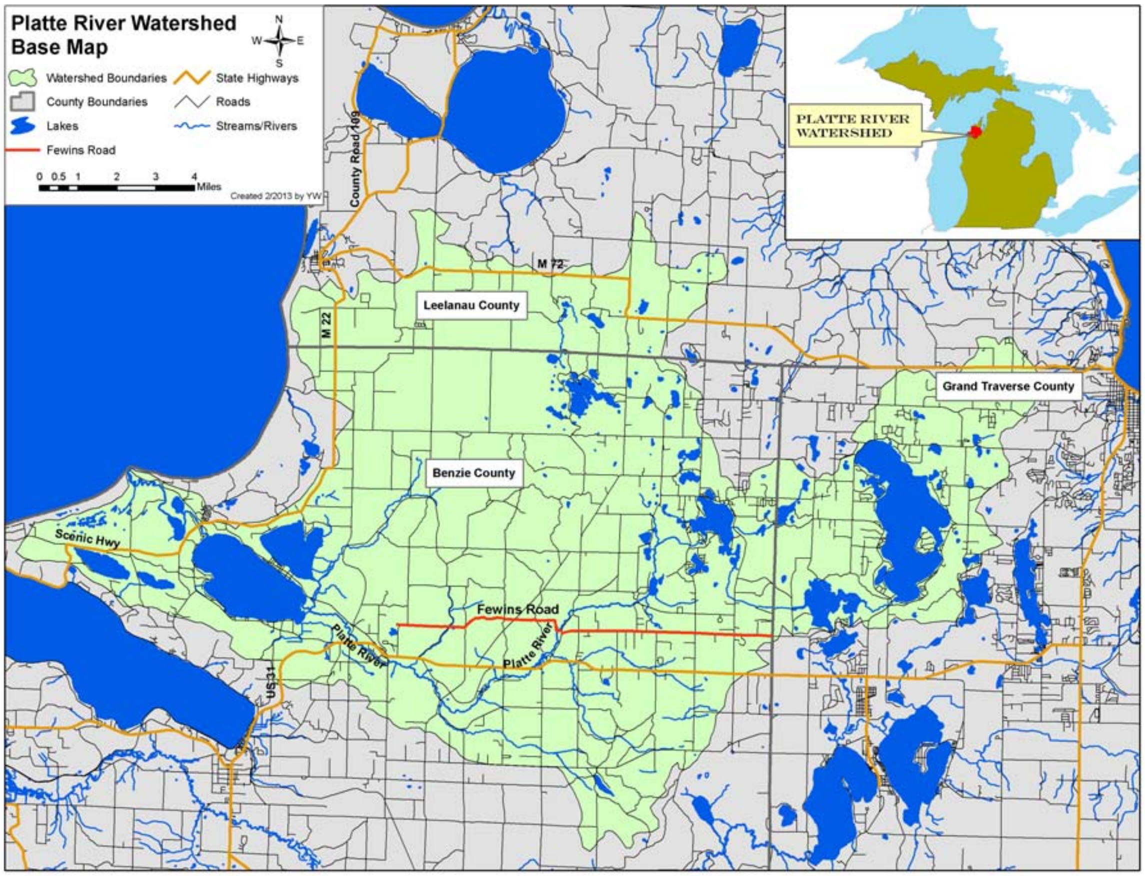
PLATTE RIVER WATERSHED

PROTECTION PLAN



Submitted February 2014, Approved August 1, 2014, Updated December 2014

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ACKNOWLEDGEMENTS

Platte River Watershed Protection Plan

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Thanks to the Platte Lake Watershed Protection Plan Steering Committee and Greg Goudy with the Michigan Department of Environmental Quality for all of your valuable assistance with the Platte River Watershed Protection Plan

Platte River Watershed Protection Plan Partners

Ann Lake Association, Benzie Conservation District (BCD), Benzie County (BC), Benzie County Road Commission (BCRC), Benzie Leelanau Health Department (BLHD), Conservation Resource Alliance (CRA), Grand Traverse Band of Ottawa and Chippewa Indians (GTBOCI), Grand Traverse Regional Land Conservancy (GTRLC), Leelanau Conservancy, Long Lake Association Michigan Department of Environmental Quality (MDEQ), Michigan Department of Natural Resources (MDNR), , , Natural Resources Conservation Service (NRCS), NW Michigan Council of Governments (NWCOG), Platte Lake Improvement Association (PLIA), Sleeping Bear Dunes National Lakeshore (SBDNL)

The Platte River Watershed Protection Plan can be downloaded at the following websites:

www.platte-lake.org or www.bcd.org

INTRODUCTION

A watershed is an area of land that drains to a common point. On a very broad scale, imagine a mountain, and think of the highest ridges on the mountain as the boundaries of the watershed. Rain, melting snow, and wind carry pollutants from the ridges and sides of the mountains into the water in the valley. Watersheds are inherently defined by topography as water always follows the path of least resistance (EPA 2008).

The rationale for watershed management is that if we responsibly manage land activities, we will protect the water within that watershed. All activities within a watershed affect the quality of water as it percolates through and runs across natural and developed landscapes. Watershed planning brings together the people within the watershed to address those activities, regardless of existing political boundaries. By working together, individuals within the watershed can design a coordinated watershed management plan that builds upon the strengths of existing programs and resources, and addresses the water quality concerns in an integrated, cost effective manner (EPA 2008).

The Platte River Watershed Protection Plan is a comprehensive document that coordinates the Platte Lake Improvement Association's ongoing efforts to protect water quality with other watershed-wide stakeholder groups to achieve designated and desired goals. The first efforts to develop a comprehensive watershed management plan began in April 2000 under a Federal Clean Water Act, Section 319 grant received by the Benzie Conservation District. A 30-member watershed council acted as the steering committee and represented most all stakeholder groups in the watershed to guide the watershed management planning effort. In 2002 the Michigan Department of Environmental Quality (MDEQ) formally approved the Platte River Watershed Management Plan and the steering committee members began working immediately to implement some of the pollution reduction tasks proposed in the plan such as non-structural improvements to road stream crossings and implementation of storm-water and lakeside buffer ordinances. (Canale et al 2010).

In 2011, the PLIA initiated an update to the original watershed plan to make it comply with the EPA 9 elements criteria in addition to the MDEQ's criteria on which is was originally based. The updated plan incorporates an extensive database of water quality data and modeling analyses to calculate pollutant loading estimations specific to the Platte River watershed. One of the main goals of the updated plan is to address the court ordered 8 mg/m^3 annual average volume weighted phosphorus standard for Big Platte Lake (Appendix A: MARCH 2000 CONSENT JUDGEMENT, NOVEMBER 2010 AND MAY2011 AMMENDMENTS.) and prescribes Best Management Practices (BMPs) in both the upper and lower watershed to help maintain the phosphorus standard.

The Platte River State Fish Hatchery (PRSFH) has historically been one of the main identified point sources for phosphorus loading in the watershed. The outflow from the Hatchery discharges into the Platte River upstream of the village of Honor, Michigan. The Hatchery is located 17.7 km upstream of Big Platte Lake and 29 km upstream from Lake Michigan (Canale et al 2010). Successful implementation of the Consent Agreement between MDNR and PLIA (May 2002) (Appendix A) has significantly reduced net phosphorus loads to the Platte River from Hatchery operations.

There is an existing approved watershed plan for the Long Lake Watershed (Long Lake Watershed Plan (LLWP 2009), which is the uppermost sub-watershed of the Platte River Watershed. This planning document and its prioritized tasks are incorporated by reference in this plan. Therefore, this plan will not go into specific detail about the issues that pertain exclusively or primarily to the Long Lake sub-watershed.

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Purpose

The Platte River Watershed Protection Plan is a comprehensive document that coordinates the Platte Lake Improvement Association's ongoing efforts to protect water quality with those of other watershed-wide stakeholder groups to achieve designated and desired goals. These goals are addressed in a consolidated task implementation chart designed to achieve and maintain the high water quality. It is important to note that this document is a planning framework that prescribes tasks designed to achieve watershed goals, however it is not regulatory in nature. The plan itself and the Steering Committee are non-political entities and neither have regulatory powers.

Introduction

The Platte River State Fish Hatchery (PRSFH) has historically been one of the main point sources for phosphorus loading in the watershed. The outflow from the Hatchery discharges into the Platte River upstream of the village of Honor, Michigan. The Hatchery is located 17.7 km upstream of Big Platte Lake and 29 km upstream from Lake Michigan (Canale et al 2010). Successful implementation of the Consent Agreement between MDNR and PLIA (May 2002) (Appendix A) has reduced net phosphorus loads to the Platte River from Hatchery operations significantly (Berridge and Canale, 2012).

The first efforts to develop a comprehensive watershed management plan began in April 2000 under a Federal Clean Water Act, Section 319 grant received by the Benzie Conservation District. A 30-member watershed council acted as the steering committee and represented most stakeholder groups in the watershed to guide the watershed management planning effort. In 2002 the MDEQ formally approved this initial Platte River Watershed Management Plan and the steering committee members began working immediately to implement some of the pollution reduction tasks proposed in the plan such as non-structural improvements to road stream crossings and implementation of storm-water and lakeside buffer zone ordinances. (Canale et al 2010)

In 2010, the PLIA initiated an update to the original watershed plan to comply with the EPA 9 elements criteria in an effort to better quantify pollutant load reduction achieved from implementation priority tasks. The updated plan incorporates an extensive database of water quality monitoring data and modeling analyses to calculate pollutant loading estimations specific to the Platte River watershed (Berridge and Canale, 2012) One of the main goals of the updated plan is to address the court ordered 8 mg/m^3 annual average volume weighted standard for Big Platte Lake (Appendix A: MARCH 2000 CONSENT JUDGEMENT, MAY 2010 AND NOVEMBER 2011 AMMENDMENTS.) and prescribes Best Management Practices (BMPs) for both the upper and lower watershed to help maintain the phosphorus standard.

Extensive water quality monitoring data and modeling analyses are used to identify the total phosphorus loads that enter the Platte River and ultimately Big Platte Lake from the main sub-watersheds in the basin and determine current and projected phosphorus loads. A previously calibrated and validated BASINS model is used to predict loads subsequent to changes in various land-use trends and population growth scenarios (LimnoTech, 2004 and 2007). The task chart identifies specific BMPs or land use decisions appropriate to maintain the court ordered Phosphorus standard for Big Platte Lake. In addition, the task chart identifies and prioritizes efforts to achieve all six main goals of the plan throughout the entire watershed. Additional data collection and analysis efforts are also proposed for tasks where more information is needed before specific BMPs can be prescribed.

There is an existing approved watershed plan for the Long Lake Watershed (Long Lake Watershed Plan (LLWP 2009), which is the uppermost sub-watershed of the Platte River Watershed. This planning document and its prioritized tasks are incorporated by reference in this plan. Therefore, this plan will not go into specific detail about the issues that pertain exclusively or primarily to the Long Lake sub-watershed.

Watershed Characteristics

The Platte River watershed is comprised of several connected river and lake segments surrounded large areas of contiguous forestland with isolated kettle lakes. The hydrology of the Platte River is relatively stable due to the deep glacial outwash deposits of permeable soils that promote infiltration and movement of the groundwater to create consistent and stable base flow throughout the year.

Much of the Platte River watershed drains areas located in the northern half of Benzie County, MI. (see Figure 1). Although it is the smallest county in the state, it is currently ranked as the third fastest in growth (Benzie County Open Space and Natural Resource Protection Plan- BCOSNRPP). Population growth in upper watershed areas of Grand Traverse County is projected to increase significantly by 2020. The growing population is predicted to convert 36% of the current forested areas into residential, commercial and industrial land use (Long Lake Watershed Management Plan, 2009). Thus, although significant measures to control point sources from the Platte River State Fish Hatchery have been attained, the Platte River and Big Platte Lake are under pressure projected increases in from non-point nutrient and sediment loads throughout the watershed.

Priority and Critical Areas

Although watershed management plans address the entire watershed, there are certain areas within the Platte River watershed that warrant more extensive management or specific protection consideration. Areas that are most sensitive to impacts from pollutants are considered **Priority Areas.** Areas that require focused monitoring, restoration, remediation and/or rehabilitation are considered **Critical Areas**.

Priority Areas –

Area 1- This area focuses on the lower watershed below Big Platte Lake and includes the wetlands, riparian corridors, and critical dune habitat around the Sleeping Bear Dunes National Lake shore and the mouth of the Platte River entering Lake Michigan.

Area 2- This area focuses on the main branch of the Platte River and tributaries and streams below Fewins Road. This area includes the majority of the critical areas within the watershed and also contains the majority of the coldwater fishery habitat for the watershed.

Area 3- This area includes the riparian wetland corridors along the upper Platte River above Fewins Road and includes Lake Ann. This area also contains several isolated kettle lakes with wetland complexes and significant amounts of forested land that maintains groundwater recharge.

Tier 1:

1. Habitat for or areas with threatened, endangered or species of special concern
2. Existing public or protected land within the SBDNL, State, Conservancies and or natural areas and preserves
3. Deadstream Swamp around the east end of Big Platte Lake and the area along the North Branch of the Platte River.
4. High Risk Erosion Areas

Tier 2:

1. Surface water bodies (lakes/streams), shorelines, wetlands and land within 500’ of Big Platte Lake, the Platte River, or Platte River tributaries.
2. High Priority Land Protection areas
3. Ground water recharge areas

Tier 3:

1. Steep Slopes
2. Wildlife Corridors

Critical Areas-

Critical Areas are specific sections of the watershed that are suspected to contribute a significant amount of pollutants or have been documented as impacted by stressors or pollutants and require restoration to achieve designated or desired uses. Critical Area designation indicates that implementation of identified tasks will be needed to achieve load reductions identified in the plan (Figure 32). The critical areas for the Platte River watershed include the following areas:

1. Un-named creek in Benzonia Township, Lat 44.6750, Long -86.0649, Benzie County identified on the 303d list of impaired waters
2. North Branch of the Platte River
3. Severely degraded road/stream crossings
4. Village of Honor Storm Water System
5. Un-identified Platte River nutrient source below Hatchery (Collision Creek) and above the Indian Hill Road bridge
6. Liquid Brine Disposal Site

Designated and Desired Uses

Identified designated uses and water quality standards for Michigan surface waters were used to assess the condition of the watershed. Michigan's surface waters are protected under Water Quality Standards for specific designated uses (R323.1100 of Part 4, Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended). These standards and designated uses are designed to 1) protect the public health and welfare, 2) to enhance and maintain the quality of water; and 3) to protect the state's natural resources. Protected designated uses as defined by Michigan's Department of Environmental Quality associated with the Platte River watershed include: agricultural, industrial water supply, navigation, warm water and/or cold water fishery, other indigenous aquatic life and wildlife, fish consumption, and partial and total body contact recreation.

None of the designated uses for the Platte River watershed are impaired on a watershed wide scale. The Michigan DEQ has reported that an unnamed groundwater stream is failing to properly allow several designated uses, including warm/cold water fishery, fish consumption and other indigenous aquatic life. The cause of impairment was identified as elevated BOD from biological contamination in the groundwater plume upstream. Other uses in the watershed are threatened by phosphorus levels that exceed the court ordered 8 mg/m^3 standard for Big Platte Lake, by soil exposed to surface runoff and by exotic species introduction and proliferation. These specific threats were identified through scientific research reports, water quality monitoring reports, steering committee member input and contributions from watershed residents, general public input and scientific experts on the Platte River watershed.

The steering committee and stakeholder input verified the need to establish specific desired uses particular to the Platte River watershed that are not addressed by designated uses based on state water quality standards. Desired uses can be defined as the ways in which people use the watershed and how they would like to manage and protect the watershed to ensure the sustainability of those uses for future generations. Desired uses for the Platte River watershed include uses for recreational, aesthetic, human health, and ecosystem preservation.

Pollutants, Sources, and Causes

Designated and desired uses may be negatively affected by a number of different pollutants and environmental stressors in the Platte River watershed. The term environmental stressor is used to describe factors that have a negative effect on the ecosystem or water quality, but are not accurately categorized as a specific pollutant. The Platte River watershed is subject to pollutant threats from excessive nutrients, sedimentation of stream channels, improper waste disposal as well as environmental stressors such as habitat loss and invasive species proliferation. Excessive phosphorus loading and sedimentation are the two primary impacts to the water quality with loss of habitat and invasive species proliferation being additional issues of concern. Other issues that threaten designated and desired uses within the Platte River watershed include toxic substances, pathogens, and thermal pollution. Table 22 identifies known or suspected sources and causes of pollutants and environmental stressors that impact specific designated or desired uses. Excessive nutrient loading of the Platte River and its tributaries in the past has led to significant degradation of the water quality and biological community of Big Platte Lake. Reduction of excessive nutrient and sediment loads to tributary streams and the Platte River itself has been found to be the most effective way of achieving a proper nutrient balance for Big Platte Lake.

Watershed Goals:

The following goals for the Platte River watershed were developed by the Steering Committee to protect the designated and desired uses of the watershed:

1. Protection of aquatic and terrestrial ecosystems.
2. Protection and restoration of the quality and quantity of water resources.
3. Preserve high quality of recreational opportunities.
4. Implementation and continued promotion of educational programs that support stewardship and watershed planning goals, activities, and programs.
5. Protection of the economic viability within the watershed while ensuring water quality and quantity resources are protected.

Each goal generally has multiple objectives that outline specific elements required to meet the goal. Tasks are then assigned to address the individual goals and multiple objectives. The detailed task implementation chart describes the task, provides interim milestones, approximates projected costs and assigns a plausible timeline for completion. The implementation tasks in Chapter 8 are designed to address individual watershed objectives under each main goal. Some of the tasks are designed to address multiple objectives.

Pollutant Load Reductions

Phosphorus loading export coefficients for various land use types from the validated BASINS model were used to quantify the expected reductions in phosphorus loading for prescribed tasks (LimnoTech, 2004). The total nitrogen and sediment loading coefficients were calculated based on measured nitrogen/phosphorus and sediment/phosphorus ratios from a significant number of dry and event water quality samples. The nitrogen and sediment loads are correlated to various land uses as a function of their corresponding annual average phosphorus export coefficient. This method is most applicable for addressing possible changes in land use and determining the potential impacts to pollutant loading from those various land use areas. Estimations of the pollutant load reductions from other specific BMP's is provided in Table 31, Pollutant Removal Effectiveness of Selected Potential Stormwater BMPs. Quantification of the BMP's impacts substantiates the efficacy of particular tasks toward reaching specific objectives for each goal, and therefore will increase the likelihood of obtaining funding for continued implementation.

Information and Education Strategy

Chapter 9 outlines an Information and Education Strategy that addresses the communication necessary for implementing the watershed protection plan. These outreach efforts are important because developing and carrying out a vision for stewardship of the Platte River Watershed will require the public and community leaders to become knowledgeable about the issues and solutions, engaged and active in implementing solutions and committed to both individual and societal behavior changes necessary.

Evaluation Procedures

An evaluation strategy will be used to measure progress during the Platte River Watershed Protection Plan’s implementation and to determine whether or not water quality is improving. The timeline for the evaluation is approximately every 5 years, with ongoing evaluation efforts completed yearly. The main purpose of the evaluation strategy is to measure how well we are doing at actually *implementing* the watershed management plan and to assess if project milestones are being met. Measuring accurate pollutant load reductions is the most essential element of the evaluation strategy since it will provide objective, quantified results. The evaluation strategy will also focus on public education of watershed issues and will monitor success of the Information and Education Strategy by looking at public perception of watershed issues over time.

CHAPTER 2: PLATTE RIVER WATERSHED DESCRIPTION

2.1 Location and Size

The Platte River watershed is contained within Benzie, Grand Traverse and Leelanau Counties of Michigan's northwest Lower Peninsula. The total drainage area is approximately 193 square miles and the primary Platte River Valley is about 14 miles in length. The watershed intersects with the jurisdictions of 14 townships, three counties and contains three villages (Figure 1). The entire watershed covers approximately 123,608 acres. The Long Lake sub-basin in Grand Traverse County forms the eastern limit of the watershed. The forested uplands of southern Kasson and Empire Townships in Leelanau County provide the northern end of this large drainage basin. Inland and Homestead Townships in Benzie County provide ground and surface water flow from the southern ends of the watershed. The Platte River watershed primarily flows westward until it ends with the Platte River flowing into Lake Michigan at Platte Bay.

In order to help focus implementation efforts particular to various sub-watersheds this plan addresses issues in three distinct regions: the upper watershed above Fewins Road, the lower watershed between Fewins Road and Big Platte Lake and the lower watershed below Big Platte Lake (Figure 2). These areas were based on the Long Lake Watershed plan, existing water quality data and the Sleeping Bear Dunes National Lakeshore.

Figure 1: Platte River Watershed – Base Map

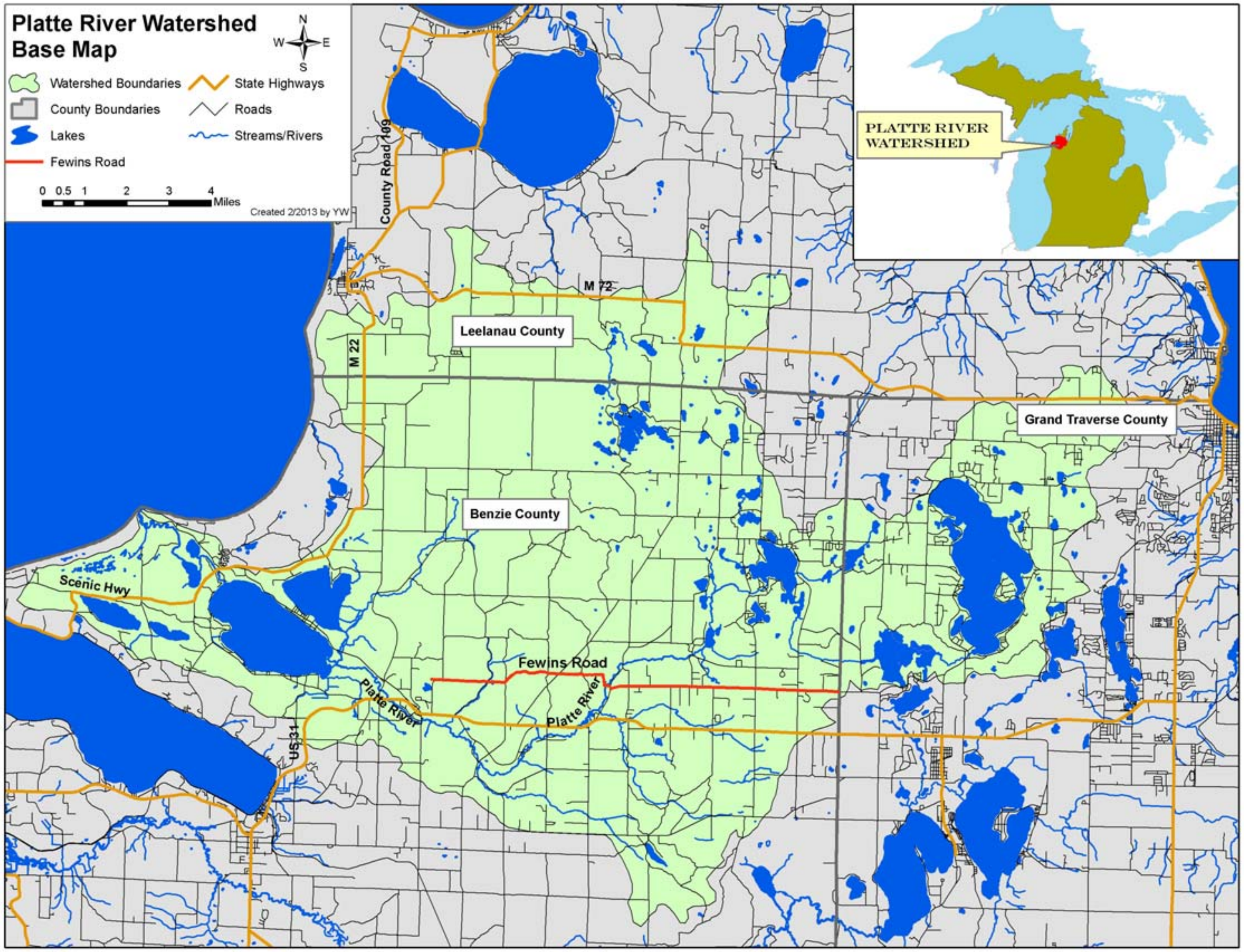
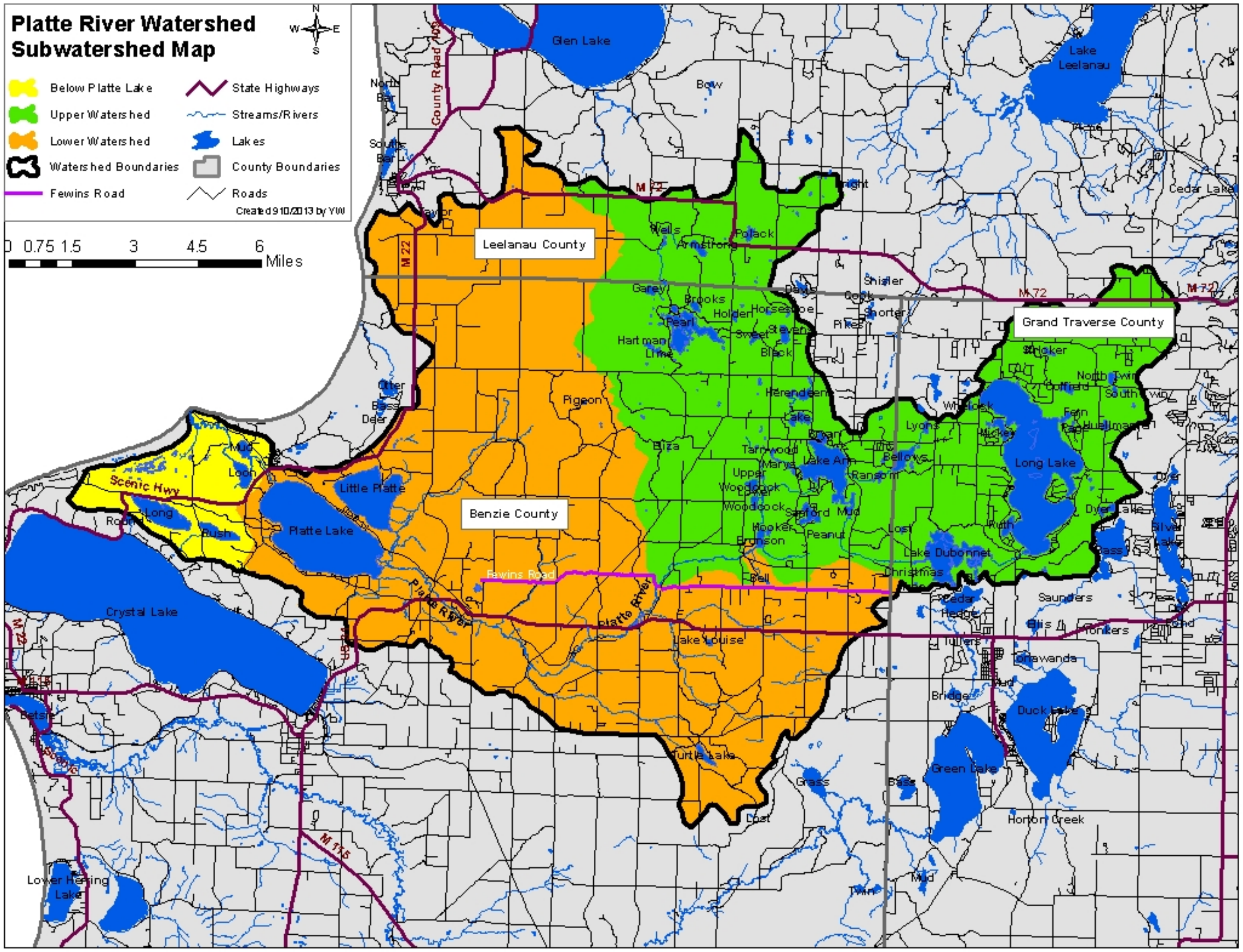


Figure 2: Platte River Watershed – Sub-watershed Map



2.2 Hydrology and Groundwater Recharge

There are over 100 individual surface water bodies in the Platte River Watershed (PRW) including numerous streams and over 50 lakes such as Big Platte Lake, Lake Dubonnet, Lake Ann, Pearl Lake, Long Lake, and Loon Lake (Figure 3, Table 1). The water bodies have a total surface area of 17,000 acres or 14 % of the total watershed surface area.

Long Lake is the largest water body in the watershed, covering 2817 acres excluding the islands with 16.7 miles of shoreline. Situated at the top of the watershed system, the lake receives the majority of its water via underground springs that drain from the surrounding uplands. It has a maximum depth of 90 feet and average depth of 24.8 feet. The lake elevation is 846 feet above sea level. The lake’s outlet, Sucker Creek, drains from the southwestern corner flowing westward into Lake Dubonnet. Sucker Creek’s surface flow in its upper reaches immediately below Long Lake becomes intermittent during low water periods.

Figure 3: Lakes in the Platte River Watershed

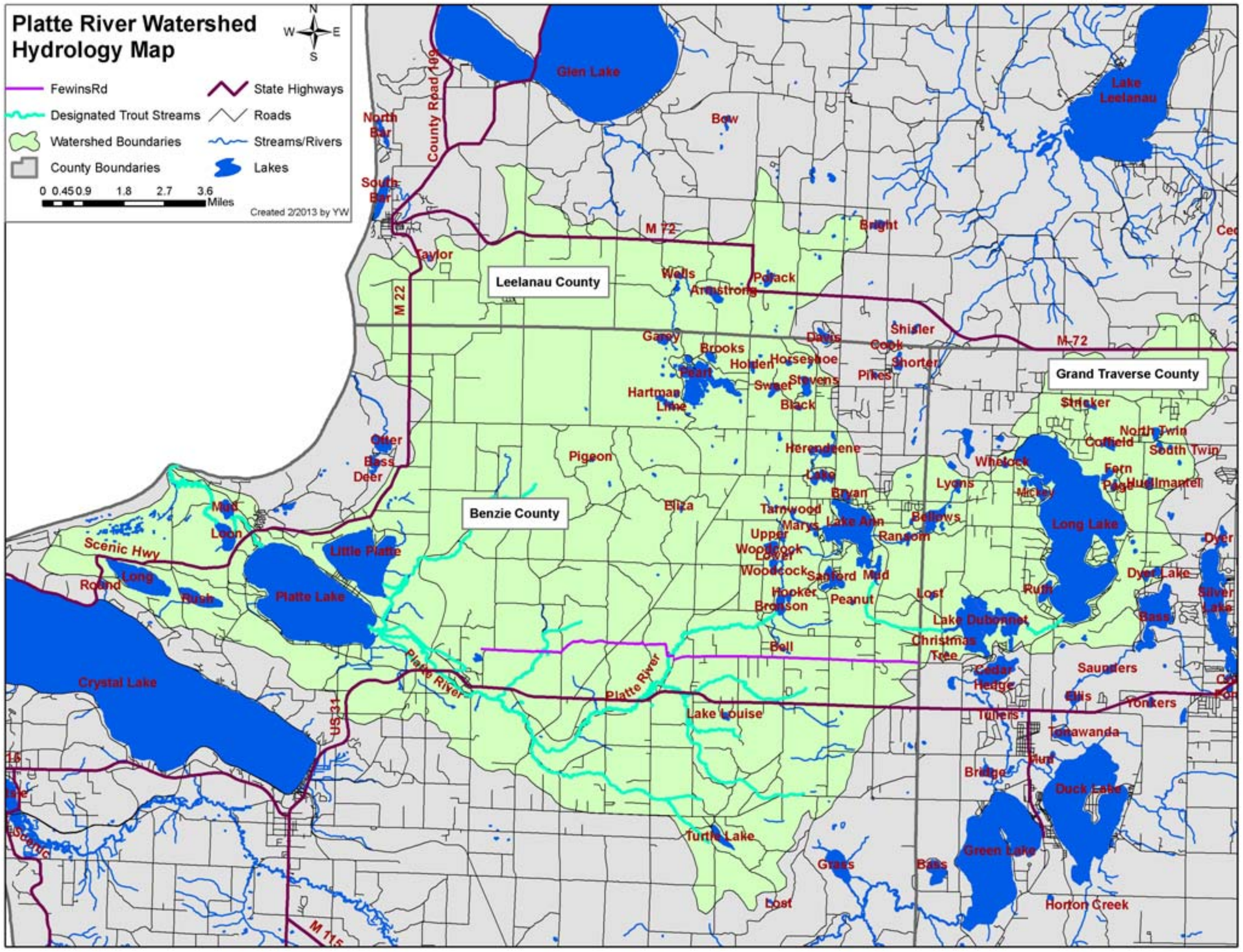


Table 1: Lakes within the Platte River Watershed

Lake Name	Acres	Lake Name	Acres	Lake Name	Acres
Armstrong Lake	40.8	Huellmantel Lake	18	Big Platte Lake	2532.4
Bell Lake	2.6	Lake Ann	501	Polack Lake	26.1
Bellows Lake	86.9	Lake Dubonnet	502.3	Ransom Lake	17.5
Black Lake	6.5	Lake Louise	10.5	Rush Lake	118.6
Bronson Lake	45.3	Lake View	55.1	Ruth Lake	43
Brooks Lake	20.9	Lime Lake	16.2	Sanford Lake	52.8
Bryan Lake	19.7	Little Platte Lake	896	Shavenaugh Lake	4.5
Christmas Tree lake	2.5	Long Lake	2817	South Twin Lake	11.5
Coffield Lake	29.5	Loon Lake	93.6	Stevens Lake	40.8
Dyer Lake	36.4	Lost Lake	7.8	Stricker Lake	13.5
Eliza Lake	3.9	Lower Woodcock Lake	21.8	Sweet Lake	20.1
Fern Lake	20.1	Lyons Lake	19	Tarnwood Lake	9.6
Fuller Lake	12.1	Marys Lake	6.7	Turtle Lake	40.9
Garey Lake	29.4	Mickey Lake	58.7	Upper Woodcock Lake	33.6
Hartman Lake	5.2	Mud Lake	87.7	Wells Lake	6.7
Harvey Lake	4.8	North Twin Lake	18.5	Whelock Lake	8.4
Herendeene Lake	38.8	Page Lake	10.5	Wiltz Lake	10.8
Holden Lake	10.5	Peanut Lake	3.7	Unnamed	279.6
Hooker Lake	6.9	Pearl Lake	302.5		
Horseshoe Lake	6.4	Pigeon Lake	1.8		

Source (GIS layer for Lakes in watershed, Michigan Center for Geographic Information)

Lake Dubonnet is a shallow water body covering 162 acres. The lake level is dam controlled to permit seasonal flooding of the riparian wetland complex surrounding much of the lake primarily for wildlife habitat purposes. The outflow of Lake Dubonnet has historically been considered the upstream limit of the main branch of the Platte River. Below the outflow, the unnamed second order stream continues flowing primarily westward until it flows through Mud Lake (33 acres) just prior to emptying into Lake Ann.

Lake Ann covers 527 acres, with a maximum depth of 75 feet. There are multiple deep basins that exceed 60 feet in depth adjacent to shallow mid-lake sand-bars. The southern end of the lake, which receives the upper Platte River, is a shallow bay with large areas of emergent vegetation. Lake Ann also receives the outflow of Ransom Creek along its eastern shoreline. The Ransom Creek drainage originates in the wetland complex adjacent to Lyons Lake (56 acres), which flows into Bellows Lake (257 acres), which then flows into Ransom Lake (17 acres) before emptying into Lake Ann.

Below Lake Ann, the Platte River continues to interact with lake systems. After receiving the outflow of Upper and Lower Woodcock lakes, the river then flows through Bronson Lake in southern Almira Township. As the river proceeds southwesterly it receives an increasing amount of input from a number of first order streams and riparian springs. The river's juncture with second order Brundage Creek just upstream of the Platte River Hatchery marks the beginning of the third order section of the Platte River as well as the general upstream limit of the coldwater fishery section.

Downstream of the Hatchery, the Platte River continues as a coldwater system, receiving Carter Creek drainage just above Pioneer Road. This sub-watershed originates in 40 acre Turtle Lake, which drains via intermittent flows down the Carter Creek channel. This groundwater fed system has a seasonally intermittent surface outflow (Carter Creek) which continues to gather groundwater inputs as it descends toward the Platter River, eventually becoming an important coldwater tributary just above the main branch of the Platte. The Platte continues as a high quality coldwater system down through Honor on toward Big Platte Lake.

The North Branch of the Platte River is a coldwater system above Little Platte Lake that originates from groundwater springs in south central Platte Township which flow westerly. The North Branch empties into the Deadstream which is just south of Little Platte Lake, which is a shallow lake with extensive vegetation. The lake's outlet flows into Deadstream or the lower North Branch, and is a warm water and low gradient stream which joins the main branch of the Platte River just above Big Platte Lake.

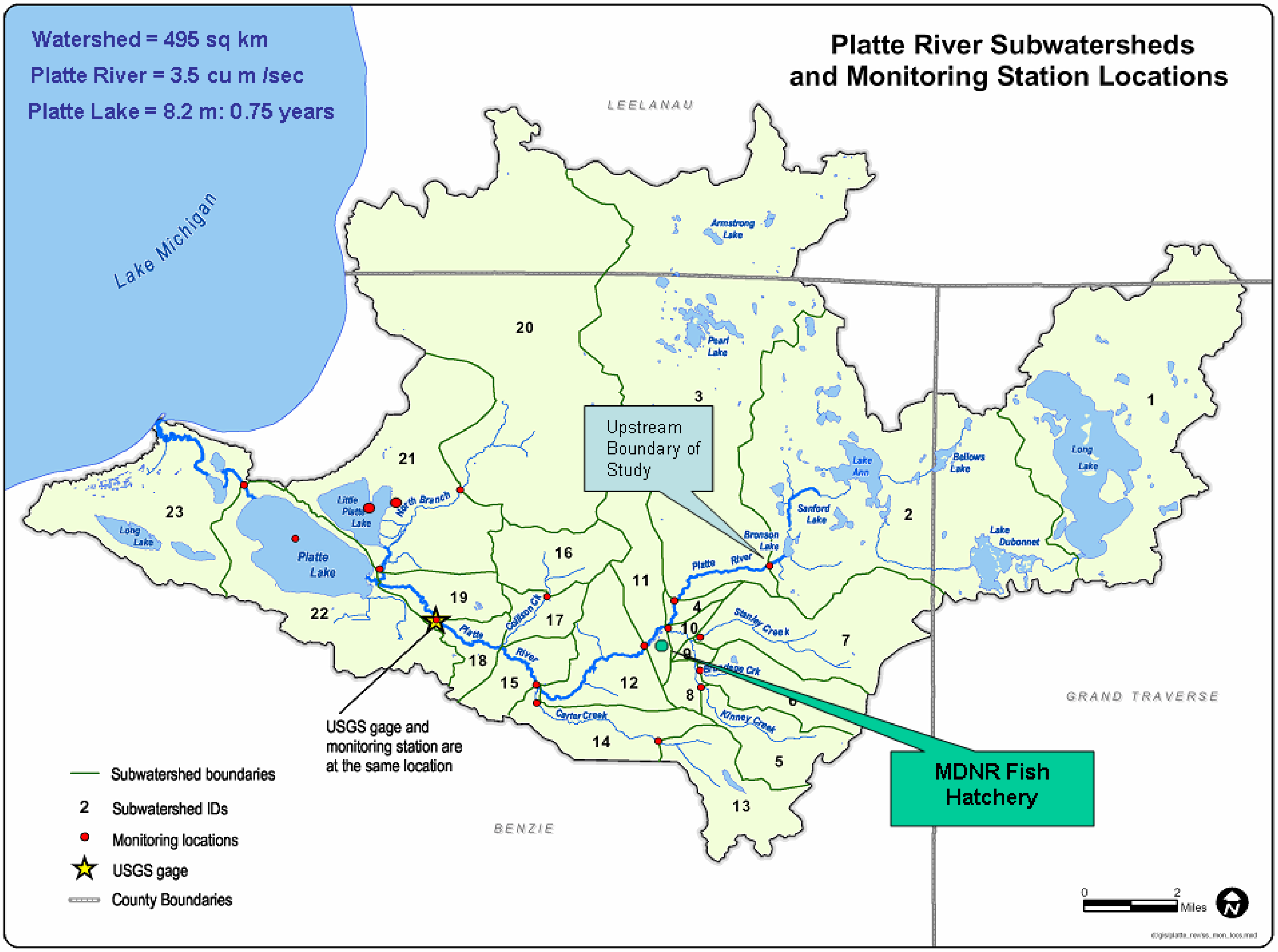
Big Platte Lake is the second largest lake in the watershed and is located in Benzie County downstream of the Village of Honor. It is approximately 3.3 miles long and 1.6 miles wide, covering approximately 2,516 acres. It has a maximum depth of 95 feet and an average depth of 24 feet. The lake also receives flow from several unnamed groundwater streams that originate mostly in the sandy, forested ridgelines overlooking the south shore of the lake. Exiting Big Platte Lake at its west end, the main branch of the Platte River continues as a warm water system that flows into the Sleeping Bear Dunes National Park and through Loon Lake (94 acres) before it completes its journey and empties into Lake Michigan's Platte Bay at Platte River Point.

The northern portion of the watershed starting in Leelanau County's Kasson and Empire Townships contains several small kettle hole lakes that are either partially connected to each other, or entirely separate. These water bodies are ultimately connected to the Platte River via groundwater aquifers. Pearl Lake (302 acres) has extensive weedy back bays and an irregular shoreline, making it the largest of these isolated systems. Pearl also has extensive natural shorelines due to the large amount of State Forest and privately protected land along the lakeshore. Other isolated lakes in the watershed include Stevens Lake (40 acres), Herendeene Lake (39 acres) and Sandford Lake (90 acres); all have moderate to heavy residential development along their shorelines.

Based on a detailed analysis of the Platte river flow, 97% of Platte river flow is base flow from infiltrated ground water and only 3% is contributed from surface runoff (LimnoTech, 2007 and Holtschlag and Nicholas, 1998). This is caused by the high permeability of the primarily sandy soils that occur across most of the predominately forested uplands throughout the watershed.

Average inflow to Big Platte Lake is approximately 120 cubic feet per second (about 3.3 million gallons per hour or 3.5 m^3/sec). At this rate, the mean hydraulic retention time for Big Platte is 0.75 years. The USGS maintains a gauging station on the River as shown in Figure 4.

Figure 4: Platte River Sub-watersheds and Monitoring Station Locations

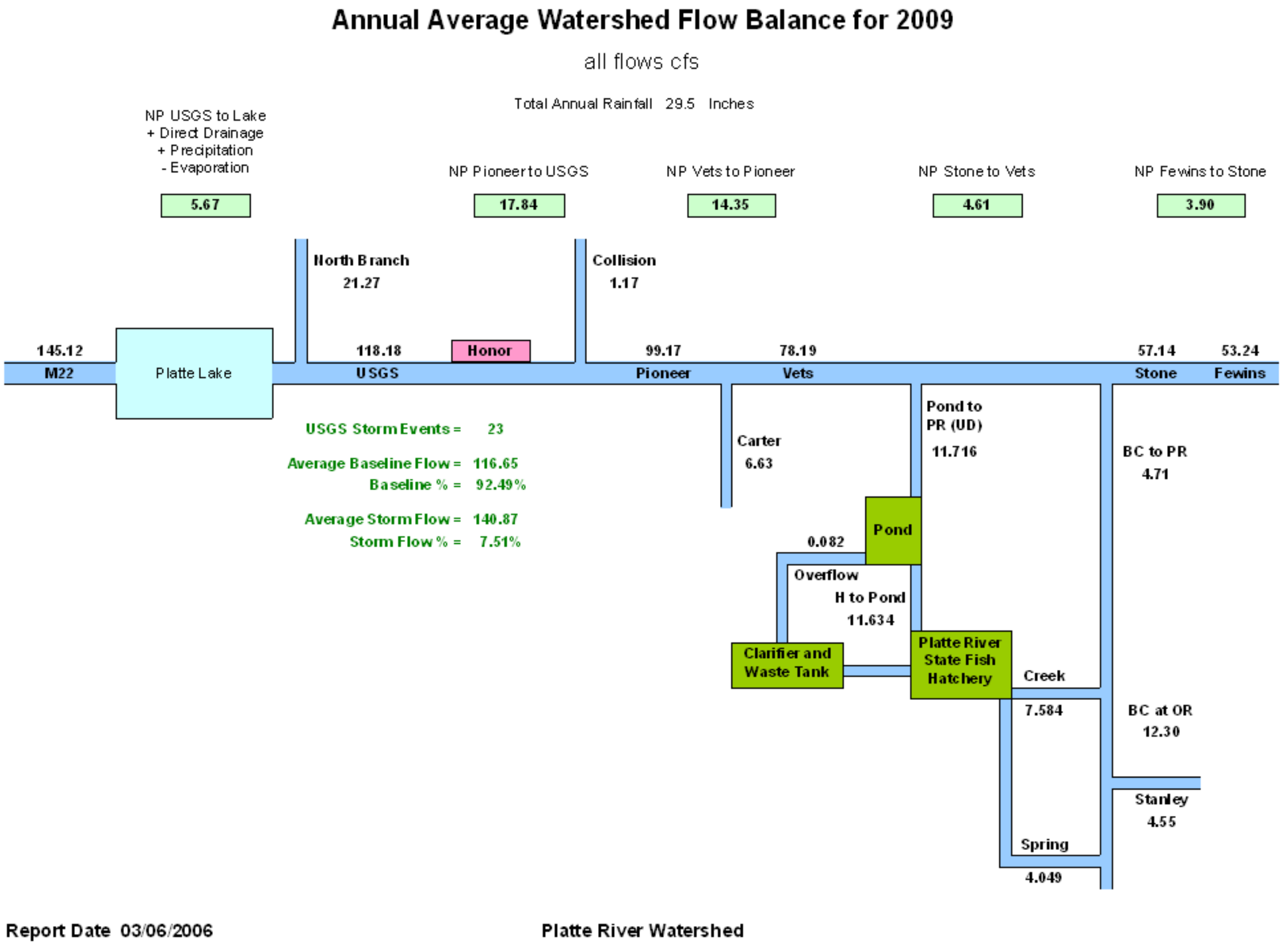


Twenty percent of the flows exceed 4.1 m^3 /sec, and 80% exceed 3.1 m^3 /sec. The lake has a surface area of 10.2 km^2 and a drainage area of 471 km^2. Big Platte receives the drainage from roughly 95 % of the watershed before emptying into Lake Michigan at the Sleeping Bear Dunes National Lakeshore.

Watershed Flow Balance

Figure 5 shows an annual average 2009 flow balance for the lower watershed starting at Fewins Road and extending to the outlet of Big Platte Lake (Berridge and Canale, 2012). The flow balance also includes the tributary water diversion and discharge by the Hatchery. Tributary and non-point flows and flows at intermediate locations on the Platte River are based on correlations with the USGS measured flows at US-31. These correlations were developed over a three-year period using flow measurements at intermediate locations in the watershed. Flow at the USGS location is about 2.2 times the flow at Fewins Road, and the Lake outlet flow is about 2.7 times that of the flow at Fewins Road. Daily hydrograph data from the Platte River at the USGS gauging station can be separated into base flow and wet weather event flows. The average flow during the storm events was 140.9 cfs. The daily average flow during dry or baseline conditions was 116.7 cfs. The storm flows occurred only about 6.3% of the time during 2009, but accounted for about 7.5% of the total amount of water that entered Big Platte Lake through tributaries. Base flow is comprised of groundwater discharge into surface waters, which accounts for 93% to 97% of the Platte River base flow depending on precipitation.

Figure 5: Annual Average 2009 flow balance for the lower watershed



In Summary, the Platte River Watershed includes a number of isolated kettle lakes, which are hydrologically connected to a main series of river and lake systems centered along the Platte River.[1]The water quality and hydrologic functions of the Platte River are relatively stable because the area contains deep glacial outwash deposits that promote consistent, high quality groundwater outflows and large areas of contiguous forestland.

The glacial geology of the Platte River watershed has created a unique matrix of lake and river systems. The highly permeable soils that dominate the upper reaches of the watershed lack significant wetland complexes to filter groundwater recharge basins. Fortunately, the intact forest cover and relatively low residential development has left areas of groundwater infiltration adequate to maintain high water quality. The majority of the watershed is comprised of forested, sandy hill complexes interspersed with broad, level upland areas that promote rapid infiltration of precipitation through highly permeable soils. These areas have a low slope gradient combined with permeable soils, which gives them a much higher potential for groundwater recharge. The subsequent emergence of groundwater springs at the base of these upland areas produces hundreds of unnamed first order streams throughout the watershed. As they flow downhill, these tiny tributaries eventually coalesce into larger named creeks as they descend toward the main Platte River valley.

Long Lake is situated at the top of the watershed, elevation wise, and therefore is dependent on infiltration of precipitation through the surrounding sandy uplands to supply its underground springs which empty into the lake floor itself. The lake’s outlet, Sucker Creek, flows intermittently through the stream substrate until collecting enough groundwater to become a perennial stream just before it empties into Lake Dubonnet. The outflow of this dam controlled impoundment marks the official beginning of the Platte River. The second order Platte flows through and/or connects with a series of lake systems, including Lake Ann, Upper and Lower Woodcock Lakes, and Bronson Lake before joining the second order Brundage Creek system immediately upstream from the Hatchery. As the main river descends below Lake Ann, an increasing amount of groundwater contribution is received from riparian springs, which slowly transforms the lake influenced, warm water upper Platte River system into a primarily coldwater stream. The cold groundwater influences become more and more prominent downstream from Burnt Mill bridge.

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[1] The ecosystems of flowing water bodies are called Lotic system and ecosystems of stationary water bodies are called Lentic system. (Wetzel, 1983)

The river transition to a primarily coldwater system is complete immediately downstream from confluence of the second order Brundage Creek drainage.

Below the Hatchery, the river exemplifies a high quality coldwater system all the way down to Big Platte Lake. The second order Collision Creek drainage empties into the river in this reach as well. Collision Creek is an important groundwater tributary that flows from the southern portion of the watershed. The next major tributary to join the Platte is the North Branch of the Platte River, also known as the Deadstream.

The Platte River watershed also contains dozens of smaller, isolated lakes that represent unique hydrologic conditions found only in glacially dominated landscapes. As the massive glacial ice sheets retreated, large blocks of ice broke away and were buried in the fine sediment. These huge ice cubes slowly melted, creating unique, often conical depressions in the landscape. The larger ice chunks left deep depressions, which dropped below the groundwater table established by underlying rock and clay lenses. The resulting lake level represents the elevation at which the surrounding soils have become saturated with groundwater. This direct connection between the lake water and local groundwater infiltration through the surrounding hillsides puts these aquatic systems at particular risk of water quality degradation from improper watershed practices.

Kettle lakes are typically small (10-60 acre) water bodies that are particularly sensitive to residential development. The lake basins are typically small with steeply sloping hills and highly permeable soils. These conditions put receiving kettle lake basins at particular risk of nutrient rich or toxic laden runoff, which can easily infiltrate groundwater recharge zones near lakeshores or directly entering the surface body in stormwater runoff. The flow of groundwater through these smaller kettle lake systems into the larger groundwater aquifers which eventually empty into the main Platte River valley is not yet well understood. Future efforts to map and identify groundwater flow through the Platte River Watershed will better refine our knowledge of how these unique hydrologic conditions. None the less, it can be assumed that the residence period for lake water in a kettle hole system is much longer than then flow-through lakes systems situated along the main Platte River valley.

Wetlands

Wetlands comprise a vital link in the preservation of high water quality in the Platte River Watershed. The Platte contains riparian wetlands in the upper reaches of the watershed that provide critical buffers between upland habitats and surface water bodies. These relatively narrow bands of wetlands along stream channels and at the base of infiltration basins protect groundwater springs and small stream channels by filtering out sediment and extracting nutrients from surface run-off before it reaches the stream channel and ultimately the lake (Figure 6).

Wetland soils and vegetation are also very important natural defenses against flooding by absorbing surface runoff and storm water and releasing it slowly into streams and groundwater. In addition to the water quality benefits of intact wetlands, the Platte River Watershed contains critical habitat for several threatened and endangered plants and animal populations (see section 2-7). The diversity of micro-habitats found within wetlands allows them to host more types of plants and animals than any other biological community.

Currently the Federal Army Corps of Engineers and the State of Michigan regulate wetlands that are 5 acres or greater or connected to the Great Lakes. Additionally, the State of Michigan also protects wetlands under state law PA 451 of 1994 if they meet any of the following conditions:

- Located within 1,000 feet of one of the Great Lakes or Lake St. Clair.
- Connected to an inland lake, pond, river, or stream.
- Located within 500 feet of an inland lake, pond, river or stream.
- Not connected to one of the Great Lakes or Lake St. Clair, or an inland lake, pond, stream, or river, and less than 5 acres in size, but the DEQ has determined that these wetlands are essential to the preservation of the state's natural resources and has notified the property owner.

A study to identify potential wetland areas, combining different sources of wetland information using Geographic Information Systems (GIS) software, was completed in early 2000 by the Northwest Michigan Council of Governments (NWMCOG) through the Special Wetland Area Management Project (SWAMP), coordinated by the Michigan Department of Environmental Quality (DEQ). The dataset is a composite of three sources of wetland information:

1. The National Wetland Inventory (NWI), conducted by the U.S. Fish and Wildlife Service.
2. The U.S. Soil Conservation Service Soil Survey, which identifies hydric soils and soils with hydric inclusions and/or components.
3. The Michigan Resource Inventory System (MIRIS) Land Cover interpretation from aerial photographs.

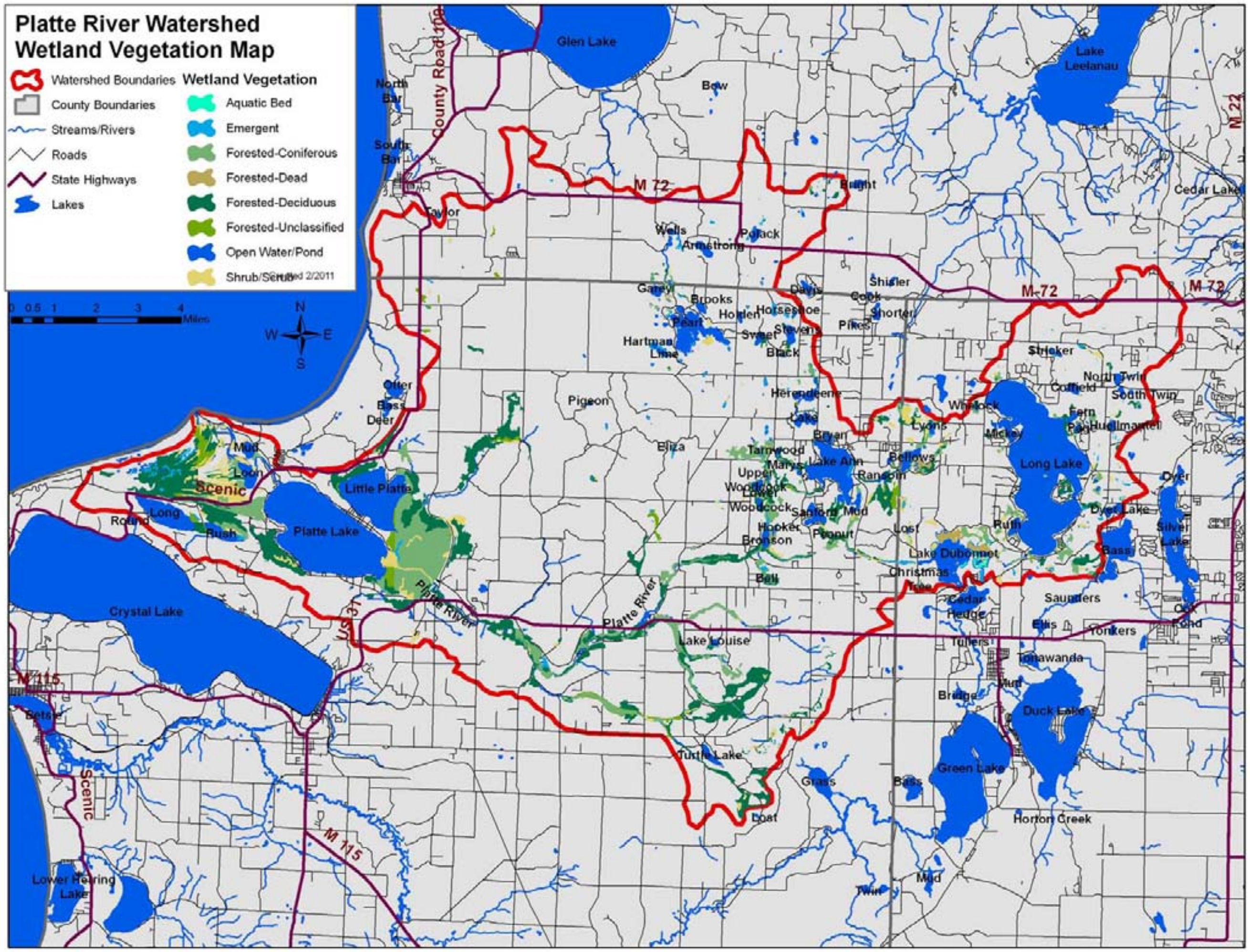
Delineated wetlands in the Platte River watershed cover 12,611 acres or 7.2 % of the total watershed area (Table 2, Figure 6). The majority of the wetlands in the PRW are forested (80%) and 45% of these forested wetlands are dominated by deciduous trees. The largest wetland complex in the watershed is found just east of Big Platte Lake. The ‘Deadstream Swamp’ as it is locally known is a large wetland the encompasses the hydrologic juncture of the North Branch of the Platte River, Little Platte Lake, the main branch of the Platte River and Big Platte Lake. The Deadstream swamp supports a diverse plant and animal community dependent on large tracts of un-fragmented landscape. Black bear are known inhabitants of the area.

These designated wetland boundaries provide a useful planning tool in determining the general location and amount of probable wetland areas, but the data has not been field checked. Localized groundwater fluctuations from disturbed hydrologic functions, unusual precipitation patterns and other external influences can drastically alter the wetland/upland boundary, thereby shrinking or growing wetland communities as compared to their official mapped boundary.

Table 2: Composite Wetland Areas in the Platte River Watershed

Type of Wetland	Acres	% of Wetlands
Aquatic Bed	45.0	0.4
Emergent Conifer	602.2 3686.4	4.8 29.2
Dead	212.3	1.7
Deciduous	5642.8	44.7
Unclassified	564.1	4.5
Open Water	307.9	2.4
Shrub Scrub	1550.6	12.3
Total	**12,611.3**	**100%**

Figure 6: Composite Wetlands of the Watershed



2.3 Geology and Soils

Geology

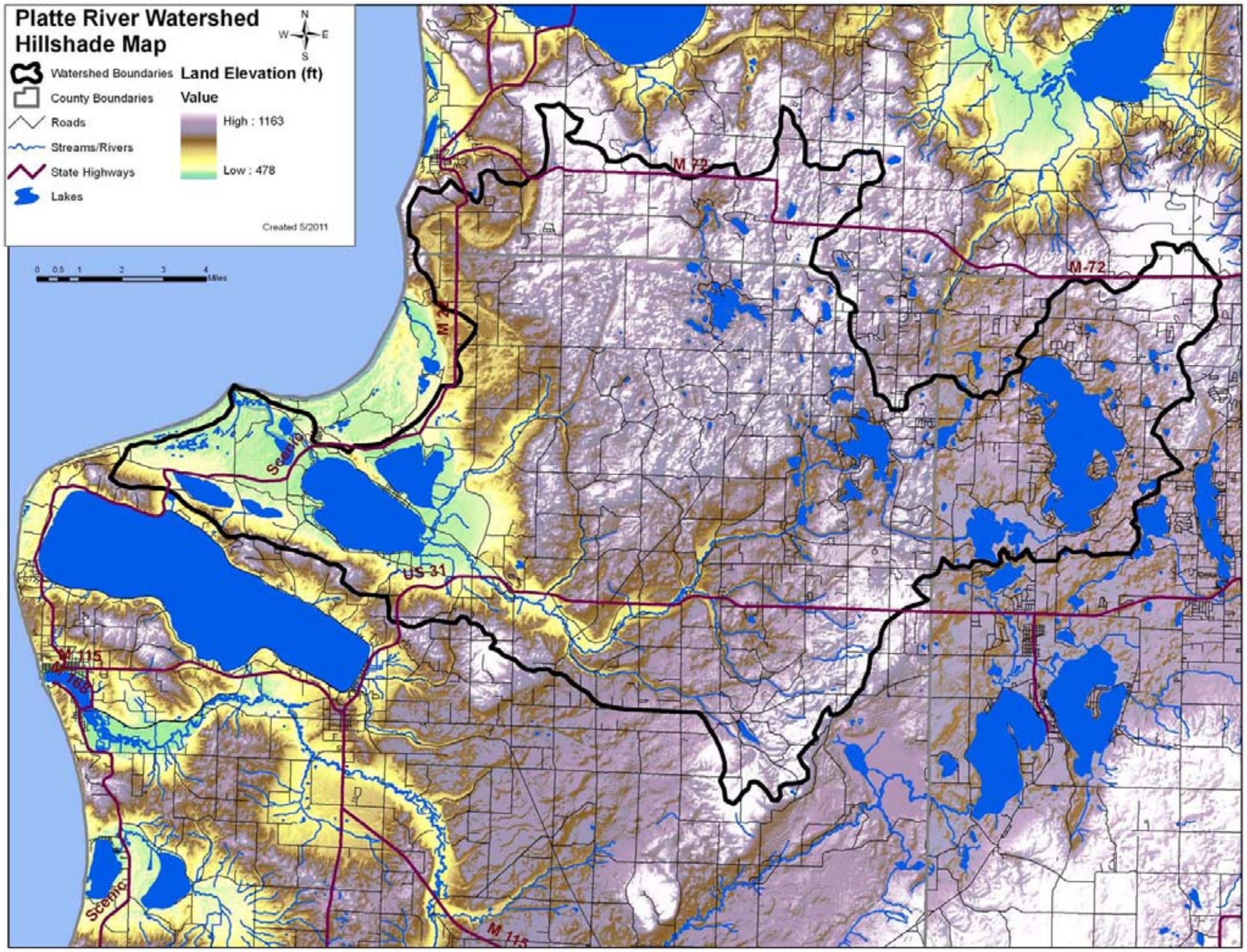
The oldest rock layers of Michigan are found at the edges of what we now recognize as the state boundaries. The bedrock below the general land area forming the Platte River basin dates back to at least the Paleozoic Era (Devonian/Mississippian Period) or about 345-405 million years ago. More recently (500,000 to 2 million years ago) during the Pleistocene Epoch, or Ice Age, four periods of glacial activity took place. The final retreat of glacial ice and the succeeding rebound of the earth surface freed of ice cover thousands of feet thick, left the landscape we see today.

The gradual northward retreat of glacial ice left deposits of soil and rock in patterns that created a narrow division between the Platte, Lake Leelanau and Bestie River Watersheds. The Platte River basin is further subdivided by similar melt water processes that formed the main stream channels and lake basins. The predominant post-glacial feature in the Platte River basin is an interconnected lake and river system. Dozens of other isolated lakes were haphazardly formed where large blocks of glacial ice broke away and slowly melted. Kettle lakes, as they are called, are found extensively throughout the watershed.

The complexity of surface and subsurface hydrologic connections within the watershed present challenges to understanding and thereby protecting water quality. The permeability of the major soil associations increases the potential for groundwater infiltration and subsurface flow that helps supply the stable flows and steady temperatures of the groundwater fed streams found throughout the Platte River Watershed. The process of storm water infiltration and movement through these porous soil complexes removes sediment and many of the excess nutrients from the groundwater flows. While many of the primary pollutants of concern are removed by groundwater infiltration, some toxins and hydrocarbons remain mobile and are transported large distances in areas with active soil hydrology, which can complicate remediation of individual contamination sites or spills.

The lack of large wetland complexes in most of the watershed increases the need to be vigilant about potential groundwater contamination. Many of the groundwater fed tributary streams throughout the Platte watershed emerges from the ground in sandy, upland northern hardwood forest environments with little or no riparian vegetation or wetlands to buffer the streams from direct stormwater run-off. The loose, sandy soils, which help promote groundwater infiltration far upstream and filter nutrients from it, can threaten water quality by easily eroding into the stream channel and re-contributing many of these nutrients back into the base flow. This underscores the importance of protecting intact riparian wetlands and other vegetation to prevent exposed soils in areas where stormwater can flow directly into surface water bodies.

Figure 7: Platte River Watershed Hillshade Map



Soils and Topography

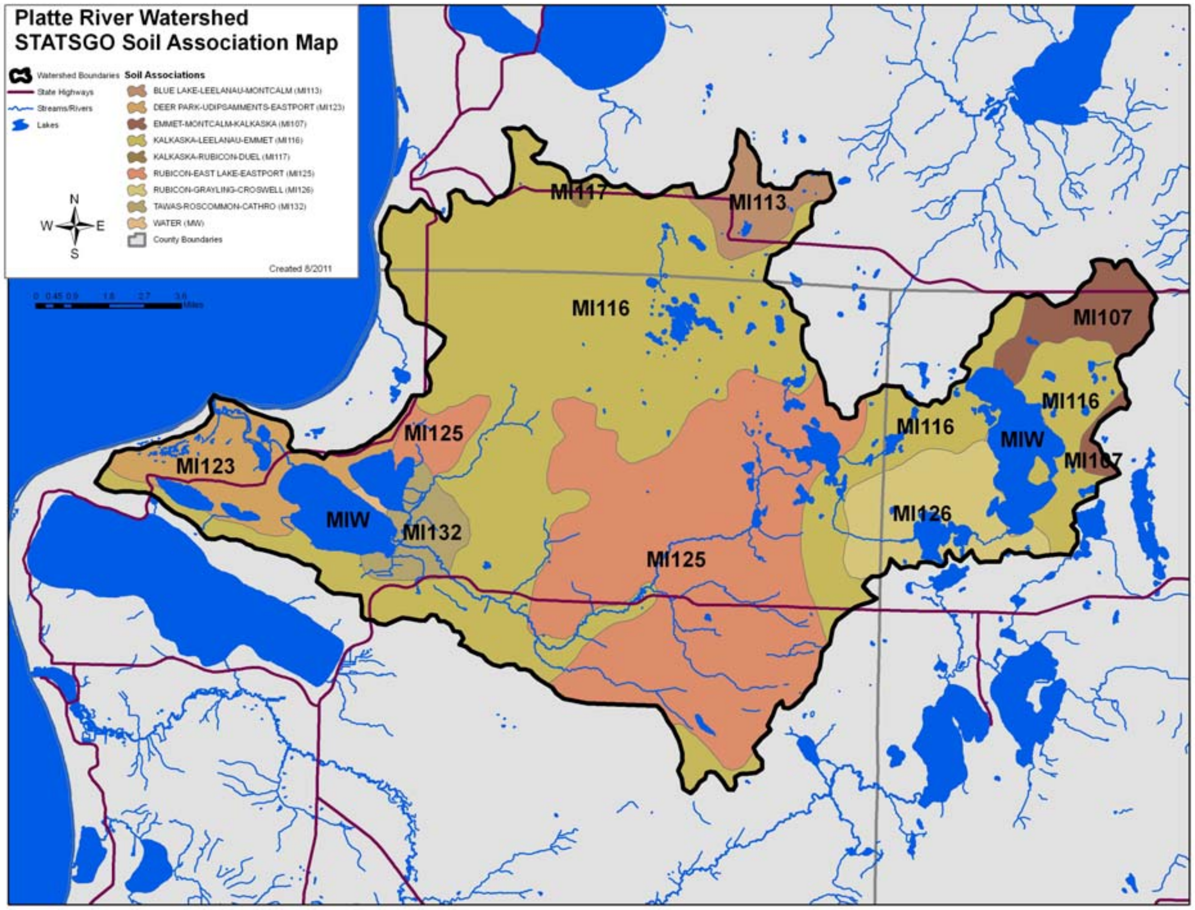
The Platte River Watershed is gently sloping with soils that range from mucky to well drained. The Platte River Watershed is bordered to the east and west by north/south running, streamlined hills formed by retreating glaciers. These hills, called drumlins, are composed of sandy and coarse loam soils that are well drained and conducive to agriculture (Figure 8).

There are eight main soil associations in the Platte River watershed:

Kalkaska-Leelanau-Emmet association makes up the majority of the soil associations comprising 48% and the Rubicon-East Lake-Eastport association comprises 28%. The Rubicon-Grayling-Croswel association comprises 6%, Deer Park-Upidsamments-Eastport and water comprise 5%, Emmet-Montcalm-Kalkaska association, 3%, the Blue Lake-Leelanau-Montcalm association and the Tawas-Roscommon-Cathro comprise 2% and the Kalkaska-Rubicon-Duel association only 0.2 %, (Figure 8).

