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THE YELLOWWOOD LAKE WATERSHED MANAGEMENT PLAN

PROTECTING, ENHANCING, AND CONSERVING YELLOWWOOD LAKE AND ITS WATERSHED

PREPARED BY:

THE YELLOWWOOD LAKE WATERSHED PLANNING GROUP

JUNE 2006

Sponsored by the Indiana Department of Natural Resources' Division of Forestry

Yellowwood State Forest ~ 772 Yellowwood Lake Road ~ Nashville, Indiana, 47448 ~ (812)-988-7945

THE YELLOWWOOD LAKE WATERSHED MANAGEMENT PLAN

PROTECTING, ENHANCING, AND CONSERVING YELLOWWOOD LAKE AND ITS WATERSHED

VISION STATEMENT: THE GROUP'S VISION IS A HEALTHY, SUSTAINABLE, BIODIVERSE YELLOWWOOD LAKE WATERSHED ECOSYSTEM THAT WILL SERVE AS A MODEL FOR WATERSHED PLANNING WHILE ALLOWING FOR A VARIETY OF HUMAN ACTIVITIES AND PROVIDING THE HIGHEST QUALITY WATER RESOURCE ATTAINABLE.

MISSION STATEMENT: THE YELLOWWOOD LAKE WATERSHED PLANNING GROUP IS A PARTNERSHIP OF CONCERNED CITIZENS AND THE INDIANA DEPARTMENT OF NATURAL RESOURCES' DIVISION OF FORESTRY, DEDICATED TO DEVELOPING AND IMPLEMENTING A SUCCESSFUL WATERSHED PLAN TO PROTECT, ENHANCE, AND CONSERVE YELLOWWOOD LAKE AND ITS WATERSHED. THE HEALTH OF YELLOWWOOD LAKE IS DIRECTLY CONNECTED TO THE HEALTH AND BIODIVERSITY OF ITS WATERSHED.

THIS PROJECT WAS MADE POSSIBLE BY A FEDERAL CLEAN WATER ACT SECTION 205(J) WATER QUALITY MANAGEMENT PLANNING GRANT TO THE INDIANA DEPARTMENT OF NATURAL RESOUCES DIVISION OF FORESTRY FROM THE INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT.

THE YELLOWWOOD LAKE WATERSHED MANAGEMENT PLAN

PROTECTING, ENHANCING, AND CONSERVING YELLOWWOOD LAKE AND ITS WATERSHED

EXECUTIVE SUMMARY

The Yellowwood Lake watershed is located in south-central Indiana, approximately ten miles east of Bloomington. Included in the larger Salt Creek and East Fork White River Watersheds, the Yellowwood Lake Watershed comprises 60% of the 14-digit North Fork Salt Creek-Jackson Creek Watershed, spans approximately 4,410 acres, and is entirely contained within Brown County. In 2004, Yellowwood Lake, a 133 acre reservoir, was included on Indiana's 303(d) list of Impaired Waterbodies for Mercury.

Unique among many small watersheds in Indiana, approximately 80% of the Yellowwood Lake watershed is publicly owned and operated by the Indiana Department of Natural Resources Division of Forestry as Yellowwood State Forest. Located within the biologically rich Brown County Hills Region, the watershed's heavily forested (90% of total acreage) landscape and deeply dissected topography attract an estimated 200,000 people each year who come to camp, boat, hike, fish, hunt, ride horses, and enjoy nature. Other pursuits within the watershed include timber harvesting on state and private land, residential development, and private equestrian facilities.

The Yellowwood Lake Watershed Management Plan: Protecting, Enhancing, and Conserving Yellowwood Lake and Its Watershed is the result of 22 months of gathering input, conducting research, and initiating discussions among state and local government representatives, university researchers, consultants, environmentalists, watershed residents, stakeholder groups, and concerned citizens in order to identify and address watershed concerns. The Yellowwood Lake Watershed Planning Group (YLWPG), formed in 2000, led the process of developing this watershed management plan.

This plan was developed as a result of the group's efforts to protect, enhance, and conserve the ecological health of Yellowwood Lake and its watershed. To accomplish this goal; the YLWPG focused its attention on three main areas in the watershed: 1) sedimentation 2) nuisance and invasive species, and 3) biological and chemical contamination. A fourth concern, group sustainability, arose as the group discussed implementation of this plan. The YLWPG conducted water quality investigations to develop problem statements, goals, objectives, and action items to address each of the four focus topics:

GROUP SUSTAINABILITY

PROBLEM: The YLWPG does not have strategic plans or future funding sources for organizational sustainability or implementation of this watershed management plan's goals.

GOAL #1: Increase watershed user awareness about impacts of nonpoint source pollution on water quality.

GOAL #2: Ensure continued financial and personnel support for YLWPG activities.

SEDIMENTATION

PROBLEM: Yellowwood Lake is filling in with sediment, causing the lake to lose depth and the macrophyte beds to expand. Visual observations from Hoosier Fly Fishers members suggest that this process has accelerated over the last decade. Sediments from the watershed can carry biological and chemical pollutants, increase water temperature, block sunlight, impair sight-dependent predation, and smother fish nesting sites. The soft, fertile sediments also provide a rich bed for aquatic plant establishment.

GOAL: Reduce storm event Total Suspended Solid (TSS) loads in the Jackson Creek by 145 lbs/day to minimize depth loss in the north end of Yellowwood Lake.

NUISANCE AND INVASIVE SPECIES

PROBLEM: Nuisance and invasive species, detected throughout the Yellowwood Lake watershed, are detrimental to native biodiversity and provide few valuable environmental functions such as nutrient uptake, soil stabilization, habitat, and forage.

GOAL: Reduce the impact of exotic and nuisance flora and fauna in the Yellowwood Lake Watershed.

BIOLOGICAL AND CHEMICAL CONTAMINATION

PROBLEM: Biological and chemical contaminants pose an undefined threat to the Yellowwood Lake watershed. This is primarily due overland runoff of pathogens, chemicals, and nutrients. Failed or failing septic systems, horses, and wildlife are known to contribute nutrients and pathogens while automobiles, fertilizers, improper chemical use/storage, timber harvesting activities, and above-ground fuel storage tanks have the potential to leak hazardous materials into the watershed. Beyond runoff, Yellowwood Lake is currently suffering from airborne mercury contamination.

GOAL #1: Reduce the risk of chemical contamination from above-ground fuel storage tanks, chemical storage, illicit dumping, and stream crossings in the Yellowwood Lake watershed.

GOAL #2: Increase public education about mercury pollution in Yellowwood Lake.

GOAL #3: Reduce average *E. coli* loads by 20,000 *E.coli*/day in 5 years and by 40,000 *E.coli*/day in 10 years to meet the State Water Quality Standards for *E. coli.*

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ACRONYMS

BMP	Best Management Practice
BOD	Biological Oxygen Demand
Chl-*a*	Chlorophyll-*a*
CWA	Clean Water Act
DEM	Digital Elevation Model
DO	Dissolved Oxygen
DoF	Division of Forestry
% DO Sat.	% Dissolved Oxygen Saturation
EPA	Environmental Protection Agency
GIS	Geographic Information Systems
GPS	Geographic Positioning System
HFF	Hoosier Fly Fishers
HUC	Hydrologic Unit Code
IAC	Indiana Administrative Code
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
IGS	Indiana Geologic Survey
ISTI	Indiana State Trophic Index
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPS	Nonpoint source
NRCS	National Resource Conservation Service
NWI	National Wetlands Inventory
QHEI	Qualitative Habitat Evaluation Index
RC&D	Resource Conservation and Development
SCI-REMC	South Central Indiana- Rutherford Electric Membership Corporation
SD	Secchi Depth (or Disk)
SDWA	Safe Drinking Water Act
SPEA	School of Public and Environmental Affairs
SRP	Soluble Reactive Phosphorous
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TNC	The Nature Conservancy
TP	Total Phosphorous
TSI	Trophic State Index
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USLE	Universal Soil Loss Equation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WEPP	Watershed Erosion Prediction Program
WQ	Water Quality
YLWPG	Yellowwood Lake Watershed Planning Group

1. PROJECT INTRODUCTION

The Yellowwood Lake Watershed Planning Group (YLWPG) is a partnership of local residents, stakeholders, and the Indiana Department of Natural Resources (IDNR) Division of Forestry that is committed to the well being of Yellowwood Lake. In 2004 they successfully submitted an application for a Clean Water Act Section 205(j) grant to develop the Yellowwood Lake Watershed Management Plan. This document summarizes the baseline information and water quality improvement goals developed by the YLWPG.

The Yellowwood Lake Watershed Management Plan is a long-term plan that aims to maintain and improve the overall good water quality of Yellowwood Lake while identifying and addressing current and potential threats to the health of the lake and its watershed. This plan, through research and stakeholder input, prioritizes the many demands placed on the watershed and the lake. The project design was based on the watershed approach commonly used for environmental management. Developed by the EPA (1995), the watershed approach outlines a coordinated framework that encourages public and private sector collaboration to address water quality concerns. The YLWPG used the four major components of the watershed approach to develop this watershed management plan: 1) targeting priority problems, 2) involving stakeholders, 3) developing integrated solutions, and 4) measuring success. This management plan is intended to serve as a model for watershed planning that allows for a variety of human activities while providing for the highest quality water resource attainable.

The water quality investigation and relationships built through this watershed planning process will hopefully provide a solid foundation for the continued improvement of the Yellowwood Lake watershed. This resulting plan is a living document and was created to serve as a guide to be used by local decision makers for outreach, education, implementation, and assistance efforts. Landowners and citizens, we hope, will be able to use this plan to increase their understanding of water quality issues. The suggestions made under this plan do not establish legal requirements; rather, they provide a framework to coordinate future efforts to protect, enhance, and conserve water quality in the Yellowwood Lake watershed.

1.1. THE WATERSHED

The Yellowwood Lake Watershed Planning Group (YLWPG) has focused its planning efforts on the Yellowwood Lake watershed. Located within the North Fork Salt Creek-Jackson Creek watershed (HUC 05120208050060), the Yellowwood Lake watershed contains all of the land that drains into Yellowwood Lake (Figure 1.1). The watershed is part of the larger Salt Creek watershed (HUC 05120208050), which drains into Lake Monroe, the City of Bloomington's main drinking water supply.

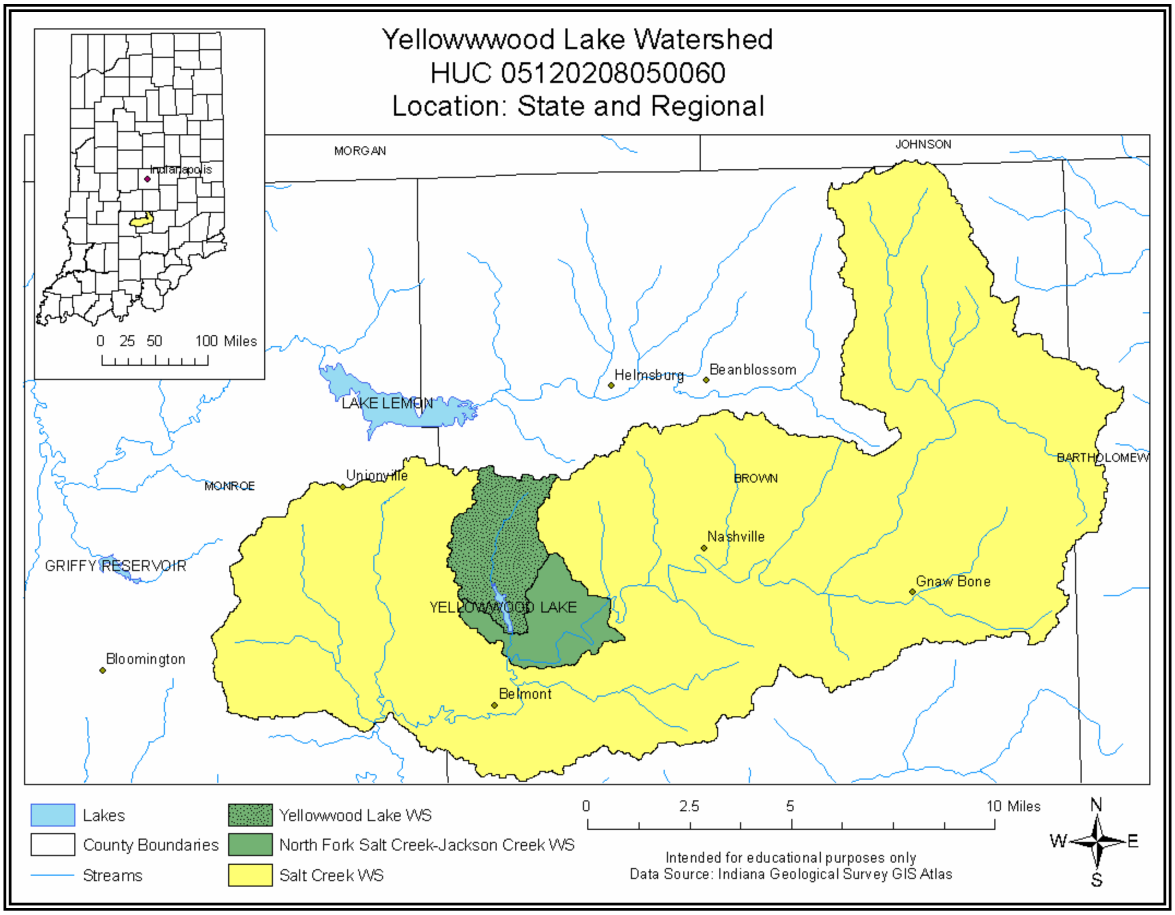

Figure 1.1. Yellowwood Lake Watershed: State and Regional

Yellowwood Lake is located in the northwestern portion of Brown County in south central Indiana. The Yellowwood Lake watershed comprises 4,410 acres (7 square miles), 80% of which (ca. 3,500 acres) is publicly owned and managed by the Division of Forestry, Indiana Department of Natural Resources (IDNR) as Yellowwood State Forest (YSF). Located 10 miles east of Bloomington, Yellowwood State Forest is 50 miles south of Indianapolis, and 22 miles west of Columbus. More than 800,000 people live within a 50-mile radius of the lake.

The watershed is bisected by Yellowwood Lake Road (a gravel county road running north and south), and is bordered on the east and west by ridge-top gravel roads. A blacktopped road forms the northern boundary. Several branches of Jackson Creek course through the watershed. Abandoned old county and farm roads, logging roads and fire lanes, and hiking trails and paths are ubiquitous throughout the watershed. YSF maintains a number of hiking and horse trails (Figure 1.2)

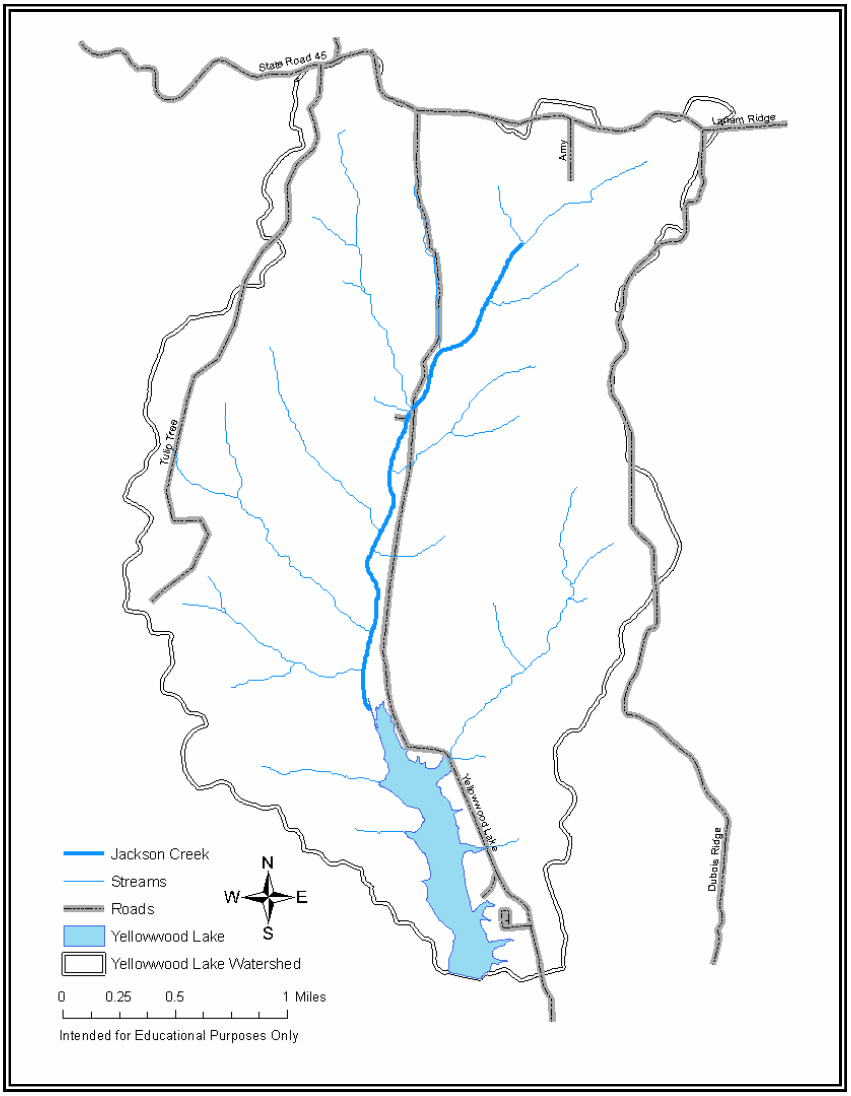

Figure 1.2. Yellowwood Lake Watershed: Local

1.2. BUILDING PARTNERSHIPS

This section outlines the development of the Yellowwood Lake Watershed Planning Group, its outreach activities, organizational structure, and the issues dealt with in this Watershed Management Plan.

HISTORY OF THE YELLOWWOOD LAKE WATERSHED PLANNING GROUP

On September 24, 2000, a group of local residents and stakeholders committed to the well being of Yellowwood State Forest initiated a partnership with the IDNR Division of Forestry to develop a long-term management plan for the Yellowwood Lake watershed. Early in the planning process, the group, now known as the Yellowwood Lake Watershed Planning Group (YLWPG), agreed that it would continue to function as a watershed advisory group beyond the completion of the plan.

Using *Working at a Watershed Level* (Council of State Governments, 1999) training workshops and course materials as their guide, in the fall of 2000 the YLWPG began to develop its infrastructure, gather background information, and create a list of potential stakeholders necessary to design a comprehensive management plan. By December 2000, the YLWPG had ratified its mission and vision statements.

In the following year, the group continued to meet on a monthly basis; additional watershed stakeholders were identified, and the group began systematically developing relationships with them. Letters about the project were sent to all the landowners in the watershed (55), a watershed database was created, and the group held its first Watershed Awareness Day. All available archival information about Yellowwood Lake was assembled. [These paper and electronic files are maintained in the Yellowwood SF Office.] Discussions with the head of field operations for SCI-REMC (local electric power provider) on REMC pesticide use and right-of-way clearing techniques in the watershed led to an agreement to work with the YLWPG on the plan. With the endorsement of the Brown County Commissioners, the head of the Brown County Highway department began to work with the group on Yellowwood Road maintenance issues. The Hoosier Flyfishers, stakeholder members of the YLWPG, agreed to take on the project of depth-mapping the lake and adopted the lake as their service project. GIS data on the lake from IU SPEA was obtained, to be entered into our base map.

By December 2002, the group included 16 stakeholder groups and 25 group members. In the winter of 2003, under the auspices of the Division of Forestry, the group applied for an Indiana Department of Environmental Management, Clean Water Act Section 205(j) Water Quality Planning Program grant, which it received in the summer of 2004. With grant funding, the group hired a watershed coordinator and began the formal planning process.

In 2003 and 2004, five group members with highly diverse stakeholder interests participated in the Natural Resources Leadership Development Institute, an intensive program developed through the Department of Forestry and Natural Resources at Purdue University. The goal of the Institute is to develop leaders within the natural resources communities who can build collaborative relations with others around contentious issues at the local level. Institute graduates become more knowledgeable about how to work collaboratively with others, build consensus, and find sustainable solutions to complex environmental issues in their communities.

Over the last five years the YLWPG has achieved a number of milestones. The Indiana Trailriders Association, an active stakeholder organization, worked in consultation with the group to design and build a state-of-the-art horse trail in the watershed that will serve as a model for other equestrian trailbuilders throughout the region. Long-term trail maintenance agreements between the Trailriders and YSF were reached as well. Likewise, agreements were reached with the SCI-REMC and the Brown County Commissioners on easement and road management principles in the watershed. Using the project review process developed by the YLWPG, a model timber harvest was proposed by YSF and reviewed and endorsed by group consensus (with one abstention).

PUBLIC OUTREACH

Encouraging public awareness and participation has been a priority of the Yellowwood Lake Watershed Planning Group. From the beginning, the YLWPG brainstormed lists of potential contacts at monthly meetings. The YLWPG began with an informal recruiting process by corresponding with identified individuals and watershed landowners through letters and conversations (Appendix A). Next, the YLWPG used press releases, public meetings, and Watershed Awareness Days (May 2001, October 2004 and summer 2005) to increase public awareness (Figure 1.3). The group also developed an informative brochure, available at the YSF headquarters, and a biannual newsletter that was circulated to watershed landowners and stakeholders. Additionally, watershed user packets and private landowner packets were also distributed.

Figure 1.3. YLWPG: Watershed Awareness Day

Because 80% of the Yellowwood Lake watershed is public land, this plan deals with concerns that reach beyond the watershed residents. Particular effort was made to include the general public in the planning process. All of the YLWPG meetings are open to the public, and quarterly meetings were held at the Brown County Library to better engage the public.

In the final stages of plan development, the YLWPG sponsored the Indiana Forested Watershed Symposium (the first such conference on this topic in the state) to focus on several of the issues faced by forested watersheds that the group had encountered during its work on the Yellowwood plan. Presentations on sedimentation, sustainable recreational use, roads and trails, forest economics, and biodiversity were presented by state and federal forest officials, economists, and researchers from Purdue and IU. More than 60 people—property managers, watershed planners, landowners, foresters, community members, environmentalists, and researchers—attended the symposium, held at the Abe Martin Lodge in the Brown County State Park in April 2006. The success of this first conference has led the Hoosier Heartlands Resource Conservation and Development Council to propose another forested watershed conference be held next year. (Appendix B).

ORGANIZATIONAL STRUCTURE

The YLWPG's 205(j) grant from IDEM is administered by the Division of Forestry as the government sponsor. The watershed coordinator, funded by the grant, reports on a daily basis to the manager of Yellowwood State Forest, but the steering committee of the planning group is responsible for establishing the coordinator's general priorities and direction. The coordinator is housed in the YSF headquarters, and most group meetings take place there. The archival files and computer databases are maintained in the YSF office.

An extensive list of stakeholders concerned with the well being of Yellowwood Lake and its watershed comprise the interest group for the plan. A core group of about twelve individuals serves as the steering committee. These individuals attend monthly meetings and participate in the decision-making process. The remaining members are kept informed via meeting minutes that are circulated to the entire group (Appendix C.)

Communication, meeting structures, and the decision-making process of the YLWPG are outlined in the Yellowwood Lake Watershed Charter, adopted in 2005 (Appendix D). Monthly group meetings operate by round table discussions facilitated by the revolving YLWPG Chair (Figure 1.4). Experts are frequently invited to address specific concerns or to provide a context for discussions. Sub-committee meetings, held as needed in addition to the monthly meetings, operate in a similar format. To promote collaborative problem solving, the YLWPG operates by consensus, utilizing a process detailed in the Charter.

Figure 1.4. YLWPG: Steering Committee Meeting

A sub-committee structure was adopted to improve the group's efficiency in dealing with the multiple facets of the plan. Three sub-committees concentrated on communications, monitoring, and plan writing. The communications committee developed and distributed informative packets for watershed dwellers and watershed visitors; published biannual newsletters; and held public meetings. The monitoring committee tackled water quality testing, land inventorying, and sedimentation and invasive species issues, and coordinated expert panels to educate the group about their concerns. The Plan Writing committee was responsible for the development of the written product. An ad hoc group organized the Forested Watershed Symposium. The YLWPG Management planning process is outlined in Table 1.1.

While these sub-committees focused on aspects of the watershed plan itself, a standing project review committee was created to review proposed activities in the watershed; to identify any areas of concern; and then to make recommendations on ways to improve outcomes and mitigate impacts. The review committee presents its recommendations to the YLWPG as a whole, which votes to support, request modifications, or oppose the proposed project (Appendix E). As with the YLWPG as a whole, the project review committee serves an advisory function.

Table 1.1. YLWPG: Watershed Planning Timeline

Date	Activity
December 2000	YLWPG partnership Initiated
	Develop Watershed Mission and Vision
May 2001	First Watershed Day
Winter 2003	Apply for IDEM 205 (j)
June 2004	Receive grant funding / Project begins
September 2004	Goals for the Plan
October 2004	Watershed Awareness Day
November 2004	Formed sub-committees
February 2005	List concerns
	Develop problem statements
May 2005	Watershed Awareness Day
June 2005	Rank concerns/ problem statements
July 2005	Expert Panels/ Goals and Objectives
April 2006	Forested Watershed Symposium held
	Draft Plan
June 2006	Final Plan

UNDERSTANDING THE ISSUES

In February of 2005, the YLWPG developed a list of concerns for Yellowwood Lake and its watershed. The concerns were then complied, combined, and compared to water quality studies to determine which of them were quantifiable problems.

The draft concerns were then prioritized using a weighted ranking system. Table 1.2.4.1 shows the results of the prioritization process. The top three concerns, listed by rank, are "the lake is losing depth," "*E. coli* levels," and "nuisance and invasive aquatic plants."

The YLWPG felt that it was important to address each of the concerns identified by its stakeholders. To properly discuss each concern, the YLWPG organized a series of expert panels consisting of university researchers, private consultants, and state resource specialists to discuss each topic. The expert panels were held an hour before monthly YLWPG meetings. Experts were asked to give a brief explanation of the problem, advise the group as to management options, and answer questions. Table 1.2 shows the expert schedule. Following the expert panel discussion, the YLWPG developed draft goals, objectives, and action items for each concern. The YLWPG's concerns are listed in Table 1.3.

Table 1.2. YLWPG: Expert Panel Schedule

TOPIC	EXPERTS
Risk of Chemical Contamination	Brian Smith (IDEM emergency spill response) Flynn Picardal (IU SPEA)
Nuisance and Invasive Species	Larry Lehman (DNR Fishery Biologist) Steve Cotter (City of Bloomington Parks and Recreation) Luke Flory (IU Biology Dept.) Ellen Jaquart (TNC)* spoke at an invasive plant workshop
Sedimentation	Greg Bright (Commonwealth Biomonitoring, Inc.)

Table 1.3. YLWPG: Prioritizing Concerns

CONCERN[1]	**TOTAL VOTES**	**% OF VOTERS (N = 12)**	**SUM OF RANK**
The lake is losing depth, the wetland is expanding, and turbidity is increasing.	7	58.3%	21
E. coli levels are above state allowed standards for full body contact.	7	58.3%	20
Nuisance and invasive aquatic plant species have been found in the lake.	5	41.7%	13
Current timber management is causing elevated erosion levels, reduced biodiversity, and decreased recreational potential.	4	33.3%	11
The condition of Yellowwood Road is causing erosion and safety hazards.	4	33.3%	9
Nuisance and invasive terrestrial species have been detected throughout the watershed.	3	25.0%	8
Phosphorous levels in the lake are causing the lake to become eutrophic.	3	25.0%	5
Gizzard shad and Yellow bass have been detected in the lake.	1	8.3%	3
Shorelines along the campgrounds, shelterhouse, and walking paths are eroded.	1	8.3%	3
The dam is unstable.	1	8.3%	0
There is a risk of contamination in the lake.	0	0.0%	0

CHALLENGES

Yellowwood Lake and its watershed present many extraordinary opportunities and several management challenges. A committed and diverse constituency of user groups is dedicated to the wellbeing of the lake. The watershed's location, within ten miles of Indiana University, enhances its accessibility and use as an outdoor laboratory and classroom. The work of the planning group itself has resulted in the creation and compilation of an unusually high level of information and research about the lake and the watershed, creating a unique baseline for further study. The general public has demonstrated its engagement with and dedication to Yellowwood many times over the years. For many visitors, the Yellowwood Lake and its watershed are their first introduction to the Indiana State Forest system.

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[1] Each group member ranked his/ her top three concerns and scored them as high, medium, or low. Concerns ranked as 'high' received three points; 'medium' received two points; and 'low' received one point. The total ranking and total number of voters was recorded. For example, "The Lake is losing depth…" scored 21/7. The twenty one represents total number of points the concern received and seven is the number of voters ranking this concern. The higher the percent of voters ranking the issue, the higher the degree of consensus within the group

Yet the forest itself is challenged by an array of threats. Invasive species—from alien plants, to gypsy moths and emerald ash borers, to over-population by deer and turkey—are a primary concern. Oak and hickory regeneration are important silvicultural issues. Sediment from the watershed has been identified by the group as the most serious threat to the lake, and many of the activities in the watershed disturb soils and potentially increase sediment input into the lake. Land use practices such as timber harvesting and increased use of public roads have the potential to increase sediment loads. Similarly, residential development has the potential to increase the risk for biological and chemical contamination in the watershed. Residential development on the 20% (ca. 900 acres) of private land within the watershed is expected to increase and private property in close proximity to public lands is highly prized. As population in the surrounding areas increases, recreational use is expected to continue to rise.

As the manager of 80% of the land in the watershed, the Indiana Division of Forestry ultimately controls the success or failure of the plan. To accommodate the multiple demands on the watershed, to fulfill its potential as a model forested watershed, and to mitigate the threats it faces, this plan includes recommendations for State Forest management that focus on the longevity of the lake, the healthy biodiversity of the forest, and the recreational and educational uses of the lake and the watershed. In addition to the recommendations included in the specific action plans in Section 8, the Planning Group recommends to the managers of Yellowwood State Forest that:

- **Long-term management activities in the watershed are conceptualized and planned on the watershed level** in order to identify and encourage native plant communities; discourage invasives; and to integrate timber, recreation, and biodiversity concerns.

- **Management of invasive species becomes an overarching priority,** including prevention, identification, monitoring, and elimination where possible

- **Trail buffer zones along trails, logging roads, etc**.—are established to control exotic invasion and to enhance the recreational and aesthetic values of trails.

- **Soil-disturbing activities in the watershed continue to be reviewed** by the Project Review committee of the YLWPG

- **Existing applicable timber set-aside programs in the watershed are reviewed**—i.e. Old Growth; Developed Recreational and Operational Facilities; Research Forests—to determine what additional acreage can be added to these zones.

- **Management practices that support the development of top soil** in the watershed are encouraged.

- **The deer population problem in the watershed is addressed**.

- **Research on the lake and the watershed is encouraged** at all levels of management, and partnerships with IU and Purdue are actively sought.

- **The position of Resource Specialist is restored**, with primary responsibility for Yellowwood Lake and its watershed and emphasis on education, invasives management, and building and maintaining stakeholder and research partnerships.

MERCURY CONCERNS

The 2004 Indiana Integrated Water Quality Monitoring and Assessment report (IDEM, 2004) lists Yellowwood Lake as a Category 5b water body. This means that there is a water impairment that exceeds state standards. For Yellowwood Lake, the warning is due to mercury contamination. As a result of this listing, there is a Fish Consumption Advisory (FCA)-Group 2 for fish caught in Yellowwood Lake. In the 2004 Indiana Lakes and Reservoirs Advisory published by the State Department of Health, IDEM, and IDNR, a Group 2 listing recommends that the general population eat no more than one meal/ week of fish caught in Yellowwood Lake while the at-risk population (women of childbearing years, nursing mothers, and children under 15) limit fish consumption to one meal/month.

The standard approach to dealing with a water contamination issue is to develop a TMDL (total maximum daily load) for the impaired water body. However, the state believes that a 'conventional TMDL is not the appropriate approach' in this situation. To date, there is no plan to develop a TMDL for Yellowwood Lake. The YLWPG is aware of the fish consumption warning in Yellowwood Lake, but realizes that the issue extends beyond the bounds of the watershed. While there is not a protocol for us to follow, the YLWPG plans to work with the state and the U.S. EPA to address our impairment. In its outreach activities, the YLWPG will attempt to make the public aware of the FCA and what they can do to decrease mercury contamination in the Yellowwood Lake watershed.

2. PHYSICAL DESCRIPTION OF THE WATERSHED

This section describes the physical setting of the Yellowwood Lake watershed. The background information provides a description of the area's geologic history, physiography, topography, soils, hydrologic features, local climate information, wetland, and a natural history of the watershed.

2.1. GEOLOGIC HISTORY

Deposited in the Paleozoic Age[2] by ancient streams and shorelines, the bedrock geology of the Yellowwood Lake watershed includes the siltstone and shale (Figure 2.1) of the Borden Group rock interbedded with sandstone and limestone that was deposited in the Mississippian Period[3]. The Borden Group includes layers from three main formations (Table 2.1).

Table 2.1. Formations of the Borden Group

Formation (in ascending order)	Composition	Origin
New Providence Shale	Greenish-gray shale and minor amounts of red shale, sandstone, ironstone, and silty dolomite	Prodelta deposits
Spickert Knob	Siltstone, silty shale, and irregularly distributed ironstone nodules and geodes	Delta-slope deposits
Edwardsville	Limestone, siltstone, sandstone, and sandy shale	Delta-platform deposits

Adapted from the Indiana Geologic Survey (Thompson, 1997)

The Yellowwood Lake watershed is approximately 20 miles south of the glacial maximum in Indiana. While glaciers covered the northern two thirds of the state, leaving behind thick consolidated surface deposits that developed into rich fertile soils, the unglaciated portion of the state consists of shallow unconsolidated surface deposits of weathered tills that have developed into fragile soil layers (Fenelon and Bobay, 1994). These thin soil layers correspond to the dominant surface geology in Brown County: stony soil over siltstone.

Figure 2.1. Jackson Creek: Shale Bedrock

[2] Deposited 488 million years ago to 251 million years ago

[3] Deposited 340 million years ago to 320 million years ago

2.2. PHYSIOGRAPHIC FEATURES

The Yellowwood Lake watershed is located within the unglaciated portion of the Norman Upland; a physiographic unit[4] characterized by long, narrow, flat-topped ridges and steeply sloped stream valleys (Fenelon and Bobay, 1994; Schneider, 1966). The Norman Upland has a well-drained, dendritic drainage system. Small streams have minimal floodplain development while larger streams have narrow flat valleys, indicative of a mature landscape (Schneider, 1966). Over time, this landscape developed from streams eroding away the soft limestone, leaving the resistant Mississippian-age siltstone and shale, shown in Figure 2.2, which comprise some of the most rugged landscape in Indiana (Gray, 1997).

Figure 2.2. Jackson Creek: bedrock streams

2.3. SOILS

Initially completed in 1946 and later updated in 1984, the Brown County Soil Survey provides an extensive map of soil types and landscape features (Nobel et *al*., 1984). The soils are related to the geology, landforms, relief, climate, and natural vegetation of a landscape. There are two major soil associations representing ten soil types in the watershed (Figure 2.3). Table 2.2 shows characteristics of each of the soil types.

BERKS-TREVLAC-WELLSTON ASSOCIATION

The Berks-Trevlac-Wellston soil association was formed in loess and in material weathered from shale, siltstone, and sandstone. The soils of this association are moderately deep[5] silty loams and can be found on ridges and slopes from 6 to 70%. Primarily used as woodland, the steep slopes and well-drained soils of the Berks-Trevlac-Wellston Association are poorly suited for cultivated crops, hay and pasture, urban uses, and recreational uses. Slope, erosion hazards, and depth to bedrock are the main management concerns for this association (Nobel et *al.,* 1984).

[4] A geographic area with similar topographic features.

[5] Average depth approximately 38 inches deep

STENDAL-HAYMOND-STEFF ASSOCIATION

The Stendal-Haymond-Steff Association was formed in silty alluvial deposits and is commonly found on floodplains along major streams and rivers. These silty loam soils are confined to level slopes ranging from 0 to 2%. This association is well suited for cultivated crops; fairly well suited for hay and pasture, woodland, and extensive recreational uses; and poorly suited for urban uses and intensive recreation due to flooding and wetness (Nobel et *al.,* 1984).

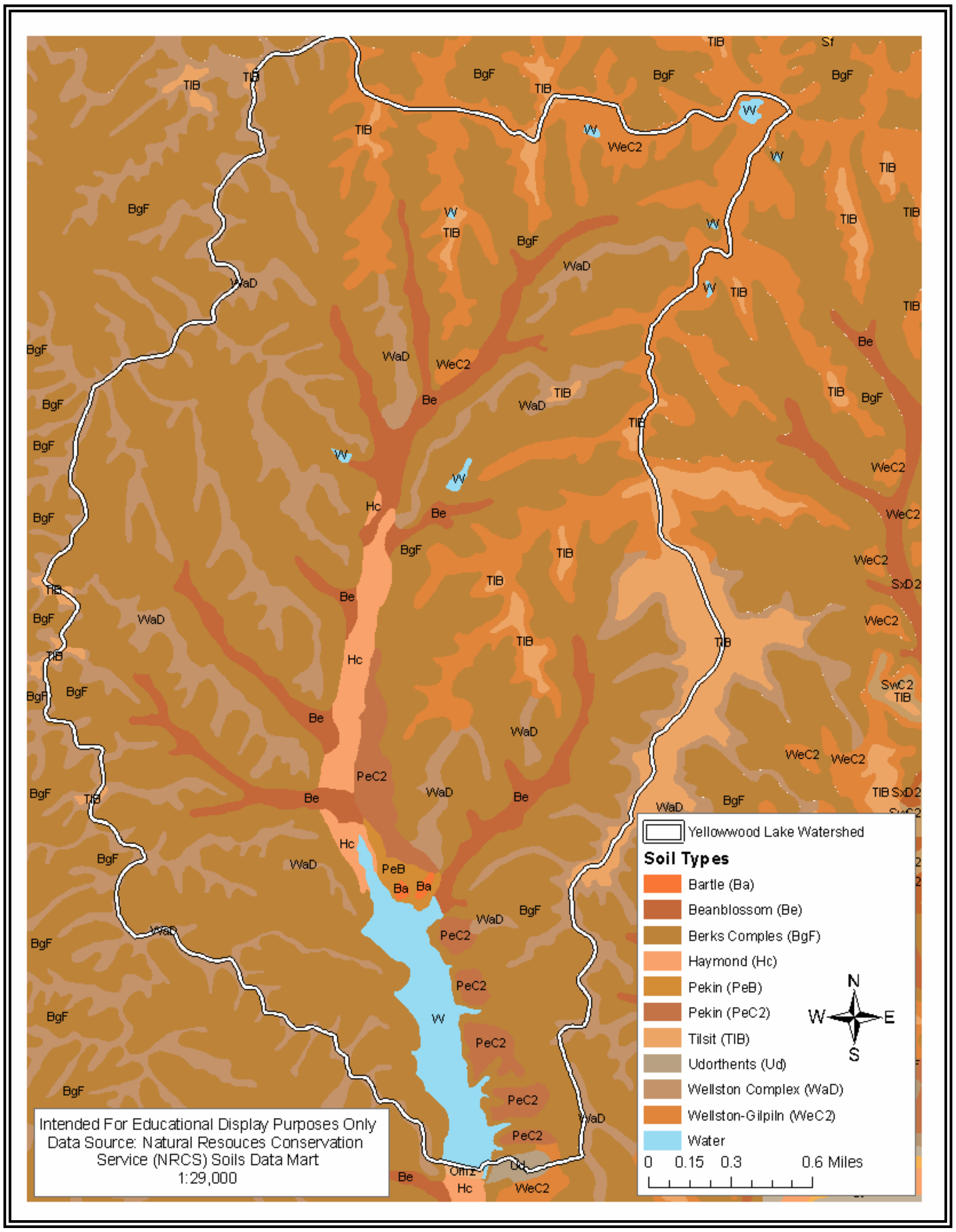

Figure 2.3. Yellowwood Lake Watershed: Soils

Table 2.2. Yellowwood Lake Watershed: Description of Soil Characteristics

Code	Name	Description	Area (acres)	% of Watershed	Slope	Woodland Management Concerns		Septic tank absorption field concerns
						Erosion Hazard	Equipment Limitation	
Ba	Bartle silt loam	Nearly level and gently sloping, deep, somewhat poorly drained soil on stream terraces	4	0.1%	0-3%	slight	slight	severe: wetness, percs slowly
Be	Beanblossom channery silt loam	Nearly level and gently sloping, deep, moderately well drained soil is on floodplains, alluvial fans, and colluvial benches	252	5.7%	--	slight	moderate	severe: flooding, wetness
BgF	Berks-Trevlac-Wellston complex	Moderately steep to very steep, well drained soils on hillsides and in the uplands	2707	61.4%	20-70%	moderate	severe	severe: depth to rock, slope
Hc	Haymond silt loam	Nearly level, deep, well drained soil is on flood plains	78	1.8%	--	slight	slight	severe: flooding
PeB	Pekin silt loam	Gently sloping, deep, moderately well drained soil is on low stream terraces	18	0.4%	2-6%	slight	slight	severe: wetness, percs slowly
PeC2	Pekin silt loam	Moderately sloping, deep, moderately well drained soil is on ridgetops and side slopes on terraces	102	2.3%	6-12%	slight	slight	severe: wetness, percs slowly
TIB	Tilsit silt loam	Gently sloping, deep, moderately well drained soil is on the tops of ridges in the uplands	128	2.9%	2-6%	slight	slight	severe: wetness, percs slowly
Ud	Udorthents	Nearly level to moderately sloping, deep to shallow, well drained to somewhat poorly drained soils are in disturbed areas or uplands, terraces, and floodplains	5	0.1%	--	---	---	---
WaD	Wellston Complex	Moderately sloping to moderately steep, well drained soils are on side slopes and narrow ridgetops in the uplands	542	12.3%	6-20%	slight	slight	severe: slope
WeC2	Wellston-Gilpin	Moderately sloping to moderately steep, well drained soils on side slopes and ridgetops	442	10.0%	6-20%	slight	slight	severe: slope

Code	Septic tank absorption fields	Forestry Equipment Use				Building Site Development			
		Haul roads	Log Landings	Skid trails and logging areas	Site preparation and planting	Shallow Excavation	Dwellings without basements	Dwellings with basements	Local Roads and Streets
Ba	severe: wetness, percs slowly	Moderate: wetness	Moderate: wetness	Moderate: wetness	Moderate: wetness	severe: wetness	severe: wetness	severe: wetness	severe: low strength, frost action
Be	severe: flooding, wetness	Moderate: flooding	Moderate: flooding	slight	slight	moderate: wetness, flooding	severe: flooding	severe: flooding	severe: flooding
BgF	severe: depth to rock, slope	severe: slope	severe: slope	severe: slope	severe: slope	severe: slope	severe: slope	severe: slope	severe: slope
Hc	severe: flooding	Severe: flooding	Severe: flooding	moderate: flooding	slight	moderate: flooding	severe: flooding	severe: flooding	severe: flooding, frost action
PeB	severe: wetness, percs slowly	slight	slight	slight	slight	severe: wetness	moderate: wetness	severe: wetness	severe: low strength, frost action
PeC2	severe: wetness, percs slowly	slight	moderate: slope	slight	slight	severe: wetness	moderate: wetness, slope	severe: wetness	severe: low strength, frost action
TIB	severe: wetness, percs slowly	slight	slight	slight	slight	severe: wetness	moderate: wetness	severe: wetness	severe: low strength, frost action
Ud	---	---	---	---	---	---	---	---	---
WaD	severe: slope	slight	moderate: slope	slight	slight	Severe: slope	Severe: slope	Severe: slope	Severe: slope, frost action
WeC2	severe: slope	slight	moderate: slope	slight	slight	Severe: slope	Severe: slope	Severe: slope	Severe: slope, frost action

(Adapted from Nobel et *al.,* 1984)

2.4. TOPOGRAPHY

The elevation in the Yellowwood Lake watershed ranges from 587 feet above sea level to 956 feet above sea level, approximately 370 feet of relief (Figure 2.4). The highest elevation in the county is 1,058 feet in nearby Brown County State Park (Hill, 1997).

Slope is a measurement of elevation change. In the watershed the percent slope varies from 0 - 90°. Low percent slopes in the watershed correspond to the hydrologic features and flat ridgetops. Digital maps of elevation and slope of the watershed were developed from a 10m Digital Elevation Model of the Belmont Quadrangle.

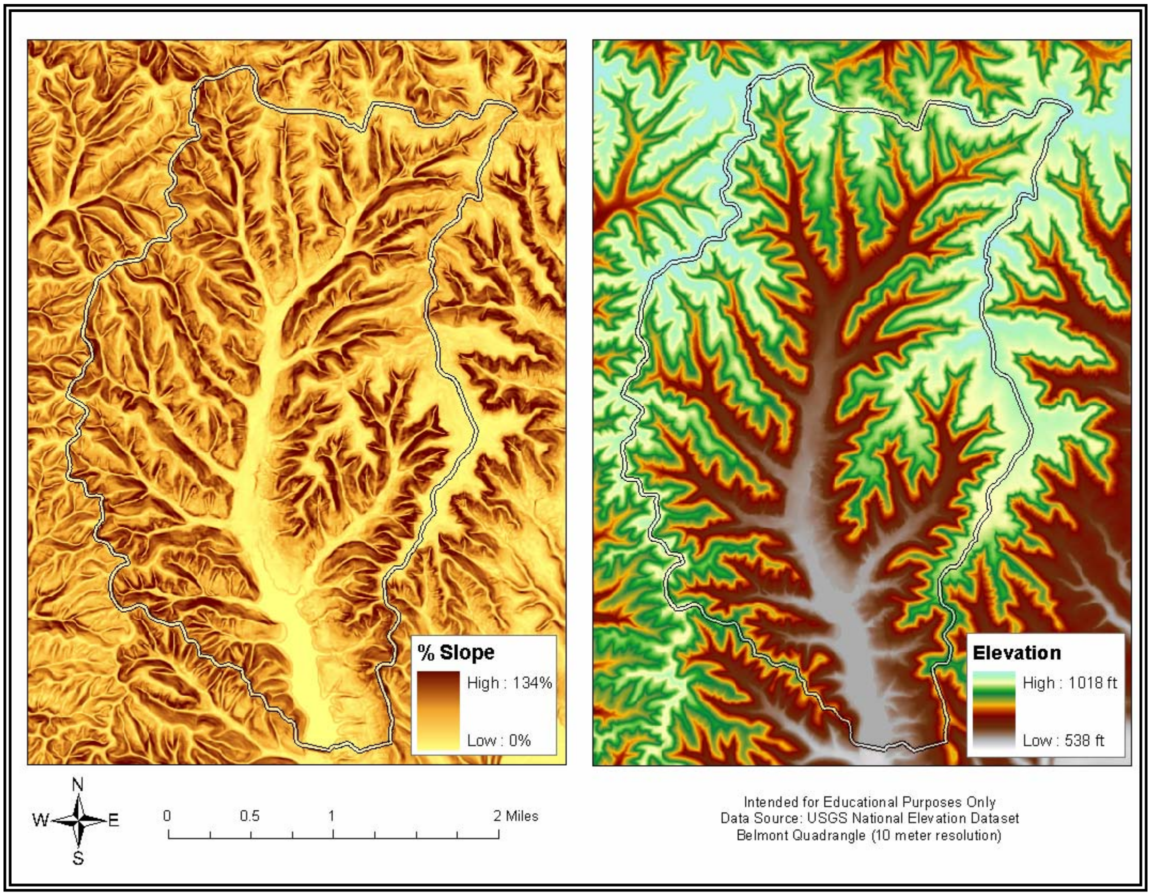

Figure 2.4. Yellowwood Lake Watershed: elevation (ft) and % slope

2.5. HYDROLOGY

This section outlines the hydrologic features of the Yellowwood Lake Watershed, including surface, sub-surface, and forested hydrology.

SUB-SURFACE HYDROLOGY

The thin, unconsolidated layer of surface deposits in Yellowwood Lake watershed is known as the Dissected Till and Residuum Aquifer System. The nature of these materials renders the aquifer an extremely limited resource. Brown County has no known wells that produce from unconsolidated materials (Maier, 2003). As a result, residents of Brown County often utilize bedrock aquifers.

The bedrock of the Borden Group is not conducive for groundwater flow because silt and shale have low tranmissivity (Hartke and Gray, 1998). With the exception of a few joints, water cannot infiltrate the bedrock and travel easily below the surface as groundwater. In fact, only 1% of the total inputs into Lake Monroe, a nearby reservoir, are from groundwater (Jones, 1997). The bedrock of the Yellowwood Lake watershed has been labeled as an aquifer with 'potential unknown' because the fracture flow through the bedrock is unpredictable (Fenelon and Bobay, 1994). Jackson Creek intersects the aquifer at the groundwater table (Fenelon and Bobay, 1994), but due to the uncertain nature of the aquifer, dry periods may cause the ground water table to fall below the streambed, causing Jackson Creek to occasionally run dry. It is possible; however, that groundwater can flow through the Yellowwood Lake watershed via the alluvium that has concentrated along lower Jackson Creek (Gray, 1989).

SURFACE HYDROLOGY

It is likely that the combination of steep slopes and impermeable shale siltstone bedrock prevent most rainwater from infiltrating the surface. Water that does not penetrate the surface moves as a sheet of overland flow (Allan, 2001) down the sides of the slopes until it runs off into tributaries, bringing sediment, minerals, and nutrients to the tributaries of Yellowwood Lake.

The heavily dissected landscape of the Yellowwood Lake watershed is dominated by confined streams (USGS, 1990). Strongly confined streams have steep slopes and minimal floodplain development. During a flood event, the steep slopes prevent water from leaving the channel, causing the stream to quickly rise. Drainage density is the ratio of total stream length within a watershed to total area of the watershed. In the Yellowwood Lake watershed, there are 2.4 miles of stream length per square mile of the watershed (2.4 mi/mi^2) (1.4 km/km^2).

Table 2.3. Yellowwood Lake Watershed Sub-catchments

Sub-catchments	Area (acres)	Percent of Watershed
Jackson Creek	3,018	68.5%
John Floyd Hollow	688	15.6%
Others	688	12.9%

The major tributary, Jackson Creek, is approximately 2.6 miles in length and flows from north to south, bisecting the watershed and emptying into Yellowwood Lake. There are 7.5 miles of perennial[6] streams and 11 miles of intermittent[7] streams in the watershed. The watershed is composed of two major sub-catchments: Jackson Creek and John Floyd Hollow. This plan occasionally uses the John Floyd Hollow sub-catchment as a control as there is no development in this drainage. The sub-catchments areas are displayed in Table 2.3. Figure 2.5 shows the hydrological features present in the Yellowwood Lake watershed.

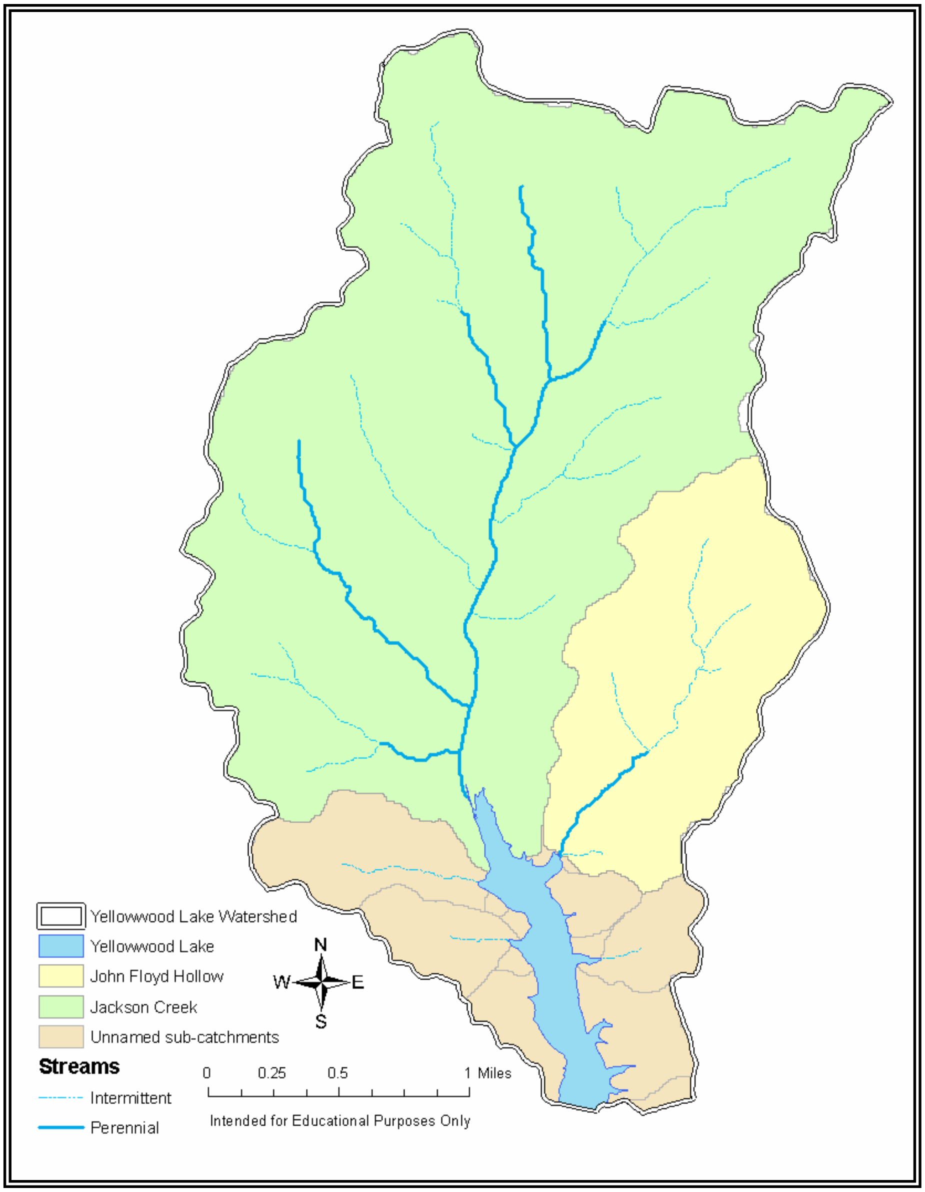

Figure 2.5. Yellowwood Lake Watershed: Hydrologic Features

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[6] A stream that normally has water in it. In this map, our perennial streams coincide with USGS Blue line streams

[7] A stream that flows only when it receives water from rainfall, springs, or some surface source such as melting snow.

FOREST HYDROLOGY

Stream flow is produced through groundwater seepage and vadose zone flow[8]. Both are supplied and replenished by rainfall and snow melt, but in forested areas only a small portion of the precipitation reaches surface waters. Some water is evaporated back into the atmosphere, some is absorbed by vegetation, and some is retained by the soil. Climate, soil types, topography, and vegetation all influence how quickly moisture will infiltrate the soil and how much precipitation will actually reach the surface water.

Changes in surface runoff from forested areas are more likely to be caused by changes in the watershed, rather than by excessive precipitation. This can be a problem because surface runoff has far more erosive power than subsurface flow. Forest floors have minimal surface storage capacity, but often substantial subsurface storage in the soil. Leaf litter, woody debris, and other such obstacles can help slow surface runoff, but other factors can increase its volume or intensity. These factors include loss of vegetative cover, soil compaction, impervious surfaces, and cut slopes of roads and other soil disturbances that transform subsurface flow to surface flow. Surface water flows down hill slopes more than 10 times faster than it flow through soil (USEPA, 2005). When more water is delivered to streams faster than usual, in-stream erosion can occur.

2.6. WETLANDS

The National Wetlands Inventory (NWI), developed by the U.S. Fish & Wildlife Service, is a clearinghouse for information on the characteristics, extent, and status of nation's wetlands. Based upon remotely sensed satellite data from the 1980's, the NWI maps include wetlands in the Yellowwood Lake Watershed.

The NWI uses a hierarchical classification system developed by Lewis et al. (1979) to describe wetlands by hydrologic, geomorphologic, chemical, and biological factors. The wetland classes in the Yellowwood Lake watershed are shown in Table 2.4. All of the wetlands in the watershed are associated with impoundments, and most are located along the northern edge of Yellowwood Lake, as shown in Figure 2.6. Due to the dated imagery used for the NWI analysis; it is likely that the four L2ABHh sections are currently joined together. The PUBGh wetlands scattered throughout the watershed are likely small impoundments constructed by private landowners for drinking water or wildlife.

[8] Vadose zone flow is the flow that occurs between the ground surface and the water table.

