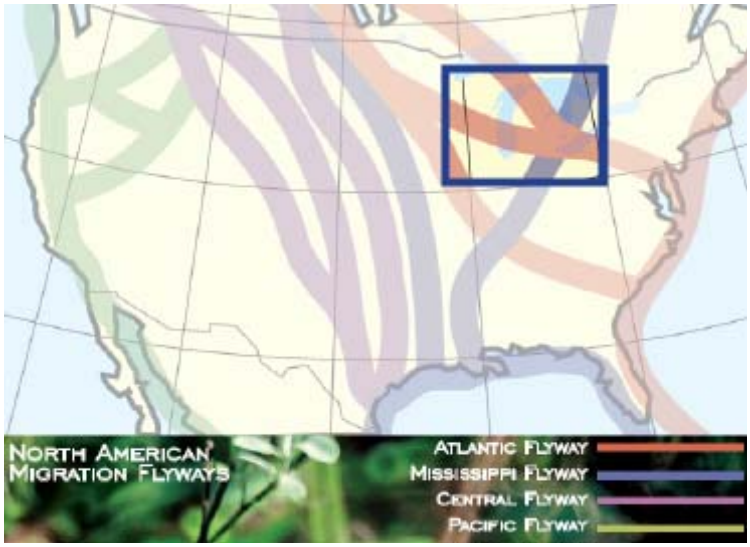


Figure 2-3 Major Bird Migration Paths through the United States (from: Byways to Flyways – A Driving Tour of Featured Birding Locations in the Windsor-Detroit Metropolitan Region. Prepared for the International Wildlife Refuge)

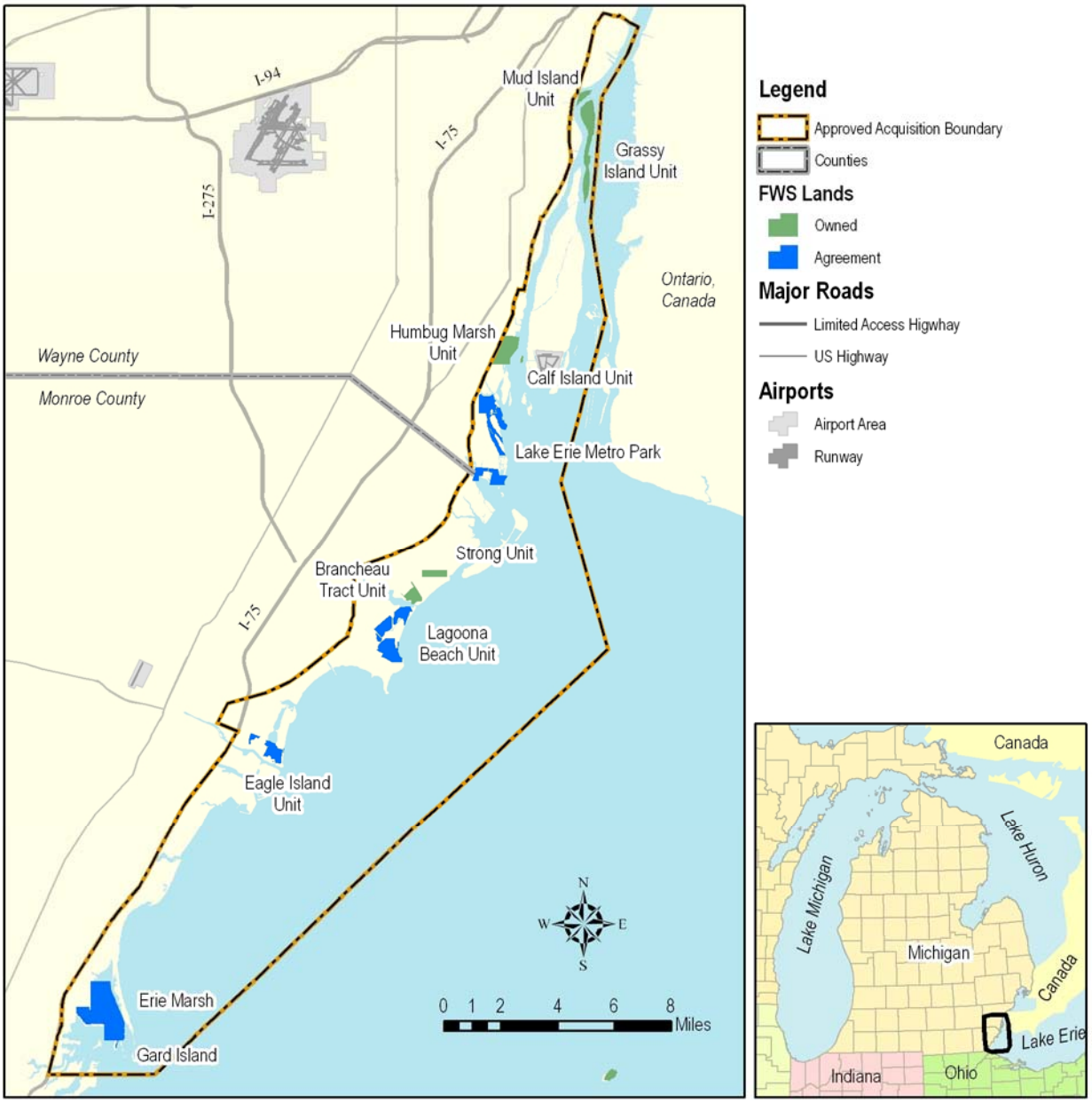


Figure 2-4 Detroit River International Wildlife Refuge Map
(http://www.fws.gov/midwest/detroitriver/)

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).

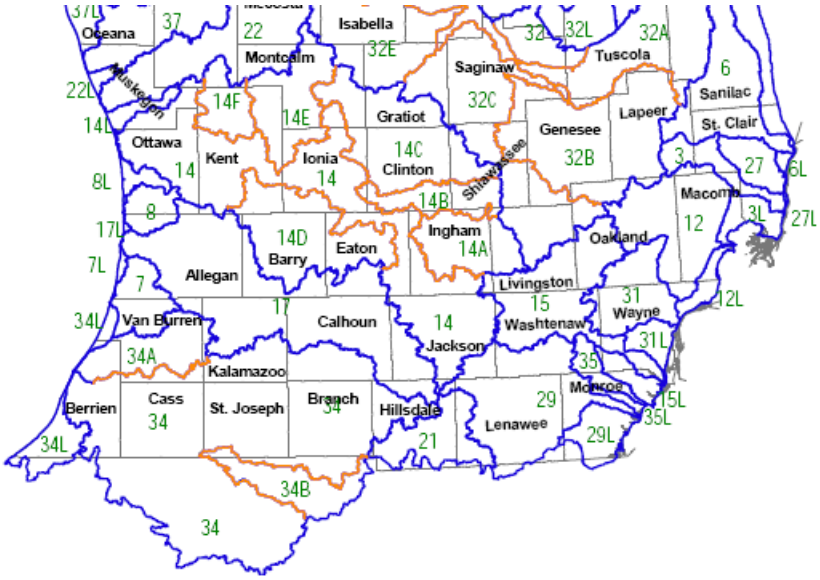


Figure 3-1 Headwaters intersection of the Raisin (watershed #29), St. Joseph (#34), Grand (#14), Kalamazoo (#17) and Maumee (#21) rivers (Clark, 1999)

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).

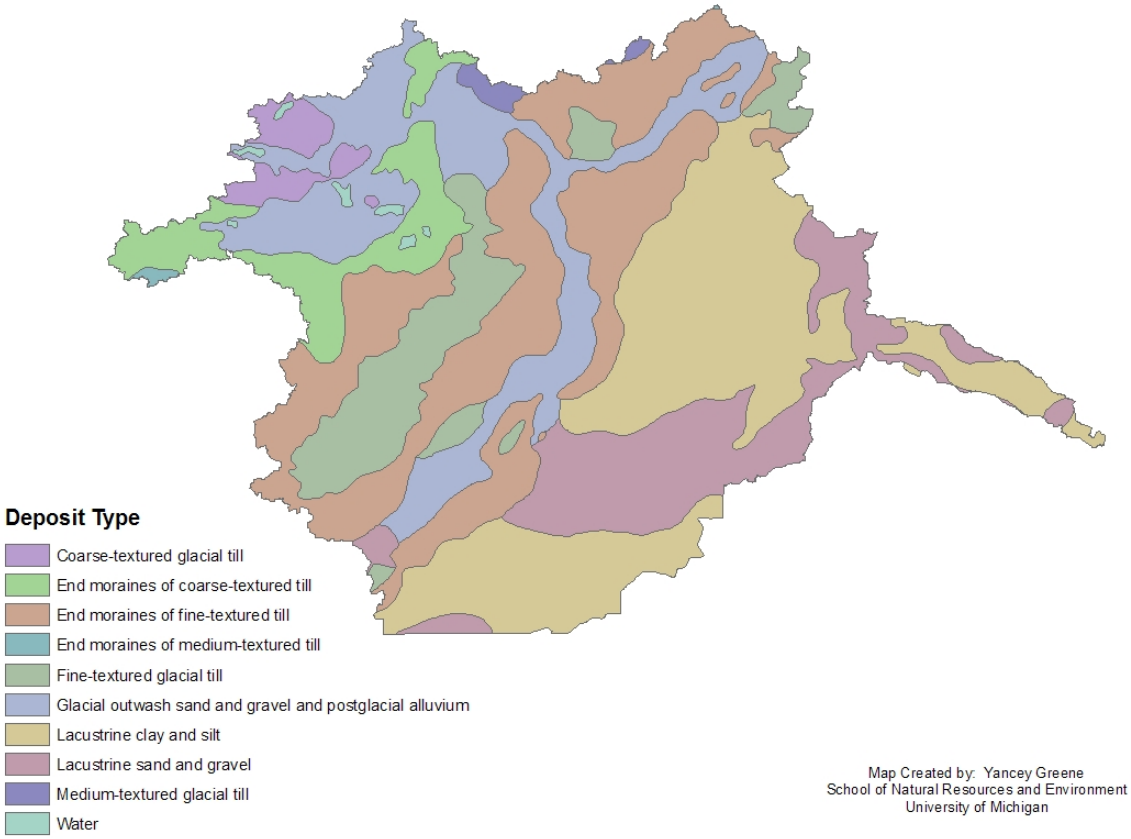


Figure 3-2 River Raisin Watershed surficial geology map (Michigan Center for Geographic Information)

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.

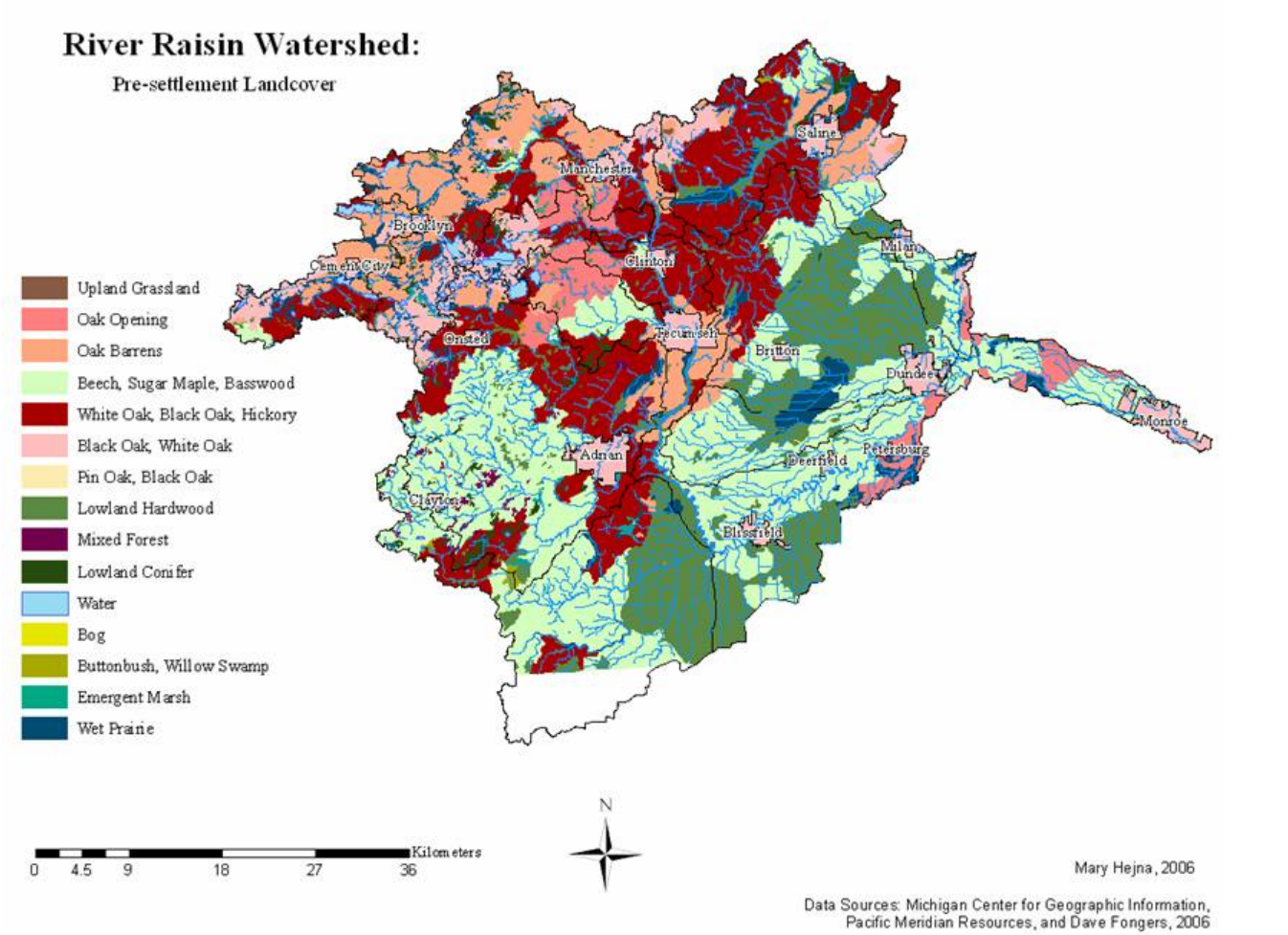


Figure 3-3 River Raisin Watershed Pre-settlement Vegetation (circa 1800)

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.