Nearly level to strongly sloping sandy soils on outwash plains characterize the Kalkaska-Leelanau association. The Rubicon soils are deep, excessively drained sandy soils on nearly level to steep topography. The Blue Lake association is characterized by well-drained, nearly level to strongly sloping, gravelly, loamy and sandy soils on outwash plains. The Deer Park association is made up of sandy soils that are well drained and strongly sloping to very steep. Eastport associations are well to moderately well drained, nearly level to gently sloping, sandy soils. In contrast, the Kalkaska-Rubicon association is found on moraines. Watershed valley floors, lakeshores and wetlands are typically composed of Lupton-Markey mucks or marl with a high pH.

Figure 8: Soil Associations of the Platte River Watershed



2.4 Jurisdictions

The Platte River watershed is comprised of portions of 14 townships within three counties: Leelanau County, Benzie County and Grand Traverse County (Figure 1, Tables 3 and 4). State of Michigan State Forest comprises almost 30% of the watershed and the Sleeping Bear Dunes National Lakeshore covers 6.3% of the watershed. (Figure 9, Table 5). About 50% of the watershed is in private ownership (49.4%), which includes about 1780 acres or 1.4% in private conservation easements.

Table 3: Percent of each to County within the watershed

County	Total Acres in the Watershed	% of County in Watershed
Benzie County	87,813	71%
Grand Traverse County	20,129	16%
Leelanau County	15,666	13%

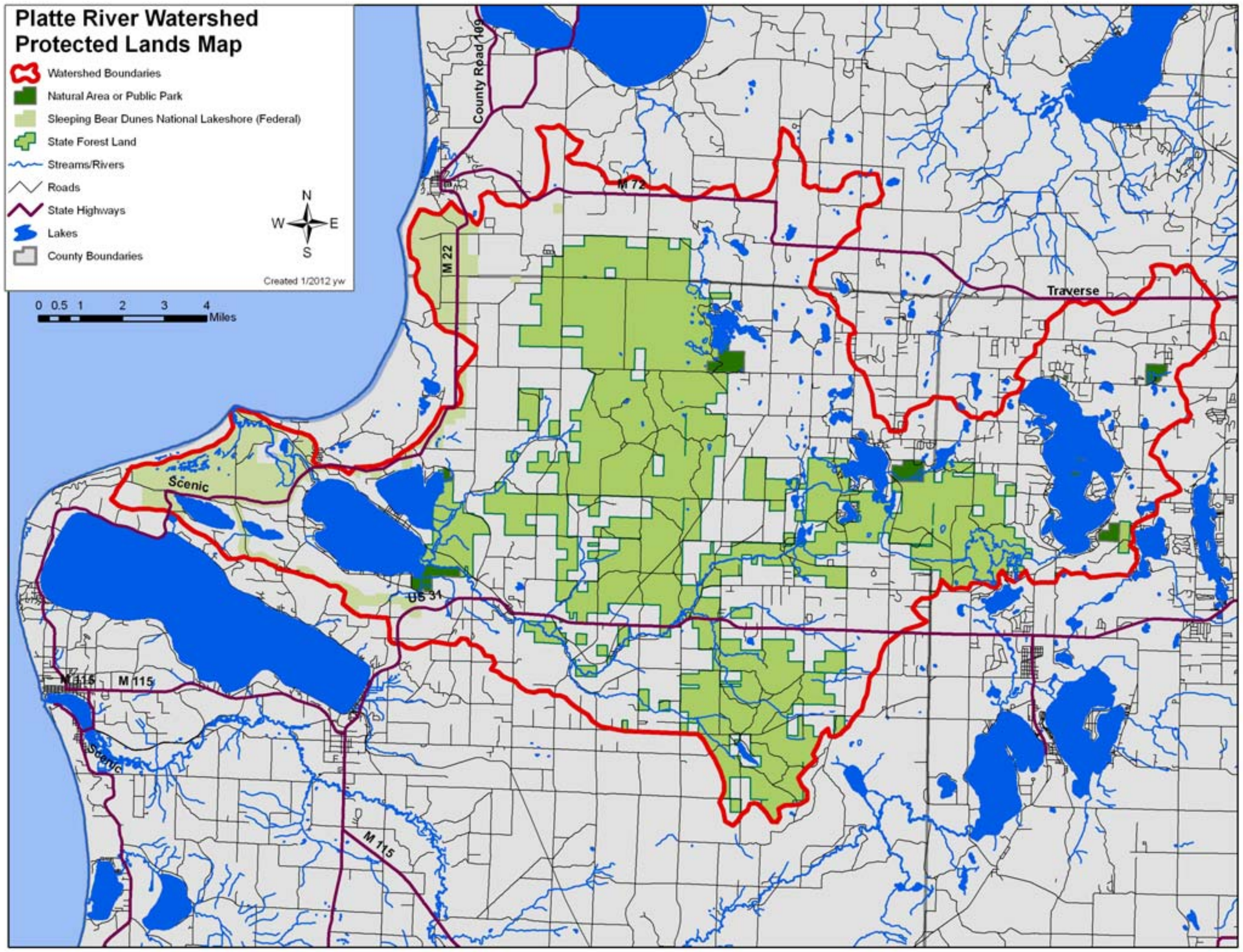
Table 4: Percent of each township within the watershed

Township	County	Acres in Watershed	% of Acres Watershed	% of Township in Watershed
Almira	Benzie	19,294.5	15.6	83.8
Benzonia	Benzie	6,069.9	4.9	28.0
Colfax	Benzie	404.7	0.3	1.8
Homestead	Benzie	12,704.6	10.3	65.5
Inland	Benzie	17,112.3	13.8	74.0
Lake	Benzie	9,597.3	7.8	42.7
Platte	Benzie	22,629.5	18.3	97.0
Garfield Twp	Grand Traverse	536.6	0.4	3.0
Green Lake Twp	Grand Traverse	2,290.2	1.9	9.8
Long Lake Twp	Grand Traverse	17,302.3	13.9	75.9
Elmwood Twp	Leelanau	612.2	0.5	4.6
Empire Twp	Leelanau	9,064.7	7.3	36.8
Kasson Twp	Leelanau	5,924.8	4.8	25.5
Solon Twp	Leelanau	64.4	0.05	0.3
Total		123,608.1	100.0	

Table 5: Public and Private Land in the Platte River Watershed

Jurisdiction	Acres	% of Watershed
Privately Protected Land (conservation easements- CE's)	1,780.0	1.4
Public Parks/Natural Areas	1,054.5	0.9
Nat'l Lakeshore	7,741.6	6.3
State Land	36,405.4	29.6
Private Land	59,260.7	48.1
Water (Lakes and Streams)	17,366.0	14.1
Total	123,608.1	100%

Figure 9: Public/Protected Lands in the Watershed



2.5 Population

Rich in land and water resources, the Platte River Watershed is home to more than 52,000 people living in three counties and covering 14 Townships (Table 6). Since the Platte River Watershed does not directly follow census boundaries, it is difficult to evaluate demographic characteristics of the exact population within the watershed boundary. According to the last census, Benzie County, Grand Traverse County and Leelanau County grew at one of the fastest rates in Northwest Michigan. From 2000 to 2010 the area's population rose 10% (Table 6) and future projections indicate a steady growth rate for years to come. Grand Traverse County showed the highest percent change in the recent census at 12%, while Leelanau County only showed a 2.8% change.

Benzie County has the sixth smallest year-round population among counties in Michigan. The Benzie County population was 11,205 in 1980, and 12,200 in 1990 and 17,525 in 2010 (Table 7). In fact, Benzie County's population grew by 31% from 1990-2000, the 4th fastest in Michigan (Benzie County Open Space and Natural Resources Protection Plan (BCOSNRPP)).

The greatest individual township population increases between 2000 and 2010 were found in Lake and Inland Townships, with 19.5% and 30.5% increases respectively. Benzie County's population doubles during summer months to nearly 26,000 persons (LLMP 2009). In Grand Traverse County, Long Lake Township's population also increased from 2000 to 2010 (Table 6). Future projections indicate a 55% increase in growth before 2020. Long Lake Township's population increased by 277% from 1970 to 1990 (Resig and Stone, 1999), with approximately 8,000 people currently residing in Long Lake Township. That number is expected to rise by 75% in the next 15 years (LLMP 2009). These increases in population and future development have the potential to impact the entire watershed through nonpoint source pollutants, increased stormwater runoff, loss of wetlands, land fragmentation and potential degradation of important groundwater recharge areas.

Table 6: Population and Population Change by Township

Township	County	1990	2000	2010	% Change
Almira	Benzie	1,449	2,811	3,645	29.7
Benzonia	Benzie	2,405	2,839	2,727	-3.9
Colfax	Benzie	415	585	657	12.3
Elmwood	Leelanau	3,427	4,264	4,503	5.6
Empire Twp	Leelanau	858	1,085	1,182	8.9
Garfield Twp	Grand Traverse	10,516	13,840	16,256	17.5
Green Lake Twp	Grand Traverse	3,677	5,009	5,784	15.5
Homestead	Benzie	1,477	2,078	2,357	13.4
Inland	Benzie	1,096	1,587	2,070	30.4
Kasson Twp	Leelanau	1,135	1,577	1,609	2.0
Lake Twp	Benzie	508	635	759	19.5
Long Lake Twp	Grand Traverse	5,977	7,648	8,662	13.3
Platte Twp	Benzie	253	342	354	3.5
Solon Twp	Leelanau	1,268	1,542	1,509	-2.1
Total	**Average = 11.0**	**36,451**	**47,842**	**52,074**	**8.1**

Table 7: Population and Population Change by County

County	1990	2000	2010	% Change (2000-2010)
Benzie	12,200	15,998	17,525	9.5
Leelanau	16,527	21,119	21,708	2.8
Grand Traverse	64,273	77,654	86,986	12.0
				Average = 8.1
Total	**93,000**	**114,771**	**126,219**	**10.0%**

Estimate – Population Division, U.S. Census Bureau

2.6 Land Use/Land Cover

The land area within the watershed is dominated by 49% forested lands, (41% deciduous and 8 % coniferous), 17% is covered by water and wetlands, followed by 20% agriculture (8% cropland, % 1.8 orchards and vineyards, and 18.9 % permanent pasture or other agriculture), and Low Density Residential (LDR) comprising 3% (Figure 10, Tables 8 & 9).

The Platte River watershed is fortunate to have almost half of its land in a forested condition (Tables 8 & 9). Deciduous forest stands comprise the single largest land use of the watershed and, with sustainable management, provide an economic resource. Well managed hardwood forests also provide important habitat and promote groundwater recharge. Wetlands (10.2 %) and Herbaceous Rangeland (9.7%) cover the majority of the remaining portions of the watershed (Table 8). These undeveloped areas (Forests, herbaceous rangeland and wetlands) comprise 70% of the watershed land use, which helps maintain the high water quality and groundwater dominated aquatic systems.

Residential homes or Low Density Residential (LDR) area, which comprises 3% of the watershed currently, is likely to increase (Table 9). Recreation is also an important activity in the Platte River Watershed, especially sport fishing and hunting. The lack of significant industry in the watershed is a legacy of the 1950's resort era that followed the crash of the resource dependent early 1900's economy. Since that time the local economy of the watershed has been based on seasonal tourism, outdoor recreation and summer residents that are drawn to the natural scenery found few other places. The high percentage of forested land in the watershed provides world-class recreational opportunities (hunting, hiking, mushrooming, etc.) along with scenic beauty enjoyed by thousands of tourists while simultaneously protecting wildlife habitat, groundwater recharge and important water quality functions.

(Source Land Use Land Cover Layer -2000, Michigan Geographic Data Library, http://www.mcgi.state.mi.us/mgdl/?action=thm)

Table 8: Land Use/Cover in the Platte River Watershed

Land Use/Cover	Acres	% Total
Beaches	8.6	0.01
Commercial and Services	246.4	0.20
Confined Animal Feeding	3.6	0.00
Cropland	10,023.4	8.11
Coniferous Forest	9,936	8.04
Deciduous Forest	50,525.5	40.9
Forested Wetland	10,105.6	8.18
Herbaceous Rangeland	12,076.6	9.77
Industrial	3,739.9	3.03
Lakes	9,202.7	7.45
Non-forested Wetland	2,505.7	2.03
Orchards, etc.	2,268.2	1.84
Other Agricultural Land	929.9	0.75
Other Urban and Built Up land	575.3	0.47
Permanent pasture	930	0.75
Reservoirs	113.23	0.09
Sandy Areas, other than	41.0	0.03
Shrub and Brush Rangeland	10,255.5	8.30
Transportation, Utilities, etc.	120.6	.10
Total	**123,608.1**	**100%**

Table 9: Grouped Land Use/Cover

Land Use/Cover Category*	Acres	% Total
Barren	49.6	0.04
Commercial	968.6	0.8
Cropland	10023.4	8.1
Forested	61671.8	49.9
Low Density Residential (LDR)	3713.7	3.0
Orchards	2268.2	1.8
Pasture	23431.9	18.9
Water	8869.5	7.2
Wetlands	12611.3	10.2
Total	**123,608.1**	**100%**

Land Use Groupings:

- *Forested: coniferous, deciduous, Agriculture: confined feeding, cropland, orchards/vineyards, other agriculture, permanent pasture, Open Shrub/Grassland: herbaceous, open land/other, shrub; Urban: commercial/services/institutional, extractive, industrial, residential; Water: lake, streams/waterways; Wetlands: forested and unforested; Barren: beach/riverbanks, sand dune*

Figure 10: Land Use in the Platte River Watershed

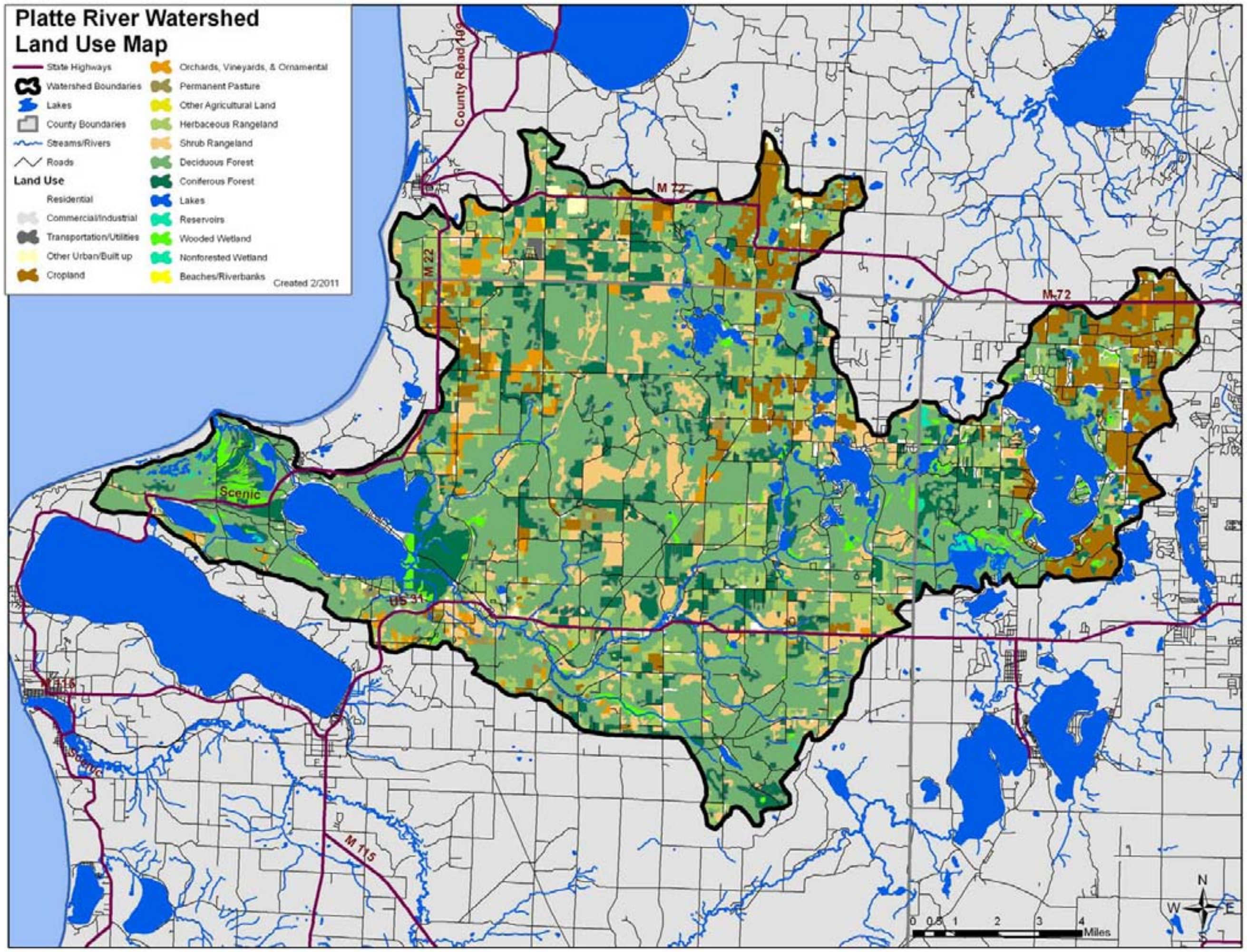
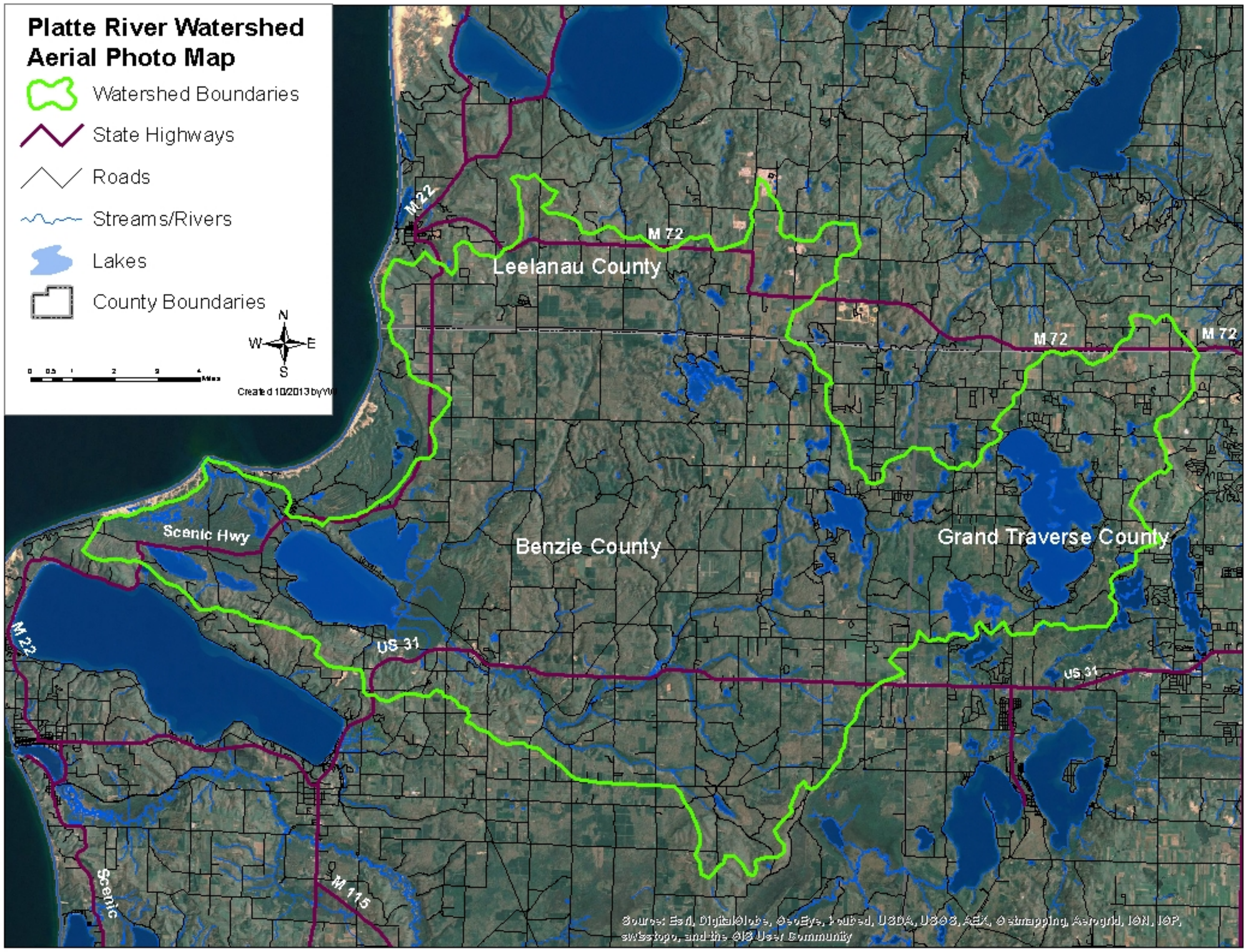


Figure 11: Aerial Photo Map Platte River Watershed



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

2.7 Threatened and Endangered Species

Table 10 is a list of all known occurrences of the Endangered (E), Threatened (T), and Probably Extirpated (X) plant and animal species of Michigan, and high quality natural communities occurring within the Platte River watershed. The species and community information is derived from the MNFI database. The watersheds are based on the 14 digit Hydraulic Unit Codes (HUC).

The species on this list are protected under the Endangered Species Act of the State of Michigan (Part 365 of PA 451, 1994 Michigan Natural Resources and Environmental Protection Act). The current list became effective on April 9, 2009, after extensive review by technical advisors to the Michigan Department of Natural Resources and the citizenry of the state. Also included in this list are Natural Communities, plant and animal species of Special Concern. While not afforded legal protection under the Act, many of these species are of concern because of declining or relict populations in the state. Should these species continue to decline, they would be recommended for Threatened or Endangered status. Protection of Special Concern species now, before they reach dangerously low population levels, would prevent the need to list them in the future by maintaining adequate numbers of self-sustaining populations within Michigan. Some other potentially rare species are listed as of Special Concern pending more precise information on their status in the state; when such information becomes available, they could be moved to threatened or endangered status or deleted from the list.

The listing is based on the polygon representation of the occurrences. Consequently any single occurrence may span watershed boundaries and be listed in more than one watershed. This list is based on known and verified sightings of threatened, endangered, and special concern species and represents the most complete data set available. It should not be considered a comprehensive listing of every potential species found within a watershed. Because of the inherent difficulties in surveying for threatened, endangered, and special concern species and inconsistent of inventory effort across the State species may be present in a watershed and not appear on this list.

Table 10: Platte River Watershed Rare Plant & Animal Species/Natural Communities List

Scientific Name	*Common Name*	*Federal Status*	*State Status*
Accipiter gentilis	Northern goshawk		SC
Ammodramus savannarum	Grasshopper sparrow		SC
Bog			
Buteo lineatus	Red-shouldered hawk		T
Charadrius melodus	Piping plover	LE	E
Cirsium pitcher	Pitcher's thistle	LT	T
Cypripedium arietinum	Ram's head lady's-slipper		SC
Dendroica discolor	Prairie warbler		E
Gavia immer	Common loon		T
Glyptemys insculpta	Wood turtle		SC
Haliaeetus leucocephalus	Bald eagle		SC
Lanius ludovicianus migrans	Migrant loggerhead shrike		E
Mesic Northern Forest			
Microtus pinetorum	Woodland vole		SC
Mimulus michiganensis	Michigan monkey flower	LE	E
Open Dunes	Beach/shoredunes, Great Lakes Type		
Philaenarcys killa	Spittlebug		
Stenelmis douglasensis	Douglas stenelmis riffle beetle		SC
Terrapene carolina carolina	Eastern box turtle		SC
Trimerotropis huroniana	Lake Huron locust		T
Williamsonia fletcheri	Ebony boghaunter		SC
Wooded Dune and Swale Complex			

This list was produced by the Endangered Species Program of the Michigan Department of Natural Resources and the Michigan Natural Features Inventory. English names in common usage or from published sources have been incorporated, when possible, to promote public understanding of and participation in the Endangered Species Program. To comment on the list or request additional copies, or for information on the Endangered Species Program, contact the Endangered Species Coordinator, Wildlife Division, Michigan Department of Natural Resources, P.O. Box 30028, Lansing, MI 48909 (517-373-1263). To report occurrences of these species, please contact: mnfi@msu.edu.

Source: http://mnfi.anr.msu.edu/

2.8 Master Plans and Zoning Ordinances

Master Plans and Zoning Ordinances

How communities manage their land use has a direct impact on the community's water resources. Zoning, master plans, and special regulations are a few of the more commonly used land management tools. Zoning ordinances, if enforced, establish the pattern of development, protect the environment and public health, and determine the character of communities. In 2006, PA 110, The Michigan Zoning Enabling Act was signed into law. This act codifies the laws regarding local units of government regulating the development and use of land. It also provides for the adoption of zoning ordinances; provides for the establishment in counties, townships, cities, and villages of zoning districts; prescribes the powers and duties of certain officials; provides for the assessment and collection of fees; authorizes the issuance of bonds and notes; and prescribes penalties and remedies. In 2008, PA 33, titled Michigan Planning and Enabling Act, was signed into law. This law consolidates previous planning acts under one statute, creating a standard structure for all local planning commissions and one set of requirements that apply to the preparation of all master plans. Since protecting water quality requires looking at what happens on land, zoning is an important watershed management tool.

Planners should recognize that stream quality is directly impacted by adjacent land use with the amount of impervious surfaces being particularly important. Land use planning techniques should be applied that preserve sensitive areas, redirect development to those areas that can support it, maintain or reduce impervious surface cover, (such as roads, driveways and parking lots) and reduce or eliminate nonpoint sources of pollution.

Zoning's effectiveness depends on many factors, such as the restrictions in the language, the enforcement, and public support. Many people assume existing laws protect sensitive areas, often only to find otherwise when development is proposed. Zoning can be used very effectively for managing land uses in a way that is compatible with watershed management goals. A wide variety of zoning and planning techniques can be used to manage land use and impervious cover in the watershed. Some of these techniques include: watershed based zoning, overlay zoning, impervious overlay zoning, floating zones, incentive zoning, performance zoning, urban growth boundaries, large lot zoning, infill/community redevelopment, transfer of development rights (TDRs), and limiting infrastructure extensions. Some benefits of zoning include: increased local control/autonomy over land use decision-making; communicating clear expectations with developers based on community needs; and an opportunity for the residents of the area to design the type of community they want to live in – one that respects their unique cultural, historic, and natural resource values.

Local officials face hard choices when deciding which land use planning techniques are the most appropriate to modify current zoning. Table 11, adapted from the Center for Watershed Protection's Rapid Watershed Planning Handbook, provides further details on land use planning techniques and their utility for watershed protection (CWP 1998). While most of these techniques are for watersheds much bigger than the Platte River Watershed, this handbook still presents many available land use planning techniques. In addition, the MDEQ has published a book titled *Filling the Gaps: Environmental Protection Options for Local Governments* that equips local officials with important information to consider when making local land use plans, adopting new environmentally focused regulations, or reviewing proposed development (Ardizone, Wyckoff, and MCMP 2003). An overview of Federal, State, and local roles in environmental protection is provided, as well as information regarding current environmental laws and regulations including wetlands, soil erosion, inland lakes and streams, natural rivers, floodplains, and more. The book also outlines regulatory options for better natural resources and environmental protection at the local level. A copy of this guidebook is available via the DEQ website: WWW.MICHIGAN.GOV/DEQ → Water → Surface Water → Nonpoint Source Pollution (look under Information/Education heading).

Table 11: Land Use Planning Techniques

Land Use Planning Technique	Description	Utility as a Watershed Protection Tool
Watershed-Based Zoning	Watershed and sub-watershed boundaries are the foundation for land use planning.	Can be used to protect receiving water quality on the sub-watershed scale by locating development out of particular sub-watersheds.
Overlay Zoning	Superimposes additional regulations for specific development criteria within specific mapped	Can require development restrictions or allow alternative site design techniques in specific areas.
Impervious Overlay Zoning	Specific overlay zoning that limits total impervious cover within mapped districts.	Can be used to protect receiving water quality at both the sub-watershed and site level.
Floating Zones	Applies a special zoning district without identifying the exact location until land owner specifically requests the zone.	May be used to obtain proffers or other watershed protective measures that accompany specific land uses within the district.
Incentive Zoning	Applies bonuses or incentives to encourage creation of amenities or environmental protection.	Can be used to encourage development within a particular sub-watershed or to obtain open space in exchange for a density bonus at the site level.
Performance Zoning	Specifies a performance requirement that accompanies a zoning district.	Can be used to require additional levels of performance within a sub-watershed or at the site level.

Urban Growth Boundaries	Establishes a dividing line that defines where a growth limit is to occur and where agricultural or	Can be used in conjunction with natural watershed or sub-watershed boundaries to protect specific water bodies.
Large Lot Zoning	Zones land at very low densities.	May be used to decrease impervious cover at the site or sub-watershed level, but may have an adverse impact on regional or watershed imperviousness.
Infill/ Community Redevelopment	Encourage new development and redevelopment within existing developed areas.	May be used in conjunction with watershed based zoning or other zoning tools to restrict development in sensitive areas and foster development in areas with existing
Transfer of Development Rights (TDRs)	Transfers potential development from a designated “sending area” to a designated “receiving	May be used in conjunction with watershed based zoning to restrict development in sensitive areas and encourage development in areas capable of accommodating increased densities.
Limiting Infrastructure Extensions	A conscious decision is made to limit or deny extending infrastructure (such as public sewer,	May be used as a temporary method to control growth in a targeted watershed or sub-watershed. Usually delays development until the economic or political climate changes.

Table adapted from Center for Watershed Protection’s Rapid Watershed Planning Handbook – page 2.4-5 (CWP 2001)

Local governance can be a complicated issue. Generally, local governments may enact zoning laws that are more stringent than the next highest ranking form of government, but not less. In any case, all applicable State laws must be followed. Most of the townships located in the Platte River Watershed have both a Master Plan and Zoning Ordinance (Tables 13 & 14). Assisting local governments in updating and enacting strong zoning ordinances to protect water quality and secure natural areas is extremely important in the Platte River Watershed and is a high priority for implementation efforts (Chapter 8). Master plans and zoning ordinances have great potential to affect water quality. Zoning ordinances have a direct role in determining the type and density of land use allowed. They regulate permitted uses of the land, for example, setting minimum/maximum lot sizes and setback requirements (from neighbors, roads, water bodies). Overall, zoning ordinances are enacted to ensure that the use of private property does not negatively affect the public's safety, health, and welfare.

Examples of zoning to protect water quality include requiring vegetative buffer zones along bodies of water, requiring greenbelt areas, protecting the integrity of soil by having filtered views along stream corridors (protects banks from erosion), or protecting wetlands. Both Garfield and East Bay Townships located in nearby Grand Traverse County have recently passed zones on bodies of water requiring greenbelt areas.

The Platte Lakes Area Management Plan Overlay District

The Platte Lakes Area Management Plan Overlay District is a zoning overlay district that has been adopted by both Lake and Benzonia Townships. In Lake Township, the ordinance amendment was approved and went into effect August 20, 2005. It was adopted for the Benzonia Township portion of Platte Lake in 2009. See Appendix C for a copy of this ordinance. It is summarized below.

The Platte Lakes Area Management Plan Overlay District, was established and is intended to protect the health, safety and welfare of the Platte Lakes Area by promoting the preservation of natural features, protecting water quality and regulating development and the use of property which borders, encompasses or contacts the surface waters, watercourses and drainage ways to the Platte Lakes Area. The shape, size and character of the property located within this district can vary greatly due to circumstances imposed by the existing water bodies, watercourses, wetlands, drainage ways and varying slopes. Therefore there is not a specific map outlining this district. The intent of the ordinance was to establish land management practices and procedures within the Platte Lakes Area that will help in the attainment and compliance with the court ordered Big Platte Lake water quality standard of 8.0 micro-grams per liter for phosphorus established in the Consent Agreement dated March 10, 2000.

The Platte Lakes Area is defined as the property immediately surrounding the Platte Lakes. Boundaries may vary due to slopes and permeability of the soils, either of which may affect the distance of the boundary from the water's edge. The interpretation of the boundaries of the area is responsibility of the Zoning

Administrator, whose decision may be appealed to the Board of Appeals. In cases where a parcel is not entirely within the boundaries of the Platte Lakes Area only those portions within the Platte Lakes area are required to comply with the regulations of the ordinance.

Navigable water bodies and watercourses, wetland areas 0.5 acre or larger in size, non-navigable waterways with tributaries from other nonnavigable waterways whose origin is from surface run off, or springs and located within the Platte Lakes Area Management Plan Overlay District are subject to the regulations set forth in the ordinance.

The ordinance includes a limit on the number of dwellings, proper engineering of impervious surfaces and drainage, protection of steep slopes, buffer strips (minimum 25 feet wide), development restrictions and limitations on construction practices, mowing recommendations, and other phosphorus control best management practices. It also prohibits fertilizer of any type within the 25 foot buffer zone.

Table 12: Master Plan and Zoning Ordinance Status Summary for Local Governments in Watershed

County	*Township*	*Master Plan*	*Zoning*
Benzie County		Y, 2009	N (Rely on individual Townships)
	Almira	Y, 2012	Y, 2012
	Benzonia	N	Y, 2012
	Colfax	Y, 2012	No zoning, in process
	Homestead	Y, 2008	Y, 2008
	Inland	Y, 2008	Y, 2008
	Lake	N	Y,2010
	Platte	N	Y, 2012
Leelanau County		Y, with updates in 2000 and 2005	N (Rely on individual Townships)
	Empire	Y, 2005	Y, 2008
	Elmwood	Y (1998)	Y (updating in 2006)
	Kasson	Y (2004)	Y, 1997, updates 2011
	Solon	Y, (2010)	Y, 1971 with updates
Grand Traverse		Y, 2002	Y
	Garfield	Y, 2007	Y, 1974 w/ updates
	Green Lake	Y, 2013	Y, 2013
	Long Lake	Y, 2005	Y

During the process of updating the PRWPP a review and summary of master plans and zoning ordinances was conducted (Tables 13 and 14). For the most part, community master plans usually have good intentions when it comes to protecting natural resources. The natural resources of this area are why many people choose to live in the Platte River region. In general however, townships and communities often lack the knowledge on how to draft and enact effective, yet enforceable, zoning requirements. The validity of a zoning ordinance, particularly one that is viewed as overly restrictive is often challenged by developers, among others. Local governments may have trouble obtaining information to back up their ordinances that will stand up in court. Additionally, it is often an argument of property rights vs. the public good, with local governments trying to show and prove that a certain ordinance is important to protect water quality.

Soil Erosion and Stormwater Ordinances

It is important to note that, in addition to zoning ordinances, counties may have separate soil erosion and/or stormwater ordinances. These ordinances come under different state enabling acts than local zoning ordinances. So, even if a township or municipality in the County does not have zoning, they still have to follow the State's soil erosion regulations enforced by Benzie, Grand Traverse, or Leelanau County. Stormwater ordinances can be extremely valuable tools in protecting water quality. It is also important to note that there are existing State and Federal statutes regarding soil erosion and stormwater runoff that must be followed as well. Storm water is addressed in the Platte Lakes Area Management Plan overlay district e.g. one must hold onsite a 3.5 inch 24 hour rain in retention basins or underground rock filled voids.

The Platte Lakes Area Management Plan Overlay District is a zoning overlay district that has been adopted by both Lake and Benzonia Townships. See Appendix C for a copy of this ordinance. It is summarized above.

Table 13: Platte River Watershed 2012 Master Plan Assessments

	MASTER PLAN ASSESSMENT								
Unit of government	*Plan Reviewed ("NA" indicates no plan) and "NP" indicates plan not provided by project deadline)*	*Master Plan Goals/ Narrative Address:*							
		Maintaining/ Promoting Community Character	**Land use limitations for environ-mental constraints**	**Protecting Shoreline/ Platte Lake/other lakes**	**Protecting Wetlands**	**Preserving and protecting Streams/ Surface Water/ Groundwater**	**Soil erosion/ Stormwater Measures**	**Protecting Dunes/ Hills/ Slopes**	**Protecting Forests/ Agriculture/ Open Space**
Leelanau County	X	X	X	X	X	X	X	X	X
Empire Twp	X	X	X	X	X	X	X	X	X
Elmwood Twp	X	X	X		X	X	X	X	X
Kasson Twp	X	X	X			X	X		X
Solon Twp	X	X		X	X				X
Grand Traverse County	X	X	X	X	X	X	X	X	X
Garfield	X				X	X			X
Green Lake	X	X			X	X			X
Long Lake Township	X	X	X		X	X		X	X

Table 13: Platte River Watershed 2012 Master Plan Assessments (Cont'd)

MASTER PLAN ASSESSMENT

Unit of government	*Plan Reviewed ("NA" indicates no plan and "NP" indicates plan not provided by project deadline)*	*Master Plan Goals/ Narrative Address:*							
		Maintaining/ Promoting Community Character	**Land use limitations for environ-mental constraints**	**Protecting Shoreline/ Platte Lake/other lakes**	**Protecting Wetlands**	**Preserving and protecting Streams/ Surface Water/ Groundwater**	**Soil erosion/ Stormwater Measures**	**Protecting Dunes/ Hills/ Slopes**	**Protecting Forests/ Agriculture/ Open Space**
Benzie County	X	X	X	X	X	X	X	X	X
Almira Township	X	X		X	X	X	X	X	X
Benzonia Twp	NA								
Colfax Township	X	X	X			X			X
Homestead Twp	X				X	X	X		X
Village of Honor	NA								
Inland Township	NP								
Lake Township	NA								
Platte Township	NA								

Table 14: Platte River Watershed 2013 Zoning Ordinance Assessments

ZONING ORDINANCE ASSESSMENT									
Unit of government	***Ordinance Reviewed (“NA” indicates no plan and “NP” indicates plan not provided by project deadline)***	***Ordinance Regulations Include:***							
		Special Districts for Environmentally Sensitive Areas	**Approval or Permits for Environmentally Sensitive Areas or Uses**	**Requirements for Shoreline/ Riparian Areas**	**Requirements for Wetland Areas (such as for areas not regulated by DEQ or US Army Corp. of Engineers)**	**Provisions to Protect Streams/ Surface Water/ Groundwater**	**Soil Erosion/ Stormwater Provisions**	**Sewer/ Water Provisions**	**Open Space Requirements**
Leelanau Co	No Zoning	---	---	---	---	---	---	---	---
Elmwood	X		X		X	X	X	X	
Empire	X			X		X		X	X
Kasson	X								
Solon	X	X	X	X	X	X	X		
Grand Traverse Co	X	X	X	X	X	X	X	X	X
Garfield Twp	X	X	X	X	X	X	X	X	
Green Lake	X	X	X	X			X	X	X
Long Lake	X	X	X		X	X		X	X

Table 14: Platte River Watershed 2013 Zoning Ordinance Assessments (CONT'D)

	ZONING ORDINANCE ASSESSMENT								
Unit of government	*Ordinance Reviewed (“NA” indicates no plan and “NP” indicates plan not provided by project deadline)*	*Ordinance Regulations Include:*							
		Districts for Environmentally Sensitive Areas	Approval or Permits for Environmentally Sensitive Areas or Uses	Requirements for Shoreline/ Riparian Areas	Requirements for Wetland Areas (such as for areas not regulated by DEQ or US Army Corp. of Engineers)	Provisions to Protect Streams/ Surface Water/ Groundwater	Soil Erosion/ Stormwater Provisions	Sewer/ Water Provisions	Open Space Requirements
Benzie Co	NA								
Almira Twp	Y			X		X		X	X
Benzonia	Y	X	X	X			X	X	X
Colfax Twp	NA								
Homestead	X			X		X	X	X	X
Inland Township	X			X		X	X	X	X
Lake Township	NA								
Platte Township	NA								

2.9 Fisheries

The Platte River watershed offers world class sport fishing for a variety of popular Michigan game fish. Both Long Lake and Platte Lakes support high quality cool water fisheries that provide anglers with exceptional opportunities for walleye, smallmouth bass and northern pike. In addition to these noted large lake fisheries there are dozens of smaller inland lakes that support healthy warm water fisheries with great pan fishing and largemouth bass angling. The Platte River itself provides a relatively poor warm water fishery in its upper reaches, but supports one of the State's more productive coldwater fisheries for steelhead, brown trout and pacific salmon in the middle and lower reaches. This following summary of the various fisheries found in the Platte River watershed is intended to provide a general description of the types and quality of fishing found in the more popular public water bodies.

Inland Lakes

Long Lake supports a diverse and healthy inland fishery. The most recent netting survey conducted by the MDNR Fisheries Division (2007), found good populations of bluegill, largemouth bass, rock bass, smallmouth bass, yellow perch, walleye and northern pike. Walleye and yellow perch are the most commonly targeted species. The lake receives a lot of fishing pressure from local and traveling anglers that fish the lake year round. Walleye were stocked heavily in the lake from 1986-1990, which resulted in a very large population of sub-legal fish. However, since the last stocking in 1995, the walleye population has relied on natural reproduction. The lake also contains a small population of muskellunge that appear to be reproducing successfully. While no records are listed in the MDNR database, it is commonly known that muskellunge were stocked in Long Lake in the early 1980's. Since none of those original fish could still be alive, it is assumed that the muskellunge spotted in the shallows by anglers every spring, along with the occasional incidental catch, are naturally reproduced descendants of that small stocking effort long ago. The lake has two public boat launch facilities, which both become crowded during peak fishing or recreation hours.

Lake Dubonnet supports a warm water fishery dominated by largemouth bass, bluegill, pumpkinseed, rock bass, and northern pike. The fishery is entirely self-sustaining and is popular with both boat and ice anglers. The northern pike tend to over populate and become stunted, thus the minimum size limit has been temporarily removed from this lake to encourage more retention of smaller pike. There is one boat launch on the lake. The MDNR plans to replace the popular fishing pier on this lake which had to be removed recently due to structural integrity.

Lake Ann: The 2004 MDNR fishery survey found healthy populations of largemouth bass, smallmouth bass, northern pike, bluegill, perch and rock bass. Brown Trout were stocked in Lake Ann from 1984-1992, however the fishery never took hold and stocking was discontinued. Otherwise, the lake's fishery is entirely self-sustaining and supports good natural reproduction of both game fish and forage species. Interestingly, the fishery survey also found decent numbers of Iowa darters, log perch and mimic shiners, indicating an overall diverse fish community. There is a public boat launch and State campground on the lake.

Pearl Lake is an isolated marl lake in Almira Township that supports good bluegill and pumpkinseed populations. The lake was surveyed in 1983 by the MDNR and again in 2008 by the Grand Traverse Band Inland Fish and Wildlife Program. Largemouth bass and northern pike were found in good numbers; however their size was moderate to small with slower than normal growth rates. The most recent survey in 2008 found an unusually large percentage of bluegill that were 8" or longer, which is quite impressive for inland lakes in Northwest Lower Michigan. Pearl Lake has no stocking history and the fishery is entirely self-sustaining. The lake has an unimproved boat launch suitable for smaller boats and canoes.

Next to Pearl Lake is Little Lime Lake, which is a shallow 15 acre lake surrounded by the Pere Marquette State Forest. The MDNR currently stocks up to 75,000 walleye fry into Little Lime every 4 years. The lake was surveyed in 1999 to determine the success of the fry stocking. The survey found a good population of largemouth bass, bluegill and northern pike, however only one walleye was captured. However, angler reports that some fish do recruit to the fishery and are harvested as adults. There is a rustic camping area and unimproved gravel launch on the lake.

Herendene Lake is a popular kettle lake in northern Almira Township that supports a good bluegill population and is very popular with local ice anglers. The last survey for the lake was conducted in 1965, which indicated good numbers of catchable perch, bluegill and largemouth bass. Recent reports from anglers indicate a similar fishery exists today. The lake relies on natural reproduction to support the fishery and there is one public boat launch. Bronson and Stevens Lakes, also in Almira Township, have similar fisheries and were also last surveyed back in the mid-1960's. Armstrong Lake is a small kettle lake in the very northern part of the watershed that does not have any survey or stocking records, however, angler reports indicate a healthy northern pike population with a large average size. Anglers have also reported catching a few large walleye consistently in the last few years, which is unexpected considering the lack of stocking records.

Turtle Lake has been stocked since as early as 1905, when the Department of Conservation (precursor to the MDNR) stocked 125,000 walleye fry. Periodic stockings of warmouth, bluegill, bass, yellow perch and walleye have occurred throughout the years since. It is a popular bass and bluegill lake with local anglers. Angler reports also indicate that the lake contains a small, but stable population of walleye along with good numbers of smaller northern pike. Turtle Lake has one public boat launch for access. The lake was last surveyed by the MDNR back in 1991.

Big Platte Lake contains a good population of bluegill and largemouth bass; however the bass tend to be smaller in size. The Grand Traverse Band surveyed the lake and found excellent numbers of larger bluegill; however they have proven difficult for anglers to locate with any consistency. Big Platte is not stocked by MDNR and the fishery is entirely self-sustaining.

Loon Lake's fishery is quite unique, yet is not well documented. The sparse amount of information available, combined with angler reports, indicates that the lake supports a healthy smallmouth bass population. The lake also provides a good panfish and largemouth bass population. The lake has very good near shore habitat since it lies within the Sleeping Bear Dunes National Lakeshore and has very few remaining homes. Loon Lake has also provided a popular channel catfish fishery in the past. The lake's fishery is influenced by migrations of coho salmon, steelhead and to a lesser degree Chinook salmon as they head upriver to spawn. In recent years, walleye and even schools of yellow perch have been seen by local anglers migrating between Lake Michigan and Loon Lake.

The Platte River is a unique coldwater fishery. Due to the large interaction with lake systems in the upper reaches of the watershed, the Platte River is actually dominated by warmwater fish above County Road 669, just up river from the Hatchery. The 2009 fisheries survey of the Burnt Mill Rd. crossing area confirmed the historic lack of brown trout or other coldwater species (Seites, 2010). Below the confluence with Brundage Creek downstream to Big Platte Lake, the river is one of the most productive and healthy coldwater fisheries in Northwest Lower Michigan. The resident brown trout population is very good and is self-sustaining through natural reproduction. Survey results have consistently found good numbers of larger adult brown trout; however, angling reports suggest they are very difficult to actually catch (Seites, 2010).

The Platte River was the inaugural stocking site for the coho salmon in the Great Lakes back in 1965 and has remained the brood stock river of that fishery program since the first returning adults in the fall of 1967. Despite only averaging 120 cfs in discharge, this tiny river is stocked with 700,000 – 800,000 coho smolts each spring. The spawning run each fall is carefully controlled in the lower river corridor by a harvest and transfer weir facility operated by the MDNR. The weir limits the number of salmon that are allowed upstream and therein limits the extra phosphorus that enters the system from decomposing dead salmon not captured at the upper weir or by anglers.

The Platte is also a very productive steelhead fishery and supports good natural reproduction of this very popular gamefish. Starting in 2011, steelhead smolts were stocked into the Platte to help boost the adult returns of spawning fish and create a back-up egg take facility at the Platte River State Fish Hatchery. In the event that the Little Manistee River adult returns are too low to meet steelhead program needs, steelhead could be reared at the Platte River State Fish Hatchery to help increase the overall state steelhead egg supply. In recent years anglers have noted a significant increase in the number of adult walleye running up the lower Platte River from Lake Michigan in the spring.

Big Platte Lake has been a popular inland lake fishing destination for native species since at least 1901 and has been actively managed by stocking native species since 1909 (Tonello, 2010). Over the last hundred or so years stocking efforts have been mostly centered around supporting the walleye fishery, although it was largely unsuccessful until the 2002 stocking. Big Platte is a trophy smallmouth bass fishery and has good self-sustaining population. Big Platte has a decent yellow perch population, although their size and growth have historically been lagging behind the state wide averages (Tonello, 2010). The northern pike fishery in Big Platte was historically quite impressive but has declined significantly since the construction of the low head dam on the North Branch of the Platte River (Deadstream). Stocking efforts coupled with the installation of a fish passage ladder have not been successful in restoring the spawning success of Big Platte's northern pike. Like Loon Lake, Big Platte also receives seasonal migrations of coho salmon and steelhead which pass through the lake system on their way upstream to spawn. These migrating fish populations influence the Big Platte fishery substantially as adults move through on their way up and as the smolts head back down each spring.

Section 2.10 (below) lists the specific fisheries surveys or management actions conducted in the Platte River Watershed. More detailed information and results for each survey can be obtained by contacting the Central Lake Michigan Management Unit of the DNR Fisheries division in Cadillac, MI.

2.10 HUMAN HISTORY

Like most rivers, the Platte underwent dramatic changes with the arrival of the first settlers. There are reports that prior to 1870, the river was so strewn with brush and downed trees that nowhere could a man walk down it. Therefore, in order to support an emerging lumber industry, the first important task was to clear the channel so logs could be floated. Settlement of this area was quite delayed compared to surrounding areas because the pine stands were limited and no roads or railroads came this way. The first road from Traverse City west was made in 1862, and there was no railroad into the Platte valley until 1895. There were, however, a string of sawmills on the river from Lake Ann to Big Platte Lake, floating logs down the shallow river using a series of freshet dams. Pine logs cut from the limited stands on the higher ground were mostly used for local building needs. There was a network of poor wagon trails connecting the farms and mill sites.

It wasn’t until the second lumbering boom hit Michigan around 1895 that the area blossomed, much to the detriment of the river as was true on many rivers in northern Michigan. The white pine eventually was gone and manufacturers turned their attention to the abundant supply of beech and maple hardwoods in the area, along with cedar and hemlock in the low areas. The hardwoods could be turned into veneer and furniture while the cedar was profitable for shingles and the hemlock for its bark. Larger mill operations started up and the inevitable towns around them, all using the river and lakes for log transport if not for power, which by that time was mostly steam. Some towns, such as Allyn, Clark’s Mill, Averytown, and Edgewater lasted only until the mill was gone and then disappeared. Others, such as Lake Ann and Honor, hung on and developed other livelihoods. Edgewater was built on the west end of Big Platte Lake to harvest the only large stand of white pine in the area, between Big Platte Lake and Lake Michigan. It was a very large operation with logs floated and stored on the lake and boards shipped on a narrow gauge tram/railroad to Lake Michigan near the river mouth where there were large loading docks. All traces of the town disappeared when the trees ran out. The Geulph Patent Cask Company of London by way of Ohio established a mil along the river in 1895 for the purpose of milling hardwood lumber and veneer for casks, growing and expanding very quickly and giving rise to the town of Honor, named for the superintendent's daughter. The expansion was facilitated by the timely arrival of the Pere Marquette railroad branch line from the south in 1895 and the Manistee & Northeastern from the east in 1898. The M & NE followed the river from Lake Ann to Honor, crossing it five times. The grade and some trestle parts can still be seen in the deep woods today. Pictures from around 1912 show huge mountains of logs stacked by the river and bare eroded hills all along the valley.

By 1915 the hardwoods were gone and the mill closed. And by 1923 both railroads had abandoned service and pulled up tracks. The last large area industry was the Desmond Charcoal Works on Carter Creek, producing charcoal in huge kilns and extracting chemicals from wood, all necessary for the war effort, and leaving a legacy of toxic chemicals in the soil and Carter Creek, which can still be found. The plant closed in 1920. Those who didn't drift away after the lumber days were over tried their hand at farming the cut-over land, but the soil was poor and the post-war economy was worse. Most of the would-be farmers gave up and large portions of the land reverted to the state for back taxes. This partially explains why the Pere Marquette State Forest occupies so much of the river valley. This was a fortunate accident for the river since second-growth forest cover was allowed to reoccupy much of the landscape.

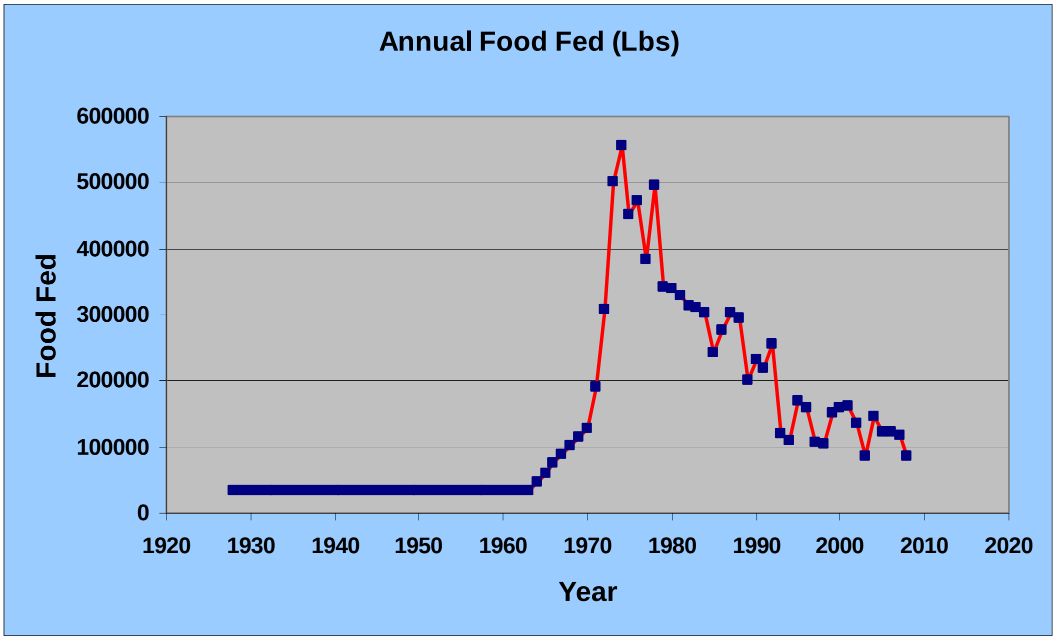
After the first world war, people from the more populated sections of the surrounding states began to vacation in larger and larger numbers and began to build summer homes. This cottage-culture then further developed into full blown second homes and retirement homes. Larger subsets have become year round homes that added to the original resident community. This has resulted in an approximate doubling of the location population in the watershed. See population section.

This new growth has had an impact in terms of increasing road use, sewage and waste handing as well as the local service economy. It has prompted much work toward controlled and environmentally neutral development via local ordinances, etc. in an effort preserve the natural state of the area and minimize the impact of increased population and related development. The creation of the Sleeping Bear Dunes National Lakeshore with the enabling legislation in 1970 as well as the Michigan salmon program, etc. further increased the desirability of the area as a place to live where one can be extremely close to nature with all its related activities. The increased human usage of the watershed over the last several decades for recreational and residential uses has created conflicts with sustaining the high water quality.

Hatchery - Early History

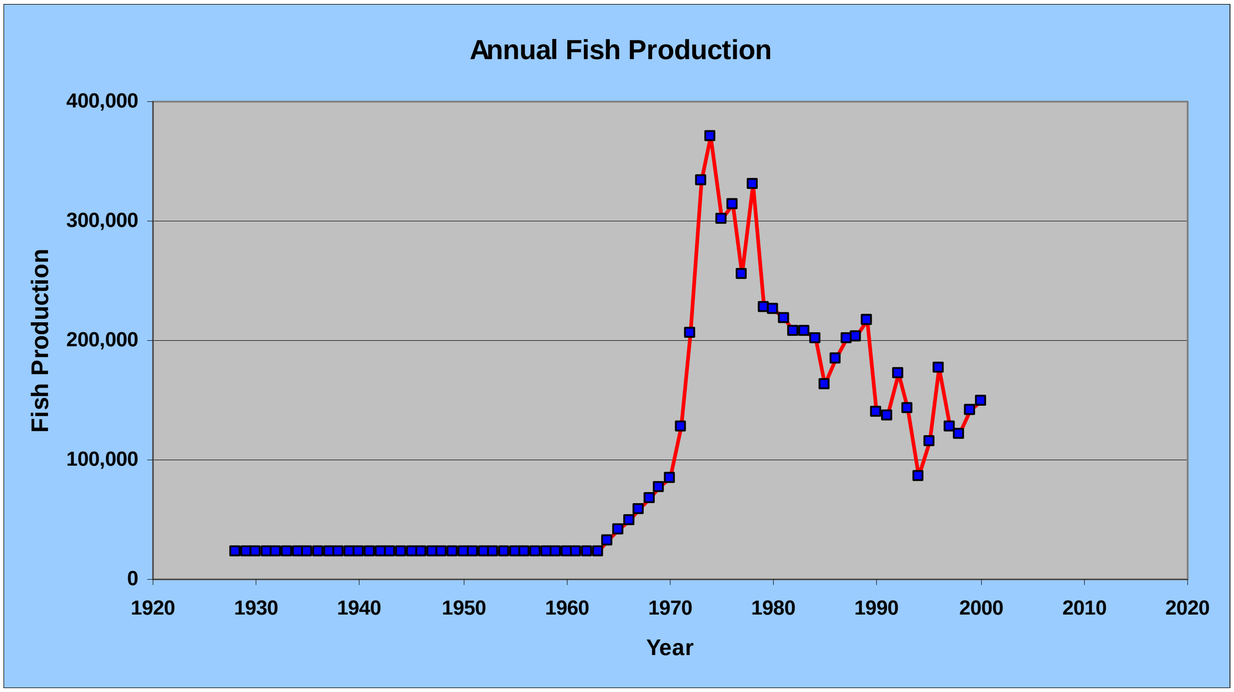
The MDNR has operated a fish culture facility on the Platte River since 1928 (See page 27, Figure 4 for a map showing the location of the MDNR Fish Hatchery). The facility began as a trout rearing station and was expanded during the period from 1966 to 1972 to support the Department's Great Lakes salmon program. Figure 12 shows the history of the use of food at the Hatchery. Approximately 16,000 kg of fish feed was used annually prior to facility expansion program. A maximum of about 250,000 kg of feed was needed in 1974 during the peak production period. Food use at the Hatchery has gradually declined and is currently about one-third of the maximum mid-1970 levels.

Figure 12: Historical Change in Food Used for Fish Production at the Hatchery



The annual production of fish at the original rearing station was approximately 10,500 kg. This fish production is about two-thirds of the amount of food fed. Figure 13 shows historical changes in fish production at the facility as a function of time that generally follows the pattern of food usage. The process water used to culture the fish becomes enriched with phosphorus from fish fecal pellets and unconsumed feed. The net phosphorus loading from the Hatchery is defined as the increase in the phosphorus concentration in the process water above background levels times the flow rate from the facility. During the period from 1928 to 1964 the phosphorus loading was relatively constant at about 74 kg/yr. This loading increased to a maximum of about 1960 kg/yr in 1974. The increase in loading was associated with increased food usage and fish production and accelerated by the fact that the phosphorus content of the feed increased because the feed composition changed from 66% waste slaughter house parts (0.24% P) and 33% fish meal (1.5% P) prior to the salmon program, to a nearly 100% diet of Oregon moist pellets that ranged from 2.0 to 3.5% P.

Figure 13: Fish Food Graph



Legal History

Long-time local and seasonal residents initially were puzzled by the rapid decline in the water quality of Big Platte Lake. Individuals first began to share their concerns with the MDNR in 1974. Subsequently the Platte Lake Improvement Association (PLIA) was established in August of 1978 for the purpose of restoring and preserving the water quality of Big Platte Lake.

The MDNR applied for a NPDES permit for the Hatchery in 1979 and the PLIA presented a lengthy list of objections. In response, the MDNR commissioned additional water quality studies of the watershed with the PLIA providing the local funding match (Bostwick, et al. 1983). This study and others (Grant, 1979) have measured the Hatchery phosphorus loading and defined baseline water quality conditions for the lake, river, and tributaries.

In the late 1970's and early 1980's, the PLIA again expressed concerns to the MDNR regarding the continuing decline of the water quality of the lake. Subsequent efforts to negotiate satisfactory responses failed, and as a consequence, the PLIA sued the MDNR in 1986 in Ingham County Circuit Court under the Michigan Environmental Protection Act (MEPA). The PLIA contended that a draft 1985 NPDES permit level of 636 kg P/yr was not adequate to protect the water quality of the lake and that salmon entering and subsequently dying in the lake should be considered by the permit. In 1988, the court agreed with the PLIA and ruled that the MDNR was polluting, impairing, and destroying Big Platte Lake. As a result, the MDNR was required to reduce phosphorus loadings from the facility to attain a volume-weighted annual average total phosphorus concentration of 8.0 mg/m^3 in the lake. In addition, the MDNR was required to use a low-phosphorus fish food (<1.0% P) and halt the migration of salmon at the lower weir. The migration part of the order was later modified to allow the passage of the first 20,000 fish then 1,000 fish per week from August 15 to December 15.

On June 12, 1998 the Michigan Department of Environmental Quality (MDEQ) issued another permit to the MDNR that regulated the discharge of the fish rearing water. On August 7, 1998 the PLIA filed for a contested case hearing seeking to invalidate or modify the permit. After many months of intensive negotiations, the MDNR and PLIA signed and entered a Consent Agreement on March 10, 2000. The agreement allows for the phased installation of state-of-art effluent control equipment. Eventually the facility discharge will be limited to 79.5 kg P/yr and no more than 25.0 kg P in any 3 month period.

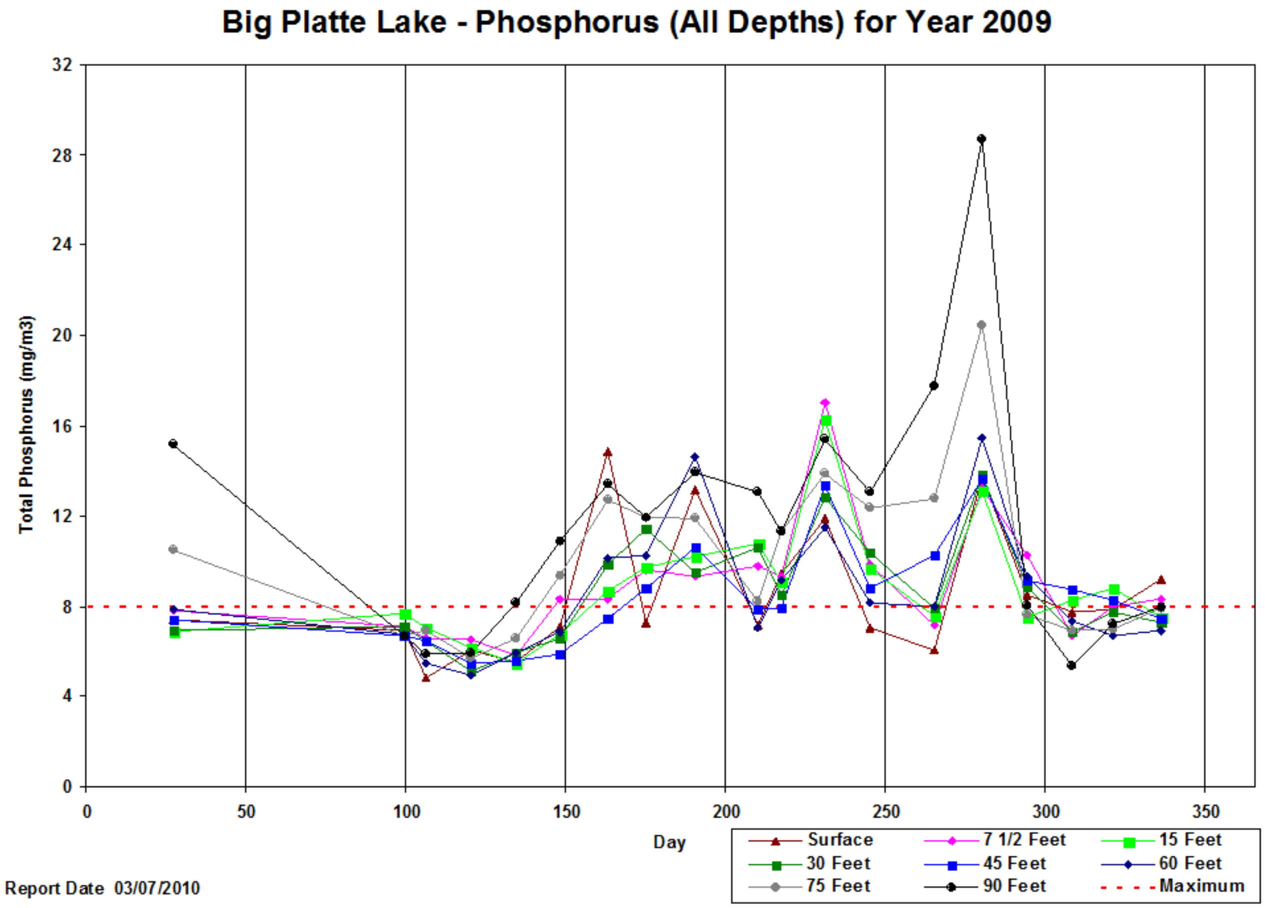
Water use at the facility is limited to 0.88 m3/sec. In addition, no more than 20,000 Coho salmon and 1,000 Chinook salmon are allowed to pass upstream from the lower weir, and that all salmon harvested at the upper egg take weir shall be removed from the watershed. The agreement requires extensive Hatchery monitoring (including antibiotics and antiseptics), compliance audits, oversight, and damage provisions. Finally, it should be noted that the Consent Agreement has brought the parties together and they are now working together to implement a comprehensive program to identify and control point as well as non-point sources of phosphorus within the watershed. **This cooperative spirit is absolutely critical and is a major accomplishment of the Consent Agreement.** This Consent Agreement provides the framework for the related monitoring and analysis issues.

Today

In close partnership with the Implementation Coordinator mandated by the 2000 Consent Agreement the PLIA and MDNR are engaged in a wide range of Hatchery, lake, river, and watershed projects intended to protect and preserve the Platte Lakes and its environs. With time, the focus has broadened to include the entire watershed and the surrounding community, and the joint efforts have begun to produce tangible results. Overall, within the last few years, lake and river water quality has significantly improved, desirable aquatic animal and plant species have begun to revive, and the sports fishing has improved significantly.

The Hatchery uses surface water to culture fish, and this water becomes enriched with phosphorus from fish waste and unconsumed feed. However, current rearing practices result in very little uneaten feed. The net phosphorus loading from the Hatchery is defined as the increase in the phosphorus concentration in the process water above background levels multiplied by the flow rate from the facility. Prior to the beginning of the salmon rearing program at PRSFH, phosphorus loading in the Hatchery effluent was not monitored. Based on what is known about the phosphorus content of earlier fish feed formulas used at PRSFH, the phosphorus contribution attributable to the Hatchery is estimated at a relatively constant 74 kg/year during the period from 1928 to 1964. This loading increased to a maximum of about 1960 kg/yr in 1974. The increase in loading was associated with increased food usage and fish production and accelerated by increases in the phosphorus content of the feed. Figure 14 shows data that define the history of changes in the phosphorus loading from the facility. Today, the mean net loading from the Hatchery is near-zero. This reduction was attained by switching to low phosphorus feeds and by significant changes, both physical and procedural, to the effluent management practices by the Hatchery. The Hatchery contributes a small fraction of the total phosphorus load that enters the Lake and is currently compliant with NPDES (National Pollutant Discharge Elimination System) requirements.

Figure 14 Big Platte Lake Phosphorus (at all depths) for 2009



PRSFH-Discharge Limits

Lakeside residents first noted deterioration of the water quality of Big Platte Lake in the early 1970's . The Platte Lake Improvement Association (PLIA) was established in August of 1978 for the purpose of restoring and preserving the water quality of Big Platte Lake. Subsequent to unsuccessful efforts to negotiate a satisfactory response from the MDNR regarding their concerns, the PLIA sued the MDNR in 1986 in Ingham County Circuit Court under the Michigan

Environmental Protection Act (MEPA). The PLIA contended that a draft 1985 NPDES permit level of 636 kg P/yr was not adequate to protect the water quality of the lake and that salmon entering and subsequently dying in the lake should be considered by the permit. In 1988, the court agreed with the PLIA and ruled that the MDNR was polluting, impairing, and destroying Big Platte Lake. As a result, the MDNR was ordered to reduce phosphorus loadings from the facility, to use a low-phosphorus fish food (<1.0% P), and limit the migration of salmon at the lower weir.

The MDNR and PLIA also signed and entered a March 10, 2000 Consent Agreement and its related amendments. The agreement allows for the phased installation of state-of-art effluent control equipment. Currently the facility discharge is limited to 79.5 kg P/yr and no more than 25.0 kg P in any 3 month period. Water use at the facility is limited to 0.88 m^3/sec. In addition, no more than 20,000 adult Coho salmon and 1,000 adult Chinook salmon are allowed to pass beyond the lower weir, and that all salmon harvested at the upper egg take weir shall be removed from the watershed. The agreement also requires extensive Hatchery monitoring (including antibiotics and antiseptics), compliance audits, oversight, and damage provisions. **Finally, it should be noted that by working together through the Consent Agreement the 2011 net phosphorus discharge was reduced to near zero.** This cooperative spirit toward water quality goal attainment is absolutely critical and is a major accomplishment of the Consent Agreement.

2.11 ECONOMY, TOURISM, AND RECREATION

(From BC website http://www.benzieco.net/about_us.htm)

Located along the shores of Lake Michigan near the northwestern tip of lower Michigan, the Platte River Watershed is abundantly rich in natural resources with many lakes, rivers, forests, and areas of productive farmland. The rich history includes the glacial formations that formed our land and dunes, the many families that date back to the early 1800s, now joined by a diverse retirement community, artists, shop owners, builders, retired factory workers, professionals, and others attracted to the beauty of the land and the casual lifestyle.