Table 2.4. Yellowwood Lake Watershed: NWI Wetlands

Wetland Code	Description	Area (acres)
L1UBHh	Lacustrine, Limnetic, Unconsolidated Bottom, Permanently Flooded, Diked/ Impounded	110.4
L2ABHh	Lacustrine, Littoral, Aquatic Bed, Permanently Flooded, Diked/ Impounded	10.2
PABFh	Palustrine, Aquatic Bed, Semipermanently Flooded, Diked/ Impounded	2.2
PEMFh	Palustrine, Emergent, Semipermanently Flooded, Diked/ Impounded	1.9
PEMCh	Palustrine, Emergent, Seasonally Flooded, Diked/ Impounded	1.0
PFO1Ah	Palustrine, Forested, Broad-Leaved Deciduous, Temporarily Flooded, Diked/ Impounded	5.5
PUBFh	Palustrine, Unconsolidated Bottom, Semipermanently Flooded, Diked/ Impounded	0.3
PUBGh	Palustrine, Unconsolidated Bottom, Intermittently Exposed, Diked/ Impounded	12.0

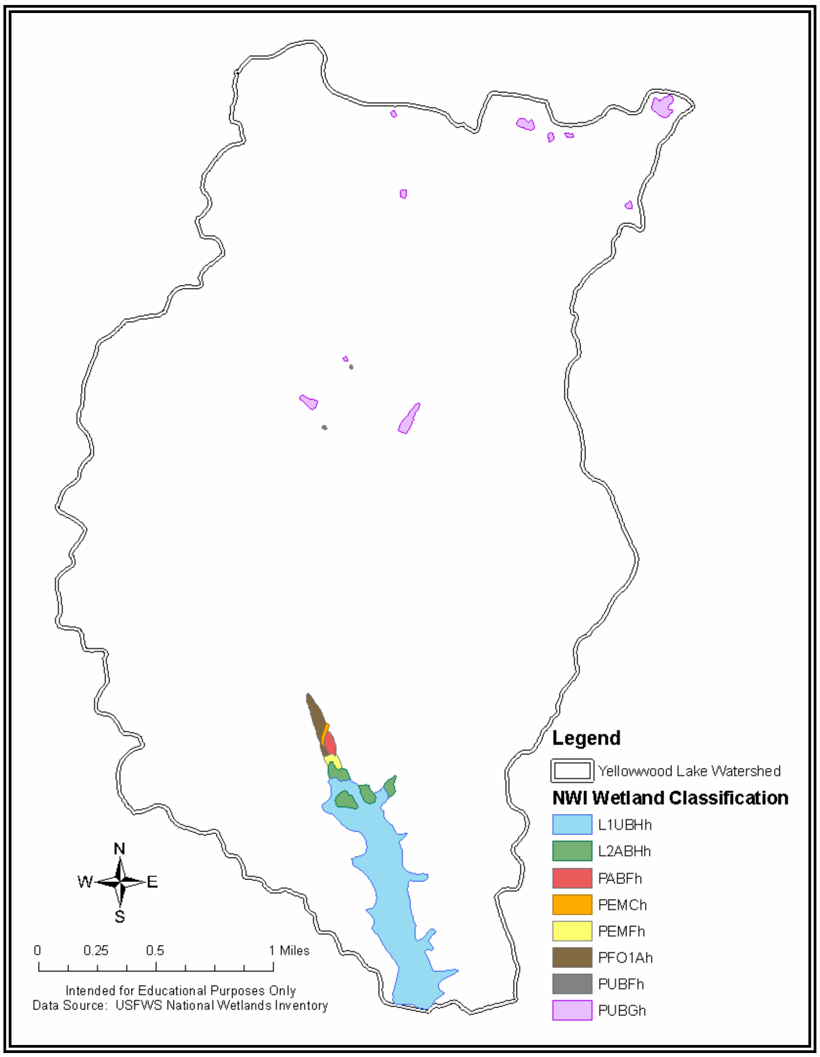


Figure 2.6. Yellowwood Lake Watershed: NWI Wetlands

2.7. YELLOWWOOD LAKE

Yellowwood Lake is located in the northwestern portion of Brown County in southern Indiana. The 131-acre reservoir was created in 1939 by damming Jackson Creek as part of the Bean Blossom Land Utilization Project of the United States Bureau of Agricultural Economics (Figure 2.7). The lake was originally created as both a drinking water source and recreational destination.

The lake had a maximum depth of 30 feet and an average depth of 14 feet in 1955. A summary of Yellowwood Lake's characteristics is presented in Table 2.5. A bathymetric map (Figure 2.8) shows that the Lake is the deepest near the dam and decreases in depth until it merges with the wetland on the north end of the lake.

Figure 2.7. Yellowwood Lake Pictures

Table 2.5. Yellowwood Lake: Physical characteristics

Watershed Area	4,408 acres
Lake Area	131 acres
Shoreline	4.5 miles
Maximum Depth	32 ft
Average Depth	14 ft
Volume	3,700 acre-feet

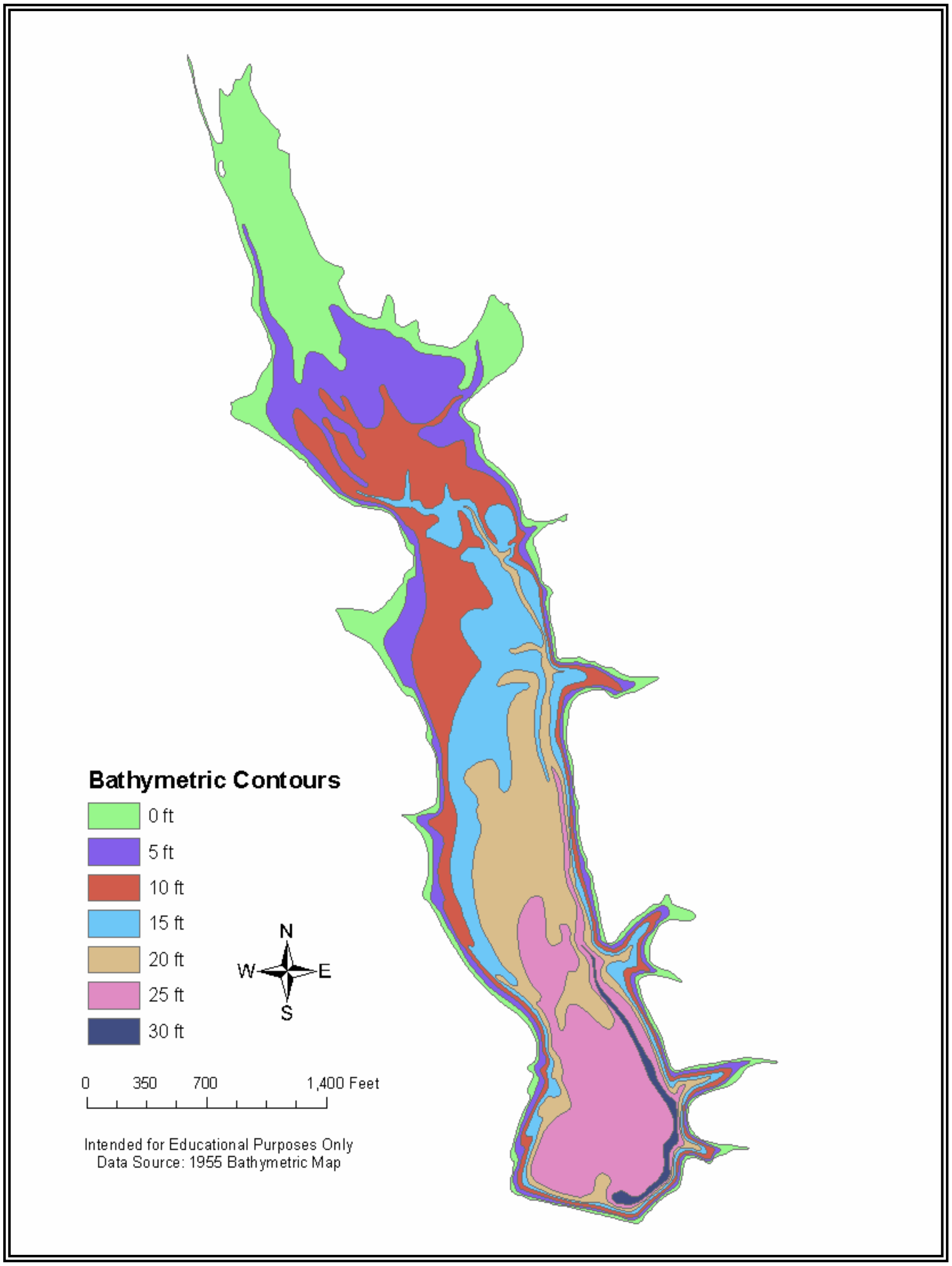


Figure 2.8. Yellowwood Lake: Bathymetric map

Visitors to Yellowwood Lake can typically enjoy a quiet relaxing visit on a beautiful, forested lake. Other than a boat livery, campgrounds, and one house there is no development along the lakeshore. The DNR rents rowboats to the public. Those who bring their own boats are restricted to using electric motors. Swimming is prohibited in the lake. Yellowwood Lake is well known for its clear waters (commonly up to 13 feet visibility), bluegill fishing, and natural habitat that is great for bird watchers.

2.8. DRINKING WATER

Yellowwood Lake provided a drinking water source for campers and the YSF office until 1989 when YSF was connected to Nashville municipal water line. Today, the primary drinking water resource for Yellowwood Lake watershed residents is an aquifer in Morgantown, Morgan County, Indiana. Owned by the Brown County Water Utility, well water is pumped to residents of northwestern Brown County. The Brown County Water Utility treats the water with chlorine and fluoride in addition to iron removal. In the summer of 2005 the YLWPG circulated a survey (Appendix F) to determine watershed land owner demographics and relationships with Yellowwood State Forest, Yellowwood Lake, and watershed stewardship. One question addressed the primary drinking water sources of those living in the watershed. Of twenty household respondents in the watershed, 65% depend on a rural water association for their drinking water. Few people depend on well water for domestic use in Brown County. The poor quality wells are generally deep, low volume, and mineral rich (Maier, 2003). There is one private well in the Yellowwood Lake watershed (IDNR, 2005). The salty well water in concert with slow recharge rates has led many Brown County residents to use ponds for their water supply. Two Yellowwood Lake watershed respondents use ponds as their primary drinking water source. Figure 2.9 shows the distribution of drinking water sources in the Yellowwood Lake watershed according to the 2005 survey.

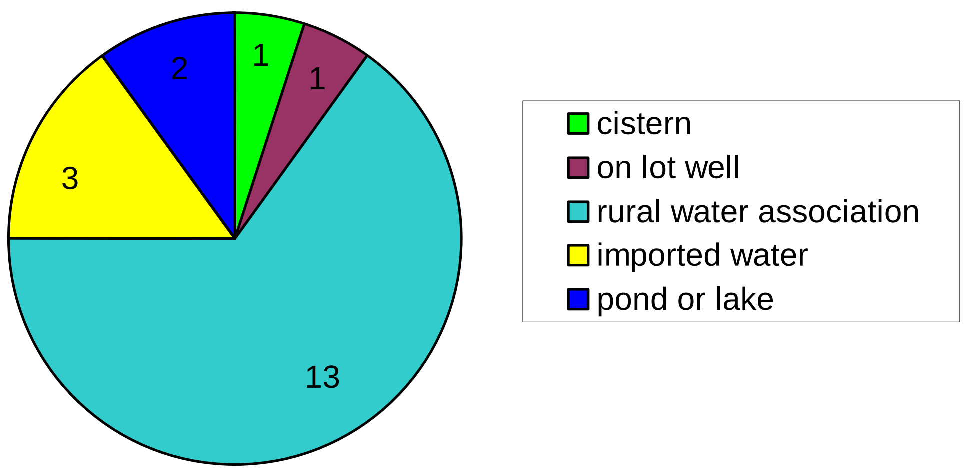


Figure 2.9. Yellowwood Lake Watershed: Drinking Water Sources

2.9. ECOREGIONS AND CLIMATE

Ecoregions are areas that are have similar ecosystems based upon the landscape, geology, soils, climate, natural vegetation, and current land use. They are identified using hierarchical coding just as watersheds are. The Yellowwood Lake watershed is located within the Norman Upland portion of the Interior Plateau ecoregion (section 71) (Figure 2.10). A deeply dissected, rugged terrain with high hills and knobs, narrow valleys, medium to high gradient streams, and silt loam soils characterizes this region. Original vegetation included oak-hickory forests on the uplands and beech forests in the valleys (Woods et al., 1998).

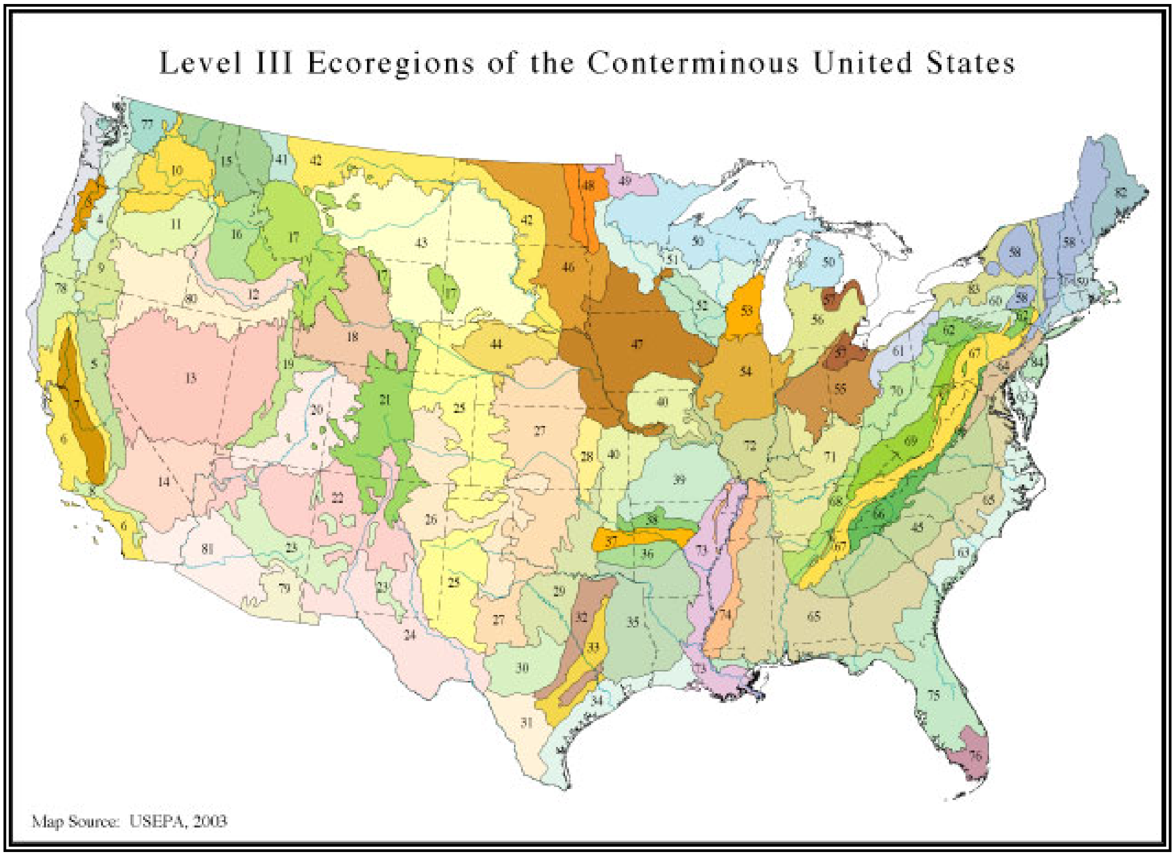


Figure 2.10. United States: Level III Ecoregions

The climate, temperature, and precipitation data in the Yellowwood Lake watershed are very similar to those in Bloomington, Indiana. Warm humid summers and moderately cold winters characterize this temperate climate. Mean monthly temperatures and precipitation values are shown in Figure 2.11 (NOAA). The average winter temperature is 32°F and the average summer temperature is 75°F. Total annual precipitation is 40.2 inches. Fifty-seven percent (57%) of the total annual precipitation usually falls from April to September, the growing season (Nobel et *al.,* 1984).

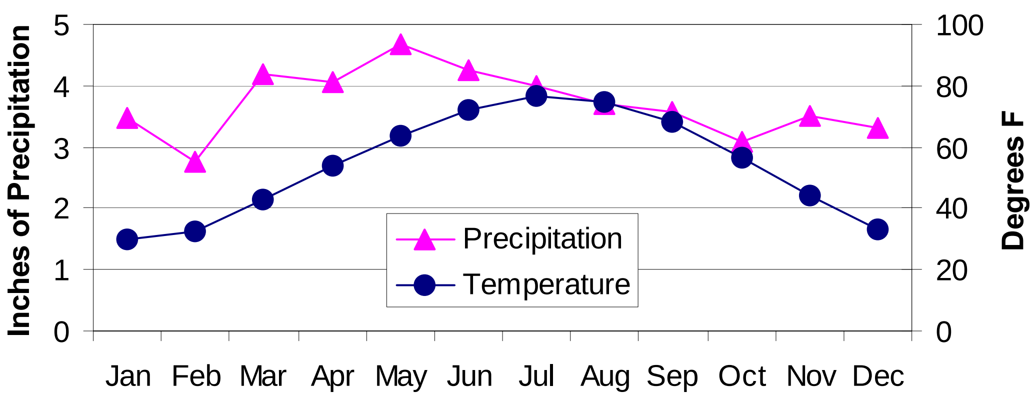
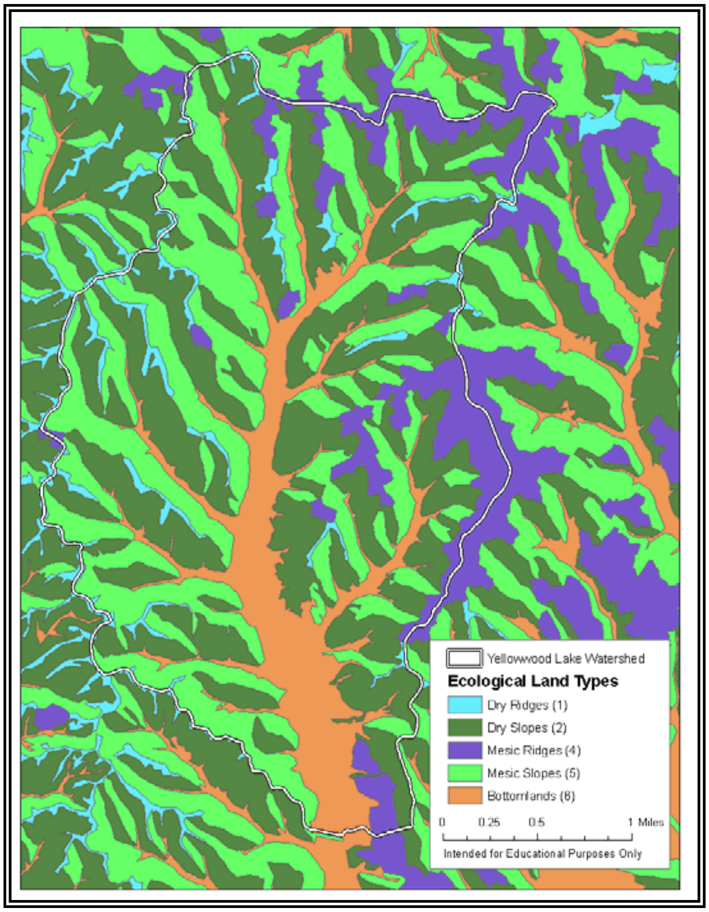


Figure 2.11. Bloomington, IN: Mean monthly temperatures and precipitation

2.10. ECOLOGICAL LAND CLASSIFICATION

Developed by many federal and state management agencies, ecological land classification systems (ECS) are used to identify, characterize, and map ecosystems. Based upon biological and physical characteristics of the landscape, an ECS can help natural resource managers understand the landscape's capabilities to support a forest or wetland, provide wildlife habitat, or support certain plant species. This information can be used to facilitate ecologically sound resource planning and management.



In 1999, an ECS analysis was conducted in the Yellowwood Lake watershed to classify forest land based upon relationships between vegetation, soils, and physiography (Zahlin, 1999). The analysis classified the watershed into six ecological land type (ELT) units (Table 2.6, Figure 2.12). The results show that mesic and dry slopes each comprise about one third of the watershed. The remainder is about equally divided between ridges and bottomland.

Figure 2.12. Yellowwood Lake Watershed: Ecological Land Types

Table 2.6. Yellowwood Lake Watershed: Ecological Land Types

Ecological Land Type		Area (acres)	Percent
ELT #	Description		
1	Dry Ridges	156	3.5%
2	Dry Slopes	1,718	39.0%
4	Mesic Ridges	445	10.1%
5	Mesic Slopes	1,419	32.3%
6a	Minor Bottomlands	5	0.1%
6b	Major (Flooded) Bottomlands	665	15.2%
	Total	4,408	100%

2.11. NATURAL HISTORY

The natural history of the Yellowwood Lake watershed is summarized by a history of the forest and description of the plants and animals inhabiting the area.

FORESTS AND TREE SPECIES

The Yellowwood Lake watershed is located within the biologically rich Brown County Hills section of the Highland Rim Natural region. The natural communities are typically uniform in composition with forest uplands dominated by oak-hickory, especially black oak, chestnut oak, whuite oak, shagbark hickory, and pignut hickory, and ravines with mesic species including American beech (*Fagus grandifolia*), red oak (*Quercus rubra*), sugar maple (*Acer saccharum*), and white ash (*Fraxinus americana*). Upper slopes often have thick growths of greenbriar (*Smilax spp.*), low growing shrubs, and sedges (*Carex picta*) (Homoya, 1985). The state threatened Yellowwood tree (*Cladrastis lutea*) is the namesake of Yellowwood State Forest, but rarely occurs in the watershed. Table 2.7 lists common trees and their corresponding site indices according to soil types found in the watershed, indicating that the watershed has moderate site productivity.

Table 2.7. Yellowwood Lake Watershed: Potential productivity of common tree species

Soil	Common Trees	Site Index	Soil	Common Trees	Site Index	Soil	Common Trees	Site Index
Ba	White Oak	75	PeB/ PeC2	White Oak	70	WaD	Northern Red Oak	71
	Pin Oak	85		Yellow Poplar	85		Yellow Poplar	90
	Yellow Poplar	85		Virginia Pine	75		Virginia Pine	70
	Sweetgum	80		Sugar Maple	75		White Oak	--
BgF	Northern Red Oak	70	TIB	Shortleaf pine	72		Black Walnut	--
	Yellow Poplar	70		White Oak	68		Black Cherry	--
	Black Oak	70		Yellow Poplar	90	WeC2	White Ash	--
Be	Yellow Poplar	95		Black Oak	74		Northern Red Oak	71
	American sycamore	--		Virginia Pine	73		Yellow Poplar	90
	Northern Red Oak	--		Scarlet Oak	74		Virginia Pine	70
	Black Cherry	--		Hickory	--		White Oak	--
Hc	Yellow Poplar	100		Red maple	--		Black Walnut	--
	White Oak	90		Southern Red Oak	65		Black Cherry	--
	Black Walnut	70					White Ash	--

(Adapted from Nobel et *al.*, 1976)

ENDANGERED, THREATENED, AND RARE SPECIES

The wide variety of plant and animal species that occur in the watershed are representative of the flora and fauna in the Brown County Hills region. Table 2.8 lists many of the globally, state, and federally listed species that are classified as endangered, threatened, or rare that may occur in the watershed.

Table 2.8. Brown County: State and federally listed, threatened, rare species

Species Name	**Common Name**	**FED**	**STATE**	**GRANK**	**SRANK**
Mollusk: Bivalvia (Mussels)					
Villosa lienosa	Little Spectaclecase		SSC	G5	S2
Insect: Coleoptera (Beetles)					
Cicindela patruela	A Tiger Beetle		SR	G3	S3
Insect: Lepidoptera (Butterflies & Moths)					
Amblyscirtes hegon	Salt-and-Pepper Skipper		SR	G5	S2
Autochton cellus	Golden-Banded Skipper		SR	G4	S2
Euphydryas phaeton	Baltimore		SR	G4	S2
Fixsenia favonius	Northern Hairstreak		SR	G4	S1S2
Fish					
Fundulus catenatus	Northern Sunfish			G5	S2
Amphibian					
Rana pipens	Northern Leopard Frog		SSC	G5	S2
Reptiles					
Colonophis kirtlandii	Kirtland's Snake		SE	G2	S2
Crotalus horridus	Timber Rattle Snake		SE	G4	S2
Liochlorophis vernalis	Smooth Green Snake		SE	G5	S2
Opheodrys aestivus	Rough Green Snake		SSC	G5	S3
Birds					
Accipiter straitus	Sharp-shinned Hawk	No Status	SSC	G5	S2B
Aimophila aestivalis	Beachman's Sparrow			G3	SXB
Ammodramus henslowii	Henslow's Sparrow		SC	G4	S3B
Ardea herodias	Great Blue Heron			G5	S4B
Buteo lineatus	Red-shouldered Hawk		SSC	G5	S3
Butea platypterus	Broad-winged Hawk	No Status	SSC	G5	S3B
Dendrocia cerulea	Cerulean Warbler		SSC	G4	S3B
Dendroica virens	Black-throated Green Warbler			G5	S3B
Haliaeetus leucocephalus	Bald Eagle	LT, PDL	SE	G5	S2
Helmitheros vermivorus	Worm-eating Warbler[1]		SSC	G5	S3B
Mniotilta varia	Black-and-white Warbler		SSC	G5	S1S2B
Wilsonia citrina	Hooded Warbler		SSC	G5	S3B
Mammal					
Lynx rufus	Bobcat	No Status		G5	S1
Mustela nivalis	Least Weasel		SSC	G5	S2?
Taxidea taxus	American Badger			G5	S2

Fed: PDL = proposed for delisting
State: SE=state endangered; ST=state threatened; SR=state rare; SSC=state species of special concern; SX=state extirpated; SG=state significant; WL=watch list
GRANK: Global Heritage Rank: G1=critically imperiled globally; G2=imperiled globally; G3=rare or uncommon; G4=widespread and abundant globally but with long term concerns G5=widespread and abundant globally; G?=unranked; GX=extinct; Q=uncertain rank
SRANK: State Heritage Rank: S1=critically imperiled in state; S2=imperiled in state; S3=rare or uncommon in state; G4=widespread and abundant in state but with long term concern; SG=state significant; SX=state extirpated; B=breeding status; S?=unranked

Species Name	**Common Name**	**FED**	**STATE**	**GRANK**	**SRANK**
Vascular Plants					
Cladrastis lutea	Yellowwood		ST	G4	S2
Epigaea repens	Trailing Arbutus		WL	G5	S3
Hydrastis Canadensis	Golden Seal		WL	G4	S3
Hypericum pyramidatum	Great St. John's-wort		ST	G4	S1
Juglans cinera	Butternut		WL	G3G4	S3
Linum striatum	Ridged Yellow Flax		WL	G5	S3
Oenothera perennis	Small Sundrops		SR	G5	S2
Panux quinquefolius	American Ginseng		WL	G3G4	S3
Panicum bicknellii	A Panic-grass		SE	G4?Q	S1
Panicum mattamuskeetense	A Panic-grass		SX	G4?	SX
Rubus centralis	Illinios Blackberry		SE	G2?Q	S1
Rubus deamii	Deam Dewberry		SX	G4?	SX
Rubus odoratus	Purple Flowering Raspberry		ST	G5	S2
Spiranthes ochroleuca	Yellow Nodding Ladies' tresses		ST	G4	S2
Stachys clingmanii	Clingman Hedge-nettle		SE	G2Q	S1
High Quality Natural Community					
Forest-upland dry	Dry Upland Forest		SG	G4	S4
Forest-upland dry-mesic	Dry-mesic Upland Forest		SG	G4	S4

Fed: PDL = proposed for delisting
State: SE=state endangered; ST=state threatened; SR=state rare; SSC=state species of special concern; SX=state extirpated; SG=state significant; WL=watch list
GRANK: Global Heritage Rank: G1=critically imperiled globally; G2=imperiled globally; G3=rare or uncommon; G4=widespread and abundant globally but with long term concerns G5=widespread and abundant globally; G?=unranked; GX=extinct; Q=uncertain rank
SRANK: State Heritage Rank: S1=critically imperiled in state; S2=imperiled in state; S3=rare or uncommon in state; G4=widespread and abundant in state but with long term concern; SG=state significant; SX=state extirpated; B=breeding status; S?=unranked

(Adapted from IDNR Natural Heritage Data for Brown County 11/20/05)

3. LAND USE DESCRIPTION OF THE WATERSHED

This section includes an overview of the watershed's landuse in terms of settlement history, demographics, historic and current landuse, and silvicultural history.

3.1. CULTURAL AND LAND-USE HISTORY

Climatic and ecological changes since the retreat of the Wisconsin Glacier more than 12,000 years ago have resulted in significant cultural changes within populations living in the region. Following the glacial retreat, Indiana's climate became warm and dry, causing the Central U.S. prairie to expand eastward into Ohio. Relic stone tools dated to 10,000 B.P. suggest a hunting and gathering society. As the riverine systems stabilized, the prairie retreated westward and the temperate forests covered most of Indiana. The emergence of pottery, mound building, and developed agricultural practices soon followed. As cultures became tied to the land they farmed, they began to establish villages and complex societies (Weddle, 1990).

The first European exploration into Indiana likely occurred in the late 17th century. At the time several Native American tribes occupied the state. It is believed that the Shawnee, Miami, and Piankeshaw tribes first inhabited this area. Prior to the first European settlements in the early 1800s, the Delaware, Miami, and Potowatomi inhabited the land (Sieber and Munson, 1991). Land conflicts between became common and after the Revolutionary War Indiana became part of the Northwest Territory in 1787. William Henry Harrison, between 1801 and 1809, enacted several treaties to acquire the southern part of Indiana from native populations. Indiana obtained the southwest corner of modern day Brown county in 1809 through the Treaty of Ft. Wayne. The remainder of the county was acquired in 1836 with the Treaty of St. Mary's (Hill-Ariens, 2004).

Brown County was officially recognized as the 77th county in Indiana in 1836. At the time, the county was also divided into five townships. Approximately 80% of the Yellowwood Lake watershed falls in Washington Township (Figure 3.1). Settled as early as 1818, the dominant occupation at the time was agriculture. However, soil erosion and competition with more progressive farming on better sites began to pressure local farmers, and Brown County began to exhibit dramatic changes (Brown County, 1995).

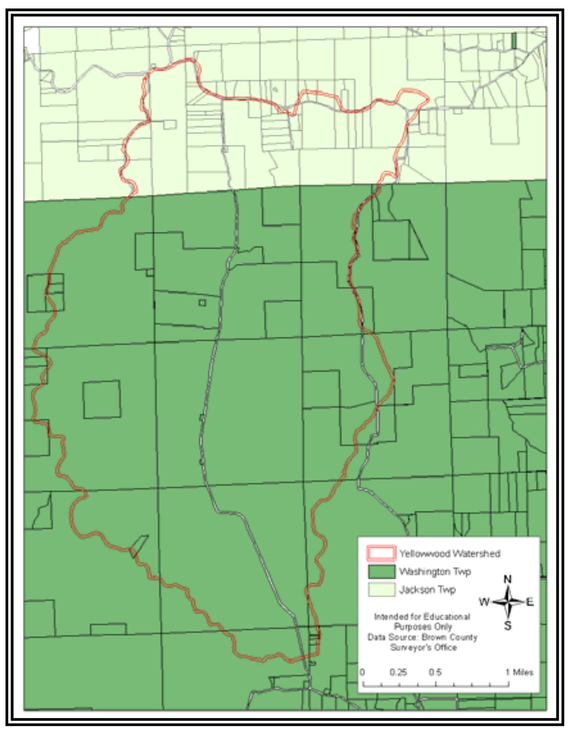


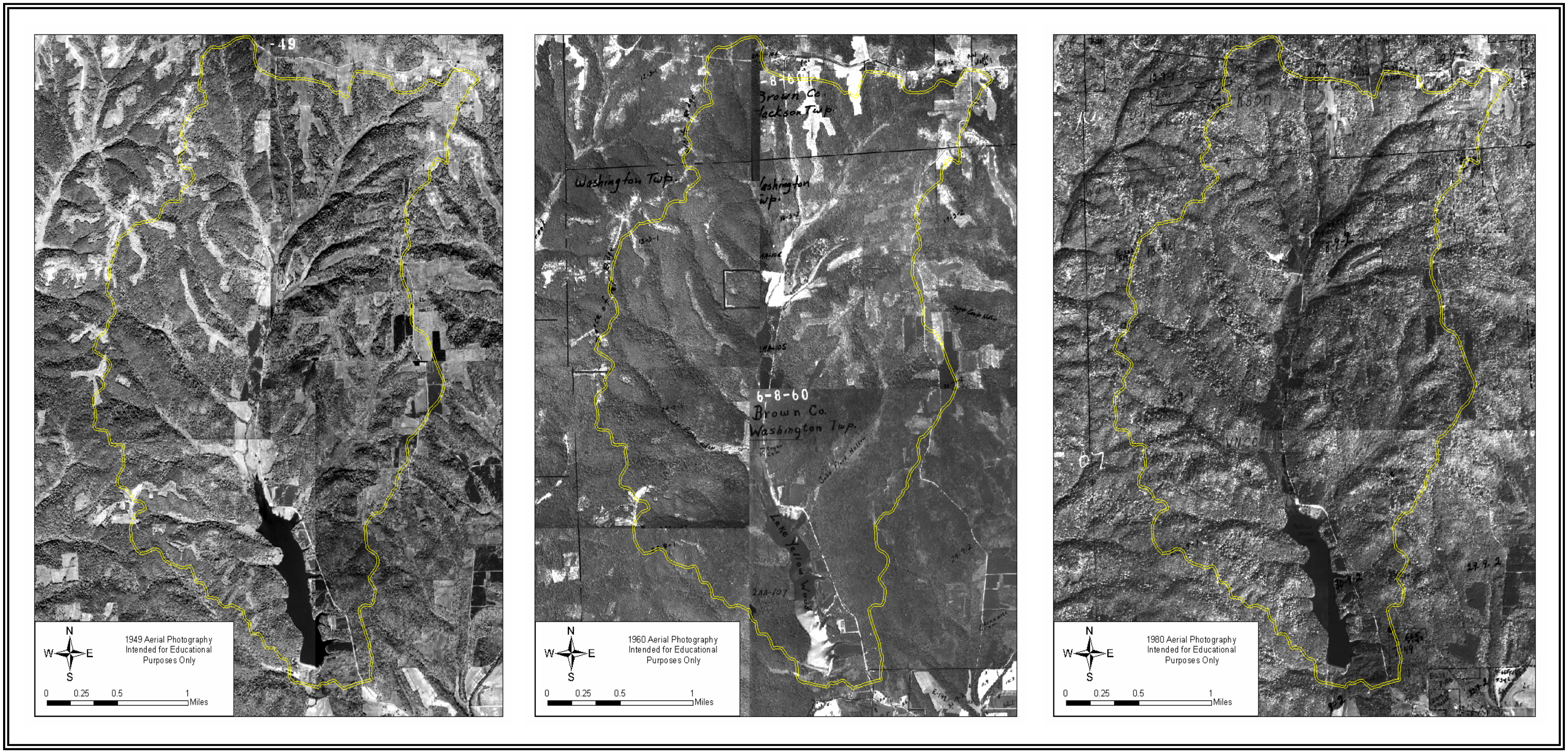
Figure 3.1. Yellowwood Lake Watershed: Townships

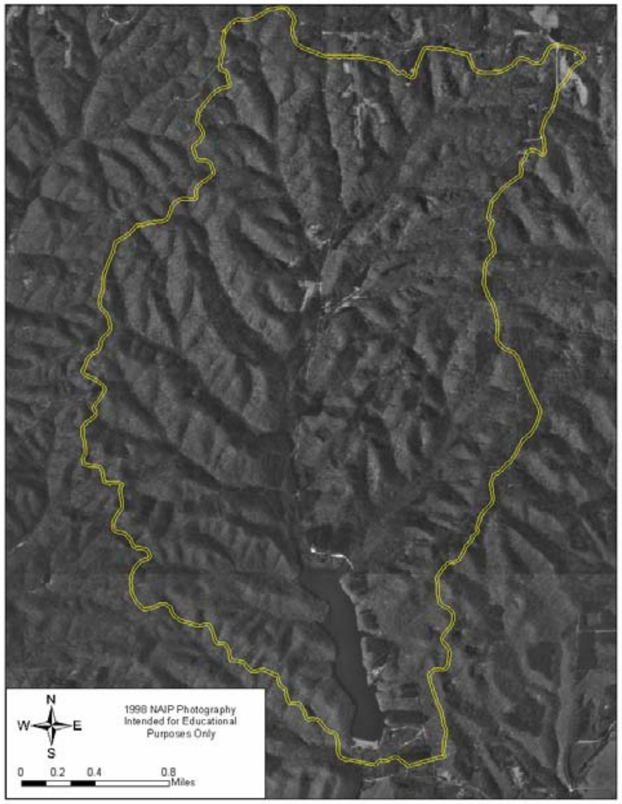
The state construction of new roads in the early 1920s made it economically feasible to access the timber resources in the area. The land spared from clearing for agriculture was quickly exploited for timber resources and livestock grazing. By 1935, 92% of Brown County was eroded (Sieber and Munson, 1991). In the early 1900s, the federal and state governments began purchasing land in Brown County with the intent to stop erosion and restore the land to something more profitable. Under the Bureau of Agricultural Economics, the Bean Blossom Land Utilization Project was created to convert the barren land into forests (Figure 3.2.2) and recreational areas. Figure 3.2 shows the watershed's recovery through a series of aerial photos.

The 1949 image shows a patch work of forest clearings, most likely for agriculture. Still visible in 1960, the cleared patches appear to be re-forested by 1980 with the exception of a patch of pasture land on the north end. From 1998 on, the images show continued forest recovery.

Figure 3.2. Yellowwood State Forest

Figure 3.3. Yellowwood Lake Watershed (Aerial Photographs 1949, 1960, 1980, 2003, and 2005)

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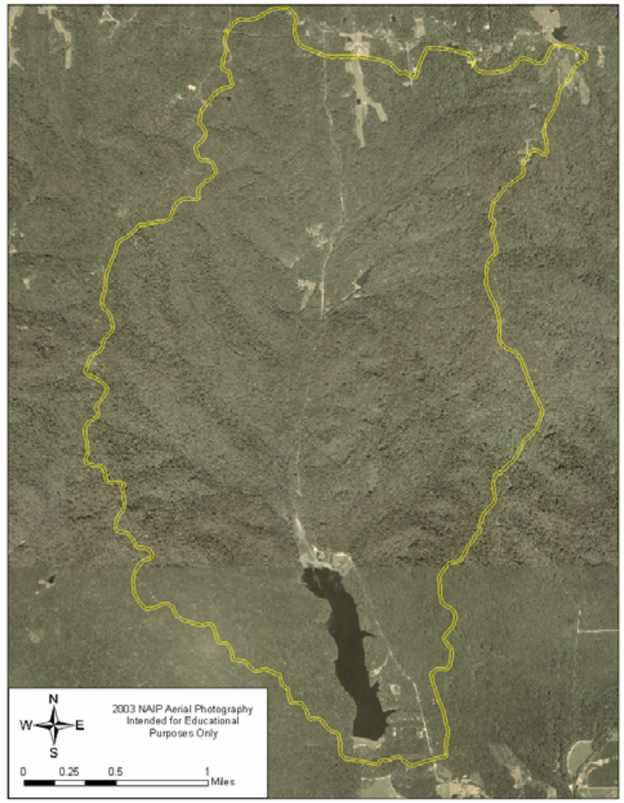
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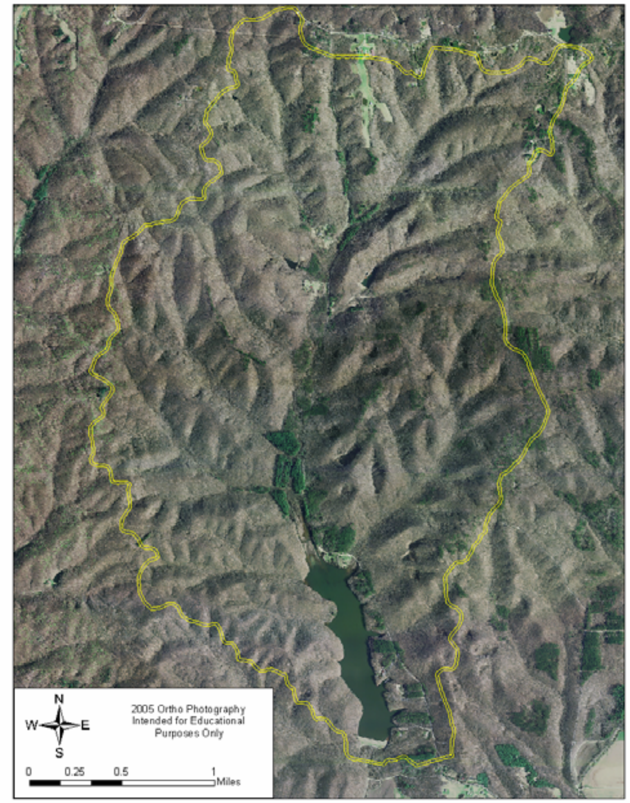
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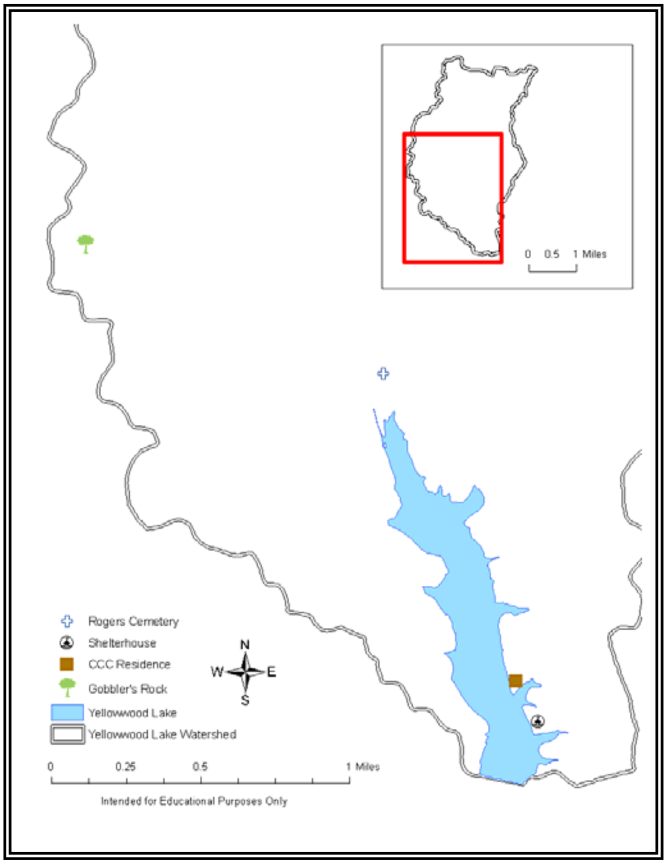
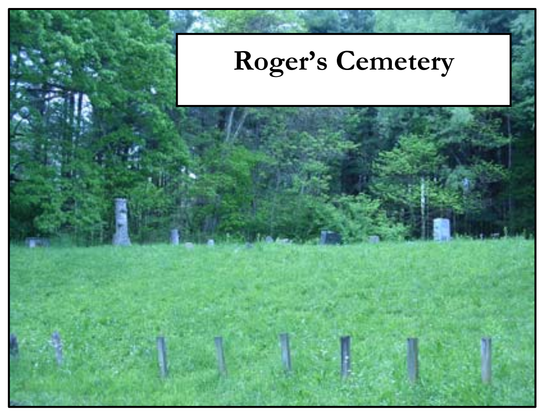
The Civilian Conservation Corps (CCC) and the Works Progress Administration (WPA) began making improvements in Brown County's landscape. In Yellowwood State Forest they planted two million trees, built a residence and shelterhouse, and constructed the dam in 1938 that created Yellowwood Lake (*Outdoor Indiana,* 1938). Remaining notable landmarks within the Yellowwood Lake watershed include the Rogers Cemetery north of the lake and Gobbler's rock (which fell in May, 2006), shown in Figure 3.4. There are also over 30 archeological sites primarily consisting of homes and farm sites. Many of these sites include foundations, cisterns, and building debris (IDNR Archeological Records).





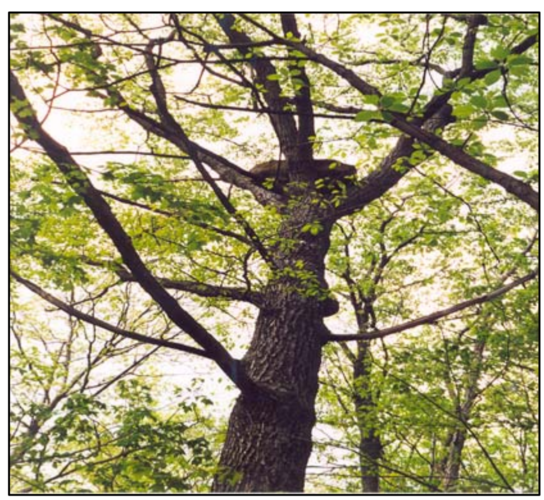


Figure 3.4. Yellowwood Lake Watershed: Notable landmarks

3.2. DEMOGRAPHICS

Brown County's population has experienced a great deal of change in the last century, as seen in Figure 3.5. (Stats Indiana, 2005). It is currently the 12th least-populated county in the state. In 1890, 10,308 people lived in Brown County. However, by 1930 only half of the population remained due to soil erosion and a declining economy. Since the late 1800s, Brown County's beautifully rugged countryside had attracted artists. T.C. Steele moved to the county in 1907. In 1926, Nashville opened its first art gallery and ever since has been known as the artist's colony of the Midwest. Thousands of tourists visit Brown County annually. The Hoosier National Forest, Yellowwood State Forest, Brown County State Park, Lake Monroe, and Lake Lemon are located within the county's border.

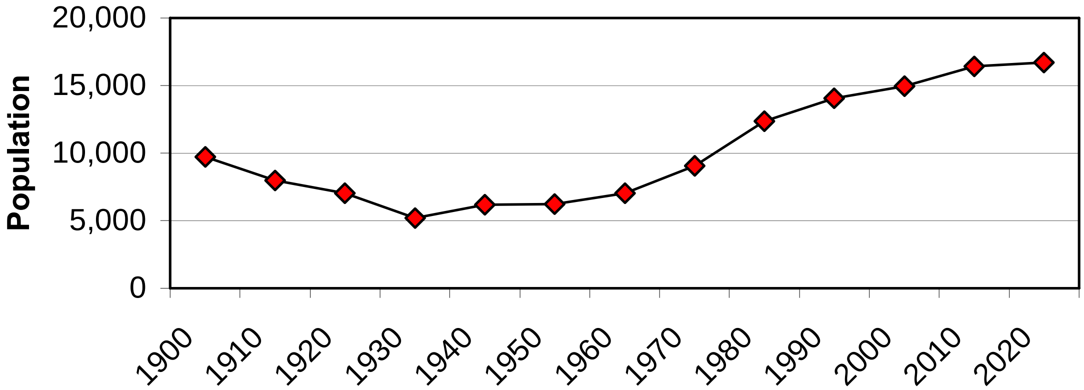


Figure 3.5. Brown County: Population projections (1900-2020)

The Yellowwood Lake watershed is currently home to approximately 55 landowners. Figure 3.6 shows the location and size of public and private land holdings in the watershed. The watershed is 80% public land (3,508 acres) and 20% privately owned (902 acres).

In 2005 the YLWPG circulated the "Yellowwood Lake Watershed Management Plan Private Landowner Survey" to 50 landowners in the watershed. Twenty-one people responded to the survey. Figure 3.7 shows that most of the watershed landowners have owned property for over 15 years. Two thirds of the respondents live in the watershed year round while the remaining third seasonally visit their property (Figure 3.8).

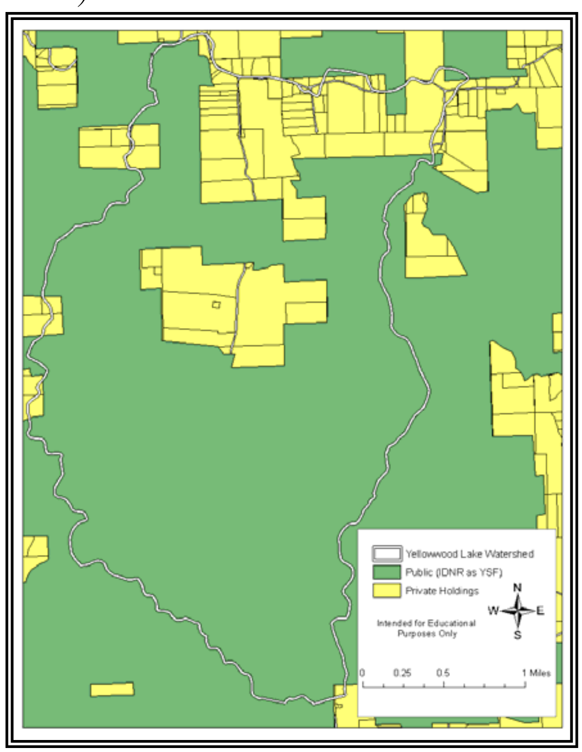


Figure 3.6. Yellowwood Lake Watershed: Public and private land

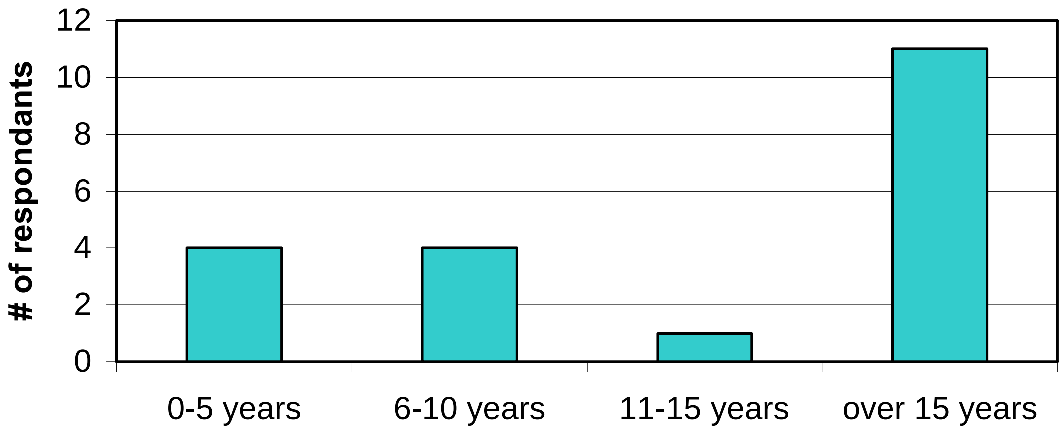


Figure 3.7. Length of time watershed residents have owned property in the watershed

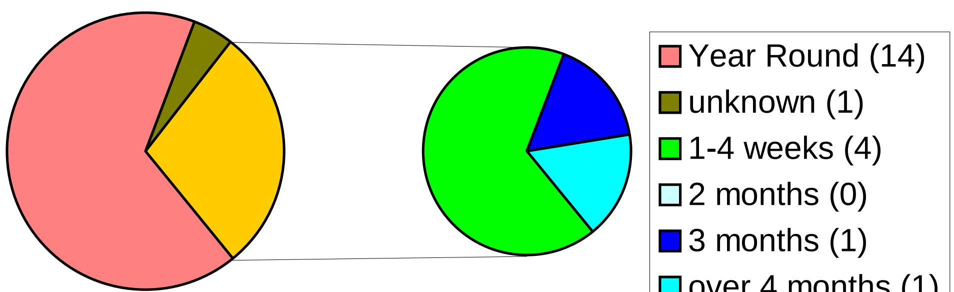


Figure 3.8. Yellowwood Lake Watershed: Length of watershed residency

3.3. CURRENT LAND USE

In 2002 the USGS released the National Land Cover Data (NLCD) set. The purpose of the NLCD was to provide relatively current, consistent, seamless, and accurate land cover data for the conterminous United States. Based on satellite data with a 30 x 30 meter resolution, the NLCD is a 21-class land cover classification system (landcover.usgs.gov). The Indiana NLCD depicts land cover conditions in Indiana in 2001(Figure 3.9, Table 3.1).

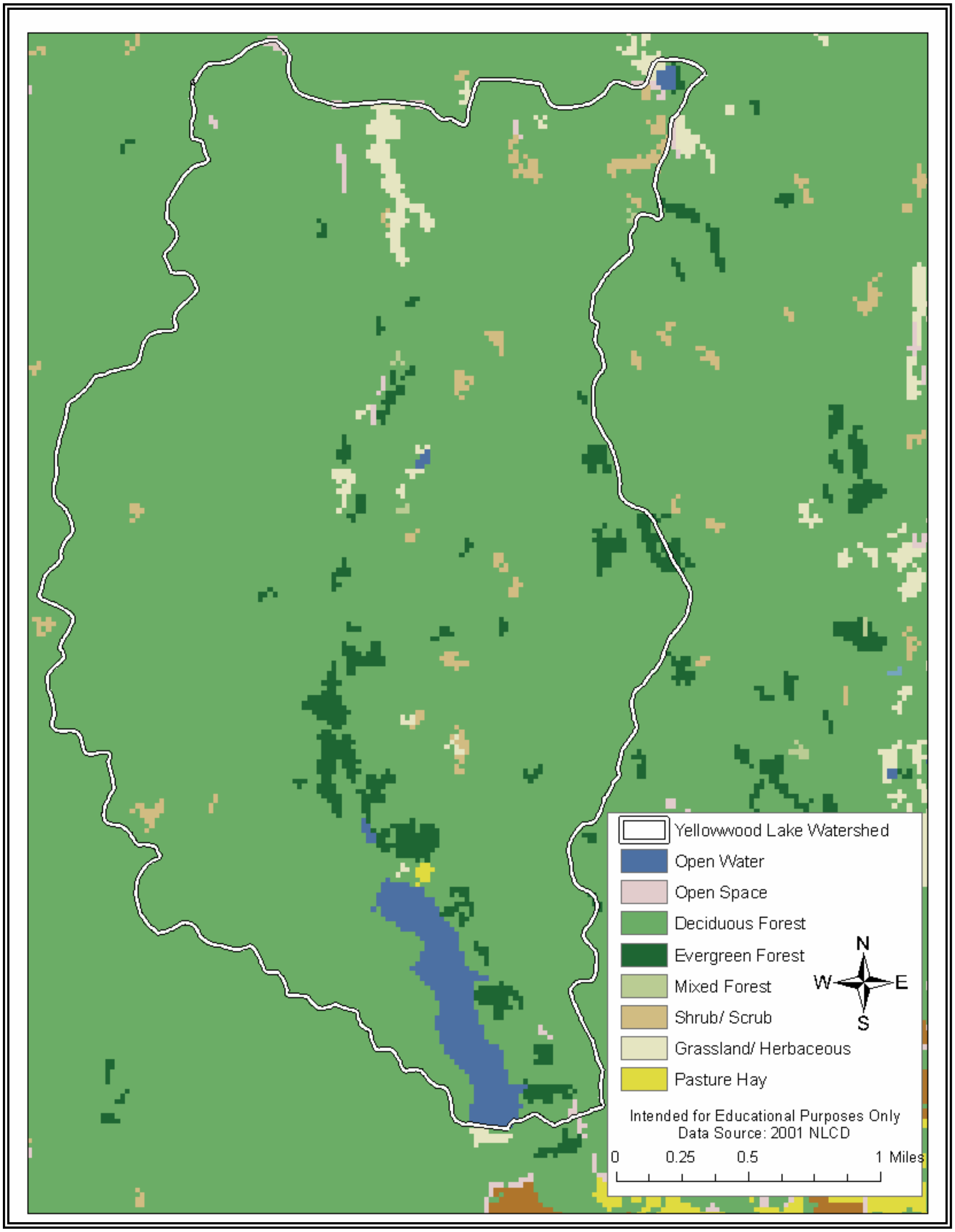


Figure 3.9. Yellowwood Lake Watershed: 2001 Landcover (NLCD)

Table 3.1. Yellowwood Lake Watershed: Landcover

Land Cover	**acres**	**%**
Open Water	114	2.6%
Open Space	12	0.3%
Deciduous Forest	4,049	91.8%
Evergreen Forest	142	3.2%
Mixed Forest	2	0.1%
Shrub/Scrub	43	1.0%
Grassland/ herbaceous	46	1.0%
Pasture/ Hay	3	0.1%
Total	4,411	100%

3.4. SILVICULTURE

Forests have not always dominated the Yellowwood Lake watershed's landscape. As stated earlier in this section, nearly the entire watershed was clear-cut for timber and livestock grazing in the early 1900s. It wasn't until the federal government purchased the land and planted millions of trees, mostly pine that the landscape began to recover. Farmland, abandoned because of the thin, highly erodable soils, began returning to forests through natural succession. Today, nearly 95% of the watershed is forested. Management of the forest, especially Yellowwood State Forest, is often debated. Forest advocacy groups argue that commercial harvesting should not be allowed on public land. However, current Indiana law states that such operations may be undertaken for forest management and revenue generation.[9] This section outlines the history of forest management, primarily as YSF, in the Yellowwood Lake watershed.

Current resource management is directed toward both the long-term integrity of the ecosystem and to provide timber production, watershed protection, and consumptive and non-consumptive use by the public including outdoor recreation (boating, fishing, hunting, hiking, trail riding, bird watching, camping, etc.), and providing wildlife habitat, conservation education, scenic value, and emotional uplift. Forest management practices are directed toward producing a healthy and vigorous forest by ensuring varied species composition, forest structure, and tree size to provide habitat diversity and aesthetic integrity within a contiguous-canopy forest context. Smaller parts of the watershed are managed as intensive recreation areas or as nature preserves, while physical limitations, uniqueness, or other factors require some areas to be managed predominately for a particular benefit. See Appendix G for more explanation on IDNR silvicultural guidelines.