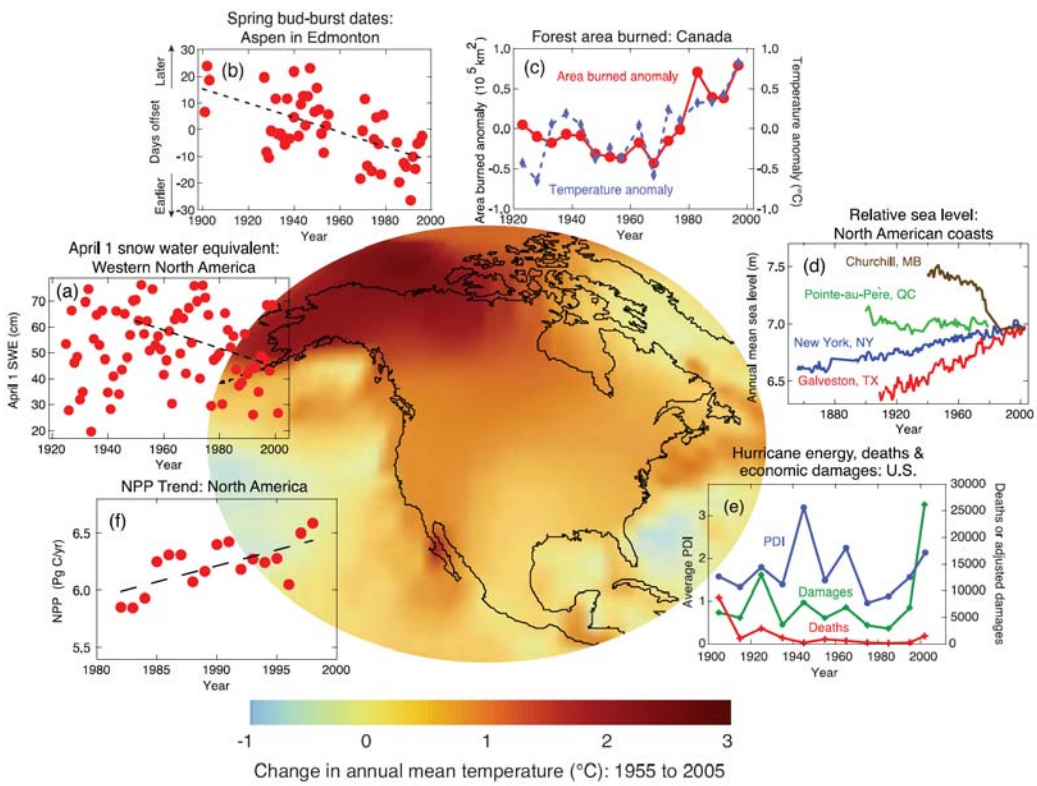


Figure 3-5 Change in North American Mean Temperature (and other parameters) since 1955

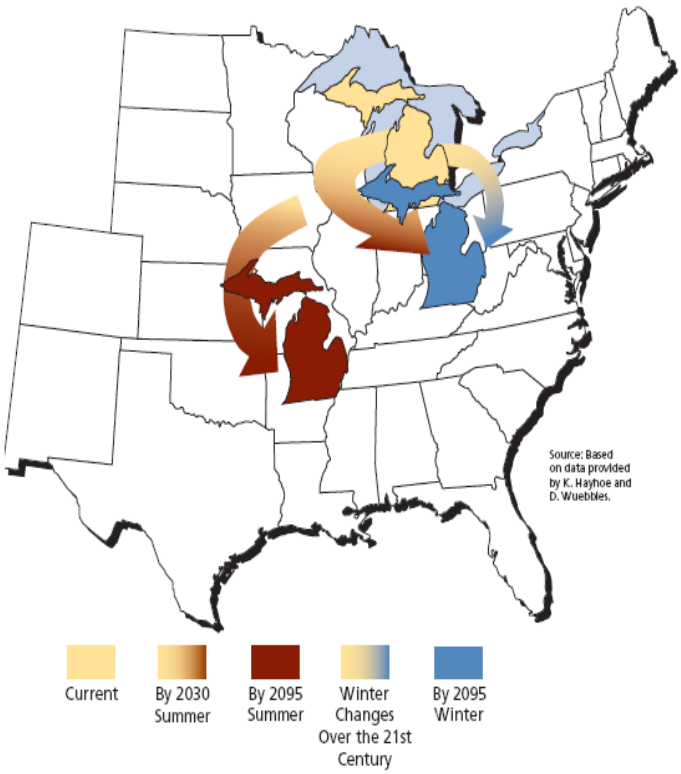


Figure 3-6 Potential Climate Change Impact on Michigan

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).

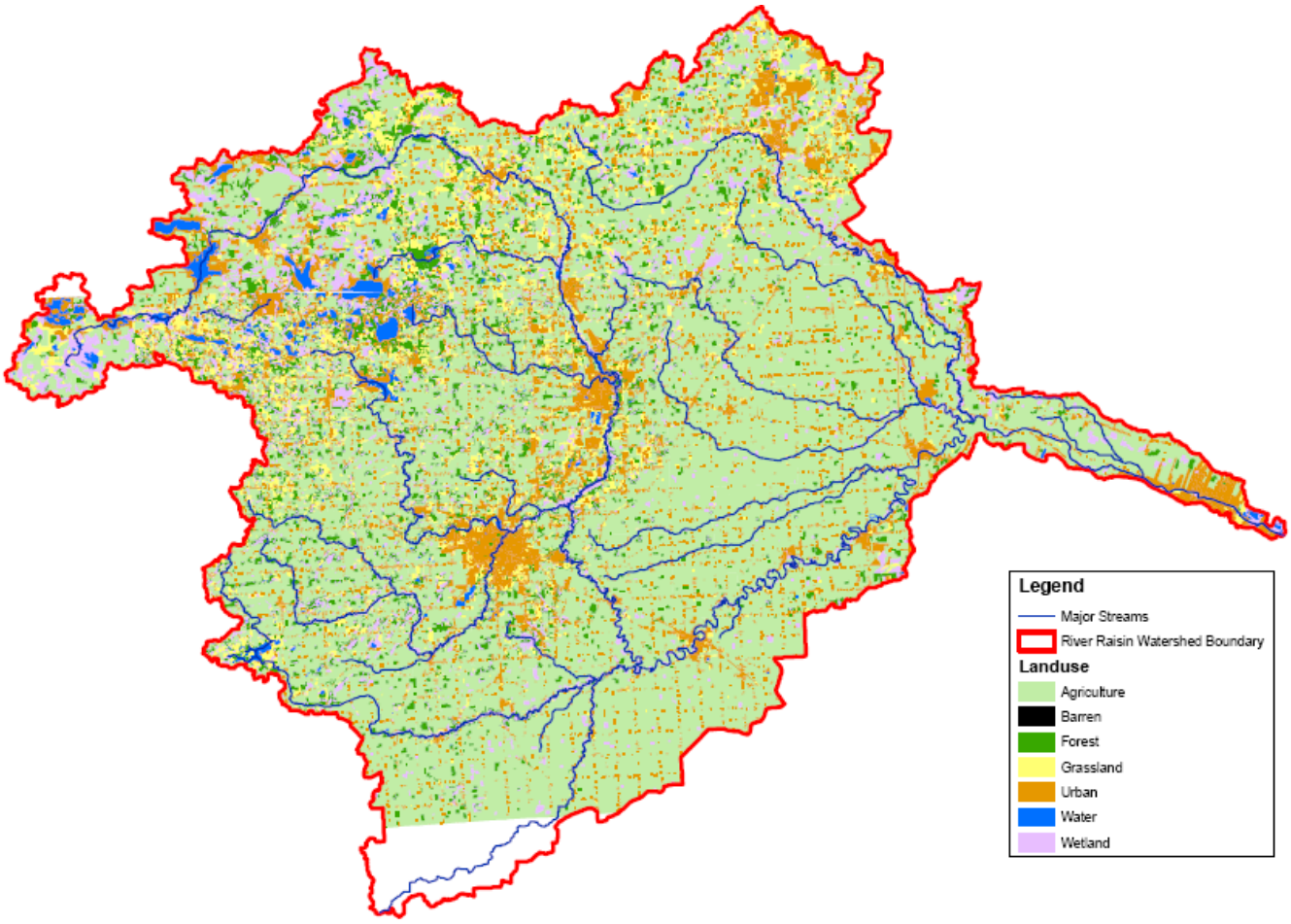


Figure 3-7 Current River Raisin Land Use (Bennett et al., 2006)

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)

		Percent of Total by Subwatershed						
Subwatershed	**Area (mi^2)**	**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

		Percent of Total (Weighted Average)						
Grouping by Extent of Ag Coverage	**Area (mi^2)**	**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

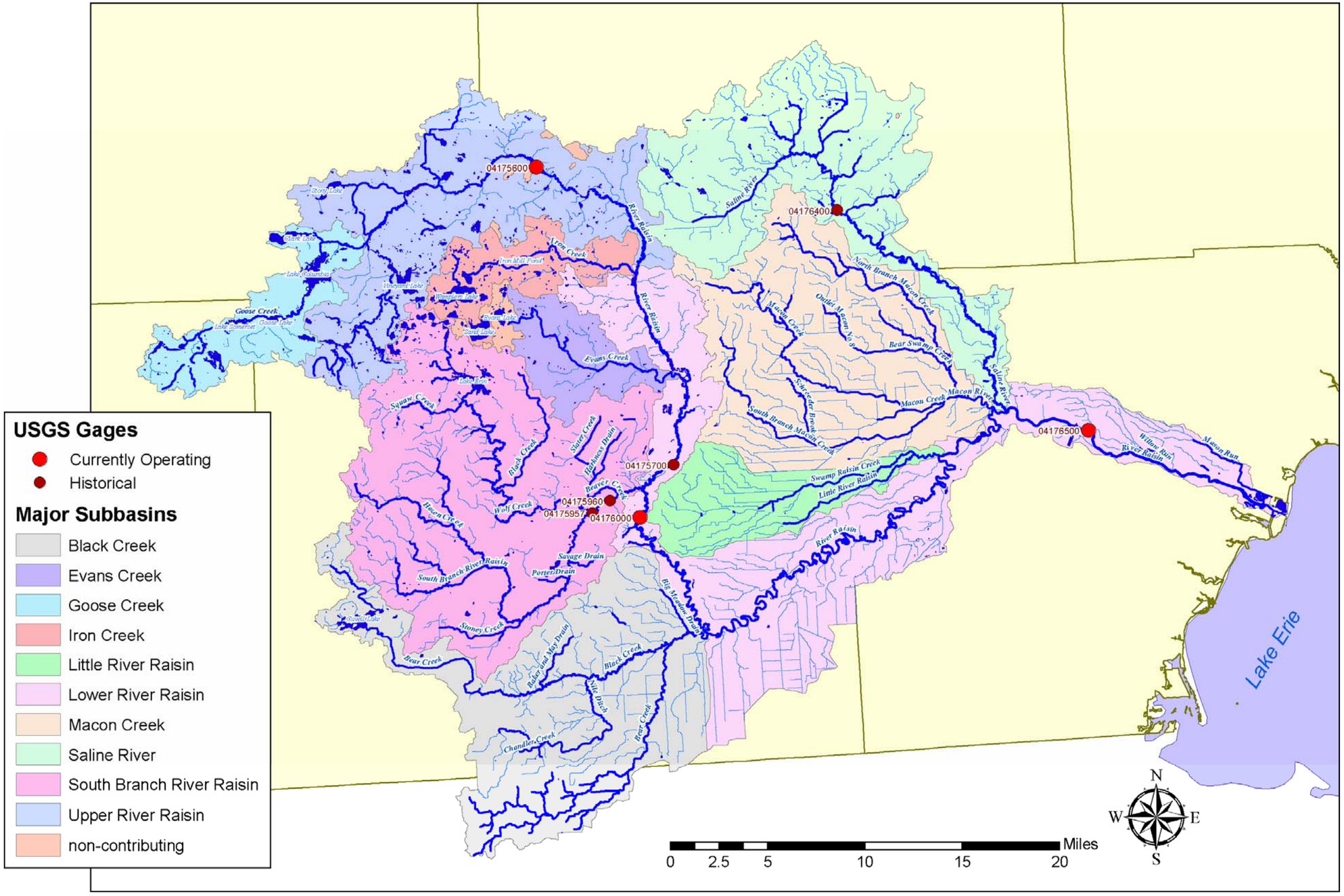


Figure 3-8 Major Subbasins of the River Raisin (Fongers, 2008)

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**).

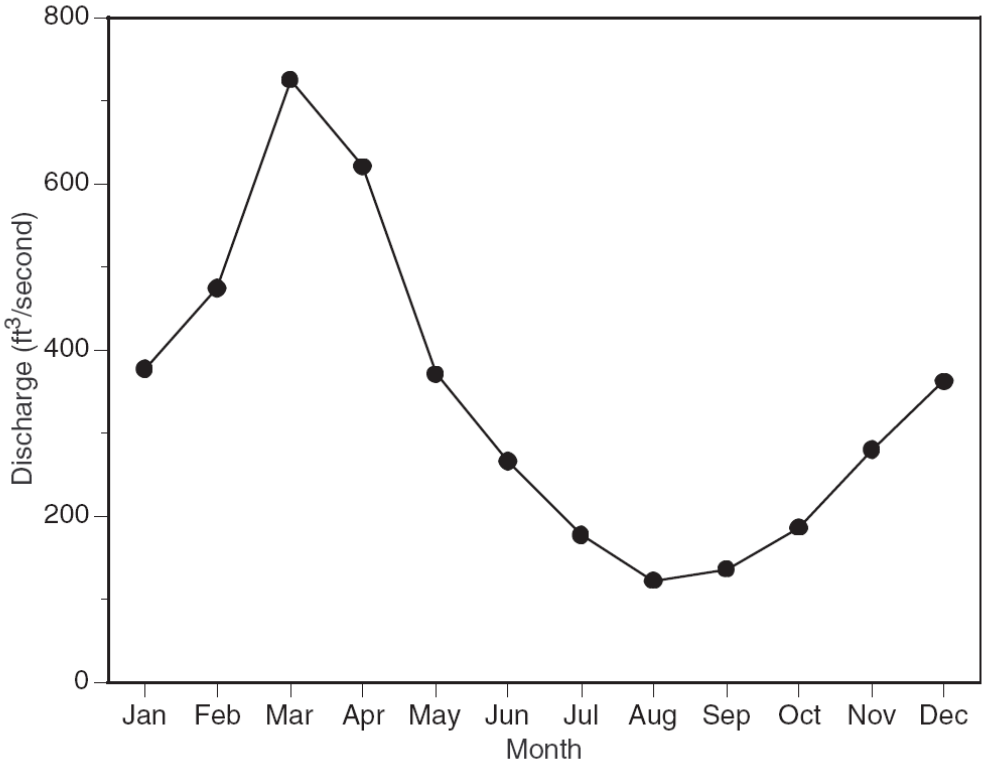


Figure 3-9 Annual Hydrograph for River Raisin mainstem east of Adrian period of record 1954 – 1994 (from Dodge 1998)

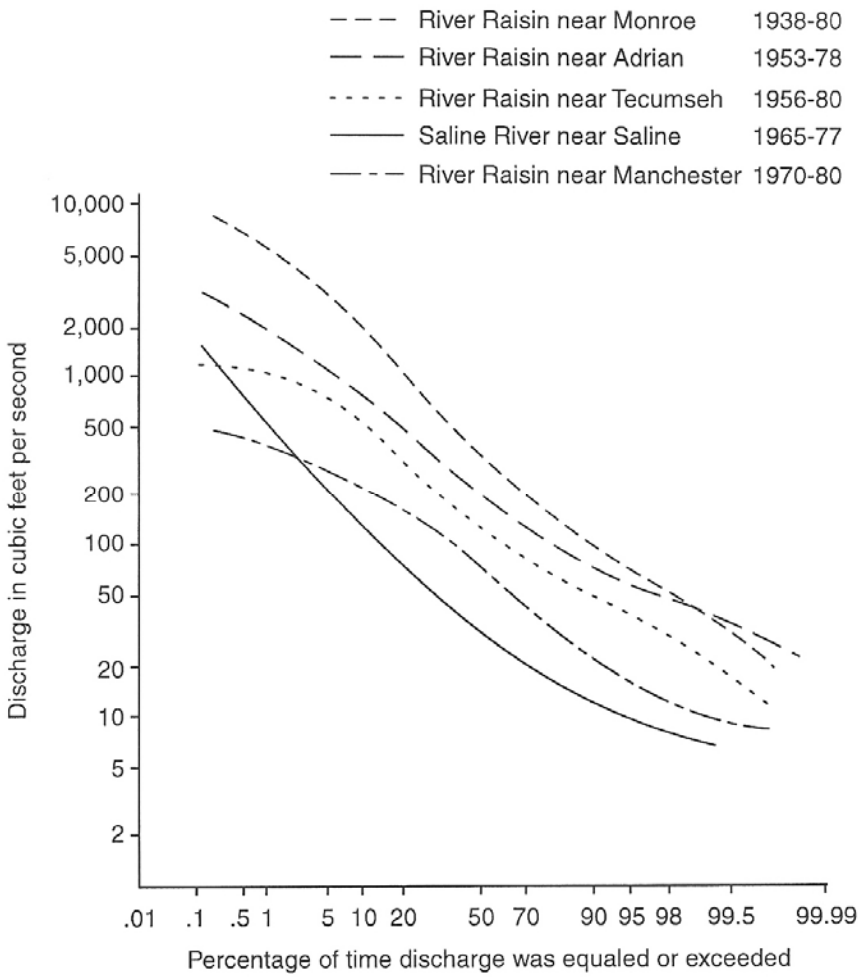


Figure 3-10 Flow duration curves for USGS gaging stations on the River Raisin (from: Dodge, 1998)

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**.