The Platte River watershed provides a variety of excellent opportunities for outdoor recreation. Fishing, ice fishing, waterskiing, swimming, boating, sailing and canoeing are a few of the water related activities enjoyed by local and visiting recreationists on the watershed’s numerous rivers, creeks and lakes. With vast areas of Pere Marquette State Forest and miles of trails, avid outdoor enthusiasts find plenty of space in the Platte River watershed for large and small game hunting, camping, snowmobile and horseback riding, as well as cross-country skiing, snowshoeing, picnicking and even morel hunting. The Sleeping Bear Dunes National Lakeshore is prominent national and international destination for tourists attracted to its unique sand dune formations perched over the sparkling blue waters of Lake Michigan. Sleeping Bear was voted the most scenic destination in the United States in Good Morning America’s August 2011 viewer’s pole. The Park, and therefore the lower watershed, has experienced significant increases in tourism interest ever since.

CHAPTER 3: EXISTING WATER QUALITY INFORMATION AND RESULTS FOR THE PLATTE RIVER WATERSHED

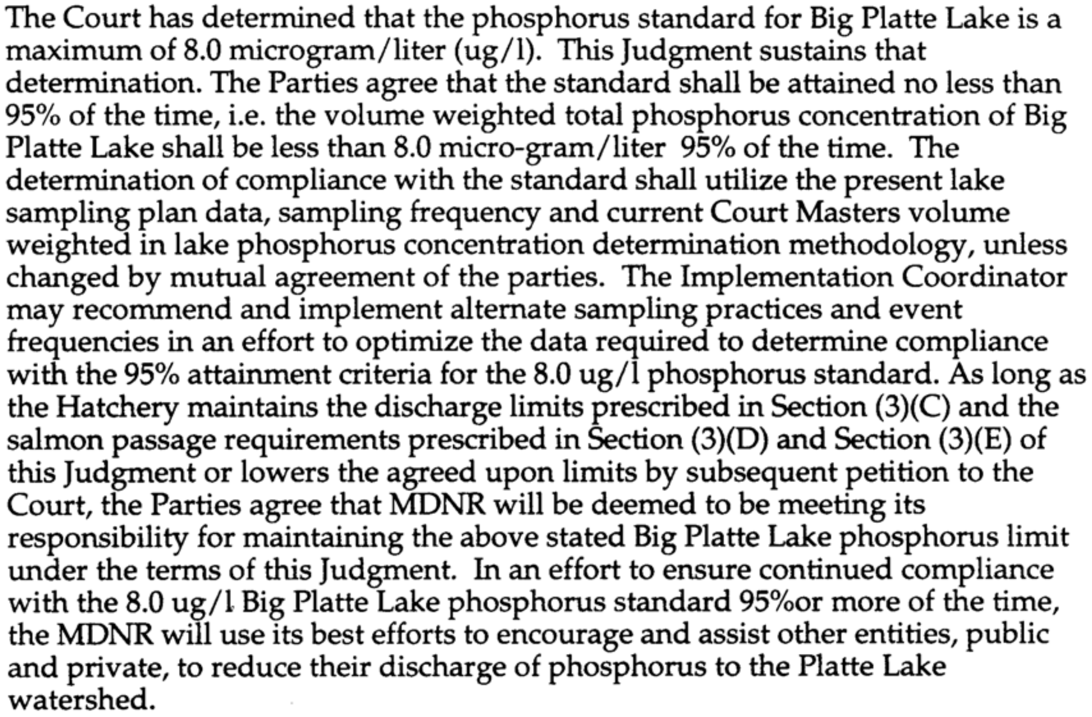
3.1 Lower Platte River Watershed Water Quality Information

The Lower Platte River Watershed between Fewins Road and Big Platte Lake has been studied extensively for total phosphorus input to the lake since the 1970s. Below is a description of the history and background of this water quality sampling program for the Platte River State Fish Hatchery and Platte River from Fewins Rd downstream to Big Platte Lake (Figure 16).

Figure 16: Photo of Platte River Watershed

Big Platte Lake-Numerical Phosphorus Standard

In addition to the limits imposed on the operations of the Hatchery, the Consent Agreement also established a numerical phosphorus standard for Big Platte Lake (Section 2.10) (Appendix A):



> The Court has determined that the phosphorus standard for Big Platte Lake is a maximum of 8.0 microgram/liter (ug/l). This Judgment sustains that determination. The Parties agree that the standard shall be attained no less than 95% of the time, i.e. the volume weighted total phosphorus concentration of Big Platte Lake shall be less than 8.0 micro-gram/liter 95% of the time. The determination of compliance with the standard shall utilize the present lake sampling plan data, sampling frequency and current Court Masters volume weighted in lake phosphorus concentration determination methodology, unless changed by mutual agreement of the parties. The Implementation Coordinator may recommend and implement alternate sampling practices and event frequencies in an effort to optimize the data required to determine compliance with the 95% attainment criteria for the 8.0 ug/l phosphorus standard. As long as the Hatchery maintains the discharge limits prescribed in Section (3)(C) and the salmon passage requirements prescribed in Section (3)(D) and Section (3)(E) of this Judgment or lowers the agreed upon limits by subsequent petition to the Court, the Parties agree that MDNR will be deemed to be meeting its responsibility for maintaining the above stated Big Platte Lake phosphorus limit under the terms of this Judgment. In an effort to ensure continued compliance with the 8.0 ug/l Big Platte Lake phosphorus standard 95%or more of the time, the MDNR will use its best efforts to encourage and assist other entities, public and private, to reduce their discharge of phosphorus to the Platte Lake watershed.

Note that because the phosphorus concentration must be maintained below 8 mg/m^3 95% of the time, the annual average concentration in the lake must be significantly lower than 8 mg/m^3(Canale et al. 2010).

Non-Point Phosphorus Sources

The Consent Agreement has provided a mechanism for the PLIA and the MDNR to work together to reduce the phosphorus discharge from the Hatchery as well as from non-point sources that originate in the watershed. As a result, the parties are currently engaged in a comprehensive program to identify and control point as well as non-point sources of phosphorus within the watershed. It is important to note that because of the successful efforts to reduce the loading from the Hatchery, most of the remaining phosphorus load originates from non-point sources associated with groundwater flow, watershed runoff, and precipitation.

The Lake also has internal phosphorus loads that result from release of phosphorus from the bottom sediments during anoxic periods and from the death and subsequent decay of migrating salmon.

Objective of Sampling Program

The ultimate goal of the sampling program is to provide scientific data that can be used to guide and design strategies to restore and preserve water quality. The improvements in Platte River watershed water quality will be achieved by reducing phosphorus loading, preventing sedimentation of stream channels and reducing soil exposure to stormwater run-off. The phosphorus loading reduction needed to meet the court ordered water quality standards for Big Platte Lake will affect public policy and expenditures, local zoning, and the attitudes and behaviors of private citizens. Thus, it is imperative that the calculations for the required phosphorus loading reduction be credible and defensible. This requires careful calibration of the watershed phosphorus loading and lake water quality mass balances and models using local water quality data.

Components of Sampling Program

The sampling program was expanded following the 2000 Consent Agreement. The current program is designed to collect appropriate water quality data and consists of the following seven sub-tasks as listed below.

Description of Sampling Program

The Big Platte Lake, Little Platte, and Platte River watershed monitoring program is quite comprehensive, and the details of the effort have evolved and expanded over time. The description below summarizes the current program.

Big Platte Lake has been sampled at the deepest location (approximately 28 m) at 8 discrete depths every two weeks since 1993 except when ice conditions restrict access. Three replicate samples are taken at each depth and analyzed for total phosphorus and turbidity. In addition, surface composite samples are collected using a 10 m vertical tube. These samples have been analyzed for total and dissolved phosphorus, nitrate, nitrite, chlorophyll *a*, turbidity, alkalinity, phytoplankton, total dissolved solids, and calcium. Vertical net hauls are used to collect zooplankton. Other measurements include Secchi depth and vertical profiles of dissolved oxygen, temperature, pH, oxidation/reduction potential, and light intensity.

Total phosphorus, turbidity, and flow have been measured at several Platte River sites and tributary locations every two weeks since 1990. The sampling locations are shown in Figure 17 and described in Table 15. The baseline stream flow data have been supplemented with measurements taken during more than 100 storm events between 2003 and 2007. Total phosphorus, turbidity, and flow were measured during these events using automated sampling equipment.

Components of Sampling Program

The sampling program was expanded following the 2000 Consent Agreement. The current program is designed to collect appropriate water quality data and consists of the following seven sub-tasks as listed below.

1. Monitor Hatchery phosphorus discharge to insure compliance with the Consent Agreement.
2. Measure the phosphorus concentration of Big Plate Lake to insure compliance with the numerical water quality standard.
3. Measure the phosphorus loading to Big Platte Lake
4. Construct water flow budget for the lower watershed
5. Construct a phosphorus loading budget for the lower watershed
6. Develop, calibrate, and verify watershed phosphorus loading models
7. Develop, calibrate, and verify water quality models for Big Platte Lake

Figure 17: Platte River Sub-watersheds and Monitoring Station Locations

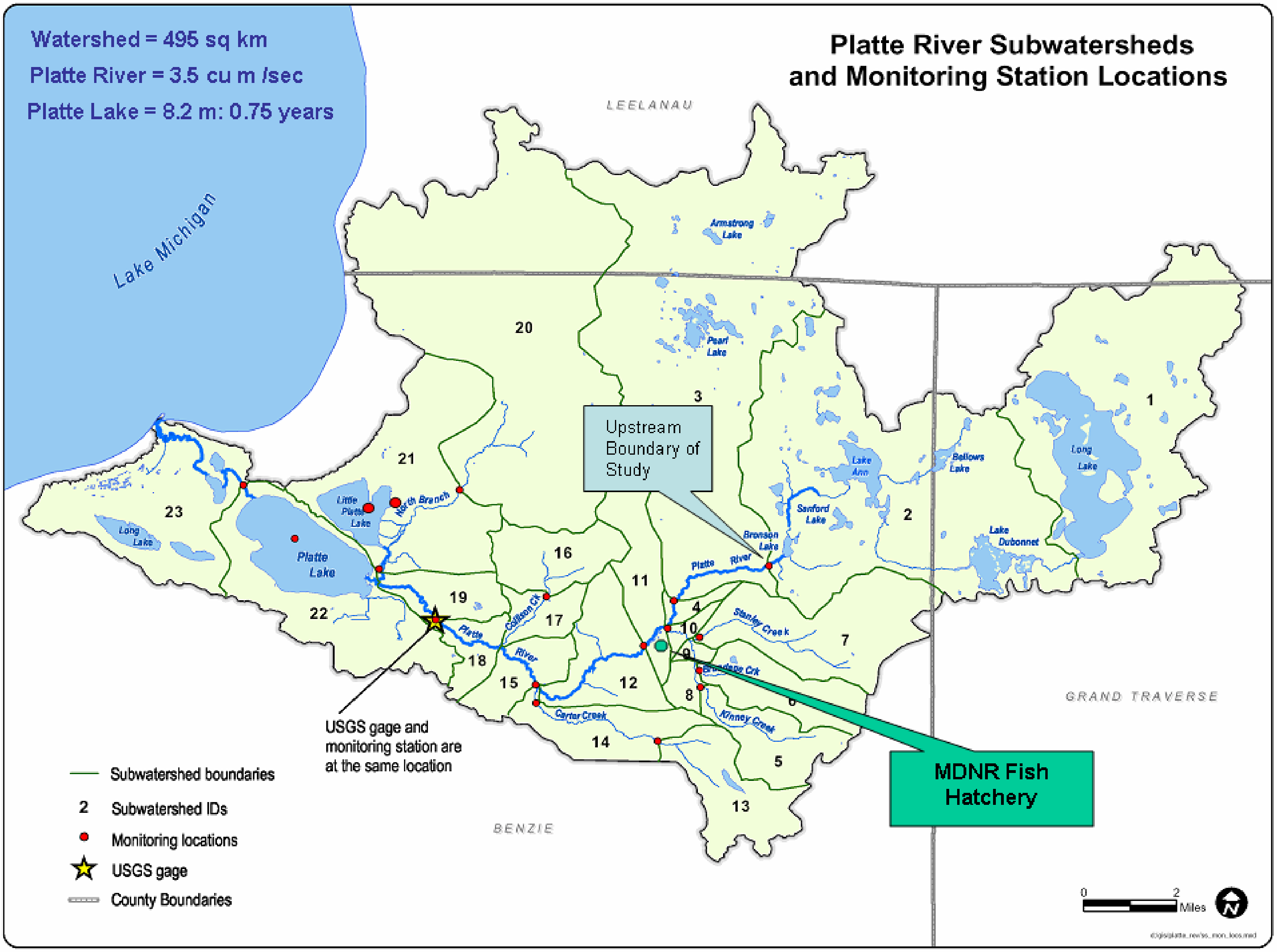


Table 15: Description of Sampling Locations

SiteID	SiteType	SiteName	Description	Latitude	Longitude
11	Hatchery	Brundage Spring at Intake	Current sampling site	44 39.015	85 54.998
12	Hatchery	Brundage Creek at Intake	Current sampling site. K&E Station 2	44 39.895	85 55.958
13	Hatchery	Platte River at Intake	Current sampling site	44 39.789	85 56.305
14	Hatchery	Screens to Treatment Pond	Current sampling site	44 39.744	85 56.314
15	Hatchery	Upper Discharge - Outfall 0002	Current sampling site	44 39.753	85 56.343
16	Hatchery	Lower Discharge - Outfall 0001	Historical site	44 39.694	85 56.398
27	Hatchery	Sludge Tank Overflow	Overflow from Waste Tank		
28	Hatchery	Clarifier Overflow	Overflow from Clarifier		
33	Hatchery	Hatchery Building	Fish and fish food site		
39	Hatchery	Backwash Main Line	Current sampling site		
1	Big Platte Lake	Big Platte Lake	Current sampling site - 90 Foot Basin	44.42.091	86.06.820
2	Big Platte Lake	Big Platte Lake - 22 Foot Basin	Historical site		
3	Big Platte Lake	Big Platte Lake - 44 Foot Basin	Historical site		
4	Big Platte Lake	Big Platte Lake - 75 Foot Basin	Historical site		
5	Big Platte Lake	Big Platte Lake - Birch Point-90' Basin	Historical site		
8	Little Platte Lake	Little Platte Lake	Current sampling site		
91	Weather	Hatchery Weather Station	Located at Hatchery site	44 39.791	85 56.192
92	Weather	PLIA Weather Station	Historical site		
41	Major Tributary	North Branch Deadsteam Dr.	Current sampling site. K&E Station 8	44 41.01	86 03.30
42	River	Platte River at M-22	River below Lake outlet. K&E Station 9.	44 42.39	86 07.08
43	River	Platte River at US 31 - USGS	USGS No. 04126740	44 40.05	86 02.05
44	Major Tributary	North Branch Hooker Rd	misc tributary	44 42.865	86 01.205
45	4	Ingleston Creek	Creek at west end of gravel pit east of White City		
46	4	Old Platte Creek	Added 9/18/2010		
47	River	Platte River - Haze Rd	Added 11/15/2010		
51	River	Platte River at Fewins Dr	Upstream of stone bridge site. K&E Station 1.		
52	River	Platte River at Veterans Park	K&E Station 3.	44 39.686	85 56.400
53	River	Platte River at Pioneer Rd	K&E Station 5.	44 39.565	85 56.642
54	River	Platte River at Indian Hill	Approx 3/8 mile below USGS. K&E Station 7.		
55	Major Tributary	Stanley Creek at Carmen	misc tributary	44 39.752	85 55.149
56	Major Tributary	Carter Creek at Brownell	K&E Station 4.	44 38.481	85 59.437
57	Major Tributary	Collison Creek	K&E Station 6.		
58	Major Tributary	East Tamarack Creek (Barnyard)	Clean branch from under US 31	44:39.888	86:03.092
59	Major Tributary	West Tamarack Creek (Landfill)	Dirty branch runs along US 31	44:39.835	86:03.245
60	Major Tributary	Tamarack Creek (Below Trout Farm)	Crosses Platte Road	44:40.068	86:02.949
61	Major Tributary	Tamarack Creek (Inlet to Miners Bay)	Assessable by boat		
62	Major Tributary	Featherstone Creek	Tributary to Little Platte Lake		
63	Small Tributary	Trib A	Garber Creek	44:40.6	86:05.17
64	Small Tributary	Trib B	Reese Artes	44:40.58	86:05.29
65	Small Tributary	Trib C	Heiman Artes	44:40.61	86:05.94
66	Small Tributary	Trib D	Pattison Artes	44:40.58	86:05.57
67	Small Tributary	Trib E	Wilcox Creek	44:40.60	86:05.32
68	Small Tributary	Trib F	Tamarack Creek Mouth	44:40.50	86:03.91
69	Small Tributary	Bixler Creek	misc tributary		
81	Major Tributary	Brundage Cr - old residence	Behind old residence off 669	44 39.846	85 55.891
82	River	Platte River - near stone bridge	Next to rock bridge by old rearing station	44 39.970	85 55.974
83	River	Platte River - near Outfall 0001	Near lower discharge 0001	44 39.898	85 56.209
20	Hatchery	Sludge Holding Tank	Truck solids waste stream	44.39.726	85.56.196
31	Weir	Upper Weir	Current fish sampling site	44 39.789	85 56.305
32	Weir	Lower Weir	Current fish sampling site	44 43.305	86 07.782

Hatchery discharge flow and phosphorus concentrations have been measured regularly since 1981. The current program collects composite samples two times per week from both the discharge and input locations to the Hatchery to permit calculation of the net loading as specified by NPDES regulations. Phosphorus concentrations are also obtained from the fish food used at the Hatchery and on sludge solids trucked away from the Hatchery. Periodic measurements of salmon tissue phosphorus also are taken to allow estimates of the amount of phosphorus in fish transported from the Hatchery. These measurements account for all of the inputs and outputs of phosphorus to and from the Hatchery and serve as the basis of a mass balance and bio-energetic model for fish production recently completed and published in peer-reviewed journals (Canale and Breck, 2013, Canale et al. 2012, and Canale, in press). The purpose of this model is to predict the phosphorus loading from the Hatchery as a function of the number and size of the fish produced and the efficiency of various facility waste treatment operations.

Other measurements complement the above routine Lake, River, tributary, and Hatchery monitoring efforts. Rain water has been collected and analyzed for total phosphorus, nitrate, and nitrite concentrations over 40 times to facilitate estimation of the atmospheric loading to the Lake. A hydro-acoustic survey was conducted to determine the density and percent coverage of macrophytes in Big Platte Lake in 2002. Macrophyte tissue phosphorus measurements were also taken to permit calculation of the mass of phosphorus associated with the plant biomass in the Lake. The phosphorus content of shoreline buffer zone plant material and debris was measured to permit estimates of the effectiveness of shoreline maintenance efforts. Migrating salmon are restricted from entering Big Platte Lake except during times when weir gates located downstream of the Lake are opened to allow upstream passage. All fish are counted as they pass the lower weir and when they eventually arrive at an upstream collection facility located at the Hatchery. Fish counts at both the downstream and upstream locations, as well as size and tissue phosphorus measurements, allow calculation of the potential internal phosphorus loading to the Lake through the decay of spawning salmon biomass. Undisturbed sediment core samples were collected in 2004 and 2005 for laboratory measurement of Sediment Oxygen Demand (SOD) and aerobic and anaerobic phosphorus sediment release rates (Holmes, 2005). These measurements are the basis of estimates of the internal phosphorus loading from the sediments to the lake water column during periods of low bottom water dissolved oxygen concentrations. Finally, a study has been completed to measure biologically available phosphorus from the Hatchery and various River and tributary locations using algal bio-assay methodologies (Qian, 2009). This study has demonstrated that although the total phosphorus loading from the Hatchery is currently a small fraction of the total phosphorus loading, it enhances the ability of otherwise unavailable phosphorus to stimulate the growth of algae.

Platte River Watershed Water Quality Data Management

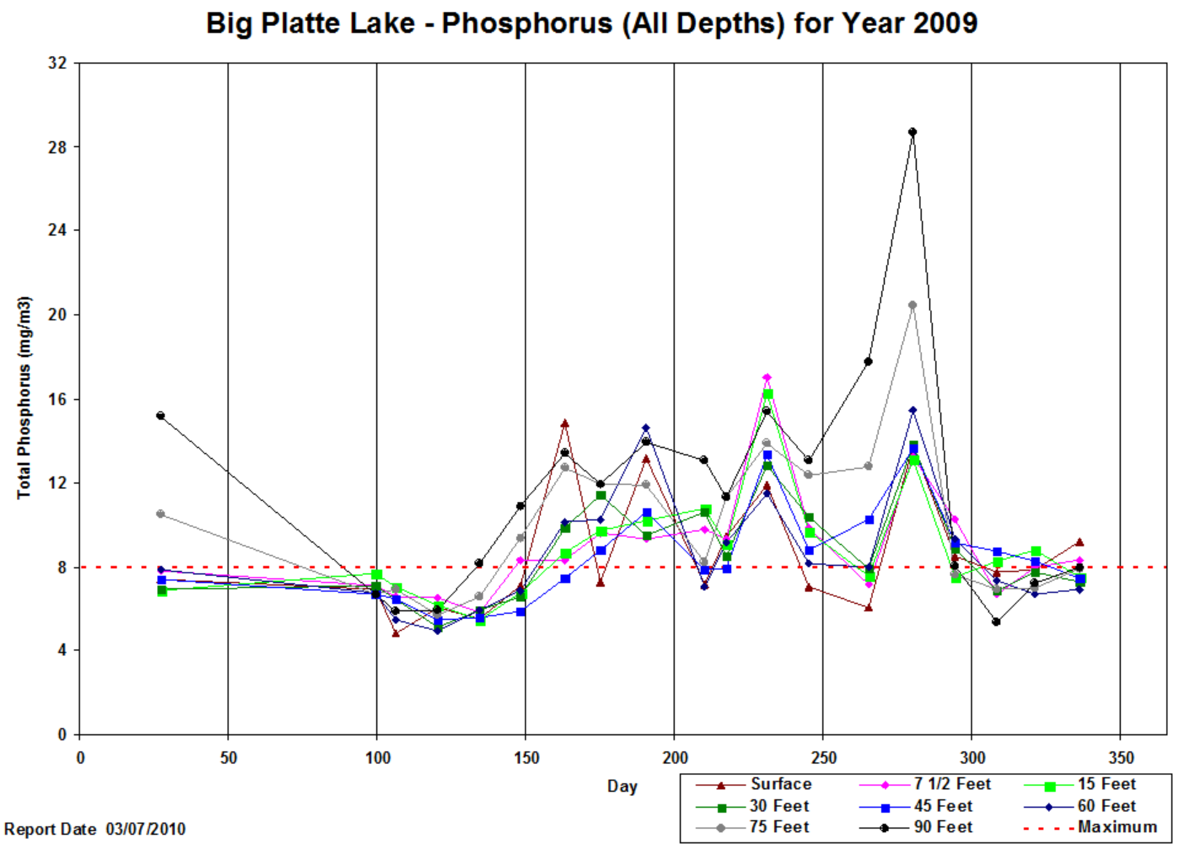
About 86,000 laboratory and field samples have been collected from the Platte River watershed since 1990 (Table 16). An ACCESS database has been developed to accommodate this large inventory of historical and current sampling data at the Hatchery, in tributary streams, at lake stations, and the Hatchery weather station, and USGS gauging station (Berridge and Canale, 2012). The Platte Lake Watershed Sampling Database consists of three components: Field; Data Manager; and Data Viewer. The field component is used to enter various measurements taken in the field or Hatchery laboratory analyses. Field measurements, bottle numbers, and measurement instructions are sent to the Data Manager and the laboratory. Laboratory results for various bottle numbers are sent to the Data Manager in the form of EXCEL spreadsheets using email. The Data Manager imports the laboratory results and matches this information with the bottle numbers obtained from the Field component. At this point, conflicts such as inconsistent bottle numbers and missing data are resolved. The Data Manager updates the Data Viewer and distributes new data files through email. The reports examined through the Data Viewer are used to track progress on the Hatchery loading and lake water quality and produce graphs and tables for annual reports. Significant communication and coordination is required among the four components to insure that all data are correctly entered and displayed.

Table 16: List of Water Quality Parameters Measured and Number of Samples Collected through 2012

Parameter	Number of Measurements
Alkalinity	2,695
Calcium	1,400
Chlorophyll	1,365
Nitrate + Nitrite	1,046
Percent Water	634
Phytoplankton	2,428
Solid Total Phosphorus	688
Suspended Solids	56
Total Dissolved Phosphorus	675
Total Dissolved Silica	255
Total Dissolved Solids	1,302
Total Phosphorus	58,079
Zooplankton	1,745
Temperature	3,880
Dissolved Oxygen	3,871
Oxidation/Reduction	1,285
Conductivity	1,285
Ph	3,174

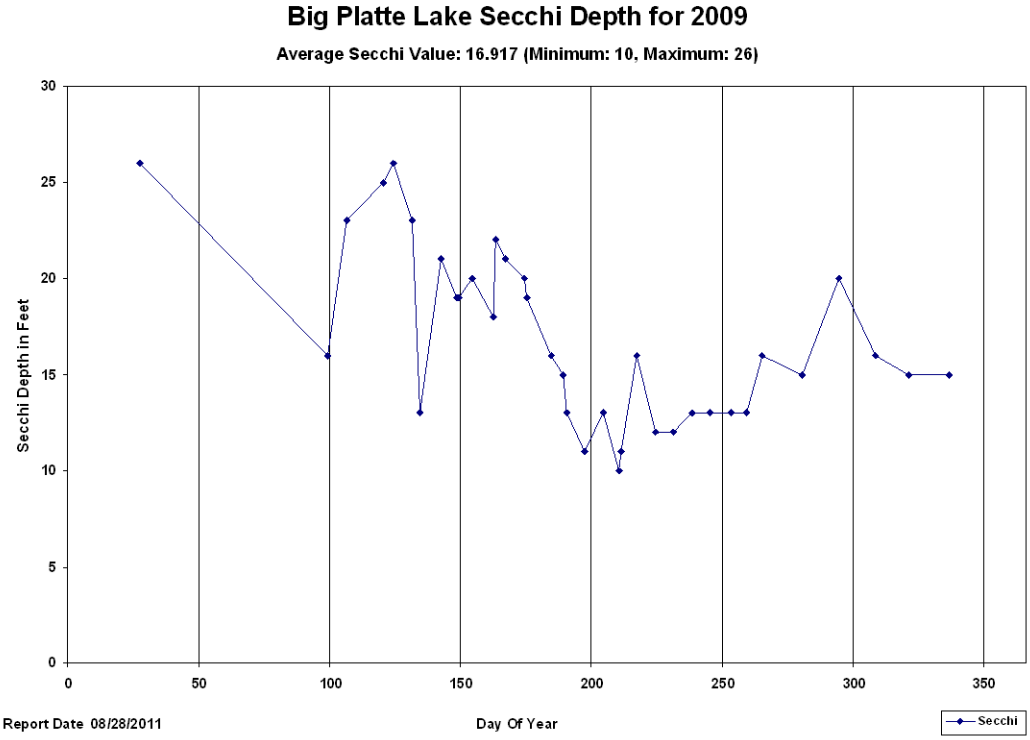
<u>Big Platte Lake- *Total Phosphorus:*</u> The total phosphorus concentration in Big Platte Lake varies with both time of year and depth. Figure 18 shows the measured concentrations in 2009. Similar variations occur in other years. The Consent Agreement mandates that the volume-weighted total phosphorus concentration of Big Platte Lake be maintained below 8.0 mg/m^3 95% of the time. The average annual volume-weighted total phosphorus concentration in 2009 was 7.9 mg/m^3. There were 149 days when the total phosphorus concentration exceeded the 8.0 mg/m^3 goal. This corresponds to about 41% attainment as compared to the 95% requirement. Figure 18 also shows that the total phosphorus concentration is higher in the bottom waters during the summer stratified period. This shows that phosphorus release from bottom sediments contribute to violations of the numerical standard.

Figure 18: Phosphorus as a function of Depth- Big Platte Lake in 2009



<u>Big Platte Lake- *Secchi Depth:*</u> Secchi depth is a common and simple method used to measure water clarity and is an important indicator of water quality. Consistent measurements of Secchi depth have made in Big Platte Lake since 1990. The 2009 seasonal variation of Secchi depth in Big Platte Lake is shown in Figure 19. Marl lakes such as Big Platte Lake may precipitate calcium carbonate causing high turbidity and low Secchi depth. Such events are usually associated with high pH conditions that occur during periods of intense algal activity. This variation is a complex function of calcite precipitation and the concentrations of plankton and phosphorus in the Lake. These relationships have been recently described by mathematical models developed by Homa and Chapra (2011) for nearby Torch Lake. Such models can be used to calculate increases in water clarity as a function of decreases in Hatchery and watershed phosphorus loading. Note that as phosphorus concentrations in the Lake decrease, that the corresponding increases in water clarity may be less than expected due to the precipitation of calcite (marl). A similar modeling approach being considered for Big Platte Lake.

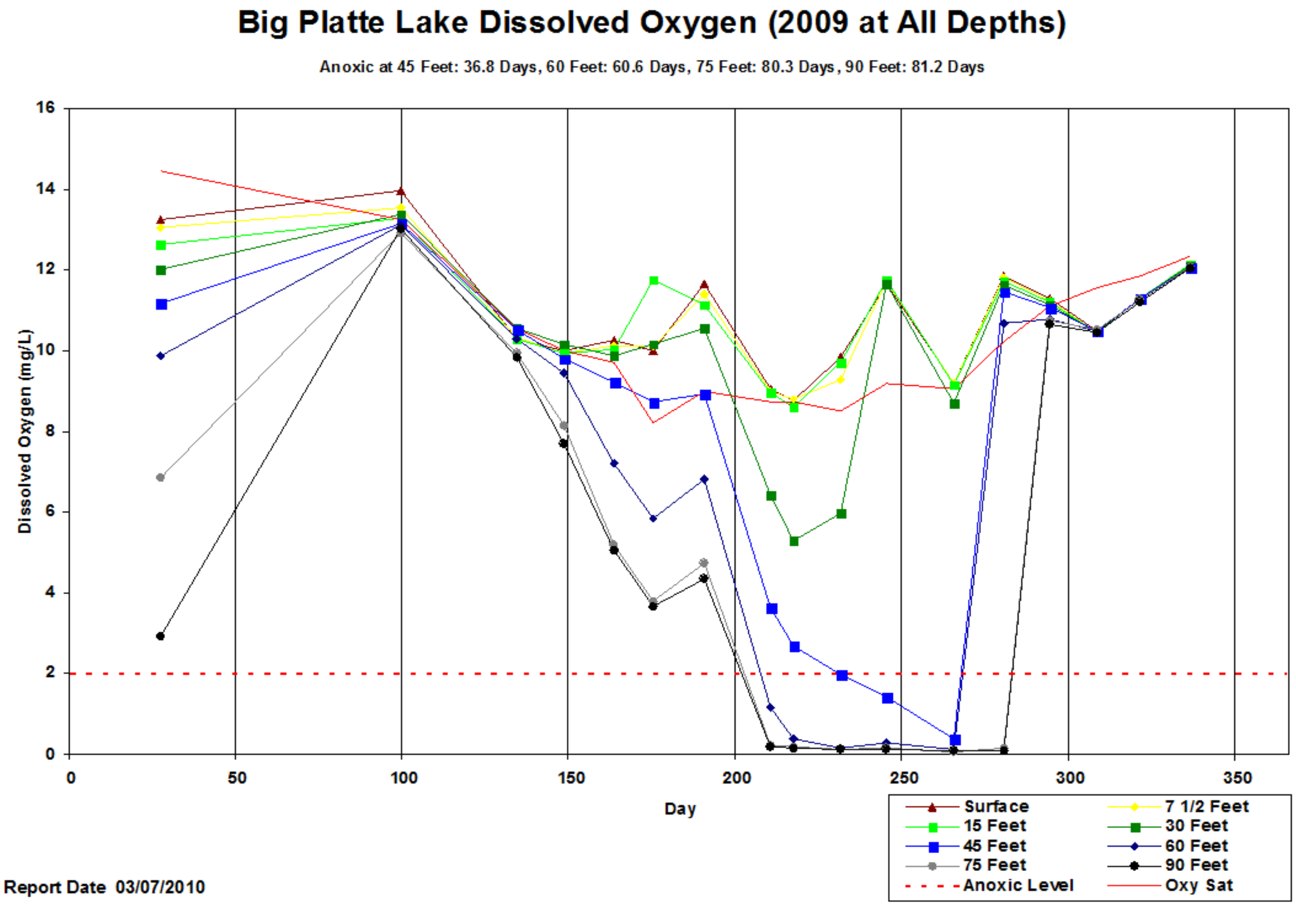
Figure 19: Secchi Disc and a function of depth- Big Platte Lake 2009



<u>Big Platte Lake- Dissolved Oxygen:</u> Figure 20 shows the annual variation of dissolved oxygen concentrations in Big Platte Lake for 2009. The dissolved oxygen depletion in the hypolimnion of Big Platte Lake is closely related to thermal stratification and the onset of spring stratification. The concentration of dissolved oxygen dropped below 2 mg/L in waters deeper than 90 feet for about 80 days in 2009. This is an important period because dissolved phosphorus will be released from the sediments during this anoxic period (Lennox, LJ 1984). Shallower water depths of 75, 60, and 45 feet experience shorter periods of low dissolved oxygen conditions as shown at the top of Figure 20. In addition, note that a single measurement during the winter showed significant oxygen depletion under ice cover. These data are used to calculate the phosphorus release from the sediments. This internal loading of phosphorus can be compared to both non-point and point sources and can be used to calculate the annual dynamics of phosphorus in the lake. Ultimately, the magnitude of the internal sources of phosphorus determines how quickly the lake will respond to changes in input

phosphorus loadings. Quantitative models have been developed to predict the magnitude of these changes (Canale, et. al. 2010).

Figure 20: Dissolved oxygen as a function of depth- Big Plate Lake



Big Platte Lake- *Plankton:* The abundance and diversity of zooplankton and phytoplankton can provide insight and a more thorough understanding of nutrient and water clarity dynamics and long-term changes in the productivity of Big Platte Lake. Phytoplankton populations have a number of water quality implications. They reflect mixing conditions in the lake, nutrient availability, and have an effect on color, foam, water transparency, and are a visible sign of nutrient enrichment. Zooplanktons are important because their phytoplankton foraging activities are implicated with mid-summer clearing events in the lake. In addition, zooplankton transfers primary production energy to fish in the lake. The fish community of the lake can affect water quality through top to bottom down mechanisms. For example, heavy fish predation on zooplankton can relieve pressure on the phytoplankton. An increase in phytoplankton can result in a decrease in water transparency. Figure 21 and 22 shows these mechanisms for 2005. These important and complex interactions are described in more detail in annual reports authored by Dr. Scott McNaught from Central Michigan University.

Figure 21: Secchi Depth vs Phytoplankton Counts – Big Platte Lake 2005

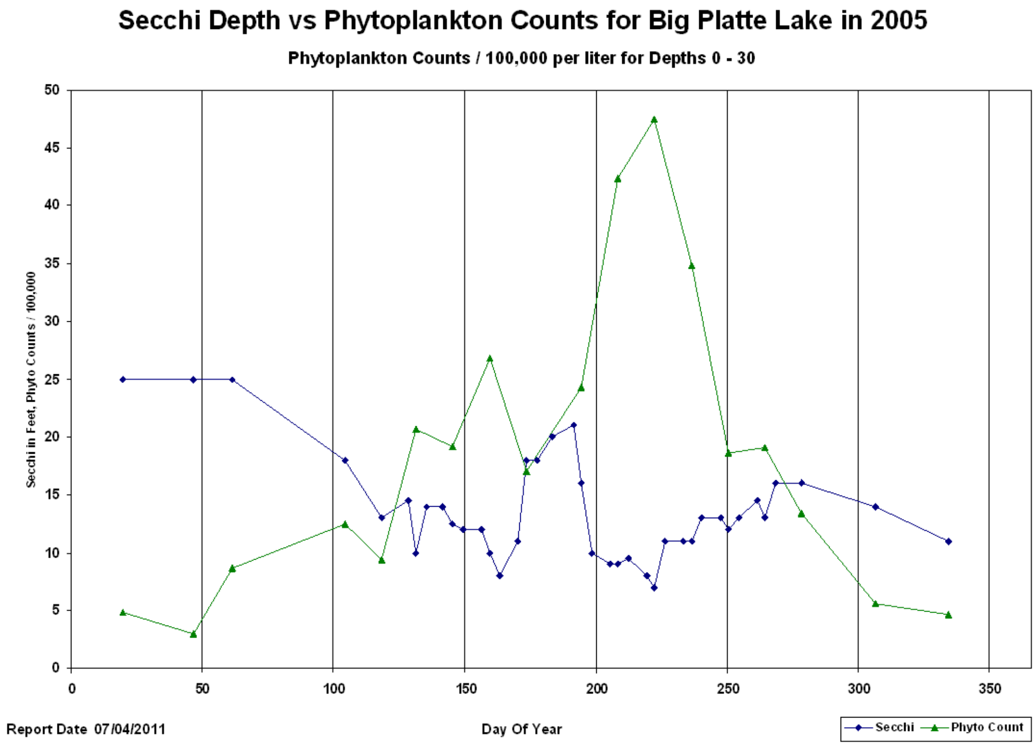
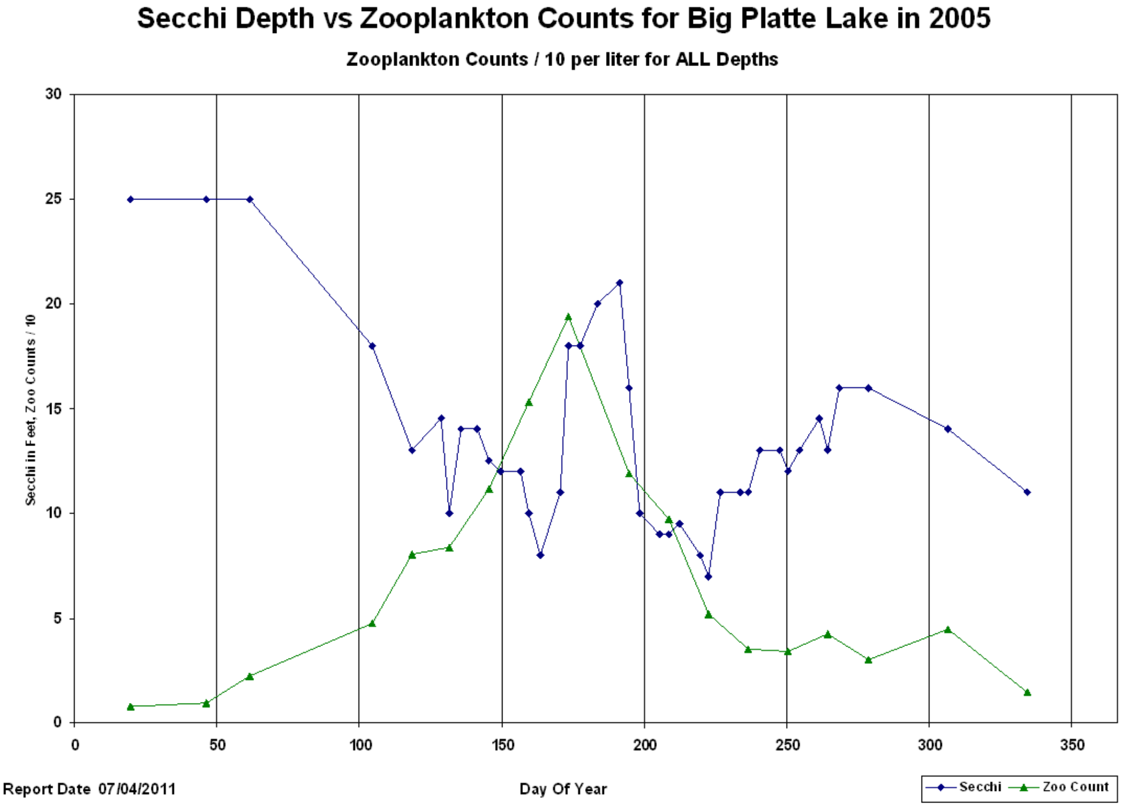


Figure 22: Secchi Depth vs Zooplankton Counts – Big Platte Lake 2005



<u>Big Platte Lake Shoreline *Cladophora*, Phosphorus and *E. Coli* Survey:</u> The Platte Lake Improvement Association conducted a shoreline survey in June and September of 2003 to measure relative abundance and density of *Cladophora* colonies around the shoreline of Big Plate Lake (Woller and Heiman 2003). The study also analyzed phosphorus concentrations and *E. Coli* levels near *Cladophora* colonies as well as tributary streams flowing into the lake. Statistical analysis showed that from June to September *E. Coli* counts declined, however *Cladophora* and phosphorus did not vary significantly (confidence interval = 95%). *Cladophora* densities were highest at shorelines with armoring (seawalls), manicured lawns and tributary outflows, however they were not significantly different. Phosphorus and *E. Coli* did not vary significantly among shoreline types. Recommendations for future shoreline studies are to evaluate *Cladophora*

presence along natural shorelines in the vicinity of tributary outflows compared to natural shorelines not in vicinity to tributary outflows.

Little Platte Lake*:* Little Platte Lake is located about one-half mile north of the north-shore of Big Platte Lake. It has a surface area of about 805 acres or about 35% of that of Big Platte Lake. The maximum depth is about 8 feet, compared to 95 feet for Big Platte Lake. Approximately 12,000 feet of the shoreline of Little Platte Lake is State of Michigan owned wetland. About one-half of the flow of the North Branch of the Platte River passes through Little Platte Lake. This flow rejoins the other half of the North Branch flow before entering the Platte River just upstream of the outfall into Big Platte Lake. The North Branch is the 2nd largest tributary to Big Platte Lake having a flow of about 20% of that of the main branch of the Platte River. Thus, the water quality of Little Platte Lake has an impact on the water quality of Big Platte Lake. A water sampling program was initiated on Little Platte Lake has helped to characterize these impacts. Unfortunately Little Platte Lake sampling was discontinued in 2009.

The data in Figure 23 show that the total phosphorus concentration of Little Platte Lake was about 6 mg/m^3 greater than that of Big Platte Lake in 2008.

Figure 23: Total Phosphorus in Big vs. Little Platte Lake

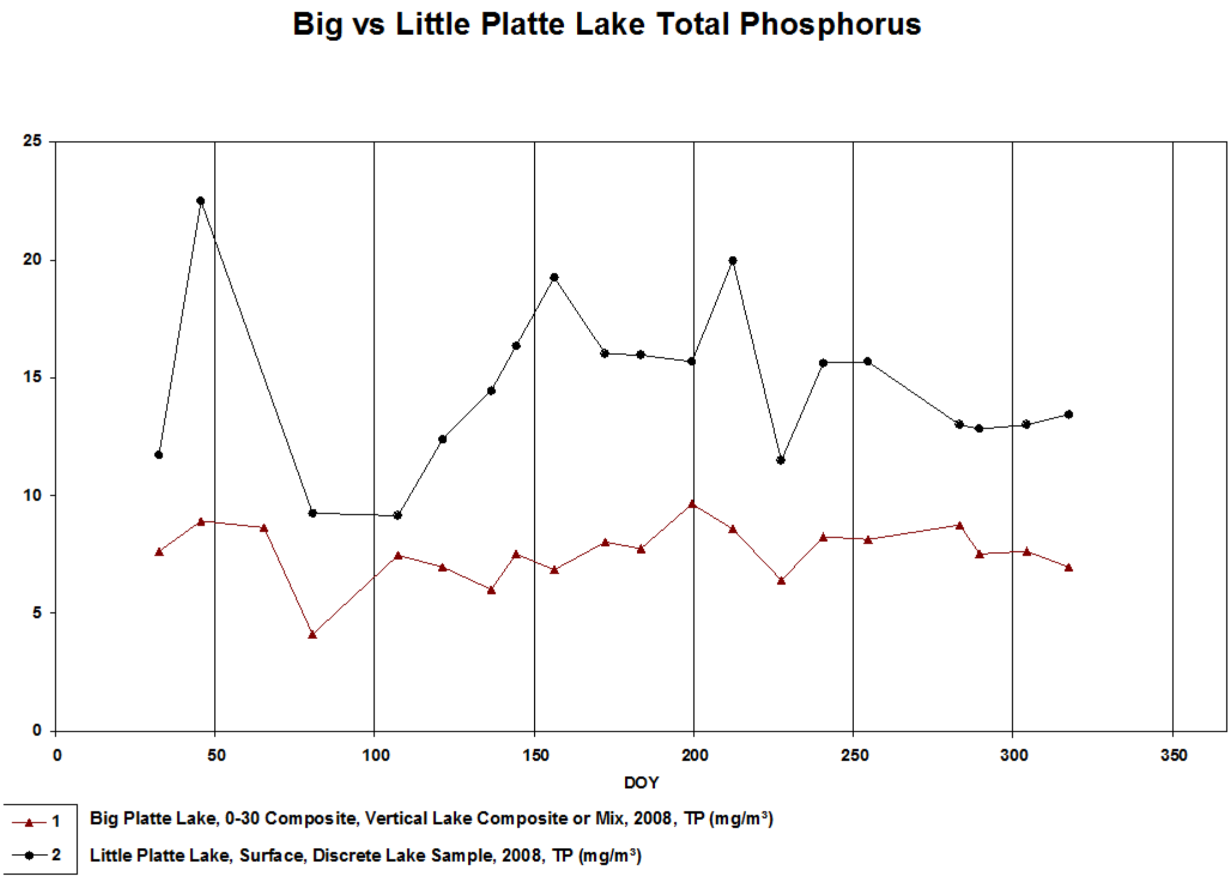
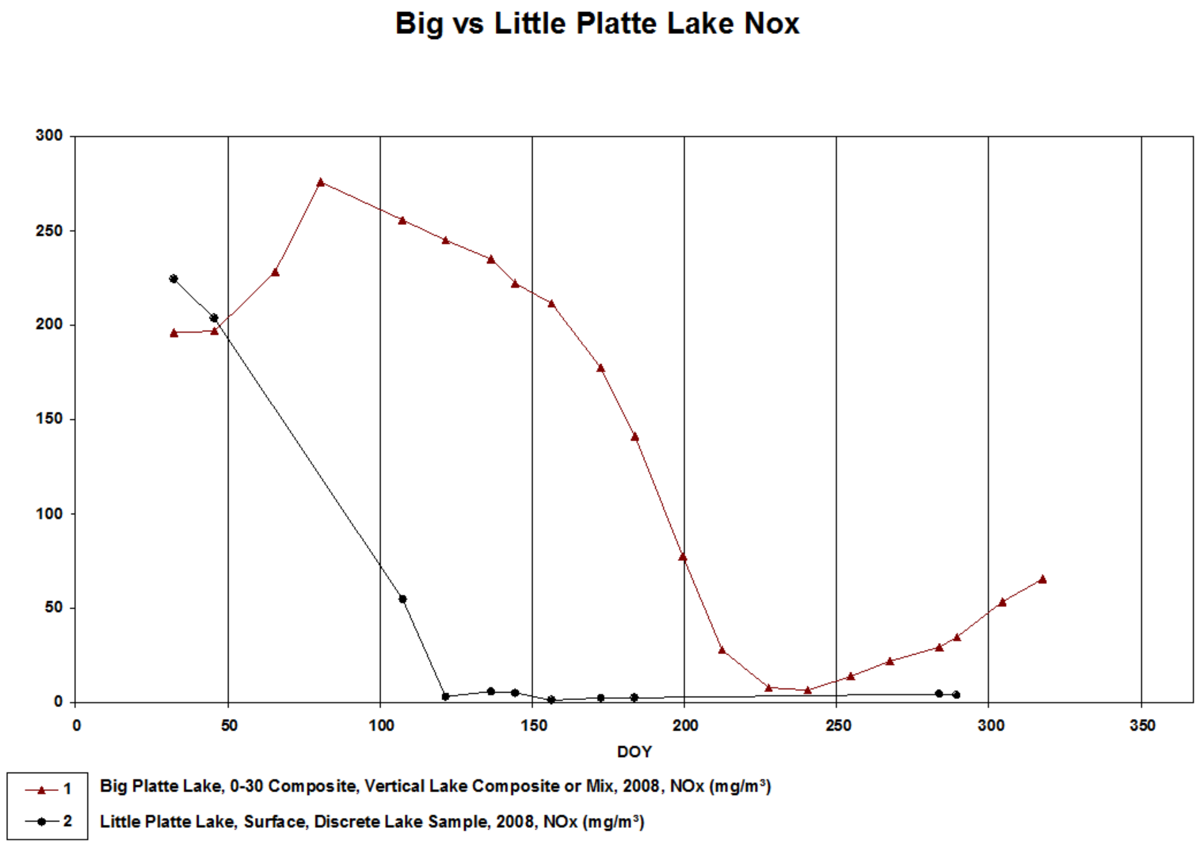


Figure 24 compares the nitrite plus nitrite concentrations in the two lakes for 2008. The concentration during spring and early summer in both lakes is about 250 mg/m$^{3.}$ This is similar to the maximum concentrations measured in rainwater during 2006. The lake concentrations decrease with the onset of summer algal growth. Note that the surface concentration in Big Platte Lake reaches a minimum of about 15 mg/m^{3} around day 235. The low summer concentrations are approaching but are not likely rate-limiting for algal growth, although some competitive advantage may be present for nitrogen-fixing blue-green species. The nitrite and nitrite concentrations in Little Platte Lake decline more rapidly and likely limit algal growth rates during the spring, and remain low for the remainder of the year. This low level of inorganic nitrogen is expected to promote the growth of nitrogen-fixing blue-green algae such as *Anabaena*.

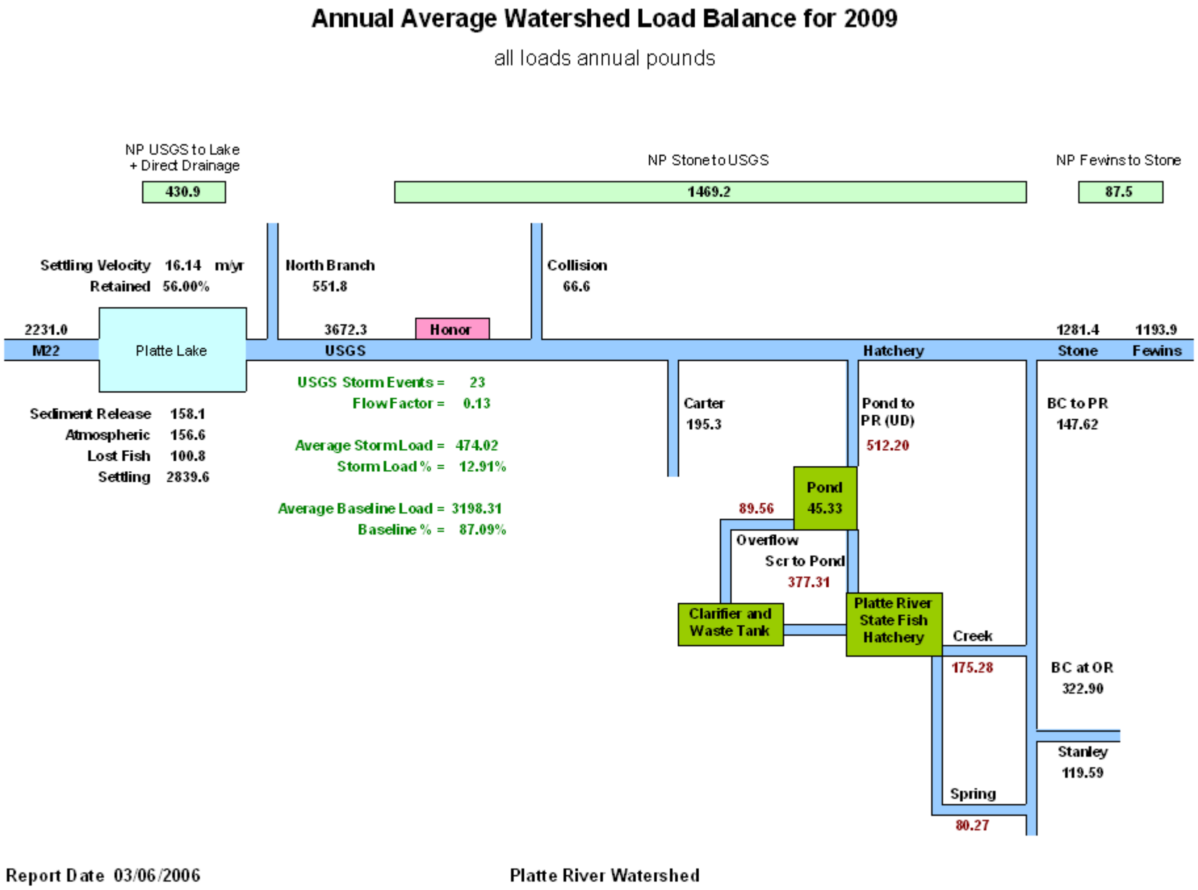
Figure 24: Nox in Big vs. Little Platte Lake



Platte River Numerical Phosphorus Guideline

The Platte Lake Improvement Association and MDNR have collected extensive data for flow and total phosphorus concentrations at various locations in the Platte River. These data have been used to construct annual average phosphorus mass balances for the river for several years. The mass balance can be used to estimate the magnitude of various phosphorus sources along the River between Fewins Road and Big Platte Lake. A typical mass balance for 2009 is shown in Figure 25. These results (and other years) show that about

Figure 25: Annual average Phosphorus loading calculations based on measurements conducted in 2009



2,500 pounds of phosphorus enter the River between Fewins Road and the USGS gauging station located just downstream from the Village of Honor. About half of these 2,500 pounds can be accounted for from known and measured sources. These known sources are Brundage Creek, the Hatchery discharge, Carter Creek, Collision Creek, and uncontaminated ground water. No other major or point phosphorus sources have been observed on this stretch of the River. The wastewater treatment facility for the Village of Honor is located within this section of the River. The facility discharges into the groundwater, and may be a factor regarding the missing source of phosphorus. Unfortunately available groundwater data are presently not sufficient to resolve the significance of the Village of Honor wastewater treatment plant on the water quality of Big Platte Lake. Furthermore, there have been documented cases, such as an unnamed tributary to Platte Lake, where contaminated groundwater broke through the soil surface resulting in large environmental impact on streams (MDEQ Staff Report, 2013).

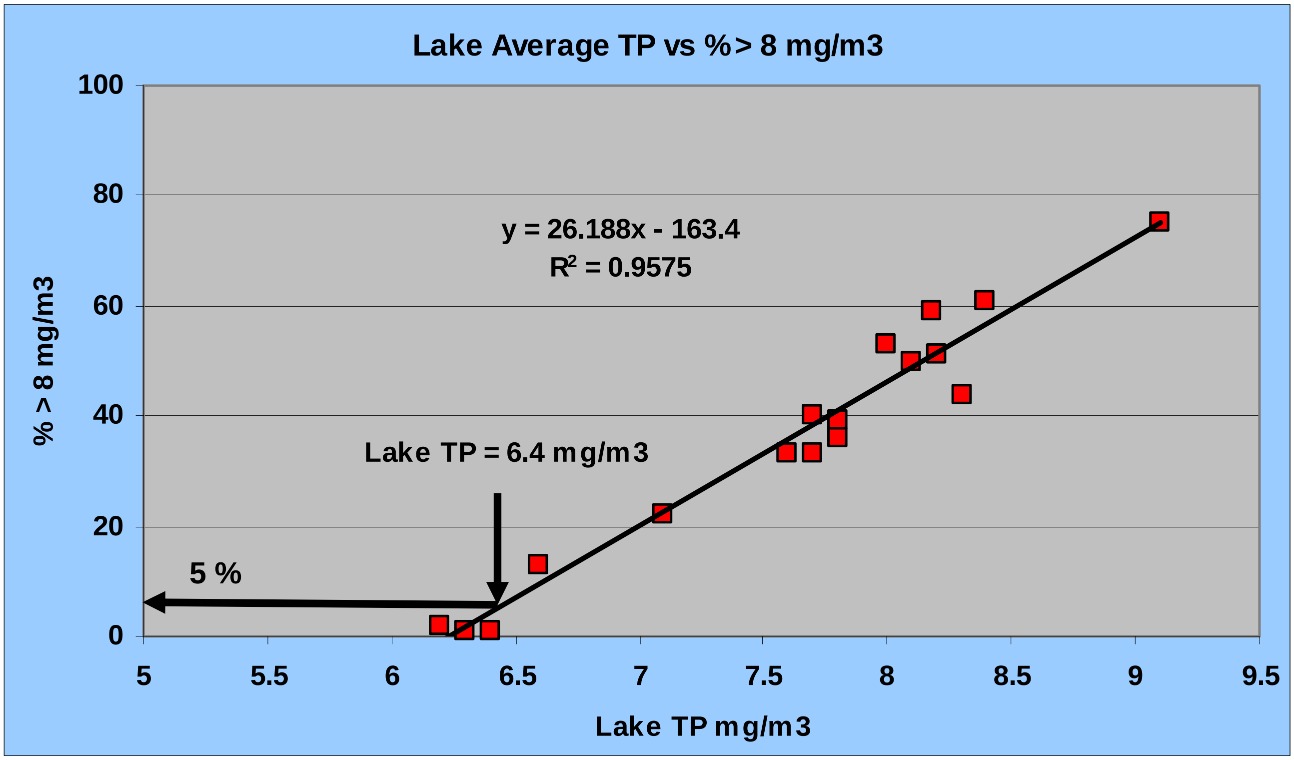
The PLIA would like to increase groundwater sampling near the Honor wastewater treatment site to resolve this issue with greater certainty. This effort would help verify the numerical phosphorus guidelines for the river, quantify the direction of groundwater flow, laboratory test of the adsorptive capacity of the local soils, construct new testing wells, and increase the temporal frequency of sampling of phosphorus and other variables such as ammonia, nitrate, chloride, and conductivity.

Big Platte Lake Numerical Phosphorus Standard

The applicable water quality standard requires that the annual average volume-weighted total phosphorus concentration of Big Platte Lake be maintained below 8.0 mg/m^3 95% of the time. This standard is a court-ordered directive that was prescribed subsequent to legal actions taken by residents of the lake against the MDNR as fully described in Canale et al. (2004). Currently the volume-weighted annual average Lake total phosphorus (TP) concentration typically varies between 7 and 9 mg/m^3 and has not complied with the water quality standard in recent years.

The sampling data can be used to find an allowable lake concentration that ensures that annual average total phosphorus concentration of Big Platte Lake is below 8 mg/m^3 95% of the time. Figure 26 shows a plot of the percent of time the concentration of phosphorus in Big Platte Lake exceeds 8 mg/m^3 during the year as a function of the annual average volume-weighted total phosphorus concentration. This plot is based on approximately 7,000 discrete phosphorus measurements collected over a period of 17 years. A linear fit of the data indicates that an annual average concentration of 6.4 mg/m^3 will insure compliance with the Lake total phosphorus standard (Canale et al, 2010).

Figure 26: Average Total Phosphorus for Big Platte Lake



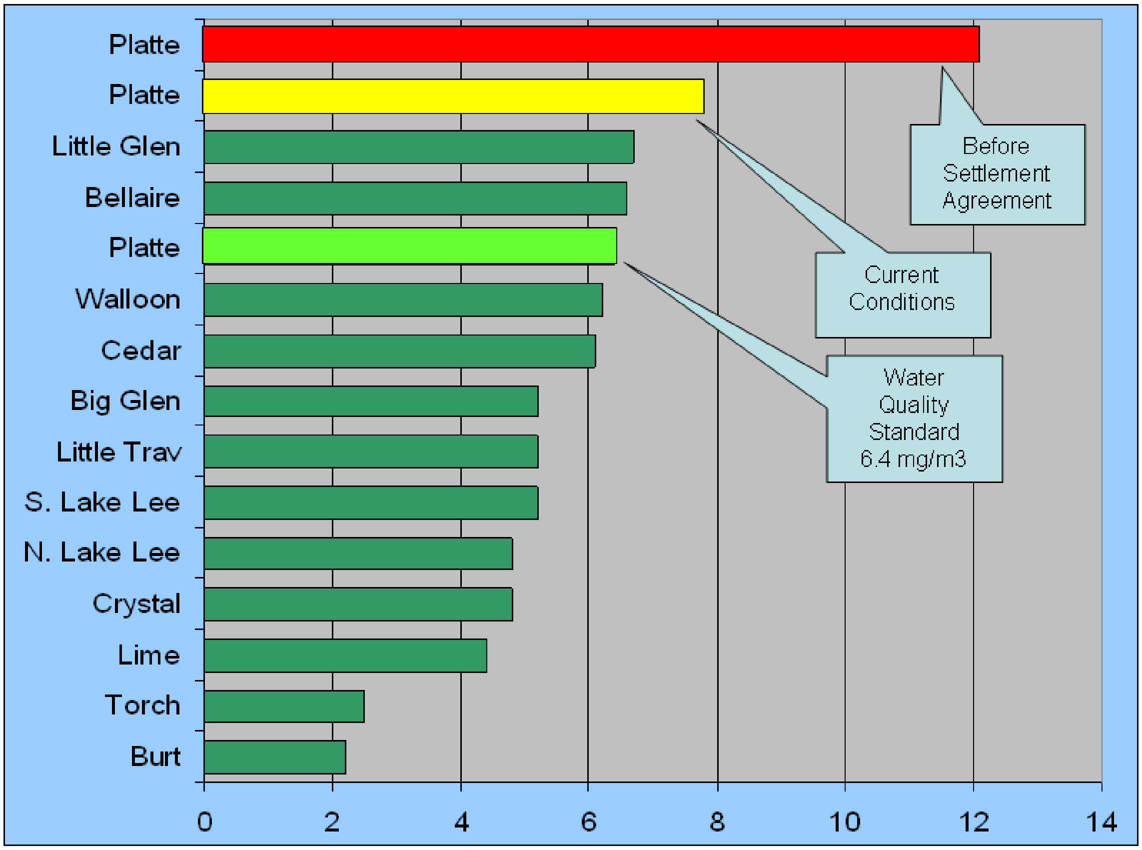
Settlement Agreement

Water Quality Standard = Lake TP < 8 mg/m3 95% of the time

This is equivalent to Annual Average TP = 6.4 mg/m3

Figure 27 shows even at 6.4 mg/m^3 the phosphorus concentration of Big Platte Lake is higher than most other lakes in the area.

Figure 27: Total Phosphorus concentrations in area lakes

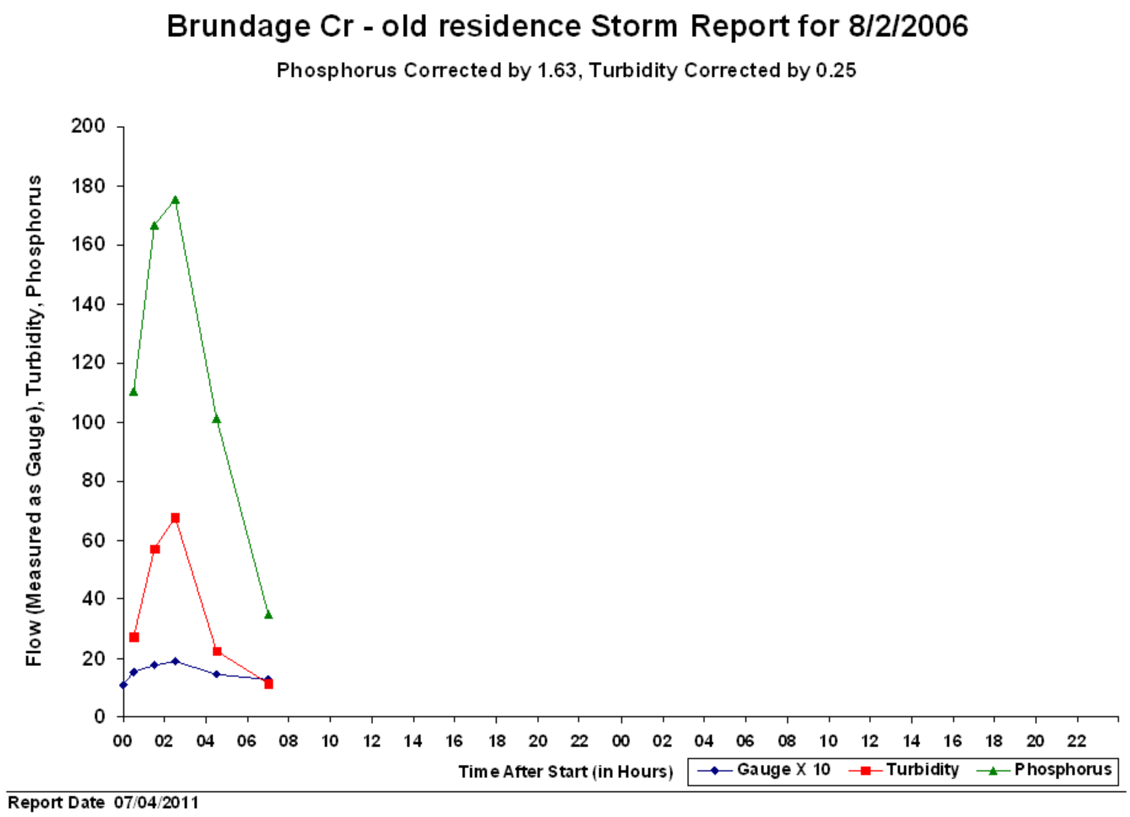


Watershed Phosphorus Balance

Figure 26 shows (page 98 above) annual average phosphorus loading calculations based on measurements conducted in 2009. Note that the development of an accurate annual phosphorus balance for the watershed is not a simple task because the Platte River and tributary loadings are highly affected by flow spikes that occur during several storm events throughout the year. The routine sampling program for the Platte River measured the total phosphorus concentration during only 5 of these storm events in 2009 from a total of 23 (see Figure 28). Thus, estimates of the total phosphorus loading into Big Platte Lake based on the 26 routine measurements are inaccurate in the sense that they under represent the importance storm events. Unfortunately, it is impractical to measure flow and phosphorus concentration during every storm event at all key locations in the watershed every year.

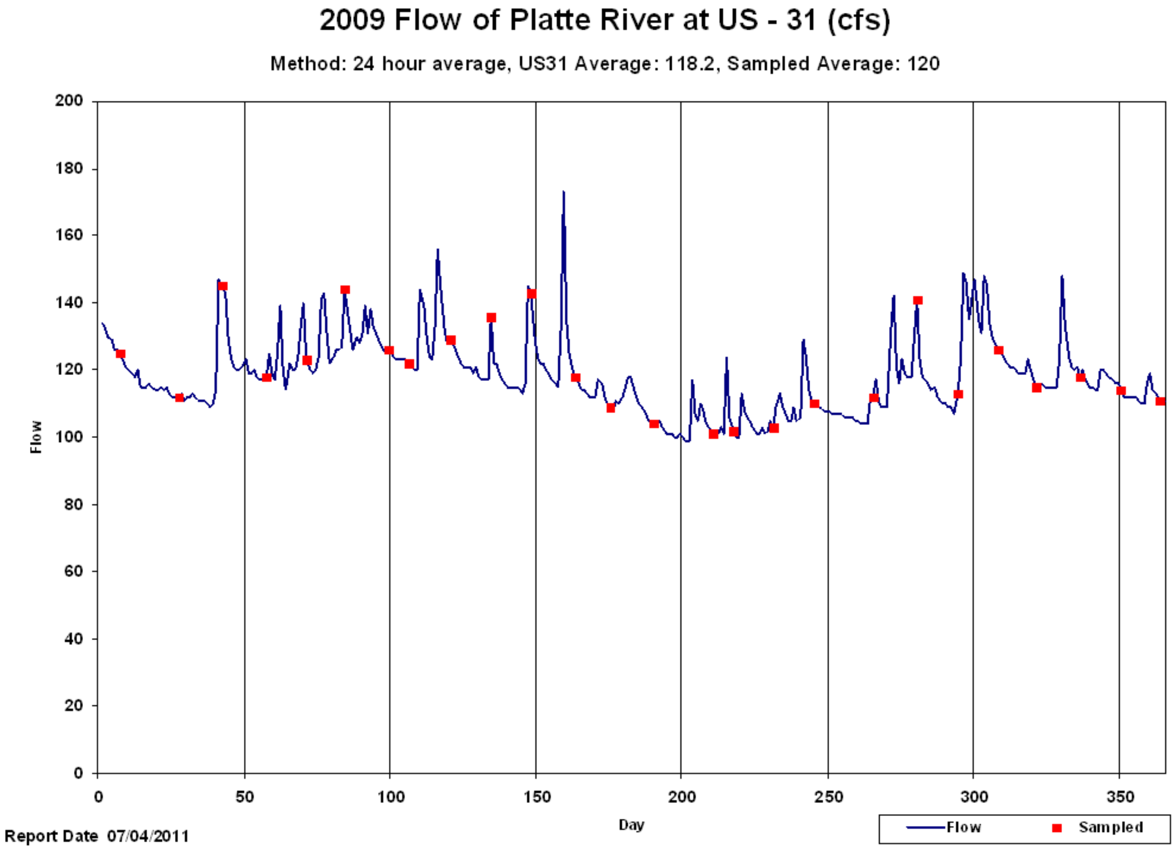
The annual average phosphorus budget shown in Figure 26 incorporates extensive storm event measurements were taken from 2004 to 2007 at the Old Residence location on Brundage Creek and at the Stone Bridge and USGS Gauging Station at Honor, MI sites on the Platte River using continuous water sampling equipment. Figure 28 shows an example of measurements for one of these storm events on Brundage Creek for 2006. The average total phosphorus concentrations during storm events at these locations were 71.7, 42.6, and 50.8 mg/m^3, respectfully. The storm event concentrations at the Fewins site and North Branch sites are assumed to be representative of those measured at the Stone Bridge site. The measured storm event total phosphorus concentrations measured at the Old Residence site on Brundage Creek were used to characterize storm events for the Stanley, Carter, and Collision Creek sites. The total phosphorus concentrations during base flow conditions were averaged for all years for Stanley, Carter, and Collision Creeks because limited measurements are available for these sites and they are no longer included in the regular monitoring program. The baseline load was determined by multiplying the annual average baseline flow and concentration times the percent of the time the flow was at baseline conditions. The storm event load was determined by multiplying the annual average storm event flow and concentration times the percent of the time the flow was at storm event conditions.