[9] (IC 14-23-4-1): "It is the declared public policy of this state to protect and conserve the timber, water resources, wildlife and top soil in the state forests for the equal enjoyment and guaranteed use of future generations. It is recognized, however, that by the employment of good husbandry, timber which has a substantial commercial value may be removed in such manner as to benefit the growth of saplings and other trees by thinning, improvement cuttings, and harvest process and at the same time provide a source of revenue to the state and local counties and provide local markets with a further source of building material."

Given the lack of mature forest when the land was acquired, there was little timber harvesting in the watershed for the first 30 years. Most of the activity was directed toward tree planting, maintaining fire trails, and creating recreational infrastructure. The earliest recorded state harvest dates back to 1951. Early harvests were primarily directed at removal of lower value species with some marketable value with a secondary objective of enhanced growth of more desirable species. Figure 3.10 shows the management units, or tracks, within the watershed. Tracks with historical harvests have been highlighted. Timber management has been practiced on approximately 3400 acres of state forest land within the watershed, with an estimated sum of 3.5 to 4.5 million board feet removed.

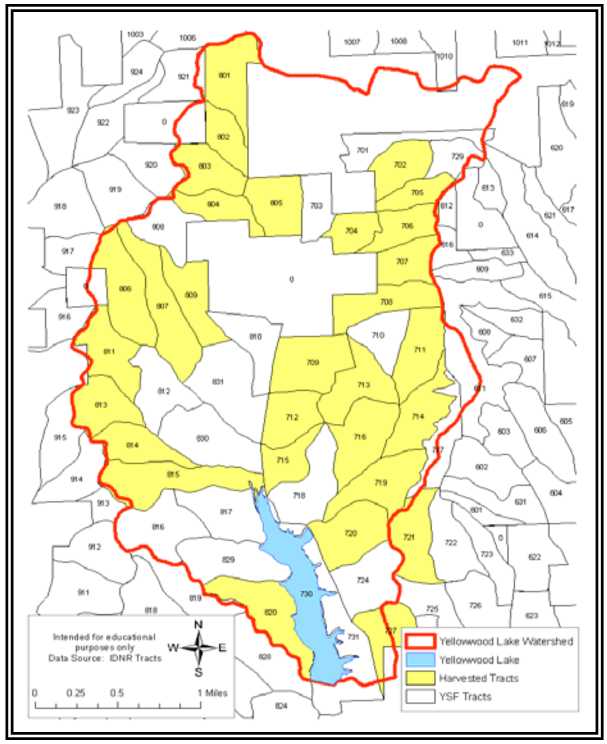
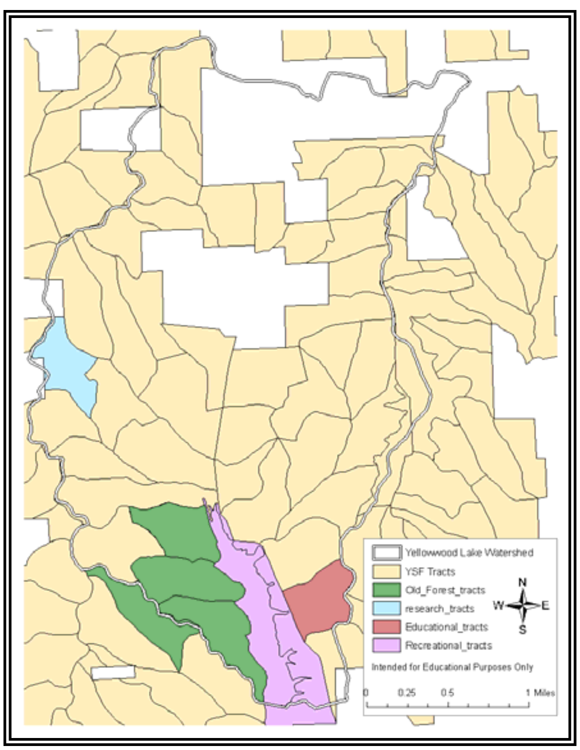


Figure 3.10. Yellowwood Lake Watershed: Harvested Tracts



Certain areas of the forest are not managed for timber production. These have been allowed to progress toward an old growth type of status. Land in this category includes approximately 364 acres of the watershed primarily including steep slopes, riparian zones, and other areas in which timber harvest would be inappropriate. The designated recreational areas immediately adjacent to the lake and campgrounds are also not managed for timber production (263 acres including the lake). Research acreage accounts for an additional 84 acres, and educational set-asides include 82 acres (Figure 3.11).

Figure 3.11. Yellowwood Lake Watershed: Special YSF tract classifications

Forest management on the privately held land within the watershed has generally followed that of the public land. Approximately 17 % of the privately held land in the watershed is forest land. Most of this land was in the same condition as that of the (now) public land in 1936. Some returned toward mature forest at this time, with the rest in natural successional forest with farm land abandonment in the 1940s and 1950s. Timber harvests on the private land are estimated to have been limited through the 1960s for the same reasons as that on the public lands. Most harvests have been by individual tree selection, with little application of regeneration openings. Figure 3.12 illustrates the private landowner timber harvesting history within the watershed.

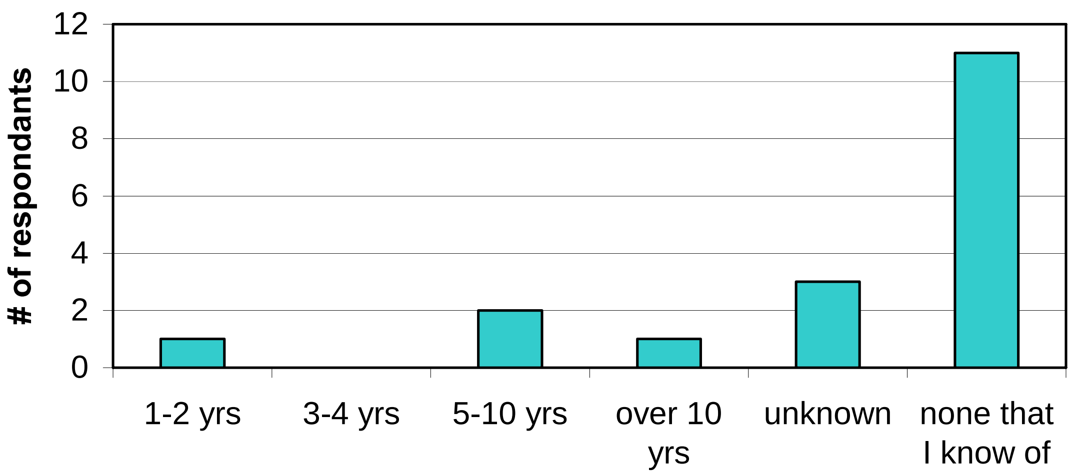


Figure 3.12. YSF: Harvested tracts

3.5. RECREATIONAL AREAS

The Yellowwood Lake watershed is unique to many 14-digit watersheds in Indiana because 80% of it is managed as a state forest. Created in 1940, Yellowwood State Forest is operated by the Indiana Department of Natural Resources' Division of Forestry (IDNR DoF). The mission of the DoF is:

The Indiana Department of Natural Resources' Division of Forestry promotes and practices good stewardship of natural, recreational and cultural resources on Indiana's public and private forest lands. This stewardship produces continuing benefits, both tangible and intangible, for present and future generations.

Yellowwood State Forest (YSF) hosts a variety of recreational opportunities for the public. There are hiking and horse trails, as shown in Figure 3.13 and primitive campgrounds along the eastern shore of the Lake, a boat dock, and a boat livery where YSF rents out rowboats. Figure 3.14 shows the location of recreational facilities within the watershed. YSF contains excellent wildlife habitat, wetlands, and a publicly accessible lake (Yellowwood Lake) used for game hunting, wildlife watching, and fishing. Wild game hunting includes deer, turkey, squirrel, raccoon, and grouse while the fishery includes large mouth bass, bluegill, catfish, and rainbow trout in the spring. An estimated 200,000 people visit YSF every year.

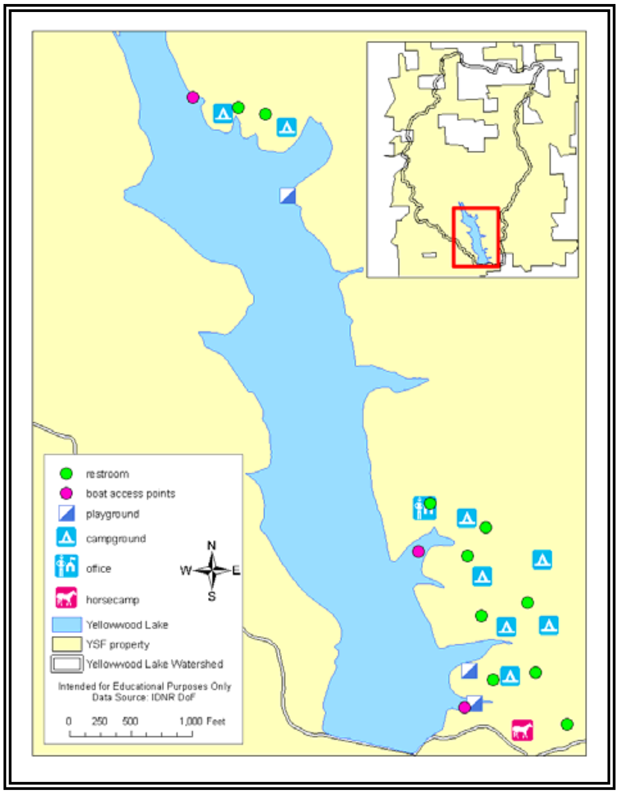


Figure 3.13. Yellowwood Lake Watershed: Recreational Facilities

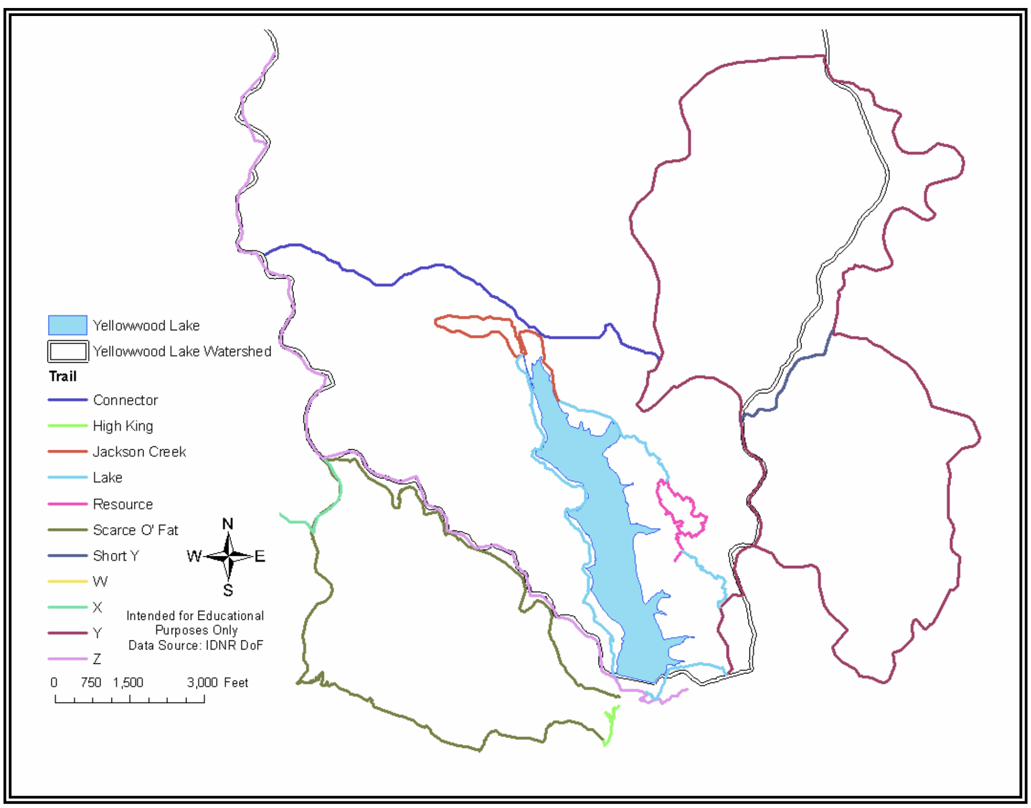


Figure 3.14. Yellowwood Lake Watershed: Trails

4. WATER QUALITY ISSUES AND BENCHMARKS

This section provides a survey of existing water quality data in the watershed. Yellowwood Lake and its watershed have been extensively studied and monitored in the past. Data in this section is from IU Limnology classes, IDEM, CLP, fishery surveys, Hoosier Riverwatch volunteers, HFF Depth surveys, and contracted sediment and storm flow samples, in addition to visual assessments conducted during this project. Tables 4.1 and 4.2, discussed in detail below, outline the current and benchmark water quality conditions in the Yellowwood Lake Watershed. Many of the metrics referenced in this table can be found in Appendix H.

Table 4.1. Yellowwood Lake: water quality benchmarks

Parameter	Current Condition	Units	Benchmark condition	Reference
Trophic Status	"good"	---	26-50	*IDEM ISTI - MS*
	"mesotrophic"	---	40 - 50	*Carlson - MS*
Epilimnetic TN	0.244	mg/L	0.35-0.65	*Nürnberg, 1996 - MS*
Nitrate + Nitrite	0.013	mg/L	0.101	*EPA Reference Conditions*
TP	0.010	mg/L	0.01 – 0.025	*Carlson – MS*
Chl-*a*	14.040*	µg/L	2.0– 8.0	
Transparency (SD)	4.3	Meter	2.0-5.0	
Turbidity	2.630*	NTU	25	*WQ std in AZ, AR, MS, and OK*
pH	7.8*	---	Range: 6-9	*IAC Title 327 – Protect Aquatic Life*
*MS = mesotrophic status, * denotes 2003 data* *EPA Reference conditions based upon 25th percentile of all seasons for lakes and reservoirs within ecoregion 71*				

Table 4.2. Yellowwood Lake Watershed Tributaries: Water quality benchmarks

Parameter	Current Condition*	Units	Benchmark condition	Reference
Nitrate	0.4	mg/L	Max: 10	*EPA Drinking Water Standard (Human Toxicity)* *IAC title 327*
TP	0.11	mg/L	0.05	*"to control eutrophication" Muller and Hensel, 1999*
			0.03	*EPA Reference Conditions*
Turbidity	46	NTU	25	*WQ Std for streams in Minnesota River and its Tributaries*
Chl-*a*	64	µg/L	1.5	*EPA Reference Conditions*
Nitrate + Nitrite	0.4	mg/L	0.345	
			10 mg/L	*IAC Title 327 – Drinking Water*
TSS	266	mg/L	Max: 50	*Utah and South Dakota Standards for Warm Water Streams – Protect Aquatic Life*
E. coli	1,280	CFU	Max: 235	*IAC Title 327 – Full Body Contact*
DO	4	mg/L	Min: 4.0	*IAC Title 327 – Protect Aquatic Life*
BOD	5.3	mg/L	1-2	*"Clean water with little organic waste" Hoosier Riverwatch*
pH	6.7	---	Range: 6-9	*IAC Title 327 – Protect Aquatic Life*
QHEI	56	---	>64	*"Fully Supporting for Designated Use" Ohio EPA*
MS = mesotrophic status *EPA Reference conditions based upon 25th percentile of all Rivers and Streams within ecoregion 71* **conditions represent worst water quality conditions sampled at contracted base or peak flow samples, (Table 4.5.1)*				

4.1. DESIGNATED USES

The Federal Clean Water Act mandates that every state must specify appropriate water uses to be achieved and protected. The appropriate water use is based upon the waterbody's use and value as public water supply; protection of fish, shellfish, and wildlife; and recreational, agricultural, industrial, and navigational purposes. In designating uses, states must examine the suitability of waterbodies for the uses based on chemical, biological, and physical characteristics, geographical setting and scenic qualities, and economic considerations (USEPA, 1997).

In Indiana, the Indiana Pollution Control Board (IPCB) is responsible for specifying the appropriate uses, or designated uses, for Indiana's waterbodies. It is the State's goal to restore and maintain the chemical, physical, and biological integrity of the waters of the state (327 IAC 2-1-1.5). The IPCB has designated all state waters, except those within the Great Lakes system (327 IAC 2-1-1) for the following uses (327 IAC 2-1-3): Full-body contact recreation (April- October); capable of supporting a well-balanced, warm water aquatic community and where temperatures permit, capable of supporting put-and-take trout fishing. All waters within the Yellowwood Lake watershed are full use designation waterbodies.

4.2. IMPAIRED WATERBODIES

Section 303(d) of the Federal Clean Water Act (CWA) requires states to identify bodies of water that are not meeting state water quality standards for designated uses. States are required to establish total maximum daily loads (TMDLs) for impaired waterbodies in order to meet water quality standards. A TMDL is the amount of a pollutant a waterbody can receive and still pass water quality standards.

In 2004, the Indiana Department of Environmental Management released the 2004-303(d) list of Impaired Waterbodies (IDEM, 2004). The list included Yellowwood Lake as Category 5b impairment with a Category 2 Fish Consumption Advisory (FCA) for mercury in Largemouth bass. The FCA is an advisory based upon the statewide collection and analysis fish samples for contaminants that have the ability to bioaccumulate such as PCBs, pesticides, and heavy metals such as mercury. The advisory groups are used to help people choose the amount and type of fish that are safe to eat. A category 2 advisory limits the fish consumption women of childbearing years, nursing mothers, and children under 15 to one meal per month. It advises women beyond childbearing years and men to eat fish no more than once per week (ISDH, 2005). The fish consumption advisory becomes more restrictive as the numbers increase.

Over one hundred water bodies in Indiana were listed for mercury impairment in 2004. Mercury causes birth defects, and irreversible brain, liver, and kidney damage. Mercury sources within the Midwest include deposition from coal-fired power plants, incineration of garbage and hospital wastes, industrial uses, and improper disposal of household mercury. There are no known sources of airborne mercury in the Yellowwood Lake watershed. The State believes that developing conventional TMDLs for mercury is not an appropriate approach. Therefore, managing mercury will be limited to education in this plan.

4.3. SUMMARY OF YELLOWWOOD LAKE WATER QUALITY

Water quality monitoring is important for characterizing lakes, understanding how they work, and documenting changes and trends. Water quality monitoring can be conducted on a daily, monthly, seasonal, yearly, or on an as needed basis. Historically, water quality monitoring in Yellowwood Lake has been sporadic. Occasionally, we have records of multiple sampling events in a single year, but the majority of the samples are from a single event. Single sample dates can help clarify general management concerns, especially when there are a series of samples over several years. However, it must be kept in mind that a single sample is only a snapshot of the lake water quality at that specific moment in time. For example, if the sample were taken after a storm, we would expect increased turbidity due to increased wave action and sediment disturbance from watershed runoff.

This section is a survey of historic water quality data in Yellowwood Lake. It includes monthly secchi depths, lake profiles from IU SPEA limnology classes, data collected by the Indiana Clean Lakes Program. Concentrations represent the average of 1m from surface and 1m from bottom, unless stated otherwise. All data points were taken at the deepest part of the lake, near the dam. All the data are in Appendix H.

LAKE PROCESSES: THERMAL STRATIFICATION

The annual circulation patterns in lakes, caused by the thermal properties of water, can have significant influences on lake biology and chemistry. As the surface water absorbs heat from the sun in the spring, it becomes lighter than the cool, dense water at the bottom of the lake that does not receive sunlight. This temperature-density difference between the surface and bottom waters eventually becomes too great for wind energy to mix and the lake becomes stratified. Thermal stratification describes the condition when warm surface waters overlie cold bottom waters (Holdren et al., 2001). Thermal stratification in Yellowwood Lake can be seen in the August 24, 2005, temperature profile (Fig. 4.1).

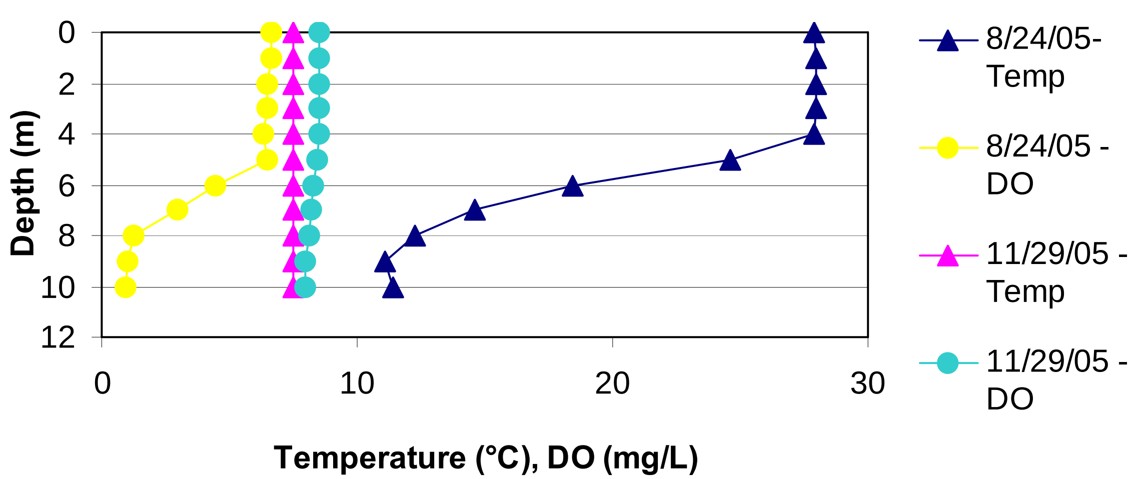


Figure 4.1. Yellowwood Lake: 2005 Summer Stratification and Winter Destratification Temperature and Dissolved Oxygen

The well-mixed, warm surface waters are called the epilimnion; while the uniformly cold, unmixed bottom waters are called the hypolimnion. The two layers are separated by a zone of rapidly changing temperature and density known as the metalimnion. As the epilimnion cools in the fall, the temperature difference between layers decreases, making mixing easier. The cooled surface waters and mixing zone progressively extend downward until the entire watercolumn is again fully mixed. This destratification process is known as fall turnover (Holdren et *al.,* 2001). Lakes that undergo the stratification and turnover process two times a year[10], like Yellowwood Lake, are known as dimictic lakes. Typical of southern reservoir stratification, Yellowwood Lake does not have a well-defined hypolimnion.

In addition to the unique temperature-density-dependent relationship of water, is its temperature-dependent ability to hold dissolved oxygen.. When a lake initially stratifies in the summer, the spring mixing and photosynthesis by plants and algae leave the hypolimnion rich in dissolved oxygen. Once the metalimnion develops however, it acts as a barrier, isolating the hypolimnion from gas exchange with the atmosphere. Since the hypolimnion is often too dark for photosynthetic production of oxygen, it can often become anoxic during summer stratification as decomposing organic matter consumes the dissolved oxygen reserve. Figure 4.2 shows the depth of the water column in Yellowwood Lake with detected dissolved oxygen (DO) levels below 1 mg/L. Hypolimnetic anoxia, while a natural process, can have important consequences on lake productivity. Fish cannot survive in an oxygen-deficient hypolimnion, but the mid-summer epilimnion may be too warm for them. Also, anoxic conditions can allow the release of nutrients such as nitrogen and phosphorous from the bottom sediments, where they can ultimately promote more algae production, organic matter decomposition, and thus more severe hypolimnetic oxygen depletion (Holdren et *al.,* 2001).

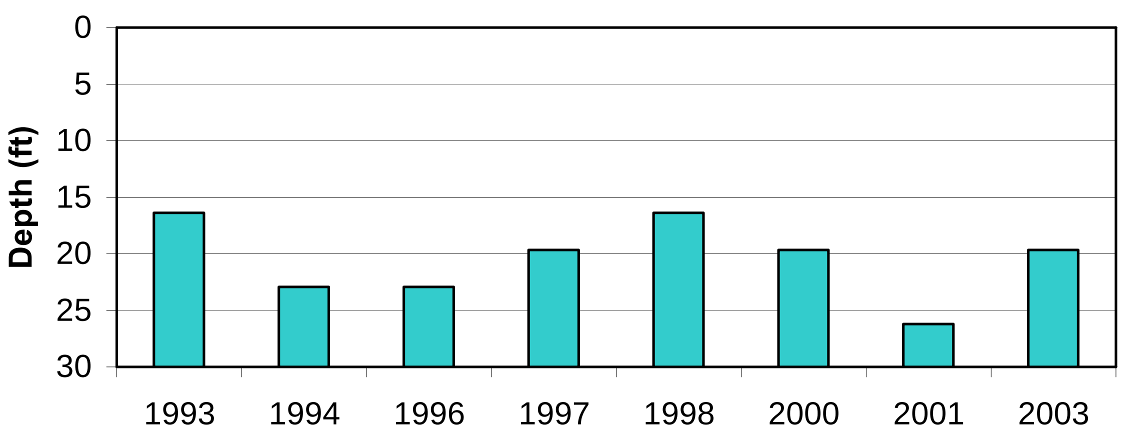


Figure 4.2. Yellowwood Lake: Anoxic portion of the watercolumn

[10] Some lakes undergo winter stratification and spring turnover as well.

LAKE PROCESSES: EUTROPHICATION

Eutrophication is the excessive addition of inorganic nutrients, organic matter, and silt which increase biological productivity. Eutrophication can naturally occur over tens and thousands of years as a result of climate, movements in the earth's crust, shoreline erosion, and accumulation of sediment. This slow, natural process can be accelerated as a result of dramatic land use changes such as building roads, cultivating fields, developing residential areas, or clearing forests, which can increase nutrient, soil, and organic matter loads. Lake succession, also known as eutrophication, can be characterized into four phases, or trophic states, with the following characteristics, adapted from Holdren et al. (2001).

- **Oligotrophy:** low productivity due to a lack of nutrients; oxygen at all depths; clear water; deep lakes can support trout

- **Mesotrophy:** moderate plant productivity; hypolimnion may lack oxygen in the summer; moderately clear water; warm-water fisheries only – bass and perch may dominate

- **Eutrophy:** excessive nutrients; blue-green algae dominate during the summer; algal scums probable at times; hypolimnion lacks oxygen in summer; poor transparency; rooted macrophyte problems may be evident

- **Hypereutrophy:** algal scums dominate in summer; few macrophytes; no oxygen in hypolimnion, fish kills possible in summer and under winter ice

STATE TROPHIC INDICES

Multiple indices exist that may be used to compare the severity of a lake's problems with other lakes in the area. These indices are referred to as "trophic state indices." The trophic state index concept is based on the belief that, in many lakes, the degree of eutrophication is primarily related to increased nutrient concentrations. In Indiana there are two trophic indices that are used, Carlson's Trophic State Index[11] (TSI) and the Indiana State Trophic Index[12] (ISTI) developed by IDEM.

While there is archived water quality data dating back to 1974 in Yellowwood Lake, complete ISTI scores only exist for 1992, 1997, and 2001 (Figure 4.3). This is primarily due a lack of biological data (e.g. blue green algae, diatoms, green algae, and zooplankton). While Yellowwood Lake has always been classified as having "good" water quality according to this index, the water quality appears to be declining. In 2001 the score was 20, only five points away from an "intermediate" water quality status. In the past, Yellowwood Lake has had an ISTI score well below the state average ISTI score. However, in 2001 Yellowwood Lake was even with the state average score. The score increased 10 point because the plankton sample revealed blue-green algal

[11] Carlson's index is the most widely used. Based on empirical data, it compares chlorophyll-a, Secchi transparency, and total phosphorous. High scores represent increased eutrophy while low scores represent clear water and low levels of nutrients and algae. The three parameters can also be used independently. For example if phosphorous concentrations are high while Secchi depth and chlorophyll-*a* are low; inorganic turbidity, not algae, is likely influencing water clarity.

[12] The IDEM index utilizes ten parameters to estimate a water quality (TP, SRP, Organic Nitrogen, Nitrate, Ammonia, dissolved oxygen saturation, how much of the water column is oxic, light penetration, Secchi depth, and plankton). Eutrophy points are awarded as a parameter's range moves towards characteristics of a eutrophic system. This index is widely used in the state of Indiana and is a good tool to compare water quality from lake to lake.

dominance. As outlined in the following sections, Yellowwood Lake is classified as an oligo-mesotrophic lake according to Carlson's TSI.

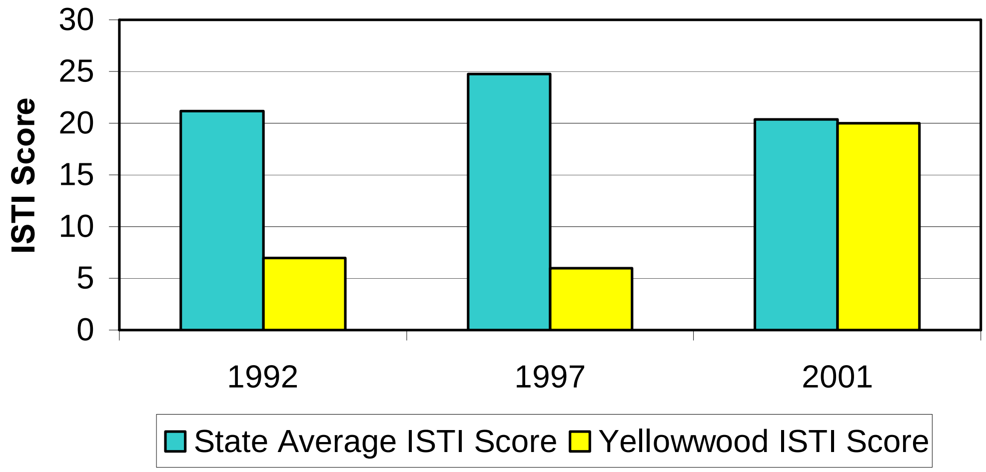


Figure 4.3. Yellowwood Lake: ISTI Scores

NUTRIENTS

Lake managers often monitor for nutrients in lakes because they are indicators of eutrophication and can provide insight into which stressors in the watershed may be influencing water quality. The nutrient data in this section includes nitrogen and phosphorous, the two most important nutrients in aquatic ecosystems, and chlorophyll-*a*, a common measure of productivity. Phosphorous and nitrogen both naturally occur in the environment and are essential to plant and animal life. However, in excessive amounts they can cause nuisance macrophyte or algal growth.

Nitrogen

Nitrogen is abundant on the earth's surface. In fact, 78% of the air we breathe is nitrogen. Sources of nitrogen in aquatic systems include atmospheric deposition, decaying organic material, septic systems, and fertilizers. Nitrogen is very water soluble and can easily travel through the watershed as groundwater, fertilizing aquatic plants and algae. Yellowwood Lake has relatively low levels of nitrogen. The historic epilimnetic total nitrogen[13] (TN) concentrations, according to Nürnberg's Trophic State Index (Nürnberg, 2001), decreased from mesotrophic/ eutrophic in the 1990s to oligotrophic since 2000 (Figure 4.4).

Ammonia (NH_3) is the end product of organic matter decomposition by bacteria. In fresh water, concentrations of ammonia are highly dependent on a lake's productivity and the amount of organic matter. If there is appreciable accumulation of organic material during summer stratification, ammonia concentrations in the anoxic hypolimnion can increase. The average hypolimnetic ammonia concentrations in Yellowwood Lake (0.16 mg/L ± 0.22, n = 13) are well within the typical range of ammonia concentrations for unpolluted surface waters (0 to 5 mg/L) according to Wetzel (2001).

[13] TN is a sum of nitrogen from nitrate/ nitrite, ammonia, and organic nitrogen.

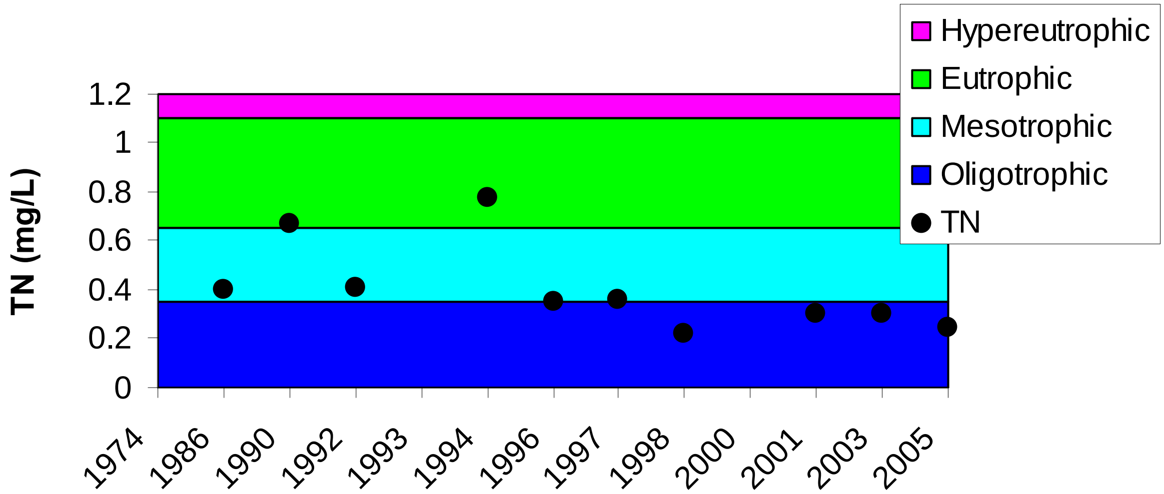


Figure 4.4. Yellowwood Lake: Epilimnetic Total Nitrogen (TN)

Phosphorous

In comparison to many of the other naturally occurring nutrients important to biota (carbon, hydrogen, nitrogen, oxygen, and sulfur), phosphorous is the least abundant and commonly limits biological productivity (Wetzel, 2001). Even small additions of phosphorous to an aquatic system can cause noxious algae blooms, accelerated aquatic plant growth, and eutrophication. Phosphorous naturally occurs in organic matter (e.g. dead plants and animals, animal waste) and can be bound to soil minerals (e.g. calcium, aluminum, and iron). It is also an important component of fertilizers, detergents, and industrial wastes.

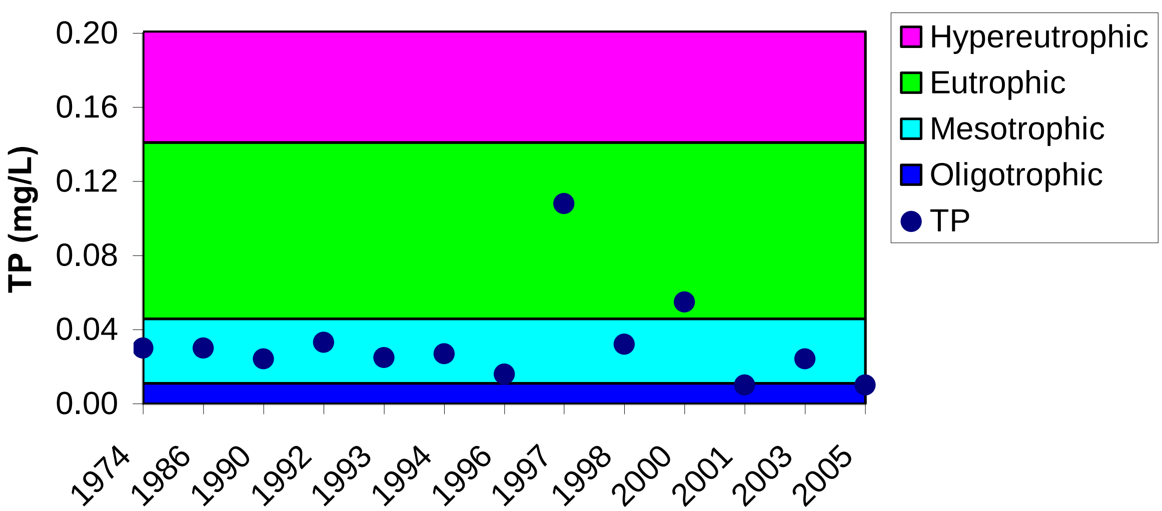


Figure 4.5. Yellowwood Lake: Epilimnetic Total Phosphorous (TP)

Yellowwood Lake has relatively moderate levels of phosphorous. The historic epilimnetic total phosphorous concentrations are primarily within Carlson's TSI mesotrophic range (Figure 4.5). Total phosphorous (TP) includes all organic phosphates and any inorganic phosphorous that may be attached to soil particles or occurring in biota (algae, zooplankton, or decomposing plant material). The biologically available form of phosphorous is orthophosphate (PO_4^{3-}). Orthophosphate is often referred to as dissolved inorganic phosphorous or soluble reactive phosphorous (SRP) which is based upon a chemical analysis used to measure orthophosphate. SRP typically constitutes a low percentage (i.e. less than 5%) of TP because it is tightly cycled by algae (Wetzel, 2001). However, in Yellowwood Lake SRP has historically comprised between 9% and 100% of the total phosphorous (Figure 4.6). The relatively high SRP concentrations indicate that the phosphorous is not being fully utilized by algae.

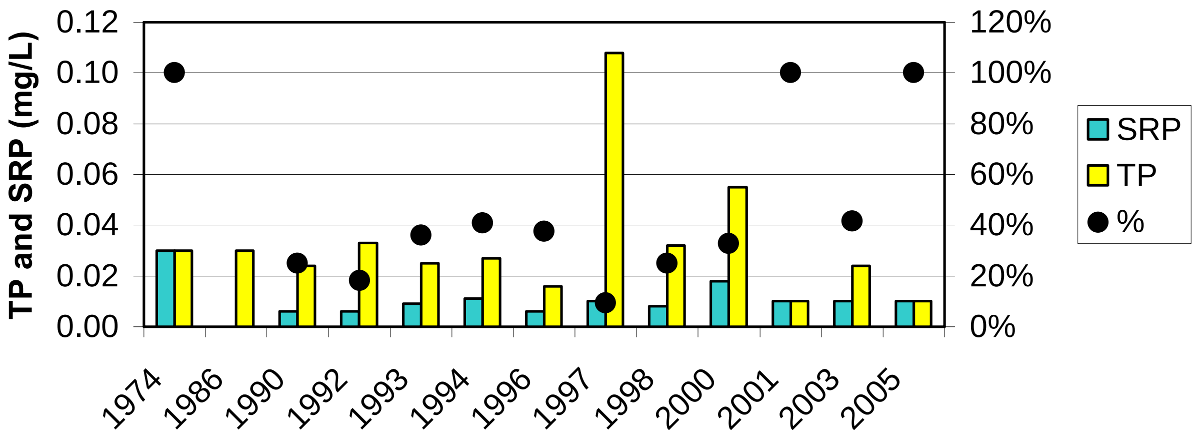


Figure 4.6. Yellowwood Lake: Epilimnetic SRP, TP, and % SRP

Limiting Nutrients

Both nitrogen and phosphorous are known as limiting nutrients. Phosphorous is the most common limiting nutrient in freshwater aquatic systems. According to the Redfield Ratio (Redfield *et al*., 1963), under ideal conditions the atomic ratio of nitrogen to phosphorous in aquatic systems is 16:1. Any deviation from this ratio can be used to predict which nutrient, phosphorous or nitrogen, is limiting. The geometric mean of the calculated historic N: P ratios in Yellowwood Lake since 1986 is 10.63 (Fig 4.7). While there is a great deal of deviation above and below 16, the geometric mean of the N: P ratios suggests that Yellowwood Lake is slightly nitrogen limited.

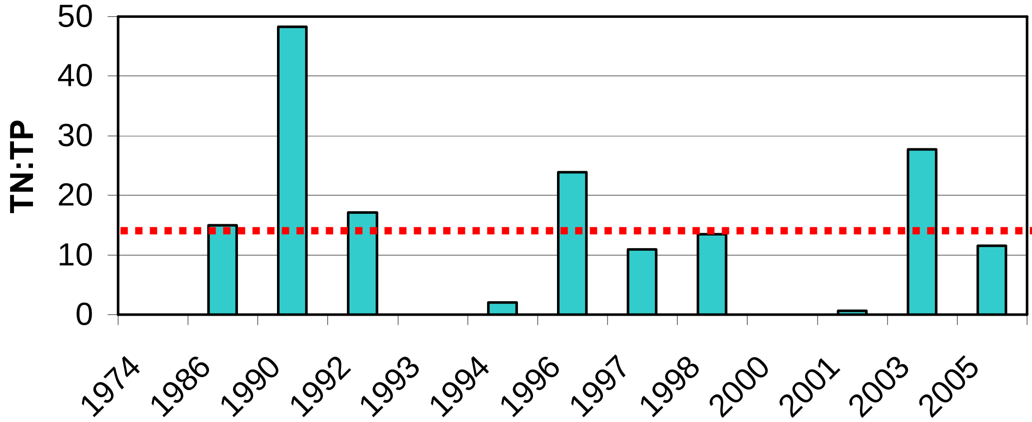


Figure 4.7. Yellowwood Lake: Total Nitrogen (TN) and Total Phosphorous (TP) Ratio

Chlorophyll-a

Like plants, blue-green bacteria and green algae contain chlorophyll-*a*, a pigment necessary for photosynthesis. Limnologists often measure Chlorophyll-*a* as an indicator of algal biomass or productivity According to Carlson's TSI, the chlorophyll-*a* concentrations in Yellowwood Lake are moderately low, falling within the meso-oligotrophic range (Figure 4.8).

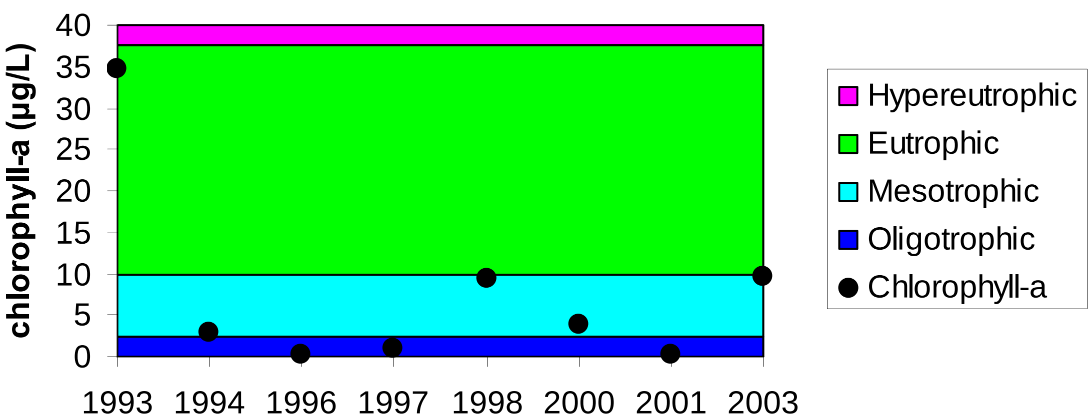


Figure 4.8. Yellowwood Lake: Chlorophyll-a

CHEMICAL AND PHYSICAL PARAMETERS

This section outlines some of the chemical and physical parameters impacting Yellowwood Lake including pH, alkalinity, light, and transparency.

pH

pH is an important measure of water quality because organisms are sensitive to pH. A pH range of 6.5 to 8.2 is optimum for most organisms. pH can be affected by both natural and anthropogenic processes. High temperatures can cause the pH to drop (become more acidic) while algae blooms can remove carbon dioxide (CO_2) from the water during photosynthesis, causing the pH to increase. Most natural waters have a pH range of 5.0 – 8.5. Yellowwood Lake has a circum-neutral pH with values from 6.6 to 7.8 (Figure 4.9).

Alkalinity

Alkalinity is also known as pH buffering capacity, or the capacity of bases to neutralize acids. It is a measure of the water's ability to resist changes in pH by neutralizing acid input. Common buffering materials include bicarbonates (HCO_3^-), carbonates (CO_3^{2-}), silicates, phosphates, and organic materials. Waters with low alkalinity are susceptible to changes in pH while those with high alkalinity are able to resist pH shifts. There are no standards for alkalinity as it is highly variable depending on local geology. Freshwater streams typically have alkalinity levels from 20-200 mg $CaCO_3$/L (BASINS, 2005). The historic average alkalinity in Yellowwood Lake ranged from 33 to 78.5 mg $CaCO_3$/L (Figure 4.9)

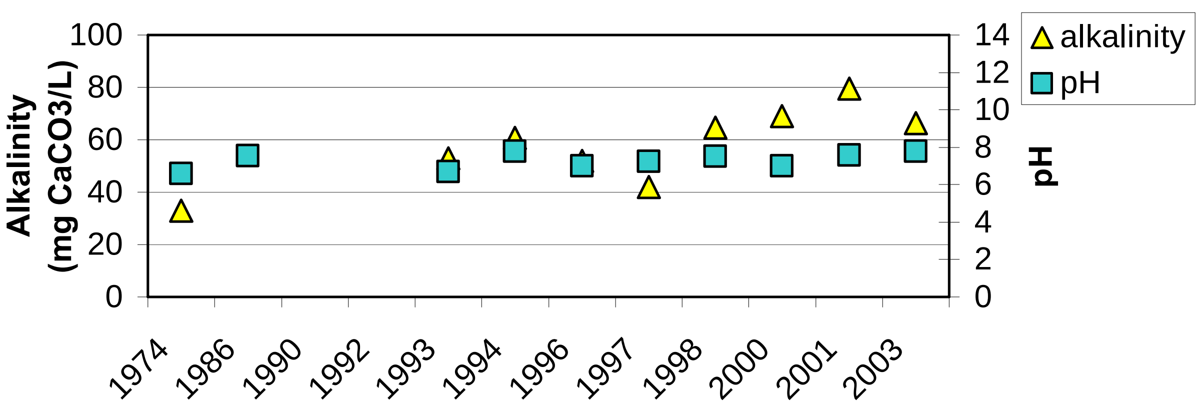


Figure 4.9. Yellowwood Lake Watershed: Alkalinity and pH

Secchi Depth

Water clarity is important to life in lakes. Without light, plants and algae would be unable to photosynthesize and sight-dependent predators would be unable to hunt. Secchi disk transparency[14] is the most common way to measure water clarity. It captures algal biomass, water color, and suspended sediments. According to Carlson's TSI, Yellowwood Lake is a mesotrophic lake (Figure 4.10). The highest recorded secchi depths in Yellowwood Lake, over 21 ft (6.5 m) occurred in July, 1994.

[14] Transparency is the amount of light scattering affecting the depth at which an object can be seen. It is measured by lowering a black and white disk into the water and recording the depth at which the disk can no longer be seen.

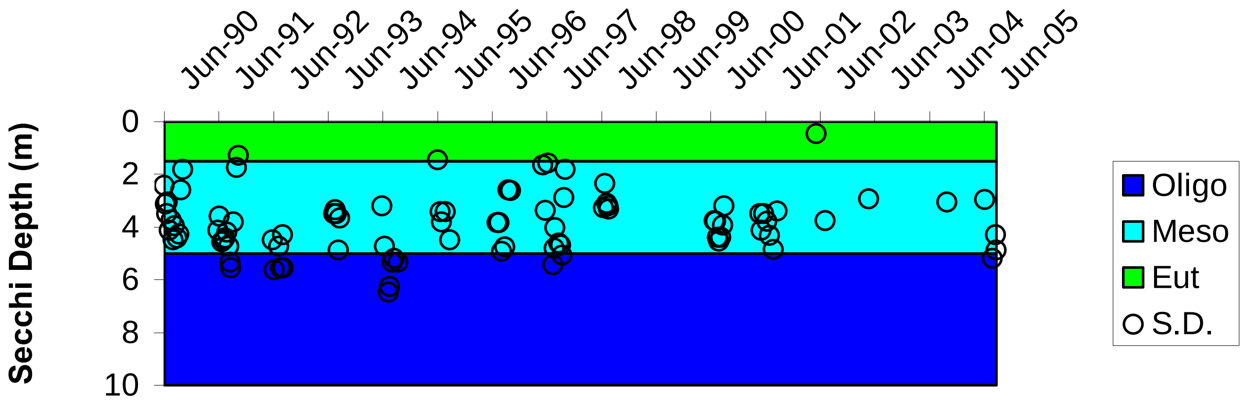


Figure 4.10. Yellowwood Lake: Secchi Depth

Light

Photosynthetic organisms cannot produce energy without light. The amount of available light decreases as it moves down the water column. In a lake, the depth below which there is insufficient light for photosynthesis is the 1% light level. Since 1993, the 1% light level ranged from 15 to 27 ft. (Figure 4.11).

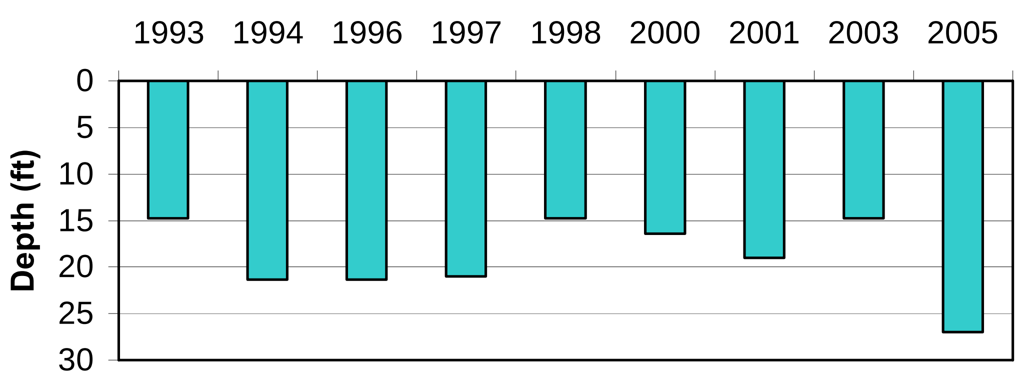


Figure 4.11. Yellowwood Lake: 1% light level

4.4. MONTHLY HOOSIER RIVERWATCH SAMPLING

Hoosier Riverwatch is a state-sponsored water quality monitoring initiative. Based upon volunteer monitoring, Hoosier Riverwatch was created to increase public awareness of water quality concerns and to develop a statewide database of water quality in Indiana's rivers and streams. The Yellowwood Lake Watershed Planning Group has participated in Hoosier Riverwatch since 2002, with chemical data collection beginning in the fall of 2004. We collected monthly samples at Jackson Creek, the major tributary to Yellowwood Lake, and quarterly samples at John Floyd Hollow (Figure 4.12). The quality assurance plan can be found in Appendix J.

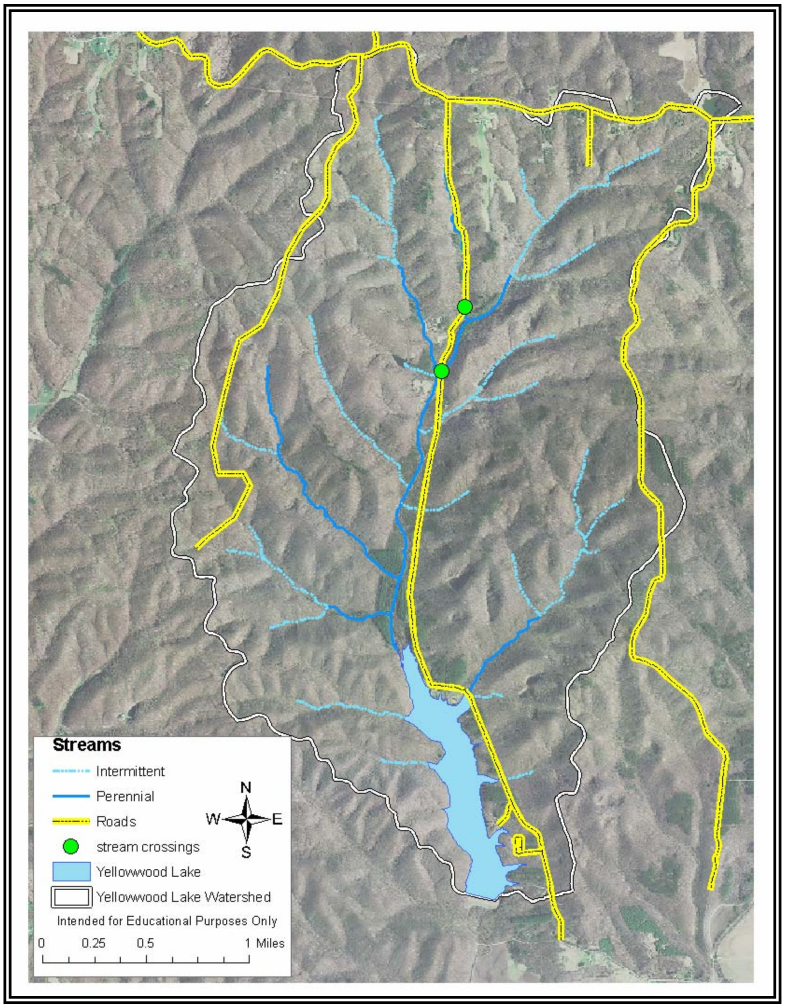
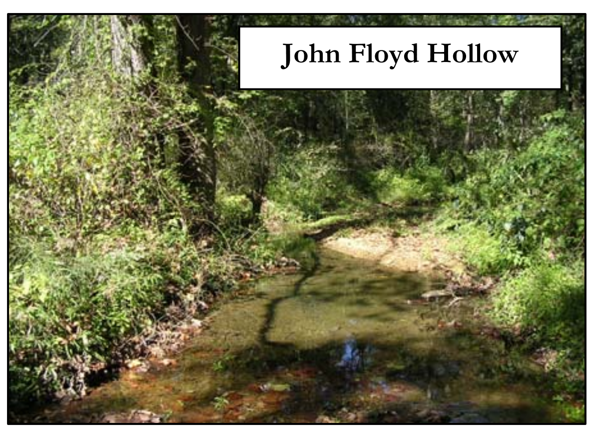


Figure 4.12. Yellowwood Lake Watershed: Water quality monitoring locations



The Hoosier Riverwatch data suggests that the Yellowwood Lake Watershed is not suffering from any significant chemical water quality impairments. See Appendix K for complete water quality data results. Nitrogen and phosphorous concentrations were consistently near or below detection levels at both sample sites. There was no detected turbidity at either site, and pH levels were within the allowed range for aquatic life according to 327 IAC 2-1-6(b).

The Indiana State Water Quality Standard for dissolved oxygen (DO) requires that the average concentration be at least 5.0 mg/L per calendar day and not be less than 4 mg/L at any time (327 IAC 2-1-6(b)). DO levels were at or below 4.0 mg/L from June to July, 2005 in Jackson Creek and September, 2005 in John Floyd Hollow. Corresponding % dissolved oxygen levels, a function of temperature, were below 50% (Figure 4.13). Low dissolved oxygen levels are usually caused by the decay of a large amount of organic material. However, streams receiving a substantial amount of ground water, as was the case in the summer of 2005, can have naturally low dissolved oxygen levels.

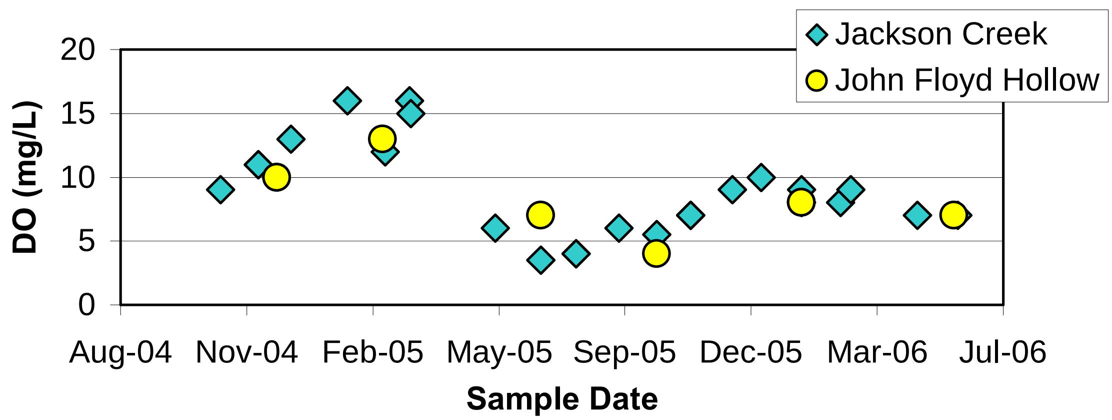


Figure 4.13. Yellowwood Lake Watershed: DO concentrations

Biological Oxygen Demand (BOD_5) is a measure of the amount of oxygen being used by bacteria to break down organic waste over five days. BOD_5 is also an indicator of how well a stream can process organic waste. Clean streams free from excessive plant growth typically have low BOD_5 levels while streams that are polluted or have lots of plant growth have high BOD_5 levels. Table 4.3 shows a rough guide to BOD_5 concentrations. BOD_5 concentrations in Jackson Creek were consistently below 2 mg/L and often below detection limits. However, in June, 2005 the BOD_5 detected in John Floyd Hollow was 6.0 mg/L, which indicates excessive organic material and bacteria.

Table 4.3. Qualitative descriptions of BOD_5 concentrations

1-2 mg/L BOD_5	Clean water with little organic waste
3-5 mg/L BOD_5	Fairly clean water with some organic waste
6-9 mg/L BOD_5	Lots of organic material and bacteria
10+ mg/L BOD_5	Very poor water quality. Very large amounts of organic material in water.