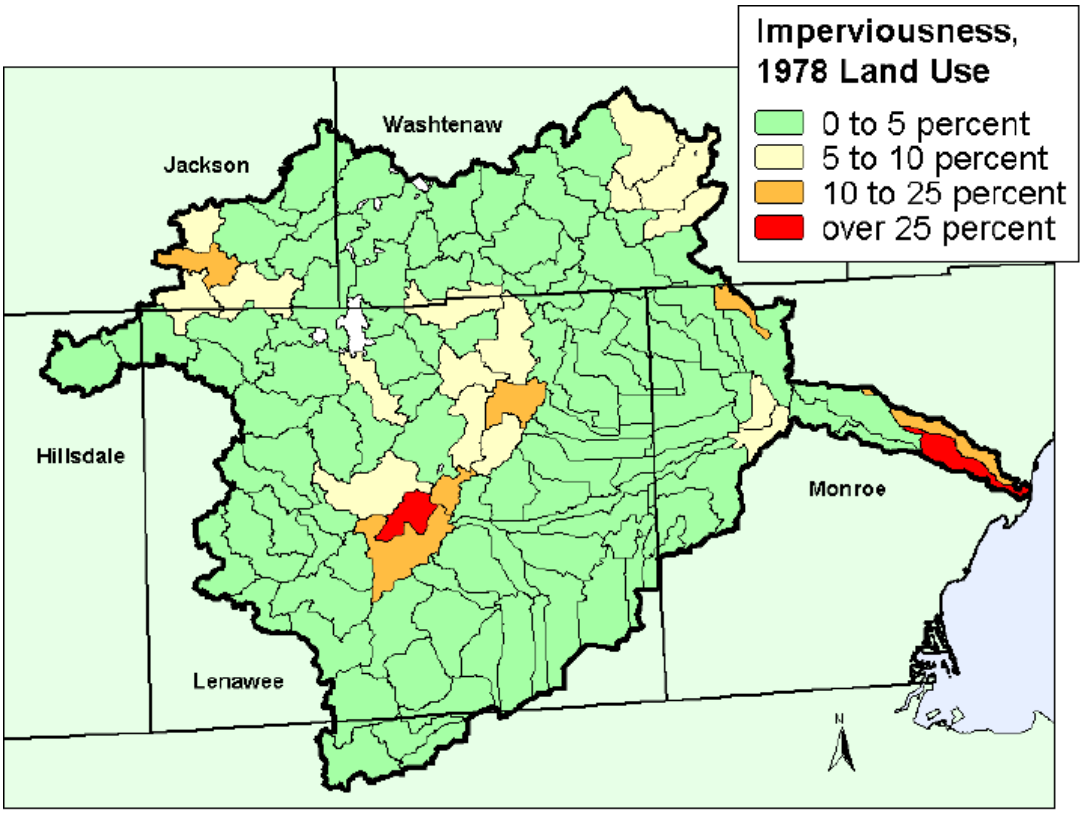


Figure 3-11 Impervious area fractions for 1978 land use (Fongers, 2006)

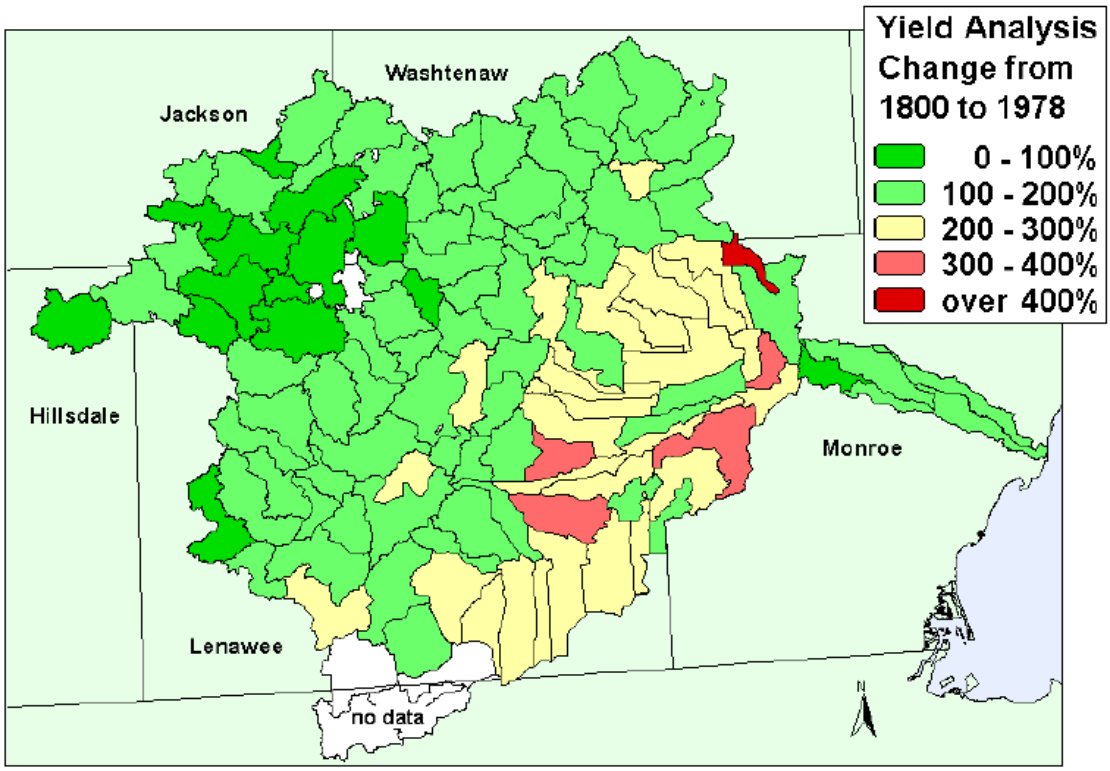


Figure 3-12 Estimated change in runoff yield from 1800 to 1978 (Fongers, 2006)

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.

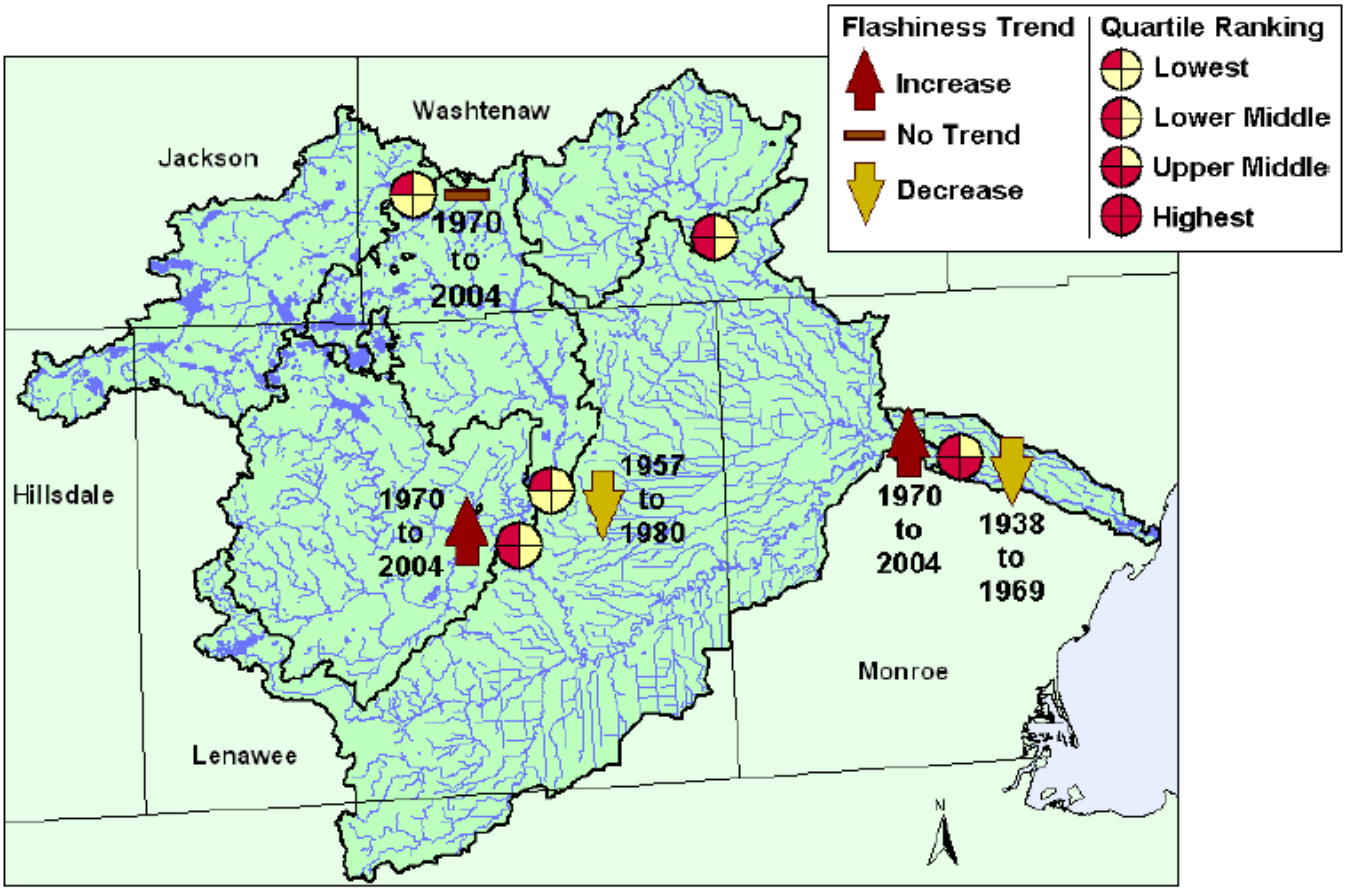


Figure 3-13 Stream flashiness index trends for River Raisin USGS gages (Fongers, 2006). Note: Quartile ranking based on Baker et al., (2004) analysis of 510 sites throughout Great Lakes states.

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**).

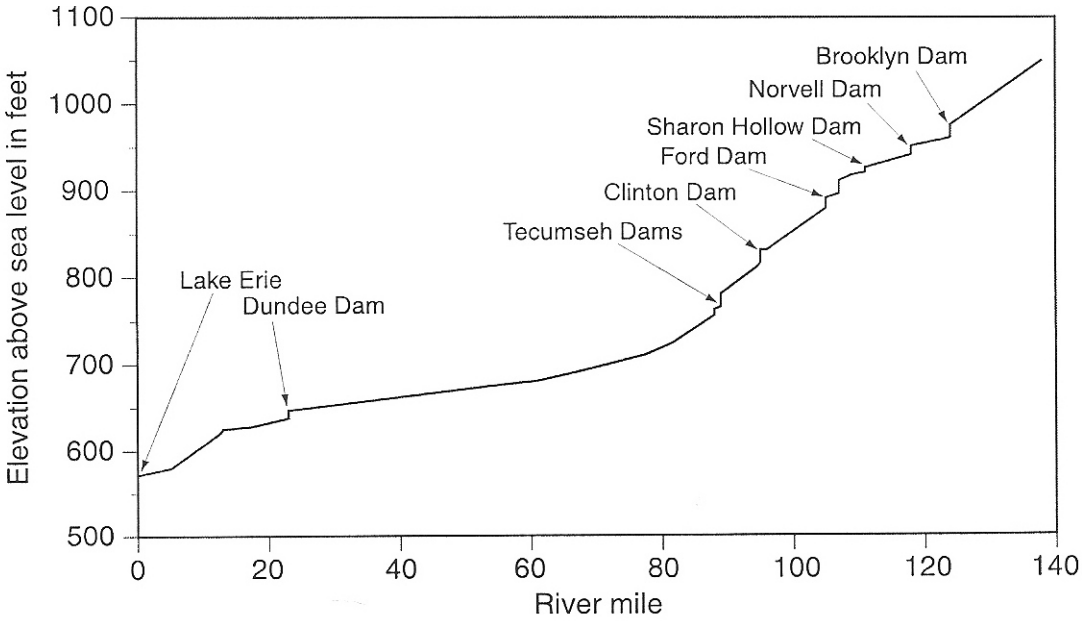


Figure 3-14 Elevation drop along the mainstem of the River Raisin (from Dodge, 1998)

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.

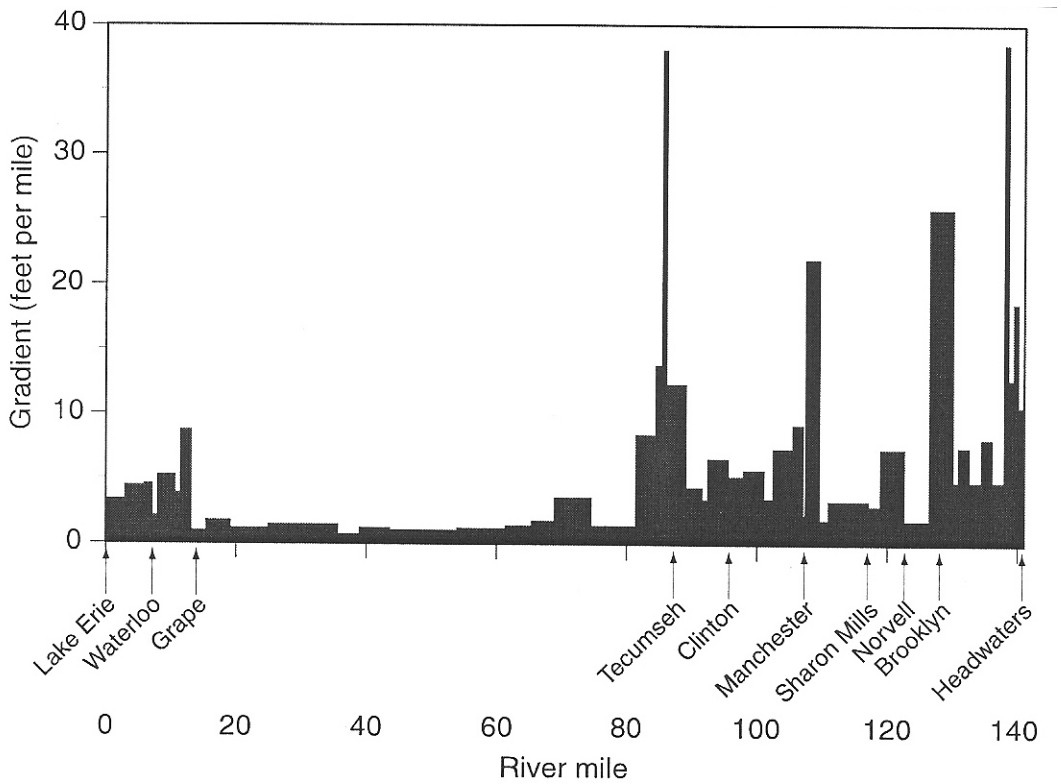


Figure 3-15 Gradient along the mainstem of the River Raisin (from Dodge, 1998)

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).