Figure 28: Brundage Creek- 2006 Old Residence Storm Report



The annual phosphorus load at the USGS Gauging Station calculated in this manner is 3,672 pounds. Note that storm events contribute 12.9% of total phosphorus load compared to only 7.5% of the flows. The total phosphorus concentration at the USGS Gauging Station at the Honor, MI site was measured 26 times during 2009. The average total phosphorus concentration of all measurements without flow-weighting was 14.3 mg/m^3 and the annual average flow was 118.3 cfs. This is equivalent to an annual load of 3,331, an amount that is about 10% lower than the annual load calculation that more accurately accounts for storm events. The difference is the result of both storm event flows and total phosphorus concentrations being disproportionate to corresponding dry weather or base flow conditions.

Figure 29: Flow of Platte River at US 31- 2009



These results along with measurements of the phosphorus loading associated with fish lost between the lower and upper weirs; atmospheric loading; and phosphorus release from the sediments and the net Hatchery loads were used to complete the phosphorus balance for the watershed as shown in Figure 26 (Page 98). These inputs and data for the annual average loading and volume-weighted total phosphorus concentration in the lake can be used to calculate an apparent settling velocity of 16.1 m/yr for 2009. This coefficient is a characterization of the net removal of phosphorus from the water column and corresponds to the permanent retention of 56% of the incoming phosphorus into the sediments. This value compares well to the long-term average value of 19.9 m/yr (Standard Deviation = 3.9 m/yr) since 1990 and with those observed in other lakes (Chapra, 1997). All these computations are automatically performed by the project database.

Annual average phosphorus loads calculated in the manner are considered reasonable representations of the hydraulic and phosphorus watershed balances despite the assumptions and approximations used in the analyses. Practical alternatives to this approach are problematic. Maximum total phosphorus concentrations during storm events are typically an order of magnitude higher than during base flow periods. Thus, load estimates based on routine measurements alone are not likely to represent the actual non-point loads because many storm event spikes are missed. Thus, the routine monitoring program needed to compile a more accurate phosphorus balance for the total watershed is likely to be prohibitive. One alternative is to use the BASINS model (Summarized below and discussed in Chapter 5) to estimate the phosphorus balance for the watershed. This model takes into account daily weather data and hydrographs for each site in the watershed. However this model requires: 1) the input of accurate data to characterize the local rainfall patterns throughout the entire watershed; 2) real-time atmospheric weather conditions; 3) knowledge of hydraulic conditions in prior years; and 4) estimation of numerous model coefficients. Thus, preparing the inputs for BASINS to simulate a given year is a significant and costly task, and not necessarily more accurate than the above approach.

Given the difficulties and limitations of both direct monitoring and BASINS modeling, the current approach is considered the best alternative and a reliable screening tool that can be reliably used for preliminary planning applications. However, if watershed planning issues arise in the future that involve large expenditures or significantly influence watershed land use, it is recommended that the full dry and wet weather monitoring program be resumed and that the BASINS model be re-calibrated. In addition, it is appropriate to explore other watershed loading models of intermediate level complexity models to predict stream flow such as those proposed by Limbrunner et al. (2005).

Figure 30: Photos of water sampling locations on the Lower Platte Watershed (Courtesy of MDNR, Ed Eisch)

Brundage Creek Carter Creek Collison Creek

North Branch Platte River, Lower North Branch Platte River, Upper Platte River, Pioneer Road

Platte River, Stone Bridge

Platte River, Vet’s Park

Platte River, M22

Platte River, USGS

Stanley Creek

3.2 WATER QUALITY OF THE SLEEPING BEAR DUNES NATIONAL LAKESHORE IN THE PLATTE RIVER WATERSHED

Water resources at Sleeping Bear Dunes National Lakeshore (SBDNL) are abundant, diverse, and of high quality. They include 27 named inland lakes, five rivers and streams, 65 miles of Lake Michigan shoreline and near shore waters, as well as an abundance of bogs, springs, and interdunal wetland. Loon Lake and the lower Platte River, including the mouth of the river entering Lake Michigan, are the primary water resources located in the Platte watershed. Although studies of these waters precede 1940, for the purpose of this watershed management plan only recent water quality monitoring program has been addressed. The following is a brief overview of the water quality monitoring program at SLBNL.

The water quality monitoring program at SLBE is part of a larger initiative to establish consistent, scientifically sound water quality monitoring within regions of the National Park Service (NPS). Since 2007, water quality monitoring at SLBE has been done in conjunction with the NPS Great Lakes Inventory and Monitoring Network (GLKN). While developing a monitoring protocol for inland lakes a national review panel, assembled by the National Park Service – Water Resources Division, recommended a suite of five parameters be measured for all NPS monitored inland lakes. In addition to these five mandated parameters (temperature, pH, specific conductance, dissolved oxygen, and flow/water level) SBDNL added a measure of water clarity (Secchi depth or transparency tube depth) to our core suite. The core suite was ranked highest among potential vital signs for aquatic systems of GLKN parks, although it was recognized that these measurements were less diagnostic of water quality degradation than biotic communities and other water quality variables, such as nutrient concentrations.

Inputs of excess nutrients, invasion and spread of exotic species, and contaminants from atmospheric fallout and surface runoff, and how these stressors affect the chemical and biological functions of lakes are key issues of concern to the NPS. The primary objective of the Park's monitoring program is to monitor water quality in order to describe the current status and to detect trends of common limnological parameters within sampled lakes.

Starting in 2007, SLBE has focused its water quality monitoring efforts on ten inland lakes, including Loon Lake, which is sampled three times during the field season by park natural resources staff. The Park uses a multi-probe datasonde to collect depth profiles of temperature, pH, conductivity, and dissolved oxygen. Additional measurements recorded on-site include water clarity, water level relative to a benchmark, and a list of physical and environmental conditions. Additionally, water samples are collected and shipped to a contract laboratory facility for analyses of the advanced suite of parameters, including: nutrients (total phosphorus, total nitrogen, nitrate+nitrite-nitrogen, ammonium-nitrogen, dissolved silica), major ions (calcium, sodium, magnesium, potassium, sulfate, chloride), dissolved organic carbon, alkalinity, and chlorophyll-a.

Of the 27 inland lakes at least partially within the SLBE boundary, very few fall within the Platte River Watershed. In fact, Loon Lake is the only inland lake within the watershed that is part of the water quality monitoring program at SLBE. All the information collected through SLBE's inland lakes water quality monitoring program is submitted to the U.S. Environmental Protection Agency (EPA) and made available to the public through the EPA's STORET database. For additional information on natural resources within the National Lakeshore, please visit the SLBE website at: www.nps.gov/slbe.

The Sleeping Bear Dunes National Lakeshore Water Resources Management Plan (Vana-Miller, 2002) summarizes the water quality data collected in the Platte River Watershed by the Park Service. Loon Lake is reported to have a water flushing rate (the amount of time it takes for water entering the lake to flow out) of only 12 days, which is remarkably fast compared to Big Platte Lake's rate of 302 days, or Lake Michigan's rate of 100 years. Loon Lake's water quality is good, which is attributed to the high flushing rate and mostly natural shoreline. Phosphorus levels have averaged 0.014mg/L, however only 8 samples were taken over 5 years. All other parameters measured were within normal levels expected for a mesotrophic lake with a high flushing rate.

The SLBE water quality program has also analyzed the water quality of the Platte River immediately below Big Platte Lake at the M-22 bridge as well as the river mouth just above Lake Michigan. Samples for both locations are remarkably similar, despite the presence of Loon Lake between them. This emphasizes the impact of the high flushing rate on the lower watershed. Phosphorus levels averaged 0.019 mg/L over 27 samples taken from 1990-1995 at both locations, while total Nitrogen was 0.27 mg/L at the M-22 bridge and 0.31 mg/L at the mouth.

3.3 WATER QUALITY RESULTS FOR THE UPPER WATERSHED

The water quality of the upper watershed, from Long Lake down to Fewins Road bridge is generally very good with low nutrients and high dissolved oxygen. Long Lake itself has been found to have low phosphorus levels in the upper and middle water columns, however the deeper portions of the lake had elevated phosphorus levels during late summer and early fall, likely due to the anoxic conditions present at the bottom of the lake (LLWMP, 2009). Seasonal precipitation variations have been determined to be the most influential factor in determining phosphorus concentrations in Long Lake. These elevated phosphorus levels in the deeper portion of the Long Lake basin suggest that it will be important to limit additional phosphorus loading sources in the future in order to avoid impairment of designated or desired uses.

The surface water quality of the watershed below Long Lake and above Fewins Road Bridge has not been extensively studied; however there are no known degradation issues of the Platte River or adjacent lakes. Additionally, the presence of sensitive biological indicator species such as brook trout, which have been observed in the Platte River below Lake Ann (Heiman, personal observation), indicate that water quality remains high, although sedimentation issues from road crossings in particular severely threaten in stream habitat and limit fishery potential.

The most significant impact in this reach below Long Lake and above Fewins Road is sedimentation of stream substrate and thermal pollution from lake systems. The degree to which thermal pollution is anthropomorphically influenced is thought to be very low since the natural course of the river system flows through and receives outflow from several warmwater lakes. Thus thermal stresses to the cold water community above Fewins Rd are considered to be an inherent natural function of the Platte River watershed. However sedimentation of the stream channel is typically a result of unfortunate land-use choices or inadequate road/stream crossings. The upper watershed is impacted by the majority of identified severe road/stream crossings in Figure 31. The sedimentation of stream substrates significantly reduces macroinvertebrate diversity, impairs native fish populations and can lead to an increase in nutrient loading from nitrogen and phosphorus attached to soil particles. Reducing sedimentation in the upper watershed will also help reduce nutrient inputs, thus addressing both of the top two pollutants.

Lake Ann water quality summary-

The Ann Lake Property Owners Association (ALPOA) has sponsored testing to monitor the quality of the water in Lake Ann since 1999. Periodically throughout the summer season between mid-May and mid-September, samples and readings are taken that measure and record clarity of the water (an indicator of the level of algae), the levels of phosphorous and chlorophyll, plus the dissolved oxygen and temperature at incremental depths from the surface to the bottom. Over the last 10 years the results have been very stable and with little variation from year to year, indicating generally very good water quality. One note of concern identified in their 2012 report was an elevated phosphorus reading in the 2012 fall sample. The spring and fall levels had averaged below 10 mg/m^3, however the fall 2012 reading was above 15 mg/m^3.

Long Lake water quality summary-

Long Lake Association also conducts routine water quality monitoring on their lake. Please see the Long Lake Watershed Management Plan (2009) for a complete summary of results and trends. Results indicate that it is still considered a high quality oligotrophic lake, however a number of warning signs indicate Long Lake could be vulnerable to degradation if long-term nutrient input is not limited (LLWP 2009).

CHAPTER 4: THREATS TO WATER QUALITY IN THE PLATTE RIVER WATERSHED

4.1: Water Quality Standards and Designated Uses

Each of Michigan's surface waters is protected by water quality standards for specific designated uses (Table 17). Designated uses as defined by the State of Michigan are recognized uses of water established by state and federal water quality laws designed to 1) protect the public's health and welfare, 2) enhance and maintain the quality of water, and 3) protect the state's natural resources.

Table 17: Designated Uses for Surface Waters in the State of Michigan

All surface waters in the state of Michigan are designated for and shall be protected for all of the following uses:
1. Agriculture
2. Industrial water supply
3. Navigation
4. Warm-water fishery
5. Other indigenous aquatic life and wildlife
6. Partial body contact recreation
7. Total body contact recreation between May 1 – October 31
8. Fish Consumption

Citation: R323.1100 of Part 4, Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended

An additional cold-water fishery state designated use applies to six (6) named designated trout streams and salmon streams along with several other unnamed first and second order coldwater streams in the watershed (Figure 31). Designated trout and salmon streams require high dissolved oxygen content and year-round temperatures below 74 degrees Fahrenheit. These are high water quality systems that depend on stable groundwater flows that are low in nutrients. The predominantly sandy loam soils of the region are highly permeable and very susceptible to the forces of erosion. Poor land use and development of land adjacent to stream corridors typically leads to excessive sediment being carried by stormwater flowing across the land into the stream channel. This can bury large woody debris and other in-stream habitat, which effectively turns the system into an aquatic desert.

Figure 31: Designated Trout Streams in the Platte River Watershed

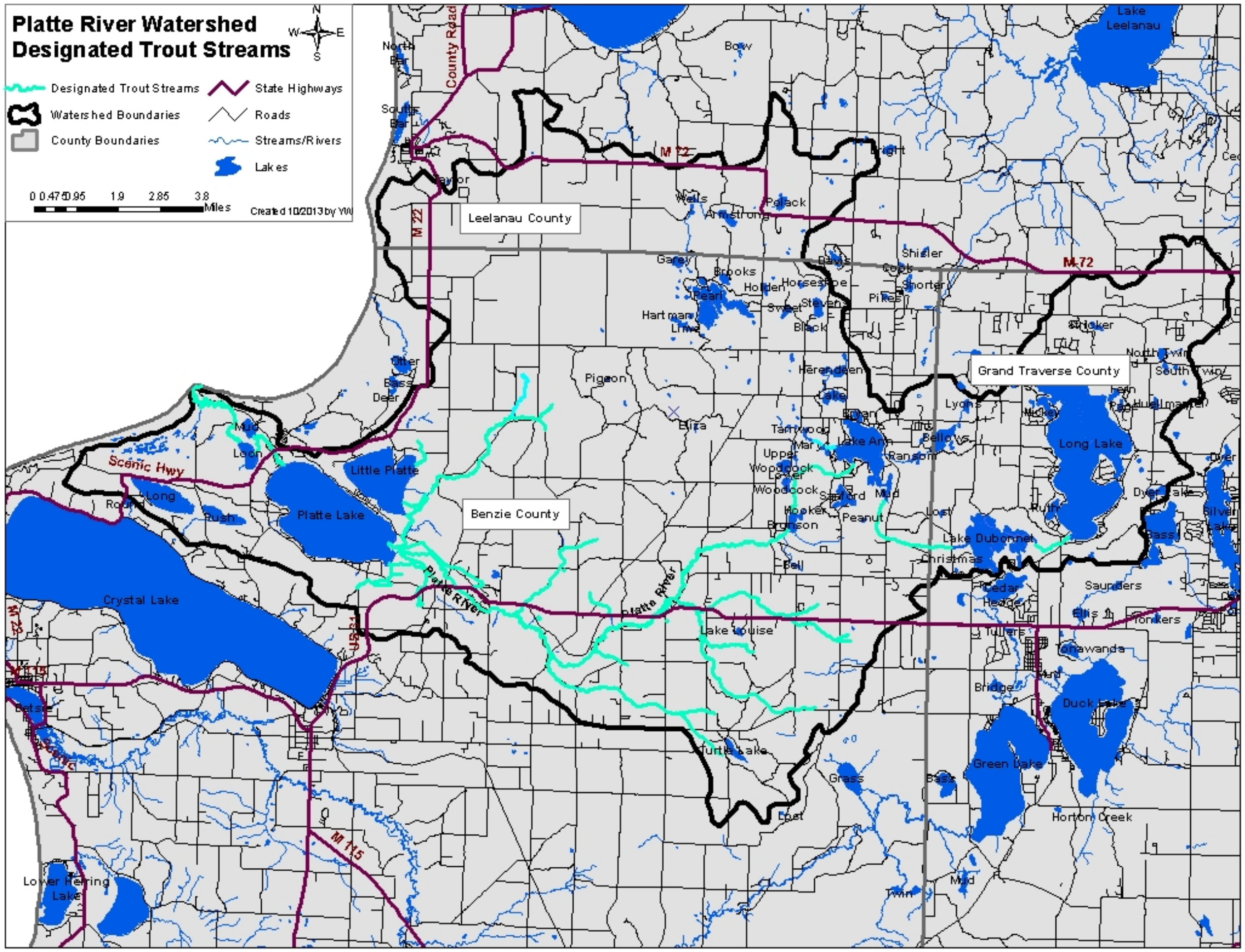


Table 18: State of Michigan Water Quality Standards 3106

Pollutant	Water quality standards*	Designated Uses affecting the Platte River Watershed
Dissolved solids	500 mg/L monthly average or 750 mg/L at any time	All
Chlorides	125 mg/L monthly average	Public Water Supply
pH	6.5 to 9/0	All but navigation
Taste or odor-	Any concentration	Public Water Supply, Industrial Water
Toxic substances (selected shown here; see rule for complete listing)	DDT and metabolites: 0.00011 mg/m3 ; Mercury, including methylmercury: 0.0013 mg/m3 ; PCBs (class): 0.00012 mg/m3 ; 2,3,7,8-TCDD: 0.0000000031mg/m3	All but navigation
Radioactive substances	Pursuant to U.S nuclear regulatory commission and EPA standards	All but navigation
Plant nutrients	Phosphorus: 1mg/L monthly average for permitted point-source discharges	All
Microorganisms	130 *Escherichia coli* per 100 ml 30-day mean of 5 or more sampling events	Total body contact recreation
	300 *E. coli* per 100 ml 30-day maximum	Total body contact recreation
	1,000 *E. coli* per 100 ml 30-day maximum	Partial body contact recreation
	Human sewage discharges (treated or untreated) 200 *E. coli* per 100 ml 30-day mean or 400 *E. coli* per 100 ml in 7 days or less	Partial body contact recreation

Table 18: State of Michigan Water Quality Standards 3106 (Cont'd)

Pollutant	Water quality standards*	Affected Designated Uses
Dissolved oxygen	Minimum 7 mg/L for coldwater designated streams, inland lakes, and Great Lakes/connecting waters; minimum 5 mg/L for all other waters Minimum 5 mg/L daily average	Cold water fishery Warm water fishery
Temperature	Natural daily and seasonal temperature fluctuations shall be preserved Monthly maximum for inland lakes: J F M A M J J A S 0 N D 45 45 50 60 70 75 80 85 80 70 60 50 Monthly maximum for inland streams in this watershed: J F M A M J J A S 0 N D 38 38 43 54 65 68 68 68 63 56 48 40	Cold water fishery, other indigenous aquatic life and wildlife, warm water fishery

**Data from Appendix B2 of DEQ's Integrated Water Quality Report – Water Quality and Pollution Control in Michigan (DEQ 2010)*

Table 19: Sections of the Watershed on Michigan's 2009 303(d) List

Water Body	Affected Designated Use	303(d) Listing Cause	Notes:
Unnamed Tributary of Big Platte Lake	Warmwater fishery Coldwater fishery Other indigenous aquatic life and wildlife	Bacterial Slimes, Organic enrichment, DO	*Benzonia Township, Lat 44.6750, Long -86.0649, Benzie County*
Big Platte Lake, vicinity of Honor	Fish Consumption	Mercury in fish tissue and PCB in fish tissue	Atmospheric deposition of mercury and other toxins are not addressed in this WMP effort because they are beyond the scope of the WMP process.*

*The DEQ does not recognize atmospheric deposition of mercury or other toxins as a treatable 303 (d) impairment

4.2 IMPAIRED AND DEGRADED DESIGNATED USES

If a body of water or stream reach is impacted to the point of not meeting the water quality standards set for a specific designated use, then it is said to be in 'nonattainment'. An annually published listing of the bodies of water and stream reaches in the State of Michigan that are in nonattainment can be found in Appendix C of the DEQ's Integrated Water Quality Report – Water Quality and Pollution Control in Michigan (DEQ 2010). The DEQ uses a rotating watershed cycle for surface water quality monitoring where each of the 58 major watersheds in the state are scheduled for monitoring at least once every five years. The Platte River watershed was last monitored in 2008 by the Surface Water Assessment Section and results determined that the designated uses were not impaired on a watershed-wide level at that time(January 2011 SWAS Staff Report). However the report did identify an unnamed tributary to Big Platte Lake that was listed on the MDEQ 303 (d) list of impaired surface waters for bacterial slimes, dissolved oxygen and organic enrichment (Table 18), which has resulted in 3.5 miles of the creek not meeting designated uses for other indigenous aquatic life or either warm or coldwater fisheries.

Due to widespread mercury contamination from industrial emissions occurring in other states lying upwind of Michigan (in terms of predominate weather patterns), all of Michigan's inland lakes, including lakes in the Platte River Watershed, are not meeting water quality standards for fish consumption. Fish consumption advisories for PCBs or mercury are the primary cause of inland lakes not meeting water quality standards (DEQ 2008). For further information on mercury sources in the environment and mercury pollution prevention strategies, please refer to publications by Sills (1992) and Mehan (1996), respectively. The problem of mercury contamination and other related toxic contamination problems (i.e., PCB, chlordane, etc.) in the Platte River watershed will not be discussed in depth in this Protection Plan, since it is caused by atmospheric deposition of industrial emissions from other states and the DEQ does not consider it to be a treatable 303 (d) impairment through the watershed management planning process as there are state and federal level efforts being directed towards this pollutant.

Degraded water bodies are defined as those that currently meet water quality standards, but may not in the near future. Currently, the designated uses of the Platte River watershed are degraded from inputs of phosphorus from various sources within the watershed, increasing human development along with exotic species introduction and proliferation. The PRWPP has identified the warmwater/coldwater fishery, other indigenous aquatic life and wildlife, and total body contact designated uses as degraded (Table 20). Degraded designated uses were ascertained through scientific research reports, water quality monitoring reports, steering committee members, and personal contact with watershed residents and scientific experts on the Platte River watershed.

Table 20: Degraded or Impaired Designated Uses in the Platte River Watershed

DESIGNATED USES	
Warmwater and Coldwater Fishery	Degraded
Other Indigenous Aquatic Life and Wildlife	Degraded
Fish Consumption	Impaired

4.3 DESIRED USES

Steering committee and stakeholder input identified the need for establishing Desired Uses to address concerns particular to the watershed that are not addressed by designated uses, which are based on state water quality standards. Desired uses are defined as the ways in which people use the watershed and how they would like to manage and protect the watershed to ensure the sustainability of those uses for future generations. They may range from very general to very specific. Desired uses often help to reflect more qualitative community concerns such as poor sport fishing opportunities or deterioration of scenic viewsheds. Desired uses for the Platte River watershed include uses for recreational, aesthetic, human health, and ecosystem preservation (Table 20).

Table 21: Desired Uses for the Platte River watershed

Desired Use Category	Location	Purpose
Recreational Opportunities	Entire watershed	*Sustain high quality inland lake fisheries, coldwater stream fisheries, hunting, paddling, swimming and boating. Develop and promote additional outdoor passive recreational activities such as mountain biking opportunities.
Aesthetics	Forested ridgelines, view corridors and surface water bodies	*Protect forested ridgelines from development to protect water quality and scenic view corridors. *Maintain water clarity and prevent 'whiting' events *Prevent excessive algal growth
Human Health	Lakes, rivers, groundwater	*Primarily groundwater potable water supply.
Ecosystem Preservation	Priority areas	*Promote sustainable watershed development *Protect fish & wildlife habitat *Preserve natural & intact riparian corridors

4.4 POLLUTANTS, SOURCES, AND CAUSES

There are a number of different pollutants and environmental stressors that adversely affect each of the designated and desired uses (Table 22). The term environmental stressor is used to describe those factors that may have a negative effect on the ecosystem, but are not necessarily categorized as contaminants that change water chemistry. It is meant to address the wide range of environmental degradation experienced in the watershed. This plan will refer to classic watershed pollutants such as nutrients, sediment, and toxic substances, as well as environmental stressors such as habitat and wetland loss. Environmental stressors representing activities and conditions that negatively impact the designated and/or desired uses of the Platte River watershed include invasive species, loss of habitat, excess nutrients, and more (Table 22).

Table 22: Pollutants and Environmental Stressors Affecting Designated Uses in the Platte River Watershed

Pollutant or Environmental Stressor	Designated Uses Affected	Desired Uses Affected
Nutrients	Warm water/Coldwater Fishery Other Indigenous Aquatic Life	Aesthetics Human Health
Sediment	Coldwater Fishery Other Indigenous Aquatic Life	Aesthetics Recreation
Invasive Species	Warmwater/Coldwater Fishery Other Indigenous Aquatic Life	Aesthetics
Thermal Pollution	Coldwater Fishery Other Indigenous Aquatic Life	Ecosystem Preservation
Loss of Habitat	Warmwater/Coldwater Fishery Other Indigenous Aquatic Life	Aesthetics Ecosystem Preservation
Toxins (Pesticides, Herbicides, Oils, Gas, Grease, Salt/Chlorides, Copper Sulfate, Microcystis)	Warmwater/Coldwater Fishery Other Indigenous Aquatic Life Fish Consumption	Human Health Aesthetics Ecosystem Preservation
Pathogens (*E. Coli*)	Total Body Contact	Human Health Recreation
Altered Hydrology	Warmwater/Coldwater Fishery Other Indigenous Aquatic Life	Aesthetics Recreation

Note: This is a general list that encompasses stressors and/or pollutants for the entire Platte River watershed. Not all reaches in the watershed are impacted by all of the pollutants and/or stressors listed above.

Sources and Causes of Pollutants

A Comprehensive Watershed Protection Table was developed listing potential (p), suspected (s) and known (k) sources and causes of watershed pollutants and environmental stressors (Table 23). This table summarizes key information necessary to focus on water quality protection, provides specific targets to act upon for watershed management and forms the basis for future implementation projects to protect the quality of the watershed. Sources and causes were identified using a wide variety of methods including: road stream crossing inventories, scientific research reports, water quality monitoring reports, steering committee member local knowledge and personal contact with watershed residents.

Table 22: Pollutants, Sources, and Causes of Water Quality Degradation in the Platte River Watershed (Comprehensive Watershed Protection Table)

Environmental Stressor or Pollutant	Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Nutrients	*Warm/ Coldwater Fishery *Other Indigenous Aquatic Life	Residential, Agricultural or Commercial Fertilizer Use (s)	Improper application (amount, timing, frequency, location, method, P content) (s)
		Septic Systems (s)	Inadequate design, sited, sized, maintained (s) High density/age of systems (s) Lack of required inspections (s)
		Point Source Phosphorus loading from Platte River Hatchery effluent (k)	Historic Hatchery production practices neglected to control phosphorus levels below the Court ordered 8 mg/Liter threshold. (k)
		Soils exposed to stormwater runoff (k)	Elimination of riparian vegetation from natural shorelines (s) Poor forestry practices, improper road construction or land use practices (s) Improper landscaping practices on private waterfront residential properties that leaves large amounts of biomass to decompose at the end of the growing season (s)
		Atmospheric Deposition (k)	Industrial emissions (k)

Environmental Stressor or Pollutant	Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Sediment	*Warm/Cold water fishery *Other indigenous Aquatic Life *Navigation	Road Stream Crossings (k)	Erosion of embankments (k) Road sanding (k) Inadequate design/construction/maintenance (k) Lack of erosion/surface runoff controls (k) Steep approaches (k) Culverts not aligned to streambed (k) Undersized culverts (k)
		Bank/Shoreline Erosion (k)	Improper culvert sizing and placement (s) Removal of riparian vegetation from natural shorelines (s) Boat traffic/wakes (p) Recreational use w/o adequate access infrastructure (k)
		Residential and Road Construction (k)	Inadequate soil erosion and stormwater management practices (k)
		Direct runoff entering water bodies from residential and developed areas (k)	Inadequate storm water management practices (k)
		Soil exposed to stormwater runoff (k)	Improper landscaping or land use practices, lack of riparian vegetation (k)
		Forestry Practices (k)	Inadequate road design, management (k) Inadequate timber harvest practices (k)
		Agriculture (k)	Runoff into streams/waterbodies (k) Poorly managed livestock operations (s)

Environmental Stressor or Pollutant	Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Invasive Species	*Warm/Coldwater Fishery *Other Aquatic Life *Navigation	Landscaping practices (k)	Availability and preference for invasive perennials at nursery and landscaping stores (k) Lack of awareness and/or concern (s)
		Anthropomorphic introduction of Invasive Species from Boat Hulls, Personal Watercraft, Live Wells, Bilges, Trailers, wading shoes, etc. (k)	Lack of restrictions on boat travel (k) Lack of awareness and/or concern (k) Not properly cleaning boats between lakes (k)
Thermal Pollution	*Coldwater Fishery *Other Indigenous Aquatic Life	Runoff from developed areas (s)	Stormwater runoff being allowed to directly enter surface water bodies (k)
		Lack of Streamside Canopy (p)	Removal of streamside vegetation (p)
		Ponds, impoundments, & other water-control devices (p)	Top draw structures (p) Poorly maintained ponds & other water control devices (p)
		Sedimentation in stream channel (s)	*See Section on Sediment*
Loss of Habitat	*Warm/ Coldwater Fishery *Other Indigenous Aquatic Life	Conversion of forested areas to developed land uses (s)	Increasing local population without sufficient land use regulations in local zoning ordinances to protect high priority land protection areas (s)
		Native habitat out competed by invasive species (s)	Availability and preference for invasive perennials at nursery and landscaping stores (s) Lack of awareness and/or concern (s) Lack of restrictions on boat travel (s) Lack of awareness and/or concern (s)

Environmental Stressor or Pollutant	Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Pathogens (*E. coli* and Fecal Coliform indicators)	*Total Body Contact	Animal Waste (p)	Poorly managed livestock operations adjacent to water bodies. (p)
		Septic Systems (p)	Poorly designed, sited, sized, maintained (p) High density/age of systems (p) Uninspected systems (p)
Toxins **(Pesticides, Herbicides, Oils, Gas, Grease, Microcystin, Etc.)**	*Warm/ Coldwater Fishery *Other Indigenous Aquatic Life *Fish Consumption	Contaminated groundwater (k)	Inadequate disposal facilities, illegal dumping (k)
		Runoff from developed areas (p)	Direct runoff of paved surfaces to surface water (roads, parking lots, driveways) (p) Infiltration to groundwater from improper storage and over use (p)
		Atmospheric Deposition (k)	Industrial emissions (k)
		Contaminated Sediments (k)	Inadequate disposal facilities, illegal dumping (k)
		Oil, Natural Gas, Hydrocarbon, & Underground Injection Wells (k)	Natural Gas Fracking operation (k), Inadequate Fracking fluid Storage (p) Abandoned Wells (leaking, uncapped) (p)
		Underground Storage Tanks (p)	Leaking tanks (p)

Environmental Stressor or Pollutant	Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Toxins **(Pesticides, Herbicides, Oils, Gas, Grease, Microcystin, Etc.)**	*Warm/ Coldwater Fishery *Other Indigenous Aquatic Life *Fish Consumption	Automobiles (p)	Oil, gas, and other leaks from cars, farm equipment, etc. (p)
		Motor Boats (s)	Inefficient (2cycle) or poorly maintained watercraft motors (s) Fuel spills (p)
		Abandoned Wells (leaking, uncapped) (p)	Improper disposal of chemicals (p) Poor adjacent land use (p)
		Improper Chemical Use & Disposal (s)	Lack of disposal facilities and/or limited hours of operation (s)
		Road Salt in Winter (k)	Runoff from roads (k)
		Liquid Brine Disposal (s)	Improper dust control management practices on roadways
Altered Hydrology	*Warm/ Coldwater Fishery *Other Indigenous Aquatic Life	Low-head dam construction (k)	Impounded section of North Branch of Platte River to allow lake level manipulation of Little Platte Lake (k)
		Stream channel alteration (p)	Sedimentation of stream channel from eroding banks (p)

The Comprehensive Watershed Protection Table (Table 23) may be used as a reference to distinguish what the major sources of pollutants and environmental stressors exist on a watershed-wide scale. However, it does not distinguish between pollutants and their sources and causes at specific locations. And, as stated earlier, not all of the pollutants listed are a problem everywhere in the watershed.

4.5 PRIORITY POLLUTANT RANKING

It is important to rank and prioritize pollutants and stressors in order to focus funding and implementation efforts. However this is a complex task due to the synergistic relationships of the pollutants and stressors, which creates greater impacts than any one pollutant or stressor does on its own. Thus it is important to recognize and address medium and low priority pollutants as well as high priority ones in order to help maintain the Platte River watershed's overall good water quality. Table 24 outlines the steering committees pollutant priorities for the watershed. Table 25 then ranks the pollutants and stressors in the Platte River Watershed.

Table 24: Pollutant Priorities for the Platte River Watershed

Pollutant	Priority in Watershed
Nutrients	High
Sediment	High
Invasive Species	High
Thermal Pollution	Medium
Loss of Habitat	Medium
Pathogens (*E. Coli*)	Low
Toxins (Pesticides/Herbicides, Oils, Gas, Grease, Salt/Chlorides, Copper Sulfate, Microcystin)	Low
Altered Hydrology	Low

The project steering committee determined that the specific sources for each pollutant and stressor are the most important items to rank and prioritize because that is where one can actually stop pollution from entering waterways (Table 24). Additionally, as noted above, because most of the pollutants and stressors are interconnected, dealing with one source and its causes could actually reduce a number of different pollutants and stressors from affecting water quality. This concept is discussed in more depth in Chapter 5.

Table 25: Pollutant Source Priority Ranking

Environmental Stressor or Pollutant	Sources: K = known, S = suspected, P = potential	Priority
Nutrients	Point Source Phosphorus loading from Platte River Hatchery	High
	Residential, Agricultural or Commercial Fertilizer Use (k)	High
	Point Source Phosphorus loading from Platte River Hatchery	High
	Septic Systems (s)	Medium
	Atmospheric Deposition (k)	Low
Sediment	Road Stream Crossings (k)	High
	Soil exposed to surface runoff (k)	High
	Residential and Road Construction (k)	High
	Runoff from developed areas (k)	Medium
	Bank/shoreline erosion (k)	Medium
	Forestry Practices (k)	Medium
	Agriculture (k)	Low
Invasive Species	Anthropomorphic introduction of Invasive Species from Boat Hulls, Personal Watercraft, Live Wells, Bilges, Trailers, wading shoes, etc. (k)	High
	Landscaping practices (k)	High

Environmental Stressor or Pollutant	Sources: K = known, S = suspected, P = potential	Priority
Thermal Pollution	Runoff from impervious surfaces (k)	Medium
	Lack of Streamside or Shoreline Canopy and Riparian Buffer (k)	Low
	Ponds, impoundments, (k)	Low
	Sedimentation in stream channels (s)	Low
Loss of Habitat	Conversion of forested areas to developed land uses (s)	High
	Native habitat out competed by invasive species (s)	High
	Conversion of forested areas to developed land uses (s)	Medium
Pathogens (*E. Coli* and Fecal Coliform indicators)	Animal Waste (s)	Low
	Septic Systems (s)	Low

Environmental Stressor or Pollutant	Sources: K = known, S = suspected, P = potential	Priority
Toxins **(Pesticides, Herbicides, Oils, Gas, Grease, Etc.)**	Contaminated Sediments (k)	High
	Improper chemical or wastewater disposal (k)	High
	Road Salt in Winter (k)	High
	Oil, Gas, Hydrocarbon,& Underground Injection Wells (p)	Medium
	Liquid Brine Disposal (s)	Medium
	Automobiles (k)	Low
	Motor Boats (k)	Low
	Atmospheric Deposition (k)	Low
Altered Hydrology	Low-head dams (k)	Low
	Stream channel alteration (s)	Low

4.6 POLLUTANTS AND ENVIRONMENTAL STRESSORS OF CONCERN

Nutrients

Nitrogen and phosphorus are critical nutrients for all types of plants, including aquatic species. In most of the Platte River watershed, phosphorus has been found to be the limiting factor associated with excessive algae growth. Phosphorus loading is the primary nutrient concern in the Platte River watershed, however nitrogen depletion in Little Platte Lake deserves further analysis. The total phosphorus concentration in Big Platte Lake varies with both time of year and depth. The Consent Agreement mandates that the volume-weighted total phosphorus concentration of Big Platte Lake be maintained below 8.0 mg/m^3 95% of the time.

The high concentration of marl (calcium carbonate) in the lake bottom and groundwater flowing into Big Platte Lake causes additional problems during high phosphorus levels. Prior to the implementation of phosphorus reduction strategies at the Platte River Hatchery, high phosphorus discharge into the Platte River caused major ‘whiting’ events in Big Platte Lake resulting from the calcium carbonate being precipitated out of the aqueous solution and floating in suspension. This dramatically reduced water clarity and made the lake much less desirable for swimming, fishing, or boating. Whiting events also caused a marked reduction in the deep water macrophytes which appeared on historical (prior to PRSFH production) Big and Little Platte Lake Plant surveys.

“Compliance with the Settlement Agreement has resulted in the Hatchery no longer being a significant nutrient source in the watershed. However, excessive loading is still occurring. Other sources of nutrient loading are residential and commercial fertilizer use, stormwater runoff (see Section 5.5 for a discussion on stormwater) and septic system effluent.

Fertilizers

Residential and agricultural fertilizer applications can be a significant source of nutrient input to the watershed. Since phosphorus is often the limiting nutrient in aquatic systems, phosphorus concentrations in fertilizers could have a dramatic impact on water quality in the Platte watershed due to the high groundwater flow and permeable soils.

Septic Systems

A septic system consists of two basic parts: a septic tank and a soil absorption field or drainfield. Wastes flow from the house into the septic tank where most solids are separated to the bottom and are partially decomposed by bacteria to form sludge. Some solids float and form a scum mat on top of the water. The liquid effluent from the septic tank, carrying disease-causing organisms and liquid waste products, is discharged into the soil absorption field. In the absorption field, the water is further purified by filtration and decomposition by microorganisms in the soil. The semi-purified wastewater then percolates to the groundwater system.

Another potential source of nutrient enrichment in the Platte River watershed is from failing septic systems. Septic systems are the most common method of treating wastewater from toilets, wash basins, bathtubs, washing machines, and other water-consumptive items in the Platte River Watershed. There is a small municipal sewer system located in the Village of Honor that also deserves further analysis to determine whether it is a significant source of phosphorus currently not accounted for in the mass balance assessment (Figure 26).

The Benzie-Leelanau District Health Department has rules for septic systems (Environmental Health Regulations, Chapter II). These rules require that “all flush toilets, lavatories, bathtubs, showers, laundry drains, sinks and any other similar fixtures or devices to be used to conduct or receive water carried sewage shall be connected to a septic tank of some other device in compliance with the minimum standards and the Michigan Department of Public Health regulations and finally disposed of in a manner in compliance with these minimum standards and the Michigan Department of Public Health regulations and any other applicable law, ordinance or regulation.” (Environmental Health Regulations, Chapter II) The rules require a percolation test and require specific setbacks of septic tanks and subsurface disposal system (or drainfield) from wells, property lines and water bodies.

The best way to prevent septic system failure is to ensure that the system is sited and sized properly and employs appropriate treatment technology and maintenance. Design requirements vary according to local site factors such as soil percolation rate, soil composition, grain size, and depth to water table.

The effectiveness of septic systems at removing pollutants from wastewater varies depending on the type of system used and the conditions at the site. Even a properly operating septic system can release more than 10 pounds of N per year to the groundwater for each person using it (Ohrel 2000). The average pollutant removal effectiveness for a conventional septic system is as follows: total suspended solids – 72%, biological oxygen demand – 45%, total nitrogen – 28%, and total phosphorus – 57% (USEPA 1993). This shows that even properly operating conventional septic systems have relatively low nutrient removal capability, and can be a cause of an increased nutrient loading into groundwater flows.

Typical Impacts from Excessive Nutrients

Impact #1: Increased weed and algae growth impact water recreation and navigation.

Impact #2: Decomposition of algae and weeds removes oxygen from lakes, harming aquatic life and reducing the recreational and commercial fishery.

Impact #3: Exotic plant species like Eurasian Watermilfoil and Purple Loosestrife proliferate under nutrient rich conditions, which increases their competitive advantage over native species

Impact #4: Some algae (i.e., blue-green algae) are toxic to animals and humans and may cause taste and odor problems in drinking water.

Impact #5: High nitrate levels in drinking water are a known human health risk.

Sediment

Sediment is comprised of fine organic soil or sand particles and sedimentation is the process whereby sediment is deposited into a stream or lake. Sediment, along with nutrients, is the number one threat to water quality in the Platte River watershed. Excessive sedimentation can severely degrade an entire aquatic ecosystem and has been identified as a major cause of degradation to aquatic life in many Michigan streams and rivers (DEQ 1998). Excessive sediment deposition in many of Michigan’s streams also severely impacts the amount of suitable habitat needed to support healthy and diverse communities of fish and fish food organisms. When sediment enters a stream it covers gravel, rocky, and woody habitat areas, thereby leading to decreases in habitat diversity and aquatic plant production. Sedimentation caused by streambank erosion may increase channel widening. Increased width and resulting shallower depth can increase the overall water temperature of a river. Because fish and aquatic insects are sensitive to habitat alteration, sedimentation results in degradation of their populations and diversity.

The most significant sediment source in the watershed is road/stream crossings. Stormwater runoff from improperly handled stormwater or poor land-use practices are other significant sources for the entire watershed. Unrestricted livestock wading in small stream systems has been found to cause significant bank erosion and sedimentation of channel substrate on some of the Platte River’s smaller unnamed groundwater tributaries. On the lower watershed below Big Platte Lake, excessive boat traffic and recreational usage contribute to excessive sedimentation of the stream channel.

Impervious surfaces (roads, rooftops and parking lots) create erosive storm water run-off forces that degrade water quality if allowed to directly enter surface water bodies. Properly infiltrating storm water run-off into groundwater flows through installation of retention basins, improving degraded road stream crossings and managing recreational traffic in the lower watershed will help prevent additional sedimentation of aquatic habitat.

Road and Stream Crossing for the Platte River Watershed

Specific road crossing sites that could be contributing to sedimentation in the Platte River watershed tributaries are delineated in the Platte River Watershed Road/Stream Crossing Inventory Report by the Grand Traverse Band of Ottawa and Chippewa Indians and Conservation Resource Alliance. This can be viewed online at www.northernmichiganstreams.org.

There are 8 road/stream crossings in the Platte River Watershed that are rated as severe. Due their potential contributions of sediment and nutrients, which are the top two pollutants, these sites have been identified above as Critical Areas. One of these sites was addressed with Best Management Practices in 2011 and repair of three additional sites are slated to be completed by 2014 (Table 26, Figure 32). The total cost for repair of all severe rated road and stream crossings in the Platte River Watershed is $1,535,000.

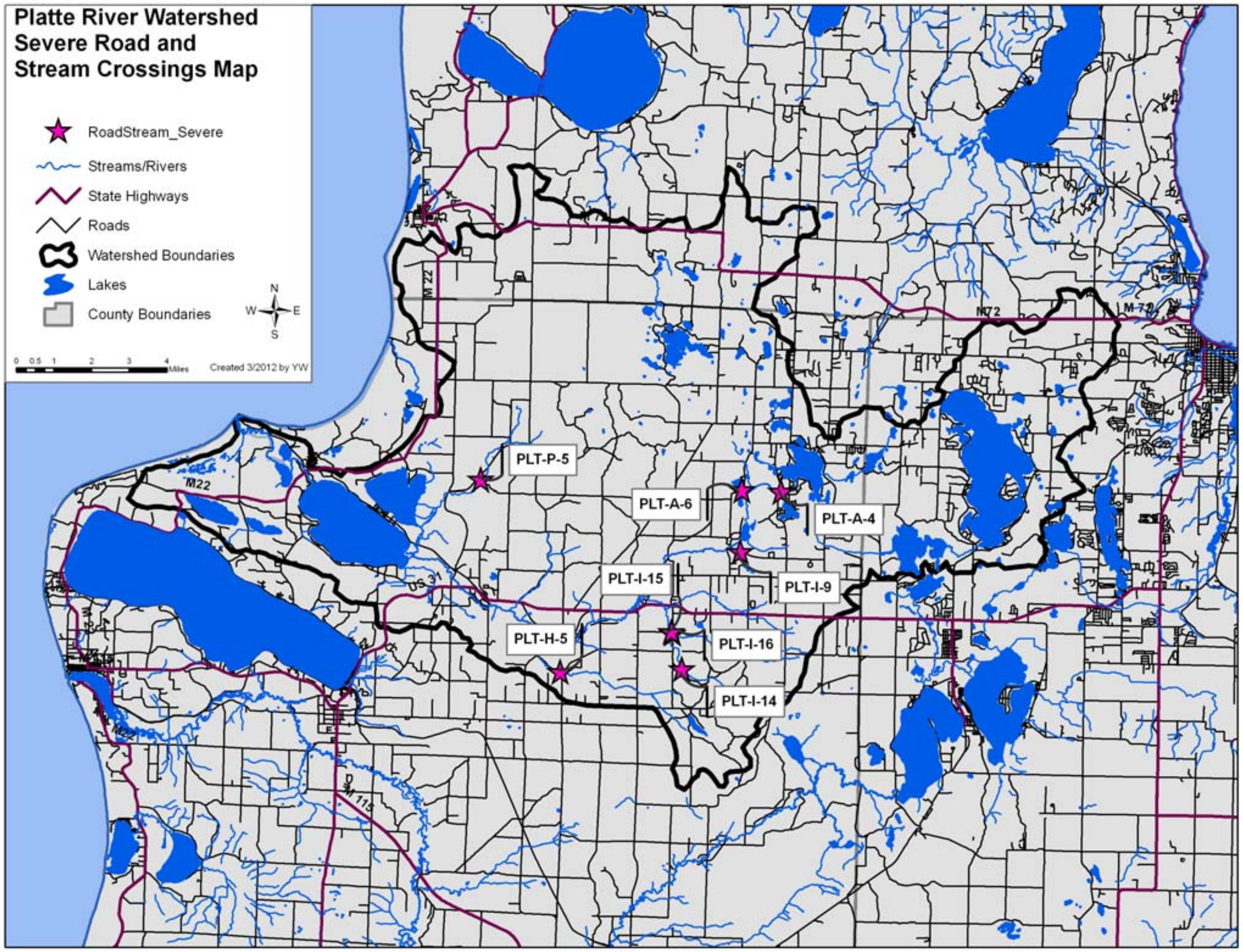
Table 26: Severe Road and Stream Crossings in the PRW and Moderate Crossings slated for modification

Site #	Rating	Road	Township	Stream	Ownership	Cost	Erosion Extent	Main Concern	Treatment	Year to Complete
PLT-A-6	Severe	Burnt Mill Road	Almira	Woodcock Tributary	State- (Adj public)	$120,000	Severe	Failing structure confining stream	Replace culvert, Vegetate	2011
PLT-H-5	Severe	North Weldon Road	Homestead	Carter Creek	State- (Adj public)	$225,000	Moderate	Both inlets obstructed with debris, undersized culverts failing and inhibiting fish passage	Replace culverts	
PLT-I-14	Severe	Two-track off N Carmean Road	Inland	Brundage Creek	Private (Adj state)	$0.00	Minor	Fish passage problem in culvert	Replace culvert, consider Dam removal	
PLT-I-15	Severe	N Carmean Road	Inland	Brundage Creek	Private (Adj state)	$160,000	Severe	Confined stream, perched	Replace culvert, Vegetate	2013-2014

Table 26: Severe Road and Stream Crossings in the PRW and Moderate Crossings slated for modification (Cont'd)

Site #	Rating	Road	Township	Stream	Ownership	Cost	Erosion Extent	Main Concern	Treatment	Year to Complete
PLT-I-16	Severe	Stanley Road	Inland	Brundage Creek	Private (Adj state)	$160,000	Severe	Concrete culvert failing due to age, stream is constricted	Replace culvert, Vegetate	2013-2014
PLT-I-9	Severe	Bronson Lake Road	Inland	Belt Lake Tributary	Private (Adj state)	$150,000	Severe	Undersized culvert, lack of vegetation and extreme slope causing embankment and shoulder erosion	Replace culvert, Vegetate, add stabilizing riprap at horse access	
PLT-P-5	Severe	Hooker Road	Platte	North Branch Platte River	State- (Adj public)	$220,000	Moderate	Undersized culvert, old and in poor condition	Replace culvert	

Figure 32: Severe Road and Stream Crossing Locations in the PRW



Typical Impacts from Sedimentation

Impact #1: Sedimentation of aquatic habitats reduces fish spawning, macroinvertebrate diversity, reduces habitat diversity, alters hydrology and navigation

Impact #2: Nutrients attached to sediment particles enter the water when suspended and increase phosphorus and nitrogen loads significant. Stormwater runoff currently contributes as much as 20% of the annual phosphorus load to the Platte River. The vast majority of the storm event phosphorus is transported on sediment particles.

Impact #3: Organically rich suspended sediments (silt) undergo aerobic respiration as they breakdown, which uses up dissolved oxygen. Excessive sedimentation with silt or other organic laden sediments can increase Biological Oxygen Demand due to the microbial decomposition, which in turn can cause in-stream dissolved oxygen concentrations to plummet below the levels required by fish and macroinvertebrates. These can lead to wide-spread fish kills and eliminate sensitive macroinvertebrate populations.

Impact #4: Excess sedimentation can impair navigation by making the water too shallow for boats and boat access.

Impact #5: Sediment accumulation decreases stream depth, and increases stream width, thereby causing the water temperature to rise.

Invasive and Nuisance Species

Invasive species (also called exotic or non-native species) have threatened the Great Lakes ever since Europeans settled in the region. Exotic species are organisms that are introduced into areas where they are not native. While many exotic species are introduced accidentally, others are intentionally released, often to enhance recreational opportunities such as sport fishing. The Pacific salmon, which was purposely stocked in the Great Lakes, is an exotic species, but not considered to be a “nuisance” species. Species are considered a nuisance when they disrupt native species populations and threaten the ecology of an ecosystem as well as causing damage to local industry and commerce. Without pressure from the competitors, parasites, and pathogens that normally keep their numbers in check, invasive species may undergo large population increases.

Stowing away on boat hulls and in bilges is the primary way many invasive species are introduced into the ecosystem. Other ways of introduction include landscaping practices and lack of awareness by homeowners of the threat (this is how purple loosestrife was introduced to Michigan) and hitching a ride on other biota like frogs and birds.

Invasive species are becoming problematic throughout many of Michigan’s inland lakes. Many of these species exhibit vast increases in numbers following their introduction, or following changes in the environment. Exotic species can affect the watershed in many ways. Zebra mussels and Eurasian watermilfoil influence the overall water quality and stability along with recreational use. Zebra mussels also alter the amount of available P by concentrating it on lake bottoms.

The most critical documented aquatic invasive species in the upper Platte River watershed are the zebra mussel and Eurasian Watermilfoil infestations in Long, Mickey and Ruth Lakes.

The Long Lake Association has an invasive species management policy, which is “to continue utilizing an integrated pest management program in order to minimize the impact of invasive species on the ecological health and recreational enjoyment of the lakes.” They have adopted this as the best means to safely and responsibly manage invasive species on the lakes, since the long term effects of chemicals on both the ecology and human health are highly debated. They will continue to closely monitor all conditions with the understanding that with most invasive species of plants and animals, complete eradication is unlikely (LLA website 2011).

In the late summer of 2010, the five currently known stands of Eurasian watermilfoil on Long, Mickey and Ruth Lakes were treated professionally by Savin Lake Services in a partnership with land owners and the Long Lake Association.

Invasive Plant Work

In recent years, invasive plants have received more and more attention as their adverse effects on natural ecosystems becomes better understood. Within the Platte River Watershed, invasive plants can be found in aquatic, wetland, and terrestrial habitats. Some species have been present for many years and are well established, while others are recently arrived and less common. The terrestrial species of primary concern have been garlic mustard, baby's breath, autumn olive, buckthorn, Canada thistle, bull thistle, kudzu, Japanese knotweed, giant knotweed, and oriental bittersweet. The latter four species are early detection/rapid response (ED/RR) priorities because of their recent introduction and destructive potential. Wetland species of primary concern are phragmites, narrow-leaved cattail, and purple loosestrife. The first two species are present in a relatively few high-density infestations in the watershed and are ED/RR priorities. Eurasian water-milfoil is the most common aquatic species, and is present in several lakes in the watershed.

Monitoring and control of invasive plants in the Platte River watershed is done by several different groups. First, many private landowners have become aware of the more common invasive species such as garlic mustard or phragmites, address the problem on their own properties. The Grand Traverse Regional Invasive Species Network (GTR-ISN) is a coalition of partner organizations coordinated by the Grand Traverse Conservation District that covers five counties, including all of the Platte River Watershed. The group has 23 partner organizations and focuses on invasive plant education, monitoring, and treatment. The Northwest Michigan Cooperative Weed Management Area (NM CWMA) is another coalition group covering Manistee, Benzie, and Leelanau Counties. This group has a full-time coordinator who divides time between the three counties and all partner organizations. Sleeping Bear Dunes National Lakeshore has staff that does invasive plant control on park property within the watershed. The Grand Traverse Regional Land Conservancy also treats invasive species found within their preserves in the watershed. The Benzie Conservation District has begun treating invasive plants in Benzie County, where most of the Platte River watershed is found. The Benzie CD participates in both the GTR-ISN and NMCWMA and has treated mostly phragmites and garlic mustard. In addition, some lake and property associations treat invasive plants within their areas of influence.

The treatment and control of invasive plants is dependent on available funding, expertise, and awareness. It is nearly impossible to eradicate a species once it is established, so priorities must be set in control efforts based on the probability of success and the value of the ecosystem being invaded. ED/RR species such as Japanese knotweed, giant knotweed, kudzu, oriental bittersweet, phragmites, and narrow-leaved cattail should be treated as soon as possible after they are detected in order to minimize the cost of control and maximize the potential for successful treatment. Of the species that are more common, it is best to treat them as soon as possible after they invade a new area. The GTR-ISN is funding control for kudzu, oriental bittersweet, and both knotweed species as the infestations become known. There have been efforts in the past three years to locate and treat infestations of phragmites and garlic mustard, which are relatively common, yet have not taken over as they have in other parts of the state. Most of the groups mentioned above have done garlic mustard control. In 2011, the NM CWMA funded phragmites treatments at three sites in the watershed. The Long Lake Association has been treating Eurasian water-milfoil for more than three years. Future infestations of invasive plants will be inventoried, prioritized, and treated as they are discovered according to availability of resources.

Typical Impacts from Invasive Species

Impact #1: Invasive species often have no natural predators and can out-compete native species for food and habitat.

Impact #2: Introduction of a single key species can cause a sudden and dramatic shift in the entire ecosystem's structure. New species can significantly change the interactions between existing species, creating ecosystems that are unstable and unpredictable. (Example: Established populations of zebra mussels can promote toxic blue-green algal blooms.)

Impact #3: In some instances invasive species can interfere with recreation in the watershed For example, rows of zebra mussel shells washed up on shore can cut beach walkers' feet, and Eurasian watermilfoil can get tangled up in boat propellers.

Thermal Pollution

The upper Platte River watershed has naturally occurring thermal warming caused by a large number of warmwater lake outflows to the river system and relative lack of groundwater input compared to lower in the watershed. Thermal pollution is not likely a significant environmental stressor to the watershed above Fewins Road. The watershed below Fewins Road receives an increasing amount of groundwater input and becomes a coldwater system. Thermal pollution increases the temperature of a body of water, and even small increases in temperature can dramatically alter natural processes. Water's ability to hold dissolved oxygen decreases as temperature increases; thereby reducing the available amount of oxygen in the water to fish and other aquatic life. Temperature also influences the rate of physical and physiological reactions such as enzyme activity, mobility of gases, diffusion, and osmosis in aquatic organisms. For most fish, body temperature will be almost precisely the temperature of the water. Fish will seek water that is in their preferred temperature ranges so as to avoid stress from elevated water temperature. If unable to avoid the higher temperatures a fish's body temperature increases, and this then changes its metabolic rate and other physical or chemical processes as well. When thermal stress occurs, fish cannot efficiently meet their energetic demands (Diana 1995). Optimal water temperatures for trout are in the 60^{o}F range (15-20^{o}C) or below. Lethal maximum temperatures vary with different trout species, but temperatures above 76^{o}F (24.4^{o}C) can be lethal.

Other sources of thermal pollution in the Platte River watershed are heated stormwater runoff from paved surfaces, the removal of shade vegetation along streambanks and shorelines, and undersized culverts at road stream crossings that create warm pools of retained water upstream, coupled with low flows and shallow pool depth below. Excessive inputs of sediment into streams and lakes may also contribute to thermal pollution. Sediment inputs can fill stream pools and lakes, making them shallower and wider and, consequently, more susceptible to warming from solar radiation.

Changes in climate due to global activities also may increase thermal pollution in a watershed. Average global surface temperatures are projected to increase by 1.5^{o}C to 5.8^{o}C by the year 2100 (Houghton et al. 2001). Increases in surface temperatures may increase stream water temperatures as well, although impacts will vary by region. Overall, increases in stream water temperature will negatively affect cold-water aquatic species. For example, cold-water fish, such as trout and salmon, are projected to disappear from large portions of their current geographic range in the continental United States due to an increased warming of surface waters (Poff et al. 2002). *T*hough actions to address climate change itself are beyond the scope of the plan, projects may be implemented that would mitigate some of the impacts (e.g. tree/shrub planting along riparian corridors to increase the leaf canopy over the stream; infrastructure sized to accommodate larger storms; etc.).

Typical Impacts from Thermal Pollution

Impact #1: Surges of heated water during rainstorms can shock and stress aquatic life, which have adapted to cold water environments. Aquatic diversity is ultimately reduced. Constant heating of rivers and lakes ultimately changes the biological character and thus the fishery value.

Impact #2: Thermal pollution decreases the amount of oxygen available to organisms in the water, potential suffocating them.

Impact #3: Warm water increases the metabolism of toxins in aquatic animals.

Impact #4: Algae and weeds thrive in warmer waters.

Impact #5: Human made impoundments increase stream temperatures creating lethal conditions for cold water species such as brook trout.

Loss of Habitat

The population of Benzie, Leelanau and Grand Traverse Counties increased by 10% from 2000 to 2010 (U.S. Census). As the population grows throughout the currently rural watershed, the increasing residential and road development fragments the large forested parcels and impedes wildlife movement. Areas of higher quality habitat become smaller and in smaller isolated pockets of remnant habitat, many of the important natural process such as seed dispersal and movement of large mammals are lost. The remaining populations become more vulnerable to disease as well and the impact of increasing nearby human development. Fortunately large portions of the Platte River watershed are already protected under State Forest or National Lakeshore management. Specifically, the vast majority of regulated wetlands are found on public lands within the Platte River Watershed that provide important habitat and water quality protection. Proper land-use practices on the private land across the watershed can help focus future residential growth near existing villages and population centers to prevent hap-hazard development of high quality forested habitat into large residential lots with no nearby community infrastructure.

Typical Impacts from Habitat Loss

Impact #1: Extinction and extirpation of native species.

Impact # 2: Habitat fragmentation, increase of edge effect

Impact #3: Loss of overall biological community stability and function.

Impact #4: Reduction of the scenic magnitude of the Platte River Watershed which is the heart of the region's attraction and draw for over a million annual tourists and residents.

Pathogens

Pathogens are organisms that cause disease and include a variety of bacteria, viruses, protozoa and small worms. These pathogens can be present in water and may pose a hazard to human health. The US Environmental Protection Agency (EPA) recommends that freshwater recreational water quality be measured by the presence of *Escherichia coli* (*E. coli*) or by the presence of a group of bacteria called *Enterococci*. Michigan has adopted the EPA's *E. coli* water quality standards. *E. coli* is a common intestinal organism, so the presence of *E. coli* in water indicates that fecal pollution has occurred. However, the kinds of *E. coli* measured in recreational water do not generally cause disease; rather, they are an indicator for the potential presence of other disease causing pathogens. EPA studies indicate that when the numbers of *E. coli* in fresh water exceed water quality standards, swimmers are at increased risk of developing gastroenteritis (stomach upsets) from pathogens carried in fecal material. The presence of *E. coli* in water does not indicate what kinds of pathogens may be present, if any. If more than 130 *E. coli* are present in 100mL of water in 5 samples over 30 days, or if more than 300 *E. coli* per 100mL of water are present in a single sample, the water is considered unsafe for swimming.

Fecal pollution entering the Platte River watershed may come from stormwater runoff, animals on the land or in the water, illegal sewage discharge from boats, or defective septic systems. Different sources of fecal pollution may carry different pathogens. Peak *E. coli* concentrations often occur during high flow periods when floodwater is washing away possible contaminants along streambanks and shorelines from waterfowl like ducks and geese.

Typical Impacts from Pathogens

Impact #1: High levels of pathogens in the water pose a threat to human health and reduce the recreational value of a waterbody, thereby degrading use and enjoyment of the watershed.

Toxins

Toxic substances such as pesticides, herbicides, oils, gas, grease, salt, and metals often enter waterways unnoticed via stormwater runoff. These types of toxins are perhaps the most threatening of all the watershed pollutants because of their potential to affect human and aquatic health. Every time it rains, these toxic pollutants are washed from the roads, parking lots, driveways, and lawns into the nearest storm drain or road ditch, eventually reaching nearby lakes and streams. Additionally, farms, businesses, and homes throughout the watershed are potential sites of groundwater contamination from improperly disposed and stored pesticides, solvents, oils, and chemicals. Stormwater runoff from impervious surfaces can also carry oils directly into surface waters or wash them into groundwater recharge basins.

Traditionally, toxic substances such as mercury and other heavy metals have been regarded as the most serious due to their human health impacts. As fossil fuels burn, chemicals are released into the atmosphere. When rain falls through the clouds, it carries these suspended chemicals to the surface water, via runoff that eventually flows into receiving lakes and streams. In addition to transporting airborne pollutants, surface runoff can also leach these toxic compounds that have accumulated in soil or on impervious surfaces, such as roads, into streams and lakes. The toxins bioaccumulate through the food web, and therefore the oldest higher vertebrates, in this case fish, contain the greatest concentrations. The Michigan Department of Health has issued a consumption warning for fish in Big Platte Lake, in the vicinity of Honor to protect human health as a result of high chlordane, mercury and PCB (polychlorinated biphenyl) concentrations.

In addition to the substances noted above, another potentially toxic substances in the Platte River watershed is sodium chloride. Sodium chloride enters the watershed primarily as a result of road salt application in the winter and subsequent runoff in the winter and spring. Higher levels of sodium chloride in streams and lakes can impair fish and macroinvertebrate communities.

Typical Impacts from Toxins

Impact #1: *Toxic chemicals entering waterbodies harm stream life, potentially causing entire reaches of a stream to be killed off if the concentrations of contaminants are high enough. Additionally, reproductive processes may be harmed.*

Impact #2: *Persistent toxic pollution in a stream may put human health and recreation at risk. Serious human health risks may include liver failure, kidney disease, and cancer.*

Impact #3: *Contaminated groundwater may pose a problem for homes and businesses throughout the watershed that rely upon groundwater wells for their drinking water. This poses a risk to human health and often requires difficult and costly cleanup measures.*

Altered Hydrology

The two major natural hydrologic functions that help drive the Platte River watershed are groundwater infiltration and discharge. As water flows out of the ground and coalesces into stream channels it carves the path of least resistance. When natural hydrologic flow patterns are altered for transportation infrastructure, large-scale water withdrawals or to create artificial lake levels, the entire hydrologic process becomes compromised. Natural sediment transport regimens become interrupted and aquatic habitat is quickly compromised. One of the main issues in the Platte watershed potentially impacting water quality is low-head dam construction, such as on Deadstream (North Branch of the Platte River below Little Platte Lake). The low-head system blocks sediment transport along the stream bottom and creates a massive back-up and accumulation of very fine sands and organic silt above the dam structure. The most common altered hydrologic condition throughout the watershed is found in the myriad of un-named groundwater tributary streams that are have been compromised by the installation of undersized culverts that creates a 'choke-point' for as well as creating biologically unsuitable current forces that can fragment stream segments. The undersized structures are also prone to creating 'perched' conditions, where the downstream end of the tube is actually perched above the receiving stream channel creating an impassable waterfall.

There was not a dam inventory available at the time of this watershed plan's creation.

Typical Impacts from Altered Hydrology

Impact #1: Compromised sediment transport system above low-head dams or undersized culverts.

Impact #2: Biologically intolerable current forces from undersized culverts.

Impact #3: Undersized culverts can promote a 'perched' condition and further fragment the stream channel

4.7 PRIORITY AND CRITICAL AREAS

Although watershed management plans address the entire watershed, there are certain areas within the Platte River watershed that warrant more extensive management or specific protection consideration. Areas that are most sensitive to impacts from pollutants are considered **Priority Areas.** Areas that require focused monitoring, restoration, remediation and/or rehabilitation are considered **Critical Areas**.

Priority Areas

Priority areas in the Platte River watershed are defined as the geographic portions of the watershed that are most sensitive to impacts from pollutants and environmental stressors. The prescribed goals, objectives and tasks for these areas typically focus on preservation and protection. The priority areas were identified by analyzing the sources, causes, and prioritization of watershed pollutants (Tables 22-23). Other resources used to identify the Priority areas include; scientific research reports, the Michigan Natural Features Inventory, water quality monitoring reports, and assessment by scientific consultants to the Platte River Watershed Steering Committee.

The priority areas for the Platte River watershed cover roughly 49% of the watershed and are divided three different tiers of protection priorities that cover three geographic portions of the watershed. These tiers and areas are described below and shown in (Figure 33):

Priority Area Descriptions –

Area 1- This area focuses on the lower watershed below Big Platte Lake and includes the wetlands, riparian corridors, and critical dune habitat around Sleeping Bear Dunes National Lake shore and the mouth of the Platte River entering Lake Michigan.

Area 2- This area focuses on the main branch of the Platte River and tributaries streams below Fewins Road. This area includes the majority of the critical areas within the watershed and also contains the majority of the coldwater fishery habitat for the watershed.

Area 3- This area includes the riparian wetland corridors along the upper Platte River above Fewins Road and includes Lake Ann. This area also contains several isolated kettle lakes with wetland complexes and significant amounts of forested land-use that maintains groundwater recharge.

Tier 1:

- Habitat for or areas with threatened, endangered or species of special concern
- Existing public or protected land within the SBDNL, State, Conservancies and or natural areas and preserves
- Deadstream Swamp around the east end of Big Platte lake and along the North Branch of the Platte River.
- High Risk Erosion Areas

Tier 2:

- Surface water bodies (lakes/streams), shorelines, wetlands and land within 500' of them.
- High Priority Land Protection areas
- Ground water recharge areas

Tier 3:

- Steep Slopes
- Wildlife Corridors

Given there is habitat for rare, endangered and/or threatened species in the Platte River Watershed (Section 2.7), the first priority area (Tier 1) focuses efforts where these species may occur as well as within the national lakeshore, state land and other protected land. Since these areas tend to have high quality habitats and include important wetlands and shoreline, continuing to protect these ecological values will contribute to the overall watershed health. Tier 1 also includes the Deadstream swamp wetland complex. This diverse wetland contains superb ecological examples of quaking bog, rich conifer swamp, poor conifer swamp, and emergent and submergent wetland communities.

Tier 2 Prioritizes the protection of all undeveloped land within 500 feet of all streams, bodies of water and wetlands in the designated priority areas. In addition, conservation planning by regional land conservancies has identified large, priority parcels tied to water quality by analyzing multiple datasets. The resulting set of mostly privately owned parcels is prioritized for voluntary permanent land protection options due to their water quality protection and wildlife corridor functions. Groundwater recharge areas are critical to groundwater driven systems such as the Platte. Groundwater recharged and discharge areas as defined by the most acceptable groundwater mapping technology available should be prioritized for protection. Keeping these areas in a natural state facilitates natural groundwater flow and promotes high water quality.

Tier 3 includes wildlife corridors and steep slopes. While there are not a lot of steep slopes in this watershed, it is important to control erosion and protect streams and water bodies with significant buffers for wildlife and water quality. It is a priority in the Platte River Watershed to implement best management practices that will protect the water bodies from increased sediment. It is also a priority to protect wildlife habitat and ecological diversity by connecting natural lands and promoting best management practices for wildlife enhancement.