(Source: Hoosier Riverwatch, 2004)

4.5. BASEFLOW AND STORMFLOW SAMPLING

The water cycle is the movement of water through the environment. As water moves through the water cycle, it replenishes streams and lakes. During most of the year, stream flow is composed of both groundwater discharge and surface runoff. Baseflow conditions exist when groundwater provides the entire flow of a stream. Groundwater discharges into streams when the water table is above the stream bed. Measuring baseflow is important when evaluating the health of a stream. Without adequate baseflow, many streams do not have enough surface water to support aquatic organisms. Since groundwater temperatures are nearly uniform year-round, baseflow is also important for maintaining stream temperature. Monitoring baseflow is also important to detect soluble pollutants such as nitrate-nitrogen that travel primarily through groundwater. Finally, point source impacts are more easily noticed during baseflow conditions.

Stormflow conditions occur during high precipitation events. During storm events, the ground becomes fully saturated and precipitation flows across the watershed as surface runoff. As surface runoff travels over the landscape it collects sediment, bacteria, nutrients, chemicals, and metals present in the watershed, focusing them in the stream channel. Stormwater monitoring provides a window into watershed land use.

The YLWPG contracted Commonwealth Biomonitoring to conduct two fall baseflow events and two spring peakflow events as part of our water quality investigation in Jackson Creek (Table 4.4). It is important to note that the 2006 stormflow sample did not capture the first spring storm. There were several large storm events in a row and the 2006 sample caught a storm near the end of the series.

Table 4.4. Jackson Creek: Base and Peak flow water quality

PARAMETER	**24-Nov-04**	**14-May-05**	**10-Nov-05**	**3-April-06**
	BASE FLOW	**STORM FLOW**	**BASE FLOW**	**STORM FLOW**
Flow (cfs)	2	270	0	25
Temperature (°C)	13	17	12.1	8.3
Dissolved Oxygen (DO) (mg/l)	9.6	8.5	4	11.1
pH (SU)	7.1	6.7	6.9	7.2
Conductivity (µS)	160	130	220	145
E.coli (MPN/100 ml)	511	1280	3	6
BOD (mg/l)	< 1	5.3	1.4	1.7
TSS (mg/l)	< 1	266	< 1	< 1
Ammonia-N (mg/l)	< 0.1	0.1	0.5	0.5
Nitrite+Nitrate (mg/l)	0.4	0.2	0.1	0.1
Total Phosphorus (mg/l)	0.11	< 0.02	0.03	0.09
Orthophosphorus (mg/l)	0.1	< 0.02	0.02	0.08
Chlorophyl *a* (µg/l)	5.5	64	14	24
Turbidity (NTU)	2	46	16	17

The bullet points listed below outline significant findings from the Base and Storm flow water sampling in Jackson Creek. While we compared the total phosphorous and chlorophyll-a data to Carlson's TSI, it is important to note that Carlson's index was developed for lakes, not streams.

- **Dissolved Oxygen:** The Indiana State Water Quality Standard for dissolved oxygen requires that the average concentration be at least 5.0 mg/L per calendar day and not be less than 4 mg/L at any time (327 IAC 2-1-6(b)). The November 2005 sample had a detected DO concentration of only 4 mg/L.

- ***E. coli*:** The Indiana State Water Quality Standard for full body contact recreational uses, from April through October, shall not exceed (1) one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period; and (2) two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period(327 IAC 2-1-6(d)). The 2004 baseflow and 2005 storm flow samples violate the water quality standard.

- **BOD:** falls within the clean to fairly clean with some organic waste range, according to Hoosier Riverwatch.

- **TSS and Turbidity:** There are no identified sediment-related criteria in Indiana. However, many other states suggest a maximum of 50 NTU for streams with healthy warm-water fish populations. All samples fall below this standard. The May 2005 sample exceeds the Utah/ North Dakota TSS standard (263 mg/L) for warm-water streams.

- **Nitrite+Nitrate:** Nitrogen concentrations in Jackson Creek are well below the Indiana State Drinking Water Quality Standard (10 mg/L Nitrate-N + Nitrite-N and 1mg/L Nitrite-N) (327 IAC 2-1.5-8-f(6)).

- **Total Phosphorous:** There are currently no standards for total phosphorous in streams. However, two samples were above the EPA's recommended maximum concentration (0.05 mg/L) for streams to control eutrophication (Muller and Hensel, 1999). The November 2004 and April 2006 samples fall within Carlson's TSI eutrophic range.

- **Chlorophyll-*a*:** There are currently no standards for chlorophyll-*a* in streams. However, the May 2005 storm event fall within Carlson's TSI hypereutrophic range, and the November 2005 and April 2006 samples fall within the eutrophic range.

QUALITATIVE HABITAT EVALUATION INDEX

The Qualitative Habitat Evaluation Index (QHEI) is a physical habitat index designed to provide an empirical, quantified evaluation of stream micro-habitat. Developed by the Ohio EPA, the index corresponds to the physical factors that affect fish and other important aquatic life (e.g., invertebrates) (Rankin, 1989). The QHEI is composed of six metrics that are related to fish communities: 1) substrate, 2) in-stream cover, 3) channel morphology, 4) riparian and bank conditions, 5) pool and riffle quality, and 6) gradient.

We conducted a QHEI at seven sites along Jackson Creek in October 2005 to evaluate its ability to support aquatic communities (Figure 4.14). Representative sites were randomly selected from the foot bridge to the first stream crossing, moving upstream. The QHEI data represent 100 meter reaches.

Each metrics is scored individually and then summed to provide the total QHEI site score. High scores represent habitat parameters shown to be correlated with streams that have high biological diversity and integrity, while progressively lower scores represent less desirable habitat features. The maximum possible QHEI score is 100. Habitat quality can be characterized from a range of QHEI scores based upon EPA 305(b) guidelines (USEPA, 1997). QHEI ranges are listed in Table 4.5.

Figure 4.14. Volunteer monitoring

Table 4.5. Qualitative QHEI values

≥ 64	fully supporting for designated uses
< 64 and ≥ 51	partially supporting for designated uses
< 51	not supporting for designated uses

The results of the QHEI survey suggest that overall Jackson Creek can support a healthy, biodiverse aquatic community. All sites downstream of the first stream crossing were “fully supporting” while the sites at and above the stream crossing were only “partially supporting”. No sample sites were designated “not supporting”. Signs of erosion, heavy silt and embeddedness, in concert with decreased riparian zone width led to low site scores. These reaches also have decreased canopy cover as the stream exits the forest, travels through pasture, and crosses Yellowwood Road. The “fully supporting” sites are located within Yellowwood State Forest, with broad riparian zones and nearly 100% canopy cover.

The cumulative QHEI scores, based upon the ability to support designated uses, are illustrated in Figure 4.15. Site scores and individual metric scores can be found in Appendix L.

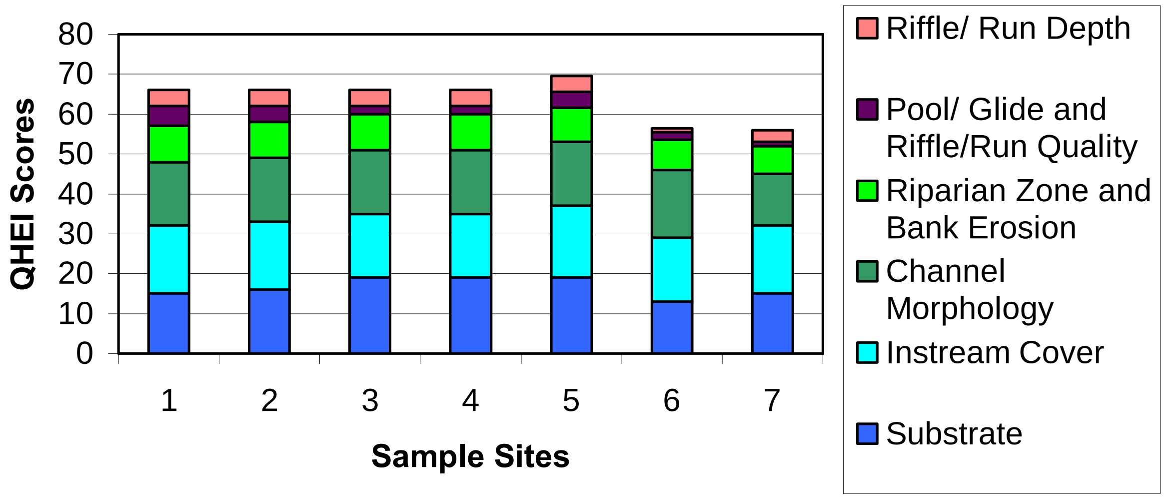


Figure 4.15. Jackson Creek: QHEI scores

4.7. MACROINVERTEBRATE MONITORING

Benthic macroinvertebrates are animals that are big enough to be seen with the naked eye (macro), which lack backbones (invertebrates), and spend at least part of their lives in or on the bottom (benthos) of a body of water. They include aquatic insects, snails, worms, mussels, and crayfish. Benthic macroinvertebrates are an extremely important part of aquatic ecosystems. They are critical part of the aquatic food web and can be used as continuous indicators of environmental quality.

Biological stream monitoring is based on the fact that different species react to pollution in different ways. Some organisms such as mayflies, stoneflies, and caddis flies are more susceptible to the effects of physical or chemical changes in a stream than are other organisms. These organisms are referred to as “pollution-sensitive,” and their presence indicates the absence of pollutants. Other “pollutant-tolerant” organisms such as midges and worms are not as sensitive to changes within a stream, and their presence or absence can be used as an indirect indicator of pollution.

The Yellowwood Lake Watershed Planning Group performed two macroinvertebrate samples in Jackson Creek in 2005. Samples were collected from a 200m reach upstream of the monthly stream monitoring site. We used the Kick Seine Net and regular dip net to sample riffles, leaf packs, undercut banks, and sediment.

Macroinvertebrate monitoring results, according to Hoosier Riverwatch (2004) (Table 4.6), indicate that Jackson Creek has a thriving, healthy macroinvertebrate population with no signs of pollution. The April sample yielded a Pollution Tolerance Index Ranking of 23, while the October sample had a score of 34. Both scores are in the ‘excellent’ range.

Table 4.6. Qualitative Pollution Tolerance Index Ranking Scores

Pollution Tolerance Index Rating	
23 or More	Excellent
17-22	Good
11-16	Fair
10 or less	Poor

To confirm the macroinvertebrate monitoring results, the YLWPG contracted Commonwealth Biomonitoring to perform a detailed benthos sample. The sampling included the calculation of three indices, the Shannon Weaver Index, Hilsenhoff Biotic Index, and Pollution Tolerance Index. The Shannon Weaver Index considers species richness, the Hilsenhoff Biotic Index and Pollution Tolerance Index measure macroinvertebrate tolerance of organic (nutrient) enrichment (Table 4.7). The sample results confirm that Jackson Creek has a thriving, healthy macroinvertebrate community.

Table 4.7. Jackson Creek: Benthos sample results

Index	Value	Interpretation
Total # of taxa	14	
Total # of EPT taxa	8	
Shannon Weaver Index	3.3	High Quality Community
Hilsenhoff Biotic Index	2.5	High Quality Community
Pollution Tolerance Index	50.1	High Quality Community

4.8. WATERBORNE PATHOGEN MONITORING

Infectious diseases caused by pathogenic bacteria, viruses, and protozoan parasites are among the most common and widespread health risk of drinking water. Waterborne pathogens are transmitted to people when they consume untreated or inadequately treated water. Some waterborne microorganisms can cause severe, life- threatening diseases (typhoid fever, cholera, or hepatitis), while others are harmless. Fecal coliform bacteria are found in the intestines and feces of warm-blooded animals, including humans, livestock, and waterfowl, and their presence often indicates recent sewage or animal waste contamination. *Escherichia coli [E. coli],* is a type of fecal coliform bacteria that is commonly used as an indicator of fecal contamination. Not all strains of *E. coli* can lead to illness in humans. However, *E. coli* commonly occurs with other intestinal tract pathogens that may be harmful to human health. Therefore, the detection of *E. coli* indicates the presence of waterborne pathogens and the potential for waterborne diseases.

Indiana currently uses *E. coli* for their bacteriological water quality monitoring. According to Indiana Water Quality standards the *E. coli* limit for full body contact recreational use, from April through October, shall not exceed the geometric mean of 125 colony forming units (CFU) per 100 ml based on no less than five (5) samples equally spaced over a thirty (30) day period, nor 235 cfu/100 ml in any one (1) sample in a thirty (30) day period. If the geometric mean cannot be calculated because five (5) equally spaced samples are not available, the limit of 235 cfu/100 ml in a single sample over a thirty (30) day period applies (327 IAC 2-1-6(d)).

Volunteers monitored *E. coli* in Jackson Creek on a monthly basis and in John Floyd Hollow on a quarterly basis using the Coliscan Easygel method. Table 4.8 shows the volunteer *E. coli* detection results. Detected *E. coli* concentrations in Jackson Creek and John Floyd were consistently well above the single sample State Water Quality Standard for total body contact recreation. The highest recorded *E. coli* concentration in Jackson Creek was 6,500 cfu/ 100ml[15] while the highest concentration of John Floyd Hollow was 4,100 cfu/ 100ml. The *E. coli* concentrations at John Floyd Hollow were consistently higher than Jackson Creek.

The YWLPG contracted two fall baseflow samples and two spring peak flow samples in Jackson Creek (Table 4.8). The May 2005 peak flow sample was over five times the single sample State Water Quality Standard for total body contact recreation. While Indiana Water Quality Standards only apply for *E. coli* samples collected from April to October, the November 24, 2005 sample was twice this legal amount. In contrast, the second highest discharge sampled, April 2006, yielded a concentration of only six colonies.

Table 4.8. Yellowwood Lake Watersehd: detected E.coli concentrations

	Jackson Creek (volunteer)		John Floyd (volunteer)		Jackson (Contracted)	
Sample Date	***E. Coli*** **(#/100 ml)**	**Discharge (CFU)**	***E. Coli*** **(#/100 ml)**	**Discharge (CFU)**	***E. Coli*** **(#/100 ml)**	**Discharge (CFU)**
October-04	34,800*	3.1				
November-04	6,800 and 6,300	2.3			511	2
December-04	600	5.8	1,200 and 1,500	1.7		
January-05	1400	2.2				
February-05	---	2.84	400	1.3		
March-05	---	4.67				
May-05	700	2.2			1,280	270
June-05	1500	0.3	1,700	0		
July-05	0, 400	0				
August-05	800	3.6				
September-05	1700	1.1	4100	0.3		
October-05	1,100 and 2,400	0				
November-05	700	1.6			3	0
December-05	800	6.1				
January-06	100 and 200	3.9	0, 100	2.5		
February-06	100	3.53				
March-06	200	5.19				
April-06	300	2.47				
May-06	600 and 400	3.16	400	2.64	6	25
* May have been contaminated						

[15] The highest detected *E. coli* concentration was 34,800 colonies/ 100 ml. This number is extremely high and we believe the sample may have been contaminated.

L-THIA

L-THIA (Long-Term Hydrologic Impact Assessment) was developed as a model to estimate changes in runoff, recharge, and non-point source pollution according to past or proposed landuse. Based on actual long-term climate data for a county, L-THIA generates long-term average annual runoff for individualized land use configurations. Applying this model to actual development patterns allows the long term effects of past, present, and future land use to be determined (Purdue, 2006).

The inputs and model results from L-THIA applied to the Yellowwood Lake Watershed are shown Appendix M. The model suggests that runoff from parking/ paved surfaces and residential land generally have higher concentrations of nutrients, sediments, metals, oxygen demand, oil/ grease, and fecal materials as compared to forests, grass/ pasture, and water/ wetlands. Fortunately, the Yellowwood Lake watershed is 95% forested, so there is little potential for runoff contamination.

Figure 4.16 illustrates varying runoff potential corresponding to three land use regimes. Situation one is current land cover, situation two is maximized forest cover, and situation three has 50% current forest cover. We can see that the average annual runoff depth and total annual volume are the highest with the least amount of forest cover, and lowest with maximum forest cover. This model shows that during rain events, forest cover will provide for increased runoff infiltration.

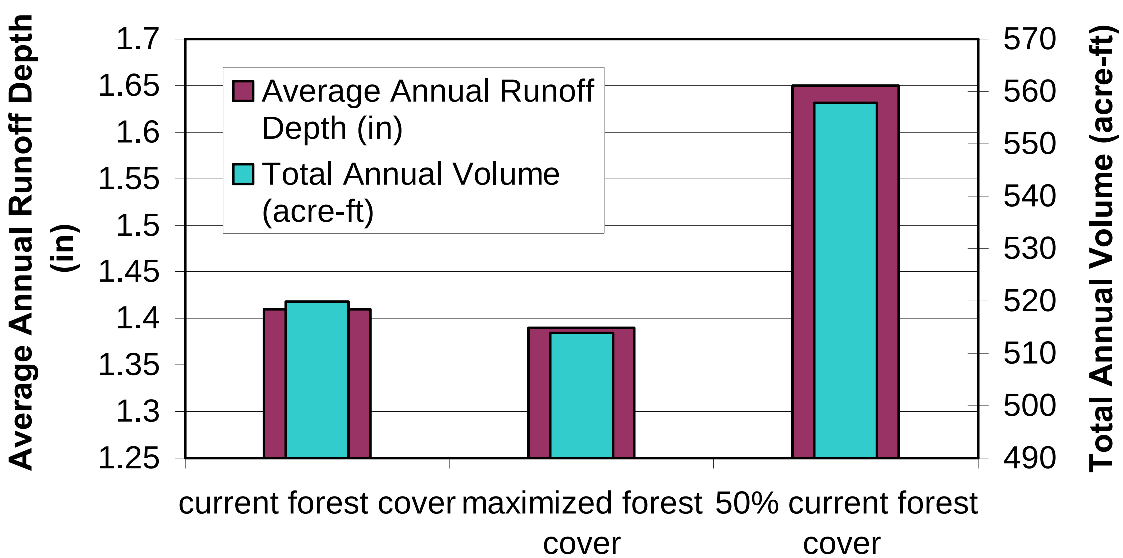


Figure 4.16. Yellowwood Lake Watershed: L-THIA Model inputs

4.10. HFF DEPTH SURVEYS

In 2002 the Hoosier Fly Fishers (HFF), a local club based in Bloomington, Indiana, commenced a series of annual depth surveys on Yellowwood Lake. The HFF strategy involved a comparison of current lake depths to a 1955 bathymetric map of Yellowwood Lake. Designed with the professional assistance of the late Daniel Willard (Professor and watershed specialist at IU SPEA) and approved by the YLWPG, the HFF methodology involved identifying strategic locations with varying probabilities of sediment accumulation. The HFF then determined lake depths by locating the pre-determined points and measuring water column depth with secchi poles and depth finders. The HFF depth studies span from 2002 to 2005 (Appendix N).

The 2005 HFF Depth survey results are shown in Figure 4.17. While a loss of depth appears to have occurred at all sample sites, the greatest depth losses are concentrated in the north end of the lake and near inlets where up to 5.5 feet of sediment has accumulated since 1955. Since 1955, Yellowwood Lake has lost an average of nearly 3 ft in depth (Table 4.9). Of the cumulative depth loss, 23% appears to have occurred since 2002. While Yellowwood Lake lost over 0.3 ft in depth from 2002-03 and 2003-04, the rate of loss appears to have slowed as less than 0.1 ft was lost in 2004-05.

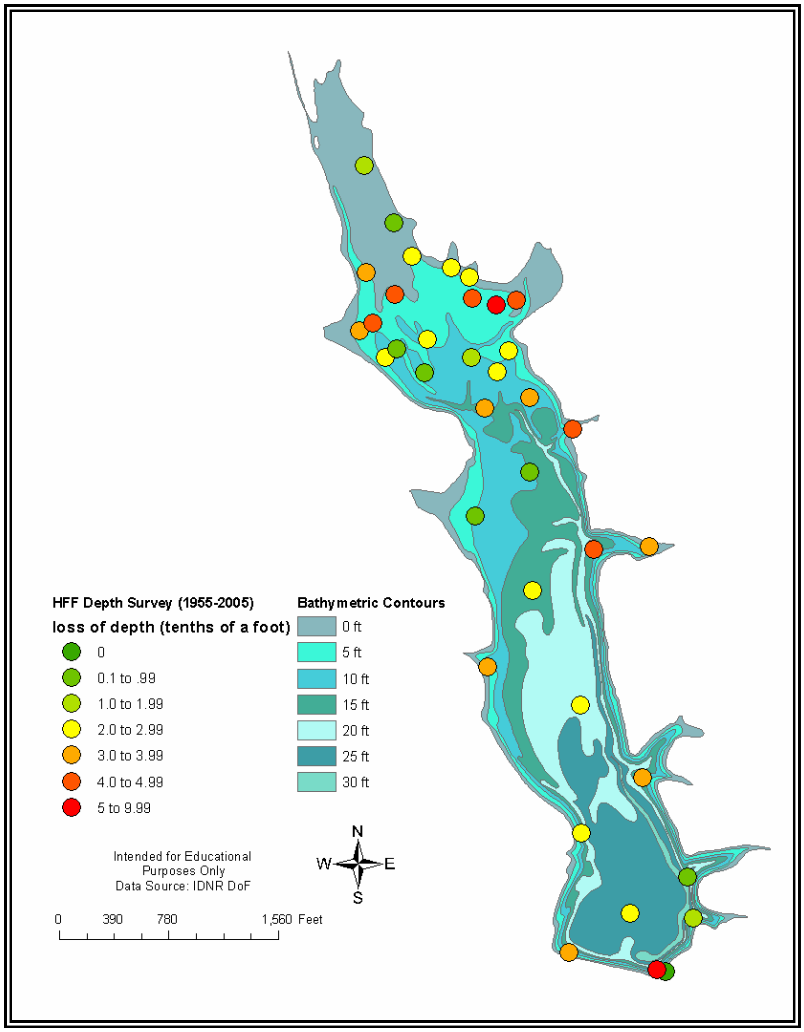


Figure 4.17. Yellowwood Lake: HFF Depth Study Results

Table 4.9. Yellowwood Lake: HFF Depth Study Results (2002-2005)

Year	04-05	03-04	02-03	02-05	55-05
Mean Depth	10.51 ft	10.62 ft	11.07 ft	11.36 ft	13.56 ft
Mean Δ Depth	0.094 ft	0.363 ft	0.306 ft	0.692 ft	2.964 ft
Median Δ Depth	0.09 ft	0.26 ft	0.30 ft	0.64 ft	2.99 ft
Number of samples	36	36	36	36	36
Standard Deviation	1.076 ft	0.878 ft	0.623 ft	1.200 ft	1.788 ft

4.11. COMMONWEALTH BIOMONITORING SEDIMENT & DEPTH SURVEYS

In the fall of 2005, the YLWPG contracted Commonwealth Biomonitoring to perform a depth study on Yellowwood Lake to complement the HFF depth survey results. For the sediment measurements, Commonwealth used a depth finder and a GPS unit to check the water depths at sites where previous depth was recorded on DNR maps. They did this along three transects (5 feet, 10 feet, and 15 feet) at the north end of the lake.

Their findings revealed that the 10 and 15 feet transect depths matched up very closely, indicating that little or no sediment deposits were present there. The 5 foot depth transect showed extensive loss of water volume in some areas. In these areas, they shoved a long piece of rebar iron into the soft upper sediments until it would no longer go any further, and then recorded the depth of penetration, along with a GPS measurement. They did this at 20 different sites and used the data to prepare a map (Figure 4.18).

In the reference bathymetric maps used as baseline data, the north end of Yellowwood Lake is all water. Commonwealth estimated that the newly formed islands contain at least 600,000 cubic feet of sediment while the delta downstream of the islands contains at least 300,000 cubic feet of sediment. They estimated that roughly a million cubic feet of sediment have been deposited since the original bathymetric map was created in 1955.

Concerned about the nature of the sediment in Yellowwood Lake, the YLWPG contracted Commonwealth Biomonitoring to perform sediment core analysis to determine ratio of organic to inorganic materials (Table 4.10). Many YLWPG members expected that the "sediment" was actually an accumulation of decaying organic material from the macrophyte beds. However, the study revealed that over 90% of the sediment was inorganic in nature (e.g. silt or clay). There was no gravel detected in the lake sediments.

Table 4.10. Yellowwood Lake: Sediment Core Analysis

Location	Depth	% Organic	% Inorganic	% silt or clay	% gravel
South End	Surface	7	93	100	0
North End	Surface	9.2	90.8	100	0
North End	2.5 ft depth	10.9	89.1	100	0
North End	5 ft depth	7.5	92.5	100	0

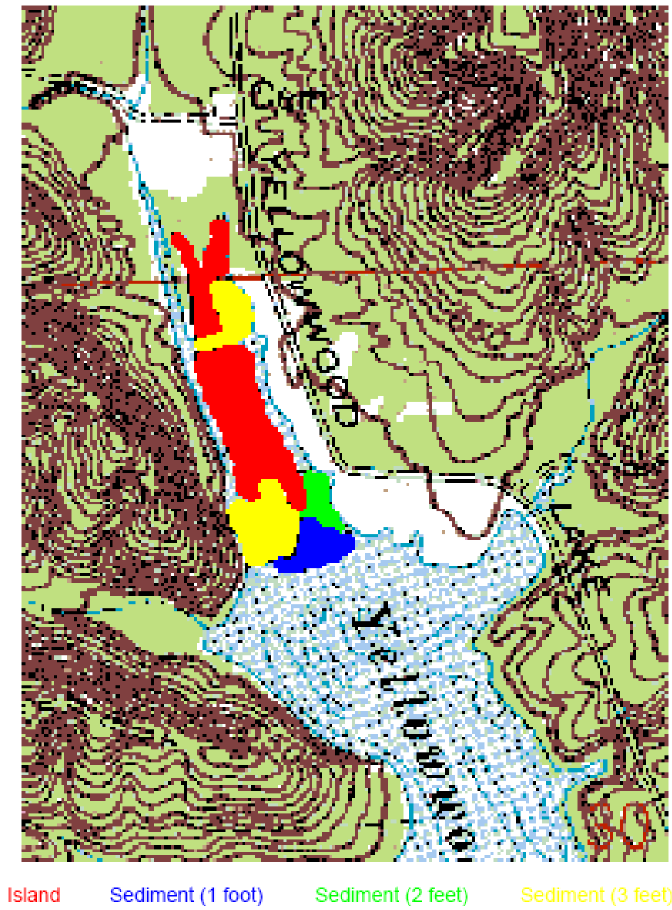


Figure 4.18. Yellowwood Lake: 2005 Sediment Depth Survey

4.12. AERIAL PHOTOS OF YELLOWWOOD LAKE

As suggested in the preceding sections, the north end of Yellowwood Lake has accumulated a great deal of sediment and aquatic macrophytes since its creation in 1939. While the impacts are easily noticed by those on the lake, the extent of the wetland expansion becomes even more obvious by examining aerial photographs (Figure 4.19). The 1949 image shows the original lake boundary. As the time series continues, we can see that the northern end filling in. The 1980 and 2003 images (both taken during winter months) show sediment accumulation and the inlet channel (Jackson Creek) becoming more defined. The 1994 and 2003 images (both taken during the summer) highlight the macrophyte beds near the campgrounds and John Floyd Hollow inlet.

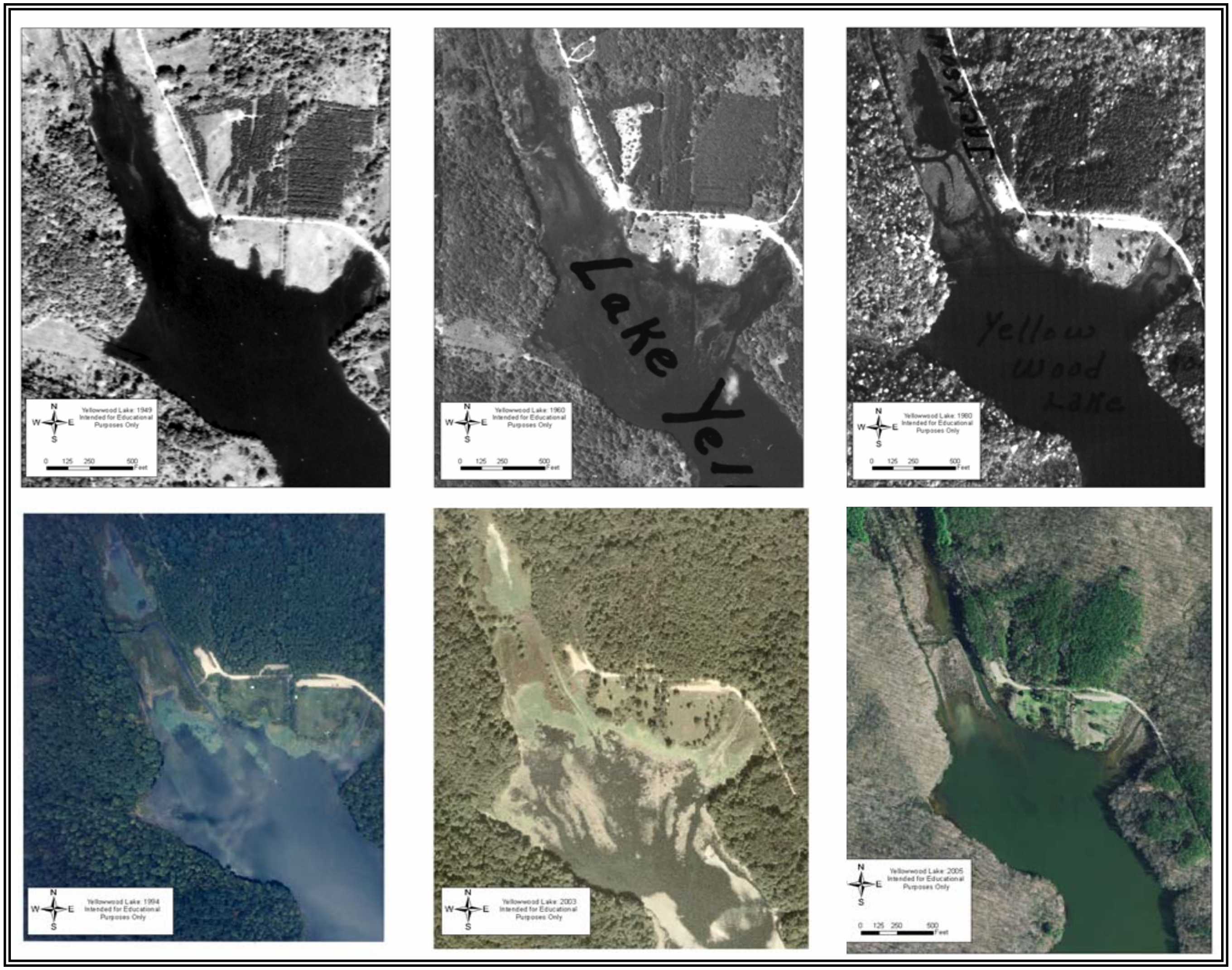


Figure 4.19. Yellowwood Lake: aerial photographs

4.13. VISUAL ASSESSMENTS: YELLOWWOOD LAKE ROAD

As part of the watershed assessment, a ground-truthing survey was conducted to obtain direct visual observations of Yellowwood Lake Road. Observations were made on July 6, 2005. We collected data at seven sites that we felt represented a range of road conditions that may be of concern to both human safety and environmental health. The condition of the logging roads, fire trails, foot paths and recreational trails in the watershed has not yet been assessed.

The observation sites were photographed with a digital camera and survey results were recorded on data sheets. The recorded data represented the average for a 100 ft segment of road . The parameters recorded for each site included road characteristics, visual signs of erosion, roadside vegetation including invasive species, and an erosion potential ranking. The erosion potential ranking is a qualitative score based on perceived erosion potential. A score of one indicates high erosion potential while a score of five signifies low potential (Table 4.11).

Table 4.11. Yellowwood Lake Road: Visual Survey Results

Site Number	1	2	3	4	5	6	7
Width (ft)	19	20	18	21	18	20	17
Composition	Paved	Gravel	Gravel	Gravel	Gravel	Gravel	Gravel
Slope	Out-sloped	Out-sloped	Out-sloped	Out-sloped	Out-sloped	Out-sloped	Out-sloped
Signs of Erosion	Minor cuts	ditch formation	ditch from grading, undersized culvert, heavy disturbance	gullies, cut-banks, siltation in stream	Cut-banks, sloughing,	Ditch, sloughing	Ditch, sloughing
Roadside vegetation	Moderate, mowed often	thick	thick	thick	thick	thick	thick
% Canopy Cover	10	60	80	0	50	50	90
Proximity to Stream	n/a	Culvert directly to lake	Culvert	At crossing	35 ft	1 ft	1 ft
Erosion Potential Ranking	5	3	3	1.5	1	2	1
Invasive Spp	*Vinca minor*	*Vinca minor, Melilotus officinalis*	*Microstegium vimineum*	*Rosa multiflora*	*Vinca minor*	*Vinca minor*	*Vinca minor*
Notes	Gravel 10-12 feet from road	gravel 17ft from road	gravel 50ft into stream		culvert ends too soon, steep cut-off, dangerous	culvert too small	

The survey results show that the primarily graveled Yellowwood Lake Road has increased erosion potential as it travels north through the watershed (Figure 4.20). The erosion potential rises from moderate to high beginning at the first stream crossing. This may be because the road closely follows the stream north of the stream crossings. As illustrated in the photographs in Appendix O, signs of erosion include cut-banks, ditch formation, and the buffer between the road and the stream sloughing off into the stream channel.

Maintenance of Yellowwood Lake Road is limited to periodic grading and frequent spot applications of gravel. Yellowwood Lake Road was heavily graded in spring 2005, and remnant disturbances are still visible. There are multiple undersized culverts on Yellowwood Road and rip-rap near the two stream crossings. Silt-fences have not been used to control sediment from Yellowwood Lake Road.

The effect of the sediment may to be proportional to the distance the sediment travels from its source; the slope steepness; and drainage type (e.g., with and without outsloping and culverts). Swift (1986) found that on unpaved roads that were out-sloped and without culverts, sediment traveled less than one meter, while it traveled up to 100 m on roads with culverts only. We observed gravel as far as 17 feet (5.18 m) away from the road near culverts and up to 50 feet (15.24 m) into the stream at a stream crossing.

Increased vegetative cover on roadside disturbed areas has been documented as reducing sediment production Swift (1984). Road condition, however, does not appear to be related to canopy cover or roadside vegetation in our survey. Roadside vegetation along Yellowwood Lake Road was thick and included four invasive plant species: *Vinca minor, Melilotus officinalis, Microstegium vimineum,* and *Rosa multiflora.*

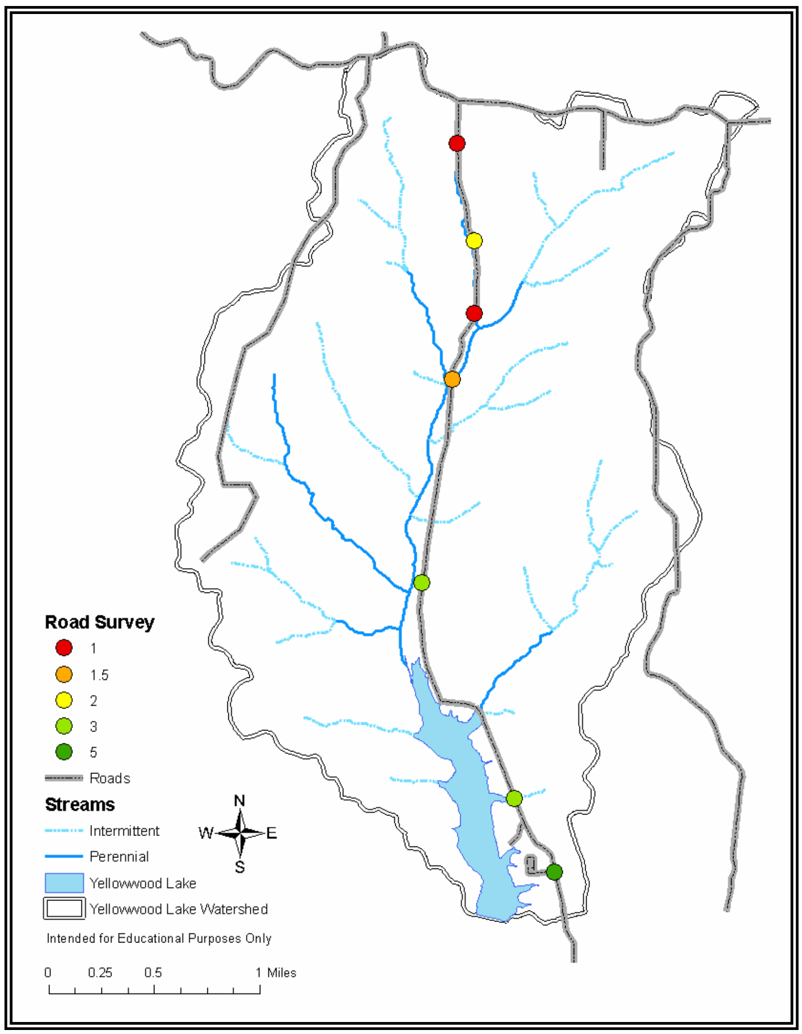


Figure 4.20. Yellowwood Lake: Erosion Potential from Road Survey Results

4.14. AQUATIC PLANTS

Dating back to a 1968 IDNR Fishery report, weeds have been a known problem in Yellowwood Lake. Table 4.12 shows the history of aquatic weed comments in IDNR Fishery Reports. The clear lake water and soft sediments encourage the proliferation of submersed vegetation, which has been detected at depths up to 15 feet since 1973. Submerged species such as Eurasian water milfoil can grow all the way to the surface, thus diminishing the lake's open water habitat.

Excess plant growth is focused in shallow waters towards the shore, coves, and the lake's northern end. Included in the 2004 IDNR Fishery Survey was a submerged aquatic vegetation survey. The survey found nine species of submersed aquatic plants in Yellowwood Lake (see Appendix P for copy of results) and a mean total rake score[16] of 3.73 (Figure 4.21) for the sixty sites sampled. The nine documented submersed plant species are shown in Table 4.13.

Table 4.12. Yellowwood Lake: IDNR Fishery Reports

Year	Comments in Yellowwood Lake IDNR Fishery Reports
1961	submerged vegetation covers 20% of the lake
1968	weed problems on the northern end and portions of several coves (mgmt recc.)
1973	weeds growing throughout the lake at 15ft depth, problems in shallows, coves, bays, and portions of the lake 5ft depth and less
1977	problem in shallow areas, growing throughout lake at 15ft depth (can't spray b/c drinking water source)
1989	weeds growing to 15ft depth (should be controlled to keep it from interfering with shoreline angling) American Lotus noted
2002	vegetation to 12 ft depth, Eurasian water milfoil noted, purple loosestrife covers 6 acres, water willow covers 75% of shoreline
2004	vegetation to 15.5 ft depth, water willow covers 75% of shoreline

The reports also noted the presence of non-native and native nuisance aquatic plants. American Lotus (*Nelumbo lutea)*, a native species to southern Indiana, was detected in the Lake in 1989 and has since become a nuisance on the northeast end of the lake (Figure 4.22). At the time, the fisheries biologists suggested that unless controlled, the Lotus is "expected to move toward the dam along the east and west shorelines and eliminate shoreline angling." This did not occur. Also a native, the 2004 fishery report indicates that water willow covers about 75% of the shoreline, extends out to 5 ft depth, and interferes with shoreline angling in some places.

[16] Rake scores are assigned on a score of one to five, with five being the worst.

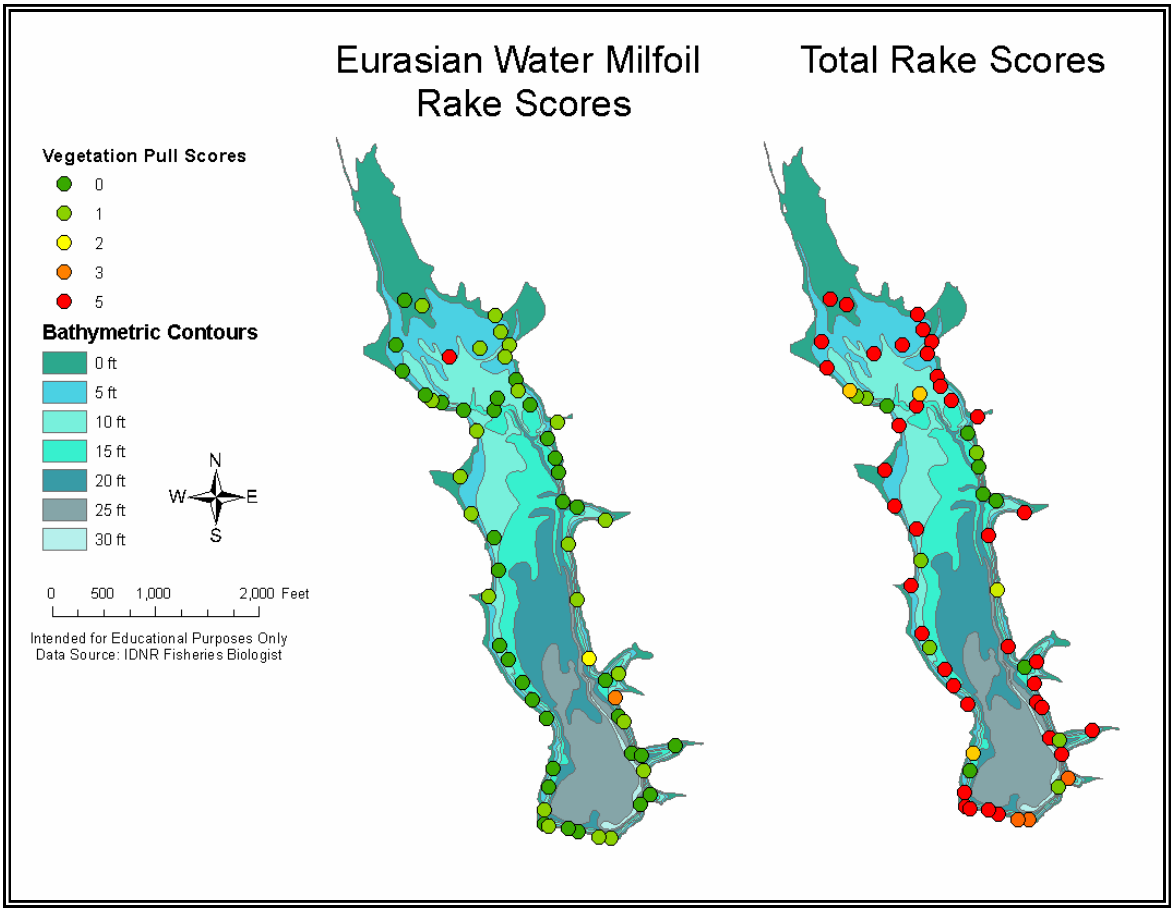


Figure 4.21. Yellowwood Lake: Rake scores

Table 4.13. Yellowwood Lake: Aquatic Weeds

Common Name	***Scientific Name***
American elodea	*Elodea canadensis*
Coontail	*Ceratophyllum demersum*
Eurasian watermilfoil*	*Myriophyllum spicatum*
Brittle naiad	*Najas minor*
Slender naiad	*Najas flexilis*
Eel grass	*Vallisneria americana*
Chara	*Chara spp.*
Leafy pondweed	*Potamogeton foliosus*
Waterstargrass	*Heteranthera dubia*
* non-native plant	

Yellowwood Lake's two non-native plants include Eurasian watermilfoil *(Myriophyllum spicatum)* and Purple loosestrife (*Lythrum salicaria*), which were first recorded in the 2002 Fishery survey. The report estimated that, at the time, Purple loosestrife covered at least 5 acres in the upper end of the lake. The United States Department of Agriculture (USDA) conducted an experimental release of *Galerucella* beetles in 2000 to control loosestrife and establish a local *Galerucella* population. While researchers have not returned to study the site, the lack of Purple Loosestrife expansion indicates that the *Galerucella* are keeping it in check. The only attempt to chemically control the aquatic plants was in 1993 when 8.5 gallons of Reward® were applied to improve shoreline fishing and rowboat access.

Figure 4.22. Yellowwood Lake: Nuisance and Invasive Vegetation

4.15. FISHERY

Warm summer surface water temperatures in excess of 80˚F and insufficient dissolved oxygen concentrations below 18 feet render Yellowwood Lake a warm water fishery. The fish population in Yellowwood Lake, as determined by DNR fishery surveys[17] and angling records[18], is dominated by bluegill and largemouth bass (Figure 14.23). Overall, biologists have rated the fish population as satisfactory for a relatively infertile impoundment. See Appendix Q for summary of fishery studies.

Bluegill
Lepomis macrochirus
(www.philaprintship.com)

Largemouth Bass
Micropterus salmoides
(www.gregfishing.com)

Figure 4.23. Yellowwood Lake: Common fish species

Yellowwood Lake has high fish diversity relative to many reservoirs in Indiana. Whereas most reservoirs have only 4 or 5 species, fishery surveys show that Yellowwood Lake has 14 species of fish. The DNR has implemented a supplemental stocking regime to provide anglers with more fishing diversity in the lake. Since 1981, the DNR stocks 3,325 channel cat fish (3.8-14.0 inches) every two years to maintain a population believed unable to sustain itself through natural reproduction. Additionally, 700 trout (mostly rainbow and some brown) have been stocked in Jackson Creek every April since 1975. The trout are mostly fished out during the first weekend after stocking. Trout have not been stocked in the lake, but a rare trout is occasionally found in the lake.

The 2002 DNR Fish Survey discovered a potential threat to Yellowwood Lake: yellow bass. Most likely illegally transported from nearby Monroe Reservoir, the yellow bass is a cause for concern because it is an efficient predator. It may out-compete the largemouth bass for food and increase predation of the bluegill.

[17] DNR Division of Fish and Wildlife Fishery Surveys (1961, 1968, 1973, 1977, 1989, 2002, and 2004).

[18] Larry Barber's personal records (1982-2004)

5. PROBLEM STATEMENTS AND SOURCE INVESTIGATION

The following section is based upon visual observations, existing water quality data and benchmark conditions to determine the extent of each water quality concern and develop problem statements that adequately summarize the main concerns within the watershed. This section is based upon discussions and decisions made by the YLWPG.

5.1. LOCAL CONCERNS

The goal of the Yellowwood Lake Watershed Management Plan is the development of a plan that will *protect, enhance, and conserve* Yellowwood Lake and its watershed. In 2005 the YLWPG circulated the "Yellowwood Lake Watershed Management Plan Private Landowner Survey" to 50 landowners in the watershed. The purpose of the survey was to gain information on residency, gauge the perceived problems from those not actively participating in the watershed planning process, and understand how those who live in the watershed use their land. Of the 50 circulated surveys, 21 were returned. A copy of the survey can be found in Appendix F.

One question in the survey asked respondents to rank a list of problems that they felt were negatively impacting Yellowwood Lake. A score of one (1) signifies 'not a problem' while a score of five (5) represents a 'major problem'. Figure 5.1 shows survey results. The legend represents the assigned scores of each respondent. Many of the watershed residents felt that septic tanks, invasive species, sedimentation (i.e. the lake is filling in), and shoreline erosion are negatively impacting Yellowwood Lake. From this survey, we can see that the resident concerns are similar to the concerns addressed in this plan. Within the 'others' category, residents listed 'lack of forest diversity' and 'lumbering'.

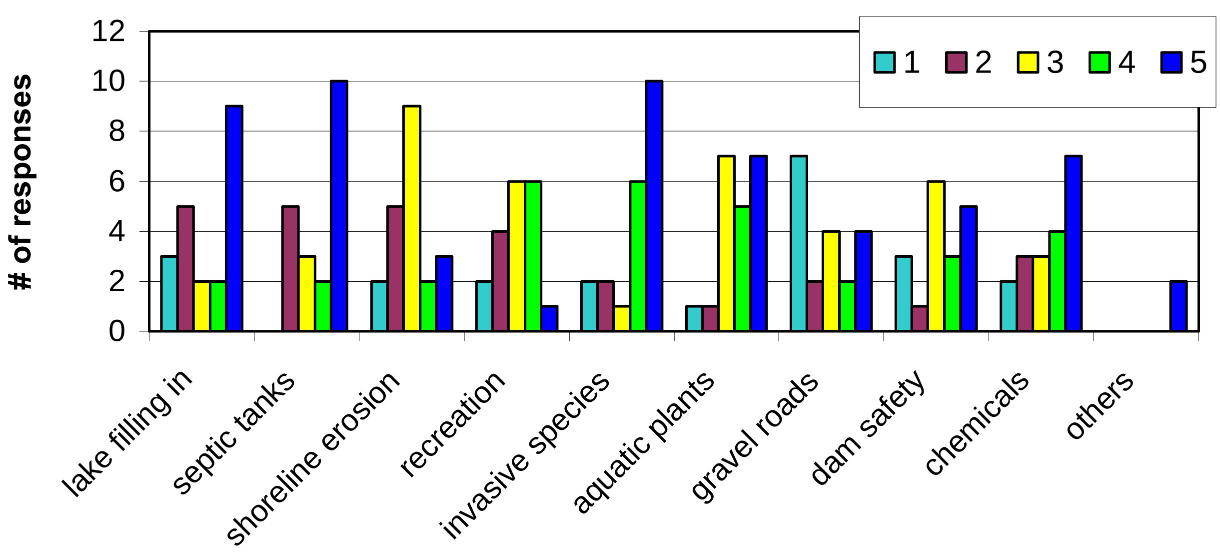


Figure 5.1. Yellowwood Lake: Watershed resident concerns

The survey also asked the residents their opinions about the condition of Yellowwood Lake. As shown in Figure 5.2, over half of the respondents believe that Yellowwood Lake has "gotten worse". Many of the residents feel that deteriorating condition of Yellowwood Lake has adversely impacted their ability to enjoy the beauty of the lake, to fish, and to canoe. Other adversely impacted activities or values listed in the survey include hiking, birding, biodiversity, and availability of food for waterfowl.

Similar to the concerns outlined in Section 1.0 of this document, the primary concerns of survey respondents are the sedimentation of Yellowwood Lake, *E. coli* contamination, and invasive species. Many of these concerns are corroborated by data collection and geographic information detailed further in this section.

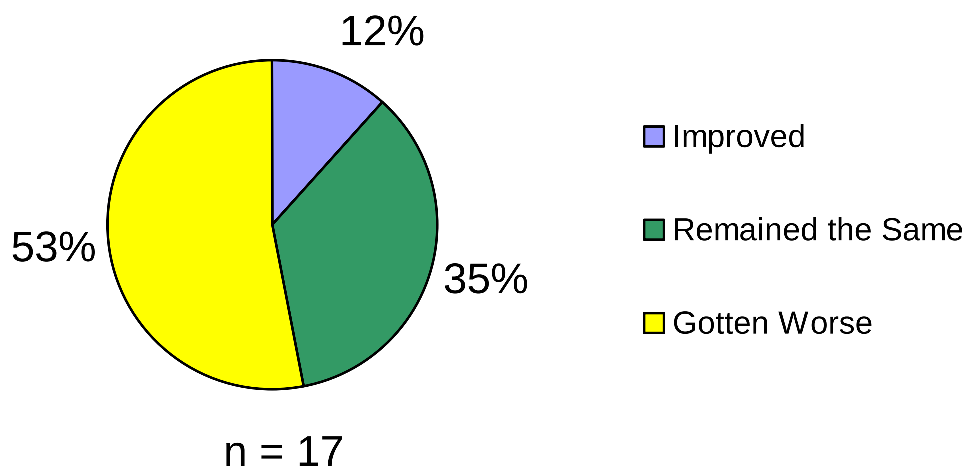


Figure 5.2. Yellowwood Lake: watershed resident perceptions

5.2. PROBLEM STATEMENTS AND SOURCE INVESTIGATION

Problem statements were developed by a prioritization process within the Yellowwood Lake Watershed Planning Group. There are four major areas for which problem statements were developed: group sustainability, sedimentation, nuisance and invasive species, and biological and chemical contamination.

GROUP SUSTAINABILITY

Problem: ***The YLWPG does not have any strategic plans or future funding sources for organizational sustainability or implementation of this watershed management plan's goals.***

In terms of volunteer participation, the YLWPG had mixed successes during the two-year management plan process. While three YWLPG members have been Hoosier Riverwatch-trained, coordinating schedules proved to be too difficult, and the watershed coordinator conducted a majority of the water quality sampling. Average monthly meeting attendance was approximately 10 of 12 steering committee members. However, the advertised public quarterly public meetings held at the Brown County Library attracted few non-YLWPG participants. In May 2005 the YLWPG hosted an invasive species workshop with the assistance of the Nature Conservancy. This event was well attended by the public (approximately 20), but few YLWPG members attended. The two watershed awareness days, October 2004 and May 2005, both had poor public attendance (approximately 5 non-YLWPG attendants). In contrast, over 60 people—forest and watershed professionals, researchers, watershed planners, and the general public— attended the Indiana Forested Watershed Symposium in April 2006. The YLWPG hopes to make this an annual event.

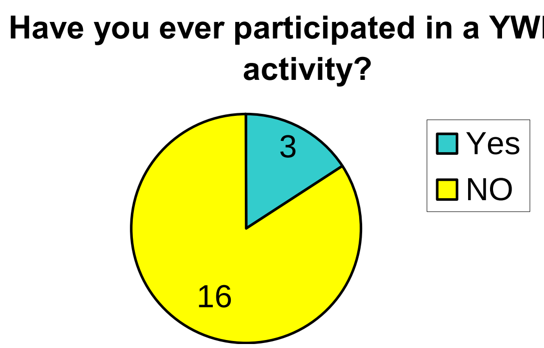


Figure 5.3. Yellowwood Lake Watershed resident participation

The 2005 Landowner Survey asked two questions to gauge participation and overall interest in the YLWPG. We found that only 3 out of 16 survey respondents had participated in an YLWPG activity (Figure 5.3). The surveys were anonymous, but we hypothesize that the three respondents are all current YLWPG members. The survey also asked what activities they would be willing to participate in (Figure 5.4). Invasive species review and becoming a YLWPG member were the most common responses.

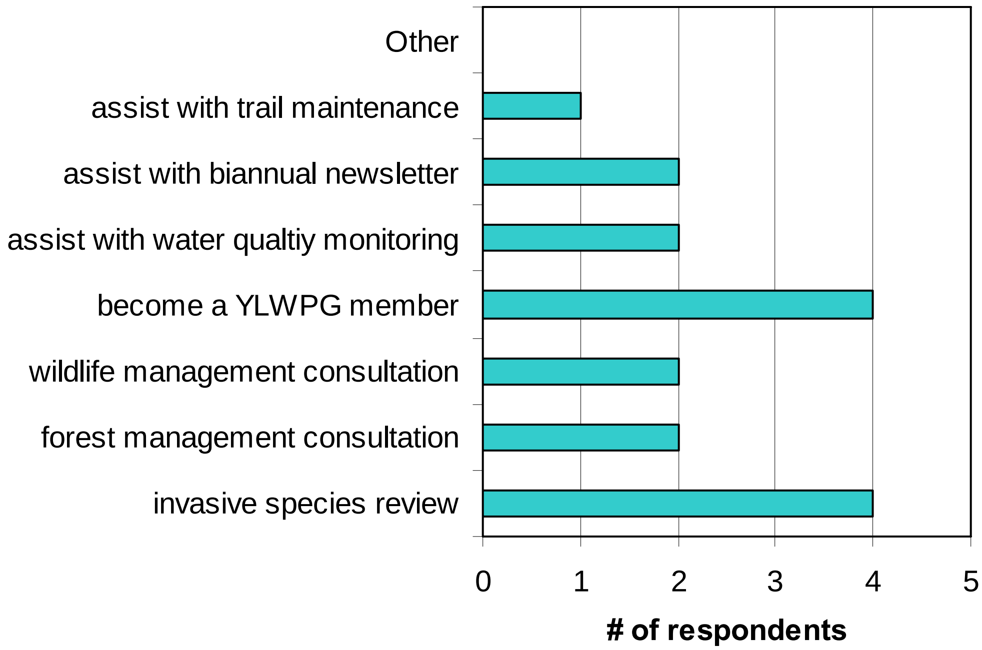


Figure 5.4. Yellowwood Lake Watershed resident interest in 8 activities

As listed in the problem statement, the YLWPG currently has no strategy for group sustainability. While this plan outlines several potential funding sources, applying for grant funding will be necessary to implement many of the identified action items listed in Section 7. Another important component to group momentum and sustainability is a paid employee charged with the welfare of the watershed. Prior to the 205(j) grant funding to hire the YLWPG's first official watershed coordinator, YSF had an Resource Management position whose duties included monitoring the lake and invasive species, public education, and working with the watershed group. Due to budget cuts, the position was eliminated, and the line was converted to other uses that do not include these responsibilities.

SEDIMENTATION

***Problem*: Yellowwood Lake is filling in with sediment, causing the lake to lose depth and the macrophyte beds to expand. Visual observations from HFF members suggest that this process has accelerated over the last decade. Sediments from the watershed can carry biological and chemical pollutants, increase water temperature, block sunlight, impair sight-dependent predation, and smother fish nesting sites. The soft, fertile sediments also provide a rich bed for aquatic plant establishment.**

The Yellowwood Lake watershed has a deeply dissected topography characterized by steep slopes and fragile soils, rendering the watershed extremely susceptible to erosion, both natural and man-made. The YLWPG has identified four major sources of erosion that are contributing to the sedimentation of Yellowwood Lake (Table 5.1). The effects of sedimentation on the Yellowwood Lake are documented by depth surveys, IDNR Fishery surveys, water quality sampling, and aerial photos, and visual observation of the expanding macrophyte beds on the north end of the lake.