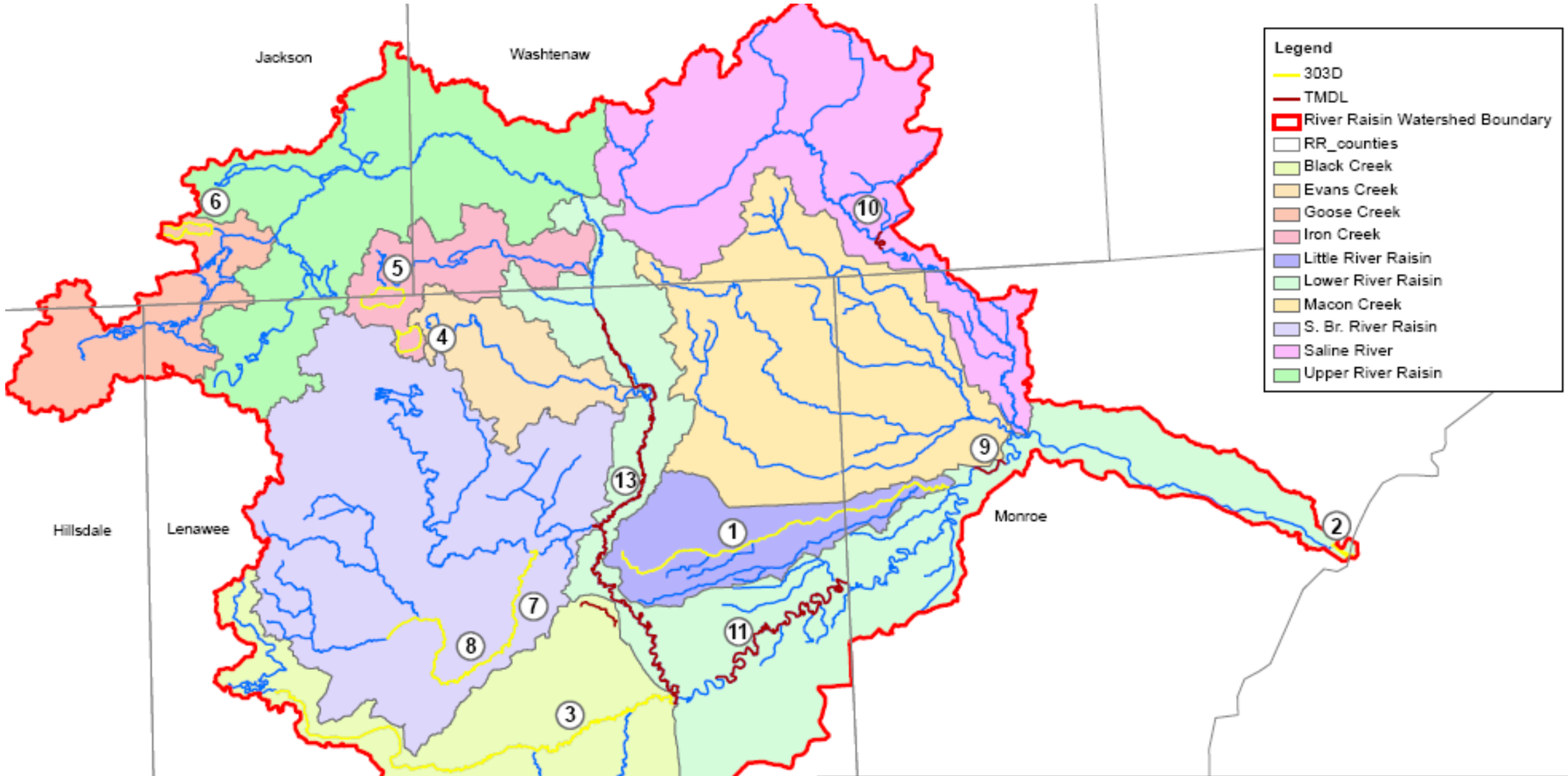
When a lake or stream does not meet WQS, a study must be completed to determine the amount of a pollutant that can be put in a waterbody from point sources and nonpoint sources and still meet WQS, including a margin of safety. The TMDL acronym is a short hand description of the process used to determine 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

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] .

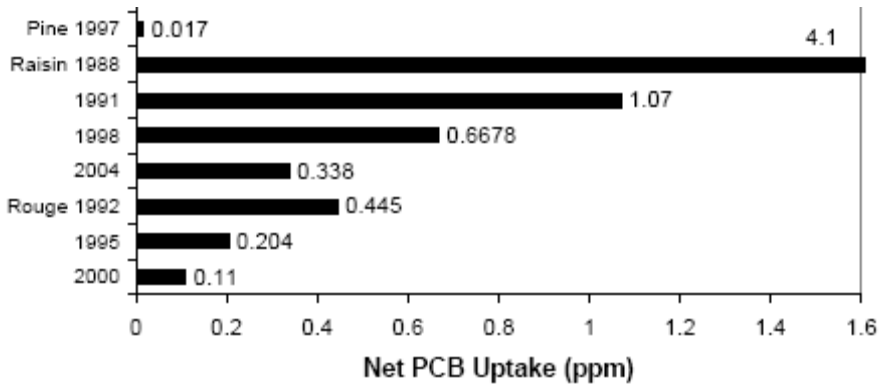


Figure 3-18 PCB Uptake in Caged Fish Studies at the mouth of the River Raisin (excerpted table from MDEQ, 2005)

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.).

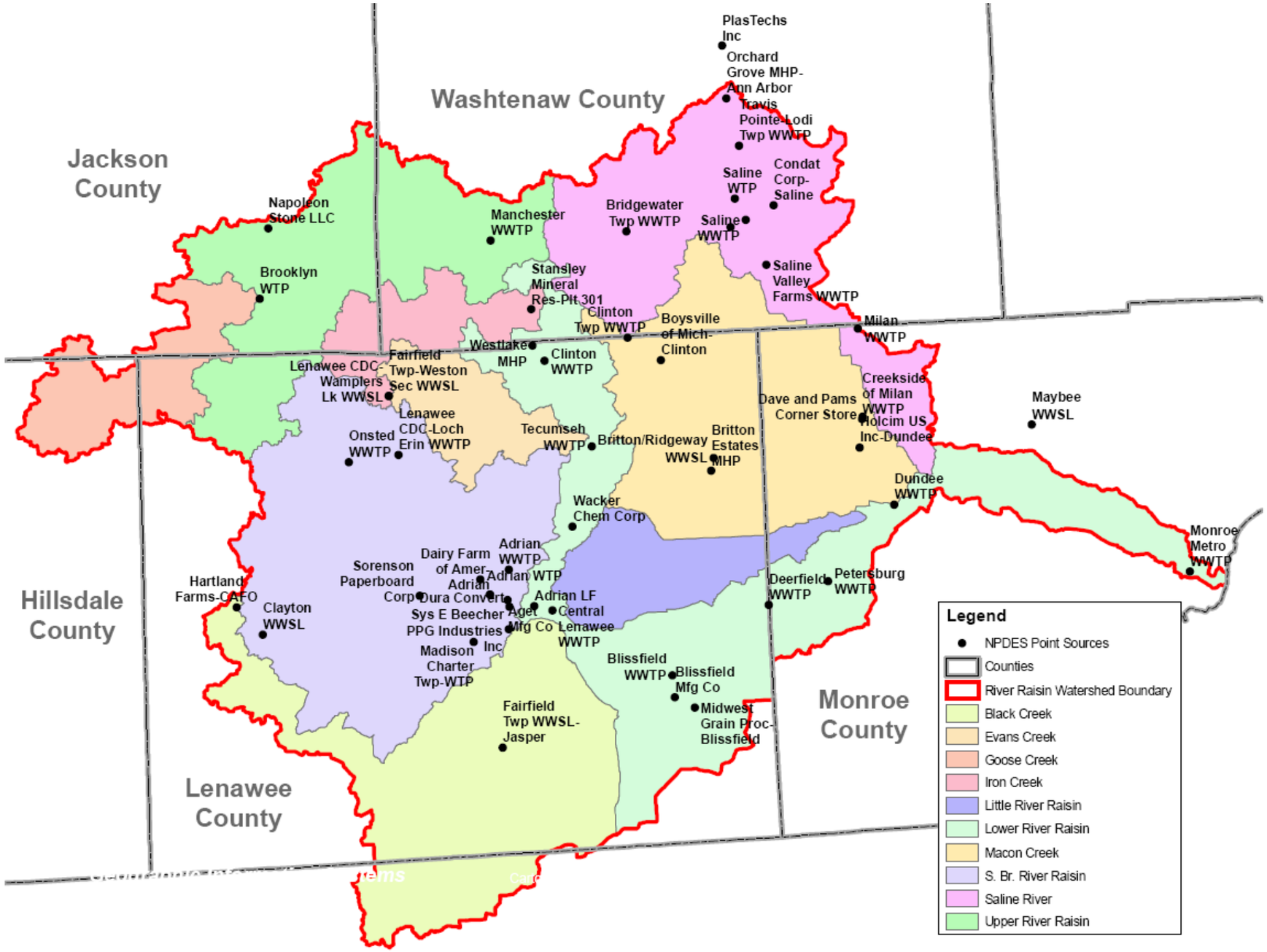


Figure 3-19 NPDES Point Source Permit Map

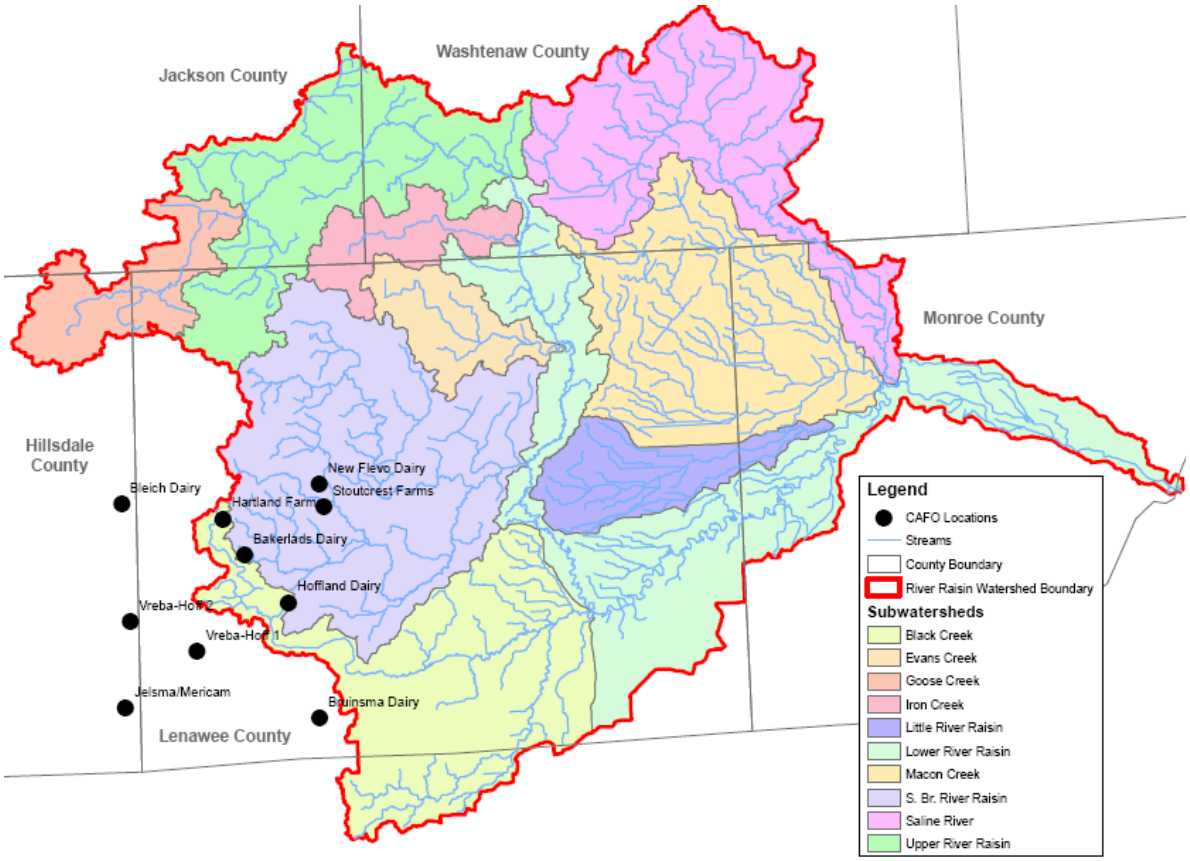


Figure 3-20 Concentrated Animal Feeding Operations Map

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.

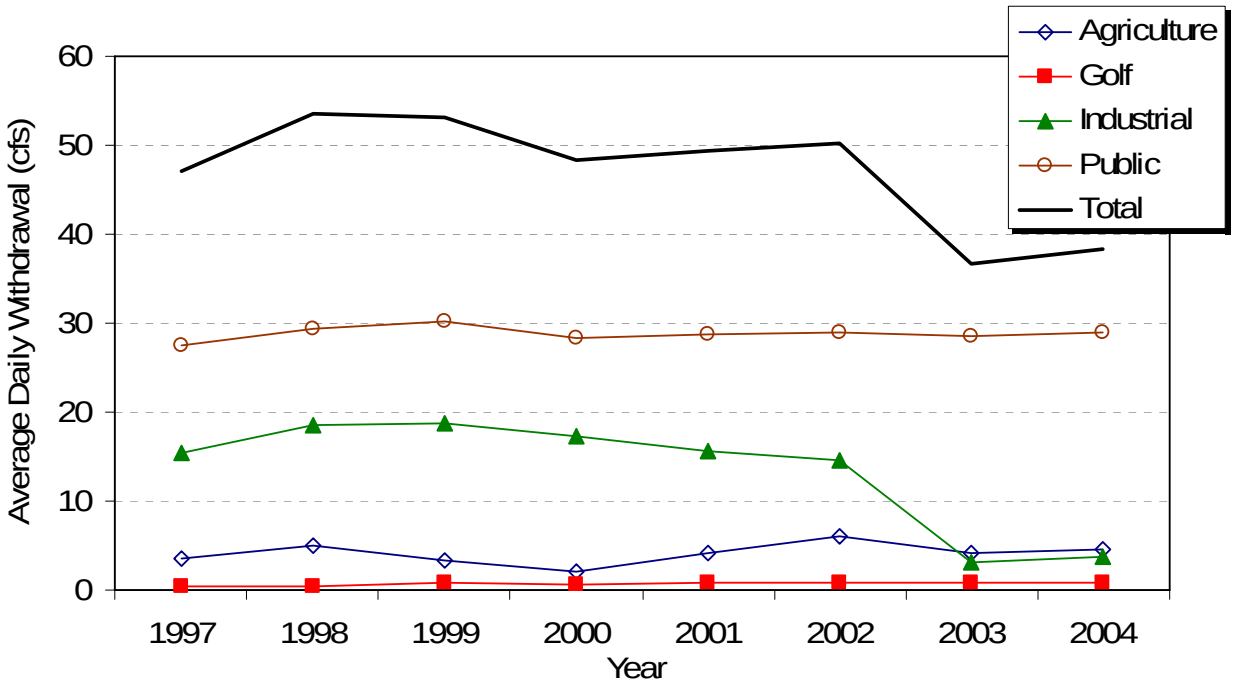


Figure 3-21 Average Annual Daily Reported Water Consumption (total surface water and groundwater withdrawals) in the River Raisin Watershed (MDEQ, 2007b)

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.