Critical Areas

Critical Areas are specific sections of the watershed that are suspected to contribute a significant amount of pollutants or have been documented as impacted by stressors or pollutants and require restoration to achieve designated or desired uses. Critical Area designation indicates that implementation of identified tasks will be needed to achieve load reductions identified in the plan (Figure 32). The critical areas for the Platte River watershed include the following areas:

i. Un-named creek in Benzonia Township, Lat 44.6750, Long -86.0649, Benzie County identified on the 303d list of impaired waters

ii. North Branch of the Platte River
iii. Severely degraded road/stream crossings
iv. Village of Honor Storm water system
v. Un-identified Platte River nutrient source below Hatchery (Collision Creek) and above Indian Hill Bridge
vi. Liquid Brine Disposal Site

Descriptions of Critical Areas-

Un-named creek in Benzonia Township, Lat 44.6750, Long -86.0649, Benzie County identified on the 303d list of impaired waters

The Michigan Department of Environmental Quality Water Resources Division assessed the condition of an unnamed tributary to Big Platte Lake in its January 2011 Staff Report. In 2003 staff from the MDEQ SWAS and Cadillac District Office conducted a chemical and biological survey of this unnamed creek in response to a complaint of strong odors and changed stream color. It was determined that the westernmost branch of this groundwater-fed stream was being impacted by contaminated groundwater venting from an illicit fruit waste disposal to an up gradient gravel pit. Macroinvertebrate and habitat conditions were determined to be degraded in comparison to other nearby streams and were not meeting Michigan's Water Quality Standards. Chemical analysis showed elevated conductivity, total phosphorus and metals concentrations, biological oxygen demand, and total organic carbon.

In 2008 SWAS found the stream to be in the same condition as the 2003 analysis, despite remediation of the disposal pit. The biological oxygen demand was found to be 30X great than expected for a groundwater-fed stream of similar size. Additionally, a thick layer of ferric iron bacterial slime was still evident on most of the substrate. Macroinvertebrate populations were also found to be dominated by tolerate organisms with very poor community scores still prevailing.

North Branch of the Platte River

The North Branch of the Platte River has been repeatedly found to carry significantly more phosphorus into the main branch of the Platte River compared to what the land-use phosphorus loading model predictions indicate. The source of the additional phosphorus is unknown. Identifying and mitigating this additional nutrient source is a critical area of concern for the Platte River's overall water quality. Since the Honor wastewater treatment facility drains into the North Branch of the Platte River drainage basin, this critical area deserves additional monitoring and groundwater flow research to determine the extent that wastewater effluent could be influencing North Branch of the Platte River phosphorus concentrations.

Severely degraded road/stream crossings

Severely degraded road/stream crossings are the most significant source excessive sedimentation to the Platte River and its tributaries. The two primary impacts of increased sedimentation in the Platte River watershed are degraded in stream habitat and increased nutrient loading from soluble nutrients within eroded soils.

Village of Honor Stormwater system

The Village of Honor storm water system is the main collection and distribution system for surface water discharge in the watershed, thus has a significant potential to impact overall water quality. Surface water run-off is not infiltrated and filtered through permeable soils, thus it carries excessive sediment, nutrients and potential toxins directly into tributary streams and the Platte River itself. Implementing Best Management Practices for the stormwater system such as properly sized infiltration basins and use of oil/grit separators will be important to reducing impacts from stormwater run-off.

Un-identified Platte River nutrient source below the Hatchery (Collision Creek) and above Indian Hill Bridge

The Platte Lake Improvement Association has collected extensive data for flow and total phosphorus concentrations at various locations in the Platte River. These data have been used to construct annual average phosphorus mass balances for the River for several years as discussed above. In particular, the mass balance calculation can be used to estimate the magnitude of various phosphorus sources along the river between Fewins Road and Big Platte Lake. A typical mass balance for 2009 is shown in Figure 26. These results (and those for other years) show that about 2,500 pounds of phosphorus enter the River between Fewins Road and the USGS gauging station located just downstream from the Village of Honor. About half of these 2,500 pounds can be accounted for from known and measured sources. These known sources are Brundage Creek, the Hatchery discharge, Carter Creek, Collision Creek, and uncontaminated ground water.

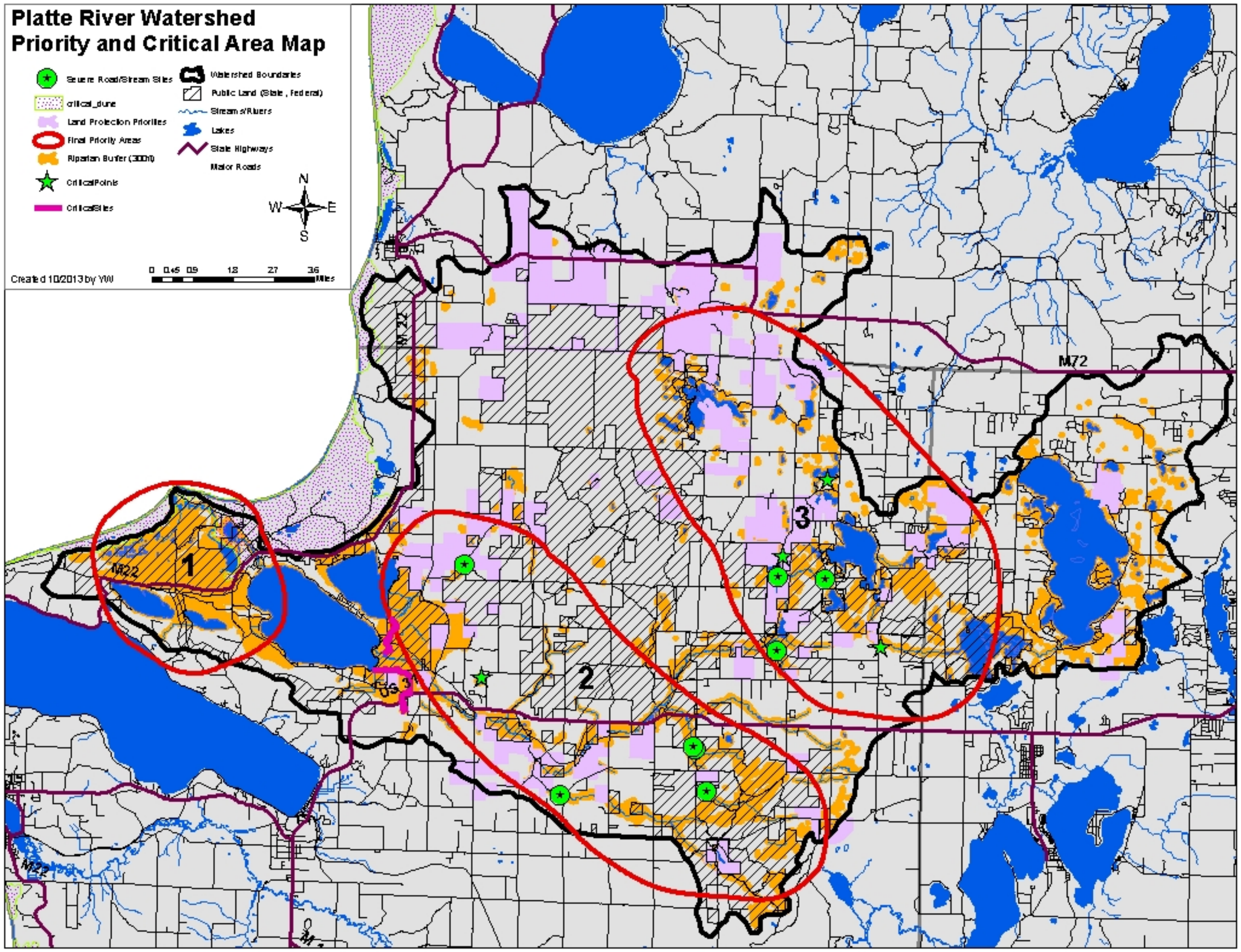
The wastewater treatment facility for the Village of Honor is located within this section of the River. This facility discharges into the groundwater, and may be a factor regarding the missing source of phosphorus. However available data to resolve this issue are inconclusive. Furthermore, there have been documented cases, such as the unnamed tributary to Big Platte Lake, where contaminated groundwater broke through the soil surface resulting in large environmental impact on streams.

The PLIA has proposed additional groundwater sampling near the Honor wastewater treatment site to resolve this issue. This effort would quantify the direction of groundwater flow, laboratory test adsorptive capacity of the local soils, construct new testing wells, and increase the temporal frequency of sampling of phosphorus and other variables such as ammonia, nitrate, chloride, and conductivity.

Liquid Brine Disposal Site

In July of 2013, it was reported that oil field brine laced with toxic petroleum byproducts was sprayed on some Benzie County roads. Tests later confirmed this. According to a post on Ban Michigan Fracking: The County Road Commission took two samples: One sample was taken from Hulbert and Fogg Roads, the other from Douglas and Fewins Roads. (http://banmichiganfracking.org/?p=1659#sthash.w17tLqUW.dpuf). The brine spill was the result of an application contracted by the Benzie County Road Commission as a means to control dust on dirt roads. The spray was reported by residents who complained about the spray's odor. The residents have also stated concerns about the potential for the chemicals to migrate to nearby drinking water wells and the nearby Platte River. Tests indicated the presence of toxins, and the DEQ is investigating. According to the Traverse City Record Eagle article (9/14/2013) oil field brine is a byproduct of oil and gas drilling used for dust control in about a dozen counties in Michigan that are permitted by the Michigan Department of Environmental Quality. According to the Benzie Road Commission manager agency officials take random samples each year for testing as part of their quality assurance program. All samples came back within acceptable tolerances, except for recent loads applied by Kalkaska-based TEAM Services LLC on roads around Douglas Road. Those tests showed several of the components were above DEQ-set tolerance levels for toxins. Those components included benzene, a known carcinogen, and toluene, a toxic industrial solvent. The Road Commission turned test results over to the DEQ. DEQ's Office of Oil, Gas and Minerals stated it will conduct a thorough investigation. Since this occurred near a wetland complex in the Platte River Watershed it will be important to monitor this area and work with the Benzie County Road Commission to conduct more thorough testing of dust control techniques in the future.

Figure 33: Priority and Critical Areas in the Platte River Watershed



4.8 CONSERVATION EASEMENTS

One of the main goals of the Platte River Watershed Protection Plan is to prevent increases in nutrient and sediment loading to the Platte River and other water bodies. The pollutant loading models discussed in Section 5.2 below are grounded in the fact that natural land uses such as forest and wetlands produce far less total nutrient and sediment loading than residential or other developed land uses. Permanent conservation easements are an important tool available to private landowners who wish to voluntarily prevent conversion of their natural lands. A conservation easement is a voluntary legal agreement between a landowner and a land trust that permanently limits a property's development potential while protecting its conservation values.

The Grand Traverse Regional Land Conservancy (GTRLC) is a small non-profit accredited land trust serving five counties including Benzie and Grand Traverse**.** The Leelanau Conservancy is a small accredited land trust serving the Leelanau County portion of the Platte River watershed. The Conservancies work with interested landowners to establish permanent voluntary conservation easements on ecologically important land.

How Conservation Easements Work

When an entity owns land, it also "owns" many rights associated with it. These property rights include the right to harvest timber, build structures, divide the property, engage in agriculture, lease mineral rights and so on (subject to zoning or other land use restrictions). Conservation easements permanently restrict or eliminate the property rights that could degrade the documented conservation values associated with the property. These perpetual restrictions run with the land and all future owners are bound by a conservation easement's terms.

Key Advantages of Conservation Easements

- Leave the property in private ownership, and owners may continue to live on it, sell it, lease it or pass it on to heirs
- They are flexible and can be written to meet the particular needs of the landowner while protecting the property's conservation values
- They are permanent, remaining in force when the land changes hands

Conservation easements can be used to protect a wide variety of land including farms, forests, wildlife habitat, and properties with scenic views. They are drafted in a detailed legal format that spells out the rights and restrictions on the owner's uses of the property as well as the rights and responsibilities of the land conservancy.

Both conservancies work with interested landowners to determine if their land qualifies for permanent protection and help them determine the most appropriate conservation easement terms to protect the documented conservation values. Every conservation easement is a unique and customized to meet the desired uses of the landowner, provided these uses will not degrade the conservation values. Generally, limitations are made on the number and location of structures and types of land use activities that can take place. For more information on conservation easements in Grand Traverse and Benzie Counties, contact the Grand Traverse Regional Land Conservancy: www.gtrlc.org or by calling 231-929-7911 or 888-929-3866. For more information on conservation easements in Leelanau County, contact the Leelanau Conservancy: www.leelanauconservancy.org or by calling 231-256-9665.

CHAPTER 5: BEST MANAGEMENT PRACTICES

5.1 TYPES OF BEST MANAGEMENT PRACTICES (BMP'S) AND SOURCES

Best Management Practices (BMPs) are any structural, vegetative, or managerial practices used to protect and improve surface water and groundwater (MDEQ 2001). Each treatment site must be evaluated independently, and specific BMPs can be selected to best protect site conditions.

Structural BMPs are physical systems that are constructed for pollutant removal and/or reduction. This can include rip-rap along a stream bank, rock check dams along a steep roadway or biodetention basins, oil/grit separators, and porous asphalt for stormwater control.

Non-structural BMPs include managerial, educational, and vegetative practices designed to prevent or reduce pollutants from entering a watershed. These BMPs include riparian buffers and filter strips, but also include education, land use planning, natural resource protection, regulations, operation and maintenance, or any other initiative that does not involve designing and building a physical structure. Non-structural BMPs focus on source control treatments which usually are more cost effective than restoration efforts after degradation has occurred (Like the common saying, "An ounce of prevention is worth a pound of cure"). Individual non-structural BMPs often address multiple pollutants or stressors simultaneously. Establishing a perpetual conservation easement over a priority area will prevent a number of different pollutants (sediment, nutrients, toxins, etc.) from entering the watershed.

Table 27 identifies possible BMPs to address common sources and causes of pollutants or stressors in the Platte River watershed as well as where to find more information about each type of BMP. The table also notes if a potential load reduction estimate is available for a specific BMP.

Table 27: BMP Examples by Pollutant Source

Major Source or Cause	Affected Pollutant	Potential Actions to Address Pollution Source/Cause	Potential Load Reduction	Information Source
Bank/Shoreline Erosion	Sediment Habitat Loss	Stream bank stabilization: bank slope reduction, riprap, tree revetments, vegetative plantings, bank terracing, etc.	Varies *(see milestones in Chapter 8)*	-Conservation Resource Alliance (CRA) -Guidebook of BMPs for Michigan Watersheds -MI Low Impact Development Manual -Green Infrastructure Manual -Michigan Ag BMP Manual
Stormwater and Impervious Surfaces	Sediment Nutrients Toxins Pathogens	-Develop stormwater management plans, d other applications such as the Platte Lakes Area Management Plan overlay district - Also See Table 28	See Tables 28 & 29	-The Watershed Center's Stormwater Management Guidebook -Guidebook of BMPs for Michigan Watersheds -MI Low Impact Development Manual -Green Infrastructure Manual -Center for Watershed Protection – Storm center website
Road Crossings - eroding, failing, outdated	Sediment Nutrients	-Road Crossing BMPs (vary widely – See Road Stream Crossings)	Varies *(see milestones in Chapter 8)*	-Guidebook of BMPs for Michigan Watersheds -MI Low Impact Development Manual -Green Infrastructure Manual

Table 27: BMP Examples by Pollutant Source (Cont'd)

Major Source or Cause	Affected Pollutant	Potential Actions to Address Pollution Source/Cause	Potential Load Reduction	Information Source
Road Crossings - eroding, failing, outdated	Sediment Nutrients	-Road Crossing BMPs (vary widely – See Road Stream Crossings)	Varies *(see milestones in Chapter 8)*	-Guidebook of BMPs for Michigan Watersheds -MI Low Impact Development Manual -Green Infrastructure Manual
Septic Systems (Leaking)	Nutrients Pathogens	-Conduct education on proper septic system maintenance including workshops, brochures, flyers, videos, etc -Septic system inspections -Ensure proper septic system design -Demo projects for alternative wastewater treatment systems -Chemical treatment of septic systems to reduce nutrient loading	Varies/ Not available	-Leelanau/Benzie Health Department -Public Information and Education Strategy (Chapter 9)
Development and Construction	Sediment Habitat Loss	-Implement soil erosion control measures -Utilize proper construction BMPs like barriers, staging and scheduling, access roads, and grading) -Establishing perpetual conservation easements with voluntary landowners in priority areas	Varies/ Not available	-MI Low Impact Development Manual -Green Infrastructure Manual -Public Information and Education Strategy (Chapter 9)

Table 27: BMP Examples by Source Cont'd

Major Source or Cause	Affected Pollutant	Potential Actions to Address Pollution Source/Cause	Potential Load Reduction	BMP Manual or Agency Contact*
Purposeful or Accidental Introduction of Invasive Species	Invasive Species	-Boat washing stations -Workshops, Brochures, Flyers, Videos, Etc. - Educational Programs	Not available	-Benzie Conservation District -Public Information and Education Strategy (Chapter 9)

* Green Infrastructure Manual: www.newdesignsforgrowth.com --> NDFG Programs; MI Low Impact Development Manual --> www.semcog.org/lowimpactdevelopmentreference.aspx; Natural Resources Protection Strategy for Michigan Golf Courses --> www.michigan.gov/documents/deq/ess-nps-golf-course-manual_209682_7.pdf

5.2 POLLUTANT LOAD REDUCTIONS

POLLUTANT LOADING FOR TOTAL PHOSPHORUS:

Upper Watershed Loading Model

The upper watershed phosphorus loading model is based on the acreage of various land uses in the upper watershed and their corresponding annual average export coefficients. The model uses eight land-use categories and export coefficients identical to those used in the BASINS model that was previously developed and validated for the lower watershed. The acreage of each land use and corresponding export coefficient is shown in Table 28. The current values for 2010 were obtained from the 2000 Land Use Land Cover layer using Geographic Information System (GIS) technology and the current National Wetlands Inventory for the Platte River Watershed area (2010). A spreadsheet model associated with this report is available that can be used to calculate changes in the upper watershed non-point phosphorus loading as the acres of land use in each category are changed in subsequent years to allow analysis of various growth scenarios.

The annual average phosphorus export coefficients are also called Unit Area Loads (UAL) and are in units of pounds of phosphorus per acre per year. The values in the model for the upper watershed are identical to the values in the Lower watershed. The export coefficients were determined by calibration of the BASINS model using extensive baseline River and tributary data as well as data from over 100 storm events. These data are available in the PLIA/MDNR ACCESS database and have been published in two peer-reviewed journal articles.

Not all the phosphorus that is generated in the upper watershed reaches the lower watershed. Some of the phosphorus is retained in various lakes and impoundments. An overall retention coefficient of 0.65 was determined by calibration so that the model calculated phosphorus load from the upper watershed matches the measured load from the upper watershed. The load from the upper watershed was measured near Fewins Road just above the Hatchery. Extensive data are available for this site. The upper watershed load for normal flow conditions is approximately 1,200 pounds per year. Note that Big Platte Lake has a well established retention coefficient of about 0.5. Thus the overall retention coefficient of 0.65 for the upper watershed seems to be reasonable because of the many impoundments and small lakes in the upper watershed. To date data and models are currently unavailable to further refine the 0.65 estimate for the upper watershed retention and to partition this result into various upper watershed lakes. Verification of the loading and retention coefficient estimates is a recommended task of future projects.

Table 28: Land Use Acres and Runoff coefficients for the Upper Watershed with a Calculation of Total Phosphorus (TP) loading to the lower watershed at current conditions (no growth)

Land Use	Acres	Runoff (lbs/acre/year)
Barren	6.3	.071
Commercial	605.6	.688
Cropland	1,574.8	.079
Forest	3,5346.1	.035
LDR	1,434.9	.219
Orchards	1,739.9	.054
Pasture	14,218.8	.071
Wetland	6,326.5	.039
Total acres	***61,253***	
Total Annual TP Loading from UPPER Watershed (lbs)	**1,205**	

Lower Watershed Loading Model

The lower watershed phosphorus loading model is based on the acreage of eight land-use categories in the lower watershed and their corresponding annual average export coefficients. The acreage of each land use is shown in Table 29. The current values for 2010 were obtained from the 2000 Land Use Land Cover layer using Geographic Information System (GIS) (2000) and the current National Wetlands Inventory for the Platte River Watershed area (2000) A spreadsheet is available that can be used to vary the acres of land uses in each category in subsequent years to allow analysis of various growth scenarios.

The load from the lower watershed has been measured for a number of years at the USGS site on the Platte River just below the Village of Honor, at M22 below Big Platte Lake, and near Fewins Road just upstream of the Hatchery. In addition, phosphorus loads are routinely measured from the North Branch of the Platte River at Deadstream Road. Extensive data are available for these sites. The lower watershed non-point phosphorus load under normal flow conditions is approximately 3,500 pounds per year. This estimate includes unmeasured direct loading into the Lake from shoreline areas in the lower watershed below the USGS and Deadstream monitoring sites.

Table 29: Land Use Acres and Runoff coefficients for the Lower Watershed with a Calculation of the Non-Point Total Phosphorus (TP) loading to Big Platte Lake at current conditions (no growth)

Land Use	Acres	Runoff (lbs/acre/year)
Forest	23,968	.035
Barren	0	.071
Orchards	443	.054
Pasture	8,904	.071
Cropland	8,427	.079
LDR	2168	.219
Commercial	303	.688
Wetland	3,989	.039
Total acres	***48,202***	
Total Annual TP Loading from LOWER Watershed (lbs)	**2,999**	

Big Platte Lake Total Phosphorus Concentration Model

Not all the phosphorus that is generated in the upper and lower watersheds reaches the outlet of Big Platte Lake before entering the Sleeping Bear National Lakeshore and Lake Michigan. Some of the phosphorus is retained in Big Platte Lake. A model has been developed, calibrated, and validated that calculates the annual average total phosphorus concentration and the amount of phosphorus retention in Big Platte Lake. The model assumes the lake is completely mixed in both the horizontal and vertical directions. It includes point, non-point, and internal loading and discharge flow through the outlet. The only model coefficient is the apparent settling velocity or retention velocity (v_s) that results in a net loss of phosphorus to the sediments. This is the simplest deterministic, yet realistic model for total phosphorus and is widely applied in various forms (Chapra, 1997). The annual average total phosphorus concentration is given in Equation 1.

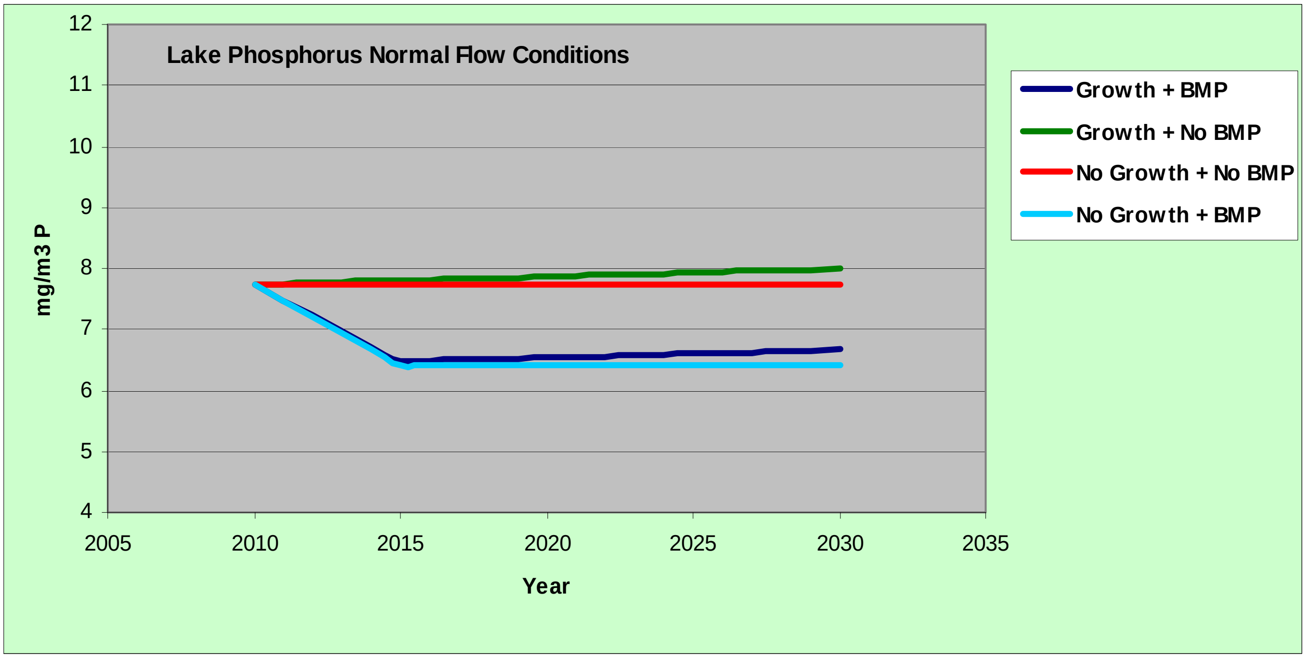
$$p = W /(Q + v_s A) \qquad (1)$$

In Equation (1), p is the annual average volume weighted total phosphorus concentration of the lake, W is the annual total point, non-point phosphorus, and internal load into the lake, Q is the annual average hydrologic flow rate leaving the lake, v_s is the apparent settling velocity, and A is the effective area where settling occurs. A worksheet is provided where known values are entered for the flow rate, volume, and settling area.

The first step in the development of the model is to construct annual average mass balances for water and phosphorus for the lake and watershed. These balances can be developed for the Platte River watershed using flow and phosphorus measurements of the river, tributary, and lake. The mass balance also includes three internal sources of phosphorus. The loading associated with fish lost between the lower and upper weirs is assumed to have an average value of 100 pounds of phosphorus per year. The loading associated with atmospheric deposition is assumed to have an average value of 160 pounds of phosphorus per year. The loading associated with phosphorus release from the sediments is assumed to have an average value of 175 pounds of phosphorus per year. These estimates are based on extensive data. These inputs and measured volume-weighted total phosphorus concentrations in the lake can be used to calculate an apparent settling velocity of 14.5 m/yr for typical normal flow conditions. This coefficient is a collective characterization of the net removal of phosphorus from the water column and corresponds to the permanent retention of about 53% of the incoming phosphorus into the sediments. Theses values compare well to those observed in other lakes (Chapra, 1997). Note that this model is a steady state approximation of the long-term sediment model published in ASCE (Canale et al. 2010). The steady state model does not directly include dynamic changes in thermal stratification, hypolimnetic oxygen depletion, and anaerobic release from the sediments. Thus the steady state version of the model may slightly over-predict the lake phosphorus concentration because it does not include gradual decreases in sediment release that may occur if loads to the lake decrease.

Model calculations give a total lake phosphorus concentration of 7.5 mg/m^3 if there are no Hatchery point sources. If a point source from the Hatchery of 175 pounds is added to the input loads, the calculated lake concentration increases to 7.7 mg/m^3. This concentration violates the Consent Agreement of an annual average concentration of 6.4 mg/m^3 which is equivalent to 8 mg/m^3 with 95% attainment. This is the No BMP and No Growth alternative shown as the red line in Figure 33. The model can be used to determine by trial and error that the total loading must be lowered by 825 lbs through BMP projects to lower the Lake concentration to 6.4 mg/m^3. This No Growth with BMP alternative is shown as the light blue curve in Figure 334 This load reduction is consistent with the numerical standard that requires that the lake be 8.0 mg/m^3 or less 95% of the time. The model allows implementation of BMP reductions to occur over a user-specified time period.

Figure 34: Model predictions of the annual average total phosphorus concentration in Big Platte Lakes for various growth and BMP assumptions



The model can also be used to test the impact of future changes in land use in either the upper or lower watershed. Growth and development in the watershed is expected to increase the loading with conversion of land uses from those with low to higher export coefficients. Conversely, conservation easements may decrease non-point loads. The most recent census data shows that the population of Benzie County increased by 9.5% between 2000 and 2010. Similarly, the population of Grand Traverse and Leelanau County grew by 12% and 2.8% respectively. These results and the area of each of the three counties in the watersheds can be used to calculate effective 10 year growth rates of 9.4% for the entire upper watershed and 8.7% for the entire lower watershed. It is assumed that the areas of Light Residential and Commercial development increase at a linear rate at these growth rates at the expense of forested land-use. As a result, the forested area decreases by 384 acres in the upper watershed and the non-point load delivered to the lower watershed increases by 43 pounds of phosphorus over a 20 year period. The forested area decreases by 430 acres in the lower watershed and the non-point load delivered to Big Platte Lake increases by 104 pounds of phosphorus over a 20 year period. The increases in lake total phosphorus concentration that are the result of watershed development are shown as the green and dark blue curves in Figure 34. This additional loading of 147 pounds will have to be offset to comply with the numerical standard if the assumed population growth actually occurs. Some or this entire offset may occur as a result of decreased internal load from the sediments as phosphorus rich sediments are purged over time as described in Canale et al 2010.

Analysis of Phosphorus Reduction Alternatives

Immediate action is needed to attain the required 825 pounds of phosphorus loading reduction. This requires an analysis of the effectiveness of various watershed management practices intended to reduce non-point phosphorus loading. A Benzie County ordinance requires lakeside residents to construct retention basins to collect the runoff from all impervious surfaces to reduce direct runoff into the Lake and facilitate percolation into the groundwater. The calibrated BASINS model for the Platte River watershed estimates that the event mean concentration of this runoff has a total phosphorus concentration of approximately 250 mg/m^3 and that local groundwater has a concentration of about 6 mg/m^3. A maximum potential phosphorus reduction of about 190 lbs/yr could be attained if 500 lakeside residents complied with the ordinance. This is equivalent to about 23% of the needed reduction in phosphorus loading to meet water quality goals under typical hydraulic flow conditions. Buffer zone ordinances have been enacted that are aimed at reducing the non-point phosphorus loads to Platte Lake. Although buffer zone vegetation reduces erosion, it is not considered effective for the removal of phosphorus over the long-term because phosphorus retained by plants in the spring and summer is released with plant senescence in the fall. Therefore, the ordinance encourages lakeside residents to circumvent this recycling by collecting beach debris and cutting, harvesting, and removing excess buffer zone vegetation 2 to 3 times per year. Measurements indicate that typical shoreline debris material has a water content of about 75% and contains about 0.25% phosphorus by dry weight. Therefore, a total phosphorus loading reduction of about 154 lbs/yr could be attained if each lakeside property owner removed approximately 500 lbs of vegetative litter and beach debris (wet weight) from their property per year. Starting in 2012, a state-wide ban on fertilizer containing phosphorus went into effect for non-agricultural applications. A typical 20 lb bag of lawn and garden fertilizer used in the area contains 10% phosphorus, or 2 lb per bag. Detailed fertilizer sales volume and application rate data are not available for the local area; however, if 50% of the 500 lakeside residents currently use one bag of fertilizer per year, then a potential reduction of 500 lb of phosphorus could be attained with the use of phosphorus-free fertilizers. It is also important to note that the reductions in phosphorus loading estimated for the actions described above are a maximum because even without the remedial measures, some phosphorus would naturally percolate into the groundwater and be adsorbed by soils. It is not easy to quantitatively evaluate the actual phosphorus reduction achieved in practice compared to the potential reductions described in the previous paragraphs.

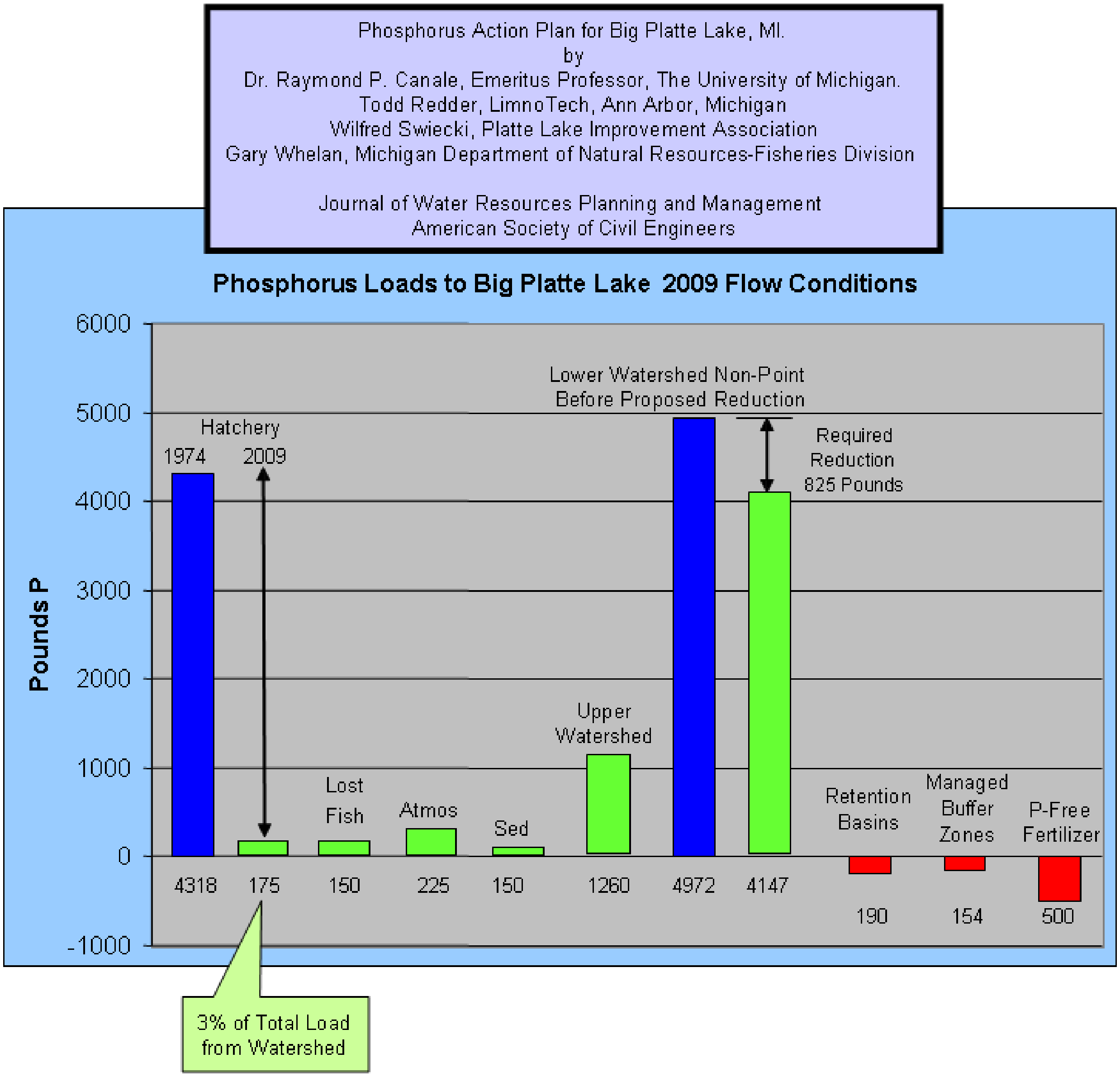
Figure 35 summarizes these calculations and characterizes the watershed phosphorus mass balance for the historical conditions as well as before and after implementation of various BMP projects. Note that the model calculations shown in Figure 35 do not account for increases in the non-point phosphorus loads that result from the future growth of population and commercial activities. Therefore, a long-term monitoring program is recommended to both verify the effectiveness of the corrective efforts and detect long-term trends in watershed development. In addition, other technologies should be explored to remove phosphorus from non-point sources to offset potential increases in loading due to further watershed development. One such approach involves adding chemicals to residential and commercial septic tank systems for the purpose of precipitating phosphorus before it reaches the groundwater and infiltrates into the lake.

The unnamed tributary into Miner’s Bay is another source of phosphorus that affects the overall Lake phosphorus mass balance. This tributary has 2 branches. The East Branch is affected by soil erosion and wastes associated with cattle and pasture operations. Limited monitoring data collected between 2003 and 2009 indicate that the average flow of the East Branch is 1.6 cfs but can attain values as high as 3.8 cfs during high runoff events. The average total phosphorus of the East Branch during this period was 26 mg/m3. The maximum concentration was 41 mg/m3. The West Branch is affected by fruit waste. Limited data between 2003 and 2009 indicate that the average flow of the West Branch is 1.7 cfs but has been measured as high as 3.8 cfs. Average phosphorus concentrations of the

West Branch are slightly elevated above background (12.1 mg/m3) but the concentration has been measured as high as 48 mg/m3on one occasion, and there is strong visual evidence of iron bacteria slime growth.

There is potential for an excess total phosphorus load of 70 lbs/yr above background based on average 2003-2009 data, but this loading could be much higher during extreme periods of high runoff. However, these estimates are based on limited data and pasture operations have discontinued and the remedial activities associated with the fruit waste are expected to further improve conditions. Therefore it is recommended that the monitoring program of both branches of the unnamed tributary be resumed. The program should measure the flow, total phosphorus, and organic content of both branches every 2 weeks for a period of one year.

Figure 35: Phosphorus Loads to Big Platte Lake- 2009 Flow Conditions


Phosphorus Action Plan for Big Platte Lake, MI.
by
Dr. Raymond P. Canale, Emeritus Professor, The University of Michigan.
Todd Redder, LimnoTech, Ann Arbor, Michigan
Wilfred Swiecki, Platte Lake Improvement Association
Gary Whelan, Michigan Department of Natural Resources-Fisheries Division

Journal of Water Resources Planning and Management
American Society of Civil Engineers

3% of Total Load from Watershed

Recommendations

The goal will be to verify that the previous calculations and BMP requirements and projects will actually bring Big Platte Lake into compliance with the numerical standard. Thus continuing to measure lake water quality conditions and the incoming phosphorus loads remains important because phosphorus loads may increase in response to future watershed development and negate the benefits of any BMP program. A key near-term goal is to determine the optimum number of samples that need to be taken in a year to be able to answer these questions with acceptable statistical confidence and reliability.

Most of the reductions in non-point loads that result from the various BMP projects will be seen as reductions of phosphorus concentrations in the Platte River and its tributaries during high flow storm events. The previous storm water monitoring program was active from 2004 through 2007. Another key goal is to resume this program to determine if storm event phosphorus and suspended solids loads change because of ongoing and future improvement projects.

The BASINS model was calibrated using watershed data collected through 2005. In the last eight years new data have been obtained and the reliability and consistency of the monitoring program has improved. It is proposed that recent data, including new storm event data, should be used to update the BASINS model calibration and expand its range into the upper watershed.

As the Platte Lake phosphorus concentration is reduced and approaches the numerical standard it is expected that corresponding improvements in lake water clarity and Secchi depth will occur. However, there may be an upper bound on improvements in water clarity because the lake is a hard water marl lake and clarity improvements may be limited due to calcite formation. Another key goal is to be able to predict the maximum improvements in water clarity that are possible to avoid unrealistic expectations on the part of watershed residents and local and state regulators.

Additional ways are needed to reduce the phosphorus loading to the lake to attain the numerical standard and to offset increases in phosphorus loading resulting from further watershed development. The PLIA has began a pilot project to explore the benefits of adding chemicals to individual septic tanks to precipitate phosphorus. Completing these studies will be important.

Little Platte Lake has about two times the phosphorus concentration of Big Platte Lake. In addition, nitrate concentrations in Little Platte Lake are very low, and these conditions favor the proliferation of undesirable nitrogen-fixing blue-green algae. The outlet of Little Platte Lake flows into the North Branch of the Platte River and eventually into Big Platte Lake. Sampling of this lake was terminated in 2009 due to budget constraints. Another key goal is to resume water sampling in Little Platte Lake and the Little Platte sub-watershed to determine the source of the high phosphorus content of Little Platte Lake and its impact on Big Platte Lake.

Pollutant Loading for Total Nitrogen and Sediment as a function of measured Phosphorus concentrations:

The PLIA also has estimated total nitrogen and sediment loading coefficients as a function of measured ratio of total phosphorus to total nitrogen or sediment concentrations for the watershed (Figure 30). The nitrogen and sediment concentrations can be correlated using this approach to various land uses as a function of their corresponding annual average phosphorus export coefficient. The total nitrogen stormwater loading coefficient is based on locally measured TN/TP ratios in Big Platte and Little Plate lakes in 2008. The suspended solids stormwater loading coefficient is derived from the averaged ratio of total suspended solids to measured total phosphorus from stormwater sampling events conducted by the PLIA in 2005 and 2007.

Pollutant Reduction Estimates for Land Conservation Practices

To help maintain the high water quality resources of the Platte River watershed it is important to address known sources of pollution while at the same time preventing increases in pollutant loading overtime from emerging or currently unknown pollutant sources. Protecting Priority Areas identified in the PRWPP with voluntary conservation easements is an excellent strategy to meet this objective. The Grand Traverse Regional Land Conservancy and the Leelanau Conservancy are the local land conservancies using these strategies to protect high quality land in the Platte River watershed, in addition to the rest of the surrounding Counties.

Land conservation BMPs are excellent ways to preserve water quality. When dealing with pollutant reduction from these specific types of BMPs we look at the amount of pollution prevented from entering the watershed by keeping the land in its natural state. The load reduction is essentially the difference between the loading from the current land use and the loading from a more developed land use.

Permanent Conservation Easement Pollutant Load Reduction (lb/yr)

The total pollutant load reduction from a permanent conservation easement is determined by subtracting the total pollutant loading coefficient for the more developed land use, such as low density residential, from the total pollutant loading coefficient for a more natural land use, such as wetland or forest.

Table 30 contains annual pollutant loading coefficients for various land uses found in the Platte River watershed as determined by measured total phosphorus concentrations and their respective nitrogen and sediment ratios. Subtracting annual pollutant loads for forested land uses in Table 28 from the annual pollutant loads for low density residential (LDR) and then multiplying by the conservation easement acreage yields an estimation of the reduction in annual pollutant load resulting from a permanent conservation easement implementation in Priority Areas.

(Low Density Residential lbs/ac/yr – Forested lbs/ac/yr) x Conservation Easement acres = Load reduction from permanent conservation easement

The overall watershed plan goal is to permanently protect 500 acres of land within identified Priority Areas throughout the watershed by 2018 (See Land Protection and Management Goals in Section 4.8.) Successful implementation of voluntary conservation easements over 500 acres will prevent an estimated 33.45 tons of sediment (or 66,900 lbs), 4215 lbs N, and 91.5 lbs P from entering the Platte River watershed each year.

Table 30: Pollutant Loading for Total Nitrogen and Suspended Solids as a Function of Measured Phosphorus Concentrations

Land Use	Acres	Phosphorus (lbs/ac/yr)	N/P ratio	Nitrogen (lbs/ac/yr)	SS/P ratio	SS (lbs/ac/yr)
Forest	23,968	.036	45	1.60	725	25.4
Barren	0	.071	45	3.25	725	51.6
Orchards	443	.054	45	2.47	725	39.2
Pasture	8,904	.071	45	3.25	725	51.6
Cropland	8,427	.079	45	3.62	725	57.4
LDR	2168	.219	45	10.03	725	159.2
Commercial	303	.688	45	31.51	725	500.0
Wetland	3,989	.039	45	1.79	725	28.3
Total acres	***48,202***					

Pollutant Reduction Estimates for Stormwater BMPs

The primary stormwater source in the Platte River watershed is direct runoff from roadways. Table 31 lists the total percent removal of phosphorus, nitrogen, sediment (total suspended solids), and metals and bacteria for selected stormwater BMPs that could be used for stormwater pollution peculiar to the Platte River watershed.

Listing BMP effectiveness by percentage is often a more useful way of conveying the data to the general public rather than using specific concentration values, which can be difficult to comprehend.

It should be noted that the percent removal values in Table 30 are comparative numbers that approximate how much pollutant is removed as compared to no BMP implementation. For example, it is assumed that porous pavement values approximate the percentage of pollutants removed compared to regular pavement storm water runoff; or that Riparian Buffer values approximate the percentage of pollutants removed as compared to runoff from a landscaped, fertilized lawn. For more specific information on these stormwater BMPs, see the Center for Watershed Protection's Stormwater Center website at www.stormwatercenter.net.

Not every BMP may be the best selection for every site. Some areas are better suited for specific BMPs than others. There are other factors to consider besides pollutant removal efficiency when deciding which BMP to use at a site. Other factors include the size of site, money available for implementation, and the purpose of the land (i.e., what the site will be used for).

Table 31: Pollutant Removal Effectiveness of Selected Potential Stormwater BMPs

Management Practice	Total % Phosphorus Removal	Total % Nitrogen Removal	Total % Suspended Solids Removal	% Metal and Bacteria Removal	Other Considerations
Riparian Buffer*	Grass: 39-88 Forest: 23-42	Grass: 17-87 Forest: 85	Grass: 63-89 Forest: N/A	n/a	- Increase in property value; Public education necessary
Porous Pavement	65	82	95	Metals: 98	$2-3/ft^2 (traditional, non-porous asphalt is $0.50-1.00/ft^2)
Infiltration Basin	60-70	55-60	75	Metals: 85-90 Bacteria: 90	$2/ft^3 of storage for a ¼-acre basin - Maintenance is essential for proper function
Infiltration Trench	100	42.3	n/a	n/a	$5/ft^3
Bioretention **(Rain Gardens, etc.)**	29	49	81	Metals: 51-71 Bacteria: -58	$6.80/ft^3 of water treated - Landscaped area anyway; Low maintenance cost; Note possible export of bacteria
Grassed Filter Strip (150ft)	40	20	84	n/a	- Cost of seed or sod

Table 31: Pollutant Removal Effectiveness of Selected Potential Stormwater BMPs (Cont'd)

Management Practice	Total % Phosphorus Removal	Total % Nitrogen Removal	Total % Suspended Solids Removal	% Metal and Bacteria Removal	Other Considerations
Sand and Organic Filter Strip	Sand: 59 +/-38 Organic: 61 +/-61	Sand: 38 +/-16 Organic: 41	Sand: 86 +/-23 Organic: 88 +/-18	Sand: Metals: 49-88;Bacteria: 37 +/-61; Organic: Metals: 53-85	Not much information, but typical costs ranged from $2.50 - $7.50/ft of treated stormwater
Grassed Channel/Swale	34 +/-33	31 +/-49	81 +/-14	Metals: 42-71 Bacteria: -25	$0.25/ft^2 + design costs ; Poorer removal rates than wet and dry swales;-Note the export of bacteria
Constructed Wetlands** **1) Shallow Marsh** **2) Extended Detention Wetland** **3) Pond/Wetland** **4) Submerged Gravel Wetland**	1) 43 +/-40 2) 39 3) 56 +/-35 4) 64	1) 26 +/-49 2) 56 3) 19 +/-29 4) 19	1) 83 +/-51 2) 69 3) 71 +/-35 4) 83	1) Metals: 36-85; Bacteria: 76; 2) Metals:(-80)-63; 3) Metals: 0-57 4) Metals: 21-83; Bacteria: 78	- Relatively inexpensive; $57,100 for a 1 acre-foot facility; - Data for 1 and 2 based on fewer than five data points

**Pollutant removal efficiencies will increase as buffer width increases. Grasses in this case mean native grasses -not regular lawn or turf grass.*

*** Wetlands are among the most effective stormwater treatment practices in terms of pollutant removal, and also offer aesthetic value. While natural wetlands can sometimes be used to treat stormwater runoff that has been properly pretreated, stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands. There are several design variations of the stormwater wetland, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.*

Values obtained from Center for Watershed Protection's Stormwater Center website (www.stormwatercenter.net) and Practice of Watershed Protection Manual (Schueler and Holland 2000).

Information on pollutant removal efficiency, costs, and designs of structural stormwater BMPs is constantly evolving and improving. As a result, information contained in Tables 28 and 29 is dynamic and may be updated to reflect new information and data as it is available.

Successful implementation of best management practices will allow responsible parties to quantify storm water pollutant reductions specific to the Platte River watershed. It is a task in this plan to develop a program to evaluate pollutant removal efficiency and costs for storm water best management practices.

CHAPTER 6: WATERSHED PLANNING EFFORTS

6.1 STEERING COMMITTEE, STAKEHOLDER AND PARTNER OUTREACH

The original Platte River Watershed plan was completed in 2002 (PRWP 2002). This 2014 Platte River Watershed Protection Plan is an update to the 2002 plan. In 2010, the PLIA initiated an update to the original watershed plan to make it comply with the EPA 9 elements criteria in addition to the MDEQ's criteria on which it was originally based. A steering committee was formed by the PLIA asking various watershed partners to sit on the steering committee such as CRA, BCD the MDNR Fisheries Department and SBDNL.

The Steering Committee met several times a year during the planning process. Information was disseminated to stakeholders in the watershed regarding the watershed plan at the PLIA annual picnic in July 2011, in newsletters put out by the BCD and PLIA and at the September 2011 stakeholder meeting, which was held at the Homestead Twp Hall on September 14, 2011. The PLIA and BCD also continued to promote the watershed plan, survey and provide updates to their constituents throughout 2012 and 2013.

Survey Results

The PRWPP Steering committee conducted a paper (Appendix D) and on-line survey (http://www.surveymonkey.com/s/N7VXX55) during the course of the watershed planning process. Below is a summary of those results:

The majority of the people answering the survey were seasonal residents (54%), 32% were full time residents and 14% seasonal visitors. The majority of the responses stated that the watershed is in better condition today than 50 years ago, which is encouraging. Some of the watershed concerns identified included overdevelopment of the Benzie corridor, and overuse of specific activities on the lower Platte River. When asked to rate the threats in the watershed, the results showed that people have very different ideas of what is threatened in their watershed. The majority of the recipients thought nutrients were the highest threat and that Coliform bacteria was the least threat in the watershed. When asked to rate the frequency and quality of the activities in the watershed, most consider wildlife observation, boating (kayaking, motorboats, canoeing), and swimming to be the most popular and of good to excellent quality. Very few rated any of the activities in the Platte River watershed as having poor quality.

Concerns raised via the questionnaire include protecting the wetlands where the Platte River enters Big Platte Lake as well as regulating the number of kayaks and canoes and tubes used on the river. On the recreational side, suggestions were made to create a portage/park on Deadstream road at the dam site due to current hazards. Others stated they like the one ramp access and would not like to see expansion of public boat launch sites. Concerns were raised about fertilizing lawns close to the shoreline and protecting ridgeline development.

In the future, people want to ensure the watershed is like it is today, if not in even better condition. Others stated they wanted it to look the way it did 100 years ago. The resounding message was to maintain if not improve water quality and restore natural habitat. The results of this survey were considered in defining the goals and objectives of this watershed plan.

Table 32: Summary of Stakeholder Watershed Survey Questionnaire Results

#1-What is your 'residential' relationship to the Platte River Watershed?

	Percent	Count
Full time resident	31.80%	21
Seasonal resident	**54.50%**	**36**
Seasonal visitor	13.60%	9
First time visitor	0.00%	0

 # 2- What do you think of the condition of the Platte River watershed TODAY compared to when you first remember it?

	Percent	Count
Better	53.70%	36
Same (no change)	22.40%	15
Worse	23.90%	16

3. How often do you enjoy the following activities in the Platte River watershed on an annual basis?

	Regularly (>2-3 times/week)	Fairly Often (2-4 times/month)	Sometimes (6 times a year)	Once a year	Never
Boating (motor)	30.8%	**33.8%**	15.4%	7.7%	12.3%
Swimming	**35.9%**	32.8%	25.0%	3.1%	3.1%
Water skiing/wakeboarding	9.5%	17.5%	25.4%	6.3%	**41.3%**
Canoeing/Kayaking	20.0%	29.2%	**38.5%**	7.7%	4.6%
Fishing (open water)	16.1%	17.7%	25.8%	12.9%	**27.4%**
Fishing (streams/rivers)	1.8%	7.1%	21.4%	16.1%	**53.6%**
Hunting	3.3%	6.6%	1.6%	6.6%	**82.0%**
Wildlife Observation	**34.8%**	25.8%	27.3%	6.1%	6.1%
Photography	17.0%	24.5%	**39.6%**	5.7%	13.2%

2. Please rate the quality (Excellent, good, fair or poor) of the activities in the Platte River watershed.

	Excellent	Good	Fair	Poor	N/A
Boating (motor)	**66.7%**	22.7%	0.0%	0.0%	10.6%
Swimming	**55.4%**	40.0%	3.1%	0.0%	1.5%
Water skiing/wakeboarding	**47.5%**	20.3%	5.1%	1.7%	25.4%
Tubing	**51.6%**	26.6%	4.7%	1.6%	15.6%
Canoeing/Kayaking	**64.7%**	29.4%	1.5%	0.0%	4.4%
Fishing (open water)	23.1%	**35.4%**	13.8%	3.1%	24.6%
Fishing (streams/rivers)	8.6%	24.1%	13.8%	1.7%	**51.7%**
Hunting	1.8%	12.3%	8.8%	0.0%	**77.2%**
Wildlife Observation	38.1%	**44.4%**	14.3%	0.0%	3.2%
Photography	**43.6%**	38.2%	1.8%	1.8%	14.5%

#5- Based on your experiences and knowledge of the watershed, please rank the following threats from most threatening (#1) to least threatening (#7).

	1	2	3	4	5	6	7
Nutrients	**47.0%**	16.7%	13.6%	12.1%	3.0%	4.5%	3.0%
Sediment	13.4%	**22.4%**	20.9%	19.4%	13.4%	6.0%	4.5%
Loss of natural habitat	**22.1%**	20.6%	14.7%	17.6%	8.8%	11.8%	4.4%
Toxic Substances	15.2%	13.6%	**24.2%**	19.7%	13.6%	6.1%	7.6%
Exotic Species	**32.3%**	23.1%	21.5%	9.2%	4.6%	6.2%	3.1%
Coliform bacteria (E.coli)	11.1%	11.1%	19.0%	12.7%	9.5%	**31.7%**	4.8%

6.2 PLATTE RIVER WATERSHED PLAN ACCOMPLISHMENTS TO DATE

Platte Lake Improvement Association

Lake Modeling

- The PLIA has been working on a mathematical model of Big Platte Lake for some time. Early versions of the model were used to understand and quantify the gross effects of excess phosphorous on lake water quality. Higher-resolution models of the lake, used together with a valid model of the watershed, will allow understanding of the impact on the lake of changes that occur in the entire watershed, in addition to just those within the lake's immediate area. The Implementation Coordinator Annual Reports provide the details of lake modeling efforts to date. (See PLIA/MDNR Implementation Coordinator Annual Reports 2000 through 2009. www.platte-lake.org .)

Lake and River Data Acquisition

- Since 1978, PLIA has been gathering and analysis of lake, river and Hatchery data. Data collected include flow rates, phosphate concentration, dissolved oxygen, turbidity, visibility, pH, temperature, and plant and animal info. The PLIA has placed a high priority on developing a computer-based water quality database which will allow easy entry of data and make it accessible to government officials, interested citizens and resource managers. (For PLIA/MDNR Data Base Information. See PLIA Website: www.platte-lake.org Contact Us)

Watershed Modeling

- The PLIA supported the development of a Platte River watershed nutrient loading model (LimnoTech, 2004 and 2007). The BASINS model will be used as input for a lake model, will allow us to determine the net effect on the lake of land use changes that occur in the watershed. (See PLIA Website: www.platte-lake.org Lake Data: May 2004 Basins Model Calibration Model Report and June 2007 Basins Model Report.)

Lake Phosphorus Modeling

- The PLIA has developed a total phosphorus model for Big Platte Lake. This model can be used to estimate changes in the annual average total phosphorus concentration in the Lake as a function of watershed loading, atmospheric inputs, and internal sources of phosphorus such as sediment release under anaerobic conditions. (See Canale et al. 2010)

Watershed Signs

- The PLIA, in cooperation with the Benzie Conservation District and Road Commission, has developed, procured and erected informational road signs within the Platte River Watershed, similar to those used in other watersheds to help identify the surprisingly wide extent of the watershed and help maintain awareness of the watershed's existence. (Total funding was $1325.30 by the PLIA from the MDNR/PLIA Settlement Agreement Penalty Funds.)

The Fish Ladder

- October 2003Via a cooperative effort of the PLIA, MDNR and the Benzie County Drain Commission, a fish ladder was fabricated and installed at the Deadstream Dam to make it easier for northern pike to enter the Deadstream to spawn. (Total funding was $12,800 by the PLIA from the MDNR/PLIA Settlement Agreement Penalty Funds.)

Side Scan Sonar Lake Profile Mapping

- September 2003: Big Platte Lake was re-mapped using an improved GPS system and side-scanning sonar, by the MDNR. The data are being used by the Implementation Coordinator to upgrade the lake model. This data also will be used to produce arguably the most accurate bottom profile map of Big Platte Lake ever made.

Macrophyte Studies

- 2003: A detailed and ongoing study of the plankton and related organisms in Big Platte Lake, sponsored by the PLIA and MDNR was conducted by Dr. Scott McNaught's group at CMU under the direction of the Implementation Coordinator, Dr. Ray Canale.

Lake Bottom Sediment Analysis

- 2003: An analysis of the sediment present at the bottom of Big Platte Lake, sponsored by the PLIA and MDNR was conducted and analyzed by the water quality lab at CMU.

Other studies the PLIA participated in:

Big Platte Lake shoreline survey cladophora , phosphorus and e-coli (2003);Phosphorus release study – Mike Holms (2005);Zebra Mussel study – Meg Wollar (2004);Bio-availability by Chin

Figure 36: PLIA Annual Picnic Photos

Conservation Resource Alliance

- Watershed Signs -On US-31, M-22, Thompsonville Rd and Warren Rd
- Restoring wild rice and bullrushes - to Big Platte Lake
- Sediment Traps- Platte River at Indian Hill Road, Veterans' Memorial Campground, Platte River State Forest Campground
- Large Woody Debris Project -Platte River - Veterans' Memorial Campground and downstream

- Updating road/stream crossing inventory-uploaded to the LIAA website
- Platte River Watershed Improvement grant, Burnt Mill and Hulbert Road are completed (see photos below)
- Reynolds Road crossing replacement- Grant from NRCS (in progress)
- Reynolds Rd., Kinney Ck., Landis Rd./Dair Ck, and the Tamarack Trout Farm- using a contract engineer firm (in progress)

Figure 37: Photos of the Burnt Mill Bridge Construction- Conservation Resource Alliance

Figure 38: Platte River (Burnt Mill) Large Woody Debris Project -Site Photos

Before-looking downstream from Bridge construction site

After-same location

Before-location of proposed log cover topped with woody debris

After-view is upstream toward same location-note gravel in this photo is where sand formerly predominated

Note sinuous channel form

Channel narrower and deeper=higher velocities and increased sediment transport

Benzie County Conservation District

- Collaborated with PLIA to develop and calibrate the EPA BASINS Watershed Model
- Corrected four eroding road-stream crossings with assistance from the Benzie County Road Commission
- Installed a Greenbelt Demonstration Project on Big Platte Lake
- Installed eleven watershed road signs
- Began leading "Leave No Trace In Your Waterway" canoe trips reaching 1,000 students, parents, and teachers

The Leave No Trace/Salmon in the Classroom program is a collaborative educational effort between Benzie Central Schools, Frankfort/Elberta Area Schools, the Benzie Fisheries Coalition, the Benzie Conservation District, Riverside Canoe Trips, Sleeping Bear Dunes National Lakeshore, and the Michigan DNR Fisheries Division. The program has existed for more than 20 years in various forms and is directed towards elementary/junior high students.

The first component of the program is a canoe trip for the students on the lower Platte River during the fall salmon run. Canoes are provided by Riverside Canoe Trips, and the students spend half the day on the river. At various stops, the students listen to education talks from the Fisheries Coalition, Benzie CD, DNR, and Park Service personnel. The talks touch on ecology, watershed protection, environmental stewardship, history of the Great Lakes salmon fishery, and the National Lakeshore. The aim of the trip is to have fun while instilling a sense of pride and stewardship for the river, watershed, fishery, and National Lakeshore. For many students, it is their first time in a canoe.

The second component of the program is that the students actually raise coho salmon fingerlings in their classrooms to be released into the river at the end of the school year. The students visit the Platte River State Fish Hatchery during the egg harvest to tour the facility and learn how it operates. Each class is then provided with fertilized salmon eggs to be raised in their classrooms. The aquariums, fish food, and other necessary equipment is provided by the Fisheries Coalition. The eggs hatch into fry and the students are responsible for feeding the fish and making sure the conditions are correct in the aquariums. There is a field trip at the end of the school year for each student to release one or more fingerlings into the river.

Figure 39: The Leave No Trace/Salmon in the Classroom program photos

Figure 39: Big Platte Lake Demonstration Site

BEFORE

AFTER

Sleeping Bear Dunes National Lakeshore

- Volunteer paddlers conduct a river cleanup for SBDNL from Riverside to Point.
- Conduct a Visitor Experience and Resource Protection study (VERP) to address visitor use and carrying capacity issue in the park (See appendix D for results on the Platte River).
- Conduct outreach and education with roving biologists along the beach, mostly targeted towards piping plovers
- Families United with Nature (FUN) club with events once a month. Some focus on water quality
- Public outreach to help with hydrology/water quality issues
- Updated the fish cleaning station across from the Platte River campground in picnic area
- Adopt a river program run by the Friends of Sleeping Bear (collect trash)
- Put in showers at the Platte River campground to help alleviate showering in Platte River.

DNR Fisheries Division CLMMU Accomplishments in the Platte River Watershed

MDNR Fisheries Division has accomplished the following surveys within the Platte River Watershed;

Bronson Lake-

- Surveyed in 1966- General survey with gill nets, trap nets, and fyke nets.

Kinney Creek-

- Surveyed in 2008- Electroshocking to collect samples of salmonids for disease testing.

- (older hook & line surveys in 1965.)

Carter Creek-

- Surveyed in 1965- hook & line survey and electroshocking.

Brundage Creek-

- Surveyed in 2011, 2010, 2008- Electroshocking to collect samples of salmonids for disease testing.
- (older surveys 1989 electroshocking, 1965 hook and line survey, 1965 electroshocking)

Gerry Lake-

- Surveyed in 2007- Status & Trends small lake survey, netting survey with fyke and gill nets.
- (older surveys in 1976, 1970)
- 1956- Mapped by the Dept. of Conservation.

Herendeene Lake-

- Surveyed in 2004- Status & Trends small lake survey, netting with fyke and gill nets.
- (older survey 1965)
- 1963- Mapped by the Dept. of Conservation

Lake Ann-

- **S**urveyed in 2004- Status & Trends medium lake survey using gill nets, trap nets, minnow seines, and a boom electroshocking boat.
- (older surveys 1992, 1983, 1975, 1973, 1950, 1948)

Lime Lake-

- Surveyed in 2005- General survey, Serns Index walleye stocking and recruitment evaluation
- (older surveys 1983, 1974, 1970, 1966, 1963)

Little Lime Lake-

- Surveyed in 1999- General survey, Serns Index walleye stocking and recruitment evaluation

Long Lake-

- Surveyed in 2007- General survey with netting and electroshocking.
- Surveyed in 2005, 2004, 2000, 1999- Local anglers collected walleye scales for age determinations
- (older surveys; see Status of the Fishery Report No. 118 (Hallock and Hettinger 2011)).

Pearl Lake-

- Surveyed in 1983- General survey, netting with fyke and gill nets.

Big Platte Lake-

- Surveyed in 2010- Status & Trends, netting and electrofishing.
- Surveyed in 2009- Serns Index walleye stocking and recruitment evaluation.
- Surveyed in 2008- Serns Index walleye stocking and recruitment evaluation.
- Surveyed in 2005- Manual removal of gar and common carp
- Surveyed in 2004- Serns Index walleye stocking and recruitment evaluation.

- Surveyed in 2003- Serns Index walleye stocking and recruitment evaluation.
- (older surveys; see Status of the Fishery Report No. 110 (Tonello 2011)).

Little Platte Lake-

- Surveyed in 1981- General netting survey with fyke and gill nets

Platte River-

- Surveyed in 2010, 2009, 2008- Status & Trends three year fixed site, electrofishing
- Surveyed in 2009- Random electroshocking at Burnt Mill Rd.
- Surveyed in 2004, 2003, 2002- Status & Trends three year fixed site, electrofishing
- Surveyed in 2005, 2004- State Wildlife grant wadeable habitat survey
- Surveyed in 2002, 2001, 2000- Haze Rd. population est. (Study)
- Surveyed in 1985, 1986, 1987- Status & Trends three year fixed site, electrofishing
- (older surveys in 1969, 1965, 1960, 1959, 1957, 1954).

North Branch Platte River (Deadstream)-

- Surveyed in 1965- Hook & line survey at three sites

Sanford Lake-

- Surveyed in 1989- general survey, netting

Turtle Lake-

- Surveyed in 1991- general survey, general survey and transfer of small bluegill to Little Traverse Lake (Leelanau County)

CHAPTER 7 WATERSHED GOALS AND OBJECTIVES

The overall mission for the Platte River Watershed Protection Plan is to provide guidance for the implementation of actions that will reduce the potential negative impact that pollutants and environmental stressors have on designated watershed uses. The overall goal is to have the Platte River watershed support all identified designated and desired uses while maintaining its distinctive environmental characteristics and high water quality.

Based on the original goals identified in the first edition of the Platte River Watershed Management Plan, the project steering committee developed five broad goals for the Platte River watershed (Table 33). Working to attain these goals will ensure that the designated and desired uses described in Chapter 4 are maintained or improved.

<u>Watershed Goals:</u>

1. Protect aquatic and terrestrial ecosystems.
2. Protect the quality and quantity of water resources.
3. Preserve high quality recreational opportunities.
4. Implement and promote educational programs that support stewardship and watershed planning goals, activities, and programs.
5. Protect the economic viability within the watershed while ensuring water quality and quantity resources are protected

Table 33: Platte River Watershed Goals

Goal	Designated or Desired Use Addressed	Pollutant/Environmental Stressor Addressed
#1-Protect aquatic and terrestrial ecosystems.	Warm/Coldwater Fishery, Other Aquatic Life, Navigation Desired Use: Aesthetics, *Ecosystem Preservation*	ALL
#2-Protect and improve the quality of water resources.	ALL	ALL
#3-Preserve high quality recreational opportunities.	Warm/Coldwater Fishery, Navigation Desired Use: *Recreation*	ALL
#4-Implement/promote educational programs that support stewardship and watershed planning goals, activities, programs.	ALL	ALL
#5-Protect the economic viability within the watershed while ensuring water quality and quantity resources are protected	Warm/Coldwater Fishery, Other Aquatic Life, Navigation, Aesthetics, *Ecosystem Preservation* Desired Use: *Recreation*	ALL

Goal #1

Protect aquatic and terrestrial ecosystems.

Designated Uses: Warm/Coldwater Fishery, Other Aquatic Life

Desired Uses: Ecosystem Preservation

Pollutants or Stressors Addressed: Invasive Species, Loss of Habitat, Nutrients, Sediment, Thermal Pollution

Objective 1.1	Protect and restore critical habitat areas for aquatic life and fish
Objective 1.2	Preserve the biodiversity of the watershed
Objective 1.3	Identify and protect wildlife corridors
Objective 1.4	Protect undeveloped shoreline habitats & promote the wise use of undeveloped shorelines
Objective 1.5	Preserve the distinctive character and aesthetic qualities of the watershed including viewsheds and scenic hillsides
Objective 1.6	Manage and control existing invasive species and minimize the spread of new invasive species
Objective 1.7	Implement and Promote Best Management Practices (BMPs) that conserve and protect the natural resources of the watershed.
Objective 1.8	Establish voluntary conservation easements with interested private landowners in identified Priority Areas.

Goal #2

Protect and improve the quality of water resources.

Designated Uses: Warm/Coldwater Fishery, Other Aquatic Life

Desired Use: Ecosystem Preservation, Human Health

Pollutants or Stressors Addressed: Nutrients, Pathogens, Sediment, Thermal Pollution, Toxins, Invasive Species, Loss of Habitat

Objective 2.1	Maintain compliance with the court order for annual phosphorus concentrations in Big Platte Lake such that they are less than 8 mg/m^3 95% of he time. Address all nutrient loading sources upstream of Big Platte Lake.
Objective 2.2	Establish BMPs to control and/or minimize the input of pathogens and toxic compounds into surface water and groundwater including reducing stormwater directly entering waterways;
Objective 2.3	Maintain/manage existing long term water quality testing program and procedures and a database system of data storage and retrieval.
Objective 2.4	Prioritize, stabilize and/or improve road-stream crossing embankments and approaches.
Objective 2.5	Maintain compliance with the state anti-degradation law for waters flowing into Sleeping Bear Dunes National
Objective 2.6	Develop a scientific based assessment and planning tool for land use decision making and for evaluating the effectiveness of restoration and water resource protection efforts.
Objective 2.7	Protect and restore priority and critical areas as outlined in Protection Plan (see Figure 32).

Objective 2.8 Assist townships in adopting and developing ordinances to protect water quality and natural resources.

Goal #3

Preserve high quality recreational opportunities.

Designated Uses: Warm/Coldwater Fishery, Navigation

Desired Use: Recreation

Pollutants or Stressors Addressed: All

Objective 3.1	Support desired recreational uses while maintaining distinctive environmental characteristics and aquatic biological communities throughout the watershed.
Objective 3.2	Maintain high quality sport fishing quality throughout the Platte River Watershed
Objective 3.3	Maintain and promote high water quality to ensure safe and clean areas for public swimming and other types of water recreation.
Objective 3.4	Maintain un-fragmented large tracts of wetland and forested habitat on public and private lands across the watershed.

Goal #4

Implement and promote educational programs that support stewardship and watershed planning goals, activities, and programs.