Table 5.1. Yellowwood Lake Watershed: Sources of erosion

Source	Stressors
Natural Erosion	• Fragile soils • Steep topography • Climate • Wildlife
Yellowwood Road	• Gravel aggregate • Grading and maintenance • Under-sized culverts • Stream channelization • Increased surface runoff • Inadequate buffers • Invasive plants
Stream Erosion	• Drainage density • Increased surface runoff • Bank scour
"Man-Made"	• Timber harvesting activities • Trails • Construction/ development • Shoreline recreation

The sediment accumulation in Yellowwood Lake during the past 65 years is less that 1% of the 1955 lake basin volume. This rate must be considered low, as near by Lake Lemon lost an estimated 3.4 % of lake volume from 1953-1974 (Hartke and Hill, 1974). This can qualitatively be attributed to two factors: (1) dense vegetation throughout the watershed which provides protection against erosion, (2) relatively low energy, low discharge of Jackson Creek, which does not transport large quantities of sediment, particularly coarse sediment. However, despite the relatively low amount of total sediment deposition, the degree of accumulation in the north end of Yellowwood Lake—as shown in the HFF depth surveys, the aerial maps, and the commissioned depth survey—is impairing the aesthetic quality and useful life of the lake.

Since the early 1980s, non-point source pollution has been recognized as a significant source of surface water quality problems. Perhaps the most ubiquitous of these pollutants is sediment eroded from the landscape, either from natural or anthropogenic sources. Timber harvesting, construction, and other soil-disturbing activities accelerate natural erosion rates, increasing the supply of sediment to surface water (Nelson and Booth, 2002).

Transported by surface runoff, sediment can cause a variety of problems. Fine sediment causes water-quality problems, both in-channel and to receiving water bodies. Clay minerals in fine sediment can form complexes with nutrients, chemicals, and heavy metals (discussed in later problem statements), adding to lake eutrophication and toxicity to aquatic organisms that live in or feed on bottom sediments (Novotny and Olem, 1994). Fine sediment can also threaten habitat and aquatic organisms by covering up habitat that certain integral parts of the food web depend on. Sediment can smother nesting sites for fish and amphibians. More so, certain types of soil particles can bind to the gills of aquatic insects or fish impairing respiration and decreasing resistance to disease. Some fine particles do not settle along stream banks. These suspended sediments cause streams to appear brown or cloudy. The suspension can impair sight dependent predation and reduce the amount of sunlight reaching the stream bottoms, limiting photosynthesis and subsequent oxygen production. In contrast, coarse sediments do not raise chemical concerns but can cause channel aggradation, which reduces flow capacity that can lead to flooding, hinder navigation, and increase channel instability (Novotny and Olem, 1994). Figure 5.5 shows fine sediments in Jackson Creek.

As listed in Table 5.1, the YLWPG has identified four major sources of erosion in the Yellowwood Lake watershed: natural, roads, streambanks, and man-made erosion. The following section will elaborate on the identified sources, with the exception of natural erosion.

Figure 5.5. Jackson Creek: fine sediments

Roads

Roads can be a major source of soil erosion in forested watersheds. In fact, Van Lear et *al.* (1995) estimated that in a forested watershed in the southeastern United States, over 80% of all sources of sediment were associated with unpaved roads. Erosion from roads can be disproportionately high because they lack vegetative cover, are exposed to direct rainfall, and have a tendency to channel water on their surfaces. More importantly, sediment derived from roads can be detrimental to terrestrial and aquatic organisms (Clinton and Vose, 2003). The amount of sediment transport from road surfaces has been documented as highly variable within and among road surface types, maintenance, and drainage. In a study that examined sediment transport from different road types[19], Clinton and Vose (2003) found that unimproved gravel roads generated the highest amount of total suspended solids (TSS). While our analysis only considers Yellowwood Road, the multiple logging roads throughout the watershed also contribute sediment.

The current maintenance regime for Yellowwood Lake Road in the watershed has resulted in crushed culverts, lack of adequate surface drainage, and inadequate rip-rack or other preventative measures at crucial spots where Jackson Creek and Yellowwood Lake Road converge, as outlined in the YLWPG road visual assessment. The YLWPG also noted evidence of gravel and silt in Jackson Creek in the QHEI assessment.

[19] Surface grading one time/year but no gravel application

Figure 5.6. Yellowwood Lake Road: Ditch erosion, crushed culverts, and degrading road conditions

Despite the observed gravel accumulation in Jackson Creek, the Commonwealth Biomonitoring sediment core analysis (Section 4.11) indicated that large gravel aggregates have not been transported to Yellowwood Lake. However, the fine silts associated with crushed gravel (Figure 5.6) are likely contributing to the inorganic sediment load.

Streambank Erosion

Jackson Creek, the main tributary to Yellowwood Lake, is currently suffering from bank erosion. Signs of erosion, heavy silt, and embeddedness were documented as causes for low site scores on the QHEI assessment. Additional evidence of in-stream erosion in Jackson Creek has been documented by windshield and local landowner observations (Figure 5.7). Visual observations suggest that in-stream erosion is evident throughout the entire length of Jackson Creek: along the road and in the protected floodplain.

Stream erosion is a natural process and necessary to maintain good aquatic habitat in a stream. Too much erosion, however, can have the opposite effect; destabilizing stream banks, destroying in-stream habitat, and causing significant pollution problems down stream.

Figure 5.7. Jackson Creek: Streambank erosion

Man-Made Soil-Disturbing Activities

There are a variety of "man-made soil disturbing activities" in the Yellowwood Lake watershed that are sources of erosion. The sources have been identified primarily through visual observations. The YLWPG has identified five major man-made soil disturbing activities in the watershed: timber harvesting, trails, construction/ development, utility easements, and shoreline recreation.

1. Timber Harvesting Activities

Much of the forest you see today in the Yellowwood Lake watershed (nearly 80%) is a result of 65 years of management by the IDNR- Division of Forestry. Part of this management has been the harvesting of timber by professional foresters, as outlined in Section 3. Timber harvesting in the Yellowwood Lake watershed also occurs on private land: from the private landowner survey, the YLWPG determined that at least four private landowners conducted timber harvests on their property (Figure 5.8).

There is no doubt that healthy forests provide maximum protection against soil erosion, yet timber harvesting activities can alter current canopy cover and cause disturbances that expose the soil to forces of erosion: water and wind. Once exposed, the soil may move down the watershed and be deposited in the north end of Yellowwood Lake. While a well-managed forest in Indiana will experience very little soil erosion due to tree cutting itself, significant erosion can occur as a result of using heavy machinery associated with timber harvesting activities (Purdue Pub. FRN-184). Construction of skid trails, log yards, and logging roads can cause soil compaction, soil movement and erosion, and even wildlife disturbances by altering the amount of sediment input, sunlight, and large woody debris recruitment to stream ecosystems, degrading water quality and in-stream habitat. Logging roads can accelerate erosion rates. However, impacts from these activities can be greatly minimized through well-planned harvesting and the stringent use of forestry best management practices (BMPs), as takes place on the watershed forestland managed by the Division of Forestry. These practices include leaving proper buffer areas (riparian zones) along streams, which greatly reduces impacts to aquatic life by maintaining stream shading and filtering sediment.

The implementation of forestry BMPs can greatly reduce erosion; they are unlikely to completely eliminate sedimentation from timber harvesting activities. The USEPA has found that the volume of fine sediment in streams is proportional to the amount of logging activities in the area (USEPA, 2005). These impacts, along with lesser known impacts of biomass removal from the forest, cannot be quantified with our current knowledge base. Therefore, the YLWPG recommends that research be targeted to understand the cumulative impacts of silviculture within Indiana's forested watersheds.

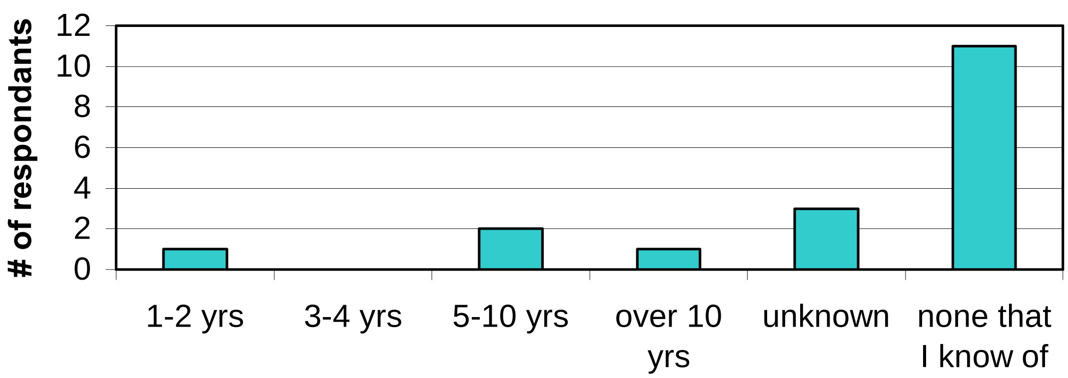


Figure 5.8. Yellowwood Lake Watershed: watershed residence harvest history

2. Trails

Trail deterioration, in the form of trail erosion, is a common problem in wildernesses and back country areas. It can significantly affect ecological, social, and managerial environments (Cole, 1983). Over time, trail segments deteriorate by natural processes and wear from recreational traffic. The magnitude of deterioration is determined by the characteristics of the trail, the environment, and the recreational use that the trail receives (Cole, 1987). Compacted soils and a corresponding lack of vegetation along trails can contribute to increased volume and intensity of surface water runoff in storm events, furthering the problem of soil erosion in the watershed.

The Yellowwood Lake watershed has an extensive trail network, although we only have maps of public trails. As outlined in Section 2, there are 14.6 miles of horse trails and 9.8 miles of hiking trails in the watershed. Research suggests that horse use causes more pronounced increases in trail width, trail depth, and litter loss than hiker use (Whittaker, 1978 and Wilson and Seney, 1994). Regardless of user, improperly designed and maintained trails are a likely source of erosion in the Yellowwood Lake watershed.

3. Shoreline Erosion

Uncontrolled, heavy foot traffic has resulted in severe erosion along the heavily used eastern shore of Yellowwood Lake (Fig 5.9). A 1993 study conducted by an Indiana University graduate student, estimated that 6.9 lbs soil yd^{-2} $year^{-1}$ are lost from the shoreline due to heavy recreational use from campers, anglers, and casual visitors. Pelloso (1993) cites a lack of pedestrian foot paths, minimal groundcover, non-stabilized shorelines, and non-anchored picnic tables as sources of increased erosion. The eroded shorelines are impairing the aesthetic beauty of Yellowwood Lake and presenting safety concerns for those who walk along the lakeshore. The frequent shoreline disturbances, in addition to the soil losses, are further contributing to the establishment of invasive plant species such as Eurasian watermilfoil.

Figure 5.9. Yellowwood Lake: shoreline erosion

4. Construction/ Development

There has been little development in the watershed in recent years. In a survey circulated to the watershed residents, only three respondents said that their homes were less than 15 years old, and six reported that there had been new construction on their property in the last ten years (Figure 5.10). Despite the lack of current development, the YLWPG is concerned about the impending risk of land parcelization and any new construction that may result.

According to a U.S. EPA fact sheet on Phase II storm water, “When it rains or snows, the water that runs off of city streets, parking lots, and construction sites can wash sediment, oil, grease, toxics, pathogens, and other pollutants into nearby storm drains. Once this pollution has entered the sewer system, it is discharged-(usually) untreated-into local streams and waterways. Known as storm water runoff, this pollution is a leading threat to public health and the environment today.” The Yellowwood Lake watershed does not have a sewer system; sediment and related pollutants are washed untreated into the streams and flushed into Yellowwood Lake.

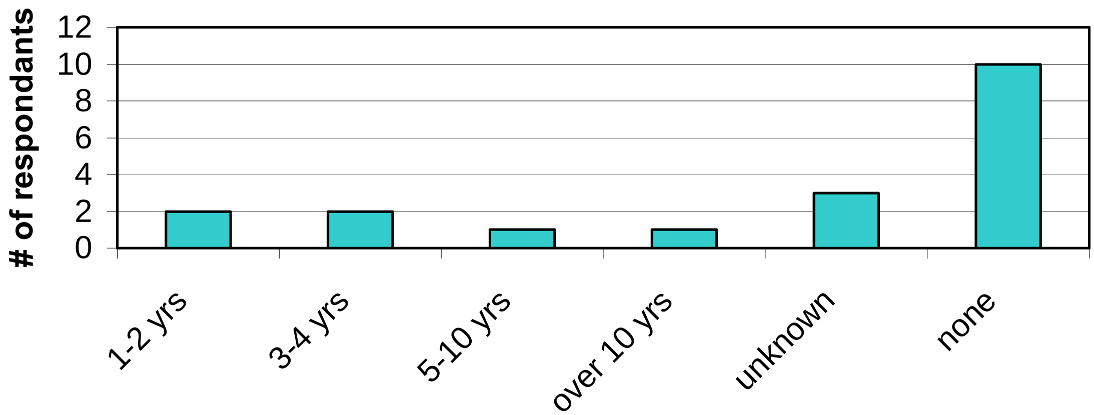


Figure 5.10. Yellowwood Lake Watershed: watershed resident construction

NUISANCE AND INVASIVE SPECIES

Problem: ***Nuisance and invasive species, detected throughout the Yellowwood Lake watershed, are detrimental to native biodiversity and provide few valuable environmental functions such as nutrient uptake, soil stabilization, habitat, or forage.***

Invasive species can quickly and seriously degrade the quality of an ecosystem by altering natural processes and reducing biodiversity. Invasive species impact nearly half of the species listed on the U.S. Federal Endangered Species Act and cost the U.S. over $100 billion each year (Pimentel et al., 2005). There are several known invasive plant species in the Yellowwood Lake watershed (Table 5.2). The invasive species listed in this study were documented through visual observations and IDNR DoF Invasive Species inventories.

The terrestrial invasive species listed in Table 5.2 vary from shrubs to grasses, but all share some similar properties. All of these plants were introduced into the United States from other countries. Since they did not originate in this country, many of them have no native predators, pests, or pathogens to help keep their populations in balance with native species. This competitive advantage allows many non-native invasive species to out-compete native species and negatively impact biodiversity and local species composition. Some of these species were brought into the Yellowwood Lake watershed by early pioneers in the 1800s, while other were introduced in the mid to late 1900s as wildlife plants, nitrogen fixers, pretty ornamentals, or soil stabilization measures. These plants typically fulfilled their intended purpose, but they had the unintended consequences of out-competing native species, moving off site, and negatively impacting biodiversity. Over time some of these plants will become naturalized, some may still be able to be eradicated, but some will cause irreversible damage to our native ecosystems.

When managing natural areas, precautions need to be taken to ensure that new non-native invasive species are not introduced in to the area. Established populations should be controlled and efforts should be made to limit the spread of established non-native invasive species. Within the Yellowwood Lake Watershed, the invasive species listed in Table 5.2 are all established and many have been for over 50 years. The goals in the watershed should be to eradicate new infestation as soon as possible, prioritize invasive species to eradicate, prevent the spread of established invasive species when possible, and actively manage for native biodiversity.

The invasive species listed in Table 5.2 are spread by humans, wildlife, water, trails, timber harvesting and other soil-disturbing activities. Soil-disturbing activities such as timber harvesting can expose mineral soil and create conditions ideal for invasive species seed germination. Heavy equipment can move invasive species seeds stored in the soil or move vegetative portions of the invasive species that may form new plants. Timber harvesting can also alter the canopy of the forest, allowing more sunlight in to the forest floor. This increase in available sunlight can be beneficial for many native plants, but can also be exploited by invasive species. If soil-disturbing activities like timber harvesting, trail construction, or road maintenance are occurring in the watershed, special care should be taken to mitigate the potential spread of invasive plants into disturbed areas. Mitigation of invasive species should follow an integrated pest management approach that uses biological, cultural, physical, and chemical tactics in a manner that strives to minimize economic, health, and environmental risks to control invasive species problems.

Native nuisance species can cause equally as much damage when their populations grow out of control. In Yellowwood Lake, American lotus and water willow populations have become so dense that they are impairing shoreline fishing. Canada Geese can contribute *E. coli* and phosphorous to Yellowwood Lake (Figure 5.11), and native wildlife species such as white-tailed deer and wild turkey can cause environmental damage by excessive foraging, while brown-headed cowbirds can parasitize other bird nests.

Both native (American lotus and water willow) and exotic (purple loosestrife and Eurasian watermilfoil) nuisance aquatic plant populations are causing problems in Yellowwood Lake. The thick aquatic jungle provides forage and shelter for fish, often impairing piciverous predation. Further, as the organic material decays, it builds up on the lake bottom, increasing the size of the littoral zone, thus expanding the area available for aquatic plant growth. Illustrated in the aquatic plant section, IDNR Fishery surveys detected rooted plants at up to 15 ft depths, which translates to 68.8% of the lake's area. Thirty-nine of 60 rake pulls from the 2004 IDNR fishery survey had scores of five, indicating dense macrophyte populations.

Figure 5.11. Yellowwood Lake: Canada Geese

Excessive macrophyte populations have created a variety of problems in Yellowwood Lake. As a recreational destination, it is important that Yellowwood Lake remain aesthetically pleasing and recreationally satisfying to the public. However, as documented earlier in this section, a large number of YLWPG members and Yellowwood Lake Watershed residents have expressed concerns about aquatic plant populations.

Many of the perceived lake impairments (Figure 5.12) can be linked to the aquatic plant populations. The two exotic species are particularly problematic to aquatic systems. Purple loosestrife out-competes native plants, provides little food and shelter for wildlife, and doe not provide water quality benefits such as nutrient retention like native wetland plants do (Thompson et al., 1987). Eurasian watermilfoil can grow quickly and form dense infestations which can shade out and replace native plants, encroach up on open-water habitat, and their winter decay can reduce oxygen levels in the water.

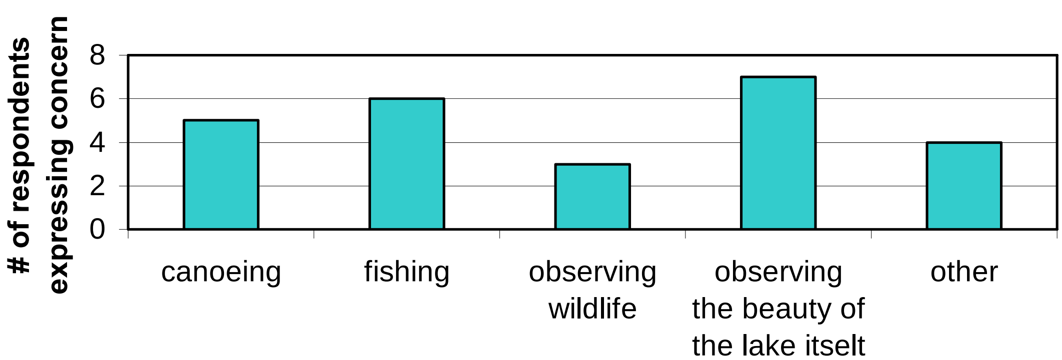


Figure 5.12. Yellowwood Lake: Perceived impaired uses

Table 5.2. Yellowwood Lake Watershed: Common Nuisance and Invasive Plant Species

Name	Picture	Description	Habitat	Problem	Current Spread in YSF	Notes
Periwinkle (*Nelumbo lutea)*		Semi evergreen groundcover, dark green waxy leaves, flowers – five petals, light blue, flowers in May, June and some in late fall.	Wood, partly shady	Forms a dense carpet that excludes native flora	Extensive areas along Yellowwood Lake Road are covered, old homesites and disturbed area	Also called myrtle. Native of Europe and northern Africa
Multiflora Rose *(Rosa multiflora)*		Thorny shrub, compound leaves with fringed stipules– 5 to 11 leaflets, flowers-white/pink in showy clusters in May and June	Varied - woods, old fields, disturbed areas	Form dense thickets that exclude native flora	Wide spread, in particular homesites and old fields	Native of Asia. Several plants infected with rose rosette (fatal disease of multifloral rose carried by a eriophyid mite) have been found on the property.
Kudzu (*Pueraria Montana*)		Annual vine, leaves alternate, legume, flowers in July – October, roots are tuberous and can have soil depths up to 9 ft	Wide variety of environmental conditions, forest edge, disturbed areas	Very aggressive, vines can grow up to 50 ft/ year	Small patches along Yellowwood Lake Road	This native of Asia was introduced into the United States for livestock forage and erosion control.
Japanese Stilt Grass *(Microstegium vimineum)*		Annual grass, 24 – 39 inches in height, upper leaf surface has a silvery stripe of reflective hairs along midline, blooms in August – September, seeds mature in September-October, reproduction is exclusively from seed, seed may remain viable for five or more years in soil	Moist woods, flood plains, stream banks	Once established it forms a monoculture. It displaces native grasses. Because Microstegium is shade tolerant, there is the potential for it to invade areas under full forest canopy. Currently seems to be spreading along roads and hiking trails.	Along Yellowwood Lake Road, utility easements	Native of Asia. In 1919, it was introduced in the US in Tennessee, probably in contaminated packing material.
Purple Loosestrife (*Lythrum salicaria*)		Perennial growing to 4 – 10 ft in height, opposite lance-shaped leaves, purple/pink flowers with 5-7 petals in spikes, blooms late July - August	Wetlands	Out-competes native wetland plants, reduces wildlife shelter and food supplies	Yellowwood Lake	Native of Eurasia.

** This table does not include all nuisance and invasive plants in the Yellowwood Lake Watershed.

Name	Picture	Description	Habitat	Problem	Current Spread in YSF	Notes
Japanese Honeysuckle *(Lonicera japonica)*		Perennial climbing vine, leaves are semi-evergreen, near tip of vine leaves are opposite and not united, flowers in May - June	Disturbed areas, old fields	Very invasive, seeds spread by birds, altars understory and herbaceous layer structure	Widespread - old fields, homesites, dams, open woods	Introduced into the US from Japan for use as an ornamental, wildlife cover, and erosion control.
Tall Fescue *(Fescue pratensis)*		Tall grass (2-5 ft), grows in thick clumps, seed matures in July and August	Disturbed habitats, old fields	Forms dense vegetative mat reducing food and nesting cover, older fescue planting may be infected with endophytic fungus that may be detrimental to wildlife health if infected vegetation is consumed	Old field and homesites	Initially planted for erosion control, forage for livestock
Autumn Olive *(Elaeagnus umbellate)*		Deciduous woody shrub, alternate, leaves ovate – dark green above, silvery below, tube shaped flowers are yellowish white, fruit matures in September - October	Disturbed areas, openings, edges, does not like wet habitats and is shade intolerant	Rapidly spreading, seeds dispersed by wildlife	widespread particularly in old field and homesite areas	Native of Asia introduced as erosion control and wildlife plantings.
Garlic Mustard *(Alliaria periolata)*		Biannual herb with leaves give off garlic odor when crushed, first year plant is a rosette of leaves that are green throughout the winter, second year plant 2 to 3.5 feet tall with heart shaped leaves, flowers small, white, four petals	Roadsides, open woods	Displaces spring wildflowers, can for large monoculture stands, impair development of micorrhizal fungi	Yellowwood Road, other populations are sure to exist but have not been identified at this time	Native of Europe, seeds maybe viable up to 7 years in the soil
Eurasian watermilfoil *(Myriophyllum spicatum L.)*		Submerged aquatic plant with whorled leaves up to one inch long that appear clipped on end. Can grow up to 10 feet in height and exhibit a reddish shoot near the surface.	Lakes and ponds	Forms dense mats of tangled plants in lakes and ponds that can interfere with recreation or out-compete other native water plants for sunlight and nutrients	Yellowwood Lake, up to 15 feet depth	Able to reproduce through stem fragmentation and underground runners, easily spread
American Lotus *(Nelumbo lutea)*		Perennial herb with rhizomatous growth, has large flowers reaching 6- 8 inches wide and 12-20 inches above water. Large circular leaves 1-2 feet across and float on the surface	Muddy, shallow waters such as lake margins	Aggressive growth form	Yellowwood Lake, north end near campgrounds	Seed pods often sold as ornamental items, it is endangered in New Jersey and Pennsylvania, but banned in Connecticut because of its invasive nature

CHEMICAL AND BIOLOGICAL CONTAMINATION

Problem: Biological and chemical contaminants pose an undefined threat to the Yellowwood Lake watershed. This is primarily due overland runoff of pathogens, chemicals, and nutrients. Failed or failing septic systems, horses, and wildlife are known to contribute nutrients and pathogens while automobiles, fertilizers, improper chemical use/ storage, timber harvesting activities, and above ground fuel storage tanks have the potential to leak hazardous materials into the watershed. Beyond runoff, Yellowwood Lake is currently suffering from mercury contamination.

Chemical Contamination

According to the EPA, a hazardous waste is a waste with properties that make it dangerous or potentially harmful to human health or the environment. Hazardous wastes include solvents, fuels, sludges, and pesticides, to name a few. Sources of hazardous wastes in the Yellowwood Lake watershed may be stationary (e.g. garages and storage facilities) or mobile (e.g. automobiles). Barring a natural disaster or major accident, the risk of exposure from these sources can be minimized by proper management.

The YLWPG has identified multiple potential sources (Figurre 5.13) of chemical contamination in the watershed that should be managed for. Sources include above-ground fuel storage tanks, timber harvesting machinery, automobiles, household chemical storage, and fertilizers. The YLWPG developed Table 5.3 to help prioritize the potential sources of chemical contamination based upon risk. Prioritizing potential sources will allow the YLWPG to focus on the greatest potential load reductions at the commencement of implementation.

Figure 5.13. Yellowwood Lake Watershed: Sources of Chemical Contamination

The number of sources in the watershed is primarily based on assumptions listed in Table 5.3. To estimate the use of chemical fertilizers in the watershed, the YLWPG asked landowners if they fertilized their land in the YLWPG Landowner Survey. Seventy-four percent (74%) of respondents said they don't fertilize (Figure 5.14). Only one respondent said they fertilized over twice a year. Fertilizers present a major risk to aquatic systems because they contain high amounts of nitrogen and phosphorous, which are naturally limited in aquatic systems. Excessive amounts of these nutrients can lead to eutrophication and increased plant growth. Fortunately, both historic lake data and recently sampled stream data do not reveal any major problems with nutrient loading.

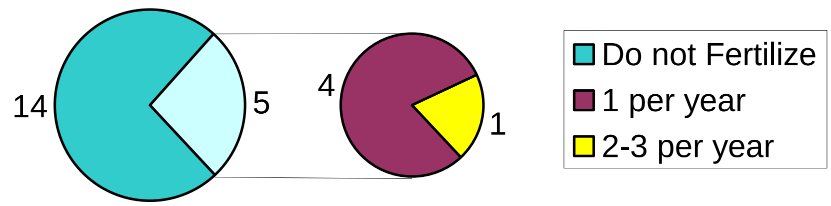


Figure 5.14. Yellowwood Lake Watershed: resident fertilizer use

Table 5.3. Yellowwood Lake Watershed: Potential sources of chemical contamination

Source	Location	Est. # in Watershed	Details	Probability of contamination	Environmental damage	*Total Risk*
Fuel storage tanks	65 m from lake Private land	3 tanks	500 gal gasoline, 500 gal. Diesel Private fuel tanks with over 55 gal. storage	**Low**	**High** - direct fuel runoff into Yellowwood Lake	***Medium***
Heavy machinery	Areas being harvested or undergoing construction, graded roads	Temporary basis only	Accidental spills or vandalism	**Low**	**Low** - likely to be contained if spill kit is properly used	***Low***
Automobile traffic	Roads and parking lots, special concern at stream crossings	2 vehicles per home, unknown through and recreational traffic	Leaking cars, ruptured tanks from stream crossings	**Low**	**Low** - small amounts of chemicals - long term build up could be a problem	***Low***
Household chemical storage	Private homes, IDNR storage	Storage to unknown extent in all homes	Improper use and storage of chemicals	**Low**	**Low** - small amounts - long term build-up could be a problem	***Low***
Fertilizers, herbicides, pesticides, & fungicides	Private homes, IDNR property, utility easements	Storage to unknown extent in few homes	Chemical Runoff	**High**	**Medium** -N and P in fertilizers can lead to eutrophication	***Medium***
Campgrounds	Along the east shore of Yellowwood Lake	campgrounds	Primitive camping cars, trucks, and R.V. parking, camping refuse	**Low**	**Low** **-** fuels leaking from automobiles - improper disposal of refuse	***Low***
Road Treatments	Yellowwood Lake Rd, Tulip Tree Rd	Periodic maintenance	Chemicals used to eliminate dust from gravel aggregate;, melt snow and ice on surface	**Medium**	**Medium** **-** small amounts of chemical build-up/ runoff issues	***Medium***

Mercury is a major problem for those who consume fish caught in Yellowwood Lake. Detected mercury concentrations led to a Category 5b impairment with a Category 2 Fish Consumption Advisory (FCA) for mercury in largemouth bass in Yellowwood Lake. Mercury is a heavy metal that bioaccumulates in the fatty tissue of fish. Mercury can cause birth defects, and irreversible brain, liver, and kidney damage. Sources include deposition from coal-fired power plants, incineration of garbage and hospital wastes, industrial uses, and improper disposal of household mercury. The mercury contamination in Yellowwood Lake is most likely airborne.

Biological Contamination

Pathogens are a common contaminant in Indiana's surface waters. In fact, nearly 3,000 miles of streams in Indiana are impaired by pathogens (indicator *E. coli*) (IDEM, 2002). With the potential to cause serious health problems, pathogenic impairments compromise the recreational value of water bodies. Pathogens are often transmitted to people when they consume untreated or inadequately treated water. A commonly used indicator of pathogens is *E. coli*, a bacterium that lives in the intestines of warm blooded animals, whose presence indicates fecal contamination. YLWPG volunteer monitors detected *E. coli* in two major tributaries, Jackson Creek and John Floyd Hollow, which were consistently above the Indiana Water Quality limit for full body contact recreational use (Figure 5.15).

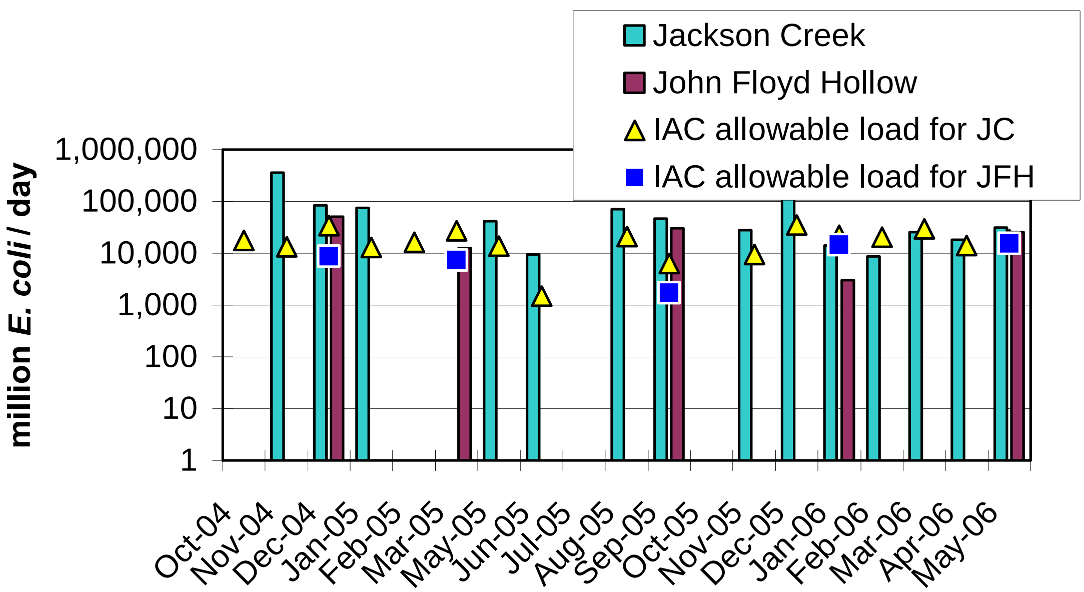


Figure 5.15. Yellowwood Lake Watershed: volunteer E. coli monitoring loads

Located midway between Bloomington and Nashville, the Yellowwood Lake watershed is beyond the reach of a municipal sewage system. Therefore, residents must rely solely on personal waste water treatment systems (i.e. septic systems). In a survey sent to landowners, 16 people confirmed that they had septic systems and one respondent said they no current wastewater disposal system. The survey also asked respondents about the history of their septic tanks (Figures 5.16 and 5.17).

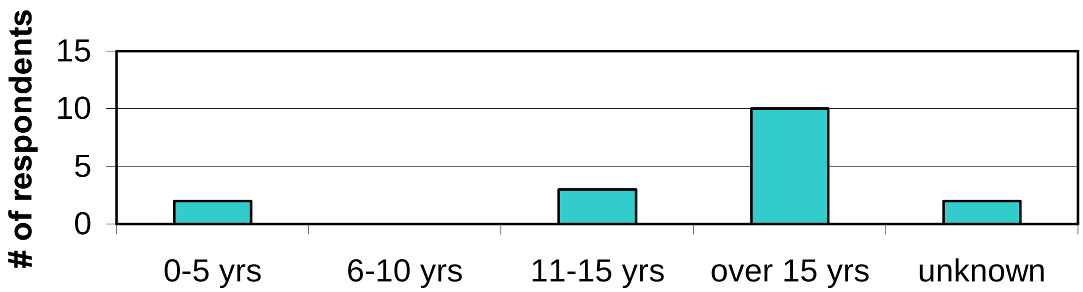


Figure 5.16. Yellowwood Lake Watershed: age of personal wastewater treatment systems

The septic system failure rate in Brown County is approximately 70% (personal comment, Brown County Health Department). This may be because the soils are poorly suited for traditional septic-tank-and-finger systems. The Brown County Soil Survey (Nobel et *al.,* 1984) indicates that the soils in 99.9% of the watershed have severe management concerns pertaining to septic absorption fields. The primary concerns[20] are slope and depth to rock (Figure 5.18). From IDEM septic loading worksheets, we can estimate that failing septic tanks in the watershed generate 53.6 billion *E. coli* / day.

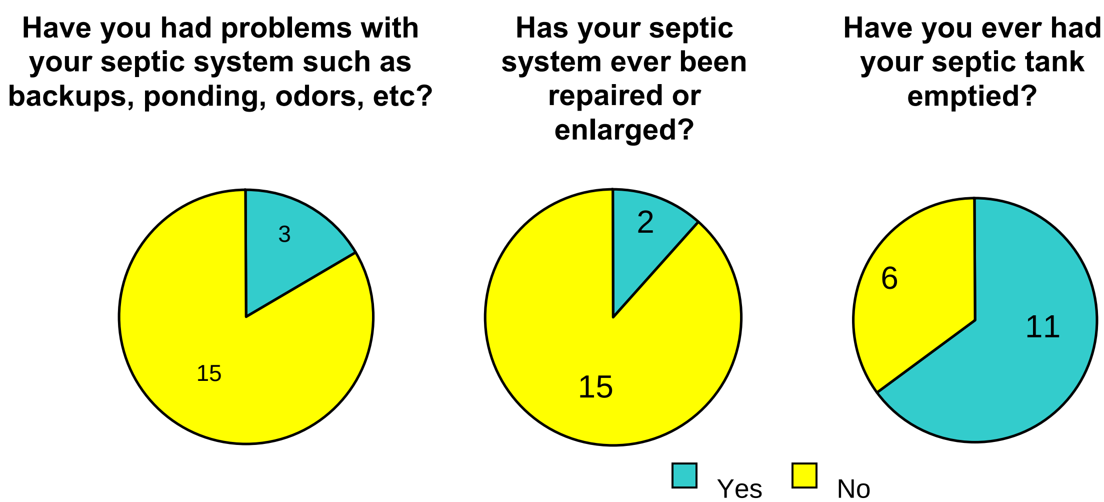


Figure 5.17. Yellowwood Lake Watershed resident personal wastewater treatment maintenance

Little is known about ambient concentrations of *E. coli* in Indiana's water, although septic systems, wildlife, geese, dogs, and livestock are each major contributors. Nearly all of the residents, in addition to approximately 20 horses and a pair of goats, in the Yellowwood Lake watershed live within the Jackson Creek drainage. There are no septic systems or boarded horses within the John Floyd Hollow drainage, yet the volunteer-detected *E. coli* concentrations in both drainages were consistently in violation of Indiana Water Quality standards. Therefore, YLWPG hypothesized that septic systems may not be the primary source of *E. coli* in the watershed. To test this hypothesis, the YLWPG contracted Commonwealth Biomonitoring to conduct additional *E. coli* monitoring at both Jackson Creek and John Floyd Hollow.

[20] Many soil types have more than one concern

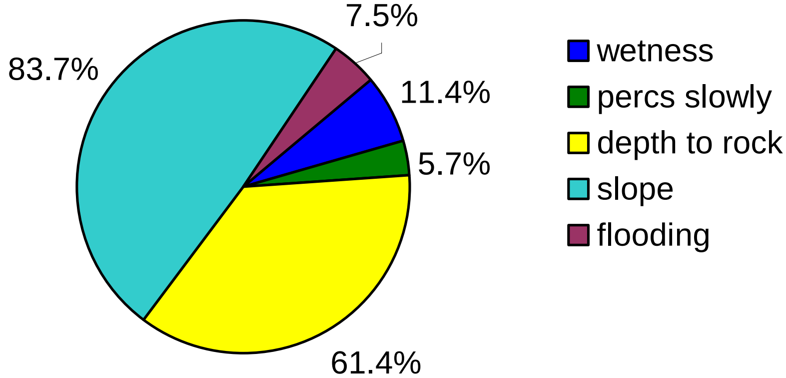


Figure 5.18. Yellowwood Lake Watershed: septic field absorption concerns for soils

The study revealed that *E. coli* loads are higher in Jackson Creek than John Floyd Hollow (Table 5.4). The geometric mean load in Jackson Creek was 1001 cfu/day while the geometric mean load for John Floyd Hollow was 23 cfu/day. However, the highest detected concentration (119 cfu/100ml) was in John Floyd Hollow. Results from this study show that the Jackson Creek drainage contributes significantly more *E. coli* to the watershed than John Floyd Hollow, indicating that septic systems and boarded animals are major sources of fecal contamination.

The YWLPG identified two possible reasons that *E. coli* concentrations in John Floyd Hollow consistently violated Indiana Water Quality Standards. The first reason is the sample location. Despite the assumption that *E. coli* attributed to wildlife is consistent across the sub-watersheds, the nearly stagnant water in John Floyd may have accumulated more *E. coli* from direct wildlife inputs. There are multiple deer paths that criss-cross the John Floyd drainage near our sample collection point.

Table 5.4. Yellowwood Lake Watershed: E. coli sampling

Date	Stream	Flow (cfs)	*E.coli* (cfu/100 ml)	Load (million cfu /day)
10-Nov-05	Jackson Creek	0	3	0.00
	John Floyd Hollow	0	0	0.00
17-Nov-05	Jackson Creek	2	98	3,621.76
	Floyd Hollow	0.3	119	659.68
23-Nov-05	Jackson Creek	1	43	794.57
	Floyd Hollow	0.15	21	58.21
29-Nov-05	Jackson Creek	3.3	48	2,926.97
	Floyd Hollow	1.2	61	1,352.62
	Jackson Creek	3.3	26	1,585.44
6-Dec-05	Jackson Creek	1.4	6	155.22
	Floyd Hollow	0.2	2	7.39

Second, over half of the Y horse trail falls within the John Floyd drainage, (Figure 5.19). Horse manure has been reported to have *E. coli* concentrations over 61,000 cfu/gram in fresh manure and over 120,000 cfu/gram in dry manure (Weaver *et al.*, 2005). There are an estimated average of 10 to 15 horses each Saturday and Sunday from April to October and 3 to 5 each Saturday and Sunday from December to February on trails throughout the watershed. Horses produce an average of 50 pounds of manure per day (Davis and Swinker, 2004). Therefore, from April to October we can estimate that manure from trail riding could generate over 1.4 billion *E. coli*/day on weekends in the watershed (10 horses x 10 % of daily manure production (=5 lbs) x 61,000 cfu/gram fresh manure).

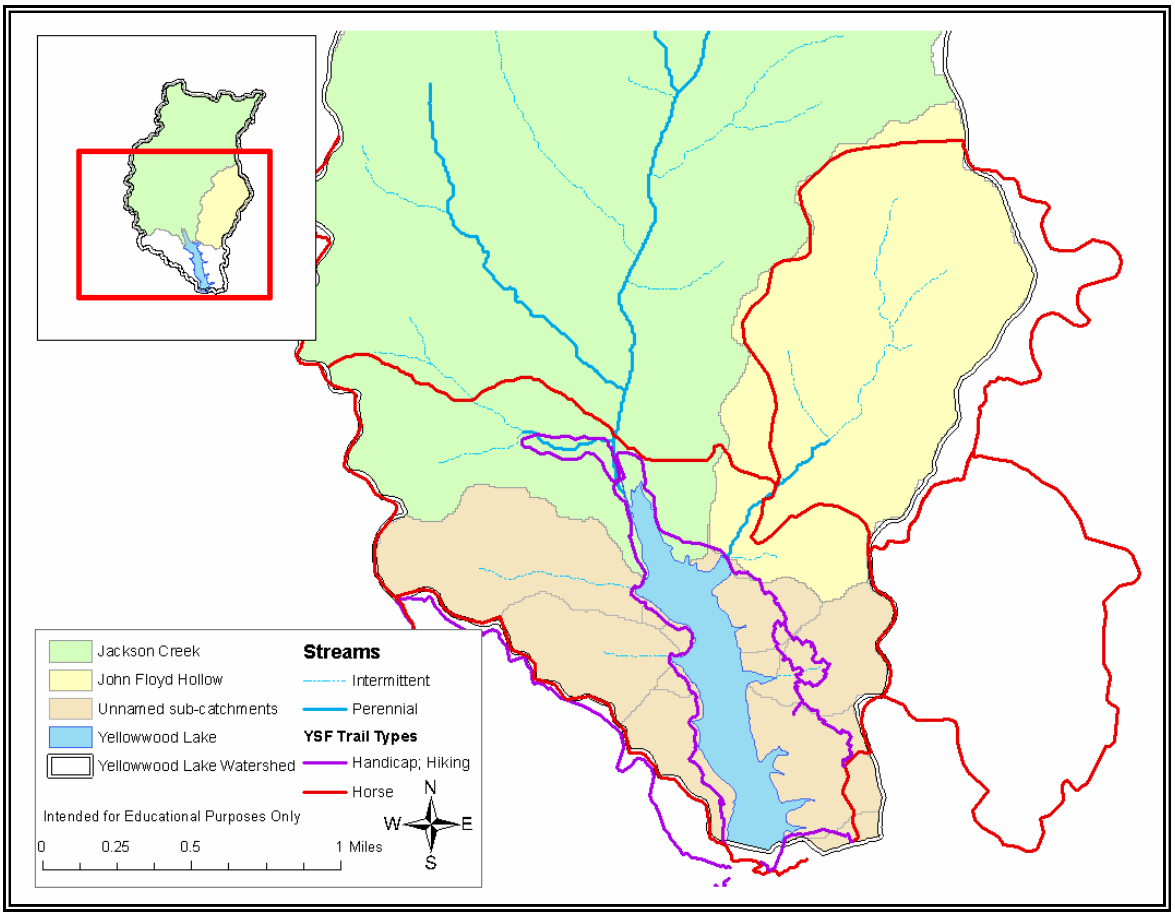


Figure 5.19. Yellowwood Lake Watershed: Horse Trails

Figure 5.20 shows the estimated relative contribution of E. coli from four identified sources: septic systems, boarded horses, trail riding, and "ambient" or wildlife. Septic systems, boarded horses, and wildlife estimates were calculated using the IDEM Bacteria Indicator tool. Septic systems, at 93% of the total estimated E. coli load, appear to be largest source of E. coli in the watershed. Trails

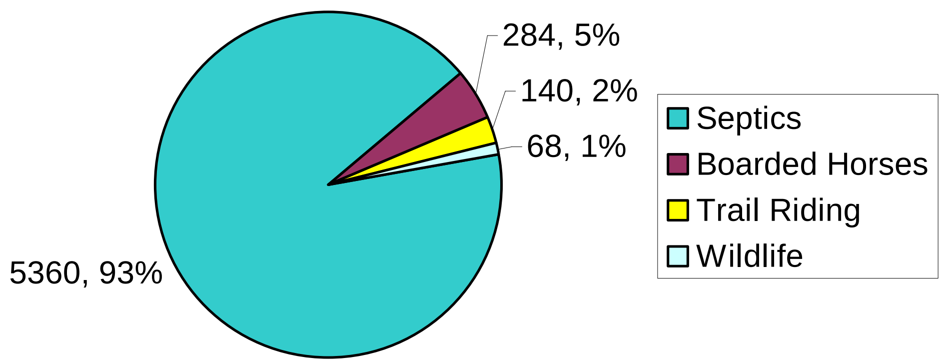


Figure 5.20. Yellowwood Lake Watershed: Relative E. coli loads from four identified sources

Brown County has a history of high E. coli concentration in its streams. Neighboring Bean Blossom Creek has recorded E. coli concentrations well above 1,500 cfu/100ml on a regular basis according to the Brown County Department of Health. Despite this trend, the YLWPG has expressed a lack of confidence in the volunteer data. They believe that the volunteer reported E. coli concentrations are too high[21]. They are further concerned about the discrepancy between volunteer and contracted samples in November 2006. Stemming from these concerns, the YLWPG does not feel that the volunteer E. coli data collected adequately represents baseline concentrations in the watershed. Therefore, further investigations are necessary to fully understand the extent of E. coli contamination in the Yellowwood Lake watershed and the lake itself.

[21] The YLWPG is not the only watershed group to have high *E. coli* concentrations based upon volunteer results, however. The Clifty Creek Watershed Project volunteer monitors, detected *E. coli* concentrations from zero (0) to 9,150 CFU/ 100 ml (Clifty Creek Watershed Plan, 2005).

6. CRITICAL AREAS

The locations of prioritized critical areas in the watershed are both discrete and watershed-wide. Due to the relatively small size of the Yellowwood Lake watershed (4,408 acres), we were able to identify specific locations of water quality threats or impairments negatively impacting the watershed. The following section outlines the critical areas for each area of concern.

6.1. LOSS OF DEPTH AND SURFACE AREA IN YELLOWWOOD LAKE

The loss of depth and surface area in Yellowwood Lake can primarily be attributed to the deposition of clays and silts from the watershed. Documented by aerial photographs, IDNR Fishery Surveys, and depth studies, the north end of Yellowwood Lake appears to be accumulating most of the sediment. Therefore, this area has been designated as a critical area for prolonging the useful life and improving the aesthetic beauty of Yellowwood Lake (Figure 6.1). The following sub-sections outline the estimated sediment loads and critical areas to control the identified sources of erosion in the watershed.

Figure 6.1. Yellowwood Lake: Critical area for sediment

AMBIENT EROSION

Soil losses from the Yellowwood Lake watershed can be attributed to a variety of sources: hillslope erosion, stream bank erosion, timber-harvesting activities, erosion from roads and trails, shoreline erosion, and past land use practices such as wildlife grazing outlined in Section 3.0. Relatively little erosion occurs on forestland. The 1997 National Resource Inventory (NRI) lists no estimated soil loss from forest land. However, Hood et al. (2002) recorded 0.14 tons/ acre-year lost from a forestland control plot. Kochenderfer and Helvey (1989) estimated an annual soil loss of 0.02 tons/ acre-year from a Fernow Experimental Watershed in West Virginia. These estimates translate to an estimated 85 – 599 tons of soil lost per year in the watershed. While ambient erosion from the watershed can contribute a substantial portion of the annual sediment load, the following sections outline the high priority sources of sediment in the watershed.

STREAM-BANK EROSION

Stream-bank erosion is a natural process that occurs in streams. Depending on the soil type and land use, stream bank erosion can account for over 40% of total soil loss in some watersheds (Smith, 1992). Normally, one to five storms generate from 50 – 90% of annual sediment losses (Beasley, 1984). Most stream erosion actually occurs during storm events. In the Yellowwood Lake watershed, the highest recorded sediment load from a storm event was 194 tons TSS/day. Corresponding phosphorous concentrations were below detection limits. From the QHEI survey, the YLWPG noted that stream habitat upstream of the first road crossing was only "partially supporting" due to signs of erosion, heavy silt, embeddedness, and decreased riparian zone width. A windshield survey also confirmed significant streambank erosion and a lack of riparian buffers where Yellowwood Lake Road is in close proximity to Jackson Creek. Therefore, the critical area for streambank erosion is a one-mile stretch of Jackson Creek where is it within 200 feet of Yellowwood Lake Road (Figure 6.2).

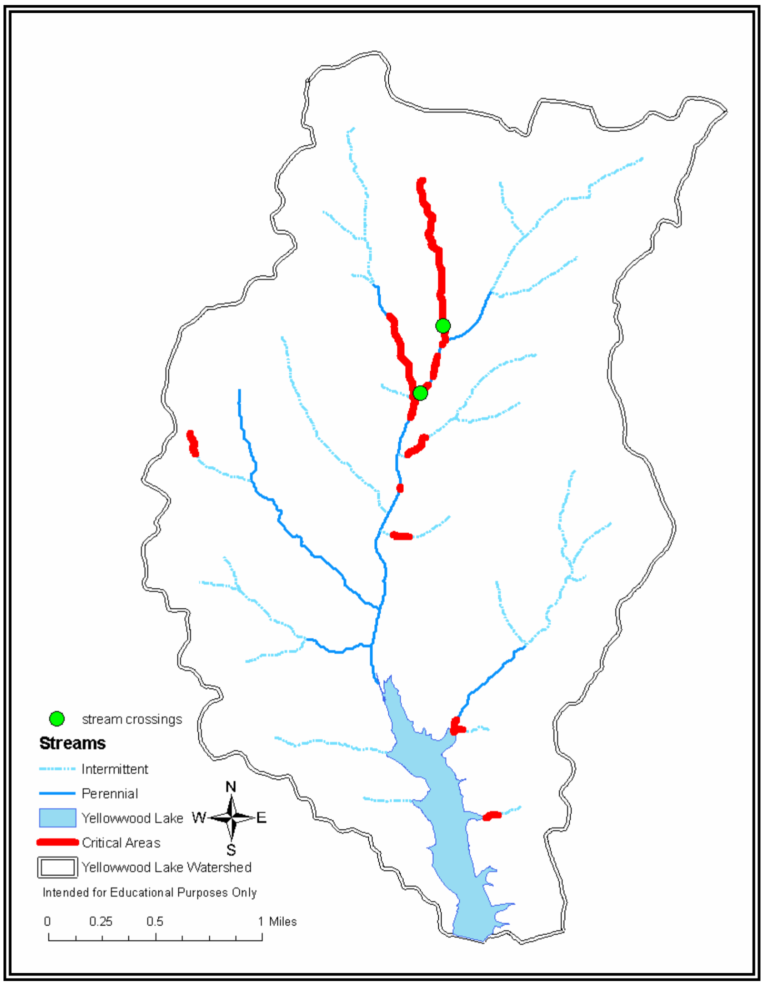


Figure 6.2. Critical Areas: Stream Banks

ROADS

Unpaved roads are a major source of erosion in the Yellowwood Lake watershed, as documented by windshield surveys, QHEI, and WEPP (Watershed Erosion Prediction Project) modeling. Erosion can come from the road surface itself, degradation of ditches, and concentrated runoff from culverts. In recent storm events, portions of Yellowwood Lake Road itself were lost to erosion. In April, 2006 YLWPG members surveyed Yellowwood Lake Road again in order to run a WEPP road simulation created by the U.S. Forest Service. The input data can be found in Appendix P. Based upon our survey data, we can estimate that approximately 111,000 pounds of sediment are leaving Yellowwood Lake Road on an annual basis, while 63,000 pounds of buffer are annually eroded away. The YLWPG has identified particularly impaired segments of Yellowwood Lake Road, all culverts, the two stream crossings, and the stretch of Yellowwood Lake Road within 200 feet of Jackson Creek as critical areas (Figure 6.3).

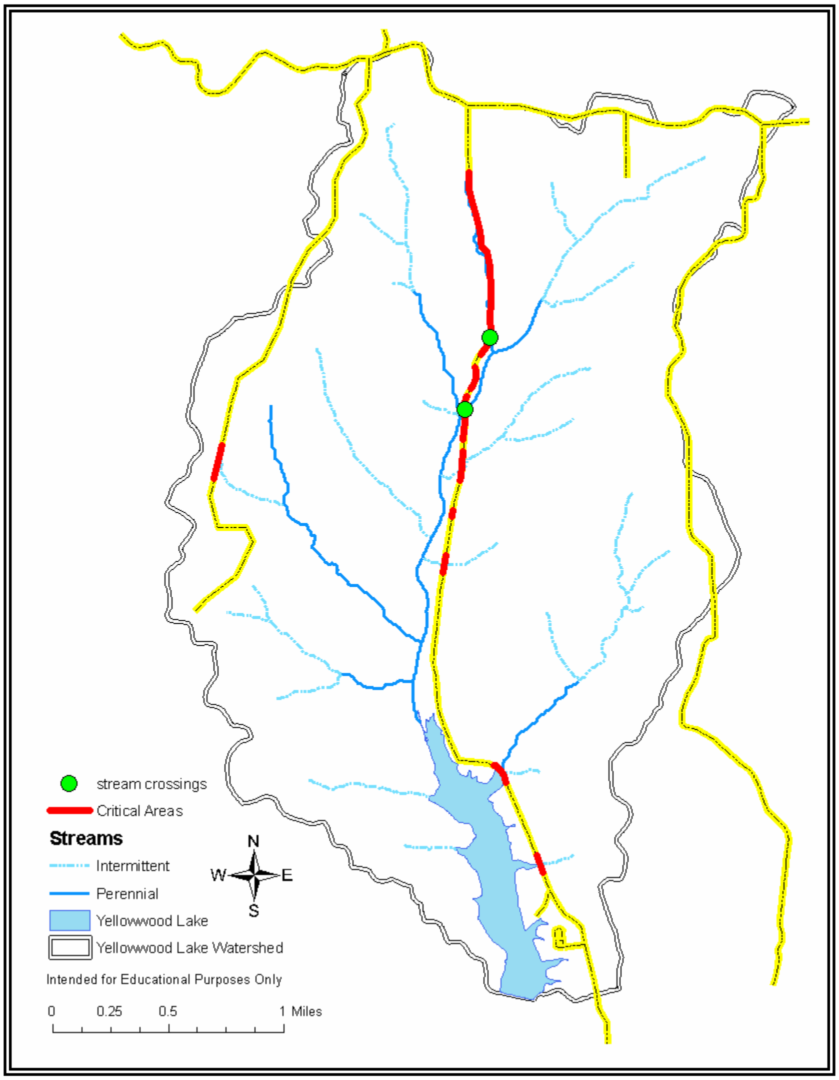


Figure 6.3. Critical Areas: Roads

SHORELINE

Unchecked recreation along the eastern shore of Yellowwood Lake has resulted in significant shoreline erosion. The erosion appears to be focused along campgrounds where recreational use is highest (Figure 6.4). Based on soil loss estimates from a 1993 graduate student study (see Section 5), 200 yards^2 of particularly eroded shorelines equates to 1,380 lbs of soil lost per year. Therefore, shorelines adjacent to the campgrounds have been identified as critical areas.