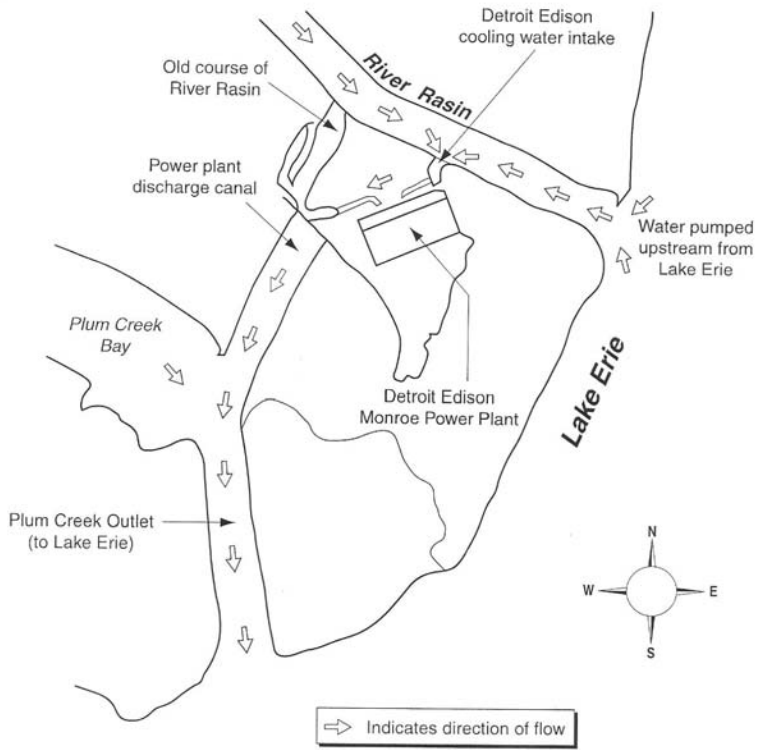


Figure 3-22 Schematic of Detroit Edison's Monroe Power Plant cooling water intake and aerial photograph of plant (circa 1981) (Dodge, 1998)

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.

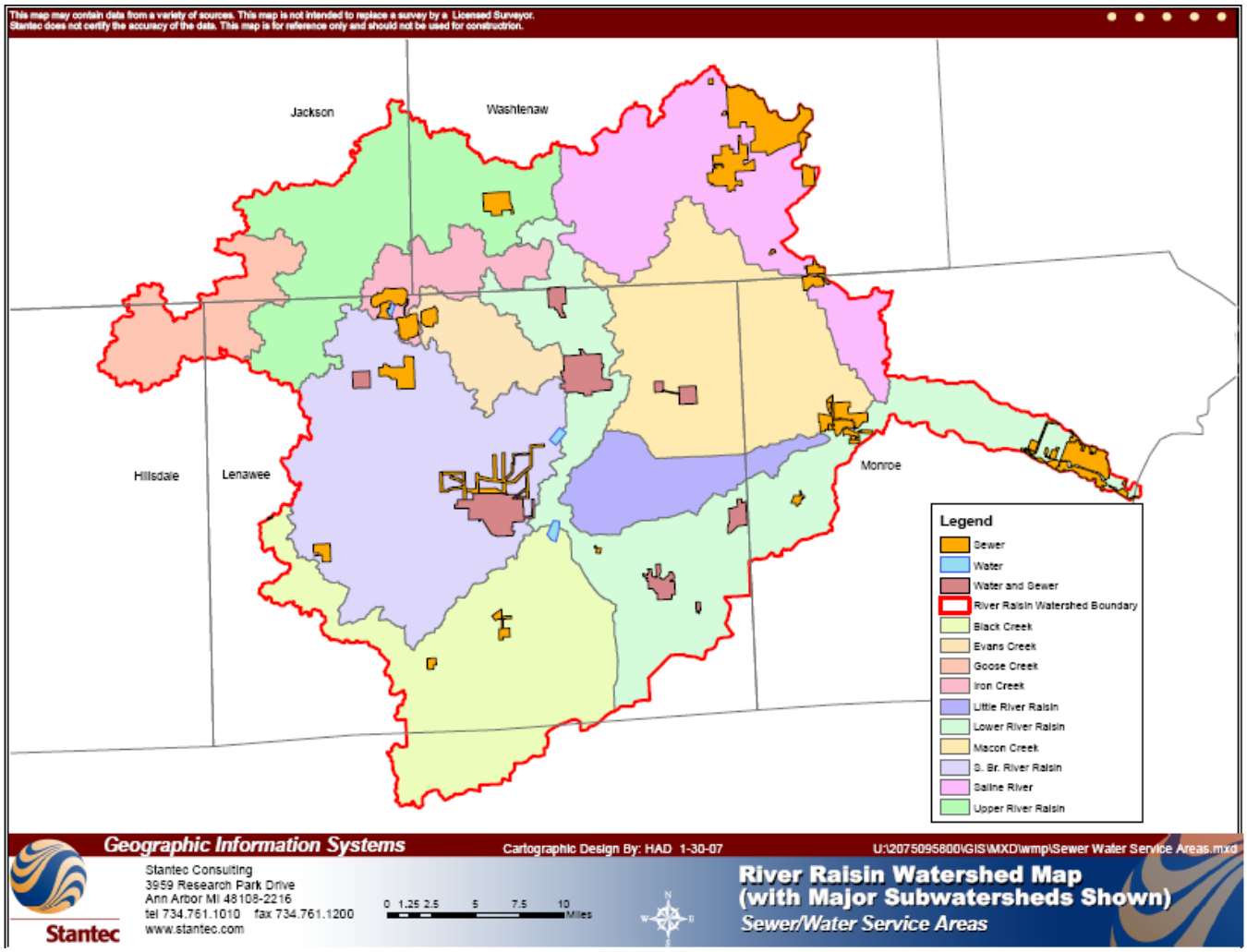


Figure 3-23 Sewer and Water Service Areas in the River Raisin Watershed

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

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).

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

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.

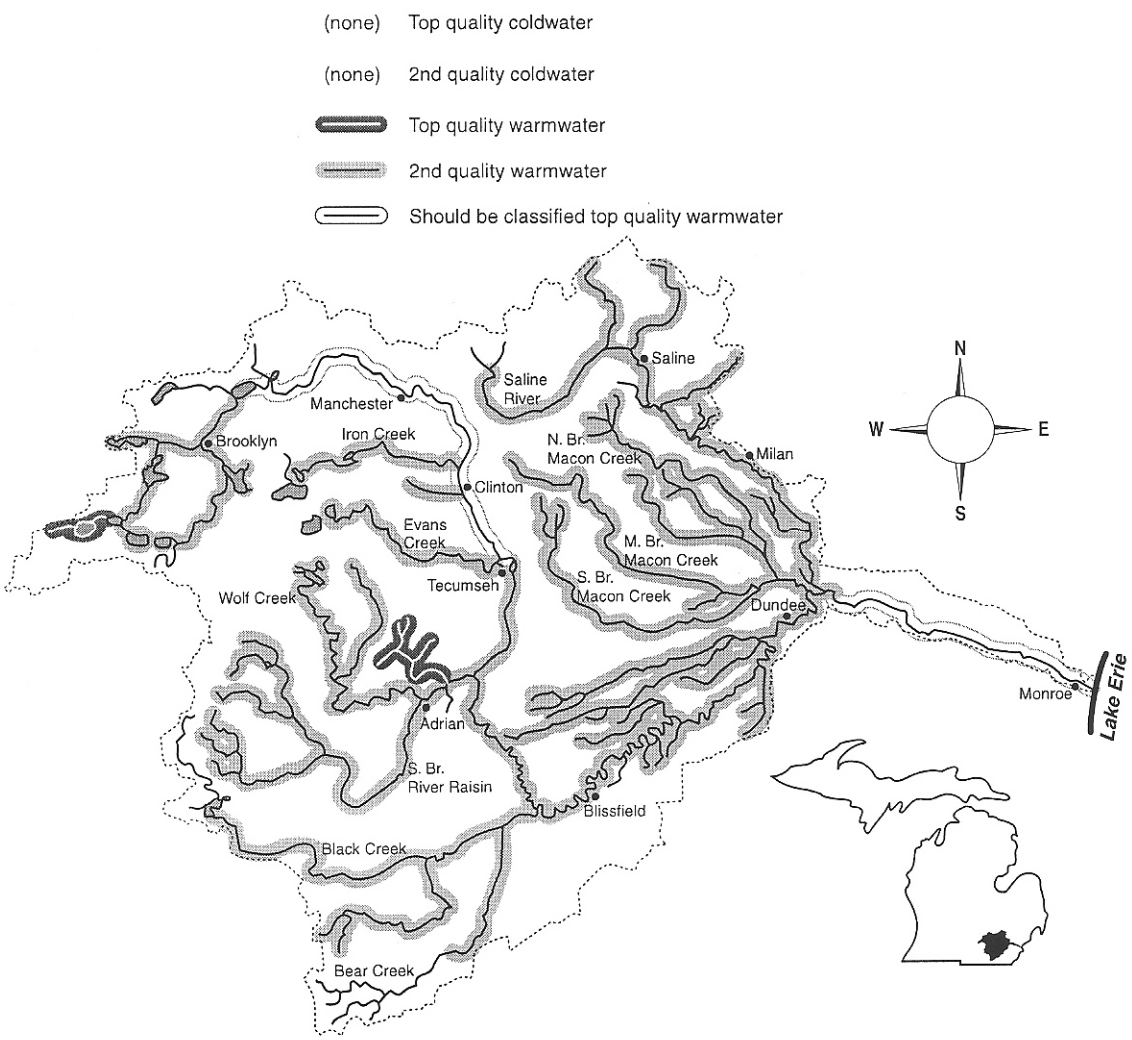


Figure 3-24 Michigan Department of Natural Resources Stream Ratings (from Dodge, 1998)

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.

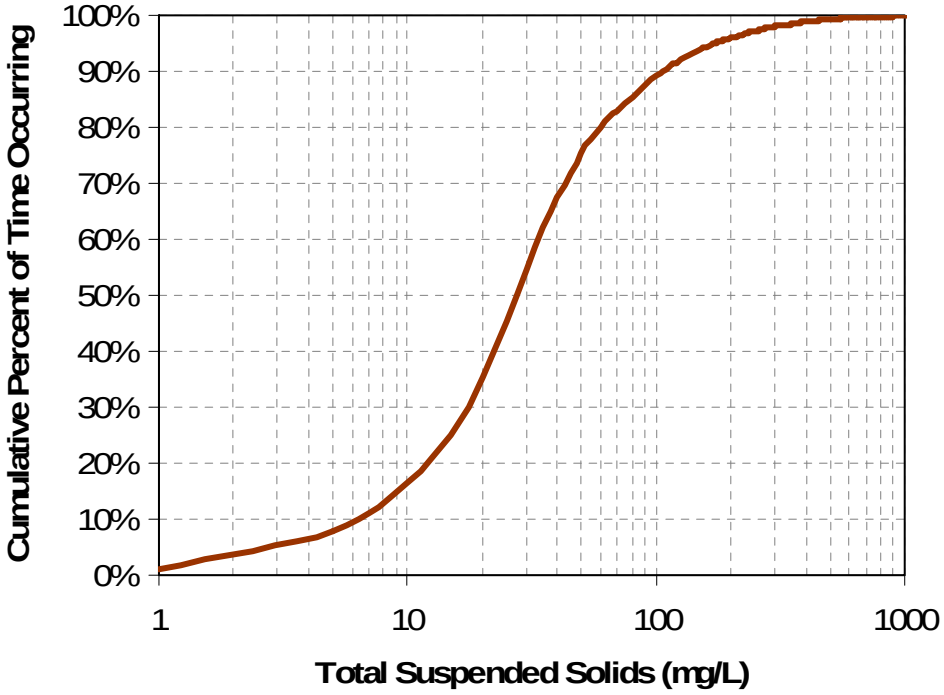


Figure 4-1 Cumulative Histogram of Total Suspended Solids Concentrations at Heidelberg College River Raisin Station at Monroe (1982-2007).

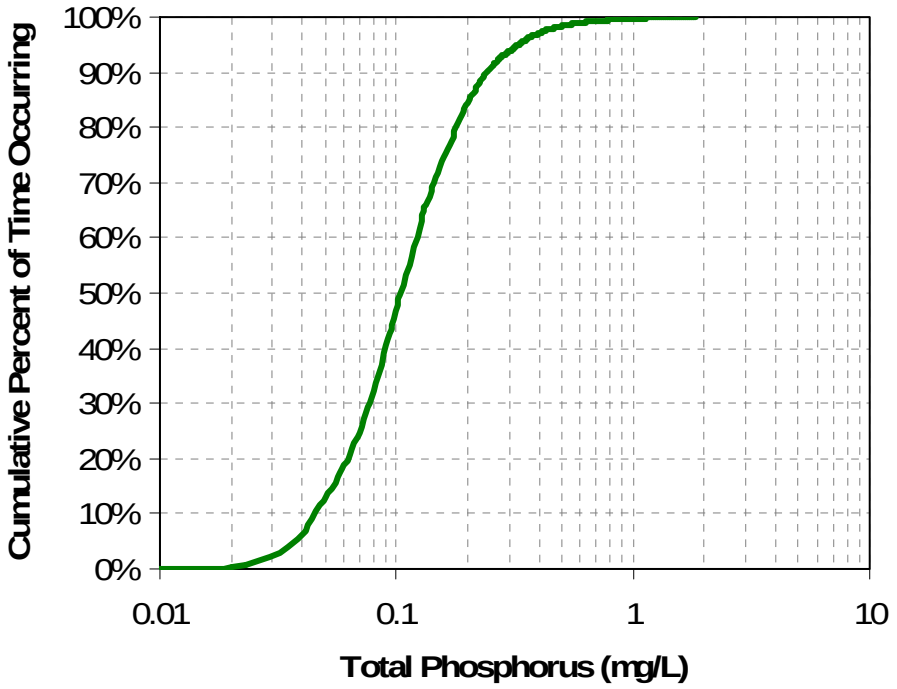


Figure 4-2 Cumulative Histogram of Total Phosphorus Concentrations at Heidelberg College River Raisin Station at Monroe (1982-2007).