Public I/E Campaign

Designated Uses: All

Desired Uses: All

Pollutants or Stressors Addressed: All

Objective 4.1	Implement Information and Education Strategy outlined in Chapter 7.4.
Objective 4.2	Increase watershed community awareness and concern for water quality by educating watershed users and the general public, lake associations, stakeholders, schools and other groups
Objective 4.3	Involve the citizens, public agencies, user groups and landowners in implementation of the watershed plan through meetings and workshops with individuals or groups.
Objective 4.4	Integrate monitoring and research findings into IE strategy as they become available.
Objective 4.5	Measure effectiveness of outreach activities in increasing awareness and reduction of Non-Point Source (NPS) pollution.
Objective 4.6	Increase awareness of proper septic system maintenance, fertilizer use and storage of organic wastes and fertilizers.
Objective 4.7	Encourage appropriate provisions during or before site plan review for water quality and natural resources in the approval process.

Goal #5

Protect the economic viability within the watershed while ensuring water quality and quantity resources are protected

Designated Uses: All

Desired Uses: All

Pollutants or Stressors Addressed: All

Objective 5.1	Promote developments and land use activities that work in harmony with watershed protection
Objective 5.2	Adopt the most economically sound approaches to ecologically sound watershed practices
Objective 5.3	When developing watershed protection policies give consideration to the property values, local business and tourism.

CHAPTER 8 IMPLEMENTATION TASKS AND ACTIONS

Objectives and Tasks

The goals detailed in Chapter 7 for the Platte River watershed were developed by the Steering Committee to protect the designated and desired uses of the watershed. The goals are recommendations for implementation efforts within the watershed. Each goal has multiple objectives that outline how the goal can be reached. Tasks were then assigned to address the individual goals and multiple objectives. The detailed task implementation chart (Table 34) has broken the task down by eight (8) major categories:

1. Water quality/attainment & maintenance of the 8.0 mg/m3 standard (WQA)
2. Fish & Wildlife habitat (FWH)
3. Shoreline/Streambank protection (SSP)
4. Best Management Practices (BMP)
5. Outreach, Information and education (OIE)
6. Water Quality Monitoring (WQM)
7. Land Protection (LP)
8. Economy, Recreation and Tourism (ERT)

This table (Table 34) describes the task by category, provides interim milestones, approximates projected costs and assigns a plausible timeline for completion. The chart also identifies possible project partners, however, this does not imply a commitment on behalf of these organizations to accomplish these task criteria. These were developed based on the prioritization of watershed pollutants, sources, and causes while also looking at the priority and critical areas in the watershed (Tables 24 & 25, Figure 32). The implementation tasks in Table 34 are designed to address individual watershed objectives under each main goal. Some of the tasks are designed to address multiple objectives under one treatment.

Priority Level

Each task has been given a priority level based on the following criteria:

High, Medium-, Low

Unit Cost/Cost Estimate

An estimated cost is provided when available and applicable. An estimated total cost is provided when it is able to be calculated. Table 35 summarizes the Goals by Designated and Desired uses.

Milestones

Milestones are identified, when possible, to establish a measurable benchmark for determining the progress on a specific task or action.

Timeframe

A timeframe of 10 years was used to determine the scope of activities and the estimated costs for implementing the tasks. The year in which the task or action is to begin or end is noted. When a task or action is ongoing, it is noted as spanning the ten years.

Funding Sources

Likely funding sources for task implementation include State and Federal grant sources (DEQ: CMI, CWA Sec. 319, GLRI, NAWCA, GLFT, MDNR), private foundations, private fundraising from the Platte Lake Improvement Association and other lake associations, local land conservancies and volunteer time.

Potential Partners

Potential partners and target audiences are outlined on the next page with acronyms. These include anyone who has the interest or capacity to implement a task or action. It is anticipated identified entities will consider pursuing funds to implement the task or action, work with other identified potential partners and communicate any progress to the Platte River Watershed Protection Plan Steering Committee or project partners.

Potential Project Partner Acronyms:

BCRC – Benzie County Road Commission

BCPRC-Benzie County Parks & Recreation Commission

BLHD – Benzie-Leelanau Health Department

CRA – Conservation Resource Alliance

EPA – Environmental Protection Agency

GTBOCI – Grand Traverse Band of Ottawa and Chippewa Indians

GTRLC- Grand Traverse Regional Land Conservancy

GTCNC- Grand Traverse County Nature Center

ISEA – Inland Seas Education Association

LeeCty – Leelanau County

LC – Leelanau Conservancy

L-CD – Leelanau Conservation District

LCRC – Leelanau County Road Commission

LCW – Leelanau Clean Water

LCHR-Leelanau Scenic Heritage Route

LGOV – Local Governments

LA- Lake Associations

MDNR – Michigan Department of Natural Resources

MDEQ- Michigan Department of Environmental Quality

BCD- Benzie Conservation District

M-DOT – Michigan Department of Transportation

MNSP-Michigan Natural Shoreline Partnership

MSU-E – Michigan State University Extension

NRCS – USDA Natural Resources Conservation

PLIA – Platte Lake Improvement Association

NWMCOG – Northwest Michigan Council of

Governments

NWMSBF-Northwest Michigan Sustainable Business Forum

OWTTF – Onsite Wastewater Treatment Task Force

SBDNL- Sleeping Bear Dunes National Lakeshore

USFWS – United States Fish & Wildlife Service

Others:

Area Libraries, Boat/Marine Retailers, Garden Centers and Nurseries, Solid waste management entities, Schools, Leelanau County Chamber of Commerce, Architects and Engineers, Local Realtors, Businesses, Landscaping Companies

Target Audiences Include:

Builders/Developers/Realtors

Schools

Households

Local Governments

Riparian Landowners

Tourists

General

Funding Sources:

DEQ: CMI- Department of Environmental Quality, Clean Michigan Initiative

CWA Sec. 319- Clean Water Act

GLRI- Great Lakes Restoration Initiative

NAWCA- National

GLFT- Great Lakes Fisheries Trust

MDNR- Michigan Department of Natural Resources

The tables on the following pages (Table 34) include the tasks for implementing the watershed plan. The evaluation strategy and the information and education strategy are presented in the next two chapters (Chapters 9 and 10).

Table 34: Tasks for Implementing the Platte River Watershed Plan

Category 1: Water quality attainment and maintenance of the 8 mg/m3 standard (WQA)

Categories/Tasks	*Priority:* HIGH, MED, LOW	*Estimated Cost*	*Milestone*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*Potential Project Partners*	*Objective(s) Addressed*
WQA 1- Maintain current water quality program to ensure the 8mg/m3 Phosphorus standard is being met for Platte Lake- including habitat, shoreline, Cladophora and other types of regular monitoring in Platte Lake, Platte River and select lakes and tributaries.	HIGH	$15,000/year (analysis and report)	Annual review of WQ monitoring results & Hatchery figures. Conduct trend analysis every 5 years starting in 2018. Report in PLIA annual report and on the website	X	X	X	X	X	X	X	X	X	X	PLIA, MDNR	1.1, 1.2, 2.1, 2.3
WQA 2- Identify sources of excess phosphorus loading in the watershed and develop action plan to decrease loading to facilitate attainment of the Lake water quality standard. Expand same day tributary monitoring, spring monitoring and groundwater monitoring for P and flow.	HIGH	$15,000 per year sampling, $5,000 analysis and report/year	Ongoing surveys every year	X	X	X	X	X	X	X	X	X	X	PLIA, MDEQ	2.3, 2.1
WQA 3-Work collaboratively with the state, PLIA and Village of Honor to ensure the Honor storm water system is not contributing to Phosphorus loading into the lower Platte River	HIGH	$2000/year	Regular meetings and annual water sampling	X	X	X	X	X	X	X	X	X	X	PLIA, MDEQ, Village of Honor	2.1, 2.3

Category 1: Water quality attainment and maintenance of the 8 mg/m3 standard (WQA) (Cont'd)

Categories/Tasks	Priority: HIGH, MED, LOW	Estimated Cost	Milestone	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Potential Project Partners	Objective(s) Addressed
WQA 4- Continue to refine BASINS loading coefficients as a function of land use to improve model accuracy.	MEDIUM	$400,000 over 10 years	-Update detailed land use analysis for individual sub-watersheds within 5 years					X						PLIA, MDNR, MDEQ, LIAA, NWMCOG	2.1, 2.3
WQA5-.Establish routine biological assessment and water quality monitoring sites for Platte River and various tributaries to verify attainment of designated and desired uses.	MEDIUM	$10,000 per assessment (2 total)	Conduct biological assessments of Platte River and tributaries every 5 years, starting in 2013 and 2018.						X					MDEQ, SBDNL, CRA	2.1, 2.3
WQA6-Define optimum sampling program for Big Platte Lake to characterize compliance with P standard and to quantify reductions in P loading to Big Platte Lake as function of watershed improvement projects.	MEDIUM	$5,000/year for 10 years	Determine optimum sampling requirements by 2014, designed and implement regime by 2015.		X	X	X	X	X	X	X	X	X	PLIA, MDNR, MDEQ	2.1, 2.3

Category 2: Fish and Wildlife Habitat (FWH)

Categories/Tasks	***Priority:*** ***HIGH, MED, LOW***	***Estimated Cost***	***Milestone***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***	***Potential Project Partners***	***Objective(s) Addressed***
FWH 1- Reestablish native riparian vegetation and promote LWD recruitment in unnamed tributary to Big Platte Lake Lat 44.6750, Long -86.0649, (DEQ 303 d list).	HIGH	$500/year for five years	Self-sustaining brook trout population present in creek again		X		X		X		X		X	MDEQ, MDNR, PLIA	1.1, 3.1, 3.2
FWH 2-.Maintain high quality anadromous steelhead and coho salmon fishery in Platte River with adult returns sufficient enough to sustain Hatchery broodstock requirements.	HIGH	$3,591,600 total over a six year period, based on the current stocking	Maintain sufficient coho returns annually. Increase number of adult steelhead returning to Hatchery by 2014.		X	X	X	X	X	X				MDNR	3.2,1.1,
FWH 3-Work with interested landowners to promote recruitment of large woody debris in lakes and rivers through-out the watershed for fish habitat.	MEDIUM	$2500/year for ten years	Establish natural shoreline demonstration sites near publicly accessible areas on 3 lakes by 2018.	X	X	X	X	X	X	X	X	X	X	MDNR, PLIA, BCD, SBDNL, CRA	1.1,1.7
FWH 4- Update Big and Little Platte Lake and Platte River fisheries status reports and monitor fisheries through out watershed.	MEDIUM	$1000/year (for 5 years) Total = $5,000	Conduct fish surveys every other year on major lakes and/or stream in the watershed.		X		X		X		X		X	MDNR, GTBOCI, SBDNL	3.1, 1.1

Category 2: Fish and Wildlife Habitat (FWH) (Continued)

Categories/Tasks	*Priority:* *HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*Potential Project Partners*	*Objective(s) Addressed*
FWH 5- Augment natural reproduction where needed with stocking desirable species in Big Platte Lake and other lakes.	MEDIUM	$16,000 over a six year period, based on the current stocking	Stable population promoting a high quality fishery in Big Platte Lake by 2015.		X	X	X	X	X	X				MDNR, GTBOCI, SBDNL	1.1, 3.1, 3.2
FWH 6- Work with interested landowners and groups to replace woody habitat in rivers and lakes where natural recruitment of woody debris has been compromised	MEDIUM	$2,500/ year for ten years	Initiate projects as funding becomes available, ongoing.	X	X	X	X	X	X	X	X	X	X	MDNR, GTBOCI, NFWS	1.1, 1.7
FWH 7-Implement BMPs and habitat restoration as needed and as funding is available. Compile list of priority areas.	MEDIUM	Estimate $80/foot for 1000 feet = $8,000 total	Initiate projects as funding becomes available, ongoing			X	X	X	X	X	X	X	X	CRA, GTBOCI PLIA, BCD	1.1, 1.7
FWH 8- Implement Wild-Link program to identify, protect and enhance fish and wildlife habitat on private property within ecological corridors throughout the watershed.	MEDIUM	$15,000/year ever other year (60k Total)	Four projects by 2015, ongoing as funding is available			X		X		X		X		CRA, BCD, GTRLC, LC	1.3, 1.4

Category 3: Shoreline and Stream Bank Protection (SSP)

Categories/Tasks	***Priority:*** ***HIGH, MED, LOW***	***Estimated Cost***	***Milestone***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***	***Potential Project Partners***	***Objective(s) Addressed***
SSBP 1- Work with interested landowners to remove invasive species, improve riparian corridors and restore degraded habitat along the Platte River and tributary streams.	HIGH	$50,000/year for 9 years	Identify priority sites and obtain cost-share funds by 2014. Complete treatment on 3 priority sites by 2018		X	X	X	X	X	X	X	X	X	CRA, MDNR, BCD	1., 1.7
SSBP 2- Conduct workshops on natural shoreline management for shoreline property owners promoting native plants, soft engineering, and natural landscaping to improve fish/wildlife habitat, reduce nutrient runoff into lakes, and decrease erosion.	HIGH	$2000/year for 10 years	2 workshops/yr.	X	X	X	X	X	X	X	X	X	X	BCD, LA, BWC, MNSP	1.4, 4.2,4.3
SSBP 3- Conduct stream bank erosion/sedimentation survey of Platte River and various tributary streams to determine sediment sources	MEDIUM	Labor $6000/year x 2 years. Total =$12,000	Initiate survey in 2014. Resurvey every 5 years		X					X				CRA, GTBOCI PLIA, BCD	1.1, 1.4, 3.4

Category 4: Best Management Practices (BMP)

Categories/Tasks	Priority: HIGH, MED, LOW	Estimated Cost	Milestone	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Potential Project Partners	Objective(s) Addressed
BMP 1-Implement invasive species treatment program, including monitoring for new and the spread of existing aquatic and terrestrial invasive species in watershed	HIGH	$10,000/year for 10 years	2014- begin treatment program for highest priority species and establish index of existing populations to prioritize treatment; 2018-address medium priority species. Review and update index.		X	X	X	X	X	X	X	X	X	BCD, LA, PLIA, CRA, GTBOCI, MDNR	1.7, 2.2
BMP 2-Inventory and monitor hydrocarbon extraction sites, including any holding ponds, transfer facilities or other treatment facilities, to verify there is no contamination of groundwater or surface water bodies.	HIGH	$500/year for 10 years ($5000 total)	Establish independent, routine (annually) analysis of groundwater in and around hydrocarbon extraction sites.	X	X	X	X	X	X	X	X	X	X	MDNR, MDEQ	1.7, 2.3
BMP 3-Inventory stormwater drains and install filter strips and other BMPs to filter storm water discharge from roadway and village stormwater systems.	HIGH	$1000/year for 10 years	Two projects/year	X	X	X	X	X	X	X	X	X	X	BCD, BCRC, CRA	1.7, 2.3
BMP 4-Implement BMPs for identified Severe and Moderate Road and Stream Crossing sites	HIGH	$200,000/year for duration of plan- Total = $1.6M	Four projects by 2015, ongoing as funding is available			X	X	X	X	X	X	X	X	CRA, NRCS, BCD	2.2, 2.4

Category 4: Best Management Practices (BMP) (Continued)

Categories/Tasks	Priority: HIGH, MED, LOW	Estimated Cost	Milestone	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Potential Project Partners	Objective(s) Addressed
BMP 5-Inventory abandoned and poorly capped wells and correct properly to prevent contaminants from moving into and among groundwater aquifers via this route.	MEDIUM	$10,000 for inventory and $2000 for report	Start inventory by 2014 work with partners to distribute a report on findings by 2016, Inventory every 10 years		X		X							MDA-Wellhead Stewardship Program, BLDHD	2.2, 2.4
BMP 6-Work with landowners to promote forest management practices that are in compliance with current BMPs, as outlined in “Quality Management Practices on Forest Land,” (1994) MDNR	MEDIUM	$30,000/year for 10 years	Establish relationships with private forestland owners and managers. Adoption of 5 management plans/yr. on private forest land.	X	X	X	X	X	X	X	X	X	X	MDNR, NRCS, BCD, CRA	3.4, 1.7, 1.3
BMP7-.Work with agricultural producers to obtain an approved Conservation Plan and implement USDA-NRCS conservation practices on their land.	MEDIUM	$25,000/year for 10 years	3 plans/year	X	X	X	X	X	X	X	X	X	X	USDA-NRCS, BCD	1.7, 4.3
BMP 8--Maintain septic tank treatment demonstration project and communicate results.	MEDIUM	$5000/year every five years (total = $10,000)	Analysis of 5, 10 and 15 treatment, figures and communication					X					X	BCD, BLDHD	4.6, 2.2
BMP –9- Conduct an inventory of existing dams or water control devices and prioritize maintenance tasks to ensure water quality protection.	LOW	$10,000	Completed inventory			X								CRA, BCD	

Category 5: Information, Outreach and Education (IOE)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*Potential Project Partners*	*Objective(s) Addressed*
IOE 1- Enhance communication to stakeholders with regular updates, including publish regular newsletters with current water quality	HIGH	$5000/year for 10 years	Publication & Distribution of 2 issues/year and One annual picnic/year and	X	X	X	X	X	X	X	X	X	X	BCD, PLIA	4.2, 4.3
IOE 2-. Continue carrying capacity studies and attempt to quantify recreational usage impacts on lower Platte River corridor (below Little Platte Lake). Establish daily carry capacity limits for peak usage seasons and implement restrictions on the number of daily users if	HIGH	$5000/yr for staff time for duration of plan (total = 10 years or $50,000)	Annual reports of estimated usage compared to carrying capacity limits established from studies.	X	X	X	X	X	X	X	X	X	X	SBDNL	4.4
IOE 3- Work with BCRC and Drain Commission to implement storm water BMPs at road stream crossings	HIGH	$1000/yr. for 10 years	Attend BCRC meetings and engage Drain Commissioner on BMPs for identified sites. Two sites completed by 2015.	X	X	X	X	X	X	X	X	X	X	BCD, PLIA, LA, BWC, CRA	4.7
IOE 4- Encourage appropriate provisions during or before site plan review for water quality and natural resources in the approval process.	HIGH	$1000/yr. for 10 years	Attend planning commission meetings regularly	X	X	X	X	X	X	X	X	X	X	BCD, PLIA, LA, BWC	4.7, 4.3
IOE 5- Publish Platte River Watershed Landowners Handbook and begin distribution throughout watershed.	HIGH	$5000	Handbook published & distributed by 2014.		X									PLIA, BCD	6.2

Category 5: Information, Outreach and Education (Continued)

Categories/Tasks	***Priority: HIGH, MED, LOW***	***Estimated Cost***	***Milestone***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***	***Potential Project Partners***	***Objective(s) Addressed***
IOE 6- Participate in Benzie Watersheds Coalition and produce PRWPP progress updates every 3 years. Involve local governmental officials with the reporting process.	MEDIUM	$3000/year for ten years	Annual picnics, bi-annual web updates, at least 3 meetings/year of the BWC. Complete 1st progress update by 2015.	X	X	X	X	X	X	X	X	X	X	BCD, PLIA, LA	4.2, 4.3
IOE7-Promote adoption of Benzie County Stormwater Control Ordinance and encourage enforcement.	MEDIUM	$10,000 for staff time	Passage of ordinance in 2014		X									BLDHD, PLIA, BCRC, MDNR	2.8, 4.4
IOE 9- Provide water quality information and news about implementation tasks progress to local and regional media.	MEDIUM	$1000/year for ten years	Publicize adherence to 8 mg/m3 standard and progress of watershed plan in annual report.	X	X	X	X	X	X	X	X	X	X	BCD, PLIA	4.2, 4,3
IOE 9- Continue publication of water quality monitoring and BASINS results in scientific literature.	MEDIUM	$1000/year for 10 years	Update website and put information in newsletters. 2 publications	X	X	X	X	X	X	X	X	X	X	PLIA, MDNR	4.2, 4,3

Category 5: Outreach and Education (Continued)

Categories/Tasks	Priority: HIGH, MED, LOW	Estimated Cost	Milestone	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Potential Project Partners	Objective(s) Addressed
IOE 10- Implement a leave no trace outreach and education program for Platte River users (tubers, canoers, kayakers) – stickers or video at liveries about ways to protect the river: litter/trash, bathroom usage, shortcutting, walking along the bottom, etc.	MEDIUM	$1,000/year for staff time for 8 years once launched- total = $8,000	Installation of I/E materials at launch points on Lower Platte River by 2015			X	X	X	X	X	X	X	X	SBDNL, BCD	2.5, 4.2, 1.4, 1.5
IOE 11- Create applications for mobile devices to link outreach and education materials to more watershed users	LOW	$5,000/5 years	Create QR code for PRWPP progress updates and display at access sites by 2015.			X	X	X	X	X				SBDNL	4.2, 4.3, 4.5

Category 6. Water Quality Monitoring (WQM)

Categories/Tasks	Priority: HIGH, MED, LOW	Estimated Cost	Milestone	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Potential Project Partners	Objective(s) Addressed
WQM 1-Conduct water quality and biological monitoring on streams and lakes in the UPPER watershed	HIGH	$8000/year for 10 years	Measure phosphorous, flow, temperature, dissolved oxygen, and pH 3x/year Monitor macroinvertebrates 2x a year	X	X	X	X	X	X	X	X	X	X	MDEQ, BCD	2.1, 2.3
WQM2- Establish watershed wide central database for water quality data.	HIGH	$12,000 to start $6,000 annual maintenance for 6 years	Raise funding and do research on feasibility by 2013. Launch website by 2017.			X		X	X	X	X	X	X	PLIA, MDEQ, BCD, LA	2.1, 2.3
WQM 3-Develop a lake nutrient loading model for other lakes in the watershed.	MED	$60K sampling, $30K development of model	Develop a lake nutrient loading model for other lakes in the watershed by 2018.						X					PLIA, BCD, MDEQ	2.1, 2.3

Category 7: Land Protection (LP)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*Potential Project Partners*	*Objective(s) Addressed*
LP 1- Establish voluntary conservation easements to protect identified Priority Areas	HIGH	$150,000/year as funding is available for 8 years	Permanent protection of 200 acres by 2015 and 500 acres (total) by 2018.			X	X	X	X	X	X	X	X	GTRLC, LC	1.8, 1.1, 1.3, 3.4
LP 2-Maintain and improve existing public access sites on public land, lakes and rivers in the watershed.	LOW	$200,000	Improved upper Platte River canoe landing and access within the next five years.				X							MDNR, SBDNL	3.4, 3.1

Category 8: Economy, Recreation and Tourism (ERT)

Categories/Tasks	***Priority: HIGH, MED, LOW***	***Estimated Cost***	***Milestone***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***	***Potential Project Partners***	***Objective(s) Addressed***
ERT 1- Advocate for zoning, master plans and ordinances that protect water quality and natural resources	MEDIUM	$1000/year (staff time) for ten years	Attend at least 2 meetings annually	X	X	X	X	X	X	X	X	X	X	PLIA, BCD, BLDHD	2.8, 4.2, 4.3, 5.1
ERT3 – Complete a plan and establish a Downtown Development Authority to generate revenue focused on revitalization of Honor.	MEDIUM	$20,000	Completion of DDA plan and formation of Board		X					X				Honor Village Council	
ERT 4- Install locational signage, informational kiosks, stairs or access ramps in feasible locations to facilitate safe human access to high quality recreation resources and prevent impacts to wetlands, shorelines and steep banks.	LOW	$2,500 for inventory and $20,000 for treatments	Inventory priority sites by 2013. Install treatments at 3 sites by 2018.	X					X					SBDNL, CRA, MDNR, BCD	4.2, 2.2, 3.1, 3.3
ERT 2-Provide economic and community development incentives to entrepreneurial business efforts that help protect and/or allow people to experience the region's high-quality natural resources	LOW	Unknown	Depends on available funding & programs				X	X	X	X	X	X	X	BCD, local governments	5.2

Short-term Implementation Task Strategy

The PRWPP short-term task implementation strategy aims to focus project partner efforts on specific high priority tasks that will continue to build on existing water quality tasks and utilize ongoing partner efforts that accomplish identified goals and objectives of the plan. Implementation of WQA-1 is the highest priority task in the plan and will remain the priority focus for the PLIA and MDNR. Investigation of additional phosphorus sources suspected or known through implementation of WQA-2 will be key next steps that will utilize existing resources and will be priority targets for any additional funding available to enhance implementation progress. WQA-3 is another priority task that will continue utilizing ongoing efforts of the PLIA and will be a priority next step for funding once WQA-2 has helped to quantify phosphorus loading potential of other watershed sources. Implementation of SSBP-1 will also be an ongoing high priority task that will utilize existing funding and partnership programs with the BCD and CRA to reduce invasive species in and along riparian areas. Lastly, GTRLC and LC will continue to implement LP-1 with voluntary landowners on a donation basis; however any available permanent land protection funds will significantly improve task progress.

Category Costs

The total cost for implementation efforts for all categories was determined using some of the information in Table 32 above, but also information from individual stakeholders and organizations who will be doing the work. The total cost for implementation of the Platte River Watershed Plan (including outreach activities) is $**9,431,600 (Table 35).**

Table 35: Summary of Implementation Task Costs by Goal-

Category	Cost
#1-Water quality attainment and maintenance of the 8 mg/m3 standard (WQA)-	$840,000
#2- Fish and Wildlife Habitat (FWH)	$3,733,100
#3- Shoreline and Stream Bank Protection (SSBP)	$482,000
#4- Best Management Practices (BMP)	$2,047,000
#5- Information, Outreach and Education (IOE)	$488,000
#6- Water Quality, Upper Watershed (WQ)	$218,000
#7- Land Protection (LP)	$1,400,000
#8-Economy, Recreation and Tourism (ERT)	$ 55,000
Grand Total	**$9,431,600**

CHAPTER 9: INFORMATION AND EDUCATION STRATEGY

One of the most important tools to use when implementing watershed protection is an effective outreach and education campaign. Watershed residents, businesses local leaders, seasonal residents, and tourists alike are often unfamiliar with watershed issues. This Information and Education (IE) Strategy addresses the communication needs associated with implementing the Platte River Watershed Protection Plan.

A variety of means have already been used by the Platte Lake Improvement Association (PLIA), Benzie Conservation District (BCD), Sleeping Bear Dunes National Lakeshore (SBDNL) and other organizations to inform the public regarding water quality issues.

This includes holding annual meetings/picnics, publishing newsletters and handouts, updating individual websites, participating in the Benzie Watershed Coalition, and collaborating with project partners. It is a task of this plan to create a landowner publication similar to the Handbooks printed for Glen Lake and Lake Leelanau landowners.

Local Research Findings

The Platte River watershed is unique in character. Many riparian landowners are not permanent residents, which provides a dilemma on how best to educate this important segment of watershed residents.

There has not been any local research regarding public knowledge of watersheds and water quality issues, but a survey completed in adjacent Grand Traverse Bay watershed by the Watershed Center Grand Traverse Bay in 2002 identified a major gap in knowledge among watershed residents. 60% of the respondents answered “don’t know” when asked which watershed they lived in (TWC 2005). This basic fact indicates that watershed organizations have a long way to go in informing and engaging the public in watershed issues.

The same study pointed out that though many area residents routinely express concern about environmental issues, there is a lack of understanding of the key issues that face the watershed. Residents in the Grand Traverse Bay watershed perceive that business and industry (17%) and sewage treatment plants (16%) are the main causes of water pollution to the bay. In truth, the Grand Traverse Region is dominated by non-smokestack industries and comparatively few discharge permit holders. Additionally, when asked what they believe to be the least cause of water pollution in the Bay, and in area lakes, streams and rivers, respondents indicated the "day to day actions of individuals" as the second least likely pollutant. These two findings would seem to indicate that the members of the general public see sources outside their individual control to be most responsible for existing and potential water quality problems (TWC 2005).

Information Source	Percent
Newspaper	46.6%
TV News	13.7%
Environmental organization newsletters	7.3%
Friends, neighbors, coworkers	5.2%
Other organizations (churches, clubs, etc)	2.6
Magazines	2.3
Radio	1.6
Schools	1.3

Other key findings relevant from the Grand Traverse survey indicate that most people get their information about the environment and water quality from newspapers and television. When this question was cross-tabulated with the respondents' age, more detail was revealed about where specific age demographic groups obtain their information about the environment (TWC 2005). It is however worth noting that since 2002, the use of the internet as a source of information, especially for the younger generation (and specifically on social networking sites).

Age Range	Preferred Source	Education Level	Preferred Source
18-25	Schools	Graduate Degree	Environmental newsletters or friends, neighbors and relatives
26-35	TV News	Some post grad	Environmental newsletters, newspapers
36-55	Newspapers	College degree	Environmental newsletters, newspapers
56-65	Environmental Newsletters	Some college, high school or some high school	Television news
66+	Newspapers		

Summary of Regional Environmental Education and Outreach Research

Note: *The following is an excerpt from the IE Strategy outlined in Chapter 7.3 in the Grand Traverse Bay Watershed Protection Plan (TWC 2005). Even though the two watersheds differ immensely in size, the summary of research findings is relevant to the Platte River watershed and will be helpful when implementing the outreach plan. When it comes to watershed education in Northern Michigan, most of the issues and attitudes are the same across watershed and municipal boundaries.*

Other regional and national research surveys regarding the environment confirm the basic findings of the Grand Traverse Bay surveys. A Roper study (Roper 2001) indicates that while there is increasing public concern about the environment, the majority of the public still does not know the leading causes of such problems as water pollution, air pollution and solid waste. This finding was also confirmed in work done by The Biodiversity Project (2003) as part of its Great Lakes Public Education Initiative. This research involved both a public opinion poll and a survey of organizations, agencies and institutions engaged in public education efforts on Great Lakes topics. An excerpt follows:

> "...organizations are making a concerted effort to provide reliable information to people who can make a difference when it comes to improving the environmental conditions in the Great Lakes Basin. However, the public opinion poll shows that, for the most part, people are just not grasping the importance of the issues facing the Great Lakes in three important ways: the seriousness of the threats, the need for urgency in taking action to address the threats, and ways that individuals can make a difference. This led us to examine the discrepancy between the level and focus of current communications and public education efforts and the gaps in public awareness. Because of this discrepancy, we concluded that the public knowledge gaps are likely to be attributed to other factors besides the content and volume of materials. Likely factors include the following three points.
>
> - Limited use of targeting (tailoring messages and delivery strategies to specific audiences).
> - Heavy reliance on printed materials and the Web – reaching already interested knowledge seekers; limited use of television and other communication tools that reach broader audiences.
> - Multiple, complex, detailed information as opposed to broad, consistent unifying themes."

The report goes on to conclude that educators need "to pay attention to a full spectrum of factors that act as barriers to the success and impact of public outreach." Factors to be considered include:

- **Targeting** – Avoid the one-size-fits-all approach.
- **Delivery** – As resources allow, use the mediums and venues that best reach the target audience. Brochures are easy, the web is cheap, but television is the most used source of information about the environment.
- **Content** – Facts and figures are important to validate a point, but it is important to address the emotional connection needed to address why people should care, why the issue is relevant, effective solutions and what your audience can do about it.
- **Context** – Many environmental threats are viewed by the public as long term issues. Issues need to be communicated in a way that makes them more tangible. Beach closings, toxic pollution, sewage spills and water exports tend to feel more immediate than loss of habitat, land use planning and other big picture issues that citizens feel more disconnected from.

The study identified a list of educational needs and actions that should be incorporated consistently in educational efforts:

- Promote understanding of the system.
- Make the connection to individuals.
- Be local and specific.
- Include a reality check on "real threats." (For example, industrial pollution was a hot topic ten years ago but, many organizations have shifted their education focus to other current and emerging threats, such as stormwater runoff,

biodiversity, etc, but the public has not caught up with this shift.)

- Emphasis on "why is this important to you" messages.
- Make the connection to policy.

Both local and regional research indicates that there are considerable gaps in the public's knowledge and understanding of current environmental issues. But, this knowledge gap is tempered by keen public interest and concern for the environment. Watershed organizations need to do a better job of making issues of concern relevant to their audiences. There is a need for ongoing, consistent and coordinated education efforts targeted at specific groups, addressing specific threats.

The Platte River watershed IE strategy addresses many of these concerns. Both local and regional opinion research findings will be considered carefully when developing messages and delivery mechanisms for IE strategy implementation.

Goals and Objectives

The goal of the IE strategy is to ***"Establish and promote educational programs that support effective watershed preservation and increase stewardship."*** Fixing an erosion problem at a road stream crossing does not involve a high degree of public involvement. But, developing and carrying out a regional vision for stewardship of water resources will require the public and community leaders to become more knowledgeable about the issues and solutions, more engaged and active in implementing solutions and committed to both individual and societal behavior changes.

The objectives of this Implementation and Education strategy focus on building awareness, educating target audiences, and inspiring action. With the PLIA working in conjunction with the Benzie Conservation District on Education and Outreach, there will be many opportunities to reach watershed residents.

Five major objectives have been identified:

1. Increase watershed community awareness and concern for water quality by educating watershed users and the general public, lake associations, stakeholders, schools and other groups.
2. Involve the citizens, public agencies, user groups and landowners in implementation of the watershed plan through meetings and workshops with individuals or groups.
3. Integrate monitoring and research findings into the IE strategy as they become available.
4. Measure the effectiveness of outreach activities in increasing awareness and reduction of NPS pollution.
5. Increase awareness of proper septic system maintenance, fertilizer use and storage of organic wastes and fertilizers.

Target Audiences

A number of diverse regional audiences have been identified as key targets for IE strategy implementation. The targets are divided into user groups and decision-making groups.

User Groups

Households – The general public throughout the watershed.

Riparian Landowners – Due to their proximity to a specific waterbody, the education needs of riparian landowners are different.

Tourists – The Platte River area is known for its scenic beauty and recreational opportunities. The significant seasonal influx of people puts a noticeable strain on area infrastructure and often on the environment. There is a growing concern that this important economic segment could eventually destroy the very reason why it exists, and that the region's tourism "carrying capacity" may soon be reached. There is clearly a growing need to educate tourists about their role in protecting the Platte River environment.

Builders/Developers/Real Estate – This region is one of the fasting growing areas in Michigan in terms of population and land use. Increasingly, homes around and near Platte River are being converted from small seasonal cottages to larger year round homes. Additionally, new developments are popping up all over the watershed. Members of the development industry segment play a crucial role in this growth and providing ongoing education opportunities about their role in protecting water quality and environmental health is critical.

Agriculture - Certain streams and wetlands in the Platte River watershed are still threatened by less than adequate agriculture practices, especially cattle wading in streams. Educating farmers about this practice would benefit the watershed by reducing erosion, protecting wetlands, and reducing nutrients and pathogens entering streams.

Education – Area educators and students, primarily K-12.

Special Target Audiences – In addition to the above, certain user groups such as recreational boaters, other sports enthusiasts, garden clubs, churches, or smaller audience segments should be targeted on specific issues.

Local Government Decision Makers

Elected/Appointed Officials – Township, village, city, and county trustees and commissioners; planning commissions; zoning boards of appeal; road and drain commissioners; etc.

Staff – Planners, managers, township supervisors, zoning administrators, etc.

Message Development

General message outlines have been established for each target audience (Table 36). These messages will be refined as implementation moves forward. They may also be modified or customized depending on the message vehicle.

Table 36: Target audience Messages

Target Audience	Messages
Households	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Water quality-friendly lawn and garden practices • Housekeeping practices and the disposal of toxic substances • Septic system maintenance • Managing stormwater on private property
Riparian Landowners	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Riparian land management including the importance of riparian buffers • Water quality-friendly lawn and garden practices • Septic system maintenance • Housekeeping practices and the disposal of toxic substances • Clean boating practices
Builders, Developers, Real Estate	• Monetary advantages of and opportunities for Low Impact Development • Identification and protection of key habitats and natural features: aquatic buffers, woodlands, wetlands, steep slopes, etc. • Advantages of and opportunities for open space protection and financial incentives for conservation • Minimize the cutting of trees and vegetation • Impact of earthmoving activities, importance of soil erosion and sedimentation control practices, construction BMPs • Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Educate about and encourage wetland mitigation where landowners will cooperate

Target Audience	Messages
Agriculture	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Riparian land management including the importance of riparian buffers and BMPs • Water quality friendly types of agricultural practices • Disposal of toxic substances and pesticides should be done responsibly • NRCS recommended Conservation Practices
Education	• Adoption and promotion of a state-approved watershed curriculum in K-12 schools. • Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Connection between watershed organizations' programs and school activities • Active participation in watershed protection activities and stewardship
Local Government Decision Makers	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • The leadership role that local governments must play in protecting the watershed • The importance of establishing sound, enforceable natural resource protection ordinances • Economic impact and advantages of environmental protection
Tourists	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Help protect the beauty that you enjoy when you are a guest • Clean boating practices • Role in controlling the spread of aquatic invasive species

**Table adapted from Grand Traverse Bay Watershed Protection Plan (TWC 2005)*

Action Plan to Implement Strategies

A complete list of tasks by category follows this narrative (Table 37); the categories are the same as those used to outline the implementation tasks in Chapter 8. Several priority areas for the Platte River watershed have been identified and the plan for rolling out the IE Strategy will correspond to these priority areas (Sections 4.5- 4.7, Tables 24 & 24, Figure 32). Additionally, the IE Strategy will support other implementation efforts to control nutrient loading, loss of habitat, input of harmful toxins, and the impacts of invasive species in the watershed, and the impacts of other pollutants outlined in Section 4.6.

The IE Strategy tasks use a diverse set of methods and delivery mechanisms. Workshops, presentations, demonstration projects, brochures, public and media relations, web sites, e-mail and other communications tools will be used for the different tasks and target audiences. Broadcast media, most importantly television, is beyond the reach of most area partner organizations – at least at a level of reach, frequency and timing that can be expected to have any impact on awareness and behavior. This is a barrier to use of this effective medium, but effort should be placed on building coalitions that can pool resources to address larger picture issues through broader-based, more long-term communications efforts. Additionally, the use of social networking websites such as Facebook and Twitter have increased exponentially over the past few years. These sites offer advantages to reaching out to a broader segment of individuals that might not be reached via other means.

Partnerships

Due to the large amount of public land under State and Federal control combined with the long history of active fisheries management within the Platte River watershed, several important and significant partnerships have developed to address issues that impact multiple management agencies. PLIA has developed a close working partnership with the MDNR in an effort to maintain the 8 ug/L Court ordered standard for Big Platte Lake. The MDNR fisheries division is also an important partner with the general public in the Platte River Watershed through its management of inland and anadromous fisheries in the watershed. The MDNR Fisheries also partners with PLIA to count and control the number of adult salmon allowed to pass upstream from the lower weir. The Benzie Conservation District works closely with the PLIA and MDNR as well as the SBDNL to implement ongoing information and education activities and invasive species control through out the watershed. The Benzie Watershed Coalition was formed in 2011 and includes several additional organizations in partnership with the Benzie Conservation District to address water quality issues within and adjacent to the Platte River watershed. The Conservation Resource Alliance, Benzie County Road Commission and Grand Traverse Band of Ottawa and Chippewa Indians have partnered with funding from the Environmental Protection Agency to complete seven stream restoration and road stream crossing improvement projects from 2008 to 2011. These are examples of the many partnerships that have formed and will continue forming as the project partners focus on implementing their respective tasks.

The total cost for implementation efforts for all categories is detailed in Chapter 8. The total costs for I & E efforts, which includes Goals 1, 2, 4 and 5 from Table 37 below is $550,000.

Table 37: Information and Education Tasks

Categories/Tasks	Priority: HIGH, MED, LOW	Estimated Cost	Milestone	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Potential Project Partners	Objective(s) Addressed
IOE 1- Enhance communication to stakeholders with regular updates, including publish regular newsletters with current water quality	HIGH	$5000/year for 10 years	Publication & Distribution of 2 issues/year and One annual picnic/year and	X	X	X	X	X	X	X	X	X	X	BCD, PLIA	4.2, 4.3
IOE 2-. Continue carrying capacity studies and attempt to quantify recreational usage impacts on lower Platte River corridor (below Little Platte Lake). Establish daily carry capacity limits for peak usage seasons and implement restrictions on the number of daily users if	HIGH	$5000/yr for staff time for duration of plan (total = 10 years or $50,000)	Annual reports of estimated usage compared to carrying capacity limits established from studies.	X	X	X	X	X	X	X	X	X	X	SBDNL	4.4
IOE 3- Work with BCRC and Drain Commission to implement storm water BMPs at road stream crossings	HIGH	$1000/yr. for 10 years	Attend BCRC meetings and engage Drain Commissioner on BMPs for identified sites. Two sites completed by 2015.	X	X	X	X	X	X	X	X	X	X	BCD, PLIA, LA, BWC, CRA	4.7
IOE 4- Encourage appropriate provisions during or before site plan review for water quality and natural resources in the approval process.	HIGH	$1000/yr. for 10 years	Attend planning commission meetings regularly	X	X	X	X	X	X	X	X	X	X	BCD, PLIA, LA, BWC	4.7, 4.3
IOE 5- Publish Platte River Watershed Landowners Handbook and begin distribution throughout watershed.	HIGH	$5000	Handbook published & distributed by 2014.		X									PLIA, BCD	6.2

Table 37: Information and Education Tasks (Cont'd)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*Potential Project Partners*	*Objective(s) Addressed*
IOE 6-.Work with agricultural producers to obtain an approved Conservation Plan and implement USDA-NRCS conservation practices on their land.	MEDIUM	$25,000/year for 10 years	3 plans/year	X	X	X	X	X	X	X	X	X	X	USDA-NRCS, BCD	1.7, 4.3
IOE 7- Participate in Benzie Watersheds Coalition and produce PRWPP progress updates every 3 years. Involve local governmental officials with the reporting process.	MEDIUM	$3000/year for ten years	Annual picnics, bi-annual web updates, at least 3 meetings/year of the BWC. Complete 1st progress update by 2015.	X	X	X	X	X	X	X	X	X	X	BCD, PLIA, LA	4.2, 4.3
IOE 8-Promote adoption of Benzie County Stormwater Control Ordinance and encourage enforcement.	MEDIUM	$10,000 for staff time	Passage of ordinance in 2014		X									BLDHD, PLIA, BCRC, MDNR	2.8, 4.4
IOE 9- Provide water quality information and news about implementation tasks progress to local and regional media.	MEDIUM	$1000/year for ten years	Publicize adherence to 8 mg/m3 standard and progress of watershed plan in annual report.	X	X	X	X	X	X	X	X	X	X	BCD, PLIA	4.2, 4,3
IOE 10- Continue publication of water quality monitoring and BASINS results in scientific literature.	MEDIUM	$1000/year for 10 years	Update website and put information in newsletters. 2 publications	X	X	X	X	X	X	X	X	X	X	PLIA, MDNR	4.2, 4,3

Table 37: Information and Education Tasks (cont'd)

Categories/Tasks	Priority: HIGH, MED, LOW	Estimated Cost	Milestone	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Potential Project Partners	Objective(s) Addressed
IOE 11- Implement a leave no trace outreach and education program for Platte River users (tubers, canoers, kayakers) – stickers or video at liveries about ways to protect the river: litter/trash, bathroom usage, shortcutting, walking along the bottom, etc.	MEDIUM	$1,000/year for staff time for 8 years once launched- total = $8,000	Installation of I/E materials at launch points on Lower Platte River by 2015			X	X	X	X	X	X	X	X	SBDNL, BCD	2.5, 4.2, 1.4, 1.5
IOE 12- Create applications for mobile devices to link outreach and education materials to more watershed users	LOW	$5,000/5 years	Create QR code for PRWPP progress updates and display at access sites by 2015.			X	X	X	X	X				SBDNL	4.2, 4.3, 4.5
BMP 6-Work with landowners to promote forest management practices that are in compliance with current BMPs	MEDIUM	$30,000/year for 10 years	Establish relationships with private landowners. Adoption of 5 plans per yr. on private forest land.	X	X	X	X	X	X	X	X	X	X	MDNR, NRCS, BCD, CRA	3.4, 1.7, 1.3
SSBP 2- Conduct workshops on natural shoreline management for shoreline property owners promoting BMPs to improve fish/wildlife habitat, reduce nutrient runoff into	HIGH	$2000/year for 10 years	2 workshops/yr.	X	X	X	X	X	X	X	X	X	X	BCD, LA, BWC, MNSP	1.4, 4.2,4.3
SSBP 3- Conduct stream bank erosion/sedimentation survey of Platte River and various tributary streams to determine sediment sources	MEDIUM	Labor $6000/year x 2 years. Total =$12,000	Initiate survey in 2014. Resurvey every 5 years		X					X				CRA, GTBOCI PLIA, BCD	1.1, 1.4, 3.4

CHAPTER 10: EVALUATION PROCEDURES

An evaluation strategy will be used to measure progress during the Platte River Watershed Protection Plan's implementation phase and to determine the degree to which water quality is improving. The frequency for the evaluation is approximately every 5 years, with ongoing evaluation efforts completed as necessary. The first aspect of the evaluation strategy measures how well we are doing at actually *implementing* the watershed management plan and assesses if project milestones are being met. The second aspect is to evaluate how well we are doing at *improving water quality* in the watershed. The following sections address each of these issues.

Evaluation Strategy for Plan Implementation

This aspect of the evaluation strategy was developed to measure progress during the implementation phase of the watershed management plan and to provide feedback during implementation. The evaluation will be ongoing and will be conducted through the existing Steering Committee. The Steering Committee will meet two times a year to assess progress on plan implementation and to learn and share information about existing projects throughout the watershed. In addition, plan tasks, priorities, and milestones will be assessed every 5 years to ensure that the plan remains current and relevant to the region and that implementation is proceeding as scheduled and is moving in the right direction.

The evaluation will be conducted by analyzing the existing watershed plan goals and objectives, as well as the implementation tasks and 'milestones' in Chapter 8 to determine progress. Key milestones include conducting necessary research and water quality monitoring, protecting priority land areas, and assisting townships with enacting ordinances to protect water quality. The proposed timeline for each task will also be reviewed to determine if it is on schedule. Other anecdotal evidence (not attached to specific plan milestones) also will be noted that indicates the protection plan is being successfully implemented, such as an increase in the number of updated or new zoning ordinances adopted that deal with water quality and natural resource protections in watershed townships and municipalities.

Additionally, a number of other evaluation tasks will be completed due to the variety of tasks involved in the watershed plan. They will include but not be limited to the following:

- Use the Steering Committee to evaluate specific projects throughout plan implementation as needed.
- Conduct targeted surveys of project partners by direct mail, phone or by website to assist in information gathering.
- Maintain a current list of future target projects, the status of ongoing projects, and completed projects, along with their accomplishments. Keep track of the number of grants received and the money committed in the watershed region to implement aspects of the plan.
- Document the effectiveness of BMP implementation by taking photographs, completing site data sheets and gathering physical, chemical and/or biological site data.

The purpose of the evaluation strategy is to provide a mechanism to the Steering Committee to track how well the plan is being implemented and what can be done to improve the implementation process. Additional development of the strategy will occur as the implementation phase unwinds.

Measuring and Evaluating Social Milestones

Chapter 9 outlines an Information and Education Strategy that addresses the communication needs associated with implementing the watershed protection plan. The strategy is important because developing and carrying out a vision for stewardship of the region’s water resources will require the public and community leaders to become more knowledgeable about the issues and solutions, more engaged and active in implementing solutions and committed to both individual and societal behavior changes.

Residents, local officials, homeowners, and the like must be educated and motivated to adopt behaviors and implement practices that result in water quality improvements.

In this respect, it is important to measure and keep track of the social impacts of the Platte River Watershed Protection Plan. The PLIA, BCD and other organizations conducting outreach must find out what types of outreach are working in the community and what types are not, along with how people's attitudes and behaviors are impacted. Just how much is social behavior changing because of the plan implementation? To answer this question, social impacts must be included when evaluating the progress of plan implementation.

Key social evaluation techniques that will be used to assess the implementation of the IE Strategy, as well as other watershed BMPs, include:

- Continued cooperation between area organizations submitting proposals to implement aspects of management plan.
- Social surveys (and follow up surveys) for homeowners, local officials, etc. to determine watershed and water quality awareness.
- Determining any increases in 'watershed friendly' design and construction (anecdotal evidence will be used).
- Increased awareness (from both the general public and local government officials) regarding the necessity of water quality protection.
- Increase in the number of townships implementing water quality protection related ordinances.
- Incorporating feedback forms into educational and public events and posting them on the Platte Lake Improvement Association website http://www.platte-lake.org/

- Maintaining a list of ongoing and completed projects protecting water quality, along with their accomplishments and who is completing/completed the project.

Short-term Information and Education Task Implementation Strategy

The ongoing highest priority task for the Information and Education strategy will focus on continuing progress of IOE-1 by the BCD and PLIA. Regular communication on progress of WQA-1 to all stakeholders through implementation of IOE-1 will be the most important way to utilize ongoing efforts and existing resources to initiate PRWPP implementation success.

Evaluation Strategy for Determining Water Quality Improvement

The EPA dictates that watershed management plans must outline a set of criteria to determine whether proposed load reductions in the watershed are being achieved over time and that substantial progress is being made towards attaining water quality standards. The evaluation strategy is based on comparing established criteria with future monitoring results. The evaluation strategy will help identify whether water quality monitoring strategies are effectively documenting the progress of implementation tasks toward achieving measurable water quality improvement. The following criteria were developed to determine if the proposed pollutant reductions in the Platte River Watershed are being achieved and that water quality is being maintained or improved:

1. **Total phosphorus concentrations in Big Platte Lake remain below the Consent Agreement maximum level of 8 mg/m^3 95% of the time.** The Consent Agreement states that the phosphorus concentration must be maintained below 8 mg/m^3 95% of the time. In order to achieve compliance with this standard the annual average volume weighted concentration in the lake must be maintained below 6.4 mg/m^3 (Canale et al, 2010).

2. **Total phosphorus concentrations in the Platte River and North Branch of the Platte River remain below 10.0** mg/m^3
   Assuming constant rates of phosphorus release from anaerobic bottom sediments, atmospheric deposition and direct shoreline input, achieving annual average concentrations of 10.0 mg/m^3 for the Platte River will reduce the Big Platte Lake phosphorus loads by approximately 800 lbs/year.

3. **Total Nitrogen concentration in Big Platte Lake, Platte River and tributaries remain above 80 mg/m^3**
   The annual average nitrogen concentration of Big Platte Lake should remain above 80 mg/m^3 to discourage the growth of nitrogen fixing blue green algae such as *Anabeana sp* and *Microcystis sp.* Nitrogen levels are not regulated in surface waters by the State of Michigan or USEPA the maximum levels should remain within statewide averages for inland lakes with a similar trophic status index as Big Platte Lake.

4. **Maintain high dissolved oxygen levels in the Platte River and tributaries.**
   Dissolved oxygen concentrations in Platte Lake and its tributaries are typically above the 7 mg/L standard that is required by the State of Michigan for water bodies that support cold-water fisheries. Thus, it should be considered that water quality throughout the watershed is being maintained if annual average dissolved oxygen concentrations in the Platte River are above 7 mg/L.

5. **Reduce nutrient inputs from stormwater**
   Depending on numerous factors, such as drainage area, land-cover type, and time period between rain events, nutrient loads in stormwater can vary widely. Extensive water quality testing by the PLIA has determined that storm events contribute as much as 15% of total phosphorus load to the Platte River watershed compared to comprising only about 7% of the flow volume. Figure 27 above illustrates the immediate impact of storm water runoff on stream systems. Water quality of the Platte River and Big Platte Lake will be

considered improved if phosphorus loading from storm events can be reduced below 5% of the total annual phosphorus load to the Platte River annually. This will result in approximately 400 lbs less phosphorus being loaded into the Platte River annually.

6. **Reduce stormwater sediment loads draining into the Platte River and its tributaries.** The peak concentrations of total suspended solids (TSS) during storm events in the Platte River and tributaries have been measured as high as 125 mg/L. Reducing the TSS during storm such events to 25 mg/L would represent an approximate 400 lb reduction in phosphorus loads. Additionally, successful management of sedimentation sources will be verified by the absence of any new severe road/stream crossings or severely eroding stream banks in future surveys. Reducing the frequency of required sand trap dredging at the Hatchery will also help verify successful reduction in sedimentation to the upper watershed.

7. **Maintain pH levels within range of 6.5 to 9.0 in Platte Lake and tributaries as required by the State of Michigan.**
   Data from the PLIA Water Quality Monitoring program show that pH levels consistently fall within this range.

8. **Maintain coldwater ecosystems in all water bodies in the Platte River Watershed that are designated coldwater fisheries.**
   The Platte River below Fewins Road and numerous Platte River tributaries must maintain water temperatures below 24° Celsius to sustain their coldwater fisheries. Water temperatures below the thermocline in Platte Lake should generally not exceed 18° Celsius throughout summer months.

9. **Prevent beach closings on Platte Lake or any public beach in the Platte River Watershed due to bacteriological contamination.**
   Prevent beach closings on Platte Lake and other beaches (public and private) due to *E. coli* levels that exceed the State of Michigan water quality standard for single day (>300 *E. coli* per 100 ml of water).

Prevent extended beach closings (there have been none to date) on Platte Lake that result from a 30-day geometric mean measurement that exceeds State standards (>130 *E. coli* per 100 ml of water in 5 samples over 30 days).

10. **Maintain or improve aquatic macroinvertebrate community diversity in streams that have been monitored and expand monitoring efforts to document and assess aquatic macroinvertebrate diversity in other streams throughout the watershed.** Current MDEQ Staff reports (2008) have determined that the Platte River and various tributary streams have acceptable macroinvertebrate communities and good to excellent habitat. Macroinvertebrate health and diversity will be verified by similar results in future sampling efforts.

11. **Reduce *Cladophora* algae growth on the Big and Little Platte shoreline associated with human induced nutrient loading.** *Cladophora* algae occurs naturally in small amounts along the shorelines of Northern Michigan lakes, but grows more extensively and densely as nutrient availability increases. Surveys on Big and Little Platte Lake, the most recent completed in 2003, have documented the location of specific *Cladophora* colonies along the shoreline, as well as the density of growth. Thus, the same information generated during future surveys can be used to determine if there were reductions in the density or size of *Cladophora* growth as a result of water quality improvement projects.

12. **Maintain chlorophyll-a concentrations in surface waters typical for lakes in Northern Michigan.** Chlorophyll-a concentrations should be maintained within normal ranges for similar lakes in Northern Michigan to prevent problems associated with large phytoplanktonic algae blooms that can cause water quality problems (e.g., low dissolved oxygen levels). Typical peak chlorophyll-a concentrations for Big Platte Lake should remain below 3 mg/m3.

13. Maintain or improve water clarity for Big Platte Lake

Minimum summertime Secchi depth should be greater than 10 feet.

CHAPTER 11 FUTURE EFFORTS

The Platte Lake Improvement Association and the Benzie Conservation District and other project partners will continue to build partnerships with various groups throughout the watershed to support future projects involving the implementation of recommendations made in this watershed protection plan. Continued support and participation from key partner groups, along with the availability of monies for implementation of the plan is necessary to keep the momentum generated by planning efforts. Partners responsible for the implementation of the plan are encouraged to review the plan and act to stimulate progress where needed and report to the larger partnership.

The PLIA has identified several priority projects to undertake in the future, in addition to maintaining its current robust water quality and modeling efforts. One of the highest priority tasks is to identify the source of excessive phosphorus loading into the North Branch of the Platte River sub-watershed. This sub-watershed contains mostly natural land with a large wetland complex, however water quality results from the PLIA sampling program have identified excessive phosphorus coming from this sub-watershed as compared to the predicted load based on the land use coefficients in the BASINS model. Understanding the sources of this discrepancy between observed and predicted phosphorus loads is a priority future effort of the PLIA.

The Leelanau Conservancy and Grand Traverse Regional Land Conservancy will continue to evaluate the extent of development on parcels in priority areas deemed important to protecting high water quality and fish and wildlife habitat, along with the region’s scenic and natural character. Voluntary conservation easements established with interested landowners will prevent conversion of natural lands in priority areas to prevent additional pollutants from entering the watershed. Over the next 5 years, the Conservancies have a goal of protecting 500 acres of land within identified Priority Areas, which will prevent 33.45 tons of sediment (or 66,900 lbs), 4,215 lbs N, and 91.5 lbs P from entering the Platte River watershed each year as determined by loading pollutant loading coefficients in Tables 28 and 29.

It is expected that the implementation phase will last more than 10 years, with some efforts expected to be conducted on a yearly basis indefinitely (i.e., monitoring). Grant funds and other financial sources will be used to implement tasks outlined in Chapter 8, including the continuation of water quality assessment and monitoring, installation and adoption of various Best Management Practices (Chapter 5), and educational tasks outlined in the IE Strategy (Chapter 9). In general, funding for short-term tasks (1-5 years) will be attained through state and/or Federal grants, other non-profit grant programs, partner organizations' budgets, fundraising efforts, and private foundations. Funding for long-term tasks will be addressed as needed. The Platte River Watershed Steering Committee will continue to meet annually during the implementation period to discuss and evaluate progress.

Important issues facing the Platte River watershed include: increasing development and the associated increase in phosphorus loading, invasive species and aging septic systems. Priority will be given to implementation tasks (both BMPs and educational initiatives) that work to reduce the impacts from these pollutants or stressors.

Public Outreach

The Information and Education Strategy highlights the actions needed to successfully maintain and improve watershed education, awareness, and stewardship for the Platte River watershed. It lays the foundation for the collaborative development of natural resource programs and educational activities for target audiences, community members, and residents. Environmental awareness, education, and action from the public will grow as the IE Strategy is implemented and resident awareness of the watershed is increased. Implementing the IE Strategy is a critical and important long-term task to accomplish.

Initial IE efforts began years ago by the PLIA and BCD. Both organizations publish newsletters and host educational events, as well as operate informative websites that seek to educate watershed residents. These outreach activities should be continued and paired with additional ones outlined in this management plan. Considerable time and effort will also continue to be put into introducing stakeholders to the watershed protection plan and its various findings and conclusions, as well as providing general information about the Platte River watershed and its valuable and unique qualities.

During the implementation phase of the IE Strategy, the critical first steps are to build awareness of basic watershed issues and sources of pollution, as well as how individual behaviors impact the health of the watershed. It will also be necessary to continue to introduce stakeholders to results and information provided in the revised management plan and show them how they can use the plan to protect water quality in the region.

CHAPTER 12: CONCLUSIONS

The Platte River Watershed Protection Plan was developed to help guide efforts to protect water quality of Big and Little Platte Lake, the Platte River and its surrounding watershed. The initial watershed plan was completed in 2002 and allowed key decision-makers, organizations, resource management agencies and the public to learn about the watershed, what issues confront it and what they can do to protect it. The original plan was prepared by the Benzie Conservation District with collaboration and input from major watershed stakeholders including the Platte Lake Improvement Association and local units of government.

In 2011 these committed partners initiated a process to update the watershed management plan, aided by private consultants, to address EPA 9 elements criteria implemented in 2006. This updated plan includes a significant amount of additional information on the watershed, pollutant concentrations, pollutant sources, load reduction estimates of various BMPs, measurable task milestones to guide plan implementation progress, and a set of quantitative criteria to evaluate the effectiveness of implementation efforts. The Platte River Watershed Protection Plan is meant to assist decision-makers, resource managers, landowners, residents and visitors in the watershed to make sustainable decisions to help maintain, improve and protect water quality.

The success of the Platte River Watershed Protection Plan will depend on continued support and participation from key partner groups, along with the availability of monies for implementation of the identified tasks. Partners responsible for the implementation of the plan are encouraged to review the plan and act to stimulate progress where needed and report to the larger partnership.

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APPENDIX A1: MARCH 2000 CONSENT JUDGEMENT

STATE OF MICHIGAN
CIRCUIT COURT FOR THE 30TH JUDICIAL CIRCUIT
INGHAM COUNTY

PLATTE LAKE IMPROVEMENT ASSOCIATION, a Michigan non-profit corporation, BIG PLATTE LAKE, a natural living body of water in the State of Michigan,

Plaintiffs,

File No. 86-57122-CE

v

HON. THOMAS L. BROWN

MICHIGAN DEPARTMENT OF NATURAL RESOURCES, an agency of the State of Michigan; GORDON E. GUYER, Director of the Michigan Department of Natural Resources; JOHN A. SCOTT, Chief of the Fisheries Division, Michigan Department of Natural Resources,

Defendants.

______________________________________/

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Attorney for Plaintiffs

James L. Stropkai (P24588)
Attorney for Defendants
Michigan Department of Attorney General
Natural Resources and Environmental Quality Division
300 S. Washington Square, Ste. 315
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(517) 373-7540

______________________________________/

STIPULATED ORDER TO AMEND CONSENT DECREE OF MARCH 10, 2000

At a session of said Court, held in the Courthouse for the County of Ingham, Lansing, Michigan, this 6th day of NOV, 2001.

PRESENT: HON. THOMAS L. BROWN
CIRCUIT COURT JUDGE

The Plaintiffs, Platte Lake Improvement Association (PLIA), and Big Platte Lake, a natural living body of water in the state of Michigan, by their attorney Frederick D. Dilley and Defendant, Michigan Department of Natural Resources (MDNR), Gordon E. Guyer, and John A. Scott by their attorneys Jennifer M. Granholm, Attorney General and James L. Stropkai Assistant Attorney General stipulate and agree to amend the Consent Judgment entered by this Court on March 10, 2000 in accordance with the following recitals, terms and conditions:

The parties pursuant to Section 7 of the Consent Decree desire to modify the frequency of sampling for suspended solids from twice weekly from the three intakes and discharges to once a month from the three intakes and discharges.

NOW THEREFORE, the parties stipulate and agree that:

1. Section 4 (Compliance Maintenance) Paragraph A (iii) of the Consent Decree shall be amended to reduce the frequency of sampling from twice weekly from the three intakes and discharges to once a month.

2. This modification of the frequency for sampling of suspended solids, is based on a detailed review by all parties and the implementation coordinator of the suspended solid data that has been collected since August 2000. This review has shown that suspended solids are discharged from the hatchery in very low concentrations and that their concentrations have no measurable impact on the Platte River, thus the costs and effort expended on the sampling would be much better spent on other monitoring efforts.

3. Section 4 (Compliance Monitoring) paragraph A(ii) be amended as follows:

The MDNR, or its successor(s), shall monitor all Hatchery inflows and outfalls for total phosphorus, temperature and flow to calculate the Hatchery discharge a minimum of twice per week (Tuesdays and Fridays) with triplicate sampling utilizing the Implementation Coordinators recommended sampling techniques, and locations, and shall use an independent laboratory for analysis of samples. Suspended solids sampling shall be monitored at all Hatchery inflows and outfalls a minimum of once per month utilizing the Implementation Coordinators recommended sampling techniques, and locations, and shall use an independent laboratory for analysis of samples. Standard composite samples (24 hour) shall be utilized for the collection of all water samples except where composite sampling is not practical (e.g. due to freezing, etc.) in which case grab sampling may be employed. The sampling shall include all water sources in use, including Brundage Spring whenever it is accessible. The sampling technique employed and other relevant details shall be noted on data sheets, which will become part of the Hatchery permanent record.

The parties, by undersigned counsel,
stipulate to entry of the foregoing order.

BOYDEN, TIMMONS, DILLEY & HANEY

Dated: Nov 1, 2001

By:
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MICHIGAN DEPARTMENT OF ATTORNEY GENERAL

Dated: 11/06/01

By: James L. Stropkai
James L. Stropkai (P24588)
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Environmental Quality Division
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IT IS SO ORDERED.

THOMAS L. BROWN

Hon. Thomas L. Brown

APPENDIX A2: NOVEMBER 12, 2010 AMENDMENT

4

STATE OF MICHIGAN
IN THE INGHAM COUNTY CIRCUIT COURT

PLATTE LAKE IMPROVEMENT ASSOCIATION, a Michigan non-profit corporation, BIG PLATTE LAKE, a natural living body of water in the State of Michigan,

Plaintiffs,

v

Case No. 86-57122-CE

HON. JOYCE DRAGANCHUK

MICHIGAN DEPARTMENT OF NATURAL RESOURCES, an agency of The State of Michigan; GORDON E. GUYER, Director of the Michigan Department of Natural Resources; JOHN A. SCOTT, Chief of the Fisheries Division, Michigan Department of Natural Resources,

Defendants.

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CONSENT ORDER SUPPLEMENTAL TO CONSENT JUDGMENT DATED MARCH 10, 2000

At a session of court held in the Ingham County Circuit
Court, State of Michigan this 12 day of NOV, 2010.

PRESENT: HON. JOYCE DRAGANCHUK
Circuit Court Judge

This matter is before the Court on the Verified Motion of Plaintiffs, from which it appears that Defendants are not in compliance with the Consent Judgment dated March 10, 2000 (the "Consent Judgment") and have violated its terms and this Court's Order to Show Cause in response. The parties have now reached an agreement concerning these matters and now propose to the Court a Settlement Agreement for Consent Order Supplemental to Consent Judgment dated March 10, 2000 (the "Settlement Agreement") regarding the disputed issues and this Consent Order Supplemental to Consent Judgment dated March 10, 2000 ("the Consent Order") for the Court's consideration.

The Court now considers and adopts the entirety of the Settlement Agreement of the parties attached hereto and made a part hereof and incorporated by reference.

Accordingly, the Court finds, and the Michigan Department of Natural Resources and Environment acknowledges, that its operation of Platte River Fish Hatchery has violated the terms and provisions of the Consent Judgment dated March 10, 2000 as set forth in paragraph one of the Settlement Agreement.

Except as specifically modified by this Consent Order and the Settlement Agreement, which this Consent Order incorporates, each and every provision of the Consent Judgment dated March 10, 2000, shall remain in full force and effect and the parties acknowledge and the Court agrees that the Court shall retain jurisdiction for the purposes of enforcing the terms and conditions of the Consent Judgment, the Settlement Agreement attached to this Order and this Consent Order.

WE CONSENT TO THE ENTRY OF THIS ORDER:

Dated: 11/8, 2010

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Attorneys for Platte Lake Improvement Association
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Dated: 11/01, 2010

MICHIGAN DEPT. OF ATTORNEY GENERAL ENVIRONMENT NATURAL RESOURCES & AGRICULTURAL DIVISION
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IT IS SO ORDERED.

JOYCE DRAGANCHUK
HON. JOYCE DRAGANCHUK
Circuit Court Judge P-39417

ATTESTED: A TRUE COPY
SUSAN M. BARKLEY
Deputy Clerk

SETTLEMENT AGREEMENT FOR CONSENT ORDER SUPPLEMENTAL TO CONSENT JUDGMENT DATED MARCH 10, 2000

Plaintiff, Platte Lake Improvement Association ("PLIA") filed its Verified Motion for an Order to Show Cause for failure to comply with the Consent Judgment dated March 10, 2000 against the MDNRE. The Court issued its Order to Show Cause For Failure to Comply With the Consent Judgment dated March 10, 2000 on June 11, 2010. The parties have now reached an agreement concerning these matters and now enter into this Settlement Agreement and the attached Consent Order Supplemental to Consent Judgment dated March 10, 2000.

1. **Platte River State Fish Hatchery Violation**. The MDNRE acknowledges that its operation of the Platte River State Fish Hatchery has violated the terms and provisions of the Consent Judgment dated March 10, 2000 (hereinafter "Consent Judgment") on several occasions during 2009. The violations of discharge effluent limits are, but not by way of limitation, as follows:

a. March 2009: 61.31 lb P vs a 55 lb P 3 month limit – 6 lb P violation.
b. April 2009: 60.76 lb P vs a 55 lb P 3 month limit – 5 lb P violation.
c. September 2009: 68.52 lb P vs a 55 lb P 3 month limit – 13 lb P violation.
d. October 2009: 110.07 lb P vs a 55 lb P 3 month limit – 55 lb P violation.
e. November 2009: 110.7 lb P vs a 55 lb P 3 month limit – 55 lb P violation
f. December 2009: 88.15 lb P vs a 55 lb P 3 month limit – 33 lb P violation
g. YTD 2009: 244.59 lb P vs a 175 lb P yearly limit – 69 lb P violation.

These discharges constitute violations of Paragraphs 3.C.v and 9.D.i, which violations are acknowledged by MDNRE.

2. **Compliance with the Consent Judgment.** To bring the facility back into compliance with the Consent Judgment, the MDNRE or its successor(s) will implement the recommendations of the Settlement Agreement Implementation Coordinator ("Implementation Coordinator") agreed upon by the parties in a timely manner and will prevent any future violations. These recommendations presently include, but are not limited to:

a. the full development of the March 14, 2010 hatchery planning model; modifications to effluent treatment; modifications to hatchery operation; and changes in production and feeding schedules.

b. modifications to the treatment system.

c. modifications to hatchery operation.

d. changes in production and feeding schedules.

e. changes to the water quality monitoring regimen.

f. a restart of the 5-year compliance period required by Paragraph 4.D.2.

3. **Remedial Measures Already Taken.** The following key effluent reduction measures have been undertaken recently by MDNRE in response to the violations which occurred in 2009:

a. In December 2009, a review of the effluent management system at Platte River State Fish Hatchery was completed with the assistance of DNRE sewerage treatment facility experts. This review identified areas in which all parties agreed that improvement should be made in the existing effluent system to reduce the risk of any future violations.

b. In December 2009, the clarifier pumping schedule was modified to minimize the flow to, and maximize the settling efficiency of, the sludge storage tank.

c. In January 2010, the rate of disc filter drum rotation below each raceway was changed to reduce flows to and improve the solids settling efficiency in the clarifier.

d. In January 2010, we initiated the addition of ferric chloride to the effluent stream at mutually agreed upon location(s) to reduce soluble phosphorus and to precipitate phosphorus in the clarifier and sludge tank. Additional refinements were completed in June 2010.

e. In March 2010, phosphorus monitoring of sludge tank and clarifier overflow streams was improved by installing an automated sampler to collect seventy-two hour samples of clarifier overflow water along with an automated sampler to sample combined backwash flows from all three disc filters. These monitors allow for better accuracy in mass balance modeling and provide data on efficacy of ferric chloride application.

f. In March 2010, the filter mesh size in C-filter building was reduced and the evaluation of the effects of smaller mesh panels on filter efficiency is in progress at this time (August 2010).

g. In March 2010, water recycling piping from the sludge tank to the clarifier was installed to allow for additional treatment of high concentrations of phosphorus in the sludge tank water.