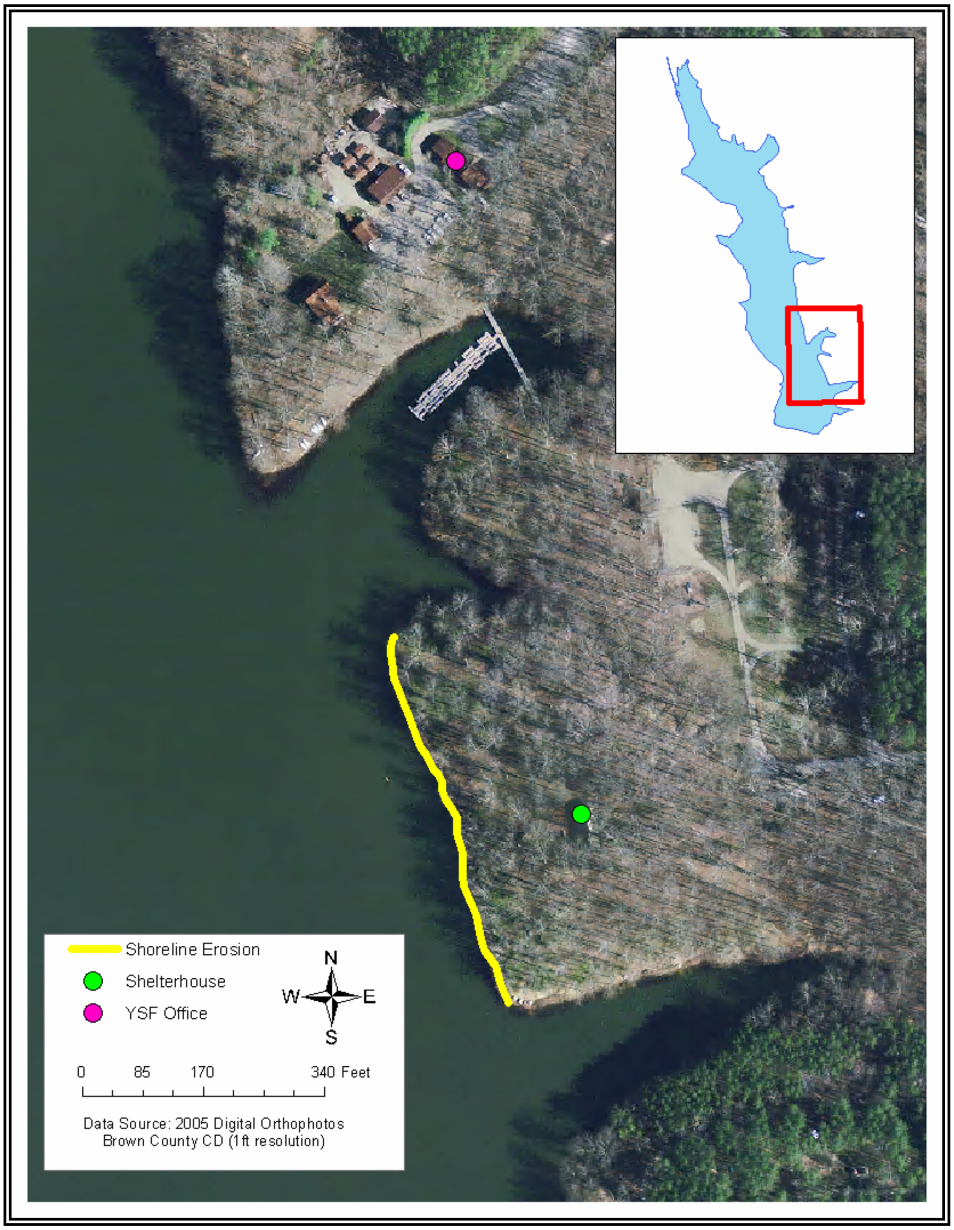


Figure 6.4. Critical Areas: lakeshore

TIMBER HARVESTING ACTIVITIES

Timber-harvesting activities, including harvesting zones, skid trails, log yards, and logging roads all cause soil disturbances, either by soil compaction or by exposing soil to the elements. With best management practices, the effects of timber harvesting activities can be minimized. Studies (Ice and Sednick, 2004) show that within a period of a few months to a few years, stream condition often reverts to pre-harvest status.

Therefore, the YLWPG has identified the locations of *all* timber harvests as critical areas for at least two years after harvesting activities commence. While streams have been proven to recover from the effects of timber harvesting, Yellowwood Lake acts as a bank, accumulating the effects of all soil-disturbing activities in the watershed. As such, the YLWPG recommends that the management areas outlined in the Indiana Logging and Forestry Best Management Practices 2005 BMP Field Guide be considered critical areas for timber-harvesting activities. On public property, these guidelines should be viewed as the minimum standards and exceeded whenever possible. Figure 6.5 illustrates the % slope and Riparian Management Zones (RMZs) in the Yellowwood Lake Watershed. The following list outlines some of the BMP standards:

- Keep road grades between 2-10% when possible
- Avoid long steep grades greater than 20%
- Expose no more than 10% bare, mineral soil, well distributed throughout an RMZ
- No heavy equipment to clear highly erodable areas or steep slopes over 20%
- All streams within the harvest areas (perennial and intermittent) should abide by the Riparian Management Zones requirements outlined in Table 6.1
- Limit firewood removal

Table 6.1. Riparian Management Zone Widths

Watershed Characteristics	**Total RMZ Widths**					
	0-5% slope	**5-10% slope**	**10-20% slope**	**20-40% slope**	**40% + slope**	**Primary RMZ**
Perennial 40' Wide	200	200	200	200	200	200 feet
Perennial 20-40' wide	75	75	75	105	105-165	75
Perennial 20' wide	50	50	65	105	105-165	35
Intermittent	25	45	65	105	105-165	-
Lakes and Ponds	35	45	65	105	105-165	35

(Adapted from IDNR, 2005)

In 2005 the YLWPG attempted to apply the universal soil loss equation (USLE) to the Yellowwood Lake Watershed. However, we found that the 'ambient' levels of erosion for forest cover in Indiana are considered "acceptable" and we could not adequately apply our model. However, applying the USLE to logging roads (Appendix R), we found that applying vegetation (e.g. buffers and seed) can significantly reduce soil losses. Therefore, the YLWPG recommends that native seed be applied to logging roads immediately after closure.

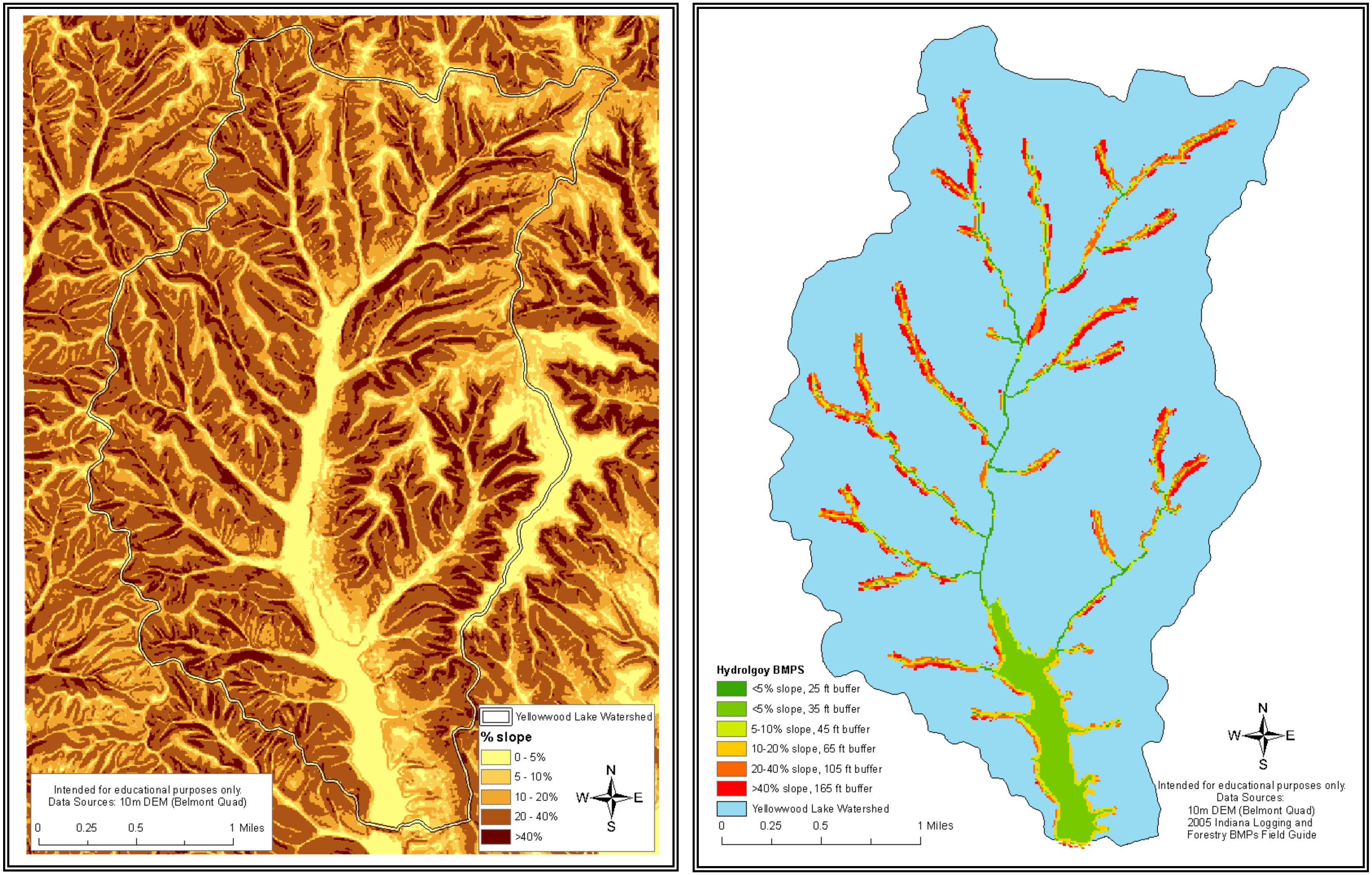


Figure 6.5. Critical Areas: Timber Harvesting

6.2. NUISANCE AND INVASIVE SPECIES

There are at least ten known invasive or nuisance species in the Yellowwood Lake watershed, spread by both humans and wildlife. The following sub-sections outline areas the YLWPG feels are critical to preventing further spread of nuisance and invasive species in the watershed.

AQUATIC INVASIVE SPECIES

Purple loosestrife, Eurasian watermilfoil, and yellow bass have all been artificially introduced into Yellowwood Lake. While no other non-native species have yet been detected, the YLWPG is concerned that Brazilian elodea, identified in nearby Griffy Lake (Monroe County), may find its way to Yellowwood Lake. The IDNR DoF currently allows individuals to bring their own boats onto Yellowwood Lake, thus creating an ever-present risk of invasive introductions. Therefore, public boat access sites have been identified as critical areas for aquatic invasive species management (Figure 6.6).

Figure 6.6. Critical Areas: Boat Access

TERRESTRIAL INVASIVE SPECIES

Yellowwood State Forest employees have detected a variety of non-native plants throughout the watershed, ranging from Japanese stilt grass to multiflora rose. Once established, invasive plants can spread extremely quickly by seed or vegetatively. Therefore, the best management options for invasive species control are preventative.

The critical areas for terrestrial invasive plants, in addition to known infestations, include:

- trail heads
- transportation corridors (e.g. roadsides and trails)
- utility easements
- private holdings
- any areas with major disturbances (e.g. timber harvest areas)

6.3. BIOLOGICAL AND CHEMICAL CONTAMINATION

The Yellowwood Lake watershed contains a variety of point and non-point sources of chemical and biological contamination. While many of the identified sources are "permanent" (e.g. fuel storage tanks, homes, traffic), others are temporary (e.g. heavy machinery during harvesting operations or road maintenance).

CHEMICAL CONTAMINATION

The YLPWG feels that the risk of chemical contamination needs to be managed for, despite the fact that the YLWPG did not detect any chemical contamination during the water quality investigation. Therefore, the YLPWG has identified the locations of "temporary" sources as critical areas, areas *whenever* and *wherever* they exist. In contrast, "permanent" sources of chemical contamination exist throughout the Yellowwood Lake watershed. However, the YLWPG has identified the following locations as critical areas for potential chemical contamination (Figure 6.7):

- IDNR maintenance area
- Locations where Yellowwood Lake Road intersects Jackson Creek

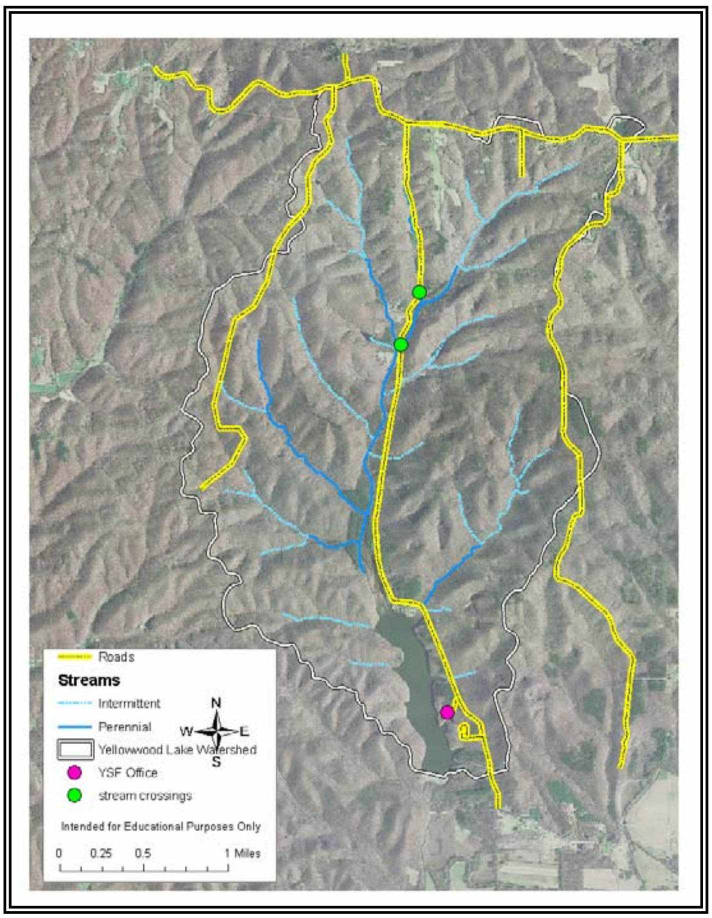


Figure 6.7. Critical Areas: Chemical Contamination

BIOLOGICAL CONTAMINATION

As outlined in earlier sections, detected *E. coli* concentrations in the Yellowwood Lake watershed were consistently above the state water quality standard for full body contact recreation. While both the Jackson Creek and John Floyd Hollow drainages exhibited excessive *E. coli* concentrations, loads from Jackson Creek were over an order of magnitude higher than John Floyd Hollow. With an estimated 93% of the relative *E. coli* loading, septic systems were clearly the major source of fecal contamination. Therefore, locations of septic systems on private holdings within the Jackson Creek drainage have been identified as the critical areas for fecal contamination management (Figure 6.8).

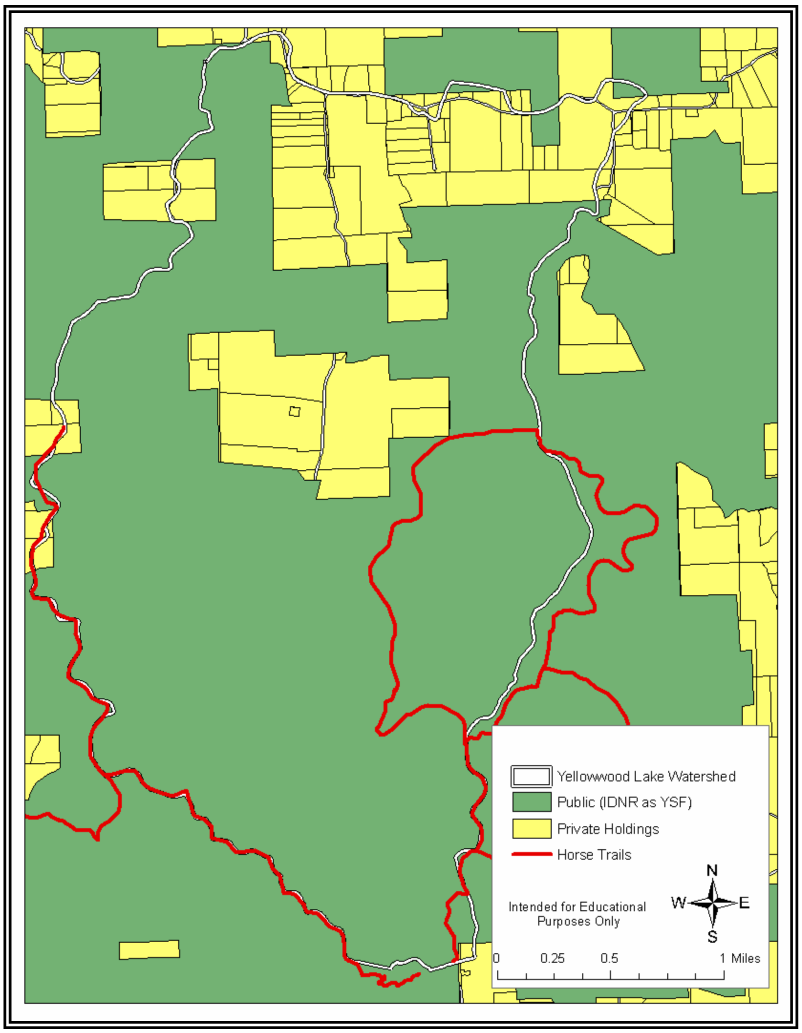


Figure 6.8. Critical Areas: Biological Contamination

7. SETTING GOALS AND CHOOSING MEASURES TO APPLY

Based on the problem statements in the previous section, existing data, and desired conditions, the YLWPG developed the following goals to prioritize and address water quality issues in the Yellowwood Lake watershed. Corresponding to each goal is a summary of the current and target conditions, followed by a list of objectives, action items, target audiences, responsible parties, tentative schedules, and potential indicators to measure progress in order of priority. The load reduction calculations can be found in Appendix S. The YLWPG would like to acknowledge that education is an integral component of each goal, but addressing water quality improvement is the ultimate goal of this watershed management plan.

7.1. GROUP SUSTAINABILITY GOALS

Problem: The YLWPG does not have any strategic plans or future funding sources for organizational sustainability or implementation of this watershed management plan's goals.

Goal(s): (1) Increase watershed user awareness about impacts of non-point-source pollution on water quality.

(2) Ensure continued financial and personnel support for YLWPG activities outlined in this plan.

Current Condition(s)	***Target Condition(s)***
• No implementation funding • No watershed coordinator or permanent staff support • Poor volunteer and stakeholder participation • No long-term organizational strategy • No long-term research support	• Funding sources to pursue implementation, hire a watershed coordinator, and establish long-term sediment research monitoring • Increased stakeholder support • Routine volunteer sampling • Develop an organizational strategic plan • Continued participation with Indiana Forested Watershed Symposia

7.2. SEDIMENTATION GOALS

Problem: Yellowwood Lake is filling in with sediment, causing the lake to lose depth and the macrophyte beds to expand. Visual observations from HFF members suggest that this process has accelerated over the last decade. Sediments from the watershed can carry biological and chemical pollutants, increase water temperature, block sunlight, impair sight-dependent predation, and smother fish-nesting sites. The soft, fertile sediments also provide a rich bed for aquatic plant establishment.

Goal(s): (1) Reduce storm event *Total Suspended Solid* (TSS) loads in Jackson Creek by 145 lbs/day to minimize depth loss in the north end of Yellowwood Lake.

Current Condition(s)	***Target Condition(s)***
• Approximately 1 million ft^3 of sediment deposition in the north end of Yellowwood Lake • Maximum storm flow TSS: 194 lbs/day • Maximum storm flow turbidity: 46 NTU • 2005 average lake depth from HFF Surveys: 10.5 ft	• Meet water quality standards for storm flow TSS (48 lbs/day) and Turbidity (25 NTU) • Maintain current average lake depth in north end of lake

7.3. NUISANCE AND INVASIVE SPECIES GOALS

Problem: Nuisance and invasive species, detected throughout the Yellowwood Lake watershed, are detrimental to native biodiversity and provide few valuable environmental functions such as nutrient uptake, soil stabilization, habitat, and forage.

Goal(s): (1) Reduce the impact of exotic and nuisance flora and fauna in the Yellowwood Lake watershed[22].

Current Condition(s)	***Target Condition(s)***
• Over 12 detected nuisance and invasive species in and adjacent to the watershed • Excessive macrophyte populations (average rake score 3. 73) are impairing recreational potential • Excessive macrophyte populations have the potential to impair the Yellowwood Lake fishery • No consistent annual fishery and macrophyte monitoring	• Prevent establishment of additional species (especially Kudzu and Brazilian Elodea) • Reduce the spread of existing infestations • Restore native macrophyte communities • Reduce # rake pulls with a score of 5 • Thorough documentation of locations of infestations • Annual monitoring of fishery, macrophytes, and terrestrial invasive species

[22] This goal has been left deliberately vague and quantitative measures will be determined once the extent of the problem is further investigated, as outlined in many of the nuisance and invasive species action items.

7.4. BIOLOGICAL AND CHEMICAL CONTAMINATION GOALS

Problem: Biological and chemical contaminants pose an undefined threat to the Yellowwood Lake watershed. This is primarily due overland runoff of pathogens, chemicals, and nutrients. Failed or failing septic systems, horses, and wildlife are known to contribute nutrients and pathogens while automobiles, fertilizers, improper chemical use/ storage, timber harvesting activities, and above ground fuel storage tanks have the potential to leak hazardous materials into the watershed. Beyond runoff, Yellowwood Lake is currently suffering from mercury contamination.

Goal(s): (1) Reduce the risk of chemical contamination from above ground fuel storage tanks, chemical storage, illicit dumping, and stream crossings in the Yellowwood Lake watershed

(*2)* Increase public education of mercury contamination in Yellowwood Lake.

(3) Reduce average *E. coli* loads by 20,000 *E.coli* / day in 5 years, and by 40,000 *E.coli* / day in 10 years to meet the State Water Quality Standards for *E. coli*.

Current Condition(s)	***Target Condition(s)***
• Hazardous chemical/fuel storage in close proximity to Yellowwood Lake and Jackson Creek • No permanent stream crossing structures on Yellowwood Road • Level 2 FCA for Mercury, many people unaware FCA exists • Samples consistently exceed the IAC single sample daily maximum of 235 cfu/ 100 ml for *E. coli*	• No chemical/ fuel storage within 500 yds of Yellowwood Lake • Permanent stream crossings on Yellowwood Road • Public awareness of FCA • Meet Indiana Water Quality standards for *E. coli* in 10 years

Problem: The YLWPG does not have any strategic plans or future funding sources for organizational sustainability or implementation of this watershed management plan's goals.

Goal #1: Increase watershed user awareness about impacts of Nonpoint Source pollution on water quality.

Objective	Action Item	Target Audience	Responsible Party	Schedule	Indicator(s)
Promote YLWPG educational activities to the public	Increase mailing list by 50 people Create YLWPG website YLWPG poster presence at local public events including county fairs, Earth Day celebrations, and YSF Open Houses Co-sponsor future Indiana Forested Watershed Symposium	Watershed residents and visitors	YLWPG	Summer 2006, on-going	# people in mailing list, # hits on website, # participants, # symposia held, # watershed awareness days held
Promote use of rural best management practices (BMPs)	Continued distribution of watershed packet materials Feature BMPs in future newsletters Host BMP workshops Provide BMP consultations for watershed residents	Watershed residents	YLWPG	On-going	# newsletters and educational materials distributed, # workshops held, # consultations

Goal #2: Ensure continued financial and personnel support for YLWPG activities.

Objective	Action Item	Target Audience	Responsible Party	Schedule	Indicator(s)
Increase participation in YLWPG planning events	Increase stakeholder involvement by 5 new organizations Coordinate monthly volunteer monitoring days	YLWPG members, local stakeholders	YLWPG	2006, on-going	# stakeholders on steering committee, # volunteer samples
Secure funding for implementation and future watershed coordinator	Apply for 319 funding Research and apply for alternative grant funding	YLWPG	YLWPG	Summer 2006	Grant dollars secured

Problem: The YLWPG does not have any strategic plans or future funding sources for organizational sustainability or implementation of this watershed management plan's goals.

Goal #2 (con't): Ensure continued financial and personnel support for YLWPG activities.

Objective	Action Item	Target Audience	Responsible Party	Schedule	Indicator(s)
Increased IDNR personnel support of watershed activities	Continued dialogue with YSF staff and YLWPG steering committee	IDNR DoF, YLWPG	IDNR DoF	On-going	# IDNR DoF hours documented that are related to watershed management # YSF attendance at monthly meetings
	Develop list of watershed monitoring criteria for YSF employees				
	Designate a resource position at YSF to work on non-traditional forest issues, including watershed planning and management				
Strategic visioning for the YLWPG	Contract a facilitator to conduct a strategic planning session	YLWPG	YLWPG	2006	# goals developed for YLWPG
	Organize and conduct a strategic planning session				

Problem: Yellowwood Lake is filling in with sediment, causing the lake to lose depth and the macrophyte beds to expand. Visual observations from HFF members suggest that this process has accelerated over the last decade. Sediments from the watershed can carry biological and chemical pollutants, increase water temperature, block sunlight, impair sight-dependent predation, and smother fish-nesting sites. The soft, fertile sediments also provide a rich bed for aquatic plant establishment.

Goal: Reduce storm event *Total Suspended Solid* (TSS) loads in the Jackson Creek by 145 lbs/day to minimize depth loss in the north end of Yellowwood Lake.

Objective	Action Item	Target Audience	Responsible Party	Schedule	Indicator(s)
Stabilize Streambanks	Research bank stabilization techniques GPS locations of all stream bank failures Establish native vegetation in riparian zones Install stream bank stabilization BMPs	YLWPG	YLWPG	2007 - 2011	# miles stream bank restored Storm sediment loads, QHEI scores
Improved road maintenance and culvert replacement	GPS culverts and develop replacement schedule Foster relationship with Brown County Highway Department to research and upgrade current maintenance regime on Yellowwood Road Monitor erosion from Yellowwood Road	Brown County Highway Department	YLWPG, Brown County Highway Department	2007 – 2011	# culverts replaced, Storm sediment loads, visual indicators of ditch erosion
Physical removal of sediment	Conduct a feasibility study and dredge north end of Yellowwood Lake	IDNR DoF	IDNR DoF	2009	# tons sediment removed
Trap sediment from critical areas	Construct sediment traps (which could also serve as vernal pools) in relict logging roads Construct temporary sediment traps on streams near man-made soil-disturbing activities and in road ditches	IDNR DoF, YLWPG, Brown County Highway Department	YLWPG, IDNR DoF, Brown County Highway Department	2006, on-going	# traps installed, lbs sediment removed, Storm sediment loads
Develop long-term sediment monitoring program	Solicit university or state researchers to use the Yellowwood Lake Watershed as a control site Continue monthly stream sampling and begin storm sampling Monitor sediment from all identified sources Continued HFF Depth surveys	YLWPG	YLWPG	2007, ongoing	# professionals contacted, # samples taken, # surveys completed

Problem: Yellowwood Lake is filling in with sediment, causing the lake to lose depth and the macrophyte beds to expand. Visual observations from HFF members suggest that this process has accelerated over the last decade. Sediments from the watershed can carry biological and chemical pollutants, increase water temperature, block sunlight, impair sight-dependent predation, and smother fish-nesting sites. The soft, fertile sediments also provide a rich bed for aquatic plant establishment.

Goal (con't): Reduce storm event *Total Suspended Solid* (TSS) loads in the Jackson Creek by 145 lbs/day to minimize depth loss in the north end of Yellowwood Lake.

Objective	Action Item	Target Audience	Responsible Party	Schedule	Indicator(s)
Reduce erosion from recreational areas	All new trails will adhere to *Tread Lightly* design and maintenance standards and identified critical areas of existing trails will be upgraded to *Tread Lightly* standards within 5 years	Hiking and Equestrian community, IDNR DoF	IDNR DoF, YLWPG, Indiana Trail Riders	2007- 2011	Miles of trails improved, # volunteer work days, # signs
	Host volunteer work days for trail maintenance				
	Display *Tread lightly* signs in critical areas				
	Work to establish line item inclusion of YSF shoreline improvement project[23] in IDNR DoF budget	Indiana Legislature, Yellowwood Lake users	YLWPG, IDNR DoF	2006 – 2007	letters sent to legislature, # articles in the paper
Encourage implementation of BMPs on private landowner construction projects	Distribute educational materials to current and future landowners on storm water BMPs	Watershed residents	YLWPG	2007, on-going	# informational materials distributed, storm sediment loads
	Organize citizen monitoring program to watch for absent or insufficient BMPs on construction projects				
Encourage use of Indiana DoF BMPs on all private timber harvests in the watershed	Distribute Forestry BMP materials to all landowners	Watershed residents	YLWPG, IDNR DoF, TNC	2007, on-going	# informational materials distributed, # landowners utilizing BMP consultations,
	Provide onsite inspections and BMP consulting for private harvests				
	Use YSF demonstration plot for landowner education				
Require use of Indiana DoF BMPs on all public timber harvests in the watershed	Continued cooperation with YLWPG review committee	IDNR DoF	YLWPG, IDNR DoF	2007, on-going	BMP monitoring reports, # harvests approved by the review committee, storm sediment loads
	BMP monitoring on all harvests				

[23] YSF already has shoreline improvement project design; they just need state funding to start work on the project.

Problem: Nuisance and invasive species, detected throughout the Yellowwood Lake watershed, are detrimental to native biodiversity and provide few valuable environmental functions such as nutrient uptake, soil stabilization, habitat, and forage.

Goal: Reduce the impact of exotic and nuisance flora and fauna in the Yellowwood Lake watershed.

Objective	Action Item	Target Audience	Responsible Party	Schedule	Indicator(s)
Increase public education and monitoring	Provide periodic updates for watershed packets	Watershed residents and YSF visitors	YLWPG	2007, ongoing	# inserts distributed, # signs posted, # recorded entries, # workshop attendees, # stations installed, # brushes available
	Develop signage at boat docks, trail heads, and in YSF office		YLWPG, IDNR DoF		
	Create an "I saw a non-native" box at the YSF office				
	Provide non-native ID workshops		YLWPG, IDNR DoF, TNC		
	Brush stations at trail heads and boat access points				
	GPS location of infested areas and develop a database to track infested areas	YLWPG, IDNR DoF, HFF	YLWPG, IDNR DoF, HFF, IDNR District 8 Fisheries Biologist		# GPS points recorded, # new infestations caught, # surveys conducted
	Encourage continued fishery and macrophyte monitoring in Yellowwood Lake				
	Organize Creel Surveys				
	Purchase and provide immediate disturbance response kits with native seed	Anyone generating large-scale soil disturbance in the watershed	YLWPG, IDNR DoF, ID	2007	# response kits distributed
Control nuisance and invasive plants in Yellowwood Lake to improve recreation	Develop terrestrial plant management plan with IPM component	Yellowwood Lake and Watershed users	YLWPG, IDNR DoF, TNC	2007, ongoing	Volume of open water habitat restored, improved user satisfaction, # infestations identified and eliminated
	Develop aquatic plant management plan with IPM component		IDNR District 8 Fisheries Biologists, IDNR Engineering, Division of Water, LARE		
	Drawdown				
	Implement management options as identified in the management plans				
	Restore native vegetation	Anglers and wildlife viewers	IDNR District 8 Fisheries Biologist, IDNR Division of Water, IDNR Division of Engineering, YLWPG	2007	Improved fishery reports, improved user satisfaction, # structures installed
	Construct habitat structures (e.g. fish cribs and buried reef material)				
	Construct fishing jetties and a shoreline trail system for better access				

Problem: Biological and chemical contaminants pose an undefined threat to the Yellowwood Lake Watershed. This is primarily due overland runoff of pathogens, chemicals, and nutrients. Failed or failing septic systems, horses, and wildlife are known to contribute nutrients and pathogens while automobiles, fertilizers, improper chemical use/ storage, timber harvesting activities, and above ground fuel storage tanks have the potential to leak hazardous materials into the watershed. Beyond runoff, Yellowwood Lake is currently suffering from mercury contamination.

Goal #1: Reduce the risk of chemical contamination from above ground fuel storage tanks, chemical storage, illicit dumping, and stream crossings in the Yellowwood Lake watershed.

Objective	Action Item	Target Audience	Responsible Party	Schedule	Indicator(s)
Proactive Risk Management for chemical use and storage	Purchase land for new YSF maintenance area	IDNR DoF	IDNR DoF, YLWPG	2007, on-going	YSF Land purchase
	Educate those who reside in the watershed and watershed visitors about proper chemical storage and disposal	Everyone living in or using the watershed			# landowner packets distributed, # signs posted in campgrounds
Proactive risk management for above-ground fuel tanks	Educate above-ground fuel storage tank owners as to proper BMPs including: • Construct shelter to shade fuel tanks to eliminate gasoline evaporation • Routine sweeping of and around fuel storage tanks • Build water bars/ berms/ or a secondary containment structures	IDNR DoF, private landowners	IDNR DoF, YLWPG	2007, on-going	# landowner packets distributed
Increase waste disposal options for rural residents.	Facilitate cooperative partnerships with County Solid Waste Management Districts and private waste removal businesses.	County Solid Waste Management Districts and privately-owned solid waste management operations.	YLWPG	2007, on-going	# Programs created, # of Amnesty and clean-up Days
	Research sustainable systems of waste removal in rural areas.				
	Increase the number of Amnesty Days for Yellowwood Lake Watershed residents.				
	Annual clean-up days				
Proactive Risk Management with industrial chemical applicators	Review and update the current REMC agreement regarding the use of herbicides on utility easements	REMC	YLWPG, REMC	2006	Updated agreement with REMC
	Outline and review IDNR policies on chemical usage for property maintenance and site preparation BMPs	IDNR DoF	IDNR DoF, YLWPG	2006	BMP monitoring

Problem: Biological and chemical contaminants pose an undefined threat to the Yellowwood Lake Watershed. This is primarily due overland runoff of pathogens, chemicals, and nutrients. Failed or failing septic systems, horses, and wildlife are known to contribute nutrients and pathogens while automobiles, fertilizers, improper chemical use/ storage, timber harvesting activities, and above ground fuel storage tanks have the potential to leak hazardous materials into the watershed. Beyond runoff, Yellowwood Lake is currently suffering from mercury contamination.

Goal #1 (con't): Reduce the risk of chemical contamination from above ground fuel storage tanks, chemical storage, illicit dumping, and stream crossings in the Yellowwood Lake watershed

Objective	Action Item	Target Audience	Responsible Party	Schedule	Indicator(s)
Provide safe vehicular passage over stream crossings	Construct permanent stream crossing	Anyone who drives on Yellowwood Road	Brown County Highway Department Brown County Commsnr	2006–2010	# car parts observed, Type of stream crossing developed

Goal #2: Increase public education of mercury pollution in Yellowwood Lake.

Objective	Action Item	Target Audience	Responsible Party	Schedule	Indicator(s)
Increase public awareness of Fish Consumption Advisories (FCA) in Indiana Lakes	Obtain informational materials about mercury contamination from ISDH	Anyone who consumes fish caught in Yellowwood Lake	DNR, IDSH, IDEM, YLWPG	2007, On-going	# of informational materials distributed
	Circulate educational materials to YWLPG stakeholders, landowners, and watershed users				
Legislative pressure to reduce mercury emissions	Commence letter writing campaign	Residents of Southern Indiana	YLWPG	On-going	# letters composed
	YWLPG letters of support for local, state, regional, and national mercury issues				
	Stakeholder education				

Problem: Biological and chemical contaminants pose an undefined threat to the Yellowwood Lake Watershed. This is primarily due overland runoff of pathogens, chemicals, and nutrients. Failed or failing septic systems, horses, and wildlife are known to contribute nutrients and pathogens while automobiles, fertilizers, improper chemical use/ storage, timber harvesting activities, and above ground fuel storage tanks have the potential to leak hazardous materials into the watershed. Beyond runoff, Yellowwood Lake is currently suffering from mercury contamination.

Goal #3: Reduce average *E. coli* loads by 20,000 *E.coli* / day in 5 years, and by 40,000 *E.coli* / day in 10 years to meet the State Water Quality Standards for *E. coli*.

Objective	Action Item	Target Audience	Responsible Party	Schedule	Indicator(s)
Continued *E. coli* monitoring	Continue monthly *E.coli* sampling in Jackson Creek Sample *E. coli* in Yellowwood Lake on a monthly basis Encourage Brown County Health Department to begin monitoring	YLWPG members, Brown County Health Department	YLWPG	On-going, monthly	# samples taken
Improved septic system maintenance	Educate septic system owners about proper maintenance Work with Brown County Health Departments to create a cooperative partnership Develop cost-share program to encourage alternative septic systems	Yellowwood Lake Watershed residents, YLWPG, Brown County Health Department	YLWPG	2006, On-going	# of septic systems influenced. Continued load reduction
Equestrian BMPs Education	Distribute educational materials to landowners with horses Implement Equestrian BMPs including: • Confinement areas to keep animals out of streams • Proper manure management	Landowners with horses in the watershed	YLWPG	2007	# BMP's installed Continued load reduction
Construction of BMPs on horse trails	Water bars to direct runoff off the trails	IDNR DoF, Hoosier Trail Riders	YLWPG	2007	# BMPs installed

8. ACTION STRATEGIES

This section outlines the action strategies necessary to achieve the water quality improvement goals listed in section 7.0. The YLWPG developed a series of action registers for each objective describing the desired final product and load reductions, technical resources, estimated costs, and potential financial partners associated with each goal. The estimated financial need necessary to achieve all tasks outlined in this watershed management plan are listed in Table 8.1.

Table 8.1. Estimated Financial Need for Implementation

Goal	1 year (all tasks complete)	5 year (all tasks complete)	One time expenditures
Group Sustainability	$53,720	$268,600	---
Sedimentation	$912,800	$1,162,000	$850,500
Nuisance and Invasive Species	$356,300	$890,600	$356,100
Biological and Chemical Contamination	$758,000	$790,000	$750,000
Total	*$2,080,820*	*$3,111,200*	*$1,956,600*

Table 8.2. Action Register: Group Sustainability

Problem Statement: *The YLWPG does not have any strategic plans or future funding sources for organizational sustainability or implementation of this watershed management plan's goals.*

Goal #1: Increase watershed user awareness about impacts of Nonpoint Source pollution on water quality.

Objective: Promote YLWPG educational activities to the public.

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Increase mailing list by 50 people	Newsletters and educational mailings	YLWPG solicitation of interested individuals	---	---
Create YLWPG website	URL to publish YLWPG documents, events, an educational materials	Server and volunteer web designer	$30/ month	---
YLWPG poster presence at local public events including county fairs, Earth Day celebrations, and YSF Open Houses	Posters developed	Poster board, updated photos and informational materials	$100	IDNR DoF
Co-sponsor future Indiana Forested Watershed Symposia	Forum to bring in experts together to discuss forested watershed management issues	Hoosier Heartland logistical support, speakers	$1,000/ event	Hoosier Heartland RC&D, TNC, IDNR DoF, SWCD

Objective: Promote use of rural best management practices (BMPs).

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Continued distribution of watershed packet materials	Watershed Packet Materials	Technical advice	$200/yr	IDNR DoF, TNC
Feature BMPs in future newsletters	Newsletters	Technical advice, mailing supplies and postage	$300/yr	IDNR DoF, TNC
Host BMP workshops	BMP workshops	Technical advice and volunteer time	$500/event	---
Provide BMP consultations for watershed residents	Qualified YLWPG members to schedule meetings with interested parties to help them design Forestry BMP strategies	Technical advice and volunteer time	---	---

Problem Statement: *The YLWPG does not have any strategic plans or future funding sources for organizational sustainability or implementation of this watershed management plan's goals.*

Goal #2: Ensure continued financial and personnel support for YLWPG activities.

Objective: Increase participation in YLWPG planning processes

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Increase stakeholder involvement by 5 new organizations	New stakeholders	Commitment from identified parties	---	---
Coordinate monthly volunteer monitoring days	Sampling data	Volunteer time, more trained volunteers	$500/yr	---

Objective: Secure funding for implementation and future watershed coordinator

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Apply for 319 funding	IDEM implementation monies	Volunteer time to research and write grant proposal(s)	---	---
Research and apply for alternative grant funding	Alternative grant funding outside IDEM		---	---

Objective: Increased IDNR personnel support of watershed activities

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Continued dialogue with YSF staff and YLWPG steering committee	Continued cooperation with the project review committee and IDNR co-sponsorship of YLWPG activities	---	---	---
Develop list of watershed monitoring criteria for YSF employees	Shared monitoring duties and results between IDNR DoF and the YLWPG	Continued cooperation	---	---
Designate a resource position at YSF to work on non-traditional forest issues, including watershed planning and management	An IDNR DoF staff member who can devote a large portion of their time to watershed work	Line item position	$50,000/ yr	IDNR DoF

Problem Statement: *The YLWPG does not have any strategic plans or future funding sources for organizational sustainability or implementation of this watershed management plan's goals.*

Goal #2: Ensure continued financial and personnel support for YLWPG activities.

Objective: Strategic visioning for the YLWPG

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Contract a facilitator to conduct a strategic planning session	Development a long-term strategic plan for the YLWPG	Hire a facilitator	$1,000	IDNR
Organize and conduct a strategic planning session				

Table 8.3. Action Register: Sedimentation

Problem Statement: *Yellowwood Lake is filling in with sediment, causing the lake to lose depth and the macrophyte beds to expand. Visual observations from HFF members suggest that this process has accelerated over the last decade. Sediments from the watershed can carry biological and chemical pollutants, increase water temperature, block sunlight, impair sight-dependent predation, and smother fish-nesting sites. The soft, fertile sediments also provide a rich bed for aquatic plant establishment.*

Goal: Reduce storm event Total Suspended Solid (TSS) loads in the Jackson Creek by 145 lbs/day to minimize depth loss in the north end of Yellowwood Lake

Objective: Stabilize Stream Banks

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Research bank stabilization techniques	A local stream restoration specialist recommended the YLWPG utilize J-hooks and periodic cross veins to stabilize stream banks along Jackson Creek, given the high energy, bedrock system that is Jackson Creek  **J-Hook**  **Cross-veins**	Technical advice from local experts	---	NRCS, IDNR DoF, IDEM, SWCD
GPS locations of all stream bank failures	Database to monitor all locations of significant streambank erosion	Trained volunteers GPS Equipment	---	---
Establish native vegetation in riparian zones	Replace invasive species in the riparian zone with native species for better soil stabilization and habitat	Native plant plugs	$5,000	IDNR DoF, NRCS, USFWS
Install stream bank stabilization BMPs	Implement bank stabilization techniques based upon professional advice to reduce sediment loads	Project funding, professional consultants to design stream restoration plan	$300,000	IDNR DoF, NRCS, SWCD, IDEM

Problem Statement: *Yellowwood Lake is filling in with sediment, causing the lake to lose depth and the macrophyte beds to expand. Visual observations from HFF members suggest that this process has accelerated over the last decade. Sediments from the watershed can carry biological and chemical pollutants, increase water temperature, block sunlight, impair sight-dependent predation, and smother fish-nesting sites. The soft, fertile sediments also provide a rich bed for aquatic plant establishment.*

Goal (con't): Reduce storm event Total Suspended Solid (TSS) loads in the Jackson Creek by 145 lbs/day to minimize depth loss in the north end of Yellowwood Lake.

Objective: Improved road maintenance and culvert replacement

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
GPS culverts and develop replacement schedule	New Culverts	Grant funding, letter of support, consultants to replace culverts	$100,000	Brown County Highway Department, Department of Transportation
Foster relationship with Brown County Highway Department to research and upgrade current maintenance regime on Yellowwood Road	Identify new grading and road design technique and sustainable types of aggregate for non-paved roads, especially those techniques listed on the Center for Dirt & Gravel Road Studies at Penn State University	Technical advice	$50,000/ yr	Brown County Highway Department
Monitor erosion from Yellowwood Road	Identify sample locations, periodic volunteer monitoring, work with local officials to survey Yellowwood Road for better model inputs	Volunteer time, technical advice and assistance	---	---

Objective: Physical removal of sediment.

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Conduct a feasibility study and dredge north end of Yellowwood Lake	Feasibility study Dredging	Grant $ and IDNR support for study, §404 permit from US ACE, NPDES permit from IDEM	$200,000	IDNR, USFWS

Problem Statement: *Yellowwood Lake is filling in with sediment, causing the lake to lose depth and the macrophyte beds to expand. Visual observations from HFF members suggest that this process has accelerated over the last decade. Sediments from the watershed can carry biological and chemical pollutants, increase water temperature, block sunlight, impair sight-dependent predation, and smother fish-nesting sites. The soft, fertile sediments also provide a rich bed for aquatic plant establishment.*

Goal (con't): Reduce storm event Total Suspended Solid (TSS) loads in the Jackson Creek by 145 lbs/day to minimize depth loss in the north end of Yellowwood Lake.

Objective: Trap sediment from critical areas

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Construct sediment traps (which could also serve as vernal pools) in relict logging roads	 Constructing vernal pools in old logging roads can provide habitat, storm water storage, and sediment traps while maintaining infrastructure.	Technical advice, bulldozers, native plant plugs	$10,000	IDNR DoF, HNF, USFWS
Construct temporary sediment traps on streams near man-made soil-disturbing activities and in road ditches	 Straw bales, sediment traps, and log jams can provide temporary sediment traps. They only work when properly installed and regularly cleaned out.	Straw bales, silt fabrics, stakes, technical assistance	$500/ yr	IDNR DoF, NRCS, SWCD

Objective: Develop long-term sediment monitoring program

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Solicit university or state researchers to use the Yellowwood Lake Watershed as a control site	Establishment of long-term sedimentation observations	Secure grant funding for long term study, university or state agency partnership	$200,000	Purdue University, Indiana University, Taylor University
Continue monthly stream sampling and begin storm sampling	Continuous monitoring for changes in sediment loads	Consistent volunteer monitoring	$500/yr	---
Monitor sediment from all identified sources	Develop better understanding of relative sediment loads		$500/yr	---
Continued HFF Depth surveys	Continue to monitor changes in lake depth	HFF volunteers	$500	---

Problem Statement: *Yellowwood Lake is filling in with sediment, causing the lake to lose depth and the macrophyte beds to expand. Visual observations from HFF members suggest that this process has accelerated over the last decade. Sediments from the watershed can carry biological and chemical pollutants, increase water temperature, block sunlight, impair sight-dependent predation, and smother fish-nesting sites. The soft, fertile sediments also provide a rich bed for aquatic plant establishment.*

Goal (con't): Reduce storm event Total Suspended Solid (TSS) loads in the Jackson Creek by 145 lbs/day to minimize depth loss in the north end of Yellowwood Lake.

Objective: Reduce erosion from recreational areas

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
All new trails will adhere to *Tread Lightly* design and maintenance standards and identified critical areas of existing trails will be upgraded to *Tread Lightly* standards within 5 years	IDNR DoF commitment to *Tread Lightly* program	YLWPG volunteers, IDNR Staff, Indiana Trailriders volunteers	$5,000	IDNR DoF, Indiana Trailriders Association
Host volunteer work days for trail maintenance	Improved trail infrastructure	Borrow supplies from IDNR, volunteer commitment	---	---
Display *Tread Lightly* signs in critical areas	Colorful, easy-to-read signs at YSF office, trail heads, and along shoreline to help educate hikers on how to *tread lightly*	Signs and brochures	$100	IDNR DoF, Hoosier Hikers, Indiana Trail Riders
Work to establish line item inclusion of YSF shoreline improvement project in IDNR DoF budget	YSF will include project in their budget requests, YWLPG will help raise public awareness and support for shoreline project through public media	Volunteer time to contact local media, legislative support	$40,000	IDNR DoF

Objective: Encourage implementation of BMPs on private landowner construction projects

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Distribute educational materials to current and future landowners on storm water BMPs	Educated landowners who will use BMPs for all construction projects	Technical advice from IDEM	$200/yr	---
Organize citizen monitoring program to watch for absent or insufficient BMPs on construction projects	Neighborly observations	Volunteers	---	---

Problem Statement: *Yellowwood Lake is filling in with sediment, causing the lake to lose depth and the macrophyte beds to expand. Visual observations from HFF members suggest that this process has accelerated over the last decade. Sediments from the watershed can carry biological and chemical pollutants, increase water temperature, block sunlight, impair sight-dependent predation, and smother fish-nesting sites. The soft, fertile sediments also provide a rich bed for aquatic plant establishment.*

Goal (con't): Reduce storm event Total Suspended Solid (TSS) loads in the Jackson Creek by 145 lbs/day to minimize depth loss in the north end of Yellowwood Lake.

Objective: Encourage use of Indiana DoF BMPs on all private timber harvests in the watershed.

Action Items	**Products**	**Resources Needed**	**Cost Estimate**	**Potential Financial Partners**
Distribute Forestry BMP materials to all landowners	Provide pictures and detailed explanations of Forestry BMP designs to all landowners in the watershed	Educational literature	$500/yr	IDNR DoF, TNC, SWCD, NRCS
Provide onsite inspections and BMP consulting for private harvests	Professional BMP advice provided free of charge by qualified YLWPG members	Volunteers	---	---
Use IDNR demonstration plot for landowner education	Tours	Volunteers	---	---

Objective: Encourage use of Indiana DoF BMPs on all public timber harvests in the watershed.

Action Items	**Products**	**Resources Needed**	**Cost Estimate**	**Potential Financial Partners**
Continued cooperation with YLWPG review committee	Public participation in the decision making process	Volunteer time to review project proposals	---	---
BMP monitoring on all harvests	IDNR DoF or 3rd party BMP monitoring	Volunteer time	---	---

Table 8.4. Action Register: Nuisance and Invasive Species

Problem Statement: *Nuisance and invasive species, detected throughout the Yellowwood Lake watershed, are detrimental to native biodiversity and provide few valuable environmental functions such as nutrient uptake, soil stabilization, habitat, and forage.*

Goal: Reduce the impact of exotic and nuisance flora and fauna in the Yellowwood Lake watershed.

Objective: Increase public education and monitoring.

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Provide periodic updates for watershed packets	Photographs and important information for invasive species management , alerts for newly detected species of concern	Technical materials	$300/yr	Sea Grant, TNC, County Extension Offices
Develop signage at boat docks, trail heads, and in YSF office	Colorful, easy to read posters and signs at critical areas	Signs from Sea Grant	$1,000	IDNR
Create an "I saw a non-native" box at the YSF office	Hands-on education and citizen monitoring opportunity	Response cards	$100	IDNR DoF
Provide non-native ID workshops	Informative sessions on plant ID and management strategies	Volunteers to lead workshops, educational materials	$200/ event	---
Install brush stations at trail heads and boat access points	Brush Stations	Building materials: (wood, gravel, brushes)	$500 per station	IDNR DoF, TNC
GPS location of infested areas and develop a database to track infested areas	Accessible GPS unit and user friendly access database	Data sheets, volunteer with Access and GPS experience	---	---
Encourage continued fishery and macrophyte monitoring in Yellowwood Lake	Regular fishery surveys to detect any changes in the fishery and provide continuous monitoring of Yellowwood Bass and macrophyte populations. HFF to monitor on years when IDNR Fishery Biologists can't sample Yellowwood Lake.	Technical Support from IDNR District 8 Fishery Biologist, volunteer hours from HFF member	$500	---
Organize Creel Surveys	fishery monitoring Formal study by IDNR Fishery Biologists or informal YLWPG/ HFF survey	Technical support to design the survey, printing supplies if volunteer, informal study conducted, volunteer time	$100	IDNR Division of Fish and Wildlife
Purchase and provide immediate disturbance response kits with quick growing annual native seed	Native seed supply	Native seed supply	$3,000/yr	IDNR DoF, TNC

Problem Statement: *Nuisance and invasive species, detected throughout the Yellowwood Lake Watershed, are detrimental to native biodiversity and provide few valuable environmental functions such as nutrient uptake, soil stabilization, habitat, and forage.*

Goal (con't): Reduce the impact of exotic and nuisance flora and fauna in the Yellowwood Lake Watershed.

Objective: Control nuisance and invasive plants in Yellowwood Lake and the watershed to maintain and develop beneficial native ecosystems.

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Develop terrestrial plant management plan with IPM component	Strategic plan for terrestrial nuisance and invasive species control.	Technical advice	$5,000	IDNR DoF, TNC,
Develop aquatic plant management plan with IPM component	Strategic plan for aquatic nuisance and invasive species control.	Technical advice	$5,000	IDNR Division of Fish and Wildlife
Drawdown	Summer or winter drawdown to desiccate plants	IDNR DoF approval	---	---
Implement management options as identified in the management plans	  *Mechanical / Manual harvesting:* hand-pulling, raking *Physical Barriers:* bottom plant barriers and drawdown *Chemical Control:* herbicides and dyes registered and approved by the USEPA	Technical advice from IDNR District 8 Fisheries Biologist, IC 4-22-2 permit for control of aquatic vegetation	Rakes -$50 Benthic barriers - $10,000 Herbicides- $5,000	IDNR DoF
Restore native vegetation	Develop healthy native plant community that will be visually appealing and improve fish habitat	Native plant plugs, volunteer hours to install plants	$10,000	IDNR DoF
Construct habitat structures	 fish cribs and buried reef material to create dynamic habitat	Old pallets, wire, cement, blocks, volunteer hours	$100	IDNR DoF
Construct fishing jetties and a shoreline trail system for better access	 Rip Rap fishing jetties to create dynamic habitat	IDNR Division of Engineering approval and design plants, rip- rap	$20,000	IDNR DoF

Table 8.5. Action Register: Biological and Chemical Contamination

Problem Statement: *Biological and chemical contaminants pose an undefined threat to the Yellowwood Lake Watershed. This is primarily due overland runoff of pathogens, chemicals, and nutrients. Failed or failing septic systems, horses, and wildlife are known to contribute nutrients and pathogens while automobiles, fertilizers, improper chemical use/ storage, timber harvesting activities, and above ground fuel storage tanks have the potential to leak hazardous materials into the watershed. Beyond runoff, Yellowwood Lake is currently suffering from mercury contamination.*

Goal #1: Reduce the risk of chemical contamination from above ground fuel storage tanks, chemical usage and storage, illicit dumping, and stream crossings in the Yellowwood Lake Watershed.

Objective: Proactive Risk Management for chemical usage and storage

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Purchase land for new YSF maintenance area	DNR maintenance facility	Land away from Yellowwood Lake that is both available and accessible	$300,000	TNC, Indiana State Legislature
Educate those who reside in the watershed and watershed visitors about proper chemical storage and disposal	Brochures, newsletters that outline proper chemical use and storage BMPs	Technical advice	$200/yr	---

Objective: Proactive risk management for above-ground fuel tanks

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Educate above-ground fuel storage tank owners as to proper BMPs including: • Construct a shelters to shade fuel tanks to eliminate gasoline evaporation • Routine sweeping of and around fuel storage tanks • Build water bars/ berms/ or a secondary containment structures	 Shade shelters and secondary containment for above ground storage tanks	Building materials, permits for soil disturbance activities on IDNR property	$1,000	IDNR DoF, IDEM

Problem Statement: *Biological and chemical contaminants pose an undefined threat to the Yellowwood Lake Watershed. This is primarily due overland runoff of pathogens, chemicals, and nutrients. Failed or failing septic systems, horses, and wildlife are known to contribute nutrients and pathogens while automobiles, fertilizers, improper chemical use/ storage, timber harvesting activities, and above ground fuel storage tanks have the potential to leak hazardous materials into the watershed. Beyond runoff, Yellowwood Lake is currently suffering from mercury contamination.*

Goal #1: Reduce the risk of chemical contamination from above ground fuel storage tanks, chemical usage and storage, illicit dumping, and stream crossings in the Yellowwood Lake Watershed.

Objective: Increase waste disposal options for rural residents.

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Facilitate cooperative partnerships with County Solid Waste Management Districts and private waste removal businesses.	Improved trash collection system for watershed residents	Logistical assistance from local waste management district employees	---	---
Research sustainable systems of waste removal in rural areas.	Improved trash collection system for watershed residents	Technical advice from local waste management district employees	---	---
Increase the number of Amnesty Days for Yellowwood Lake Watershed residents.	Predetermined days when watershed residents can freely dispose trash a local landfills	Logistical assistance from local waste management district employees	$5,000/ event	Brown County Solid Waste Management Districts and Recycling Center
Annual clean-up days	Organized trash and recycling collection days for watershed residents to properly dispose and recycle of chemicals, batteries, and bulk items	Rent a large truck to haul away trash	$1,000/ event	Brown County Solid Waste Management Districts, Friends of Yellowwood

Problem Statement: *Biological and chemical contaminants pose an undefined threat to the Yellowwood Lake Watershed. This is primarily due overland runoff of pathogens, chemicals, and nutrients. Failed or failing septic systems, horses, and wildlife are known to contribute nutrients and pathogens while automobiles, fertilizers, improper chemical use/ storage, timber harvesting activities, and above ground fuel storage tanks have the potential to leak hazardous materials into the watershed. Beyond runoff, Yellowwood Lake is currently suffering from mercury contamination.*

Goal #1: Reduce the risk of chemical contamination from above ground fuel storage tanks, chemical usage and storage, illicit dumping, and stream crossings in the Yellowwood Lake Watershed.

Objective: Proactive Risk Management with industrial chemical applicators

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Review and update the current REMC agreement regarding the use of herbicides on utility easements	REMC's continued commitment to non-herbicide maintenance of utility easements	REMC personnel time to review agreement	---	---
Outline and review IDNR policies on chemical usage, for property maintenance, and site preparation BMPs	Informed YLWPG members	IDNR DoF personnel time to review agreement	---	---

Objective: Reduce the risk of chemical contamination at stream crossings.

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Construct water permanent stream crossings	Culverts and/or bridge	Technical assistance	$500,000	Brown County Highway Department

Problem Statement: *Biological and chemical contaminants pose an undefined threat to the Yellowwood Lake Watershed. This is primarily due overland runoff of pathogens, chemicals, and nutrients. Failed or failing septic systems, horses, and wildlife are known to contribute nutrients and pathogens while automobiles, fertilizers, improper chemical use/ storage, timber harvesting activities, and above ground fuel storage tanks have the potential to leak hazardous materials into the watershed. Beyond runoff, Yellowwood Lake is currently suffering from mercury contamination.*

Goal #2: Increase public education of mercury pollution in Yellowwood Lake.