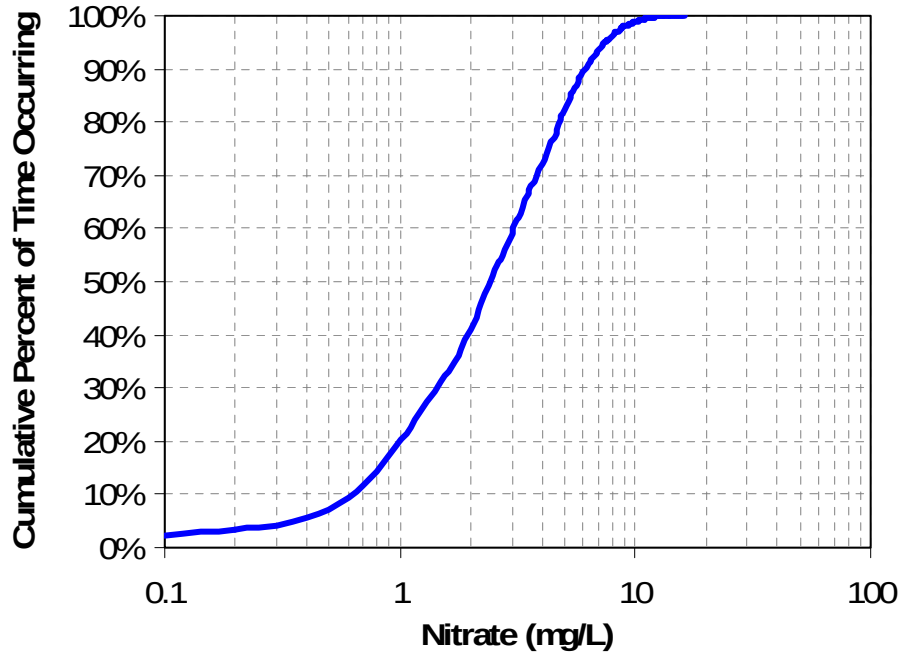
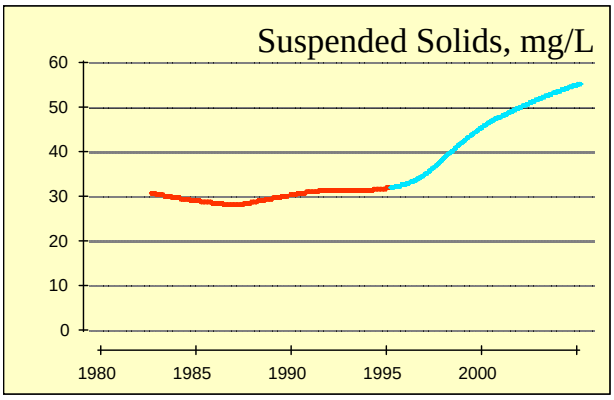


Figure 4-3 Cumulative Histogram of Nitrate Concentrations at Heidelberg College River Raisin Station at Monroe (1982-2007).

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.



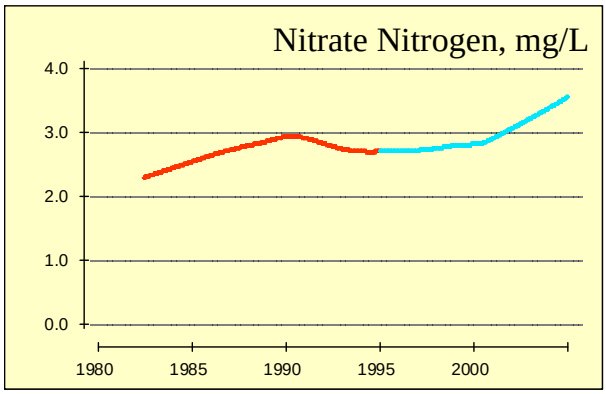
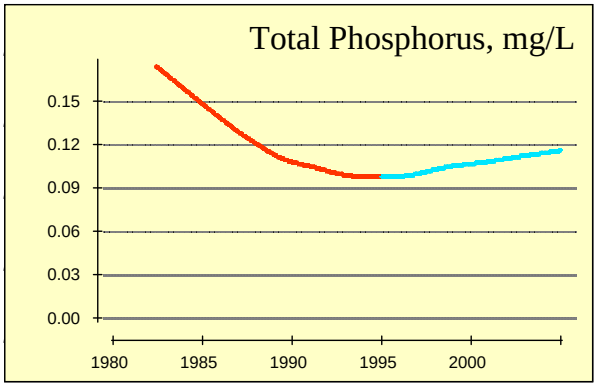


Figure 4-4 Average annual, flow-corrected Suspended Solids and Nitrate concentrations at Heidelberg College River Raisin station at Monroe (Suppnick, 2008).



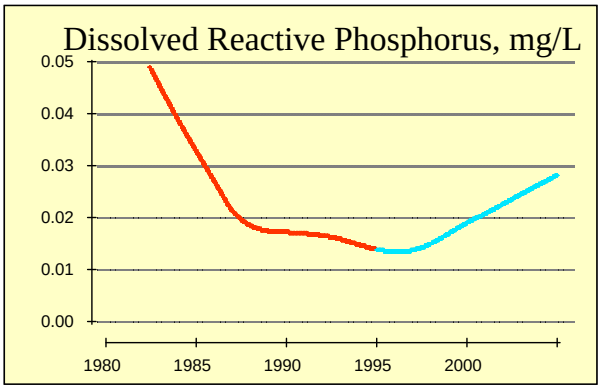


Figure 4-5 Average annual, flow-corrected Total Phosphorus and Dissolved Reactive Phosphorus at Heidelberg College River Raisin station at Monroe (Suppnick, 2008)

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.

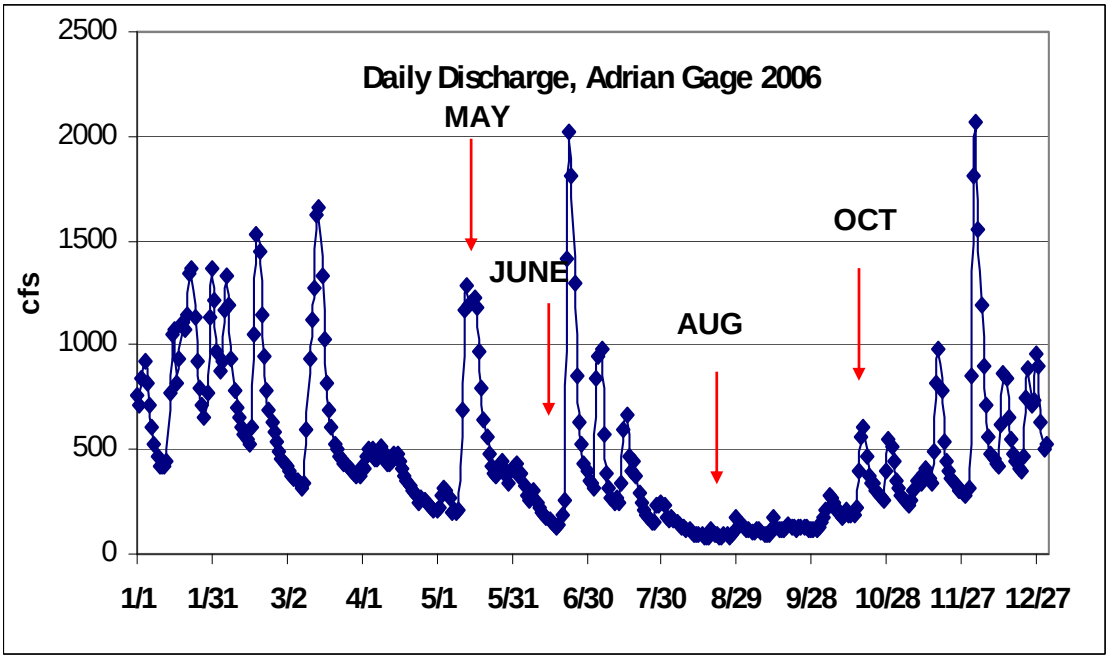
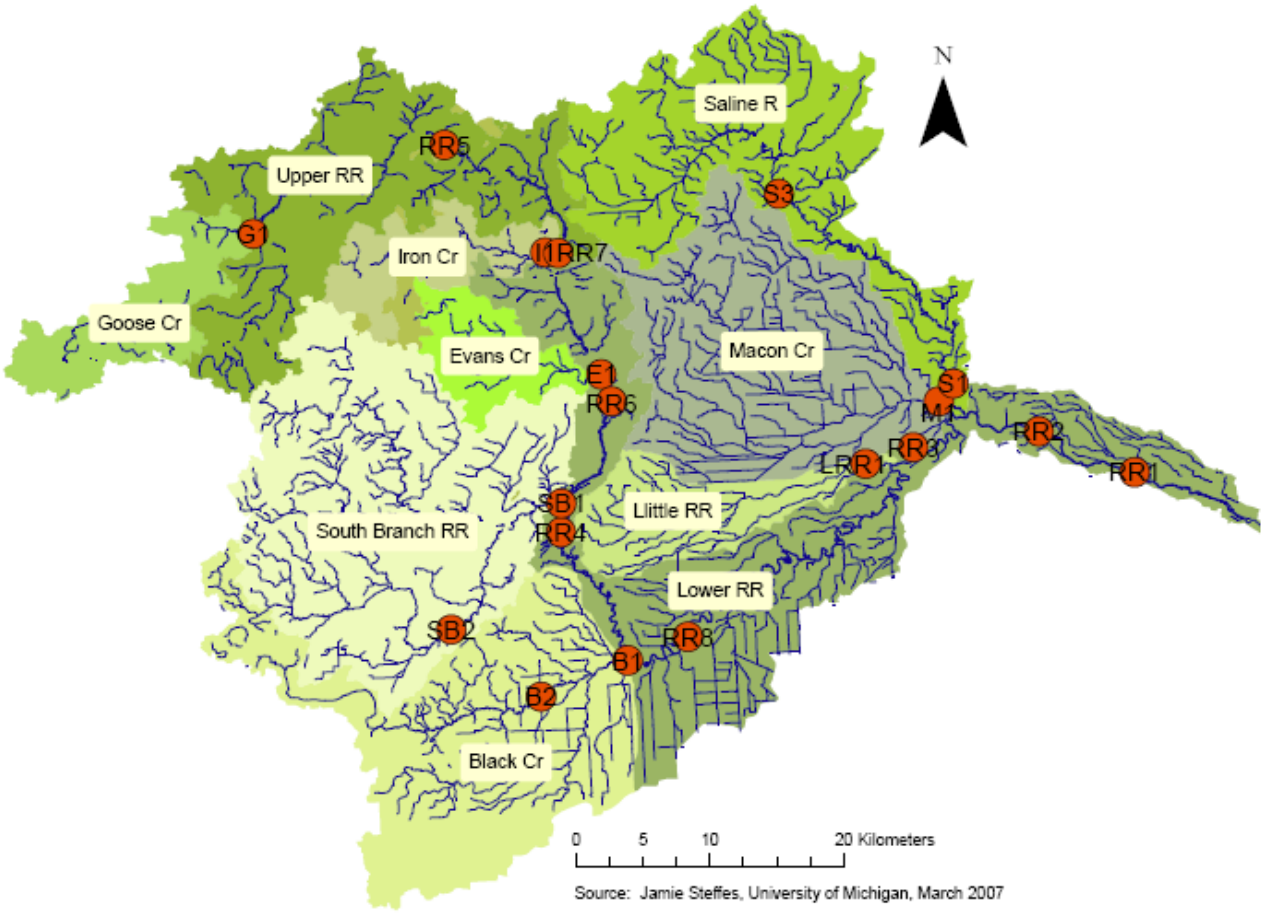


Figure 4-6 Water Quality Sampling Dates and Flow at Adrian USGS Gage

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.

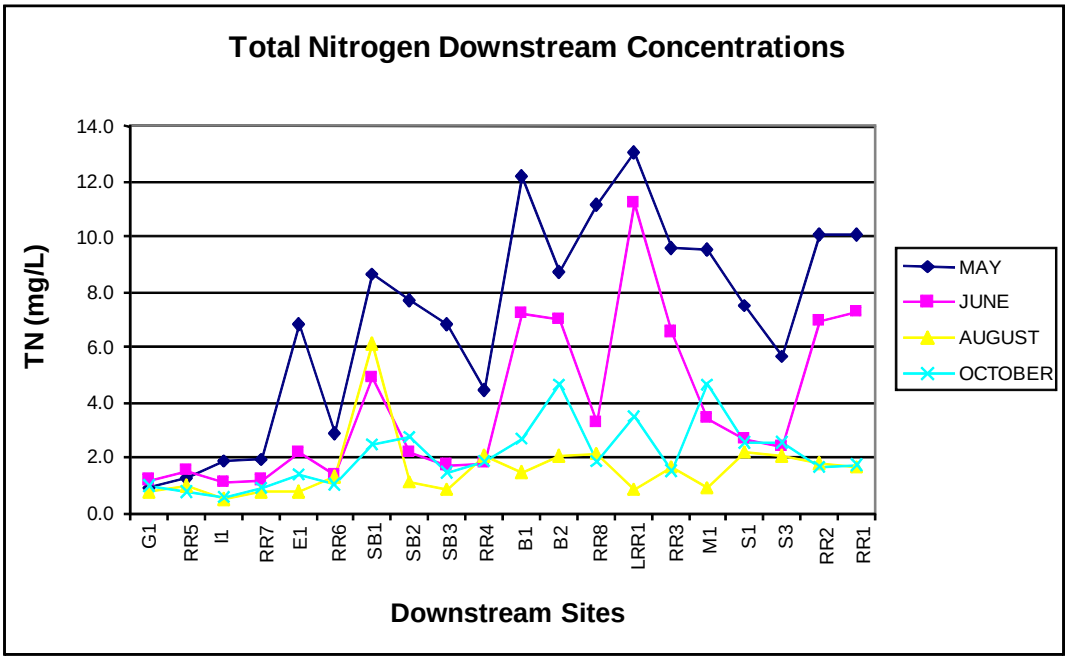


Figure 4-8 Concentrations of TN measured during May, June, August, and October sampling events. Sites are arranged from left to right in an approximate upstream-downstream pattern.

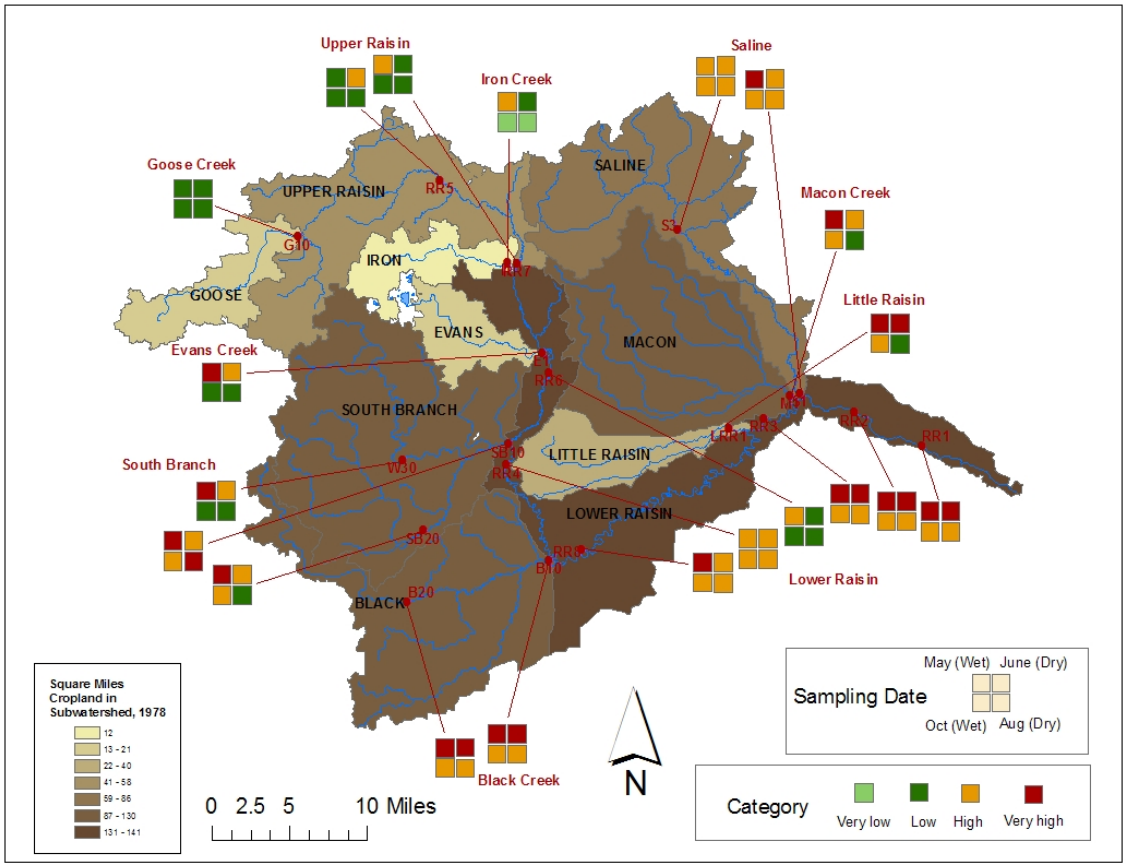


Figure 4-9 Range of concentrations of TN from synoptic surveys in the River Raisin watershed. Concentration categories (mg/L) are very low (less than 0.70), low (0.70-1.50), high (1.50-6), and very high (greater than 6)

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.