4. **Additional Effluent Reduction Measures to be Undertaken**. The following key effluent reduction measures shall be undertaken by MDNRE going forward at the direction of the Implementation Coordinator, but not by way of limitation:

a. In 2010, dredge sufficient captured solids from the effluent finishing pond to ensure its continued viability as a waste management system using a plan agreed upon by all parties.

b. In the fall of 2010, the sludge storage tank will be emptied with water from the sludge tank used for lawn irrigation on site and all solids will be removed and disposed of outside of the watershed.

c. In August 2010 and after relevant training is completed, DNRE will conduct real time phosphorus analysis at the PRSFH to determine screen and water treatment effectiveness and to allow for rapid adjustments of the ferric chloride operation. In June 2010, the purchase of the agreed upon new equipment and reconditioning of existing analytical equipment along with the necessary supplies was complete and training in their operation began.

d. By December 2010, a plan to decant water from the sludge storage tank and remove it from the waste stream will be investigated with possible development and implementation in 2011.

e. In 2010 and beyond, the DNRE, with the assistance of the Implementation Coordinator, will develop improved effluent loading early warning measures concerning phosphorus concentrations, to include:

   i. improvements to the mass-balance model for the hatchery;

   ii. development of appropriate statistical relationships between easily measured variables and phosphorus concentrations;

   iii. improvements to the bioenergetics model component of the mass-balance model.

This includes improving the understanding of feed metabolism and salmon bioenergetics by collecting detailed fish rearing data under both normal rearing conditions and experimental conditions. These data will be used to improve the efficiency of feeding schedules with the goal of reducing phosphorus discharges. The resulting hatchery operation model will be used by the DNRE in lieu of previous models.

5. **Watershed Monitoring and Judgment Compliance Audits**. As a result of these violations, the DNRE will restart the five year monitoring period for the watershed lake and river monitoring program as required in the Consent Judgment, Paragraph 4.D.ii and continue to conduct water quality monitoring in the Platte River Watershed for an additional five years from the date of this agreement. Likewise, the Judgment Compliance Audits referenced by Paragraph 5 of the Consent Judgment shall continue for an additional five years from the date of the most recent violation.

6. **Compliance with the Settlement Agreement**. The parties expect that in addition to the measures described and mandated in paragraphs 4 and 5 above, the Implementation Coordinator will continue to provide evidenced-based recommendations on what practices should be employed by the MDNRE or its successor(s) to ensure compliance with this Settlement Agreement, the Consent Order Supplemental to Consent Judgment and the Consent Judgment. The MDNRE or its successor(s) will implement those recommendations after approval by both parties. Where no agreement between the parties can be reached with respect to the adoption and execution of the Implementation Coordinator's recommendations, the parties agree to refer to the Consent Judgment dispute resolution process (Paragraph 8) before proceeding to Court.

7. **Penalty Funds**. As a consequence of its acknowledged violations set forth in Paragraph 1 above, and in accordance with the Consent Judgment provisions contained in Paragraph 9, the DNRE will pay the sum of $118,000 in penalty funds to the PLIA Watershed

Improvement Account no later than January 1, 2011. The parties agree that a portion of these funds, once deposited, will be voluntarily contributed by PLIA to help defer some of the costs of the dredging of the Platte River State Fish Hatchery effluent finishing pond as well as for other key watershed enhancement projects. For these purposes, the PLIA agrees to voluntarily provide $90,000 from the Watershed Improvement Account to help fund pond dredging. This is a voluntary contribution by PLIA and in no way establishes a precedent for future use or application of penalty funds contributed by MDNRE to the PLIA Watershed Improvement Account. In consideration of this voluntary contribution, MDNRE agrees to modify Consent Judgment Paragraph 4.D.ii to grant the PLIA the option to use penalty funds deposited into the Watershed Improvement Account to defray the PLIA's 2% contributions to the lake and watershed monitoring costs for a period of five years beginning with calendar year 2010 charges.

8. **Attorney Fees and Other Fees.** The DNRE agrees to reimburse to PLIA its attorney and other fees associated with PLIA's efforts in connection with the Motion for Order to Show Cause, issuance of the Order to Show Cause and the resolution which has resulted in this Settlement Agreement and its execution. Any dispute concerning the reasonableness and necessity of these attorney fees and costs will be resolved by the Court and, if disputed, the Court may also award actual attorney fees in connection with seeking and obtaining the attorney fees required by this provision.

9. **Best Efforts to Reduce Watershed Phosphorous Discharges.** The DNRE or its successor(s) further agrees to redouble its efforts per Paragraph 3.F.ii. of the Consent Judgment, to include, but not be limited to, direct, timely and proactive input into the Federal, State and local permitting process for all proposed point and non-point source surface and/or ground water discharges within the Platte River watershed in order to minimize the potential adverse impacts

of such discharges on the achievement and maintenance of the Platte Lake Phosphorus concentration standards mandated by the Consent Judgment.

10. **Effect of this Agreement**. It is the parties' intent and that the effect of this Settlement Agreement that as except as specifically modified herein, each and every provision of the Consent Judgment dated March 10, 2000 shall remain in full force and effect and reassert that the Court shall retain jurisdiction for the purposes of enforcing the terms and conditions of the Consent Judgment, this Settlement Agreement and any Order entered pursuant the Settlement Agreement.

PLATTE LAKE IMPROVEMENT
ASSOCIATION

By: ______________________
Wilfred J. Swiecki
Its: President

Dated: 9/29, 2010

RHOADES McKEE
Attorneys for Platte Lake Improvement
Association

By: ______________________
Frederick D. Dilley (P26090)
Business Address:
161 Ottawa Avenue, NW, Suite 600
Grand Rapids, MI 49503
Telephone: (616) 235-3500

MDNRE

By: ______________________________
Rebecca A. Humphries
Its: Director

MDNRE

By: ______________________________

Its: ______________________________

Dated: 11/01, 2010

MICHIGAN DEPT. OF ATTORNEY GENERAL ENVIRONMENT NATURAL RESOURCES & AGRICULTURAL DIVISION

By: ______________________________
~~James E. Riley (P23992)~~
Darryl Paquette (P73604)
Attorney for Michigan Department of Natural Resources & Environment

Business Address:
P.O. Box 30755
525 W. Ottawa St., Fl. 6
Lansing, MI 48909
(517) 373-7540

APPENDIX A3: MAY 6, 2011 AMENDMENT

Rhoades McKee PC
attorneys & counselors

161 Ottawa Avenue NW, Suite 600
Grand Rapids, MI 49503-2793
Phone 616.235.3500 Fax 616.233.5269
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GRAND RAPIDS
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direct dial (616) 233-5164
fdilley@rhoadesmckee.com

May 9, 2011

Darryl Paquette
Assistant Attorney General
Environment Natural Resources
& Agriculture Division
525 W Ottawa St, Floor 6
P.O. Box 30755
Lansing, MI 48909

Re: Platte Lake Improvement Association v Michigan Department of Natural Resources, et al
Case No. 86-57122-CE

Dear Mr. Paquette:

Enclosed please find a true copy of the Consent Order regarding Disposal of Phosphorus Supplemental to Consent Judgment Dated March 10, 2000 with respect to the above referenced matter.

If you have any questions, please feel free to call me.

Yours very truly,

RHOADES McKEE PC

Fred Dilley
Frederick D. Dilley

Enclosure
cc: Wilfred Swiecki w/encl.

LOOKING FORWARD.
GIVING BACK.
1960 2010

U:\59\59034\001\Cor\Paquette3.Doc:tlm

STATE OF MICHIGAN
IN THE INGHAM COUNTY CIRCUIT COURT

PLATTE LAKE IMPROVEMENT
ASSOCIATION, a Michigan non-profit
corporation, BIG PLATTE LAKE, a natural
living body of water in the State of Michigan,

Plaintiffs,

v

MICHIGAN DEPARTMENT OF NATURAL
RESOURCES, an agency of The State of
Michigan; RODNEY STOKES, Director of the
Michigan Department of Natural Resources;
KELLEY D. SMITH, Chief of the Fisheries
Division, Michigan Department of Natural
Resources

Defendants.

Case No. 86-57122-CE
HON. JOYCE DRAGANCHUK

Frederick D. Dilley (P26090)
Rhoades McKee PC
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600 Waters Building
161 Ottawa Avenue, NW
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James E. Riley (P23992)
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Attorney for Defendants
Assistant Attorney General
Michigan Department of Natural Resources &
Environment
P.O. Box 30755
525 W. Ottawa St., Fl. 6
Lansing, MI 48909
(517) 373-7540

CONSENT ORDER REGARDING DISPOSAL OF PHOSPHORUS SUPPLEMENTAL TO CONSENT JUDGMENT DATED MARCH 10, 2000

At a session of court held in the Ingham County Circuit
Court, State of Michigan this 5th day of May, 2011.

PRESENT: HON. JOYCE DRAGANCHUK
Circuit Court Judge

This matter is before the court for an amendment to the Consent Judgment dated March 10, 2000 (the "Consent Judgment"). The parties have reached an agreement to add to the Consent Judgment and now propose to the Court the following paragraph, to be added and incorporated as Paragraph (3)(C)(viii) (under OPERATION OF THE HATCHERY, Hatchery Effluent Limit):

> viii. All materials (solid and liquid) that contain phosphorus and that are removed for disposal from the Hatchery Sludge Tank, Treatment Pond, and Raceways, or are removed from the hatchery premises as a result of any other facility-related operation or activity, shall be removed, without the reasonable possibility of re-entry, from the Platte River watershed unless specifically agreed upon by both parties.

In all other respects, the Consent Judgment and Settlement Agreement for Consent Order Supplemental to Consent Judgment Dated March 10, 2000 of November 1, 2010 (the "Settlement Agreement"), remain in full force and effect.

The Court now considers, adopts, and incorporates Paragraph (3)(C)(viii) into the Consent Judgment, and the Consent Judgment, as amended according to this Consent Order, and Settlement Agreement shall remain in full force and effect, and the parties acknowledge and the Court agrees that the Court shall retain jurisdiction for the purposes of enforcing the terms and conditions of the Consent Judgment, the Settlement Agreement, and this Consent Order.

WE CONSENT TO THE ENTRY OF THIS ORDER:

Dated: May 3, 2011

RHOADES McKEE
Attorneys for Platte Lake Improvement Association

By: ______________________
Frederick D. Dilley (P26090)
Business Address:
161 Ottawa Avenue, NW, Suite 600
Grand Rapids, MI 49503
Telephone: (616) 235-3500

Dated: 4/29, 2011

MICHIGAN DEPT. OF ATTORNEY GENERAL ENVIRONMENT NATURAL RESOURCES & AGRICULTURAL DIVISION
Attorney for Michigan Department of Natural Resources & Environment

By: ______________________
James E. Riley (P23992)
Darryl Paquette (P73604)
Business Address:
P.O. Box 30755
525 W. Ottawa St., Fl. 6
Lansing, MI 48989
(517) 373-7540

IT IS SO ORDERED.

JOYCE DRAGANCHUK

HON. JOYCE DRAGANCHUK
Circuit Court Judge
P-39417

ATTESTED: A TRUE COPY
REBECCA MONTROY
Deputy Clerk

Rhoades McKee PC
attorneys & counselors

161 Ottawa Avenue NW, Suite 600
Grand Rapids, MI 49503-2793
Phone 616.235.3500 Fax 616.233.5269
RhoadesMcKee.com

GRAND RAPIDS
GRAND HAVEN

May 9, 2011

Frederick D. Dilley
direct dial (616) 233-5164
fdilley@rhoadesmckee.com

Ingham County Circuit Court
Clerk of the Court
Veterans Memorial Courthouse
313 W. Kalamazoo
P.O. Box 40771
Lansing, MI 48901-7971

Re: Platte Lake Improvement Association v Michigan Department of Natural Resources, et al
Case No. 86-57122-CE

Dear Clerk:

Enclosed please find a Proof of Service for filing with the Court in the above referenced matter.

Yours very truly,

RHOADES McKEE PC

Frederick D. Dilley

Enclosure
cc: Wilfred J. Swiecki w/encl.
Darryl Paquette w/encl.

STATE OF MICHIGAN

IN THE INGHAM COUNTY CIRCUIT COURT

PLATTE LAKE IMPROVEMENT
ASSOCIATION, a Michigan non-profit
corporation, BIG PLATTE LAKE, a
natural living body of water in the
State of Michigan,

Plaintiffs,

Case No. 86-57122-CE

v

HON. JOYCE DRAGANCHUK

MICHIGAN DEPARTMENT OF
NATURAL RESOURCES, an agency of
The State of Michigan; GORDON E.
GUYER, Director of the Michigan
Department of Natural Resources; JOHN
A. SCOTT, Chief of the Fisheries Division,
Michigan Department of Natural
Resources,

Defendants.

Frederick D. Dilley (P26090) RHOADES McKEE Attorneys for Plaintiffs 161 Ottawa Avenue, NW, Suite 600 Grand Rapids, MI 49503 (616) 235-3500	Darryl Paquette Attorney for Defendants Assistant Attorney General Environment Natural Resources & Agricultural Division P.O. Box 30755 525 W. Ottawa St., Fl. 6 Lansing, MI 48909 (517) 373-7540

PROOF OF SERVICE

Teresa L. McBride, an employee in the law firm of Rhoades McKee, P.C., attorneys for the above-named Plaintiff on May 10, 2011, served a true copy of:

- CONSENT ORDER REGARDING DISPOSAL OF PHOSPHORUS SUPPLEMENTAL TO CONSENT JUDGMENT DATED MARCH 10, 2000 by depositing same in the United Stated Mail and addressed as follows:

Darryl Paquette
Assistant Attorney General
Environment Natural Resources
& Agricultural Division
P.O. Box 30755
525 W. Ottawa St., Fl. 6
Lansing, MI 48909

I declare that the statements above are true to the best of my information, knowledge and belief.

Teresa L. McBride
Teresa L. McBride

APPENDIX B1- 2004 LIMNOTECH BASELINE REPORT

Platte River Watershed Baseline Calibration Report

Prepared for:

Ray Canale
May 11, 2004

Photo credit: Michigan DNR

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Ann Arbor, Michigan

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SUMMARY

The Platte River watershed, which contains Big Platte Lake, is predominantly rural in nature. Historically, Big Platte Lake has been impaired by phosphorus due to loadings from both watershed sources and from a fish hatchery, which discharges to the Platte River upstream of Big Platte Lake. Since peaking in the 1970's, both the hatchery and watershed phosphorus loadings have been greatly reduced, resulting in improvements in Big Platte Lake water quality. However, increasing development in the watershed may threaten water quality in the future.

The objective of this study was to complete a baseline water quality calibration for the Platte River watershed, to support comprehensive watershed management. This baseline calibration was completed using historical flow and phosphorus data that were available at the time of project initiation. The calibration discussed in this report is considered baseline because it is not possible to completely understand watershed processes without additional information. Data gaps identified include wet weather water quality data for the mainstem of the Platte River and its tributaries, total suspended sediment and total phosphorus data collected concurrently, information on the hydrology of North Branch Platte River, and information on the morphometry of the upstream lakes located in the eastern portion of the watershed. The baseline model calibration discussed in this report will be refined in a subsequent phase of the project, to take advantage of additional data that are currently being collected.

Under this baseline calibration phase of the project, a linked watershed and water quality model have been developed and a baseline flow and total phosphorus calibration have been completed using the Hydrological Simulation Program - FORTRAN (HSPF) component of Better Assessment Science Integrating Point and Nonpoint Sources (BASINS). This model simulates both point and nonpoint source loads in the Platte River watershed including the loads to two lakes (Big Platte Lake and Little Platte Lake) and predicts instream flows and phosphorus concentrations at various locations throughout the watershed. The baseline calibration takes advantage of a fairly substantial dataset of flow and total phosphorus data that were readily available at the initiation of this project phase. The calibration period was defined as March 1990 through December 2000 to take advantage of data collected at the USGS flow gage (USGS gage operation began in March 1990) and the availability of meteorological data used to calculate evaporation (at the time this project was initiated, these data were available through December 2000).

The model does a good job predicting flows at the USGS gage, both at an annual and daily time scale. However, additional data collection including flow measurements upstream of Little Platte Lake, is recommended to improve the model's ability to predict flows in the North Branch Platte River. The baseline phosphorus calibration to available data is considered adequate. Currently, the model tends to over-predict instream phosphorus concentrations and is not capturing some seasonal variations observed at several stations.

The phosphorus calibration is considered preliminary because there were no sediment data available to support this calibration and limited wet weather total phosphorus data. Phosphorus data used for the baseline calibration were primarily collected during dry weather, with the exception of data collected from Brundage Creek. The model predicts wet weather phosphorus concentrations at the Brundage Creek station that are in the same

range as the measured data. The phosphorus calibration is expected to be improved during a subsequent phase of this project, with the use of site-specific rainfall data (collected at the fish hatchery) and model calibration to wet weather sediment and total phosphorus data.

This report discusses the development of the HSPF component of BASINS for the Platte River watershed and the completion of a baseline calibration for flow and phosphorus for the period March 1990 – September 2000.

This report is divided into sections discussing:
- Background
- Objective
- Data discussion
- Baseline calibration
- Discussion

BACKGROUND

The Platte River watershed is located in the northwest part of Michigan's Lower Peninsula. The Platte River flows eastward from numerous natural headwater lakes and through Big Platte Lake before finally emptying into Lake Michigan. This watershed is approximately 495 km^2 in size and is currently very rural in nature. The predominant land use is forest (57%), followed by permanent pasture/open lands (16%). Developed lands comprise approximately 6% of the watershed area (Figure 1). There is only one point source discharge in the watershed. This is a Coho and Chinook salmon hatchery that discharges to the Platte River upstream of Big Platte Lake.

"Since the 1920's, the State of Michigan has operated a fish hatchery on the Platte River, approximately 14 km upstream of the lake. In the early 1970's the hatchery was expanded and production shifted from rainbow trout to salmon and other anadromous fish (Walker, 1998)." The water quality of Big Platte Lake declined noticeably in response to this expansion in fish production and the increased phosphorus loading from the hatchery. After a lengthy court case, the Michigan Department of Natural Resources (MDNR) and the Platte Lake Improvement Association (PLIA) agreed on a program to reduce the hatchery phosphorus discharge. The agreement on hatchery discharges was completed in 2000. As a result, the hatchery loadings have declined and water quality in Big Platte Lake has improved.

In order to maintain high water quality in the lake in the future, a watershed-scale modeling study has been initiated. The goal of the study is to reduce nonpoint sources of phosphorus through comprehensive watershed management, focusing not only on current loadings, but also expected future loadings resulting from increased development. This report presents the baseline model calibration for flow and phosphorus.

OBJECTIVE

The objective of this phase of the study was to develop the BASINS model for the Platte River watershed and complete a baseline calibration for flow and total phosphorus using existing data.

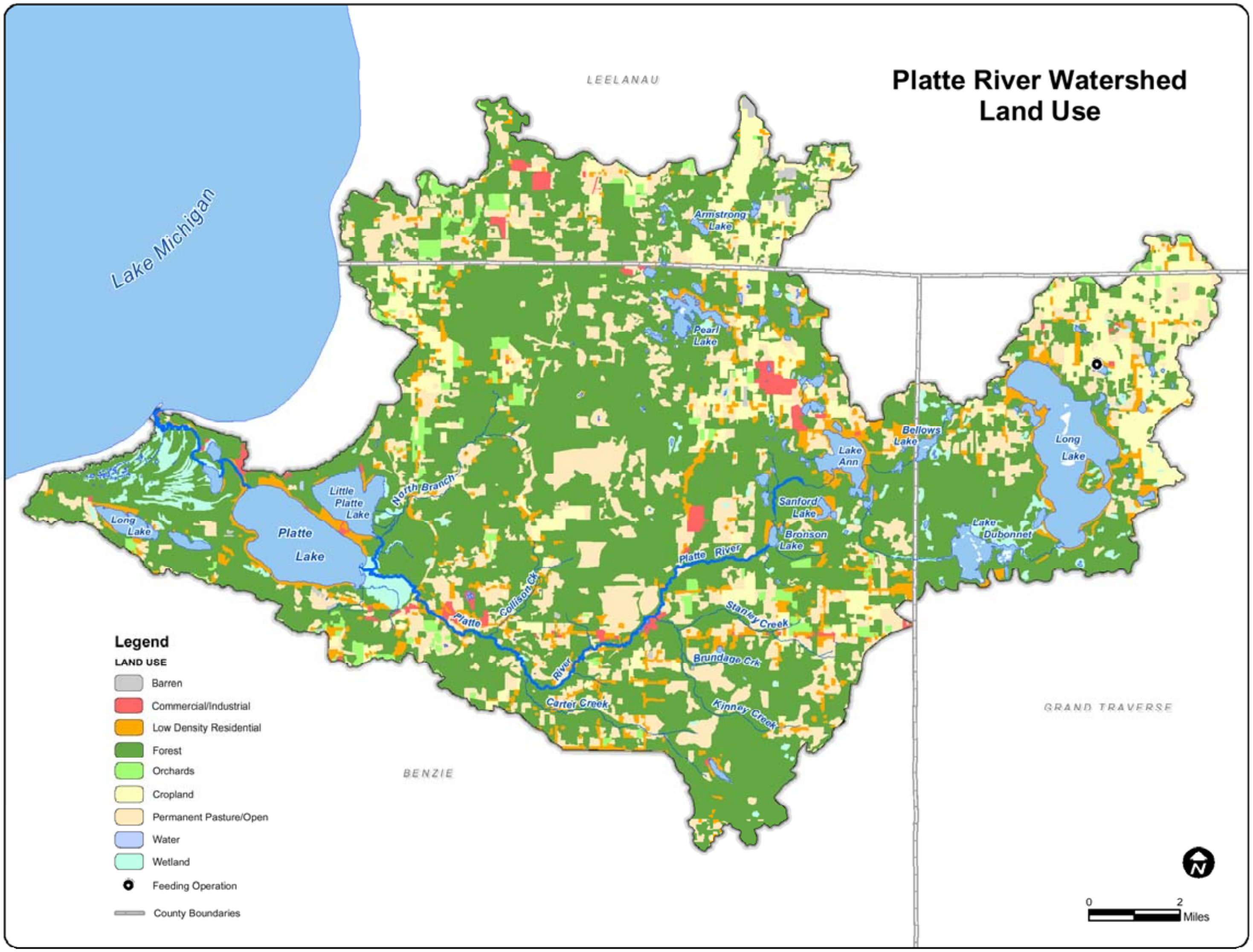

Figure 1. Current land use in the Platte River watershed

DATA DISCUSSION

In a previous phase of the project, the HSPF component of the BASINS model was recommended and selected for application to the Platte River watershed. BASINS is a multipurpose environmental analysis system for performing watershed- and water-quality-based studies. It was developed by the U.S. Environmental Protection Agency's (EPA's) Office of Water and comprises a suite of interrelated components for performing the various aspects of environmental analysis (USEPA, 2001).

The discussion that follows provides a summary of:

- Available input data to support model development
- Available flow and water quality data to support the baseline calibration
- Baseline calibration approach

Input data to support model development

The Platte River watershed boundary was delineated using information obtained from the Michigan Department of Environmental Quality (MDEQ) and compared to the stream network to verify boundaries. The watershed boundary defines the study area and includes portions of three counties. Model inputs obtained for this study area to characterize pollutant sources include soils, land use, hydrographic information and point source data. Climatological data were also obtained and incorporated into the BASINS and HSPF modeling system. A brief description of each data set and its use follows.

Soil information

Soils data are used to estimate model parameters related to infiltration, water storage, and susceptibility to erosion. The USDA STATSGO soil data for the watershed were obtained for the Platte River watershed.

Current land use

Land use data were available in GIS format from the Benzie County Conservation District (Benzie County 1996 data and Grand Traverse County 2000 data) and Land Information Access Association (Leelanau County, 2000 data). Data processing needed to produce a coherent map of land use within the watershed included merging the land use data for the three counties and reclassifying the land use (because the original land use coverages contained many land use classifications that are treated similarly within the model). This consolidation was based on professional judgment, using the labels and descriptive information available with the data. Land use development to support the modeling was previously documented in a memorandum (11/14/02 memo from P. Moskus and C. Theismann to R. Canale). A copy of this memorandum is presented in Appendix A. The final land use categories used to represent current conditions in the model are presented in Table 1. A map showing current land use in the Platte River watershed is shown in Figure 1.

Table 1. Current land use distribution within the Platte River watershed

Land Use Category	Percent of Watershed
Commercial/Industrial	0.6%
Low Density Residential	5.6%
Permanent Pasture/Open	16.1%
Cropland	8.6%
Orchard	1.8%
Feeding Operations	<0.1%
Forest	56.5%
Barren	0.3%
Water	7.8%
Wetlands	2.7%

Hydrologic characteristics

The stream network for the Platte River and its tributaries was obtained in GIS format from the State of Michigan. This information was used to define the reach network in the BASINS model. To populate the model "F-tables", which describe stream morphology and define the relationship between stream depth, area, volume and flow for each stream reach, river cross-sections were measured for the mainstem of the Platte River and many of its tributaries. Mark Mitchell collected this cross-section information. Continuous flows were obtained from the USGS for a gage located on the Platte River near Honor, MI (USGS gage 04126740) for the period March 1990 – September 2000, which is the baseline model calibration period. This gage is currently operable and more recent flows measured at this station will be used in the subsequent phase of this project, to coincide with water quality monitoring being conducted in 2004.

Point source

As noted previously, the Michigan Department of Natural Resources operates a fish hatchery on the river system that is the only permitted point source discharge in the Platte River watershed. Measured effluent flows and concentrations were used to calculate hatchery phosphorus loads for the baseline calibration period.

Climate data

Climatological data are used to simulate the hydrologic cycle. Precipitation and evaporation data, along with soil properties, are used to predict the rainfall-runoff relationship. In addition, the runoff generated by precipitation or snowmelt may cause erosion and transport pollutants to the receiving water. Air temperature, dew point temperature, evaporation, and solar radiation data are used in the snowmelt, stream water temperature, and evaporation modules of the model.

Climatological data are available at three stations near the watershed that are affiliated with national or international data collection organizations. The NCDC maintains two sites where hourly or daily climate data is recorded. These are Frankfort (daily) and Traverse City (hourly). IADN maintains a site that collects hourly data at the Sleeping Bear Dune National Lakeshore. In addition, the fish hatchery has been collecting climatological data for the past several years. Data type and availability are detailed in Table 2.

Table 2. Meteorological station summary

Station	**Period of Record (Source)**	**Data types**
Traverse City	1970-1995 (BASINS via NCDC) 1995-1998 (NCDC)	Hourly precipitation 1970-1998, Daily max temp, min temp, snow depth 1970 – 1998.
Frankfort	1970-2003 (NCDC)	Daily data: precipitation, snow depth, max temp, min temp
SBDNL	1991-2000 (IADN)	Hourly precipitation, solar radiation, relative humidity, temperature, wind speed
Hatchery	1999 – 2003 (Hatchery staff)	30 minute intervals of temperature humidity index, avg. temperature, min temp, max temp, % humidity, wind speed, precipitation,

Because an accurate characterization of climatic conditions is an important model input, differences between the four climate stations were analyzed prior to determining the station(s) that would be used for model inputs. Variations in precipitation were noted between the stations, for the period that all four stations were operable, as shown in Table 3.

The precipitation comparison in Table 3 shows higher amounts of precipitation recorded at Sleeping Bear Dunes in all but two of the years, during which the most precipitation was recorded at Frankfort. This pattern of higher precipitation near the Lake Michigan shoreline was supported by a review of surface wetness maps and data obtained from NOAA http://lwf.ncdc.noaa.gov/servlets/SSMIBrowser , which also showed higher precipitation close to the Lake Michigan shoreline and lesser amounts inland. For the months where the fish hatchery gage was operable on a regular basis (January 2000 – July 2000), precipitation recorded at this gage was compared to the other three stations. Precipitation at the hatchery is most similar to that recorded at Frankfort and Traverse City. These two stations were selected for use in the model. The hatchery data were not used due, in part to the short period of record available at this station, and because in 2000 there were quite a few days when the equipment failed (personal communication with Gary Whelan, e-mail dated 12/22/03) and there are no rainfall data available for those days. It is expected that the hatchery data will be used in the subsequent modeling phase.

At this time, the higher precipitation recorded at the Sleeping Bear Dunes site is not thought to be reflective of conditions observed farther inland in the study area and is not being used in the model.

Table 3. Annual precipitation at each station (inches)

Year	Frankfort	Traverse City	Sleeping Bear Dunes	Fish Hatchery
1992	41.56	28.6	38.86	
1993	38.48	34.8	38.95	
1994	34.87	28.29	30.01	
1995	39.7	29.1	50.2	
1996	37.52	34	53.25	
1997	28.99	24.8	29.43	
1998	38.21	28.7	40.41	
1999	32.2	25.8	35.67	a
2000	30.3	27.1	40.98	15.15[b]

[a] Data were only for 12/20/99 – 12/31/99 and are not summarized in this table
[b] The precipitation value of 38.86 inches on December 3, 2000 was omitted from this analysis

As shown above, significant differences in annual precipitation volume were noted between the four stations. While the three long-term gages noted above are sufficient for completing the baseline calibration, it will be important to use the data collected at the fish hatchery to complete the event calibration (subsequent project phase), as this station will better capture the timing of storms which will be important in completing the event calibration for flow and water quality.

Other model inputs, including air temperature, dew point temperature, wind speed, cloud cover, and solar radiation data were obtained from the Frankfort and Traverse City NCDC sites. Evaporation was calculated using the Penman equation as implemented by WDMUtil program (Penman, 1948 as cited in the WDM program (BASINS, 2001)). Data collected at the Frankfort and Traverse City NCDC stations were used.

Available flow and water quality data to support baseline calibration

Historical flow and total phosphorus data are available for several locations throughout the study area (Figure 2). Both the frequency and period during which these data were available were considered when selecting the baseline calibration period.

Table 4 presents the stations with data available for calibrating baseline flows and total phosphorus. The sampling site at the USGS gage has the longest record for flow and total phosphorus. For this reason it was used as the primary calibration site for both parameters. Flows were also recorded several times per week on the North Branch of the Platte River at Dead Stream road. This gage site is not ideal for flow calibration because the hydrology in this area is complex and not well understood at this time. The braided channels upstream of this station as well as the routing of a portion of this stream's flow through Little Platte Lake are not possible to represent accurately in the model without additional information. Information that would improve the description of flow routing in this area includes the amount of North Branch Platte River flow that enters Little Platte Lake, and the amount that bypasses Little Platte Lake entirely and information on Little Platte Lake outflows.

Phosphorus data were available at the USGS station and at a few other sites in the watershed (See Table 4). These locations were used in the baseline phosphorus calibration to assess the ability of the model to predict watershed phosphorus loads and predict instream phosphorus concentrations at various locations. The station downstream of the Platte Lake outlet was not used in the baseline calibration as water quality at this station is dominated by lake processes and is not as reflective of watershed processes. Furthermore, phosphorus cycling in Platte Lake is very simply represented within BASINS. Because the Platte Lake outlet station's (station 5) primary value is for calibrating the lake model and because this portion of the system (the lake) is being modeled in more detail separately by another researcher, this baseline calibration did not focus on calibrating phosphorus at this downstream station. The Brundage Spring station (station 7) was also omitted from the phosphorus calibration. Brundage Spring phosphorus samples are collected downstream of a pond outlet. This pond is not currently being simulated in the model and so it was not appropriate to compare model output to data collected at this station.

Table 4. Available flow and total phosphorus data for baseline calibration

Station	Period of Record	Frequency
1. Platte River upstream of fish hatchery	11/89 – 4/90 3/99 – present	Once per month (phosphorus and flow) TP collected twice per week
2. Platte River downstream of hatchery	11/89 – 1/91	At least once per month (phosphorus and flow)
3. Platte River at USGS gage station	11/89 – 11/00 3/90 – present	At least once per month (phosphorus) Daily (flow)
4. North Branch at Dead Stream Road	11/89 – 11/00 5/96 – 3/03	TP samples collected 1 per month except between May 1994 and March 1996. Flow collected several times per week.
5. Platte Lake outlet	11/89 – 5/94	Samples collected once per month except between January 1991 and August 1992.
6. Brundage Creek	10/89 – present	TP samples collected approximately twice per week
7. Brundage Spring	3/99 – present	TP samples collected approximately twice per week

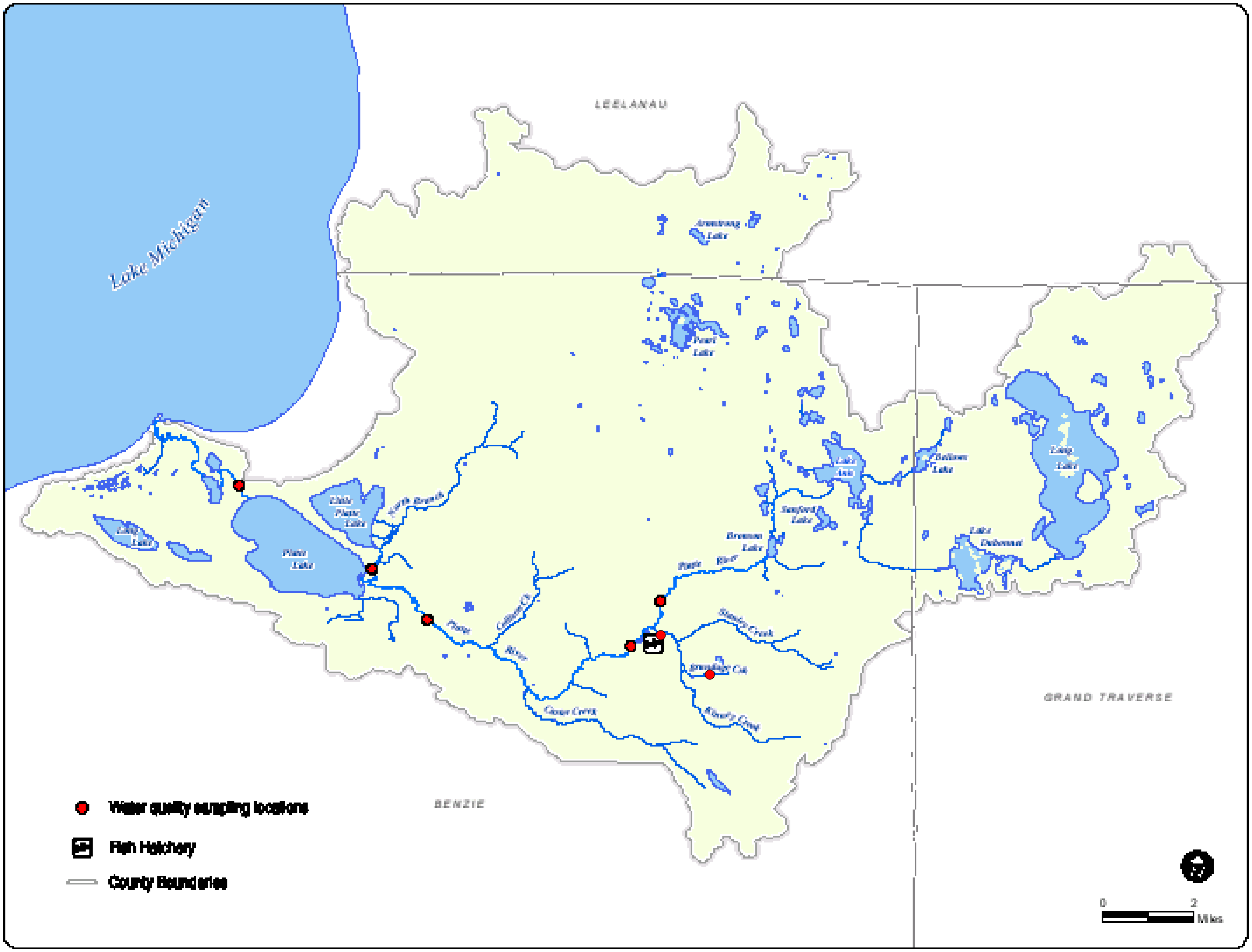

Figure 2. Sampling station locations

BASELINE CALIBRATION

This section discusses the baseline calibration approach, the selection of a baseline calibration period and the calibration results.

Baseline calibration approach

Model calibration is the process of comparing site-specific observations, in this case flow and phosphorus data, to model output, and adjusting the model parameters until the predictions are within an accepted target range of the measured values. The tuning of model parameters is done in a consistent manner and within the range of theoretically defensible values found in literature. The first step to the BASINS model calibration is the calibration of hydrology. Model parameters controlling the amount and timing of runoff, groundwater and streamflow were modified within an acceptable range until an acceptable match between observed and simulated flows is achieved. Once the flow calibration was achieved, the model was then applied to calibrate water quality. The hydrology calibration was not modified when calibrating water quality. Typically, a model is calibrated for suspended sediment after the flow calibration is completed. However, because there were no suspended sediment data available for the baseline calibration, the phosphorus calibration was completed next. In completing the phosphorus calibration, the processes that affect the transport and fate of phosphorus were adjusted within the acceptable range to best match available data. This is discussed in more detail in the following sections.

Baseline calibration period

This section discusses period selection for conducting the baseline calibration. The time period was selected based on the availability of historic meteorological, flow and phosphorus data.

The flow calibration encompasses the period March 1990 through September 2000. The baseline flow calibration period begins on 3/27/1990 because this is the date that the USGS Platte River flow gage began operating. The baseline calibration ends in September 2000 because at the time this work was initiated, the meteorological data used to estimate evaporation were only available through 2000. Meteorological data used to estimate evaporation are now available through a more recent time. Data collected after 2000 will be used to support the next phase of the modeling, which will also take advantage of recently collected instream flow and water quality data, as well as climatic data being collected at the fish hatchery.

The baseline total phosphorus calibration encompasses the period March 1990 through September 2000, to coincide with the flow calibration period. Because the model was set up to begin running in January 1990, comparisons to total phosphorus data collected between January and March 1990 are also included in the figures that follow later in this report. The total phosphorus calibration is considered preliminary because there are no sediment measurements available.

Data gaps identified

In reviewing the available data, several data gaps were identified. First, no suspended sediment data were available for the calibration. Second, limited phosphorus samples have been collected during wet weather events. Event total phosphorus data are important to support total phosphorus calibration. Third, the North Branch Platte River flow routing and flow upstream of Little Platte Lake are not well understood. Finally, limited information is available to describe the morphometry of the numerous lakes located in the eastern portion of the watershed.

Suspended sediment data will improve the phosphorus calibration because phosphorus binds to sediment. Therefore, watershed erosion and scoured sediment are potential sources of instream phosphorus. To calibrate the model for sediment and phosphorus, concurrently collected in-stream suspended sediment and phosphorus data are needed. Recently collected event phosphorus data as well as information relating turbidity and suspended solids will be used to further calibrate this watershed model in the next phase of this project. The wet weather event data will also aid in calibration by better defining site specific EMCs for the Platte River watershed and in-stream response to nonpoint source loadings.

It is currently planned that the baseline calibration will be revisited and refined during a subsequent phase of this project. Additional data collection is also planned and will include instream suspended sediment and phosphorus concentrations during dry and wet weather, as well as precipitation data collected within the study area, at the fish hatchery. It is recommended that at least one additional flow monitoring station be established upstream of Little Platte Lake to confirm that the BASINS model is representing watershed flows well in this area and determine if the existing rain gages well represent precipitation in this watershed. It is also recommended that a field visit be conducted to estimate the percentage of North Branch flows that enter Little Platte Lake and the percent that bypass the lake.

Limited information is available to describe the morphometry of the numerous lakes located in the eastern portion of the watershed. It is recommended that additional information on the volume, depth, surface area, and outlet characteristics of these upstream lakes be collected for use in the model.

Calibration results

The results of the baseline flow and total phosphorus calibration are discussed in this section.

Hydrology

Model calibration is best conducted on a “weight of evidence approach” (Donigian, 2003) that considers both graphical and statistical comparisons (Thomann, 1982). Model performance and calibration are evaluated through qualitative and quantitative measures, involving both graphical comparisons and statistical tests. The metrics used for assessing the calibration were:

- Total water balance in the calibration periods (Figure 3);
- Water balance for individual months (representing wet and dry periods) (Figure 4) and individual years (Figure 5);
- Comparison of probability of exceedance curves for monitored and simulated flows (Figure 6); and
- Visual comparison of monitored and simulated hydrographs (daily time series) (Figures 7-10).

Only those flows measured at the USGS gage between March 1990 and September 2000 were used for the calibration. Other flow data were used for visual comparison to the model predictions. As the following figures show, the annual and seasonal trends observed at the USGS are reproduced well by the model.

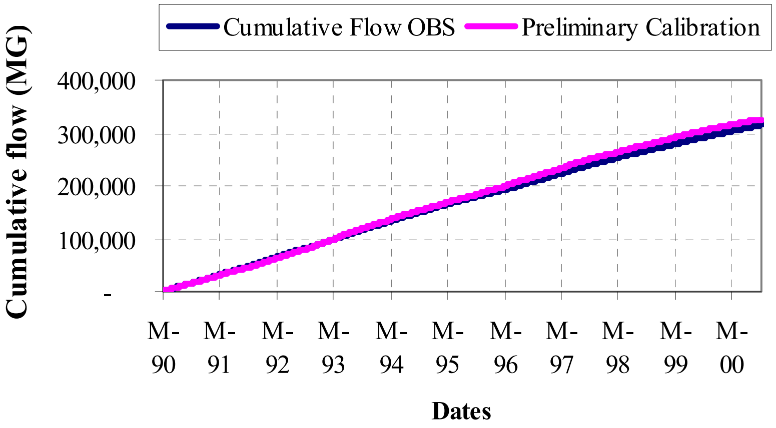

Figure 3. Comparison of cumulative flow during calibration period

Figure 3 shows that the cumulative volumetric flow simulated at the USGS gage is similar to that observed. The cumulative flow difference over the ten-year calibration period equaled 3%. This indicates that over the ten-year calibration period the model does not exhibit significant bias for prediction of flow.

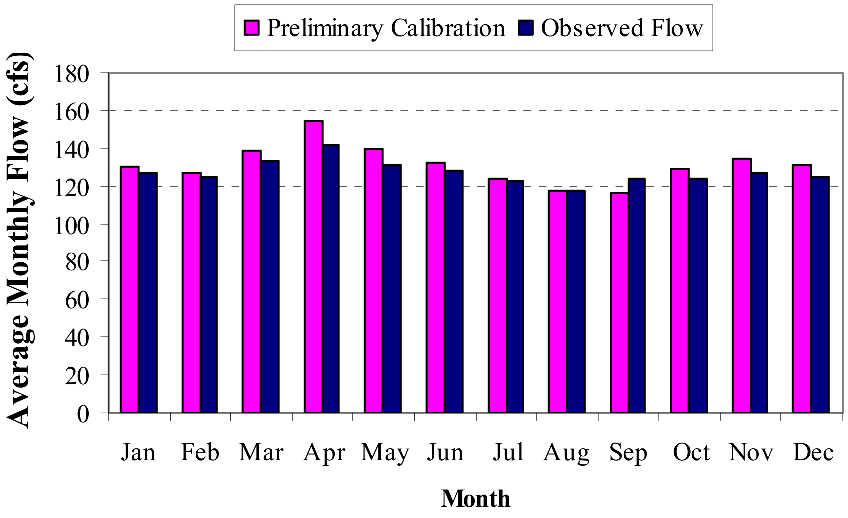

Figure 4. Comparison of monthly average flows during calibration period

Figure 4 shows the average monthly flows observed and predicted during the ten-year calibration period at the USGS gage. This figure shows that the model reproduces the seasonal hydrologic response of the watershed. Overall, the simulated monthly flows are equal to or higher than the measured flows for all months except September. On average, the highest precipitation was recorded in September at both the Frankfort and Traverse City gages, with over an inch more precipitation recorded at the Frankfort gage, on average than at the Traverse City gage. It is suspected that the model results are reflective of spatial variations in precipitation and that these will be resolved during the subsequent modeling phase when the fish hatchery precipitation data will be used.

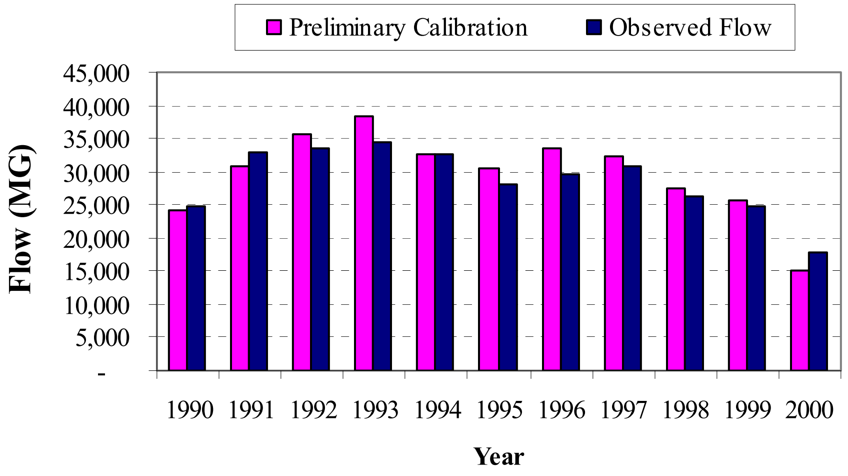

Figure 5. Comparison of annual flow volumes during calibration period

Figure 5 compares the annual volume observed and simulated at the USGS gage. Annual flow volume predictions at the USGS gage range from being 16% lower than observed flows in 2000, to 13% higher than the observed flows in 1996. As discussed previously, the long-term average difference is only 3% (simulated > observed). Model results indicate that the model is adequately simulating the long-term hydrologic response within the watershed and simulates variations in flow volume during dry and wet years. However, based on a review of meteorological data from the Standing Bear, Traverse City and Frankfort locations, it was noted that precipitation volume varies spatially, and quite significantly in some years. While the available meteorological data are adequate for long term-simulations, it is expected that more site-specific meteorological information will improve the calibration during the next phase of the modeling. These data, which are currently being collected at the fish hatchery, will be used to drive the next phase of the modeling that will focus on event calibration.

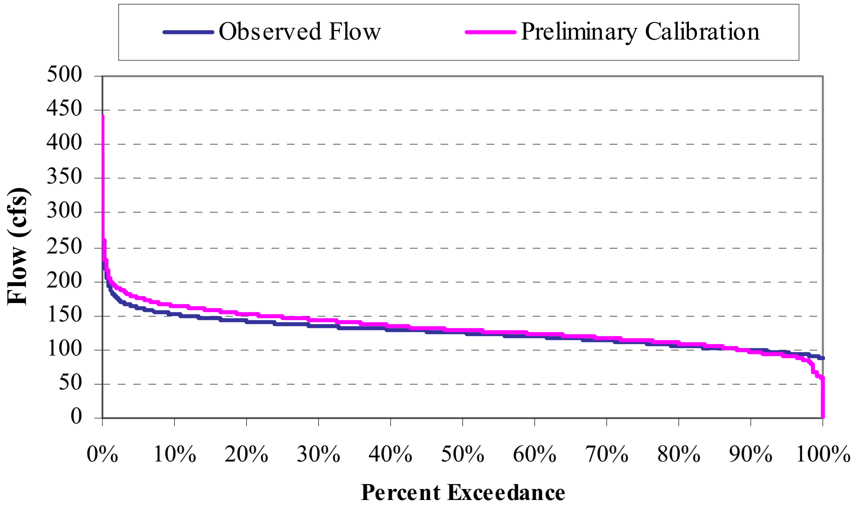

Figure 6. Percent exceedance comparison of daily average flows (3/90-12/00)

Figure 6 presents the percent of average daily flows that exceed a given flow, for both simulated and observed flows at the USGS gage. The similarity in the observed and simulated flows indicates that the flows predicted by the model are within a similar range and occur with similar frequency as those observed at the gage. In addition, the shape of the frequency of exceedance curve indicates that the Platte River is groundwater-fed (Seelbach, 1997).

Figure 6 illustrates that the model is slightly over-predicting observed flows during high-flow conditions and under-predicting observed flows during drier conditions. This may reflect spatial variations in precipitation and be caused by the use of precipitation gages located outside the watershed. It may also reflect the impact of the numerous lakes that are located upstream of the USGS flow gage. These lakes serve to mediate the high flows and likely contribute flows during dry conditions. Hydraulics for these lakes were estimated using limited bathymetric data. The calibration would be improved by incorporating additional information on the volume, depth, surface area, and outlet characteristics of these lakes into the model.

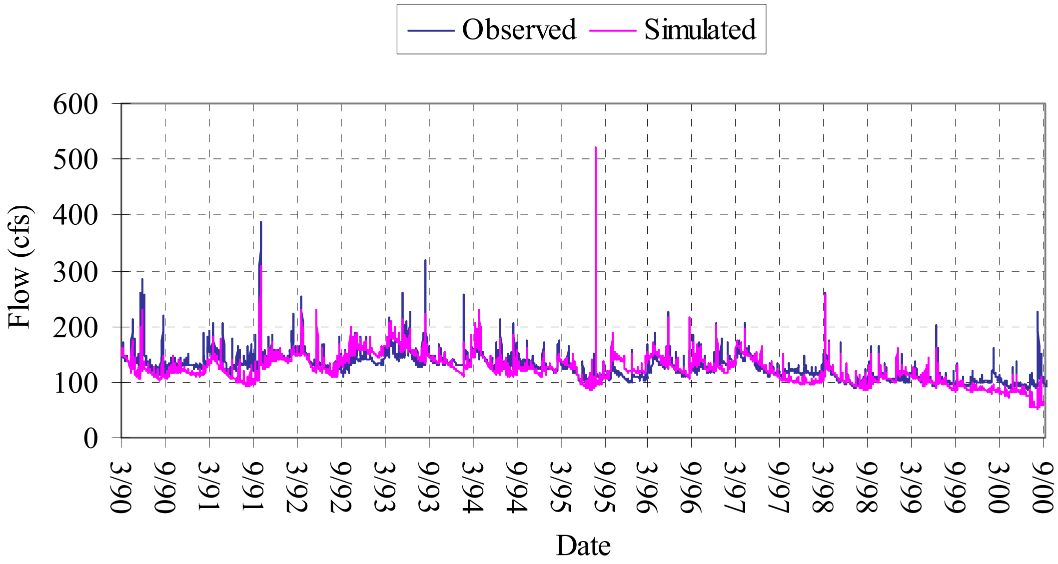

Figure 7. Daily average flow comparison at Platte River USGS gage 04126740.

Figure 7 shows the daily average flows simulated by the model and those observed at the USGS gage. This site has the most reliable and longest flow data set available on the Platte River. For this reason it was the primary flow calibration site. The model predicts flow similar to that observed at the gage for the entire 10-year period, and predicts periods of low and peak flow reasonably well. This indicates that the model likely represents the hydrology of the watershed upstream of the USGS gage well.

Figure 8 shows the percent difference between predicted and observed flows over the 10-year period. Daily flow at the USGS gage is over-predicted by up to 79% and under-predicted by 73%. On average, as discussed previously, the model does a good job predicting flow at the USGS gage and these large variations in daily flows, which are rare, likely reflect storms which did not occur in the study area, but which were recorded at the Frankfort or Traverse City gages or conversely, storms which occurred in the study area but which were not captured by the two precipitation gages.

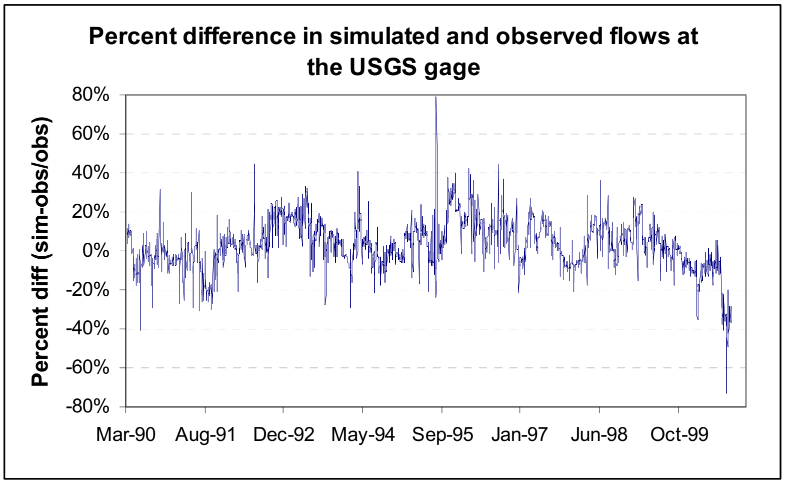

Figure 8. Percent difference in simulated and observed flows at the USGS gage

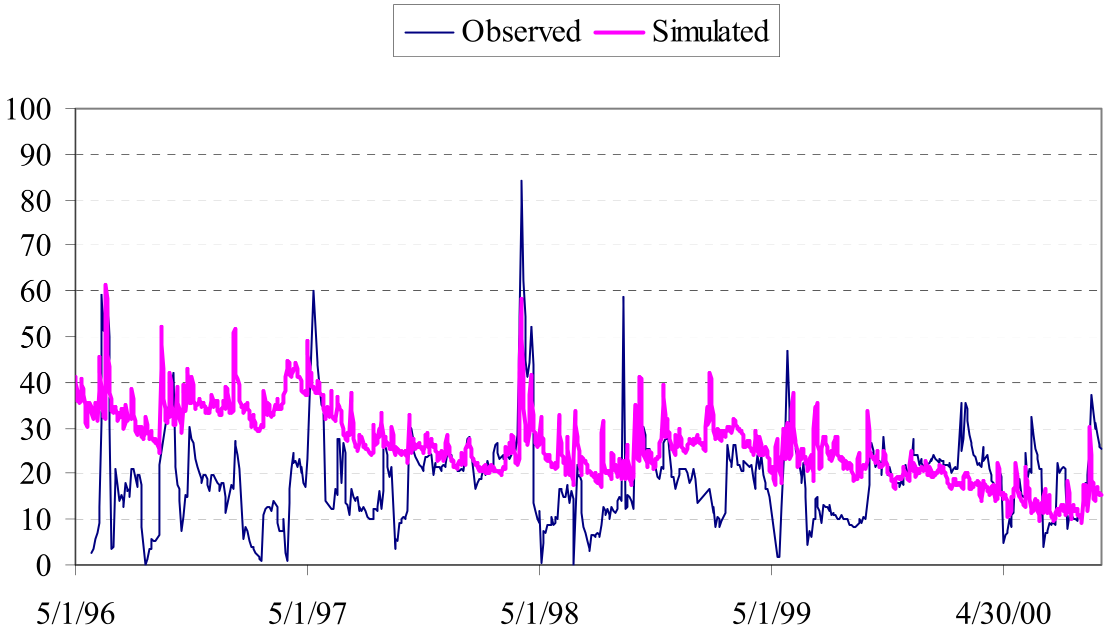

Figure 9. Daily average flow comparison for North Branch Platte River at Dead Stream Rd.

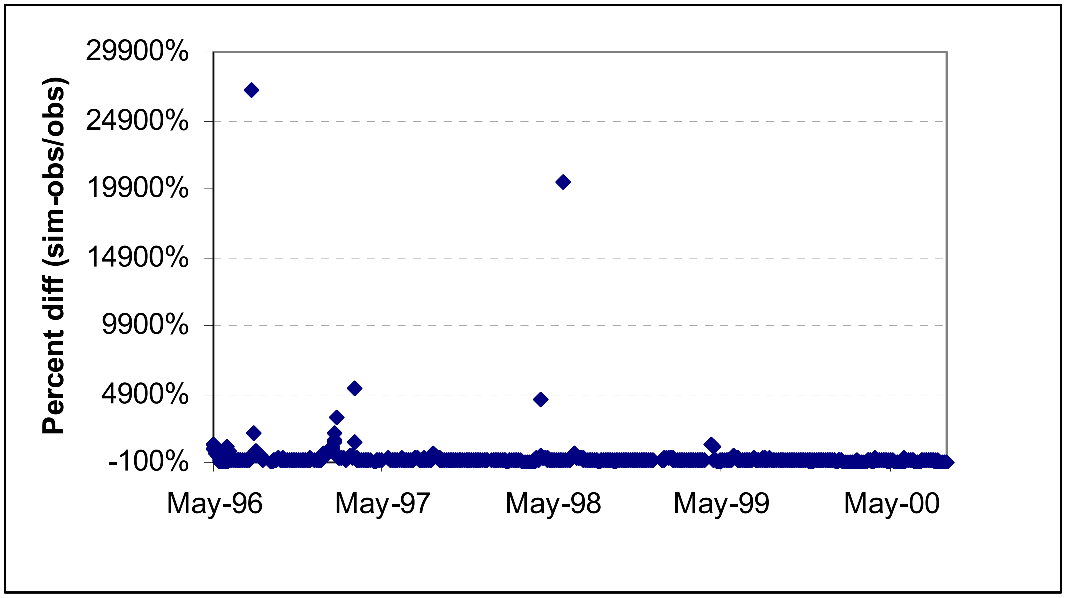

Figure 10. Percent difference in simulated and observed North Branch Platte R. flows

Figure 9 shows the predicted and observed flows in North Branch Platte River at Dead Stream Road and Figure 10 shows the percent difference in predicted and observed flows. This station was not used for the hydrology calibration. However, it is useful to compare predicted and observed flows. As shown in these figures, the predicted flows at this station do not compare as well to the observed data as at the USGS station and the model consistently over-predicts the observed flows. This points to needed improvements in representing the hydrology of the area in BASINS (e.g., braided streams and Little Platte Lake). These results may also indicate that precipitation patterns in this watershed are different from those reflected at the existing climate stations or that this river's flows and possibly Little Platte Lake's hydrology are influenced by Lake Michigan (e.g., via groundwater). It is recommended that at least one additional flow monitoring station be established upstream of Little Platte Lake to confirm that the BASINS model is representing watershed flows well in this area and determine if the existing rain gages well represent precipitation in this watershed. It is also recommended that a field visit be conducted to estimate the percentage of North Branch flows that enter Little Platte Lake and the percent that bypass the lake. This information should help improve the flow calibration at this station.

Total Phosphorus

The preliminary phosphorus calibration focused on comparisons between simulated and measured phosphorus concentrations and loads at five of the seven stations using data collected between March 1990 and September 2000, coinciding with the period selected for the flow calibration. Where available, data collected between January and March 1990 are also included in the calibration figures because the model runs included this period. As discussed previously, the station located downstream of the Platte Lake outlet and the Brundage Spring stations were excluded from this baseline calibration. The station downstream of the Platte Lake outlet was excluded because concentrations at this site are influenced more by lake processes than watershed processes and this station would therefore not be a good station for calibration of the watershed modeling. The Brundage Spring station was excluded because it is reflective of water at the pond outlet, and this pond is not simulated in the watershed model.

The total phosphorus calibration proceeded in a three-step iterative process. The event mean concentrations (EMCs) for each land use were estimated using the HSPF model, and compared to literature values (Table 5). Next, diffuse loadings generated by the model (unit area loads) were compared to the range cited in the literature. Finally, model parameters were adjusted until simulated TP was similar to in-stream total phosphorus measurements at the sampling stations.

Primary calibration parameters included:

- Hydrology parameters affecting overland flow volumes such as infiltration (INFILT), groundwater storages (UZSN, LZSN), and interception (INTERCP).
- Pollutant loading parameters such as accumulation rate (ACQOP), maximum storage (SQOLIM), and groundwater concentration (IOQC, AOQC) of TP.
- Pollutant washoff parameters such as the rate of runoff that will remove 90% of pollutants (WSQOP).

Hydrology parameters are mainly adjusted during flow calibration. However, the volume of overland flow affects the rate pollutants washoff the land surface. Thus, having reasonable overland flow predictions are necessary. Once a suitable flow calibration is reached pollutant loading and washoff parameters are adjusted to match EMC and UAL data.

The resulting baseline calibration was attained using model-predicted EMCs and unit area loads (UALs) that are at or near the low end of what is typically cited in the literature. This may be reasonable for this watershed, considering that the dominant soil types in the Platte River watershed are sandy and have higher infiltration and lower phosphorus content than other areas of the country.

Table 5. Simulated total phosphorus EMCs and UALs compared to literature

	EMCs (ug/l)		UALs (kg/ha/yr)	
Land use	**Simulated**	**Literature**	**Simulated**	**Literature**
Commercial/Industrial	153	200-1,100[d]	0.88	0.19-6.23[b]
Low Density Residential	48	520[f]-570[g]	0.23	0.46-0.64[c]
Grassland/Open space	8	10[g]	0.02	NA
Cropland[a]	21	20 – 1,700[d]	0.06	0.08-3.25[b]
Orchard	21	NA	0.07	NA
Feeding Operations	718	2,900 – 3,600[d]	4.21	21-795[b]
Forest	9	10 – 110[d]	0.04	0.02-0.83[b]
Barren	20	80[e]	0.02	NA
Wetlands	8	80[f]	0.02	NA

NA – data for specific land use not located.
a. Includes literature values for "general agriculture"
b. Reckhow et al., 1980.
c. EPA, 1999
d. Loehr, 1974
e. Ross and Dillaha, 1993
f. Keiser, 2004
g. Baird and Jennings, 1996

Total phosphorus data were compared to model results at 5 locations (Figures 11 through 16). Some of these sites are impacted primarily by non-point sources and others are impacted by the hatchery effluent as well as non-point sources. Sites not influenced by the hatchery effluent include station 1 (Figure 11 and Figure 12, Platte River above the hatchery), station 4 (Figure 15, North Branch Platte River at Dead Stream Road), and station 6 (Figure 16, Brundage Creek). Sites that are influenced by hatchery effluent include station 2 (Figure 13, Platte River below hatchery), and station 3 (Figure 14, Platte River at the USGS gage). Total phosphorus samples were also collected downstream of the Platte Lake outlet (Station 5) and from Brundage Spring (Station 7). The phosphorus cycling in Platte Lake is very simply represented within BASINS. Because this portion of the system (the lake) is being modeled in more detail separately by another researcher, and because this water quality monitoring station is more strongly influenced by lake process than watershed processes, this baseline calibration did not focus on calibrating phosphorus at this downstream station. The Brundage Spring site was not used because water quality samples were collected downstream of a small headwater pond that is not being simulated in the model at this time.

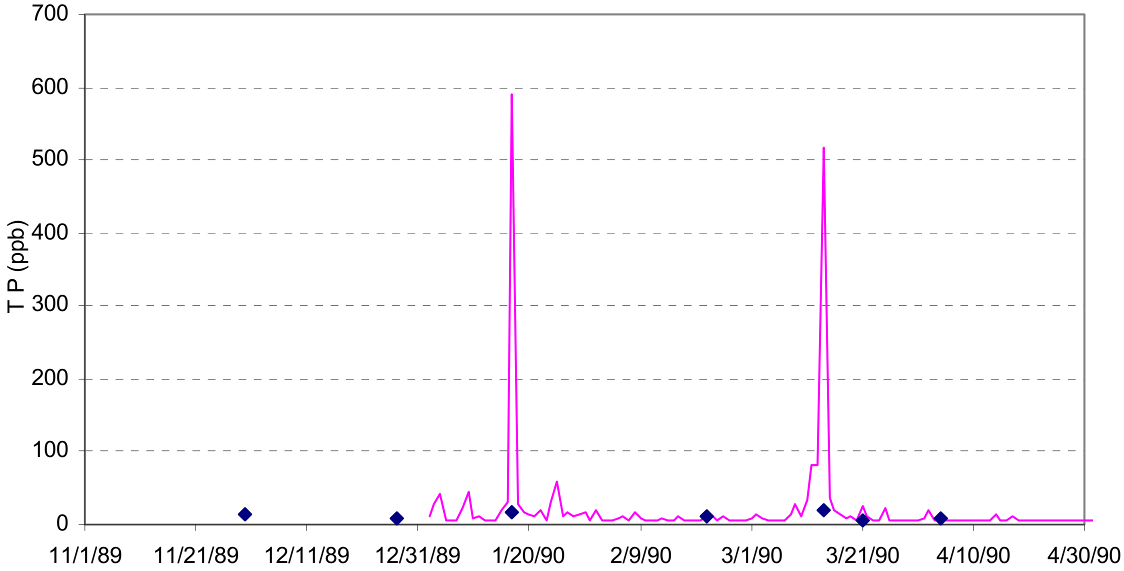

Figure 11. Simulated and observed total phosphorus at station 1, Platte River above the hatchery January 1990 – April 1990

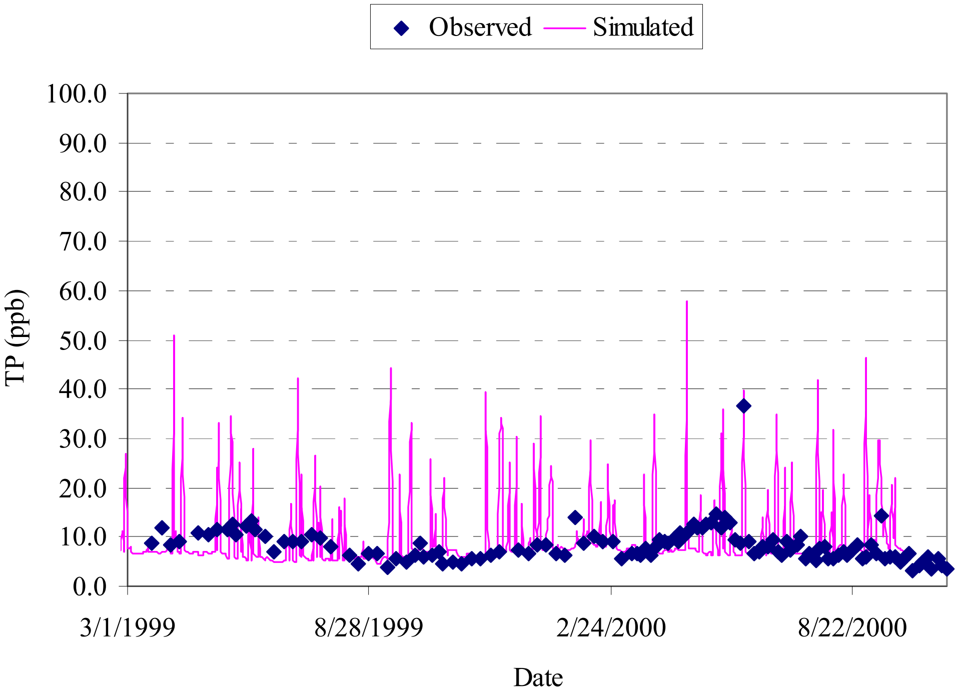

Figure 12. Simulated and observed total phosphorus at station 1, Platte River above hatchery, from March 1999 – September 2000

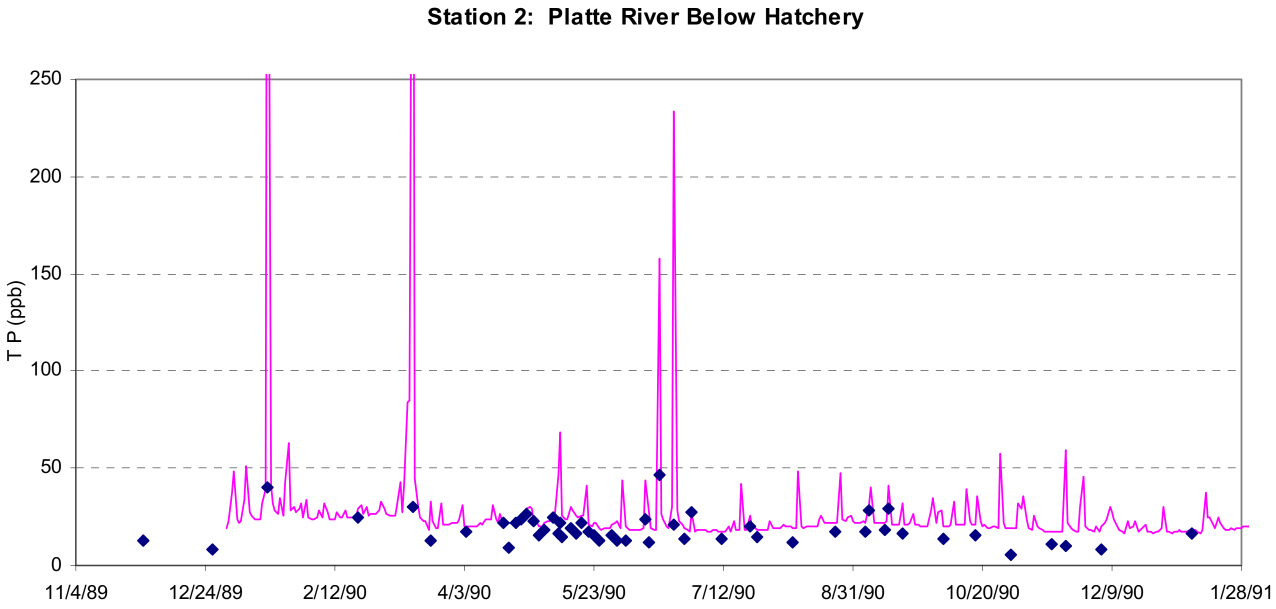

Figure 13. Simulated and observed total phosphorus at station 2, Platte River below hatchery

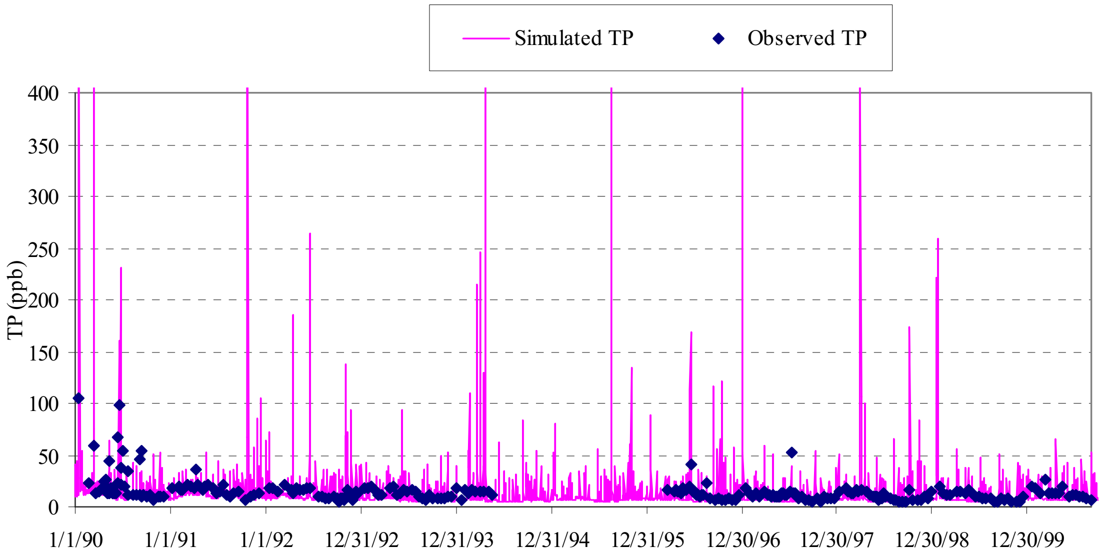

Figure 14. Simulated and observed total phosphorus at station 3, USGS gage

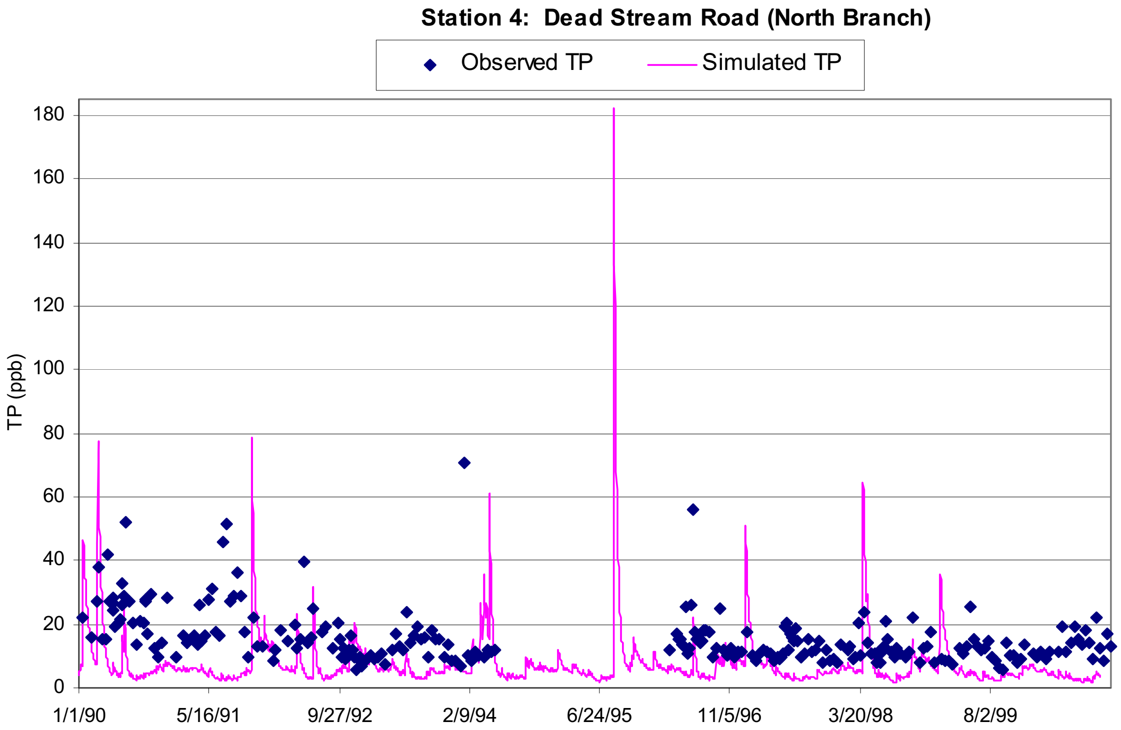

Figure 15. Simulated and observed total phosphorus at station 4, North Branch of the Platte River at Dead Stream Rd.