Objective: Increase public awareness of Fish Consumption Advisories (FCA) in Indiana Lakes

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Obtain in formational materials about mercury contamination from ISDH	FCA material– posters, flyers, and/or booklets	Technical advice and materials from ISDH and IDEM	---	---
Circulate educational materials to YWLPG stakeholders, landowners, and watershed users	FCA material– posters, flyers, and/or booklets	FCA booklets and FAQ sheets on mercury for distribution	$200/yr	---

Objective: Legislative pressure to reduce mercury emissions

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Commence letter writing campaign	Letters and informational materials circulated to YLWPG mailing list	Technical advice on mercury issues, identification of current mercury issues	$500/yr	---
YWLPG letters of support for local, state, regional, and national mercury issues	Periodic YLWPG endorsed letters of support to local, state, regional, and national mercury issues	FAQ sheets to distribute, postage	$500/yr	---

Problem Statement: *Biological and chemical contaminants pose an undefined threat to the Yellowwood Lake Watershed. This is primarily due overland runoff of pathogens, chemicals, and nutrients. Failed or failing septic systems, horses, and wildlife are known to contribute nutrients and pathogens while automobiles, fertilizers, improper chemical use/ storage, timber harvesting activities, and above ground fuel storage tanks have the potential to leak hazardous materials into the watershed. Beyond runoff, Yellowwood Lake is currently suffering from mercury contamination.*

Goal #3: Reduce average *E. coli* loads by 20,000 E.coli / day in 5 years, and by 40,000 E.coli / day in 10 years to meet the State Water Quality Standards for *E. coli.*

Objective: Continued *E. coli* monitoring

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
E. coli monitoring in Jackson Creek	Monthly and period storm samples to track *E. coli* concentrations	Easy Gel Coliscan materials, trained volunteers	$200/ yr	Hoosier Riverwatch
E. coli monitoring in Yellowwood Lake	Monthly samples to track *E. coli* concentrations	Easy Gel Coliscan materials, trained volunteers	$200/ yr	

Objective: Promote septic system maintenance

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Educate septic system owners about proper maintenance	Decreased number of failing septic tanks , annual reminders about septic maintenance	Technical materials and experts	$200/yr	---
Work with Brown County Health Departments to create a cooperative partnership	Cost-share program for septic system improvement	Trust and scheduled meetings with Brown County Health Department and other local watershed groups	---	---
Develop cost-share program to encourage alternative septic systems		Grant funding	$250,000	---

Objective: Educate equestrian boarders about proper manure disposal BMPs

Action Items	Products	Resources Needed	Cost Estimate	Potential Financial Partners
Distribute educational materials to equestrian boarders	Brochures, newsletters, watershed packet inserts	Technical materials and experts	$200/yr	---

9. MONITORING EFFECTIVENESS

The Yellowwood Lake Watershed Planning Group is a partnership of concerned citizens and the Indiana Department of Natural Resources' Division of Forestry, dedicated to developing and implementing a successful watershed management plan to protect, enhance, and conserve Yellowwood Lake and its watershed. The YLWPG recognizes that continued cooperation, research, and financial support are critical components to the successful implementation of this plan.

The YLWPG steering committee will continue to meet on a regular basis for the purpose of implementing the plan. Continued member participation is vital to ensure the YLWPG vision and purpose are upheld. This will be accomplished by quarterly project reviews by the YLWPG chairperson. Annually, the steering committee will review the project efforts according to this Plan's goals, objectives, and action items.

The YLWPG acknowledges that this management plan is a living document that will need to be periodically updated to address changing and future concerns of its group members. Therefore, the YLWPG will host annual public meetings to solicit public input and participation in the watershed planning and implementation process.

Overall project progress will be tracked by measurable items such as attendance at events and BMPs installed. The ultimate goal, highest quality water resource obtainable, will be tracked by monthly water quality sampling to determine annual load reductions. The YLWPG monitoring plan (Tables 9.1-9.4) outlines the monthly, quarterly, and annual progress goals.

Table 9.1. Monitoring for Effectiveness: Group Sustainability

Problem: The YLWPG does not have any strategic plans or future funding sources for organizational sustainability or implementation of this watershed management plan's goals.

Progress Reports	**Indicator Description and Responsible Party**
Goal #1: Increase watershed user awareness about impacts of Nonpoint Source pollution on water quality.	
Semi-Annually	YLWPG will establish and update a watershed website
	YLWPG will circulate newsletters
Annually	YLWPG will update mailing list
	YLWPG will co-host Indiana Forested Watershed Symposium
	YLWPG will circulate BMPs and call for volunteers
Goal #2: Ensure continued financial and personnel support for YLWPG activities.	
Monthly	YLWPG trained volunteers will conduct water quality samples
Quarterly	YLWPG and IDNR will discuss how the partners can mutually benefit from each other
Annually	YLWPG will create and review list of absentee stakeholders, and invite them to actively participate
	YLWPG will conduct a strategic planning session
5 years	YLWPG will review possible grants to apply for

Table 9.2. Monitoring for Effectiveness: Sedimentation

Problem: Yellowwood Lake is filling in with sediment, causing the lake to lose depth and the expansion of macrophyte beds. Visual observations from HFF members suggest that this process has accelerated over the last decade. Sediments from the watershed can carry biological and chemical pollutants, increase water temperature, block sunlight, impair sight-dependent predation, and smother fish nesting sites. The soft, fertile sediments also provide a rich bed for aquatic plant establishment.

Progress Reports	**Indicator Description and Responsible Party**
Goal #1: Reduce storm event Total Suspended Solid (TSS) loads in the Jackson Creek by 145 lbs/day to minimize depth loss in the north end of Yellowwood Lake.	
Monthly	YLWPG will conduct monthly sediment samples, including major storm event samples
Quarterly (as needed)	YLWPG will conduct QHEI surveys as part of the monthly water quality sampling
	YLWPG will install, monitor, and maintain temporary sediment traps
	YLWPG will document signs of ditch and stream bank erosion with digital photographs and GPS points
	IDNR and YLWPG will review progress on any public timber sales
Annually	YLWPG members will estimate average sediment load reduction
	YLWPG and IDNR DoF will schedule volunteer trail work days
	YLWPG members will circulate updated BMP materials to watershed landowners
	YLWPG will meet with Brown County Highway Department to discuss road improvement projects
	YSF will include shoreline stabilization project in their budget request
Every 2 years	YLWPG will survey Yellowwood Road and Jackson Creek for improved model inputs
5 years	YLWPG will have restored 7 miles of stream bank
	YLWPG will have replaced 25% of damaged culverts
One time event	YLWPG will review and begin research into dredging feasibility study
	YLWPG members will identify and contact professionals who may be interested in a long term sediment study

Table 9.3. Monitoring for Effectiveness: Nuisance and Invasive Species

Problem: Nuisance and invasive species, detected throughout the Yellowwood Lake Watershed, are detrimental to native biodiversity and provide few valuable environmental functions such as nutrient uptake, soil stabilization, habitat, and forage.

Progress Reports	**Indicator Description and Responsible Party**
Goal #1: Reduce the impact of exotic and nuisance flora and fauna in the Yellowwood Lake Watershed.	
Quarterly	YLWPG will review comment cards and any new locations of invasive species for immediate management
	YLWPG will GPS locations of new reported invasive species infestations
	YLWPG and IDNR will contact local newspapers for support of shoreline improvement plan
Annually	YLWLPG and IDNR DoF will discuss drawdown options
	YLWPG will circulate updated invasive species information to watershed landowners and watershed users
	YLWPG will report progress on development of brush stations and disturbance response kits with IDNR DoF and TNC
	YLWPG will host invasive species workshops
	YLWPG, HFF, and IDNR will construct habitat enhancement projects (e.g. cribs)
	Either IDNR Fisheries Biologist or HFF will present written or oral fishery report to YLWPG
	YLWPG will work the IDNR Fisheries Biologist to conduct a creel survey
One Time Event	YLWPG will work with IDNR to schedule a drawdown to control aquatic vegetation

Table 9.4. Monitoring for Effectiveness: Chemical and Biological Contamination

Problem: *Biological and chemical contaminants pose an undefined threat to the Yellowwood Lake Watershed. This is primarily due overland runoff of pathogens, chemicals, and nutrients. Failed or failing septic systems, horses, and wildlife are known to contribute nutrients and pathogens while automobiles, fertilizers, improper chemical use/ storage, timber harvesting activities, and above ground fuel storage tanks have the potential to leak hazardous materials into the watershed. Beyond runoff, Yellowwood Lake is currently suffering from mercury contamination.*

Progress Reports	**Indicator Description and Responsible Party**
Goal #1: Reduce the risk of chemical contamination from above ground fuel storage tanks, chemical storage, illicit dumping, and stream crossings in the Yellowwood Lake Watershed	
Quarterly	YLWPG will report progress on relationship with County Solid Waste Management Districts and privately-owned solid waste management operations
	YLWPG will review progress on steam crossings, reporting any signs of spills or damaged car parts
Annually	The YLWPG will distribute updated BMPs and stewardship reminders to landowners
	IDNR will report on prospects of a new land purchase for YSF maintenance area
	YLWPG will invite REMC and IDNR to review herbicide policies
Goal #2: Increase public education of mercury pollution in Yellowwood Lake	
Quarterly	YLWPG will review current policies regarding mercury pollution, and circulate letters as necessary
Annually	The IDNR will update educational signage to reflect any changes in the FCA warning for Yellowwood Lake
	YLWPG will distribute educational materials on changes in the FCA warning for Yellowwood Lake
Goal #3: Reduce average E. coli loads by 20,000 E.coli / day in 5 years, and by 40,000 E.coli / day in 10 years to meet the State Water Quality Standards for E. coli.	
Monthly	YLWPG members will sample E. coli in Jackson Creek and Yellowwood Lake
Annually	YLWPG members will estimate average load reduction as a result of improved septic system maintenance and equestrian BMPs
5 years	YLWPG will inventory septic systems in the watershed, YLWPG will calculate load reduction to see if target reduction of 20,000 E. coli/day goal was reached
10 years	YLWPG will calculate load reduction to see if target reduction of 40,000 E. coli/day goal was reached, and the average water sample meets Indiana Water Quality Standards

10. REFERENCES AND APPENDICES

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APPENDIX A. INFORMAL RECRUITING LETTER

Dear Yellowwood Lake neighbor,

Last fall, the Friends of Yellowwood, a group of local residents committed to the well being of Yellowwood State Forest, and officials from the Division of Forestry, Indiana Department of Natural Resources, met to discuss ways we could work together. This discussion led to the creation of a partnership to develop a management plan that would "protect, enhance, and conserve Yellowwood Lake and its watershed."

For a plan to succeed, everyone with a stake in the watershed should have a chance to have input into the plan. As a property owner in the Yellowwood Lake watershed, your participation in the creation of the plan is sincerely encouraged.

Although only 20% of the land in the watershed is in private ownership, activities on private land have direct and important impacts on the lake. With your help, we hope to understand what these impacts are and how best to preserve and enhance what is considered the third purest lake in Indiana. Your involvement, even in this very early stage, will help us craft a watershed plan that addresses the concerns and meets the needs of property owners in the watershed.

We are all very fortunate to live and work in such an extraordinarily beautiful and relatively undisturbed area. Our quality of life is enhanced by our proximity to the State Forest and the lake, as are our property values. We owe it to future generations to preserve this unique and lovely resource so that our children and their children may experience it for themselves.

If you are interested in learning more about the Yellowwood Lake Watershed Planning Group, please give us a call at either of the following numbers, or contact us via email at one of the addresses below. We're planning a watershed awareness day for Saturday, April 21st; keep your eyes open for our next mailing with details. We look forward to hearing from you!

Sincerely,

Yellowwood Lake Watershed Planning Group

For the Friends of Yellowwood:
Linda Baden and Charles Cole
1504 Yellowwood Lake Road
Nashville, In. 47448
(812) 988-0025
lbaden@indiana.edu

For the Division of Forestry, Yellowwood State Forest:
Brenda Stine, Resource Specialist
Yellowwood SF Headquarters
772 Yellowwood Lake Road
Nashville, In. 47448
(812) 988-7945
bstine@dnr.state.in.us

APPENDIX B: INDIANA FORESTD WATERSHED SYMPSIUM AGENDA

Indiana Forested Watershed Symposium
Thursday, April 6, 2006
Abe Martin Lodge, Brown County State Park

Sponsored by: YLWPG, IDEM, TNC, IDNR-DoF, BCSWCD, and HHRC&D

Agenda

9:30 – 9:35	**Welcome, Logistics (breaks, restrooms, questions, lunch, displays),** **Quick mention of YLWPG, mission and watershed plan (Dan)**
9:35 – 10:00	**Dan Ernst, IDNR Division of Forestry** **Introduction on Indiana Watersheds** (Dan Shaver will introduce and field questions)
10:00 – 11:15	**Les Wadzinski, Hoosier National Forest** **Recreation and Trails** (Yvette will introduce and field questions) (Dan will send group to break)
11:15 – 11:30	**Break**
11:30 – 12:15	**Karyn Moskowitz, Green Fire Consulting Group, LLC** **Non-commodity Economics** (Linda will introduce and field questions) (Dan will send the group to lunch)
12:15 – 1:00	**Lunch**
1:00 – 1:45	**Laura Bowling, Purdue University** **Sedimentation** (Jennifer will introduce and field questions)
1:45 – 2:30	**Steve Hall, FMSM Engineering** **Sedimentation** (Jennifer will introduce and field questions)
2:30 – 2:45	**Break**
2:24 – 3:30	**Keno Koehl, Hoosier National Forest** **Roads** (Yvette will introduce and field questions)
3:30 – 4:15	**Vicky Meretsky, IU SPEA** **Biodiversity** (Dan will introduce and field questions)
4:15 – 4:20	**Wrap-up, thank all speaker and sponsors (Dan)**

APPENDIX C: YLWPG GROUP MEMBERS AND STAKEHOLDERS

Group Members
Jim Allen, Yellowwood State Forest
Linda Baden, Friends of Yellowwood, watershed landowner
Charles Cole, Friends of Yellowwood, and watershed landowner
Forest Gras, Indiana Forest Alliance, and watershed landowner
Joanna Gras, Heartwood, watershed landowner
Gerald Long, area landowner, Indiana Forestry and Woodland Owner's Association
Tim Mather, Larry Barber (to 2003), Hoosier Flyfishers
Chris Riehl, Indiana Trailriders Assn.
Yvette Rollins, Indiana Horse Council and the Indiana Trail Riders Association
Tim Roualet, logger (to 2006)
Sarah Sauter, Watershed Coordinator, Indiana University graduate student
Dan Shaver, The Nature Conservancy
Brenda Stine, Yellowwood State Forest, DNR (to 2004)

Stakeholders
DNR Division of Forestry (Jim Allen)
DNR Division of Soil and Water Conservation (Jerod Chew)
DNR Division of Fish and Wildlife (Larry Lehman)
REMC (Larry Terrell)
IDEM Watershed Division (Nathan Rice, Jennifer Boyle)
Watershed residents (55 landowners in YSF database)
Friends of Yellowwood (Charles Cole, Brad Salmon, Linda Baden)
Environmentalists (Forest Gras, Indiana Forest Alliance; Joanna Sparks; Heartwood)
Logging Industry (Tim Roualet, Indiana Forest Industry Council, Indiana Hardwood Timberers Assn.)
Horsepeople (Chris Riehl, Yvette Rollins, Indiana Trailriders)
Fisherpeople (Tim Mather, Kevin Montague, Dan Willard, Hoosier Flyfishers)
Recreational users of watershed and lake
Educators (Jen Weiss, William Jones, Dan Willard, Leah Garlotte)
Forest Issues (Dan Shaver, The Nature Conservancy; Gerald Long, Indiana Forestry and Woodland Owner's Association; Tim Roualet, Blue Ox Timber Company; Jim Allen, IDNR Division of Forestry; Forest Gras, Joanna Sparks, Indiana Forest Alliance)
Hikers (Susan Middeldorf, Hoosier Hikers' Council)
Researchers (Laura Bowling, Purdue; Bill Jones, IU SPEA)

APPENDIX D: YLWPG CHARTER

Yellowwood Lake Watershed Planning Group Charter

Background

In October 2000, a group of local residents and other stakeholders committed to the well being of Yellowwood State Forest joined with officials from the Indiana Department of Natural Resources' Division of Forestry to develop a management plan that would "protect, enhance, and conserve Yellowwood Lake and its watershed."

Current activities within the heavily forested (90% of total acreage) watershed include logging on state and private land, residential development, and private equestrian facilities. The forest is visited by an estimated 200,000 people each year, many of whom come to camp, boat, hike, fish, hunt, and picnic, gather wild foodstuff, bird watch, ride horses, and study and photograph nature. As the center of developed facilities within the forest, the area around the lake receives more use than the majority of the forest. Yellowwood's two developed camping areas—one for general use and the other reserved for horseback riders—the forest office, picnic area, and boat rental area are all located directly on the lake shore. Boaters and fishermen frequent the lake area as do admirers of particularly rare species such as the freshwater jellyfish that appear in the lake in the fall; bird-watchers prize the Yellowwood Lake area because it has one of the highest migratory bird census counts in Indiana. Special habitats are also present near the lake, such as the extensive wetland at the top of the watershed.

Many of the activities on the lake and in the watershed cause substantial ground disturbance as well as increased chemical input into the lake. As population in the area increases, recreational use is expected to continue to rise. Similarly, residential development on the 20% (ca. 900 acres) of private land within the watershed is likely to increase. Thus, the decisions facing the managers of the forest regarding allocation of land and other resources to facilitate, manage, and mitigate the activities in the watershed area are becoming increasingly more complex and require the best available data on their impacts.

Anecdotal accounts by long-time residents within the watershed, fisherman that have long frequented the lake, as well as officials of the forest itself describe an ongoing trend of sedimentation in the lake since its creation in 1939. In order to assess the accuracy of these accounts, a depth survey was conducted during the summer of 2002 by the Hoosier Fly Fishers (HFF), with the professional assistance of Dr. Dan Willard. The data collected during this survey were then compared to lake depth data collected by the IDNR Division of Water in 1955. The results of this survey show an average loss of depth throughout the lake of 2.4 feet. At some points as much as 4 to 5 feet of depth appear to have been lost since the 1955 measures. Unfortunately, we have been unable to obtain any detailed account of the methods used to conduct the original 1955 survey and are thus unsure of the level of accuracy that can be attributed to that data. The data recently collected by the HFF, however, are considered to be extremely reliable as a baseline by which future sedimentation can be measured.

Purpose

The Yellowwood Lake Watershed Planning Group (YLWPG), with funding from a 205(j) federal grant, has been working to develop a watershed management plan that will "protect, enhance, and conserve Yellowwood Lake and its watershed," while identifying and addressing current and potential threats to the health of the lake and its watershed (including the mercury contamination that has resulted in a fish consumption advisory and 2002 303(d) listing). With stakeholder input, the plan will prioritize the many, sometimes competing, demands on the watershed and the lake.

The Yellowwood Lake Watershed Planning Group envisions a plan that will serve as a model for planning in a heavily forested watershed; allow for a variety of human activities within a healthy, biodiverse ecosystem; and provide for the highest quality water resource obtainable. Once a plan has been adopted and implemented, the YLWPG will continue to serve as an advisory body to the DNR and watershed stakeholders, focusing on the long-term health and well-being of the lake and its watershed.

Study Area

Yellowwood Lake is located in the northwestern portion of Brown County in Southern Indiana. The 133-acre reservoir was created by damming Jackson Creek in 1939 as part of the Bean Blossom Land Utilization Project of the United States Bureau of Agricultural Economics. The Yellowwood Lake watershed comprises almost 4,400 acres, 80% of which (ca. 3,500 acres) is publicly owned and managed by the Division of Forestry, Indiana Department of Natural Resources (IDNR), as Yellowwood State Forest (YSF). The remaining 20% (ca. 900 acres) is privately owned by approximately 55 families or individuals. Ninety percent of the watershed is forested; the built environment consists of homes, barns, sheds, and pastures; State Forest facilities, logging roads, and trails; utility easements; and one paved and 3 gravel county roads. Located ten miles east of Bloomington, Yellowwood State Forest is 50 miles south of Indianapolis, and 22 miles west of Columbus. More than 800,000 people live within a 50-mile radius of the lake.

Stakeholder Groups and Participants

The planning process itself already has forged, and will continue to foster, a community of individuals and groups—including area residents, recreational users, IDNR resource managers, university faculty and students, loggers, local officials and citizens groups, utility operators, and others—dedicated to preserving this rare water resource.

<u>Members and Alternates.</u> In the event that a Group member cannot attend a meeting, he/she may be represented by an alternate of his /her choosing without concurrence of the Group. Alternates are encouraged to attend Group meetings along with the Group member, but should be fully briefed by the Group member before attending any meetings as the sole representative.

<u>Voluntary Withdrawal and Replacement Appointments.</u> If a Group member withdraws from the Group, he/she may appoint a replacement (typically their alternate) From the same organization without concurrence of the Group. If the member is unable to appoint a replacement from his/her organization, the facilitators may appoint a replacement member from the same Primary Interest Category. Replacement members are expected to take the learning initiative and spend extra time prior to their first Group meeting reading through all the past meeting summaries and this charter and talking with the facilitators and other Group members to be sure they understand the state of the Group's activities, how the Group operates and what will be expected of them. Replacement members should strive to minimize the impact of the loss of the member they're replacing on the Group's progress toward its goal (i.e. a set of consensus recommendations).

New Member Appointments

A strong effort was made during the forming of the Group to encourage participation by representatives from all the various interests in the study area. While it is certainly the Group's desire to be inclusive and sensitive to the many various interests, the Group recognizes the need to remain focused and moving ahead if the Group's goal (i.e. a set of consensus recommendations) is to be achieved. When evaluating potential new members, the Group should first ensure that the interests that the potential new member would represent cannot reasonably be covered by an existing Group member. If the Group decides there is in fact a need to have additional interests represented, then the Group will identify potential candidates and review their qualifications (e.g. past experience in collaborative Group processes, knowledge about the issues and the interests they represent communications mechanisms for sharing information, etc.). The Group will decide by consensus if a particular candidate should be added to the Group. Once added to the Group, new members are expected to spend extra time prior to their first full meeting educating themselves on the Group's history, operations and expectations in the same fashion as is required for replacement Group members. New members must make every effort to minimize the impact of their addition on the Group's progress toward its goal (i.e. a set of consensus recommendations). Once the active negotiations have begun (i.e. once a comprehensive trial balloon (see below for description of trial balloons) has been floated to the Group), new members will not be added unless the Group decides by consensus that the specifics of the trial balloons under consideration significantly impact previously unidentified Primary Interest Categories.

Constituent Representation
Group members will be expected to represent (1) themselves, (2) organizations to which they belong; or (3) groups of constituents from a similar Primary Interest Category. Ideas presented within Group discussion will not be assumed to be the official position of the organizations or groups represented unless specifically stated to be so.

Responsibilities of Group Members
<u>Attending Meetings</u> .
Each Group member or alternate is expected to attend Group meetings and Group Members are expected to fully participate in all meetings. In the event that a member or alternate is not able to attend a meeting of the Group, and the member is not in agreement with any actions taken by the Group during his/her absence, that member has until the meeting
summary review at the next meeting to register his/her dissatisfaction with actions taken. A limited amount of time will be devoted to old business at meetings. E-mail may be used to expedite this process.

<u>Preparing for Meetings</u>
Group members shall read appropriate materials and arrive prepared to work. Materials presented for discussion must be distributed at least one week in advance of the meeting or as practical.

<u>Keeping Constituents Informed</u>
Members are expected to keep constituents informed through active but informal means. Members will receive meeting minutes and flip chart summaries for keeping constituents informed.

<u>Understanding and Abiding by the Charter</u>
Group members and alternates are expected to read, fully understand and conduct themselves in accordance with the requirements of this charter.

Responsibilities of the Meeting Chairs
Meeting Chairs will be chosen from the Group on a rotating basis for a term of three months. The primary task of the meeting chair is to guide the meetings to stay within the bounds set by the Group's charter. The responsibilities include managing the Group's agenda, ensuring written records of the meetings are kept and circulated, helping the group stay on task and on process, protecting Group members and their ideas from attack, and helping members reach consensus. The meeting chairpersons will not express their views on any substantive issues and will be solely concerned with the process of the group. Facilitators may be brought in from outside the group when necessary.

Meeting Summaries

The watershed coordinator, acting as Group secretary, will keep minutes and disseminate them to the Group members, alternates and interested parties. Summaries from the previous meeting will be sent out at least one week prior to each upcoming meeting. Email will be the primary form of information dispersal and correspondence with the option of having material faxed or mailed to those that do not have access to email. Summaries shall include an attendance record, a summary of actions taken at the meeting, and other information pertaining to the deliberations. Discussion of new substantive issues will not commence until the summary of the preceding meeting is approved.

Agendas
At the end of each meeting, the Group will specify a tentative agenda for the following meeting. The meeting chair will develop draft-meeting agendas prior to each meeting. Final agendas will be approved by the Group at the start of each meeting and will include opportunities for public comment as required by this charter.

Roster
The watershed coordinator, acting as Group secretary, will maintain a roster listing the names and contact information of individuals who have agreed to: (1) participate as active members and alternates of the Group; (2) abide by this charter; and (3) demonstrate a desire to reach consensus through this process.

Decision Process
<u>Use of Consensus</u>
The Group will operate by consensus and Group decisions will be made only with concurrence of all members represented at the meeting. Consensus is the decision rule that allows collaborative problem solving to work. The rule allows building of trust and the sharing of information, especially under conditions of conflict. Consensus does not mean that everyone will be equally happy with the decision, but all do accept that the decision is the best that could be made at the time.

Consensus requires sharing of information, which leads to mutual education, which, in turn provides the basis for crafting workable and acceptable alternatives. Consensus promotes joint thinking of a diverse group and leads to creative solutions. Also, because parties participate in the deliberation, they understand the reasoning behind the recommendations and are willing to support them.

In making decisions, each Group member will indicate his/her concurrence on a specific proposal using a five-point scale. The scale allows Group members to clearly communicate their intentions, assess the degree of agreement that exists, and register their dissatisfaction without holding up the rest of the Group. The five-point scale is as follows:

1 —Endorsement (i.e. Member likes it).
2 —Endorsement with Minor Point of Contention (i.e. Basically, member likes it).
3 —Agreement with Minor Reservations (i.e. Member can live with it).
4 —Stand Aside with Major Reservations (i.e. Member doesn't like it, but doesn't want to hold up the Group)
5 —Block (i.e. Member won't support the proposal and intends to block it).

Facilitators will measure the Group's consensus on a given proposal by open polling of the Group members present. Ratings will not be considered from any alternates or interested parties present when determine the Group's level of consensus. The levels of consensus are:

- Consensus—All Group members present rate the proposal as a 1, 2 or 3.
- Consensus with Major Reservations—All Group member's present rate the proposal as a l, 2 or 3, except at least one Group member rates it as a 4.
- No Consensus—Any Group member present rates the proposal as a 5.

When measuring consensus for very important decisions (e.g. the Group's final recommendations), the facilitators will typically conduct a role call allowing each Group member to rate the proposal in question one at a time and acknowledging the Group member's rating.

For the Group's final written report, any Group member that rates a recommendation as a 4 can specify their dissention in a written statement of 500 words or less for inclusion in the final written report if the member so chooses. Any Group member that rates a recommendation as a 5 is required to specify their dissention in a written statement of 500 words or less for inclusion in the final written report. Dissenters who share the same basic concerns can use a single dissention statement of 100 words or less. Dissenters will also identify themselves by name / organization on their dissention statements. The number of members standing for or against any proposal will not be reported.

Summary of the majority opinion shall accompany the final recommendation.

Use of Trial Balloons to Reach Final Consensus Recommendations

A trial balloon is defined as an informal, preliminary proposal that attempts to comprehensively bring together recommendations to address the Group's issues and interests. Trial balloons are completely non--binding and may be withdrawn, in whole or in part, at any time prior to signing an agreement. Trial balloons are very helpful tools for progressing the Group towards consensus and Group members are encouraged to use them liberally. Because the interests vary and often compete with each other, Group members should structure trial balloons to address all the primary interests, not just the particular Group member's interests (i.e. keep trial balloons focused on mutual gains and remain open to compromise).

Input from and Information to the Public, News Media, Elected Officials

The Group is intended to be representative of the public through the members' own organizations or affiliations, as well as through their work with other groups. All Group meetings are open to observation by the public, except for closed meetings (see below). A public comment period(s) of set duration (near the beginning, at the end or both) will be provided at each meeting of the Group and public speakers will have time limits set to allow as much participation as possible. The Group will not normally attempt to respond to public comments at the meeting in which they were made. The meeting chairs have the right to deny the floor to public speakers that are simply repeating previously delivered messages or that are unruly and chairs will ask unruly public speakers to leave the premises. Summaries of Group meetings will be available to the public upon request and will also be available on the Group's website.

Except for closed meetings (see below), members of the press are welcome to attend Group meetings. Group members and alternates are present to present their interests and the interests of the groups and organizations they represent to the media. Group members and alternates will not address specific positions held by other Group members or alternates, or negatively characterize the Group, other Group' members, alternates, represented organizations or their interests in the media. Group members and alternates will also advise the leadership of organizations they represent that their organization should not participate in these negative media statements. Press points will be available at the end of each meeting. Group members, alternates and the organizations they represent will reframe from negotiating through the news media and will therefore avoid strong statements, whether for or against, to the media concerning the trial balloons of any Group member.

Group members acknowledge a common desire to allow the Group the greatest opportunity to reach consensus agreement on its final recommendations. Group members therefore will not encourage elected officials to adopt resolutions or take positions for or against any trial balloons proposed by Group members. Nothing shall prevent members of the Group from approaching any agency or organization for the purpose of gathering information.

Closed Meetings
For the discussion of personnel issues only, the Group may determine that all or a portion of a meeting should be closed.

Ground Rules
In order *to* have the most efficient and effective process possible; Group members and alternates will follow these basic ground rules:
A. Treat each other, the organizations represented in the Group and the Group itself with respect at all times and put personal differences aside in the interest of a successful Group.
B. Stick to the topics on the meeting agenda; be concise and not repetitive.
C. Work as Group players and share all relevant information. Focus on honesty with tactfulness.
D. Ask if they do not understand.
E. Openly voice any disagreement with other members in the meetings.
F. Look for mutually beneficial solutions.
G. Follow through on their commitments.
H. Share information discussed in the meeting with the organizations / constituents represented.
I. Encourage freethinking and share relevant information with the Group.
J. Commit to issues in which they have an interest.
K. Speak one at a time in meetings as recognized by the facilitator.
L. Everyone will participate, but none will dominate.
M. Focus on the problem, not the person.
N. Agree that it is OK to disagree.
O. Honor a two-minute time limit for statements and responses.

Dismissal of Group Members or Alternates
Group members and alternates acknowledge the importance of understanding this charter and communicating effectively with the organizations they represent. They also acknowledge that the success of the entire Group depends on their personal commitment to reach consensus and to conduct themselves according to the basic principles set out in this charter. Any Group member or alternate can be dismissed From the Group if the Group determines by consensus that the member or alternate's actions or the official actions of the organization they represent have been substantially contrary to the Group's charter.

<u>Procedure</u>
Any Group member can propose the dismissal of another member or alternate at any time. The member proposing the dismissal will inform the facilitator and, the facilitator will inform the member or alternate that has been proposed for the dismissal and will establish a closed session of the Group prior to beginning the Group's discussion. In the closed
session, the Group member proposing the dismissal will provide a brief explanation of the grounds for dismissal, particularly pointing out actions taken that were contrary to the Group's charter. The member or alternate that is proposed for dismissal will be given an opportunity to explain their actions or the official actions of their organization to the rest of the Group, either during the same closed session, or during a closed session at the next Group meeting. The Group member or alternate that was proposed for dismissal will be required to leave the room prior to the Group's deliberations. If an alternate is proposed for dismissal, the associated Group member will abstain from the decision-making process (i.e. the five-point scale rating). In rating proposals to dismiss members or alternates, Group members will not accept a lack of knowledge of the charter's requirements or a lack of clear communication between the Group member or alternate and their organization's officials as legitimate explanations for contrary behavior.

Actions Upon Dismissal

If the Group determines that dismissal is in order, the member or alternate will be asked to leave the premises for at least the remainder of that particular meeting and may only participate as a public observer in future Group meetings. Dependent on the circumstances, the Group may also decide that the individual will not be allowed to return to any future meetings in any capacity. If the cause of the dismissal was official actions of the member or alternate's organization contrary to the charter, the organization will not be allowed to have any members or alternates on the Group. Under no circumstances will:

- A Group member or alternate be re-instated to the Group once they have been dismissed.
- The Group will decide if appointment of a suitable replacement is in order and will pursue replacements as necessary. . . .
- A Group member or alternate be dismissed simply because they or the organization they represent doesn't agree with the positions or interests of the rest of the Group.

Changes to the Charter

Changes to the charter can be made at any meeting of the Group through a consensual procedure.

Revised and adopted: July 20, 2005---Yellowwood Lake Watershed Planning Group

Jim Allen, Property Manager, Linda Baden, Charlie Cole, Dan Shaver, Yvette Rollins, Joanna Gras, Forest Gras, Tim Mather, Sarah Sauter (Watershed Coordinator), Gerald Long

APPENDIX E. REVIEW PROCESS

Review Questions, Approved March 23, 2004.

Yellowwood Lake Watershed Project Review

1. **What are the purposes, benefits and possible alternatives of project?**
    a) What is the purpose and potential benefits of the activity?
    b) What benefits would be realized by not conducting this activity?
    c) Are there environmentally friendly alternatives materials, equipment, or methods that could be utilized?
    d) Are there alternative actions that would fulfill the purpose and benefits of the activity?

2. **How does the activity contribute to the conservation [and enhancement] of biological diversity of the forest and the Yellowwood watershed?** (11)
    a) How will the activity impact biodiversity on the site and at the watershed level?
    b) Have forest dynamics, major disturbances, and catastrophic events been factored into biodiversity decision-making?
    c) Has the integrity of unique habitats (glades, seeps, rock outcrops, etc.) been maintained within the activity area? Have unique habitats and sites at environmental risk been identified and protected by the activity?
    d) What impacts will the activity have on wildlife within the watershed? How does this fit in with the overall wildlife management for the area?

e) According to the Natural Heritage Database and site-specific information, what species of state and global significance are impacted by this activity? Are any known endangered, threatened, rare or special concern species impacted? If negative impacts exist, can the activity be modified to avoid or lesson the impacts? Has available expertise been contacted to assess the impact?

    f) What follow-up work will be required to mitigate the effects of the planned activity or to ensure sustainability?
    g) What plans have been made to prevent and monitor for the encroachment of invasive species? How would the introduction of invasive species affect adjacent sites?
    h) Will this activity lead to forest fragmentation? What impacts could occur due to the effects of fragmentation within the scope of this particular site?

3. **How does the planned activity maintain or improve the productive capacity of the site and the watershed?**
    a) Have significant non-timber products and habitats been identified?
    b) Have growth, mortality, and harvest rates on the site and in the watershed been determined?
    c) What plans are there for regeneration?
    d) Will the activity maintain the long-term capacity of the site for timber production and watershed protection?
    e) Will BMP-trained loggers be used? What training will be required of contractors? (We would like to pursue a requirement that all loggers have attended BMP training before operating within the watershed.)
    f) What kind, amount, and duration of supervision will be given to the activity by the YSF staff?
    g) Does sustainability standard exist for this type of activity? If so, does the activity comply with the standard? Has the accumulative impacts been considered?

4. **How does the proposed activity maintain the [long term] health and vigor of the forest and its watershed?** (11)
   a) Are tree species selection, stocking levels, age-class distribution, regeneration methods, insect and outbreaks, fuel loads, and wildfires being managed to reduce risk and insure long-term forest vigor?
   b) Are fuel loads, insect and disease populations, and overall forest vigor taken into account in the proposed activity?
   c) Does the proposed activity include plans to monitor, prevent, and respond to incidents (fire, chemical spills, trespass, etc.) and include cooperation with local, state, and federal agencies and neighboring landowners as appropriate?
   d) What is the approximate biomass of this site? What effect will the proposed activity have on the level of biomass?

5. **What provisions are made to protect soil and water resources?**
   a) Is current mapped data on soils and terrain included in the plan and used in management decisions?
   b) Are storm dynamics recognized and planned for?
   c) How will soil stability, water quality, and soil productivity be protected and enhanced? What provisions have been made to control soil movement?
   d) Are appropriate guides and plans in place and followed in road placement, log landings, design, maintenance, and retirement, especially at stream crossings?
   e) Are fire use, management, and response planned for and conducted appropriately?
   f) Are the State Best Management Practices understood and incorporated in the plan and complied with during all phases of the activity?
   g) Are wetland hydrological function and aquatic habitat considered in the proposed activity?
   h) What is the "background" level of sediment for this site, and how will the activity change this?
   I) What provisions are in place to contain any noxious spills? Will heavy machinery be inspected for leaks and spills?

6. **What social and economic benefits and impacts will the proposed activity have?**

   a) Have both long-term and short-term economic and social goals for the site, landscape, and region been considered in the proposal?
   b) What are the potential economic and social costs of this activity?
   c) What user conflicts are likely to occur (short-term and long-term) and how will they be mitigated?

7. Does the proposal comply with laws and rules and implement applicable guidelines?
   a) Have sites with cultural or archeological uniqueness or significance been identified and considered?
   b) Is the project in compliance with local, state, and federal laws, regulations, and state BMP guidelines?
   c) Will safety rules be followed during the planning and conduct of the activity? What are they?
   d) What are the potential impacts on neighbors and the community during the proposed activity?
   e) How will aesthetic concerns be taken into consideration?

f) How does this activity fit into existing local land use plans and ordinances? If not, what are the discrepancies, and can they be mitigated?
g) Does the activity fit into the overall management plan for Yellowwood State Forest? Does the activity fit within the short- and long-term goals for the site impacted?
h) How has the public been given the opportunity to comment on the activity?

8. What impacts cannot be avoided by this project?

a) What irreversible and irretrievable commitments of resources that would be involved if the proposed action should be implemented?
b) What adverse short and long term environmental impacts are expected that cannot be avoided should the proposal be implemented? Are the impacts substantial enough to halt the proposal?

YLWPG Project Review Process
Process Approved 2/15/05 by YLWPG

The Yellowwood Lake Watershed review committee has been established to review and evaluate private and public projects within the watershed and to make recommendations to the Yellowwood Lake Watershed Planning Group (YLWPG), based on the guidelines contained in the watershed plan. Below is an outline of the process.

1. A standing chair for the review committee is selected by the YLWPG and will be responsible for the process.

2. A project review is initiated. If a project is active, then the review chair should contact project manager and request permission to provide recommendations.

3. The project review is assigned to a 3-4-person sub-committee; the project initiator should be on the committee but is not required to be, especially in the case of private landowners.

4. The sub-committee clarifies the project.

5. Subcommittee notifies stakeholders (including YLWPG) by mailings, e-mail, or phone calls. Notification should include the description of the project, project location, public input meeting date/location, mission statement of group, and contact information. Key stakeholders and experts should receive follow-up phone calls.

6. Sub-committee gets appropriate public input: could be any of the following, open house, newspapers, bulletin board, mailings, public meetings, or others. Method will be based on the needs of the proposal. All communications about the project will include ways the public can comment on the proposal. All projects may not need public input at this stage. If a public meeting is held, it should include a facilitator, introduction, public comment period, and committee review of written comments and outside expert advice. If possible, a recommendation should be made from group.

7. Sub-committee provides an analysis of impacts to the YLWPG after completion of review and consideration of comments. The YLWPG will be provided with sub-committee project materials in advance of this meeting.

8. Group reaches a consensus decision. *Decision document should include a summary of the recommendations of the group.*

9. Stakeholders are notified of the decision. It should be noted this is an advisory group, and the decision should be to advise ways to improve the project to prevent negative impacts to the watershed, although recommendations for or against the project may occur.

It is recommended that the YLWPG be informed of the process along the way. Projects to be considered are State Forest projects listed at the open houses, soil-disturbing projects, projects directly impacting the lake, activities that offer educational opportunities, and others as deemed necessary.

A record of projects and decisions are to be keep so we can determine the need for review of future projects. A fact sheet could be developed for similar projects that can be given to project managers to guide them and eliminate the need for duplicate reviews.

If a public meeting is held we need to make sure the public knows what we are wanting from them. The public should know the purpose is to provide advice to mitigate impacts of projects, and not just to ascertain if they agree or disagree with the project.

The Review committee will be responsible for follow-up assessments of the completed projects, with written reports to be included as part of the documentation of the project.

Purpose of the review committee

The Yellowwood Lake Watershed review committee has been established:
1. To formalize a review process to evaluate private and public projects within the watershed and
2. To implement the process and make recommendations to the Yellowwood Lake Watershed Planning Group (YLWPG), based on the guidelines contained in the watershed plan.
3. To follow-up on completed projects and assess their success or failure.

APPENDIX F. 2005 PRIVATE LANDOWNER SURVEY

Dear private landowner,

On July 2004 the Yellowwood Lake Watershed Planning Group (YLWPG) received a grant from the Indiana Department of Environmental Management (IDEM) to develop a long-term management plan for the Yellowwood Lake watershed. The Yellowwood Lake watershed includes all of the land that drains into Yellowwood Lake. The watershed includes approximately 3,500 acres of Yellowwood State Forest and 900 acres of privately owned land (map enclosed). We have contacted you because you live in the Yellowwood Lake watershed.

The goal of our watershed management group is to develop a plan that will protect, enhance, and conserve Yellowwood Lake and its watershed while allowing for human uses. In our efforts to understand human uses in the watershed, we have developed a 21-question private landowner survey. We hope that you will help us by spending a few minutes to fill out this **anonymous** survey. The survey includes questions about how you use both the State property and your own land.

The results of the survey will help us in two ways. First, we want to know how you feel about Yellowwood Lake and what your concerns are. The management plan will strive to address those issues. Second, in order to address your concerns, we need to understand the sources of the problems. From fishing in your canoe to working in your garden, almost everything we do has an impact on Yellowwood Lake. Thus, your input is vital to the success of our plan.

Please fill the survey out to the best of your ability and return it to us in the provided stamped envelope. Let me stress again that the survey is anonymous. If you have any questions, please don't hesitate to contact Sarah Sauter at 988-7945 or ssauter@dnr.in.gov.

Thank you for sharing your concerns with the Yellowwood Lake Watershed Planning Group.

Sarah Sauter
Watershed Coordinator
Yellowwood Lake Watershed Planning Group

Yellowwood Lake Watershed Management Plan: Private Land Owner Survey

Question 1

How long have you lived in the Yellowwood Lake Watershed?

a. 0-5 yrs
b. 6-10 yrs
c. 10-15 yrs
d. More than 15 yrs

Question 2

Are you a year-round or seasonal resident?

a. Year-round (10 months or more)
b. Seasonal (less than 10 months)

Question 3 (For seasonal residents only)

How often do you visit your residence in the watershed per year?

a. 1-4 weeks
b. 2 months
c. 3 months
d. Over 4 months

Question 4

The following lists presents concerns voiced by YLWPG members. Indicate which of the problems you consider to be important to Yellowwood Lake by ranking them (1 being 'not a problem' and 5 'a major problem').

a.	Lake filling in	1	2	3	4	5
b.	Human wastes from septic tanks	1	2	3	4	5
c.	Shore erosion	1	2	3	4	5
d.	Public use/abuse by recreational users	1	2	3	4	5
e.	Invasive species	1	2	3	4	5
f.	Aquatic plants	1	2	3	4	5
g.	Gravel roads	1	2	3	4	5
h.	Dam safety	1	2	3	4	5
i.	Risk of chemical contamination	1	2	3	4	5
j.	Other ___________________________	1	2	3	4	5

Question 5

In your opinion, do you believe that the condition of Yellowwood Lake has:

a. Improved
b. Remained about the same
c. Gotten worse

Question 6

In which of the following uses of Yellowwood Lake do you participate?

a. Canoeing
b. Fishing
c. Observing wildlife
d. Observing the beauty of the lake itself
e. Other

Question 7

In your opinion, which, if any of the listed uses have been adversely affected by deterioration of water quality in Yellowwood Lake?

a. Canoeing
b. Fishing
c. Observing wildlife
d. Observing the beauty of the lake itself 7
e. Other

Question 8

How often do you visit the lake?

a. Never
b. 1- 2 times per year
c. Once a month
d. Once a week
e. Several times a week

Question 9

How often to you visit Yellowwood State Forest (YSF)?

a. Never
b. 1-2 times per year
c. Once a month
d. Once a week
e. Several times a week

Question 10

In which of the following uses of YSF do you participate?

a. Hiking
b. Camping
c. Hunting
d. Horseback riding
e. Wildlife viewing
f. Other ______________________

Please answer the following questions about your residence in the Yellowwood Lake watershed

Question 11

What is your drinking water source?

a. Cistern
b. Pond or lake
c. On-lot well
d. Rural water association
e. Bottled or imported water

Question 12

What is the age of your house?

a. 0-5 yrs
b. 6-10 yrs
c. 11-15 yrs
d. More than 15 yrs
e. Unknown

Question 13

What type of wastewater disposal system does your house have?

a. Septic tank with passive drain field (soil adsorption field)
b. Septic tank with active (pumped) soil adsorption field
c. No septic tank, passive drain field
d. Cesspool (dry well)
e. Holding tank
f. Holding tank for transport/ off-site disposal
g. None

Question 14

What is the age of your present waste disposal system?

a. 0-5 yrs
b. 6-10 yrs
c. 11-15 yrs
d. More than 15 yrs
e. Unknown

Question 15

Part A.

Have you ever had problems with your septic system such as backups, ponding, odors, ect?

a. Yes
b. No

Part B.

Have you ever had had your septic tank emptied?

a. Yes
b. No

Part C.

Has your septic system ever been repaired or enlarged?

a. Yes
b. No

Question 16

Has there been any new construction on your property in the last:

a. 1-2 yrs
b. 3-4 yrs
c. 5-10 yrs
d. Over 10 yrs
e. Unknown
f. No new construction

Question 17
Part A.

Do you fertilize your lawn?

a. Yes
b. No

Part B.

How many times a year?

a. 1
b. 2-3

Question 18

Have you conducted a timber harvest on your property in the last:

a. 1-2 yrs
b. 3-4 yrs
c. 5-10 yrs
d. Over 10 yrs
e. Unknown
f. There have been no timber harvests that I know of on my property

Question 19

If yes, were erosion control practices used?

a. Yes
b. No

Question 20

Have you ever participated in a Yellowwood Lake Watershed Planning Group activity?

a. Yes
b. No

Question 21

What watershed management review activities would you be willing to participate in?

a. Invasive species review
b. Forest management consultation
c. Wildlife management consultation
d. Become a member of the YLWPG
e. Assist with water quality monitoring
f. Assist with the biannual newsletter
g. Assist with trial maintenance
h. Other ____

Question 22

Why did you choose to live in the watershed? ____
____

APPENDIX G. SILVILCUTURE

The forest timber resource in the watershed is managed on a sustainable basis, stemming from the idea that overall growth should equal or exceed volume removal from timber harvest, natural mortality, and thinning. Most units of management, called tracts, are reviewed every 20 years to determine management activities. Figure 3.5.1 shows the tracts within the Yellowwood Lake watershed. Timber management is based on an uneven age management system, with removal of individual trees as they reach an age of decline for species in this region, normally between 100 and 150 years in age. Stand density is also considered in management decisions, with intermediate cuttings employed for stands in which the size and number of trees have passed a density at which stagnation of growth occurs. These intermediate cuttings assist the development of the existing trees, but are not designed to establish new trees. Intermediate cuttings can involve commercial harvesting or pre-commercial timber stand improvement operations. A commonly used intermediate cutting is the improvement cutting. This retains the more desirable trees while removing defective or poor quality trees. In areas where the removal of the diseased, injured or mature tress results in a stocking percentage where the space is not being fully utilized, then the decision to make a group selection opening may occur. This opening is the removal or cutting of all trees on a site, generally less than 5 acres, and provides for enhanced regeneration, primarily of the intermediate and shade intolerant tree species. The application of regeneration openings is based on the desired outcome of the stand, and not on any set rotational age. The timber harvest and timber stand improvement operations employed in the watershed involve a combination of the regeneration and intermediate methods on the same tract. Singletree selection, group selection, improvement cutting, and thinning are usually done in the same operation.

Best Management Practices (BMPs) are used on all state harvest operations. These practices start in the planning stage with proper skid trail, haul road and yard layout to account for boundaries, access control, streams and drainages, existing roads, trails and yards; slopes and critical areas. Special considerations for layout provide protection for riparian zones, personnel, sensitive areas, and the future stand of timber. During the operation attention to contaminants, ground conditions, litter and equipment operation is taken. Immediately following a harvest operation or other soil disturbing activity in the watershed, all areas of exposed soil are revegetated (either natural or artificial) and proper water control diversions installed. Steep areas may require the use of a mulch to provide immediate cover. Follow up work is conducted to see that all diversions are working properly and that ground cover has become established in critical areas.

APPENDIX H. WATER QUALITY BENCHMARKS

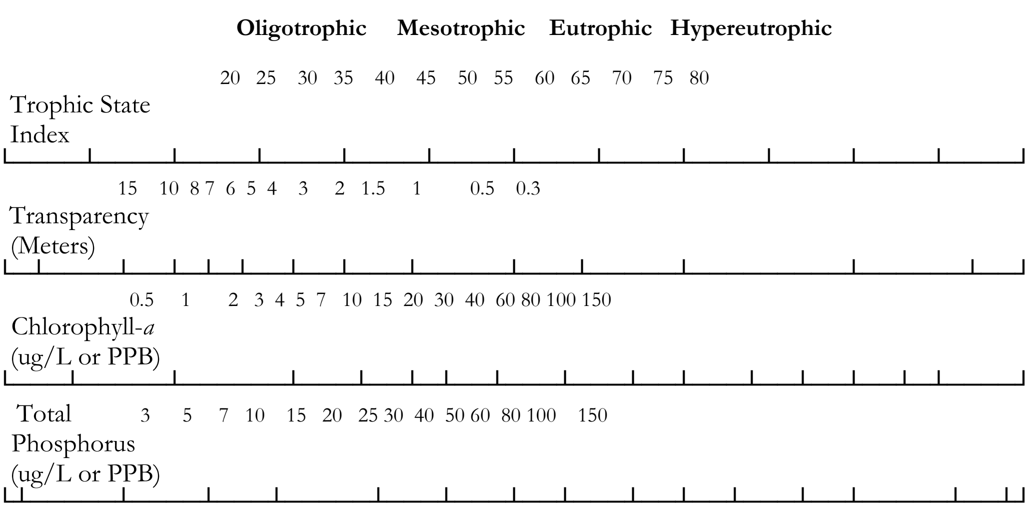
The Indiana Trophic State Index

	Parameter and Range		*Eutrophy Points*
I.	Total Phosphorus (mg/L)		
	A.	Below 0.03	0
	B.	At least 0.03	1
	C.	0.04 to 0.05	2
	D.	0.06 to .19	3
	E.	0.2 to 0.99	4
	F.	1.0 or more	5
II.	Soluble Phosphorus (mg/L)		
	A.	Below 0.03	0
	B.	At least 0.03	1
	C.	0.04 to 0.05	2
	D.	0.06 to .19	3
	E.	0.2 to 0.99	4
	F.	1.0 or more	5
III.	Organic Nitrogen (mg/L)		
	A.	Below 0.5	0
	B.	At least 0.5	1
	C.	0.6 to 0.8	2
	D.	0.9 to 1.9	3
	E.	2.0 or more	4
IV.	Nitrate (mg/L)		
	A.	Below 0.3	0
	B.	At least 0.3	1
	C.	0.4 to 0.8	2
	D.	0.9 to 1.9	3
	E.	2.0 or more	4
V.	Ammonia (mg/L)		
	A.	Below 0.3	0
	B.	At least 0.3	1
	C.	0.4 to 0.5	2
	D.	0.6 to .09	3
	E.	1.0 or more	4
VI.	Dissolved Oxygen: Percent Saturation at 5 foot Depth		
	A.	114% or less	0
	B.	115% to 119%	1
	C.	120% to 129%	2
	D.	130% to 149%	3
	E.	150% or more	4
VII.	Dissolved Oxygen: Percent of measured water column with at least 0.1 ppm dissolved oxygen		
	A.	28% or less	4
	B.	29 to 49%	3
	C.	50 to 65%	2
	D.	66 to 75%	1
	E.	76 to 100%	0
VIII.	Light Penetration (Secchi disk)		
	A.	Five feet or under	6
	B.	Greater than five feet	0
IX.	Light Transmission (Photocell): Percent of light transmission at a depth of 3 feet		
	A.	0 to 30%	4
	B.	31 to 50%	3
	C.	51 to 70%	2
	D.	71% or more	0

X.	Total Plankton per Liter of Water - sampled from a single vertical tow between the 1% light level and the urface		
	A.	less than 3,000 organisms	0
	B.	3,000 to 6,000 organisms	1
	C.	6,001 to 16,000 organisms	2
	D.	16,001 to 26,000 organisms	3
	E.	26,001 to 36,000 organisms	4
	F.	36,001 to 60,000 organisms	5
	G.	60,001 to 95,000 organisms	10
	H.	95,001 to 150,000 organisms	15
	I.	150,001 to 500,000 organisms	20
	J.	greater than 500,000 organisms	25
	K.	blue-green dominance	10 additional points

Trophic Class	Total Points
High Quality (oligotrophic)	0-25
Intermediate (mesotrophic)	26-50
Lowest Quality (eutrophic)	51-75

CARLSON'S TROPHIC STATE INDEX



APPENDIX I. HISTORIC WATER QUALITY DATA

IU-SPEA Limnology Classes

Date	Sep-85								
depth	0	1	2	3	4	5	6	7	8
Secchi						5.2			
Temp	26.1	26.2	26.2	26	24.4	20.7	16	11.4	9.3
Light (footcandles)	7000	2500	1500	1000	750	500	14	3	0.5
DO (mg/L)	6.9	7.2	7.3	7.7	8.3	8	4.8	3.2	0
DO (% sat)	86	90	92	96	101	92	50	30	0
Turbidity	1.7	1.4	1.4	1.6	1.9	1.4	7.5	7.5	17
pH	7.4	7.7	7.5	7.7	7.7	7.7	7.4	7.2	6.9
Alkalinity (m eq)	0.93	0.8	0.75	0.75	0.78	0.84	0.8	0.81	1.7
Conductivity	130	123	124	123	120	130	132	143	166
Color (Pt units)	10	10	10	10	10	30	50		70

Date	Sep-83							
DEPTH (m)	0	1	2	3	4	5	6	7
SOLUBLE PHOSPHORUS (mg/L)		0.009	0.008	0.009		0.008		0.008
TOTAL PHOSPHORUS (mg/L)	0.025	0.025	0.006	0.202	0.367	0.026	0.026	
AMMONIA (mg/L)	-0.001	-0.001	-0.001	-0.001	-0.001	0.128	0.078	0.696
NITRATE (mg/L)	0.12	0.125	0.12	0.12	0.11	0.10	0.05	0.05
TOTAL ORGANIC NITROGEN (mg/L)								
TURBIDITY (NTU)	1.5	1.45	1.4	1.3	1.4	4.1	7.1	9.6
ALKALINITY (mg CaCO3/L)	44.0	44	44.0	44.0	44.0	44.5	62.0	87.0
pH	7.1	6.8	6.9	7.1	7.1	6.6	6.6	6.7
TEMP (^{o}C)	22.0	22	22.0	22.0	22.0	20.0	15.5	13.0
% LIGHT TRANSMISSION	100	29.5	9.0	3.5	1.3	0.4	0.0	0.0
DISSOLVED OXYGEN (mg/L)	8.0	8.05	8.1	8.0	7.9	0.2	0.0	0.0
% OXYGEN SATURATION	91.5	92.05	92.6	91.5	90.3	2.2	0.0	0.0
CONDUCTIVITY (umhos/cm)	140	141.5	142	142	142	127	141	160
CHLOROPHYLL (ug/L)	12.3	34.6	39.3		81.3	72.2	30.6	
SECCHI DISK (m)	2.3							

	Sep-1994										Sep-1996								
DEPTH (m)	0	1	2	3	4	5	6	7	8		0	1	2	3	4	5	6	7	8
SOLUBLE PHOSPHORUS (mg/L)	0.009	0.011	0.011	0.009	0.009	0.009	0.012	0.012	0.011		0.003	0.006	0.005	0.007	0.002	0.006	0.002	0.008	0.078
TOTAL PHOSPHORUS (mg/L)	0.009	0.027	0.024	0.035	0.033	0.032	0.037	0.100	0.034		0.022	0.016	0.016	0.015	0.016	0.015	0.021	0.079	0.287
AMMONIA (mg/L)	0.043	0.029	0.021	0.021	0.029	0.031	0.044	0.034	0.053		0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.02	3.688
NITRATE (mg/L)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002		-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006
TOTAL ORGANIC NITROGEN (mg/L)	0.712	0.750	0.862	0.654	0.616	0.942	0.655	1.455	0.940		0.277	0.338	0.286	0.315	0.357	0.346	0.407	1.792	5.718
TURBIDITY (NTU)	1.10	0.98	0.99	1.045	1.20	1.50	2.00	7.40	1.90		1.2	1.1	1.0	1.1	1.1	1.0	4.6	11.0	14.0
ALKALINITY (mg CaCO3/L)	48.0	45.0	46.0	46.0	45.0	47.0	52.0	76.5	49.5		40.0	44.0	42.0	41.0	41.0	45.0	45.0	60.0	97.0
pH	8.05	8.05	8.10	8.08	8.01	7.87	7.09	7.52	7.25		7.3	7.4	7.5	7.4	7.5	7.2	6.6	6.6	6.6
TEMP (^{o}C)	26.5	25.5	23.9	23.5	23.3	23.0	21.8	16.1	11.5		23.3	23.5	23.5	23.5	23.5	23.5	17.5	13.0	11.0
% LIGHT TRANSMISSION	100	59.3	33.7	23.7	13.7	7.4	3.6	0.5	0.0		100.0	24.0	18.7	7.7	6.6	4.1	2.8	0.6	0.0
DISSOLVED OXYGEN (mg/L)	7.7	7.8	7.8	7.8	7.2	6.4	1.2	0.9	0.1		7.3	7.3	7.3	7.4	7.4	7.3	0.2	0.1	0.1
% OXYGEN SATURATION	98.2	97.3	94.5	94.3	85.8	76.1	14.0	9.3	0.9		85.5	85.9	85.9	87.1	87.1	85.9	2.1	1.0	0.9
CONDUCTIVITY (umhos/cm)	182	175	170	168	168	169	168	168	170		141.0	141.0	141.0	141.0	141.0	142.0	117.0	115.0	170.0
CHLOROPHYLL (ug/L)	3.88	2.78	0.45	2.48	2.48	5.92	4.23	63.73	14.41		0.41	0.19	0.650	0.650	-2.54	0.71	-	19.67	43.06
SECCHI DISK (m)	4.75										3.9								