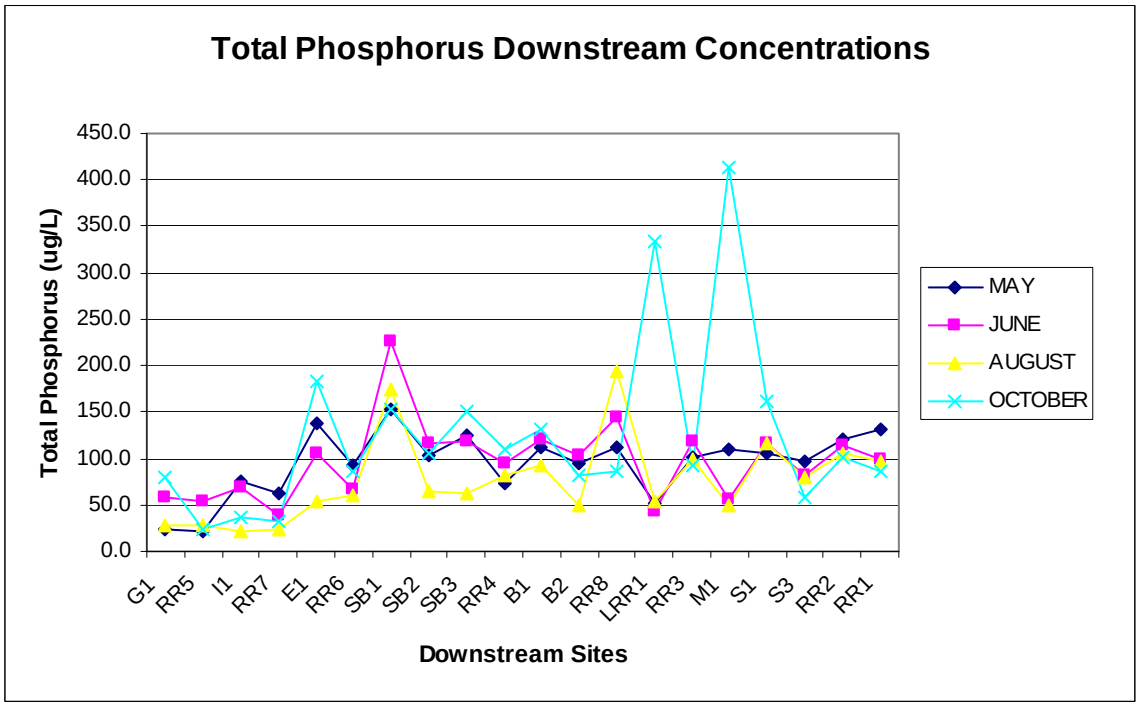


Figure 4-10 Concentrations of TP measured during May, June, August, and October sampling events. Sites are arranged from left to right in an approximate upstream-downstream pattern.

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**).

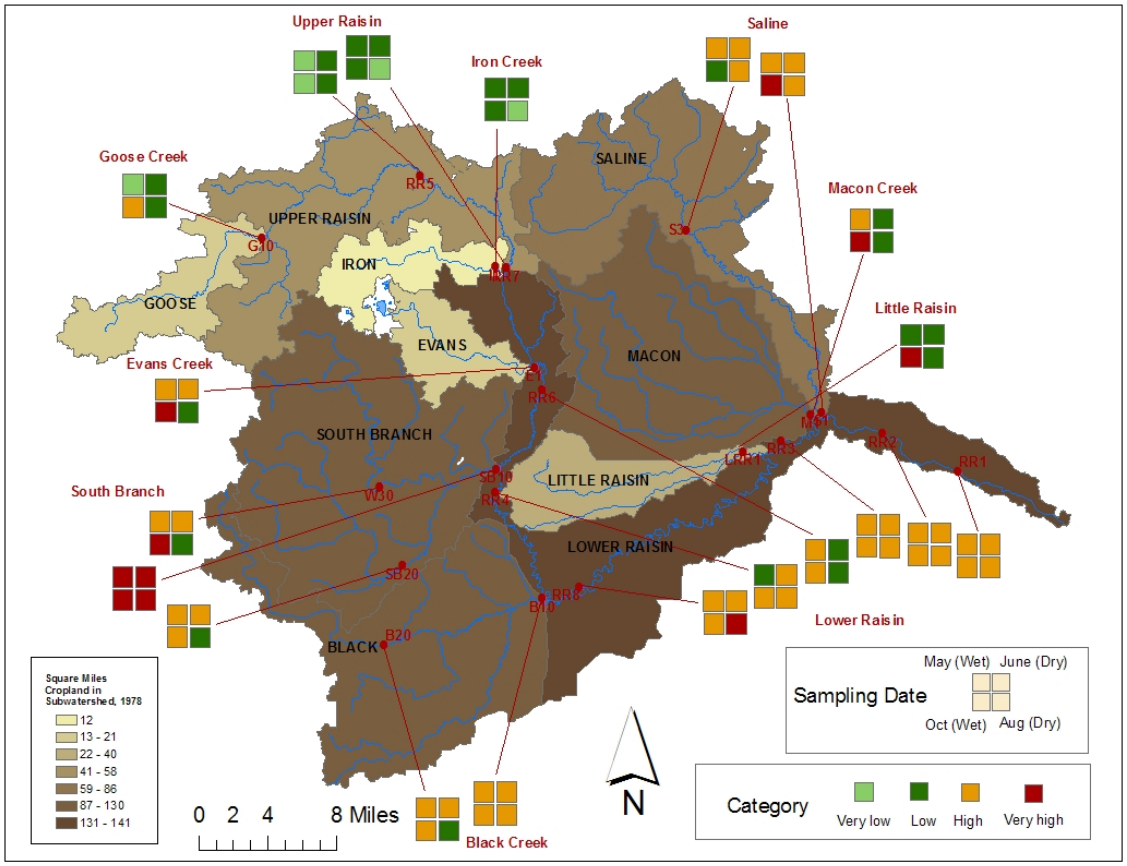


Figure 4-11 Range of concentrations of TP on four sampling dates in the River Raisin watershed. Concentration categories (µg/L) are very low (less than 25), low (25-75), high (75-150), and very high (greater than 150).

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**).

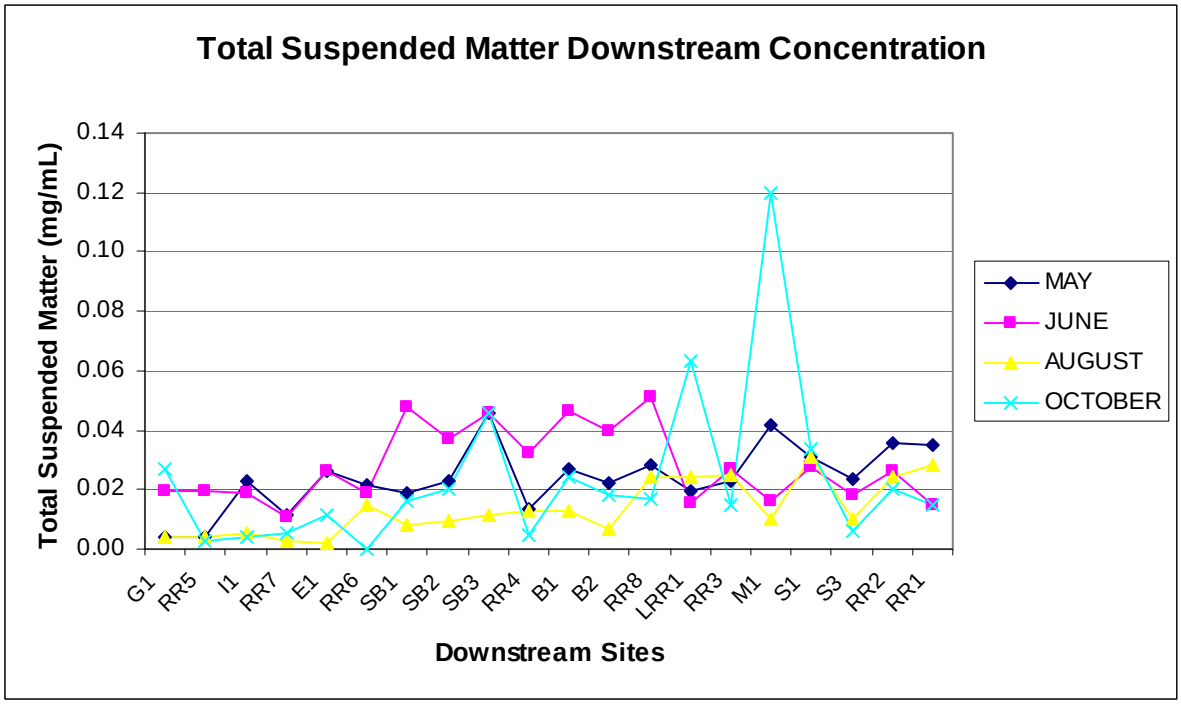


Figure 4-12 Concentrations of TSM measured during May, June, August, and October sampling events. Sites are arranged from left to right in an approximate upstream-downstream pattern.

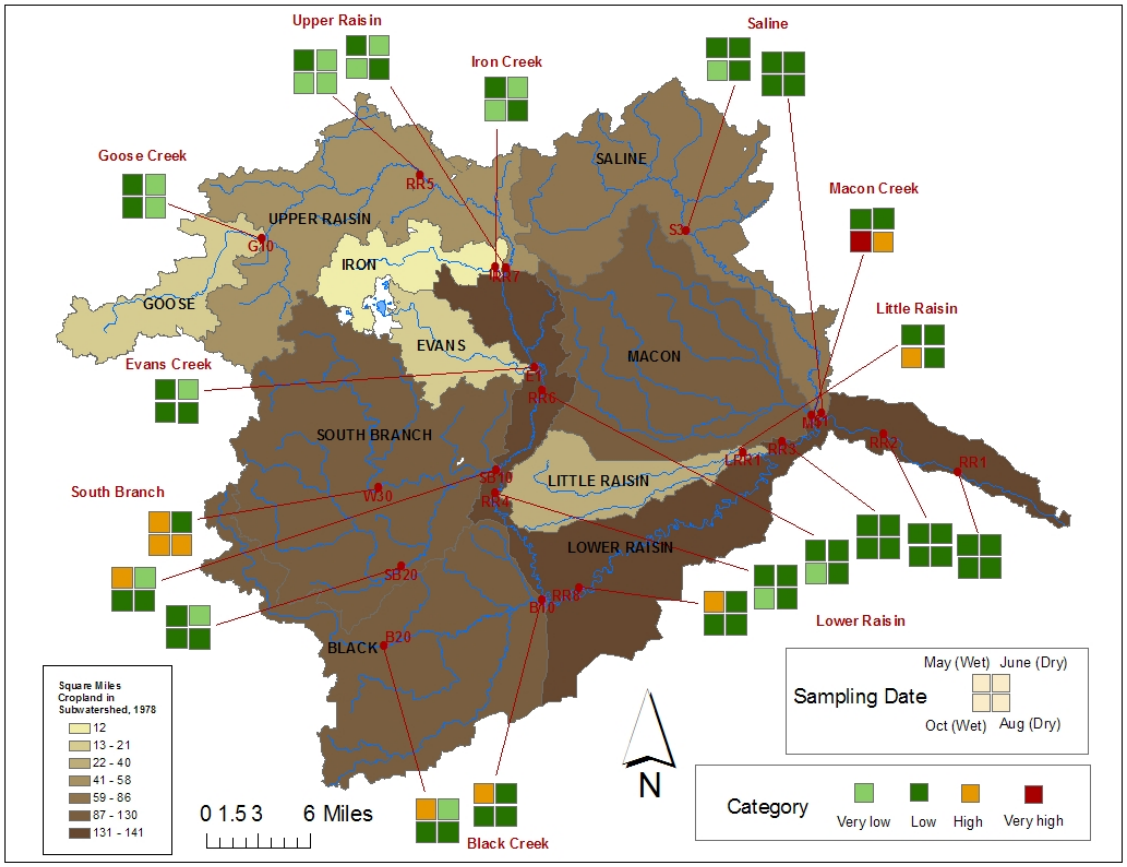


Figure 4-13 Range of concentrations of TSM on four sampling dates in the River Raisin watershed. Concentration categories (g/L) are very low (less than 10), low (10-40), high (40-80), and very high (greater than 80).

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.

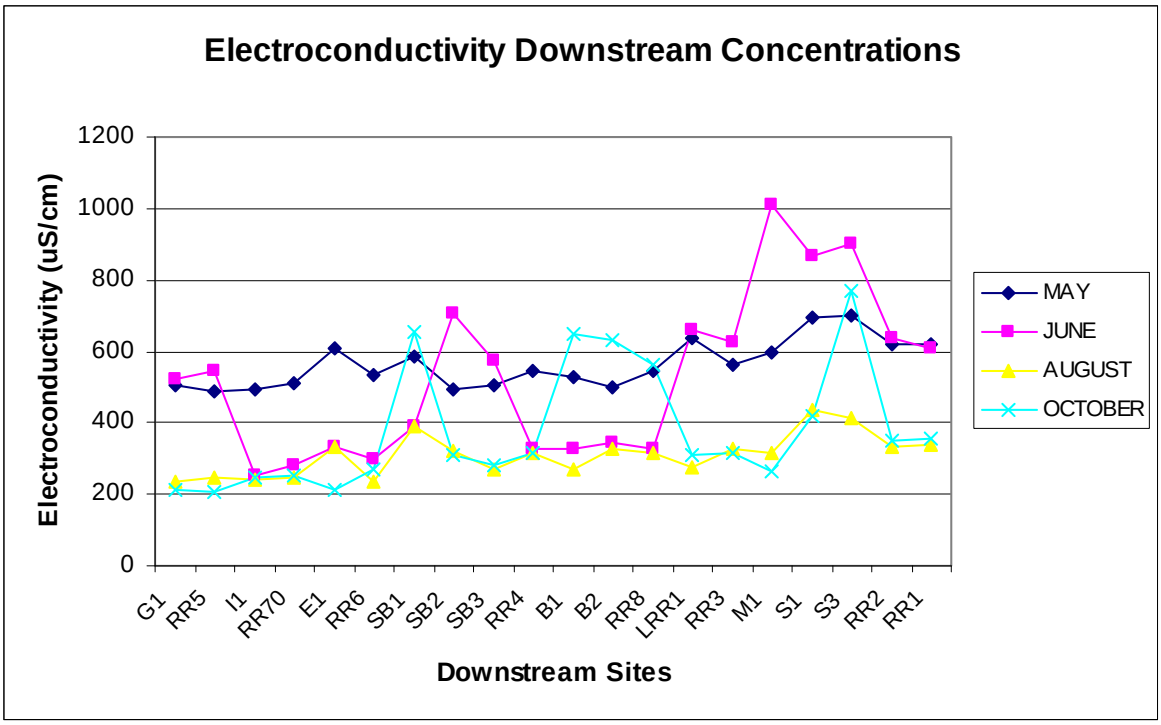


Figure 4-14 Conductivity values measured during May, June, August, and October sampling events. Sites are arranged from left to right in an approximate upstream-downstream pattern.

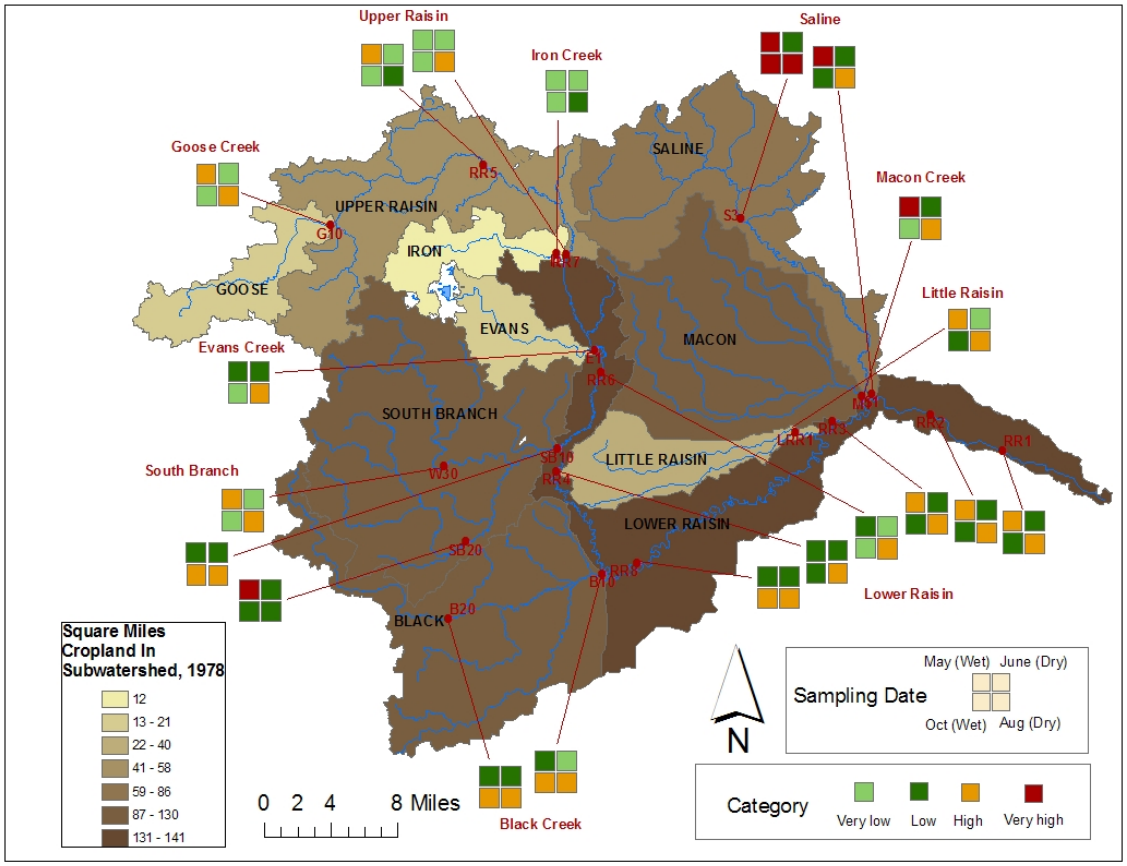


Figure 4-15 Range of conductivity values on four sampling dates in the River Raisin watershed. Value categories (µS/cm) are very low (less than 300), low (300-500), high (500-700), and very high (greater than 700).

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**).

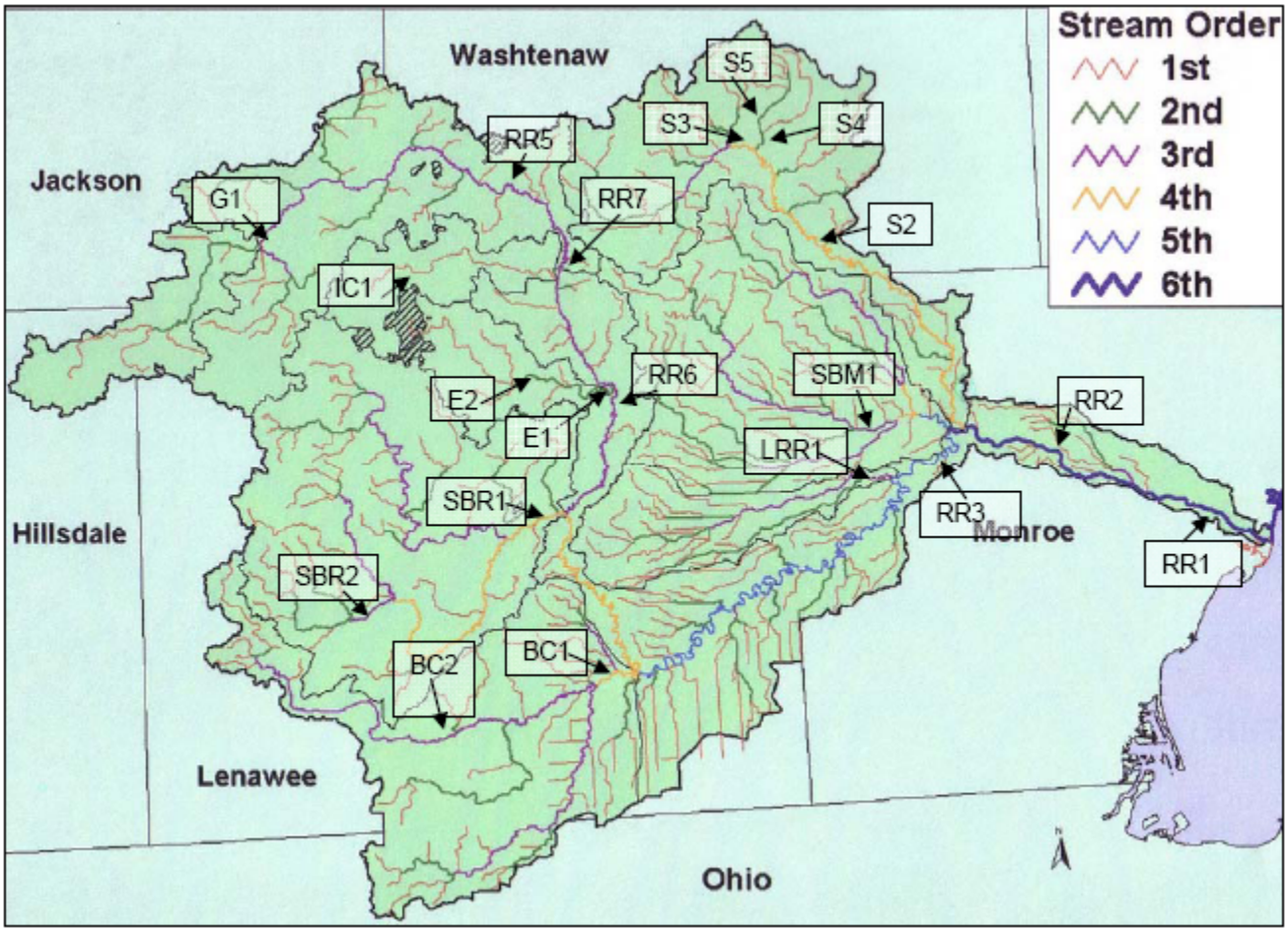


Figure 4-16 Marcoinvertebrate sampling sites in the River Raisin

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.

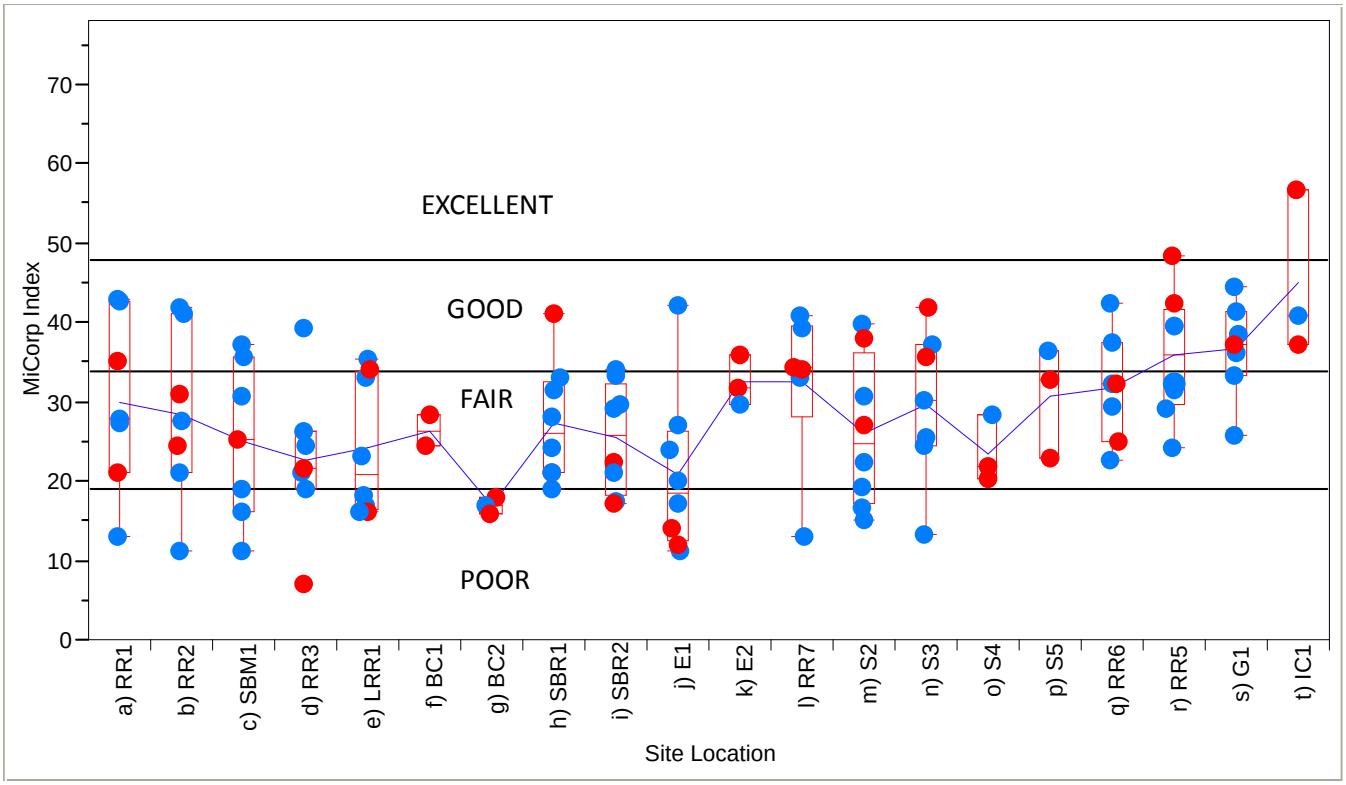


Figure 4-17 Macroinvertebrate sampling summary using the MI Corps Index (type and diversity quality). From: Adopt-A-Stream program sampling from 2002-2007.

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**).

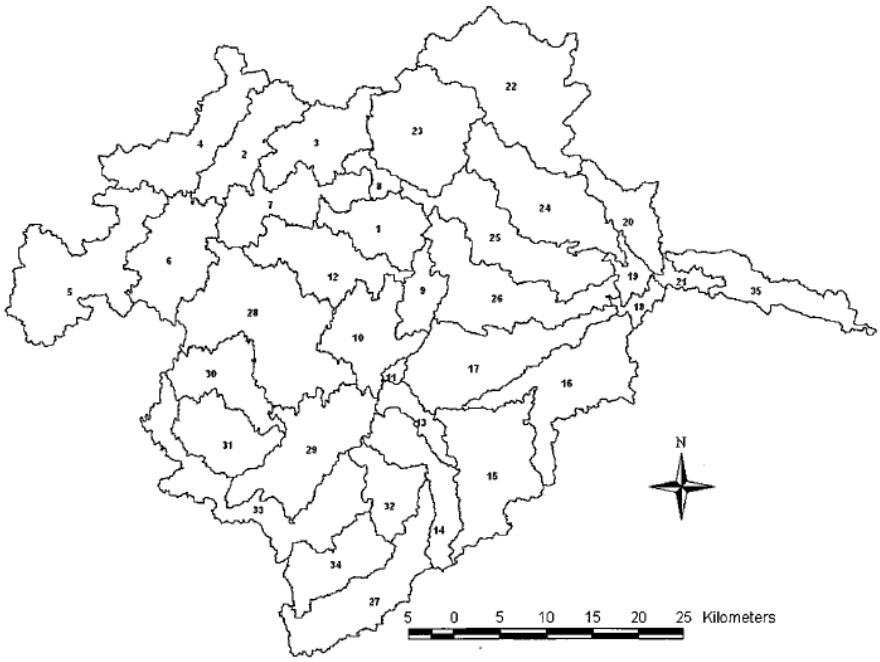


Figure 5-1 SWAT-Identified Sub-Basins of the River Raisin

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**).

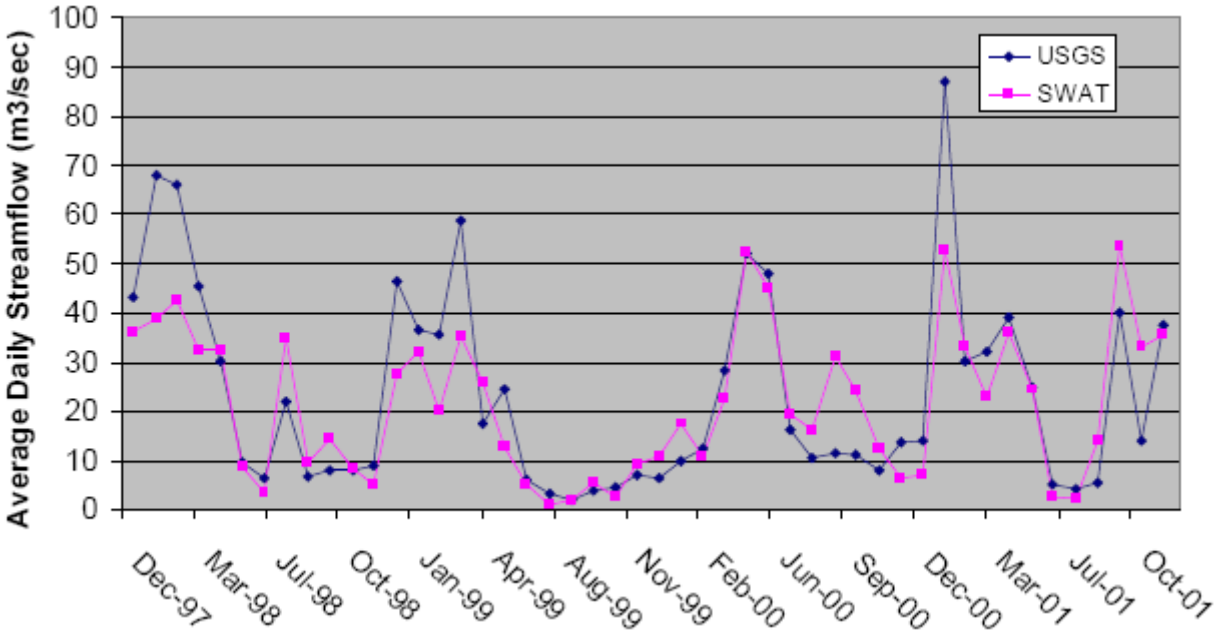


Figure 5-2 SWAT Model Hydrologic Calibration Comparison with USGS Gage on the River Raisin near Monroe (1998-2001).

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