Date	Sep-1998										Sep-2000								
DEPTH (m)	0.0	1	2	3	4	5	6	7	8		0	1	2	3	4	5	6	7	8
SOLUBLE PHOSPHORUS (mg/L)	0.007	0.008	0.002	0.035	0.025	0.026	0.005	0.152	0.395		0.018	0.018	0.017	0.018	0.020	0.021	0.040	0.115	0.124
TOTAL PHOSPHORUS (mg/L)	0.029	0.032	0.034	0.028	0.036	0.032	0.049	0.052	0.139		0.048	0.055	0.047	0.048	0.058	0.055	0.090	0.093	0.096
AMMONIA (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.247	1.358		0.018	0.018	0.018	0.018	0.018	0.018	0.022	0.026	0.415
NITRATE (mg/L)	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033		<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022
TOTAL ORGANIC NITROGEN (mg/L)	0.288	0.185	0.207	0.193	0.185	0.225	0.278	0.285	0.422										
TURBIDITY (NTU)	1.70	1.60	1.80	1.80	2.20	2.20	3.00	3.60	5.20		0.75	0.70	0.71	0.89	0.82	3.00	3.50	4.10	4.55
ALKALINITY (mg CaCO3/L)	45.30	44.50	44.25	45.75	47.50	48.00	52.00	85.00	113.00		57.00	57.00	49.00	50.00	49.00	49.00	69.00	81.00	101.50
pH	7.90	8.00	8.00	7.98	7.70	7.10	6.90	7.00	7.00		7.60	7.60	7.40	7.80	7.50	7.80	6.40	6.40	6.30
TEMP (^{o}C)	24.00	24.00	23.90	23.90	23.60	20.60	14.90	12.50	11.20		25.60	25.80	25.55	25.40	25.20	24.70	18.80	15.70	13.10
% LIGHT TRANSMISSION	100.00	20.36	7.75	3.19	1.26	0.41	0.11	0.02	0.00		100.00	21.74	9.87	6.68	3.69	1.02	0.14	0.04	0.00
DISSOLVED OXYGEN (mg/L)	7.18	7.30	7.20	7.20	5.50	0.28	0.02	0.01	0.01		6.65	6.39	6.46	6.24	6.13	3.86	0.69	0.61	0.59
% OXYGEN SATURATION	86.00	87.00	85.00	86.00	63.00	2.80	0.10	0.10	0.10										
CONDUCTIVITY (umhos/cm)	137.10	137.80	137.55	137.40	137.20	133.00	124.80	140.50	162.40		157.00	155.00	157.50	159.00	159.00	160.00	165.00	168.00	185.00
CHLOROPHYLL (ug/L)	4.72	9.44	11.40	9.66	10.13	8.11	16.78	7.69	9.06		2.40	3.81	7.02	8.73	7.56	23.04	23.46	12.18	9.48
SECCHI DISK (m)	2.40										3.8								

Date	Sep-2003								
DEPTH (m)	0	1	2	3	4	5	6	7	8
SOLUBLE PHOSPHORUS (mg/L)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.025
TOTAL PHOSPHORUS (mg/L)	0.027	0.024	0.023	0.024	0.040	0.037	0.037	0.047	0.074
AMMONIA (mg/L)	0.016	0.013		0.019	0.019	0.013	0.013	0.013	0.114
NITRATE (mg/L)	0.020	0.019	0.021	0.022	0.039	0.079	0.030	0.013	0.013
TOTAL ORGANIC NITROGEN (mg/L)	0.358	0.271	0.231	2.530	0.541	0.637	0.425	0.486	1.446
TURBIDITY (NTU)	1.40	0.96	1.30	2.40	4.45	2.70	2.60	4.30	5.25
ALKALINITY (mg CaCO3/L)	45	46	40	46	47	50	58	87	109
pH	8.3	8.4	7.8	8.1	7.4	7.1	7.2	7.2	7.2
TEMP (^{o}C)	25.4	25.1	24.6	24.3	23.8	21.5	17.0	13.2	11.1
% LIGHT TRANSMISSION	100	26.69	12.84	6.00	2.09	0.38	0.16	0.00	0.00
DISSOLVED OXYGEN (mg/L)	8.81	8.90	9.10	8.80	6.79	1.31	0.93	0.90	0.83
% OXYGEN SATURATION	107.2	108.4	109.6	105.5	80.5	14.4	9.8	8.5	7.7
CONDUCTIVITY (umhos/cm)	140	140	141	140	149	148	149	150	173
CHLOROPHYLL (ug/L)	5.42	9.67	9.03	7.95	20.75	9.18	9.98	18.41	6.15
SECCHI DISK (m)	3.9								

IDEM Data

Year	Indiana Trophic Score	Secchi (m)	Light trans @ 3' (%)	1% Light Level (ft)	DO Saturation @ 5' (%)	% Water Column Oxic	pH - epi	pH - meta	pH - hypo	avg pH
2001	20**	3.4	40.0	19.0	102.0	88	8		7.15	7.575
1997	6	4.8	58	21	96.2	100	7.71		6.79	7.25
1992	8	4.3	44		97.29	100				
1990	8	3.499147	39		94	78				
1986	20**	5.2	60		93	100	8.1	7.9	7	7.6
1974	10	4.3	90	19	85	100	6.8*	6.6*	6.4*	
Year	**Conductivity - epi (umhos)**	**Cond - meta**	**Cond - Hypo**	**avg Cond**	**Alk - epi (mg/L)**	**Alk - meta**	**Alk - hypo**	**avg alk**		
2001	170		170	170	52		107	79.5		
1997	120			120	38.9		44.9	41.9		
1992										
1990										
1986	161	145	196	167.3						
1974					34	32	32	32.6		
Year	**NO3 - epi (mg/L)**	**NO3 - meta**	**NO3 - hypo**	**NH3 - epi (mg/L)**	**NH3 -meta**	**NH3 - hypo**				
2001	0.013		0.013	0.018		0.294				
1997	0.022		0.027	0.018		0.17				
1992	0.128		0.127	0.022		0.019				
1990	0.075		0.065	0.018		0.311				
1986	<0.1	<0.1	<0.1	<0.1	<0.1	0.8				
1974				0.1	0.1	0.1				
Year	**Chlorophyll a (mg/m3)**	**Plankton (#/L)**	**Blue-green dominance (%)**	**Blue-greens (#/L)**	**Greens (#/L)**	**Diatoms (#/L)**	**Other algae (#/L)**	**Rotifers (#/L)**	**Zooplankton (#/L)**	
2001	0.25	6779	81.3	5512	31	638	535	51	11.5	
1997	0.85	4054	23	918	47	235	2823	12	19.6	
1992		12402	0.9	114	33	8823	2865	567	0	
1990		10621	2.3	241	670	8256	986	468	0	
1986										
1974										
Year	**Org N - epi (mg/L)**	**Org N - meta**	**Org N - hypo**	**SRP - epi (mg/L)**	**SRP - meta**	**SRP - hypo**	**Total Phos - epi (mg/L)**	**Total P - meta**	**Total Phos - hypo**	
2001	0.271		1.357	0.01		0.049	0.01		0.124	
1997	0.32		0.578	0.01		0.005	0.108		0.089	
1992	0.26		0.496	0.006		0.008	0.033		0.085	
1990	0.574		0.981	0.006		0.005	0.024		0.036	
1986	0.2	0.3	1.6				<.03	<.03	0.07	
1974	0.8	0.2	0.5	<.03	<.03	<.03	<.03	0.05	0.05	

APPENDIX J. QUALITY ASSURANCE PLAN

10.1. QUALITY ASSURANCE PROJECT PLAN

10.2. FOR

10.3. YELLOWWOOD WATERSHED

10.4. ARN # A305-4-46

Prepared by
Gerald G. Long for the Yellowwood Watershed Planning Group
Sarah Sauter, Yellowwood Watershed Planning Coordinator

Prepared for
Indiana Department of Environmental Management
Office of Water Management
Watershed Management Section

Approved by:

Project Manager: ______________________________ ______________
Sarah Sauter Date

WMS QA Manager: ______________________________ ______________
Betty Ratcliff Date

WMS section Chief: ______________________________ ______________
Linda Schmidt Date

Watershed Planning Branch Chief: ______________________ ______________
Martha Clark Mettler Date

Introduction

Water quality testing will be conducted as a part of the watershed planning process for the Yellowwood Lake watershed. Current water quality parameters will be determined to validate previously collected data on water quality; provide baseline data for ongoing testing, and to assist in providing information on potential sources of pollution.

10.5. SECTION 1: STUDY DESCRIPTION

10.5.1. HISTORICAL INFORMATION

Yellowwood Lake is a 133-acre reservoir built in 1939 by damming Jackson Creek. Approximately 3500 acres of the 4400-acre watershed is publicly owned and managed by the State of Indiana as a part of Yellowwood State Forest. This land was purchased by the Resettlement Administration of the U.S. government in 1936-1937. At the time, much of the land was cutover forest that has been heavily farmed and grazed. Through tree planting and natural regeneration, most of this land has returned to second-growth hardwood forest. Timber harvesting has occurred on 2,900 acres of the state-owned watershed since 1951.

Previously collected water quality data for Yellowwood Lake include survey tests conducted in conjunction with Fisheries Surveys in 1961, 1969, 1973, 1977, 1989 and 2002; IDEM water quality testing in 1974, 1986, 1990, 1992, 1997 and 2001; IDEM trophic state index score assigned in 1994; and numerous graduate student laboratory reports conducted in Limnology classes at Indiana University (reports on file in Yellowwood State Forest office). The results of these tests have consistently indicated that the water quality of the lake is excellent (the 1994 IDEM trophic state index score was 8). The primary water quality problem in the watershed has been identified as sedimentation of the lake with loss of lake depth and overgrowth of vegetation in the headwaters of the lake. Sources of sedimentation in the Yellowwood Lake watershed may include gravel roads and soil erosion. The problem of sedimentation of the Yellowwood Lake has been recognized for many years, and was first reported in the Fisheries survey conducted in 1961. This report identified the sedimentation, but reported that there was little or no pollution of the lake.

10.5.2. STUDY GOALS

The overall goal of this study is to produce a watershed plan for the Yellowwood Lake Watershed. The immediate goal of the water quality testing study is to gather baseline data to support the watershed plan. We expect that this data will support the assumption that no serious water contamination issues exist, and provide additional data to support the assumption that the primary problem is sedimentation of the lake. The baseline water quality data will also support future water quality monitoring to protect the watershed.

10.5.3. STUDY SITE

The Yellowwood Lake Watershed comprises almost 4400 acres, approximately 80% of which is part of Yellowwood State Forest, and 20% is privately owned. The majority of the privately owned land is within the northern most part of the watershed. The land is generally hilly, with small ridge tops, some steep slopes and limited creek bottom areas. Approximately 90-95% of the watershed is second growth hardwood forest. Timber harvesting is the only commercial land use of any scale. There are no commercial farming operations, and livestock is generally limited to a low number of horses on the upper (northern) reaches of the watershed. The built environment consists of homes, barns, sheds, pastures, State Forest facilities, logging roads, trails, utility easements, one paved road and three gravel county roads. The drainage immediately adjacent to the lakeshore consists exclusively of State Forest property. The built environment in this area includes recreational facilities (e.g. campground and picnic areas, boat launching sites, boat rental dock) and support facilities (one residence and an office area).

The primary water quality sampling site for this study is on Jackson Creek, immediately above (north of) the lake and below the confluence of the last major tributary (Sol Pogue Hollow) to enter Jackson Creek. Jackson Creek at this site drains approximately 65% of the Yellowwood Lake watershed. An access road leads to this site and a footbridge crosses the creek at this site. The coordinates of the sampling site are approximately 39°N 11’ 49” and 86°W 20’ 56”. This site will be used for the monthly water quality sampling of all parameters throughout the test period and for the macroinvertebrate monitoring.

The secondary sampling site is an intermittent stream draining John Floyd Hollow. This intermittent stream drains approximately 40-50% of the watershed not represented by Jackson Creek (approximately 15-18% of the total watershed). The coordinates of this sampling site are 39°N 11’ 33” and 86°W 20’ 28”. Water quality sampling at this site will be conducted at quarterly intervals.

Water quality sampling during base flow and storm flow events will be conducted from a site on Jackson Creek north of the primary sampling site by contractors. Hagen Bridge crosses over Jackson Creek at this study site. The coordinates of this site are 39°N 12’ 49” and 86°W 20’ 42”. Water quality sampling will be conducted during two base flow and two storm flow events, with specific timing dictated by the flow events. Water quality parameters to be measured during each of the monthly, quarterly, base and storm flow events include dissolved oxygen (DO), E. coli, pH, biochemical oxygen demand, phosphates, nitrogen (nitrate/nitrite), turbidity (transparency/turbidity) and flow.

A map of the watershed boundaries and study sites is included in Appendix A.

10.5.4. SAMPLING DESIGN

The sampling design is targeted. The primary focus is testing in the main tributary immediately above the lake and in the largest secondary tributary of the lake to confirm water quality throughout the year, and to identify any specific water quality issues. The following parameters will be determined at each sampling period: dissolved oxygen, E. coli, pH, biochemical oxygen demand, total phosphates, nitrates (nitrate/nitrite), and turbidity (transparency/turbidity) and flow. The Yellowwood Lake Watershed Water Testing Work Sheet can be found in Appendix B.

Macroinvertebrate monitoring will be conducted twice at the primary study site in accordance with Riverwatch Macroinvertebrate sampling protocol (Appendix C). Macroinvertebrates will be collected via a combination of the Kick Seine Sampling Method in riffles and Dip Net Sampling when riffles are absent. A copy of the Riverwatch Biological Monitoring Data Sheet is in Appendix D.

Flow rates for each sampling period will be calculated from measurements of average width, average depth, average velocity, and a roughness coefficient. Average width will consist of three stream width measurements taken from where the water touches each side of the bank. Three depth measurements taken across the stream in two transects will comprise the average depth. Timing a floating object over a measured distance three times will comprise the average velocity measurements. Velocity measurements that cannot be made because of too rapid or too slow flow will be considered to be peak flow or base flow conditions, respectively. Roughness scores are as follows: 0.8 for gravel or rocky bottom, 0.9 for sandy, muddy, or bedrock bottom. The Riverwatch Flow Calculation Worksheet is included in Appendix E. Rainfall measurements will be considered in relation to peak flow in final analysis of the data.

Plans for addressing any potential water quality issues that may be discovered in the water quality sampling and macroinvertebrate monitoring will be addressed in the watershed management plan. Other potential issues related to water quality (e.g. erosion potential, changes in hydrology, land use) will be identified by visual inspection during the development of the watershed plan.

10.5.5. STUDY TIMETABLE

Water quality monitoring will begin in October 2004. This will be referred to as month 4 in this plan. The monthly water quality sampling at the primary site will be conducted during months 4 through 21. The quarterly water quality sampling in the John Floyd Hollow will be conducted every third month, beginning with month 4 (e.g. months 4, 7, 10….). The actual sampling dates for the quarterly sampling may vary by $\pm$1/2 month.
Base and peak flow measurements will occur about September to October and April to May, respectively, for 2 years. Specific times for sampling may vary from these dates, depending upon actual flow events. The second peak flow measurement may occur January to March, if a peak flow event occurs during this time. Macroinvertebrate data will be collected during April and October 2005.

10.5.6. AN ESTIMATED TIMETABLE FOR SAMPLE FREQUENCY IS IN APPENDIX F.

10.5.7. SECTION 2: STUDY ORGANIZATION AND RESPONSIBILITY

Project manager: Sarah Sauter

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Quality Assurance: Sarah Sauter
Yellowwood Watershed Planning Coordinator

Performance and systems audits: Gerald Long

10.5.8. SECTION 3: DATA QUALITY OBJECTIVES

All testing for water quality parameters will be done in accordance with the Advanced Chemical Testing Instructions of Hoosier Riverwatch (Appendix G). Persons conducting the water quality testing are Yellowwood Lake Watershed Planning Group (YLWPG) members and will have completed the Hoosier Riverwatch advanced chemical testing training. Data quality objectives for these measurements are given below.

Precision

Precision for each quantitative parameter tested in monthly sampling (primary site, Jackson Creek) will be determined by testing duplicate samples during the first monthly sampling and every consecutive third monthly sampling period (i.e. months 1, 4, 7, 10 etc). The relative percent difference (RPD) will be determined for each set of duplicate samples. Precision for each quantitative parameter tested in the quarterly sampling will be determined by testing duplicate samples during the first quarterly sampling and every other sampling period thereafter. Duplicate samples will not be tested during the base flow and storm flow sampling. Any duplicate with an RPD of over 10% will be accepted with note and investigated to prevent error in additional testing. An RPD of over 50% will be investigated and deemed an outlier if no reasonable explanation for the deviation is found.

Precision for the macroinvertebrate identification will be achieved by appropriate training of individuals conducting the testing and by use of reference identification sheets. Representative specimen(s) of each of the organisms counted during one of the macroinvertebrate identification samplings will be preserved (70% alcohol) in separate containers and retained for potential verification of identification. Each container will be labeled with the date, identification, and initials of the person conducting the sampling.

10.5.8.1. Accuracy

Accuracy will be accepted as the accuracy values listed for the Hoosier Riverwatch instructions. These are +/- 10% for phosphorus and nitrates; +/- 0.0001 g for total solids; +/- 1 mg/L for dissolved oxygen; and +/- 0.2 pH units. The accuracy for E. coli is considered 'high' (results are reported as < or >200 colonies/100ml). Accuracy will be tested once per quarter for the water quality tests by the use of standards and field blanks (e.g. culture for E. coli with no added sample or distilled water). These will be recorded on a Yellowwood Lake Watershed Water Testing Work Sheet with a note that these are field blanks, and an indication of which reagent(s) were excluded from each test, and a record of the results. Contaminated field blanks will be investigated to find the source of error and ensure the integrity of future water quality tests. Contamination may result in the need to resample or unusable data. In all cases contamination will be noted on the Yellowwood Lake Watershed Testing Work Sheet and in the QA reports.

10.5.8.2. Completeness

At least 5 of the 6 possible monthly data points for each parameter must be collected during each 6-month period of the study. At least 5 of the scheduled 7 quarterly samples must be collected. All base flow and storm flow samples must be collected (actual dates may vary). Actual sampling dates for successful tests for each parameter may be different. All listed macroinvertebrate sampling must be conducted.

10.5.8.3. Representativeness

The representativeness of the testing will be determined during the audits of the data. The data will be considered to be representative if the sampling/testing plan was followed, the proper techniques were used/documented, the precision tested, and any obvious outliers in the data are explained or superseded by additional data.

10.5.8.4. Comparability

The results of this study will be compared to other watershed results in the Hoosier Riverwatch Database to judge the accuracy of our sampling and analytical methods. Additionally, Yellowwood Lake data will be compared to other watersheds with similar trophic index scores and watersheds with known sedimentation and erosion problems. The data will be considered comparable if there are no substantive differences (e.g. no relative percent differences >50% among measurements) between collected Yellowwood data and select watersheds in the Hoosier Riverwatch Database.

10.5.9. SECTION 4: SAMPLING PROCEDURES

Sampling procedures will follow the Advanced Chemical Testing Instructions for the Hach test kits published by Hoosier Riverwatch (www.HoosierRiverwatch.com).
The procedures are included in Appendix G.

Each sampling event will be documented on a copy of the Yellowwood Lake Watershed Water Testing Work Sheet (Appendix B). The site identification, date, time, air temperature and water temperature will be recorded. The person(s) conducting the sampling will sign and date the sheet. Sampling will be conducted by one or more of the volunteers listed under "Water quality sampling and macroinvertebrate analysis" in Section 2: Study Organization and Responsibility. Each of these individuals has completed the Riverwatch Training.

10.5.10. SECTION 5: CUSTODY PROCEDURES

In most cases, the same person(s) conducting the sampling will conduct sample analysis and no custody procedures will be required. The person(s) conducting each test will initial the respective test block on the Yellowwood Lake Watershed Water Testing Work Sheet. All data sheets and samples to be analyzed and/or archived will be archived in a designated file in the Yellowwood State Forest Office.

10.5.11. SECTION 6: CALIBRATION PROCEDURES AND FREQUENCY

Calibration procedures will be conducted for the pH pen. The pH pen will be calibrated according to the Hoosier Riverwatch Advanced Chemical Testing Instructions before each use. This calibration will be noted on the Yellowwood Lake Watershed Water Testing Work Sheet (Appendix C). Standards will be used whenever possible to test the reliability of the reagents used.

10.5.12. SECTION 7: ANALYTICAL PROCEDURES

Analytical procedures will follow the Advanced Chemical Testing Instructions for the Hach test kits published by Hoosier Riverwatch (www.HoosierRiverwatch.com; Appendix G). Specific results for each test will be recorded on the respective copy of the Yellowwood Lake Watershed Water Testing Work Sheet. Results will be recorded as the immediate results obtained for each test conducted (e.g. ml of sodium thiosulfate added in the final step of the dissolved oxygen test). The person(s) conducting the tests will convert the results to actual measurements (e.g. mg/ml dissolved oxygen) and record these on a copy of the Riverwatch Chemical Monitoring Work Sheet at the completion of each sampling/testing replicate.

The macroinvertebrate identification will be carried out by visual inspection and results indicated on a copy of the Hoosier Riverwatch Biological Monitoring Data Sheet. The person conducting the sampling/identification will initial and date this data sheet. A Yellowwood Lake Watershed Water Testing Work Sheet will be filled out for each macroinvertebrate identification sampling to document the sampling time and location. A note will be made on the work sheet indicating that it is used for the macroinvertebrate testing.

10.5.13. SECTION 8: QUALITY CONTROL PROCEDURES

Quality control procedures will consist of the following:
-Persons conducting the testing will have completed the Hoosier Riverwatch advanced training. Procedures in this QA project plan will be reviewed with all persons conducting testing and QC procedures by the author of the QA plan.
-Replicate samples will be analyzed (test for precision) at the intervals described above. Standards and field blanks will be used to gauge the accuracy of the field analyses.
Quarterly inventory and documentation of expiration dates of reagents (to be conducted by the Yellowwood Watershed Planning Coordinator (report to be filed).
-The measurements recorded on the Riverwatch Chemical Monitoring Work Sheet will be checked against the actual results recorded on the Yellowwood Lake Watershed Water Testing Work Sheets (conversions recalculated) on a quarterly basis. This will be done by the Yellowwood Watershed Planning Coordinator. The coordinator will make copies of all reports and file them in a location other than the file of the originals. The coordinator will file a report that these checks were conducted.
-The specimens retained from the macroinvertebrate identification will be examined by a person trained in identification (other than the person originally performing the identification). This person will indicate this verification on the bottom of the biologic monitoring data sheet, with initial and date.

10.5.14. SECTION 9: DATA REDUCTION, REVIEW, AND REPORTING

Data Reduction will consist of the following:
-Conversion of actual results of tests to the equivalent measurements (as indicated above under analytical procedures).
-Transcription of all measurements to a spread sheet (or other listing of all data by location, test and date).
-Conversion of water chemical monitoring results to a water quality index ratings (according to Hoosier Riverwatch instructions and forms) and transcription of these to a spreadsheet of results.
-Conversion of macroinvertebrate identification to a pollution tolerance index (according to Hoosier Riverwatch instructions and forms) and transcription of these to a spreadsheet of results.

Data Review will be done on a quarterly and semi-yearly basis as indicated in quality control procedures (above) and audits (below).

The data will be reported in the Yellowwood Lake Watershed Plan as the following:

1. Listing of all results by sampling date, location and test
2. Graph(s) of specific test results for a location by date, if these tests differ substantively by date

3. Listing of all quality results (water quality index ratings and pollution tolerance indicators) by date and/or location
4. Subjective interpretation of results in the text of the Yellowwood Lake Watershed Plan will include an overall assessment of water quality and identification of any specific water quality problems.
5. A hard copy of interpreted results will be included in quarterly and semi-annual progress reports that will be sent to IDEM

10.5.15. SECTION 10: PERFORMANCE AND SYSTEMS AUDITS

Audits will be conducted every 6 months by the author of this QA plan.
Audits will include a check to make sure that all data, data reductions, QC checks and reports as specified by this plan are present in the appropriate files. Any deficiencies noted will be reported to the Yellowwood Watershed Planning Coordinator and the Yellowwood Forest manager.

10.5.16. SECTION 11: PREVENTIVE MAINTENANCE

All equipment used in the field tests will be cleaned and handled as indicated in the Hoosier Riverwatch advanced training.

10.5.17. SECTION 12: DATA QUALITY ASSESSMENT

10.5.17.1. Precision

Precision will be checked during the QC and audit reviews of the data. Any deviations of relative percent difference of more than 10% will be investigated to ensure that these were addressed by additional testing or otherwise explained. Any deviations of more than 50% will be investigated and judged to be outliers if no reasonable explanation is found. If any data point is judged to be an outlier, the justification for this will be recorded.

10.5.17.2. Accuracy/Bias

Accuracy will be checked during the QC and audit reviews of the data. Any variations seen will be investigated, and included in the QC and audit reports.

10.5.17.3. Completeness

Completeness will be addressed during the audit reviews of the data. Any deficiencies exceeding the specifications in this QA plan will be documented.

10.5.18. SECTION 13: CORRECTIVE ACTION

The Yellowwood Watershed Planning Coordinator in consultation with the Yellowwood Forest manager will determine corrective action for any deficiencies noted. The specific corrective action taken will be determined by the specific nature of the deficiency, and will be documented with the QC and audit reports.

10.5.19. SECTION 14: QUALITY ASSURANCE REPORTS

Quality assurance reports will consist of the QC and audit reports and will be submitted with the quarterly progress reports required for the watershed-planning grant.

10.5.20. REFERENCES CITED

Advanced Chemical Testing Instructions, Hoosier Riverwatch (www.HoosierRiverwatch.com).

Previous water quality reports for Yellowwood Lake (on file in the Yellowwood State Forest Office).

Dear Betty Ratcliff,

The Yellowwood Lake Watershed Planning Group (ARN #A305-4-46) would like to submit a proposed amendment to our Quality Assurance Project Plan. We request that the QAPP be amended to include in-lake sampling techniques. Currently, our contract only includes stream sampling in two tributaries of Yellowwood Lake. We feel that assessing the conditions in the lake are critical to understanding the threat of eutrophy in Yellowwood Lake. Yellowwood State Forest is an expanded volunteer for the Indiana Clean Lakes Program. According to Carlson's Trophic State Index, our total phosphorous levels are in the eutrophic range. The Yellowwood Lake Watershed Planning Group would like to explore this apparent trend further. We propose the following in-lake sampling.

First, we hope to contract two water column chemistry samples: one during stratification and one post stratification. The stratification sample will include an epilimnetic sample one meter from the surface and a hypolimnetic sample one meter from the bottom. Both samples will be analyzed for total phosphorous (TP), soluble reactive phosphorous (SRP), Nitrate, Ammonia, pH, and alkalinity. Additional parameters include: temperature and DO sampled at on meter intervals from surface to bottom, chlorophyll-a, plankton (for only the stratification sample), and light (photoactive radiation). These samples will help us to understand the trophic status of the lake, assess changes in trophic status, and allow us to estimate internal phosphorous rates. The contractor will be required to use standards, field blanks, lab blanks, and use sampling and analytical methodology consistent with EPA standards.

The YLWPG would also like to contract sediment coring in Yellowwood Lake. We will use the sediment core results in two ways. First, we will look at sediment phosphorous concentrations to further our estimates of internal phosphorous loading. The contractor will determine total phosphorous (TP), soluble reactive phosphorous (SRP) concentrations in the sediment. Second, we propose a series of transects throughout the lake that will be used to estimate the sediment load that has entered Yellowwood Lake since it origin. The sediment cores will be analyzed for length of core, length of recent sediment, and location of any additional layering.

Please accept our proposed amendment to the Yellowwood Lake Watershed Quality Assurance Project Plan. If you have any questions, please contact Sarah Sauter at 812-988-7945 or ssauter@dnr.in.gov.

Thanks,

Sarah Sauter

Yellowwood Lake Watershed Coordinator
772 South Yellowwood Lake Road
Nashville, IN 47448

APPENDIX K: HOOSIER RIVERWATCH RESULTS

Jackson Creek

Sample Date	Air Temp(°C)	Water Temp(°C)	DO (% sat.)	DO (mg/L)	CFU/ 100 ml	pH	BOD (mg/L)	TP (mg/ml)	OP (mg/L)	Nitrate (mg/l)	Nitrite (mg/)	Turbidity (NTU)	Discharge (CFS)
Oct-04	15	13	85%	9	34,800*	6.8	-	8*	-	0.46	-	-	3.06
Nov-04	20	13	103%	11	6,800	7	13*	BDL	-	0.02	-	-	2.28
Nov-04	20	13	103%	11	6,300	7.1	9*	BDL	-	0.04	-	-	-
Dec-04	10	5	100%	13	600	6.9	-	0.2	-	0.4	-	-	5.82
Jan-05	0	0	107%	16	1,400	6.8	-	0.02	0.02	0.264	-	0.45	2.22
Feb-05	14	7	94%	12	-	-	-	BDL	-	8.8	-	-	2.84
Mar-05	11	6	125%	16	-	-	-	BDL	BDL	0.11	-	-	4.67
Mar-05	11	6	115%	15	-	-	-	BDL	BDL	0.088	-	-	-
May-05	21	18	70%	6	700	6.7	2.5	-	BDL	BDL	BDL	>60	2.39
Jun-05	29	20	37%	3.5	1,500	7	BDL	-	BDL	BDL	BDL	>60	0.26
Jul-05	23	18.5	43%	4	0	6.5	BDL	-	BDL	BDL	BDL	>120	0.00
Jul-05	23	18.5	43%	4	400	6.7	1	-	BDL	BDL	BDL	>120	-
Aug-05	20.5	24.5	70%	6	800	6.5	1	-	BDL	1.1	BDL	>120	3.63
Sep-05	21.5	17	57%	5.5	1,700	7.5	1	-	BDL	0.44	BDL	>120	1.11
Oct-05	20	15	74%	7	1,100	7	1	-	BDL	BDL	BDL	>120	0.00
Oct-05	20	15	74%	7	2,400	7	1	-	BDL	BDL	BDL	>120	-
Nov-05	19	10	79%	9	700	6.8	BDL	-	BDL	BDL	BDL	>120	1.63
Dec-05	17	7	80%	10	800	6.9	BDL	-	BDL	BDL	BDL	>120	6.06
Jan-06	13	6	64%	8	100	6.3	BDL	-	BDL	BDL	BDL	>120	3.85
Jan-06	13	6	70%	9	200	6	BDL	-	BDL	BDL	BDL	>120	-
Feb-06	12	6	64%	8	100	6.6	BDL	-	BDL	BDL	BDL	>120	3.53
Mar-06	14	9	75%	9	200	6.3	BDL	-	BDL	1.1	BDL	>120	5.19
Apr-06	18	11	65%	7	300	6.8	1	-	BDL	BDL	BDL	>120	2.47
May-06		14	65%	7	600	6.6	2	-	BDL	BDL	BDL	>120	3.16

John Floyd Hollow

Sample Date	Air Temp(°C)	Water Temp(°C)	DO (% sat.)	DO (mg/L)	CFU/ 100 ml	pH	BOD (mg/L)	TP (mg/ml)	OP (mg/L)	Nitrate (mg/l)	Nitrite (mg/)	Turbidity (NTU)	Discharge (CFS)
Dec-04	12	8	83%	10	1,200	6.7	-	BTD	-	BTD	-	-	1.5115126
Dec-04	12	8	83%	10	1,500	6.6	-	BTD	-	BTD	-	-	-
Feb-05	9	4	98%	13	400	-	-	0.14	BTD	0.132	-	-	1.2800462
Jun-05	29	20	75%	7	1,700	7.7	6	-	BTD	0.88	BTD	>60	0
Sep-05	21.5	17	42%	4	4,100	6	1	-	BTD	0.88	BTD	>120	0.299
Jan-06	14	6	64%	8	0	6.5	BTD	-	BTD	1.1	BTD	>120	2.4895121
Jan-06	14	6	64%	8	100	6.5	BTD	-	BTD	1.1	BTD	>120	-
May-06		12	65%	7	400	6.6	1	-	BTD	BTD	BTD	>120	2.64

APPENDIX L: QHEI SCORES

Parameters	Scores						
Site	1	2	3	4	5	6	7
Substrate	15	16	19	19	19	13	15
instream cover	17	17	16	16	18	16	17
channel morphology	16	16	16	16	16	17	13
riparian zone and bank erosion	9	9	9	9	8.5	7.5	7
pool/glide and riffle/run quality	5	4	2	2	4	2	1
riffle/run depth	4	4	4	4	4	1	3
Final Score	66	66	66	66	70	57	56

APPENDIX M: L-THIA MODEL INPUTS AND RESULTS

Table 1. Runoff concentrations from land use in the watershed according to L-THIA

		Land Cover Types				
		Forest	**Water/ Wetlands**	**Grass/ Pasture**	**Parking/ Paved Spaces**	**Residential ½ acre**
	Curve Number	70	0	74	98	83
Pollutants	**Nitrogen**	0.7	0	0.7	1.82	1.82
	Phosphorous	0.01	0	0.01	0.57	0.57
	Suspended Solids	1	0	1	41	41
	Lead	0.005	0	0.005	0.009	0.009
	Copper	0.01	0	0.01	0.009	0.009
	Zinc	0.006	0	0.006	0.08	0.08
	Cadmium	0.001	0	0.001	0.00075	0.00075
	Chromium	0.0075	0	0.0075	0.0021	0.0021
	Nickel	0	0	0	0.01	0.01
	COD	0.05	0	0.05	25.5	25.5
	BOD	0	0	0	49.5	49.5
	Oil Grease	0	0	0	1.7	1.7
	Fecal Coliform	20	0	20	2000	2000
	Fecal Strep	0	0	0	5600	5600

All concentrations are in ppm except the last two pollutants which are in number per 100 ml, the Hydrologic Soil Group for all land cover types was C

Table 2. Land Cover area of L-THIA permutations

	Forest	**Water/ wetlands**	**Grass/ Pasture**	**Parking/ Paved Spaces**	**Residential ½ acre**
Current forest cover	4417	140	88	1	4
Maximized forest cover	4270	140	0	0	0
50% current forest cover	2089	140	1928	10	10

Table 0.1. Runoff Estimate from Current Land Use

		Land Cover Types				
		Forest	**Water/ Wetlands**	**Grass/ Pasture**	**Parking/ Paved Spaces**	**Residential ½ acre**
	Area (acres)	4177	140	88	1	4
Runoff Statistics	**Average Annual Runoff Volume (acre-ft)**	502.70	0	13.80	2.07	1.29
	Runoff Depth (in)	1.45	0	1.89	24.95	3.11
	Total Annual Volume (acre-ft)	519.86				
	Average Annual Runoff Depth (in)	1.41				
	Average Rainfall Depth (in)	46.14				

Table 0.2. Runoff Estimates from Maximized Forest Cover

		Land Cover Types				
		Forest	Water/ Wetlands	Grass/ Pasture	Parking/ Paved Spaces	Residential ½ acre
Runoff Statistics	Area (acres)	4270	140	-	-	-
	Average Annual Runoff Volume (acre-ft)	513.89	0	-	-	-
	Runoff Depth (in)	1.39	0	-	-	-
	Total Annual Volume (acre-ft)	513.89				
	Average Annual Runoff Depth (in)	1.39				
	Average Rainfall Depth (in)	46.14				

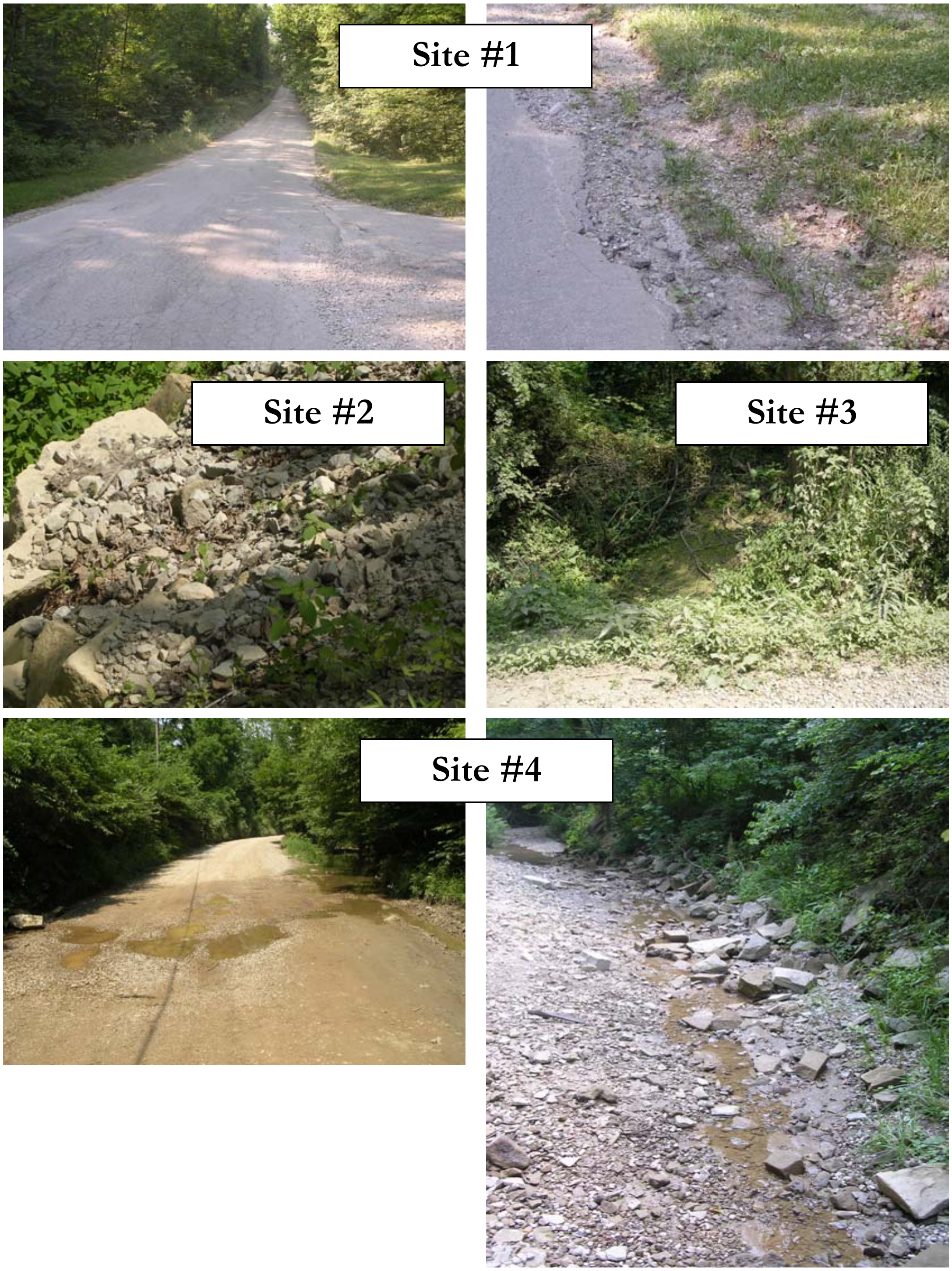
Table 0.3. Runoff Estimates from 50% current forest cover

		Land Cover Types				
		Forest	Water/ Wetlands	Grass/ Pasture	Parking/ Paved Spaces	Residential ½ acre
Runoff Statistics	Area (acres)	2089	140	1928	10	10
	Average Annual Runoff Volume (acre-ft)	251.41	0	302.44	20.70	3.22
	Runoff Depth (in)	1.45	0	1.89	24.95	3.89
	Total Annual Volume (acre-ft)	557.79				
	Average Annual Runoff Depth (in)	1.65				
	Average Rainfall Depth (in)	46.14				

APPENDIX N: HFF DEPTH SURVEY RESULTS

#	Overflow	Collector	Latitude	Longitude	2005 Depth	2004 Depth	2003 Depth	2002 Depth	1955 Depth
1	0	LWB, WD	39-10-640	86-20-353	0	0	0	0	0
2			39-10-703	86-20-310	23.01	21.5	24.5	26	25
3			39-10-642	86-20-365	22.01	23.5	24.5	25	32
4			39-10-663	86-20-499	21.51	19.5	22.5	23	25
5			39-10-709	86-20-405	27.01	26.5	27.5	29	30
6			39-10-751	86-20-318	24.51	21.5	21	22	25
7			39-10-804	86-20-478	22.51	23	23.5	25	25
8			39-10-869	86-20-385	21.01	23	22.5	23	25
9			39-10-955	86-20-479	22.01	23	23.5	25	25
10			39-11-001	86-20-618	6.51	7.5	7.26	9	10
11	0	LWB, WD	39-11-090	86-20-549	17.01	17.5	17.5	19	20
12			39-11-138	86-20-457	15.51	16	15.5	18	20
13			39-11-179	86-20-636	8.7	7.9	8.26	8	9
14			39-11-230	86-20-553	14.01	13	13.5	15	15
15			39-11-280	86-20-487	10.91	11	11.4	11	15
16			39-11-318	86-20-552	11.01	12	12	12	15
17			39-11-306	86-20-620	11.01	11.5	11.5	12	15
18			39-11-349	86-20-600	7.01	9.5	10.56	10	10
19			39-11-348	86-20-711	9.01	11	10.5	12	10
20			39-11-387	86-20-706	7.51	7.2	8.5	10	10
21			39-11-398	86-20-809	3.51	3.4	3.8	4	7
22			39-11-407	86-20-788	5.71	6.1	6	6	10
23			39-11-441	86-20-754	5.71	5.8	7.4	8	10
24			39-11-485	86-20-728	2.01	3	1.8	3	5
25			39-11-472	86-20-669	2.51	1.9	2.06	2	5
26			39-11-460	86-20-642	2.41	2.3	2.86	3	5
27			39-11-427	86-20-602	4.51	5	5.06	5	10
28			39-11-433	86-20-571	0.6	0.4	0.66	1	5
29	0	LWB, WD	39-11-467	86-20-798	1.31	1.2	1.46	1	5
30			39-11-366	86-20-770	7.91	7.2	8.26	7	10
31			39-11-376	86-20-753	9.11	9.5	9.1	10	10
32			39-11-525	86-20-755	4.41	3.6	3	3	5
33			39-11-593	86-20-799	3.81	4	4	4	5
34			39-11-436	86-20-638	5.11	4.9	5.36	6	10
35			39-11-366	86-20-639	8.41	8.5	9.66	9	10
36			39-11-373	86-20-583	7.71	7.7	7.96	8	10
37			39-11-141	86-20-373	1.81	2	2.2	3	5
38					0	0	0	0	1
39					0	0	0	0	1
40					0	0	0	0	1
41									

APPENDIX O: ROAD VISUAL ASSESSMENT PHOTOGRAPHS



Site #5

Site #6

Site #7

APPENDIX P. 2004 IDNR FISHERY SURVEY, YELLOWWOOD LAKE, RAKE SCORE RESULTS

Depth	All	American elodea	Coontail	Eurasian watermilfoil	Brittle naiad	Slender naiad	Eel Grass	Water-stargrass	Chara	Leafy pondweed
6.5	5	1	5							
9.5	5		5	1						
16.5	0									
4	3	1	1		1	1	1			
3.5	5		5				1			
9.5	5		5							
11.5	5		5							
15	1		1							
8	5		5		2					
4	5		4	1		1		2		
8.5	1		1							
10.5	5		5							
7	5		5	1	1					
3.5	5		5	1	2					
1.5	5		1	1	1				5	
15	0									
11	1		1							
9	1		1	1						
3	3		3							
4	5		5							
5.5	5		5							
2	5		5							
2.5	5		5	1						
7	5		3	5	1					
13.5	5		5							
13.5	3		3							
7	5		5	1						
2.5	5		5	1						
3	5		3	1	5					
2	5	1	5	1	2					
5	5		5	1						
9	5		5							
11	5		5	1						
13.5	5		5							
6.5	5		5	1						
15.5	0									
9	1						1			
12.5	0									
8.5	0									
8.5	0									
3.5	5	1	5	1				1		
6	5	1	4	1			2			1
5	2	1	1	1		1				
6	5	1	4	2						
20.5	0									
4	5	1	5	1	1			3		
2.5	5	1	5	3		1			1	1
12	5		5							
3.5	5	3	1	1	1	1				1
13.5	5		5							
15.5	1		1							
9.5	5		5		1					
2	5	2	5	1	1	1		3		
13.5	4		4							
9	1		1				1			
6	4	3	1	1						

6	4	2	3	1						
10	5		5							
14	5		5							
2.5	5	2	1	1			1	2		

APPENDIX Q: FISHERY RESULTS

Fish Species (% of catch)	1961	1968	1973	1977	1989	2002	2004
Redear sunfish	26.2	13.9	10.4	4.9	19.9	3.3	8.4
Black Crappie	12.4		6.3	2.4	0.6		0.3
White Crappie	1	3.5				0.3	
Bluegills	23.4	38.4	39.8	45.3	44.8	37.1	39.4
Warmouth bass	9.3	13.3	9.3	2	3	4.6	3.9
Green sunfish	1.7	0.8					
Longear sunfish	15.9	7.6	6.3	1.4	3.3		12.3
Largemouth bass	7.2	9.4	15.6	38.9	21.7	27.2	18.7
Grass pickerell	1	0.5	0.74	0.2		0.3	0.3
White sucker	0.3	0.2		1.5	0.6	0.7	
Yellow bullhead		2.6					2
Yellow Perch		6.5	2.6	2.7	1.2	1.3	0.6
Hybrid sunfish		2.1			0.3	19.9	3.1
Brown Bullhead		0.2			0.3	0.3	
Brook Silverside		numerous	numerous	numerous		0.3	5.3
Black Bullhead			2.6	0.5	0.3		0.8
Yellow Bullhead	1.4		6.7	0.2		2.3	2
Blackstripe topminnow			present	present			
Channel Catfish					2.1	1.3	3.1
Rainbow trout					0.6		
Gizzard shad					1.5	0.3	0.6
Yellow bass						0.7	1.4
Total Fish	**290**	**338**	**269**	**655**	**337**	**302**	**358**
Total Species	**11**	**14**	**12**	**13**	**14**	**14**	**14**

APPENDIX R: RUSLE

Soil Type	% Slope	Management	CMZ	Models	T (t/ac/yr)	Sediment Delivery (t/ac/yr)	Sediment Load (lb/ft/yr)	Projected Sediment Delivery (t/0.25 ac/month)	Projected Sediment Load (lb/ft/month)
Wellston silt loam - 40% (complex comprises 51% of watershed)	**6.0**	CRP - vegetated buffers	16	Vegetative Cover	3.00	0.25	1.70	0.01	0.14
		Bare road - low traffic	36	Minor Skid Trail - no BMP	3.00	32.00	220.00	0.67	18.33
		Bare road - heavy traffic	36	Major Skid Trail - no BMP	3.00	32.00	220.00	0.67	18.33
		Seeded road - red fescue	36	Major Skid Trail - BMP	3.00	1.90	13.00	0.04	1.08
		Mulched road	36	Gravel Road	3.00	14.00	93.00	0.29	7.75
	15.0	CRP - vegetated buffers	16	Vegetative Cover	3.00	0.71	4.90	0.01	
		Bare road - low traffic	36	Minor Skid Trail - no BMP	3.00	110.00	780.00	2.29	65.00
		Bare road - heavy traffic	36	Major Skid Trail - no BMP	3.00	110.00	780.00	2.29	65.00
		Seeded road - red fescue	36	Major Skid Trail - BMP	3.00	6.10	42.00	0.13	3.50
		Mulched road	36	Gravel Road	3.00	45.00	310.00	0.94	25.83
Berks silt loam - 50% (comprises 35% of watershed)	**6.0**	CRP - vegetated buffers	16	Vegetative Cover	3.00	0.29	2.00	0.01	
		Bare road - low traffic	36	Minor Skid Trail - no BMP	3.00	36.00	250.00	0.75	20.83
		Bare road - heavy traffic	36	Major Skid Trail - no BMP	3.00	36.00	250.00	0.75	20.83
		Seeded road - red fescue	36	Major Skid Trail - BMP	3.00	2.20	15.00	0.05	1.25
		Mulched road		Gravel Road		15.00	110.00	0.31	9.17
	15.0	CRP - vegetated buffers	16	Vegetative Cover	3.00	0.81	5.60	0.02	
		Bare road - low traffic	36	Minor Skid Trail - no BMP	3.00	130.00	880.00	2.71	73.33
		Bare road - heavy traffic	36	Major Skid Trail - no BMP	3.00	130.00	880.00	2.71	73.33
		Seeded road - red fescue	36	Major Skid Trail - BMP	3.00	7.00	48.00	0.15	4.00
		Mulched road	36	Gravel Road	3.00	52.00	360.00	1.08	30.00

APPENDIX S: MODEL INPUTS AND LOAD REDUCTIONS

Sedimentation

Turbidity and total suspended solids (TSS) are often used as measures of sediment transport in fluvial systems. It is difficult to find an agreed upon standard for TSS and turbidity because of the wide fluctuations in annual deliveries. The State of the Minnesota[24] established a water quality standard for turbidity as an indicator of water clarity. To meet water quality standards, turbidity levels must be no greater than 25 nephelometric turbidity units (NTU). According to the Minnesota Pollution Control Agency, 25 NTU is approximately equivalent to 58 to 66 mg/L of total suspended solids. The YLWPG has chosen this Minnesota Water Quality Standard for our target sediment loads.

	Daily TSS Loads	Annual TSS Loads*	Turbidity
Current Condition	194 tons/ day	1,940 tons/yr	46 NTU
Target Condition	48 tons/ day	480 tons/yr	25 NTU
Reduction	145 tons/ day	1,450 tons/yr	21 NTU
* estimated 10 major storm events per year			

Streambanks

Method: IDEM Load Reduction Workbook

Model Inputs	Bank #1	Bank #2
Length (ft):	26,400	26400
Height (ft):	4	3
Lateral Recession Rate (ft/yr):	0.3	0.2
Soil Weight (tons/ ft^3):	0.045*	0.045*
Soil P Conc (lb/lb soil):	0.0005*	0.0005*
Soil N Conc (lb/lb soil):	0.001*	0.001*
* Default		

		Sediment (tons/yr)	Phosphorous (lbs/yr)	Nitrogen (lbs/yr)
Current stream bank erosion	**Bank #1**	1,425.6	1,211.8	2,423.5
	Bank #2	712.8	605.9	1,211.8
	Total	2,138	1,817.6	3,635.3
Load reduction from bank stabilization (70% efficiency)	**Bank #1**	997.9	848.2	1,696.5
	Bank #2	499.0	424.1	848.2
	Total	1,496.9	1,272.3	2,544.7

The majority watershed erosion is stream bank erosion during storm events. Therefore, the detected TSS loads most accurately reflect stream bank erosion. Stabilizing streambanks to reduce associated sediment loads by 70% (1,496 tons/yr) would exceed our TSS load reduction goal (1,450 tons/yr). This load reduction goal corresponds to roughly 7 miles of stream bank stabilization.

[24] (mrbdc.mnsu.edu/mnbasin/fact_sheets/stateofriver_2001.html#5)

Roads

Method: Watershed Erosion Predictor Program (WEPProads)

Inputs and Outputs:

Average annual sediment leaving road (lb)	Average annual sediment leaving buffer (lb)
110,893	63,284
Inputs:	
Bloomington, IN	
Silt Loam-5 year run	
Average annual precipitation: 41 in	

Inputs are on the following page.

Road Design	Road Surface	Traffic Level	Road Gradient	Road Length (ft)	Road Width (ft)	Fill Gradient	Fill Length (ft)	Buffer Gradient	Buffer Length (ft)	Rock Fragment
Ib: inslope, bare, iv: inslope, vegetated, or: outslope rutted, ou: outsloped, unrutted, N: Native, G: Gravel, P: Paved, H: High, L: Low, N: None										
iv	G	L	1	800	8	1	1	5	700	20
iv	G	L	1	800	8	1	1	12	500	20
ou	G	L	5	400	6.6	30	8	10	100	20
ou	G	L	1	400	6.6	1	1	5	100	20
ou	G	L	1	800	5.8	10	1.5	1	15	20
ib	G	L	1	800	6	1	1	1	20	20
ib	G	L	1	800	6	1	1	1	20	20
ib	G	L	1	800	6	1	1	1	20	20
iv	G	L	1	800	6.5	15	3	1	25	20
ib	G	L	1	800	6	1	1	1	10	20
ou	G	L	1	200	6	45	2	1	1	20
iv	G	L	20	400	6.1	45	5	1	1	20
iv	G	L	20	400	8.8	20	2.8	5	5	20
ou	G	L	20	400	8.8	20	3	40	40	20
iv	G	L	1	861	25	1	3	5	1000	20
iv	G	L	1	861	26	1	3	5	1000	20
iv	G	L	1	861	24	1	3	5	1000	20
iv	G	L	5	861	27	1	3	12	1000	20
iv	G	L	5	861	26	1	3	12	1000	20
iv	G	L	5	861	24	1	3	12	1000	20
ou	G	L	1	646	21	30	25	10	323	20
ou	G	L	1	646	20	30	25	10	323	20
ou	G	L	1	646	20	1	3	5	323	20
ou	G	L	1	646	21	1	3	5	323	20
ou	G	L	1	861	18	10	5	1	48	20
ou	G	L	1	861	19	10	4	1	48	20
ou	G	L	1	861	18.5	10	4.5	1	48	20
ib	G	L	1	861	19.1	1	3	1	65	20
ib	G	L	1	861	19	1	3	1	65	20
ib	G	L	1	861	20	1	3	1	65	20
ib	G	L	1	861	21	1	3	1	65	20
ib	G	L	1	861	19.5	1	3	1	65	20
ib	G	L	1	861	19.6	1	3	1	65	20
ib	G	L	1	861	19.2	1	3	1	65	20
ib	G	L	1	861	19.3	1	3	1	65	20
ib	G	L	1	861	19.8	1	3	1	65	20
iv	G	L	1	861	21	15	10	1	80	20
iv	G	L	1	861	20	15	10	1	80	20
iv	G	L	1	861	21.5	15	10	1	80	20
ib	G	L	1	861	18.5	1	3	1	32	20
ib	G	L	1	861	19	1	3	1	32	20
ib	G	L	1	861	19.5	1	3	1	32	20
ou	G	L	1	646	20	45	6.5	1	3	20
iv	G	L	20	646	19	45	16.15	1	3	20
iv	G	L	20	646	20	45	16.15	1	3	20
iv	G	L	20	646	28	20	9	5	16	20
iv	G	L	20	646	28.5	20	9	5	16	20

ou	G	L	20	646	28.424	20	9.69	40	130	20
ou	G	L	20	646	28	20	9.69	40	130	20

E. coli

Indiana currently uses *E. coli* for their bacteriological water quality monitoring. According to Indiana Water Quality standards the *E. coli* limit for full body contact recreational use, from April through October, shall not exceed the geometric mean of 125 colony forming units (CFU) per 100 ml based on no less than five (5) samples equally spaced over a thirty (30) day period, nor 235 cfu/100 ml in any one (1) sample in a thirty (30) day period. If the geometric mean cannot be calculated because five (5) equally spaced samples are not available, the limit of 235 cfu/100 ml in a single sample over a thirty (30) day period applies (327 IAC 2-1-6(d)). The following tables outline the estimated load reductions and inputs for the IDEM Bacteria Indicator Workbook.

	Average *E. coli* load
Current Condition*	66, 800 cfu/day
Target Condition	16,800 cfu/day
5 yr reduction	20,800 cfu/day
10 yr reduction	40,00 cfu/day

**Calculations based on average of volunteer detected E. coli concentrations*

Method: IDEM Bacteria Indicator Workbook

	Model Inputs		
***E. coli* from septic systems**	Estimated # septics:		35
	Estimated # people served by septics:		130
	Assume a failure rate for septics in the watershed		70%
		Geese	0
		Deer	50
Wildlife (#/mi²)	Forest Land	Beaver	10
		Raccoons	50
		Other	50
		Geese	50
		Deer	20
	Pasture Land	Beaver	0
		Raccoons	0
		Other	0
livestock	Horses		20

All other values in IDEM Bacteria Indicator Workbook are default

	Jackson Creek Drainage
Estimated *E. coli* loads from 70% septic failure rate	53.6 billion cfu/day
Load Reduction from only 35% septic failure rate	28.4 billion cfu/day