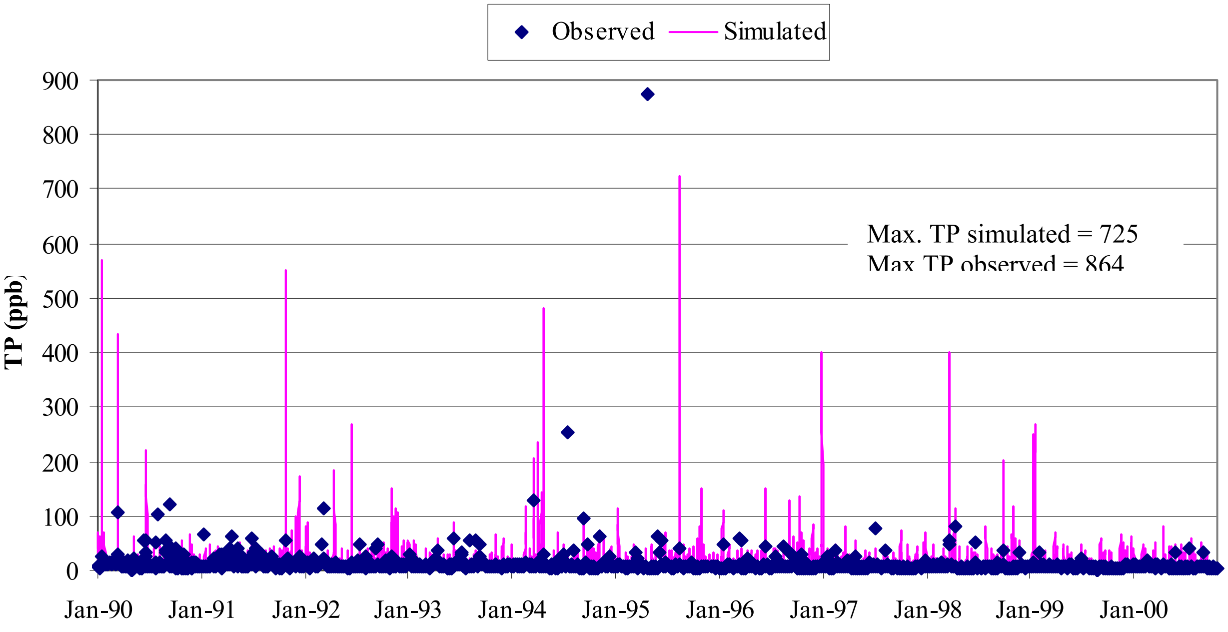

Figure 16. Simulated and observed total phosphorus at station 6, Brundage Creek at hatchery intake

Figure 17 illustrates the percent difference in simulated and observed phosphorus concentrations at each of the monitoring stations.

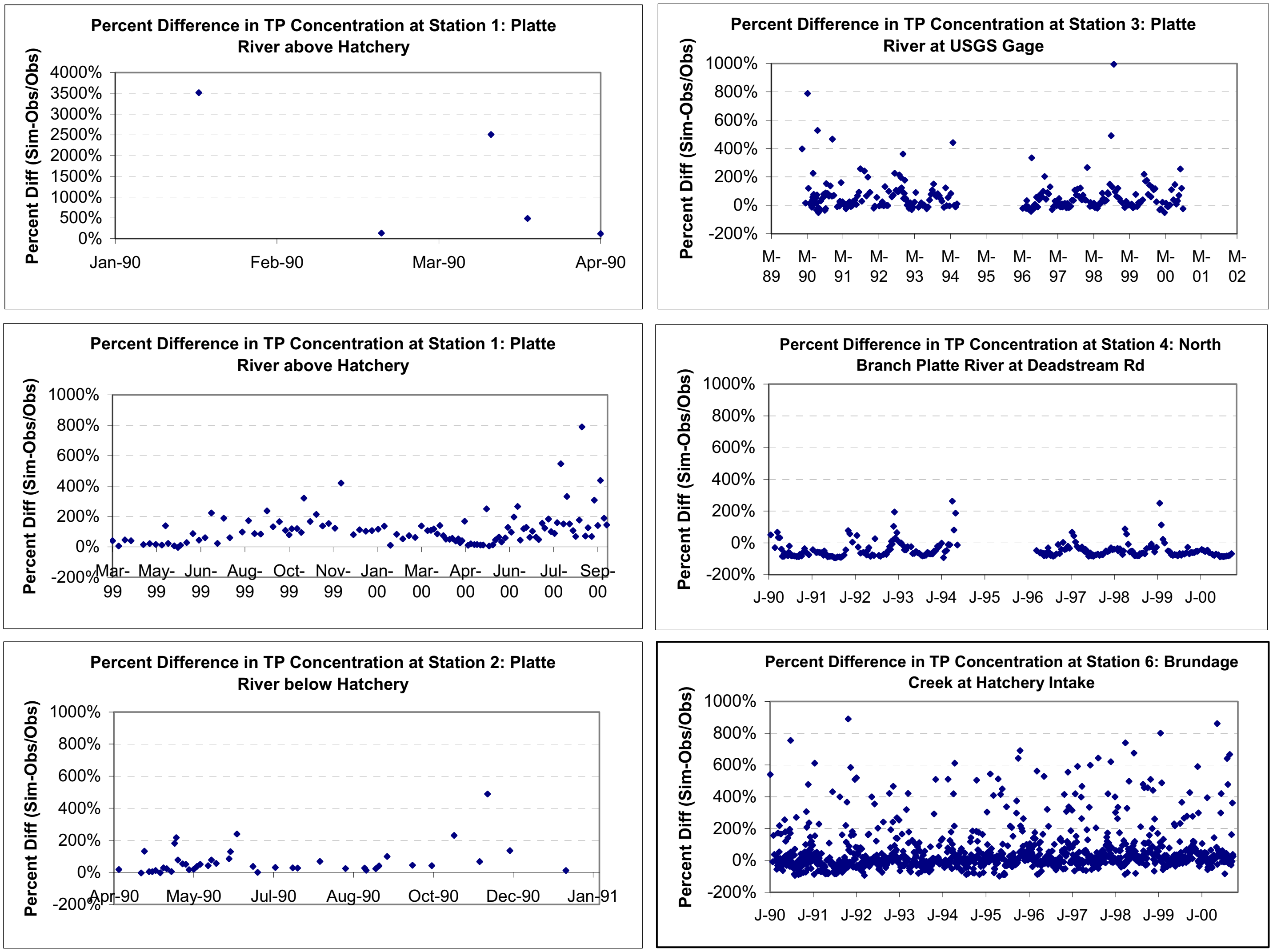

Figure 17. Percent difference in predicted and observed total phosphorus concentrations

Through visual comparisons of simulated and observed phosphorus concentrations, it was determined that the baseline total phosphorus calibration is acceptable for both dry and wet weather conditions at most stations. It should be noted that because most of the phosphorus data available for calibration were collected during dry weather (with the exception of Brundage Creek), and because there were no sediment data available for calibration, the phosphorus calibration is considered preliminary. The model does appear to be consistently over-predicting total phosphorus concentrations during dry weather, with the exception of North Branch of the Platte River at Dead Stream Road, where the model more consistently under-predicts total phosphorus concentrations. This may be due, in part, to the fact that the model is under-predicting flows at the USGS station during dry conditions, which would result in less dilution of phosphorus loads during low flow. Conversely, the model is over-predicting flows in the North Branch Platte River and the low predicted phosphorus concentrations at this site may be a result of too much dilution during dry conditions. It is expected that the phosphorus calibration will improve once the hydrologic calibration is revised using site-specific meteorological data collected at the hatchery, and additional information on the flow routing on the North Branch Platte River. The additional sediment data that will be collected this year is also expected to significantly improve the phosphorus calibration during wet and dry conditions.

Most of the wet weather data available for the baseline calibration were collected at the Brundage Creek hatchery intake. As such, the wet weather phosphorus calibration can best be examined by reviewing the Brundage Creek graph. The range of model predictions compared reasonably well with the phosphorus measurements at this station, with maximum predicted concentrations equaling 725 ug/l and a maximum measured concentration equaling 864 ug/l. It does appear that there were some storms that the model is simulating (due to rainfall observed at Frankfort or Traverse City), which were not reflected in the observations. There are also some instances where the model did not simulate a storm (due to no rain observed at the two rain gages), but where it appears a rain event did occur in the watershed. These differences are expected to be improved in the next phase of this project, due to the availability of recent climate data at the fish hatchery. Similar to what was observed at other stations, the dry weather phosphorus concentrations are being over-predicted by the model. The quality of the wet weather calibration at the other stations is difficult to assess at this time due to a lack of wet weather data. The routine monitoring at these other stations resulted in 11 sampling events that occurred on the same day that it rained more than 0.5 inches. As the infrequent sampling during wet weather events reflects, samples collected on days with rain were not part of coordinated efforts to collect data that would characterize the water quality of storm runoff. The samples were collected on days with rainfall by chance.

In reviewing the calibration plots for the North Branch Platte River, it has been noted that phosphorus concentrations appear to be varying seasonally. This seasonality is not captured by the model at this time and these variations may point to the need for an improved model of Little Platte Lake. It has also been noted in Walker (1998), that, “In a study of the St. Paul water supply (Walker, 1992; Walker et al., 1989), similar seasonal patterns were observed in watersheds containing high percentages of wetlands.” The wetlands upstream of the Dead Stream Road station may similarly be causing the seasonal patterns in phosphorus concentrations.

DISCUSSION

A baseline calibration of flow and total phosphorus was completed during this phase of the project using data and information that were available at project initiation. This calibration focused on the 1990-2000 period, to take advantage of available flow, total phosphorus and climatic data. As noted previously, several data gaps were identified that will need to be addressed before the calibration can be finalized. Specifically, the model calibration is currently limited by a lack of instream suspended sediment data (collected during dry and wet weather), concurrent collection of storm event concentrations for suspended sediment and phosphorus, precipitation data collected in the study area and flow measurements on North Branch Platte River upstream of Little Platte Lake. The calibration would also be improved by incorporating additional information on the volume, depth, surface area, and outlet characteristics of the upstream lakes located in the eastern portion of the watershed into the model. These data gaps are discussed in more detail below.

There are no instream suspended sediment data available during the baseline calibration period and wet weather phosphorus data are only available at one of the stations. The lack of these data adds uncertainties to the modeling, especially during wet weather events, as it is not currently possible to assess the accuracy of wet weather phosphorus predictions throughout much of the watershed. For example, phosphorus tends to bind to sediment, and the erosion and transport of sediment laden with phosphorus is a primary means of phosphorus reaching the stream. Thus, the amount of sediment delivered to the stream has an impact on instream phosphorus concentrations. Furthermore, once the phosphorus reaches the stream it settles or is resuspended along with the sediment.

Collection of concurrent suspended sediment and phosphorus data during wet weather events will provide a better understanding of site-specific runoff concentrations (event mean concentrations), sediment and phosphorus interaction, and peak storm concentrations.

Additionally, it is expected that the calibration will be improved by collection of rain data within the watershed, such as that which has been initiated at the Platte River fish hatchery. It is recommended that the precipitation data collected at the fish hatchery be used to compliment the Frankfort and Traverse City precipitation data in the next phase of this project to more accurately characterize variations in precipitation patterns throughout the watershed.

It is recommended that additional flow measurements from the North Branch Platte River upstream of Little Platte Lake (e.g., at Indian Hill or Hooker Road) be obtained, and an estimate of the percent of North Branch flows that bypass Little Platte Lake be made. This will also help improve the hydrology calibration at the Dead Stream Road station and it is expected that this will also benefit the phosphorus calibration at this station. Once available, all of the aforementioned data will be used to refine the calibration and provide a better understanding of the processes occurring within the stream and watershed.

The numerous lakes located in the eastern portion of the watershed were described in the model using limited information. The calibration would also be improved by collecting and incorporating additional information on the volume, depth, surface area, and outlet characteristics of these upstream lakes into the model.

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APPENDIX A. LAND USE DOCUMENTATION MEMORANDUM

Limno-Tech, Inc.
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Memorandum

DATE: November 14, 2002
PROJECT: **PLATTE2**

TO: **Ray Canale**

FROM: **Penelope Moskus**
Chad Theismann

CC:

SUBJECT: **Platte Watershed Land Use**

The purpose of this memorandum is to provide some background information on the land use developed for the Platte River watershed. This memorandum will provide a brief overview of the data sources and data processing that occurred when producing the current Platte River watershed land use map.

Data sources

The data that were compiled for mapping the current Platte River watershed land use were obtained from several sources. These are presented in Table 1 below, along with the date of the land use data.

Table 1. Land use sources

County	LTI obtained data from:	Date
Benzie	Ron Harrison	1996
Grand Traverse	Ron Harrison	2000
Leelanau	Paul Riess, Land Information Access Association	2000

Data processing

Data processing needed to produce a coherent map of land use within the watershed included merging the land use for the three counties and reclassifying the land use. In merging the land use data, it was noted that some small gaps in the data occurred near the county boundaries. These gaps were very small, ranging from 25-75 feet. The approach used for classifying the gaps was to apply the adjacent land use to the gap, from the coverage that had the most recent date.

The land use coverages contained many land use classifications. These were classified using different labels, as shown in Table 2 below. In order to develop a consistent land use classification scheme for the entire watershed that does not vary by county, some of the land uses were renamed. Additionally, many similar land uses were consolidated into a more general category for modeling (e.g., beaches were reassigned to the “barren” category). This consolidation was based on professional judgment, using the labels and descriptive information available with the data. Table 2 presents the different labels that were assigned to land uses in the watershed and the consolidation that LTI undertook when developing the Platte River watershed land use map.

Table 2. Consolidation of land use classifications

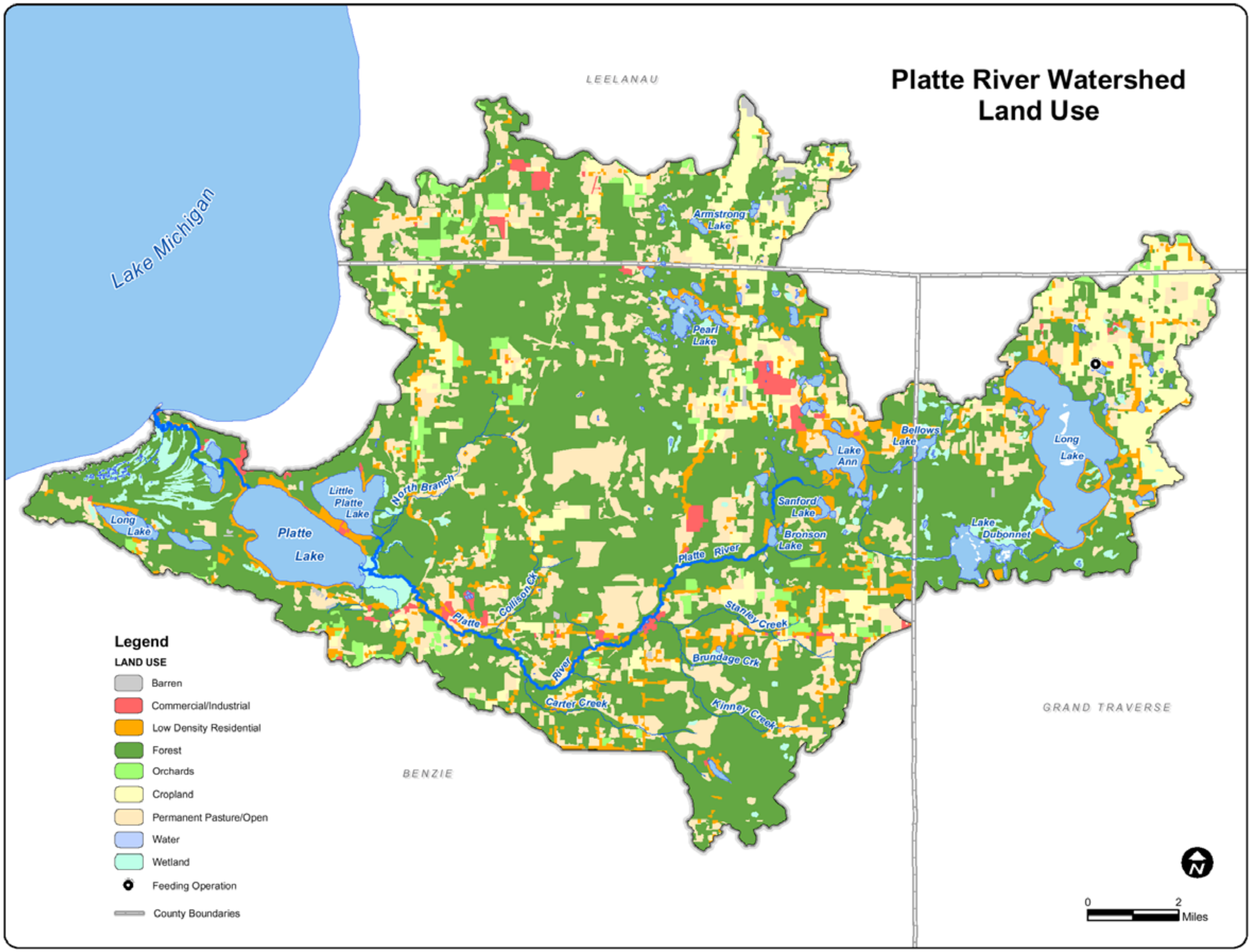
LABEL1	LABEL2	LABEL3	LTI_category
Agricultural Land	Agriculture	Cropland Other Agriculture	Cropland
	Other Agricultural Land	Other Agricultural Land	
	Cropland	Cropland, Rotation, and Permanent Pasture	
	Cropland, Rotation, and Permanent Pasture	Cropland, Rotation, and Permanent Pasture	
		Orchards	Orchard
	Orchards, Vineyards, and Ornamental	Orchards, Vineyards, and Ornamental	
	Confined Feeding Operations	Confined Feeding Operations	Feeding Operations
	Permanent Pasture	Permanent Pasture Permanent Pasture	Permanent Pasture/Open
Rangeland	Herbaceous Rangeland	Herbaceous Rangeland	
	Open space/Rangeland	Herbaceous Shrub (blank)	
	Shrub Rangeland	Shrub Rangeland	
Urban or Built Up	Open and Other	Cemeteries Outdoor Recreation	
	Open Land	Cemeteries Other Outdoor Recreation	
	Commercial	Church County Road Comm. Outdoor Recreational Primary/Central Business District School Secondary Business/Strip Commercial Services, Institutional Shopping Center/Mall Township Hall Vacation Resort	Commercial/Industrial
	Commercial, Services, and Institutional	Commercial, Services, and Institutional Institutional	
	Transportation	Air Transportation	
	Transportation, Communication, and Utilities	Air Transportation Communication Facilities	
	Industrial	Industrial Industrial Park	
	Residential	Low Density Mobile Home Park Multi-Family, Low Rise Single Family, Duplex	Low Density Residential
	Extractive	Open Pit	Barren
Barren	Barren	Beach Sand Dune	
	Beaches and Riverbanks	Beaches and Riverbanks	
Forest Land	Broadleaved Forest (Generally Deciduous)	Aspen, Birch Lowland Hardwood Northern Hardwood	Forest
	Coniferous Forest	Christmas Tree Plantation Lowland Conifer Pine	
	Forestry	Aspen/White Birch Association Christmas Tree Plantation Deciduous Lowland Conifer Lowland Hardwood Northern Hardwood Other Upland Conifer Pine	
Water	Lakes	Lakes	Water
	Reservoirs	Reservoirs	
	Water	Lake Stream	
Wetlands	Forested (wooded) Wetlands	Shrub/Scrub Wetland Wooded Wetland	Wetlands
	Non-Forested (non-wooded) Wetlands	Aquatic Bed Wetland Emergent Wetland	
	Wetlands	Aquatic Bed Emergent Flats Shrub, Scrub Wooded	

Table 3 presents the land use distribution within the Platte River watershed, after the reclassification was complete. Figure 1 presents a map of the current land use in the Platte River watershed, that reflects the land use distribution shown in Table 3.

Table 3. Land use distribution after consolidation

Land Use Category	Percent of Watershed
Commercial/Industrial	0.6%
Low Density Residential	5.6%
Permanent Pasture/Open	16.1%
Cropland	8.6%
Orchard	1.8%
Feeding Operations	0.0%
Forest	56.5%
Barren	0.3%
Water	7.8%
Wetlands	2.7%

Figure 1. Current Land Use in the Platte River Watershed



APPENDIX B2- 2007 LIMNOTECH FINAL CALIBRATION REPORT

LimnoTech
Water | Environment | Scientists | Engineers

MEMORANDUM

DATE: June 1, 2007

FROM: Todd Redder

PROJECT: PLATTE3

TO: Ray Canale

CC: Dave Dilks, Penelope Moskus

SUBJECT: Platte River Watershed Model Calibration & Application (final draft)

Summary

The purpose of this memorandum is to document the Phase II calibration and application of the Platte River watershed model. The watershed simulation tool, which is based on the *Hydrologic Simulation Program – FORTRAN* (HSPF) model found within the overall EPA BASINS framework, includes simulation of hydrology and flow, as well as instream total phosphorus (TP) and total suspended solids (TSS) concentrations derived from watershed sources (Bicknell, et al.; http://www.epa.gov/ceampubl/swater/hspf/).

The watershed model was originally configured and a baseline calibration was conducted during Phase I of the project (LimnoTech, 2004). The Phase II effort built on the earlier effort by updating and extending input datasets (e.g., daily precipitation) and calibrating the watershed model to robust datasets collected by the Platte Lake Improvement Association (PLIA) for flow, TP, and TSS during the 2003-05 period. The results of the calibrated model for the 1990-2005 period compare favorably to daily observed USGS flows at Honor, data-based estimates of annual TP load at key locations, and peak TP concentrations for most wet weather events. In addition to direct model-data comparisons for system locations, the unit area loads (UALs) associated with each land use type were compared against literature values and values used for other LimnoTech projects to confirm that the values obtained via calibration were reasonable.

The calibrated model simulations 1990-2005 period were used to identify “high load” (i.e., wet), “low load” (dry), and “typical” (average load) years. Year 1992 was selected as the “High” period because it has the highest annual TP load during the 1990-2005 period. Year 2000 was selected as the “Low” year because it has the lowest annual TP load during the 16-year period. Year 2004 was selected as the “typical” year because its TP load to Big Platte Lake (4,662 lb/yr) was most similar to the 1990-2005 average annual TP load (4,634 lb/yr).

The watershed model GUI (Graphical User Interface) application involved running HSPF single year simulations for years 1992, 2000, and 2004 to generate a set of baseline “High”, “Low”, and “typical” TP loadings, respectively. Unit area loads (UAL) for all land uses were extracted from the model for these years. The UAL values and hatchery point source loading data were used to develop a spreadsheet-based graphical user interface (GUI) tool that allows the user to modify land use distribution and point source loadings on a subwatershed basis. This tool can be used in the future to investigate the impact of any such proposed land use changes or point source discharges on annual TP loading to Big Platte Lake under “High”, “Low”, and “typical” watershed loading conditions. The GUI tool also permits the user to investigate the potential benefits of watershed best management practices (BMPs) in specific subwatersheds.

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Background

The Platte River watershed is located in the northwest region of Michigan's Lower Peninsula. The Platte River flows westward from numerous natural headwater lakes and through Big Platte Lake before finally emptying into Lake Michigan. The watershed area is approximately 495 km^2 in size and is currently very rural and largely forested. The predominant land use is forest (57%), followed by permanent pasture/open lands (16%). Developed lands comprise approximately 6% of the watershed area. A coho and chinook salmon hatchery is the sole point source that discharges to the Platte River upstream of Big Platte Lake.

"Since the 1920's, the State of Michigan has operated a fish hatchery on the Platte River, approximately 14 km upstream of the lake. In the early 1970's the hatchery was expanded and production shifted from rainbow trout to salmon and other anadromous fish (Walker, 1998)." The water quality of Big Platte Lake declined noticeably in response to this expansion in fish production and the increased phosphorus loading from the hatchery. As a consequence, the Michigan Department of Natural Resources (MDNR) and the Platte Lake Improvement Association (PLIA) agreed on a program to reduce the hatchery phosphorus discharge to 175 lbs/year. The agreement on hatchery discharges was completed in 2000. As a result, the hatchery loadings have declined and water quality in Big Platte Lake has improved.

In order to maintain high water quality in the lake in the future, the MDNR and the PLIA are working together to evaluate and determine the impact of non-point phosphorus loading to the lake. A watershed-scale modeling study was initiated as part of Phase I of the project and now has been completed in Phase II. The ultimate goal of the study and the model application is to control non-point sources of phosphorus through comprehensive watershed management, including anticipated future loadings resulting from increased land development within the watershed. This summary memorandum presents the final model calibration for flow, phosphorus, and suspended solids in the Platte River watershed upstream of Big Platte Lake.

Review of Data Sources

The Phase II watershed model calibration took advantage of input datasets utilized in the previous modeling effort whenever possible. Model inputs used previously for current land use, soil characteristics, and stream network characteristics were not modified in any way. Details regarding these datasets are available in a previous project report (LimnoTech, 2004). The primary modifications to the Phase II watershed model involved extending the simulation period to cover the entire 1990-2005 period where newly available comprehensive hydraulic and water quality data are available.

Climate Datasets

Climate datasets that were updated and extended for the 2001-2005 period included:

- Daily precipitation and minimum/maximum air temperature data at the National Climactic Data Center (NCDC) station in Frankfort, MI (COOP ID: 202984);
- Hourly precipitation at various Traverse City NCDC stations (used to disaggregate (i.e., apportion) daily Frankfort data into hourly values);
- Daily estimates of evaporation rates for surface water;
- Daily estimates of potential evapotranspiration (PET) rates; and
- Radar maps of daily rainfall available from the National Weather Service.

Table 1 provides a summary of annual precipitation at Frankfort for the 1990-2005 period as well as annual mean daily streamflow observed at the USGS gage location in Honor, MI. Daily precipitation data were disaggregated into hourly values using hourly precipitation distribution data available for several Traverse City NCDC stations. Daily datasets for minimum/maximum air temperature, evaporation, and potential evapotranspiration were input directly to the watershed model.

Table 1. Platte River Watershed Annual Precipitation and Streamflow

Year	Total Precipitation[1] (inches)	Mean Daily Streamflow[2] (cfs)
1990	39.6	136[3]
1991	39.3	140
1992	41.6	142
1993	38.5	147
1994	34.9	138
1995	38.3	120
1996	37.5	125
1997	29.3	131
1998	38.2	112
1999	32.2	105
2000	30.3	101
2001	42.0	113
2002	29.4	132
2003	31.3	125
2004	39.7	134
2005	27.2	121
Average	***35.6***	***126***

Notes:
[1] Data compiled from daily NCDC data available online for Frankfort (supplemented with data available for Beulah and Traverse City).
[2] Computed based on daily observed flow records for the USGS gage at Honor, MI.
[3] Based on an incomplete record; data collection for 1990 began on March 27th.

The selection of the Frankfort NCDC daily precipitation dataset was based on an analysis that compared all available local precipitation datasets to USGS streamflow data available for the Platte River. In addition to the Frankfort NCDC dataset, precipitation datasets available for Beulah (daily total), Traverse City (hourly and daily) were evaluated. The hatchery precipitation dataset was not included in the final analysis because there were significant inconsistencies between this dataset and the before mentioned precipitation datasets that could not be resolved. The USGS flow data was analyzed using hydrograph separation techniques, which yielded estimates of monthly runoff and baseflow quantities.

The key conclusion of precipitation and flow analysis was that the Frankfort precipitation dataset provided the most consistent match to annual and monthly runoff quantities for the Platte River watershed. National Weather Service radar maps were used in a qualitative manner to analyze specific cases where significant deviations occurred between the Frankfort rainfall data and the River response at the Honor gauging station. Based on preliminary flow calibration results from the watershed model, it was determined that the Frankfort dataset was sufficiently accurate to support model calibration. The complete precipitation and flow analysis, including a discussion of radar rainfall data, is documented in a previous memorandum (LimnoTech, 2006) that is provided as Appendix D to this memorandum.

Flow Calibration Datasets

The model flow simulation was calibrated using the following data sources:

- Continuous USGS mean daily flow data for Honor, MI (1990-2005);
- Periodic stage data and flow estimates available for various locations from recent PLIA monitoring (2003-05); and
- Daily average snow pack depth data available for the Frankfort NCDC station (1990-2005).

The USGS daily flow dataset served as the primary target for the overall watershed flow calibration, and the Frankfort NCDC snow depth dataset was specifically used to parameterize and calibrate the snow accumulation and melt calculations in the watershed model. The annual mean daily streamflow for the USGS gage station is provided in Table 1.

The PLIA stage/flow datasets were used to establish the upstream boundary inflow for tributary reaches, including Brundage Creek, North Branch Platte River, Carter Creek, and Collison Creek. Estimates of point-in-time flows were developed for each monitoring location using raw water stage measurement and stage-discharge curves provided by PLIA (Ray Canale, personal communications).

Water Quality Calibration Datasets

Recent instream measurements of total phosphorus (TP) and turbidity available from the PLIA monitoring program were used as the basis for calibrating the model water quality simulation for TSS and TP. The PLIA datasets characterize a variety of dry and wet weather events at key locations for 2003-05 within the mainstem of the Platte River and several major tributaries. Monitoring locations for which TP and turbidity data were used to support model calibration include:

- Platte River at Fewins Road;
- Platte River at Stone bridge;
- Platte River at Veteran's Park;
- Platte River at Pioneer Road;
- Platte River at the USGS gage location;
- Stanley Creek;
- Brundage Creek at Old Residence;
- Carter Creek;
- Collison Creek; and
- North Branch Platte River at Deadstream Road.

Raw TP and turbidity data were provided in the form of a Microsoft Access database. Turbidity (NTU) measurements were converted to estimates of TSS using regressions provided by PLIA (Ray Canale, personal communications).

Watershed Model Calibration

The watershed model calibration effort consisted of two major steps, including calibration of simulated runoff and subsurface (groundwater) flows followed by calibration of simulated water quality (i.e., TP and TSS concentrations) at key locations within the main stem Platte River and its tributaries.

General Approach

Model calibration involves the process of comparing model predictions for parameters of interest to site-specific measurements and iteratively adjusting model coefficients to achieve an acceptable fit between predicted and observed values. The process of model calibration is important not only in terms of optimizing the model fit to available field data, but also in terms of developing a better conceptual understanding of how the physical system behaves and responds under different environmental conditions.

For the Platte River watershed model, the parameters of interest include flow/hydrology and total phosphorus (TP). Total suspended solids (TSS) is a parameter of secondary interest that should be calibrated for the purpose of supporting the TP calibration. Calibration of the model flow simulation was conducted first in order to provide the necessary information to the water quality simulation. A rough TSS calibration was conducted next to establish reasonable scour and washoff rates for watershed soils. The TP calibration was conducted as a final step in the process, although some additional calibration of the TSS parameter was necessary to achieve the best fit for both water quality parameters.

The watershed model calibration encompasses the 1990-2005 period because 1) USGS daily flow data are available for nearly this entire period, and 2) substantial TP and TSS data are available from the PLIA monitoring program for the 2003-05 period. Although PLIA monitoring data are also available for year 2006, sufficient climate data were not available at the time of model development and calibration.

The model calibration was limited to the portion of the watershed extending from Fewins Road to Big Platte Lake. The rationale for representing the upstream lake system using a boundary condition at Fewins Road is discussed in the "Data Gaps Identified" section below. A detailed discussion of the upstream boundary condition development for flow and TP and TSS concentrations is provided in the "Upstream Boundary Condition Development" section.

Data Gaps Identified

The original (baseline) watershed model calibration conducted by LimnoTech identified several data gaps that limited how well the model could simulate observed flows and TP concentrations in the Platte River. Key data gaps identified in the final report (LimnoTech, 2004) and associated recommendations are summarized below:

1. Wet and dry weather TSS data are needed to further refine the TP calibration. Additional sampling was recommended.
2. Additional TP wet weather data are needed to refine the TP calibration. Additional sampling was recommended.
3. Significant uncertainty exists in the watershed and flow calibration for North Branch Platte River and Little Platte Lake. It was recommended that a flow gage be installed on North Branch upstream of Little Platte Lake and a field visit be conducted to better understand the influence of Little Platte Lake inflow/outflow on North Branch outflows to the mainstem Platte River.
4. Limited information is available regarding the morphometry and hydraulic behavior of numerous lakes located upstream of Fewins Road in the eastern portion of the watershed. Lakes that likely have a significant influence on flows and TP loads to Fewins Road include Bronson Lake, Lake

Ann, Bellows Lake, Lake Dubonnet, and Long Lake. It was recommended that information on the volume, depth, surface area, and outflow characteristics of these lakes be collected to improve model predictions of total outflow and TP load to the mainstem Platte River below Bronson Lake.

Data gaps #1 and #2 were addressed by the PLIA monitoring conducted during the 2003-05 period, and this monitoring effort continues. Data gaps #3 and #4 have not been addressed; therefore, there continues to be uncertainty in how to characterize the watershed model for 1) North Branch Platte River and its interaction with Little Platte Lake, and 2) the upstream system of lakes that supply the background flow and TP load at Fewins Road. These data gaps were taken into consideration when configuring and calibrating the watershed model, as discussed in the below sections.

Upstream Boundary Condition Development

The upstream system of lakes that contribute flow and TP load to Fewins Road were not simulated directly in the model. Instead, PLIA monitoring data available for Fewins Road and the nearby Stone bridge location were used to develop upstream boundary conditions TP and TSS concentrations. The daily inflow at Fewins Road (Q_{Fewins}, in cfs) was calculated from observed flows at the USGS gage (Q_{USGS}, also in cfs) using the following regression: $Q_{Fewins} = 0.49*Q_{USGS} - 4.98$ (Canale, et.al., 2006).

For dry/wet weather days where data were available, observed concentrations were used to specify the TP/TSS boundary concentrations. Concentrations during wet weather events were specified on an hourly basis to capture trends of observed TP concentrations during the course of the event. For days where data were not available, TP and TSS concentrations were specified as follows:

- Concentrations for dry weather days (rainfall at Frankfort < 0.20”) were specified on a monthly basis per the values provided in Table 2. These values were based on TP/TSS PLIA measurements available for the USGS sampling location for the 2004-05 period.

Table 2. Monthly Dry Weather TP/TSS Concentrations at Upstream Boundary

Month	TP Concentration (ug/L)	TSS Concentration (mg/L)
1	22.6	15.5
2	19.7	14.8
3	14.9	11.1
4	15.4	11.8
5	12.9	10.4
6	13.6	9.8
7	13.7	7.6
8	10.1	5.9
9	8.6	4.9
10	8.2	4.8
11	11.1	8.0
12	13.6	10.0

- TP and TSS boundary concentrations for wet weather days (rainfall at Frankfort > 0.20”) were specified based on correlations between daily rainfall and average daily wet weather concentrations for individual rainfall amounts. As for the dry weather analysis, the PLIA TP/TSS datasets for the USGS location were used to support the development of the rainfall-concentration correlations.

Data for the USGS location were used in place of the Stone bridge TP/TSS datasets because: 1) the USGS and Stone bridge concentration data demonstrate good consistency, and 2) the USGS dataset is more comprehensive in terms of number of dry/wet events sampled and frequency of sampling during wet weather events. The approach described above was applied to develop daily flow and hourly TP and TSS concentration time series covering the 1990-2005 calibration period. Table 3 summarizes the annual average flow and the total annual TP loading by year.

Table 3. Annual Flow and TP Load at Upstream Boundary (Fewins Road)

Year	Annual Average Flow (cfs)	Annual TP Load (lb/yr)
1990	63.7	2,196
1991	64.0	2,165
1992	65.0	2,237
1993	67.4	2,302
1994	63.3	2,091
1995	54.1	1,834
1996	56.8	1,893
1997	59.8	1,857
1998	50.2	1,730
1999	46.9	1,525
2000	44.7	1,451
2001	50.9	1,812
2002	60.1	1,997
2003	56.6	1,845
2004	61.3	2,033
2005	54.8	1,826
Average:	***57.5***	***1,925***

Flow Calibration

General performance targets have been established by researchers and engineers for streamflow calibrations using the BASINS/HSPF model. These performance targets allow model users such as planners to evaluate the success of a BASINS calibration for a particular watershed compared to results from other watersheds. The established calibration criteria are shown in Table 4 (Donigian, 2002). These targets are applicable when comparing annual and monthly model predictions of streamflow to mean annual and monthly data-based flows.

Table 4. General Calibration/Validation Targets or Tolerances for BASINS Hydrology/Flow (Donigian, 2002)

% Difference Between Simulated and Recorded Values		
Very Good	Good	Fair
< 10	10 - 15	15 - 25

Annual and monthly results of the Platte River watershed model flow calibration at the USGS gage location are summarized in Figure 1. The annual and monthly comparisons of predicted and observed flows are provided in Figure 2 and Figure 3, respectively. (It should be noted that year 1990 is not included in Figures 2-3 because that year has an incomplete flow record.) The summary in Figure 1 indicates that the mean absolute percent difference between simulated and observed stream flows is 4.3% on an annual basis and 5.7% on a monthly basis for the full calibration period (1990-2005). These results compare very favorably with the calibration performance targets generally associated with the BASINS/HSPF model (Table 4). The 2003-05 daily time series comparison of BASINS-predicted flow and USGS observed flow at the Honor, MI gage location is provided in Figure 4, and additional flow calibration figures for the Platte River and North Branch are provided in Appendix A to this memorandum.

As an additional test of the flow calibration, LimnoTech also used the USGS's HYSEP and PART software programs to estimate the base flow contribution to the daily flow time series simulated by the BASINS model. Based on this analysis, the monthly base flow component predicted by the BASINS model ranged between 84-99%, which compares very well with data-based estimates of monthly base flow that fall in the range 88-99%. This data-based range for baseflow contribution was also confirmed by an independent PART analysis conducted by the USGS (Ray Canale, personal communication).

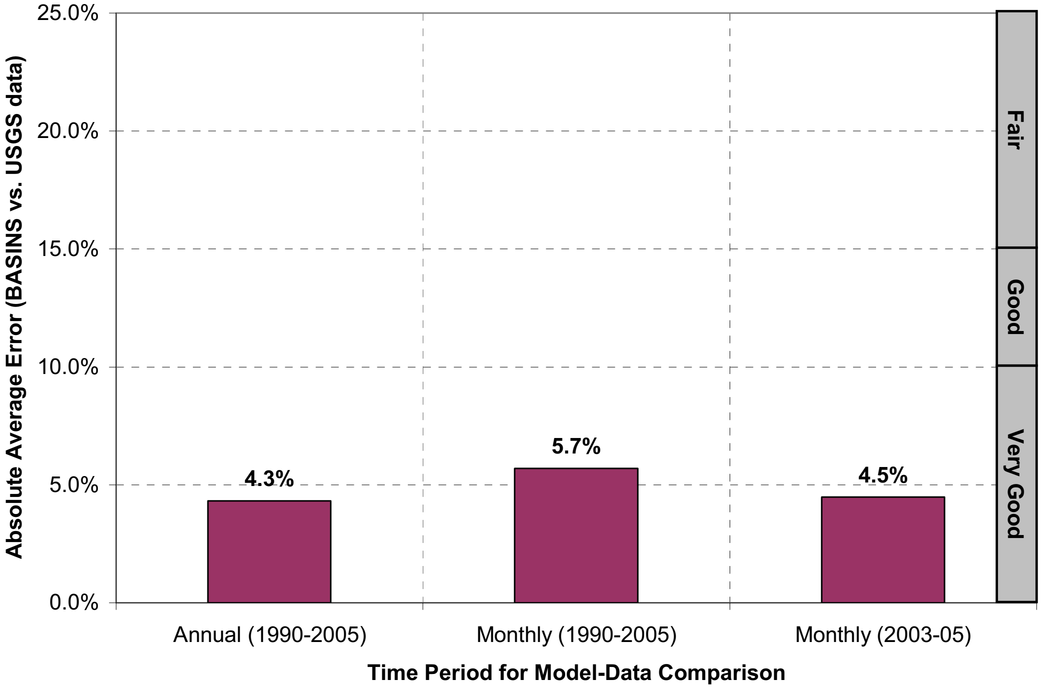


Figure 1. Annual and Monthly Mean Errors for Model-Predicted Flow Relative to USGS Data

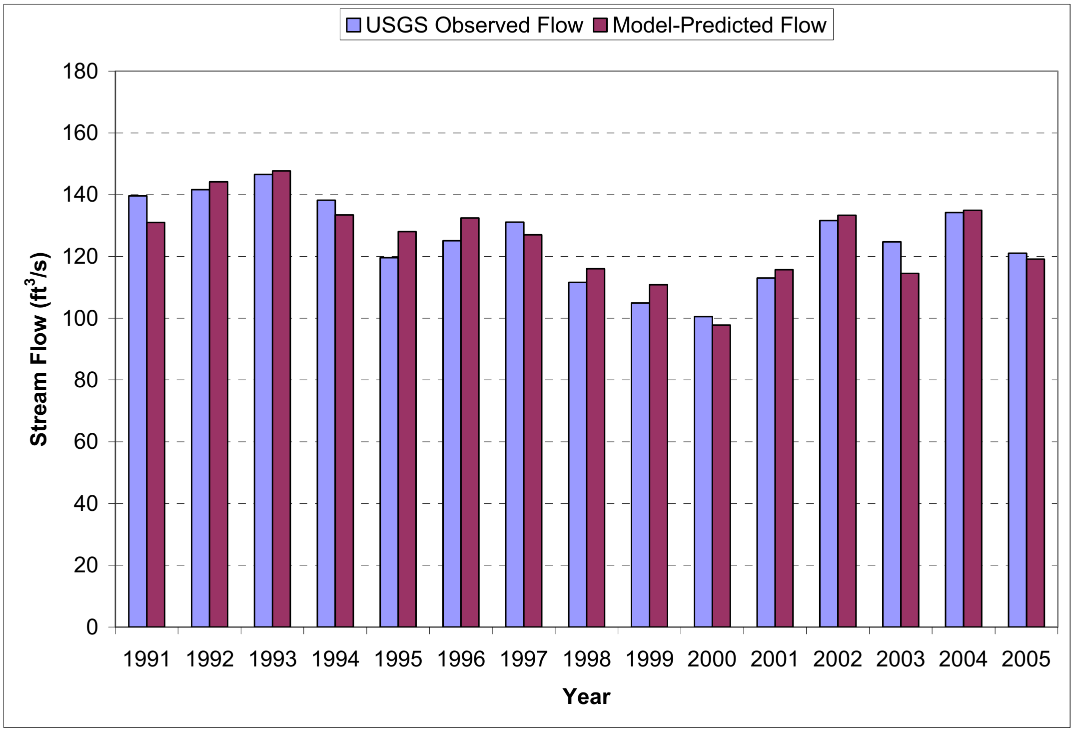


Figure 2. Annual Average Model-Predicted and Observed Flow at USGS Gaging Station

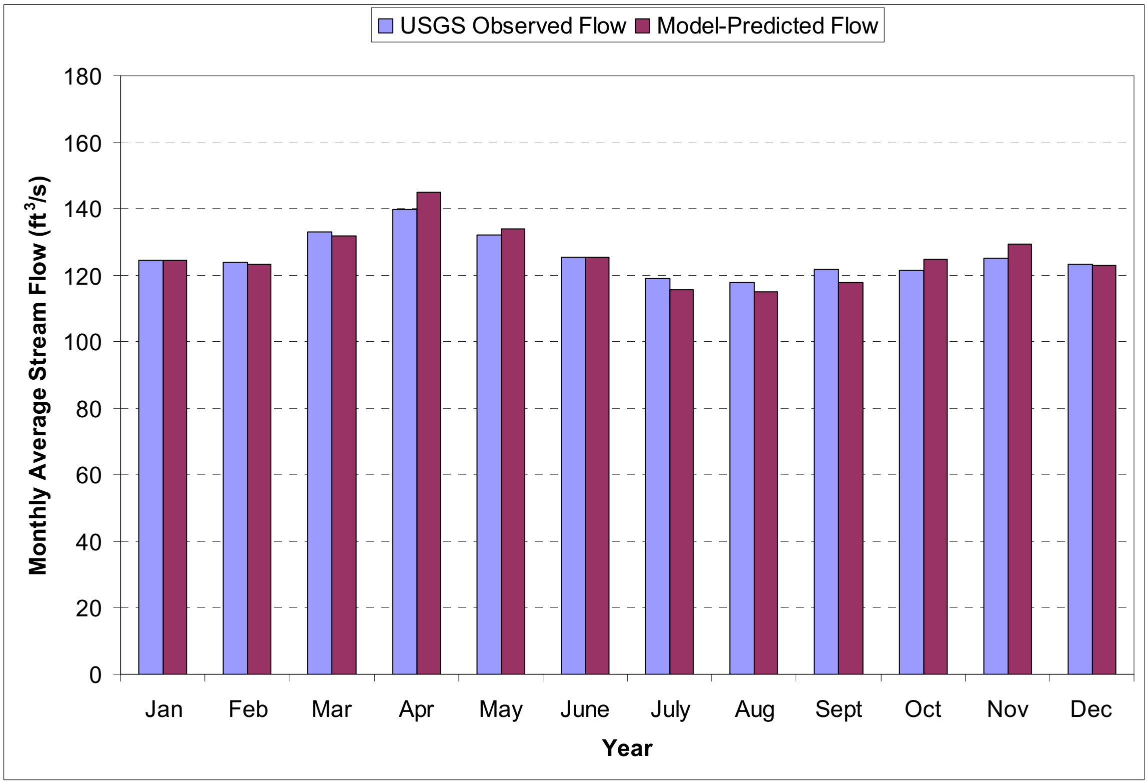


Figure 3. Monthly Average Model-Predicted and Observed Flow at USGS Gaging Station (1991-2005)

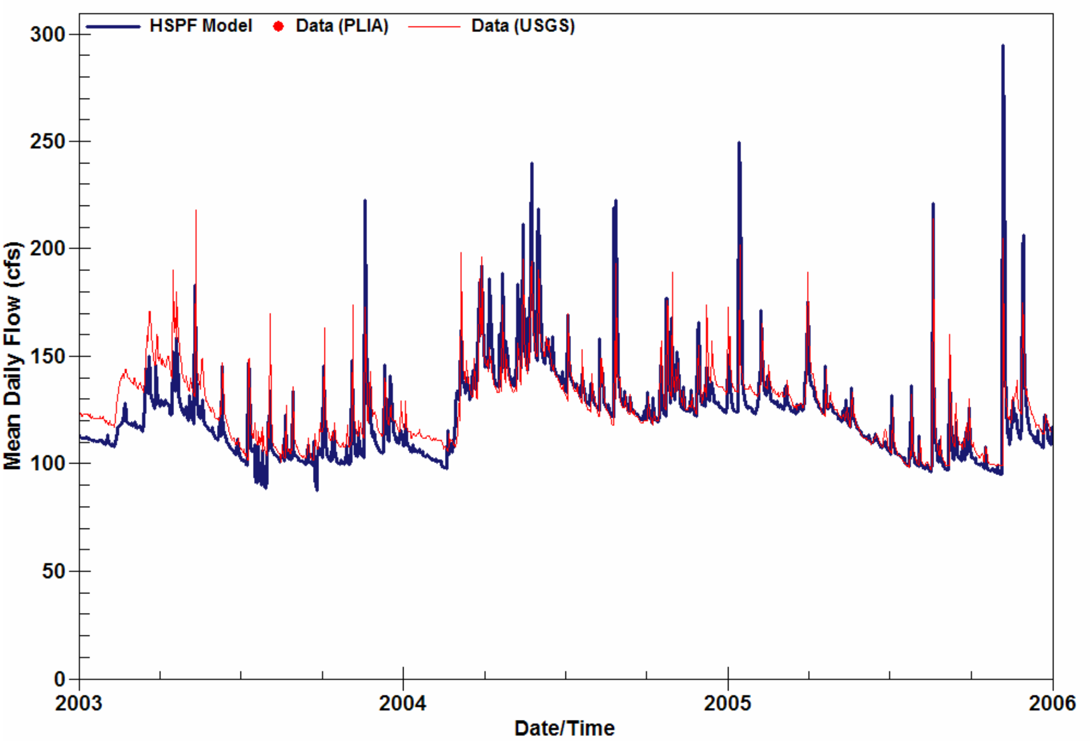


Figure 4. Model-Predicted and Observed Daily Flow Time Series at the USGS Gaging Station

Total Phosphorus Calibration

The watershed model was calibrated to total phosphorus (TP) data collected by the PLIA during the 2003-05 period. The calibration focused on achieving a good fit between model and data at key watershed locations in terms of 1) TP loading estimates for year 2005, and 2) individual dry and wet datasets for various locations. Total suspended solids (TSS) data were available for many of the wet weather events and locations where TP was sampled; therefore, it was possible to use TSS data as an additional constraint on the TP calibration. As discussed previously, TP and TSS concentrations were input to the model on an hourly basis at the Fewins Road location to represent the load/concentration contribution from the upstream lake systems. The bar chart in Figure 5 compares model results and data-based estimates for annual TP loading for locations where sufficient (wet and dry) weather TP data were available to develop a reasonable estimate.

The data-based TP loading estimates are not 100% accurate because the TP concentration was not sampled on an hourly or daily basis for direct comparison to the model load predictions. The 2005 TP dataset for the four locations in Figure 5 includes a reasonable distribution of dry weather and wet weather event samples; however, there remain uncertainties in the data-based estimates because not every day or event is precisely represented. The comparison in Figure 5 illustrates that the model predictions are within approximately 20% of the data-based estimates at each location, which indicates a very good overall fit considering the inherent uncertainties in the data-based estimates.

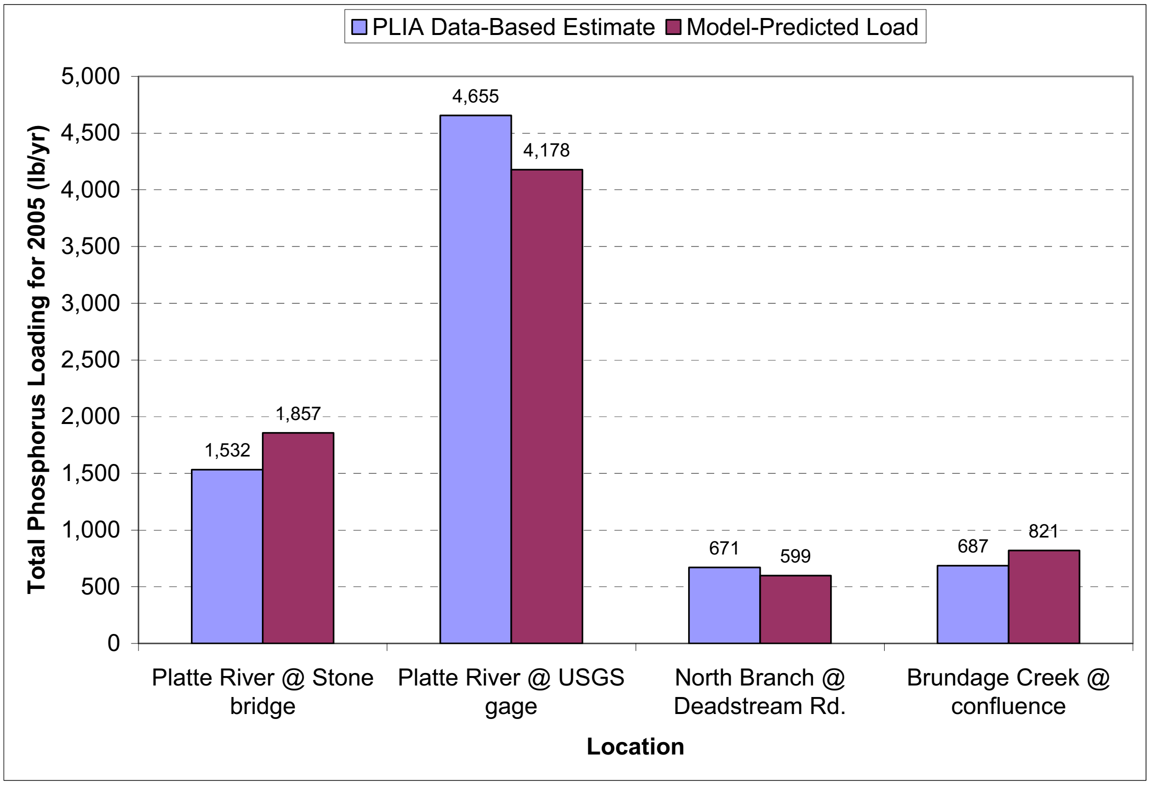


Figure 5. Annual TP Load Comparison for Model-Based and Data-Based Estimates

In addition to accurately simulating the data-based TP loadings at key locations, the model calibration also reproduces the dry and wet weather TP concentrations at those locations. Figures 6a and 6b show the model-data comparison at the USGS gage location for the 2003-05 period and the June 20 – July 22, 2005 period, respectively. Figure 6a illustrates the model simulation captures the overall behavior of TP concentrations at the USGS gage during the PLIA sampling period. The model closely reproduces the observed dry weather concentration patterns and also accurately reflects TP concentrations for most sampled wet weather events. In particular, Figure 6b shows that the model closely reproduces the observed TP concentration profile for the July 4, 2005 wet weather pattern.

The TP simulation results for Brundage Creek provide a similarly good fit to available TP concentration data. Figures 7a and 7b show the simulated and observed TP concentrations at Old Residence for the 2003-05 period and the June 20 – July 20, 2005 period, respectively. Figure 7a illustrates that the model predictions reproduce the observed TP dry and wet weather concentrations quite well at this location. Similar to the USGS gage location, Figure 7b illustrates that the model closely reproduces the observed TP concentrations at Old Residence for the July 4, 2005 wet weather event (and surrounding days).

The North Branch Platte River is the major tributary that enters the mainstem Platte River between the USGS gage location and the entrance to Big Platte Lake. Therefore, it is important that TP loading and concentration data for this tributary be accurately simulated as well. Figure 8 compares model-predicted and observed TP concentrations for the North Branch Platte at Deadstream Road for 2003-05. A review of the data suggests that seasonal patterns exist at this location, most likely due to the influence of Little Platte Lake. It should also be noted that the relatively smooth concentration profile evident for the North Branch Platte is the result of the attenuation of peak TP concentrations that enter Little Platte Lake during wet weather events. As the result of this attenuation effect, peaks in TP concentration are only evident for the largest watershed runoff events.

Initial simulation results for the North Platte under-predicted the (annual) average TP concentration at Deadstream Road (13.8 ug/L) by approximately 4 ug/L. It was hypothesized that this under-prediction is due to natural and/or human activities in Little Platte Lake. The observed seasonal patterns in TP concentration suggest that increased breakdown of organic matter and the subsequent release of phosphorus from wetland areas may occur during the summer months. Human activities that might contribute additional phosphorus to Little Platte Lake include loadings from septic systems and general stormwater runoff from private residences located along the lake. Because hydraulic and TP concentration information for Little Platte Lake are very limited, a constant TP load (139 lb/year, or 0.38 lb/day) was introduced to Little Platte Lake to increase the model-predicted concentrations to the average observed concentrations. It is recommended that a sampling program be designed and implemented to revolve the apparent discrepancy between the model and the data for the North Branch watershed including Little Platte Lake.

The complete set of model-data TP calibration figures is provided in Appendix B to this memorandum, including time series graphics for mainstem Platte River locations, Brundage Creek (at Old Residence), and North Branch Platte River (at Deadstream Road). Total suspended solids (TSS) model-data comparisons are not shown or discussed here for brevity; however, a set of TSS calibration graphics can be found in Appendix C.

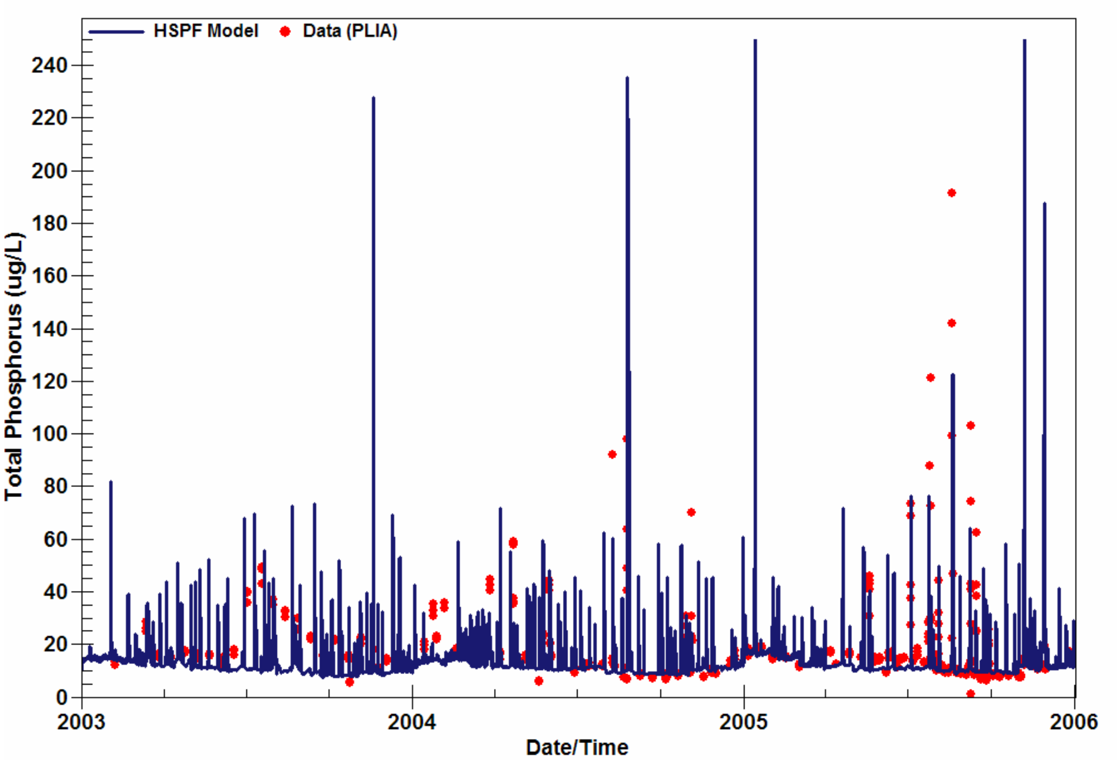


Figure 6a. Simulated and Observed TP Concentrations for the Platte River at the USGS Station

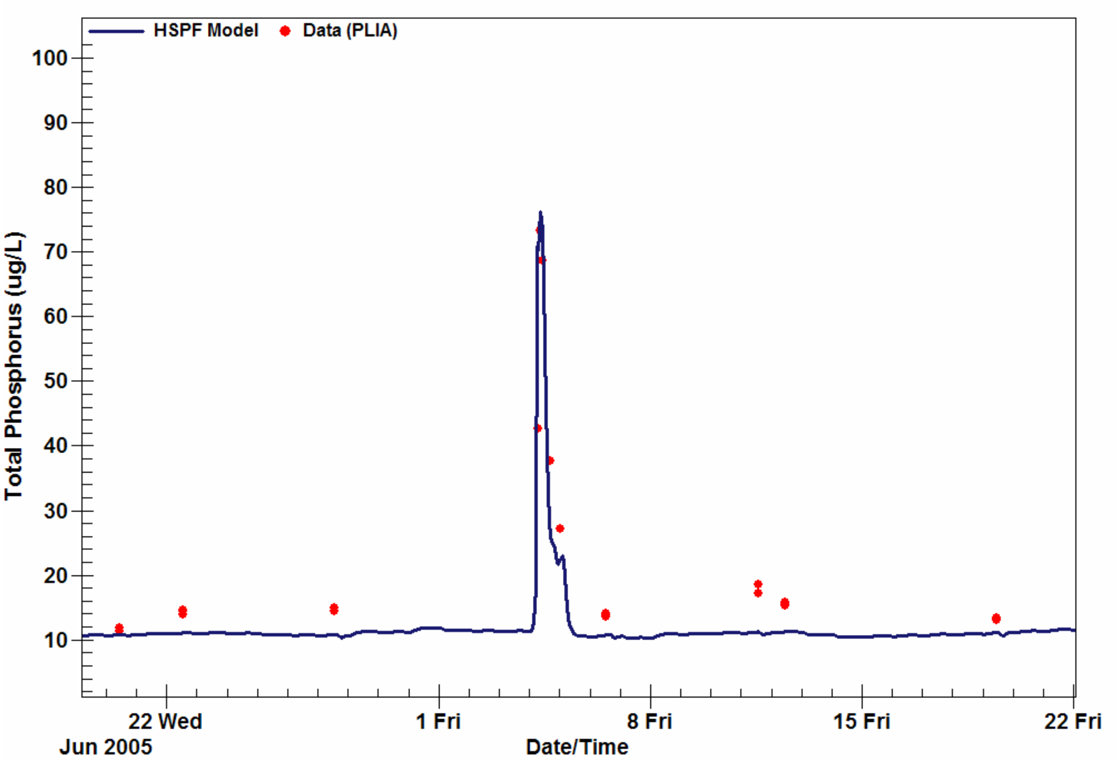


Figure 6b. Simulated and Observed TP Concentrations for the Platte River at the USGS Station (June 20 – July 22, 2005)

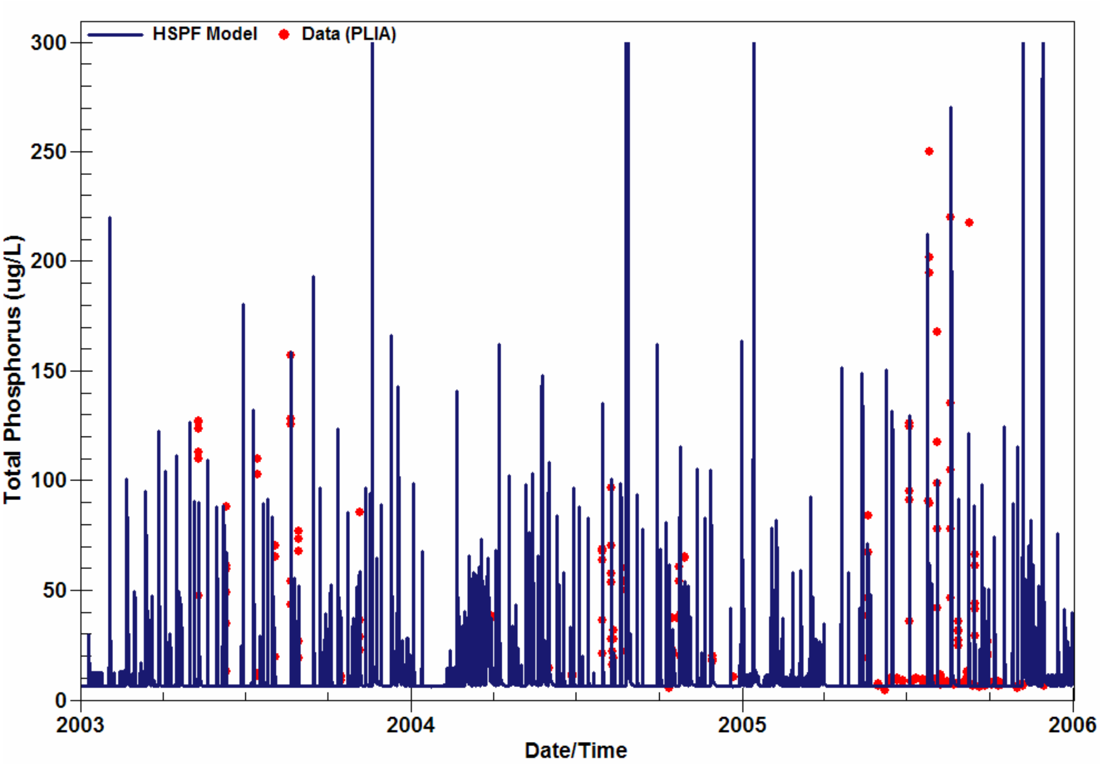


Figure 7a. Simulated and Observed TP Concentrations for Brundage Creek at Old Residence

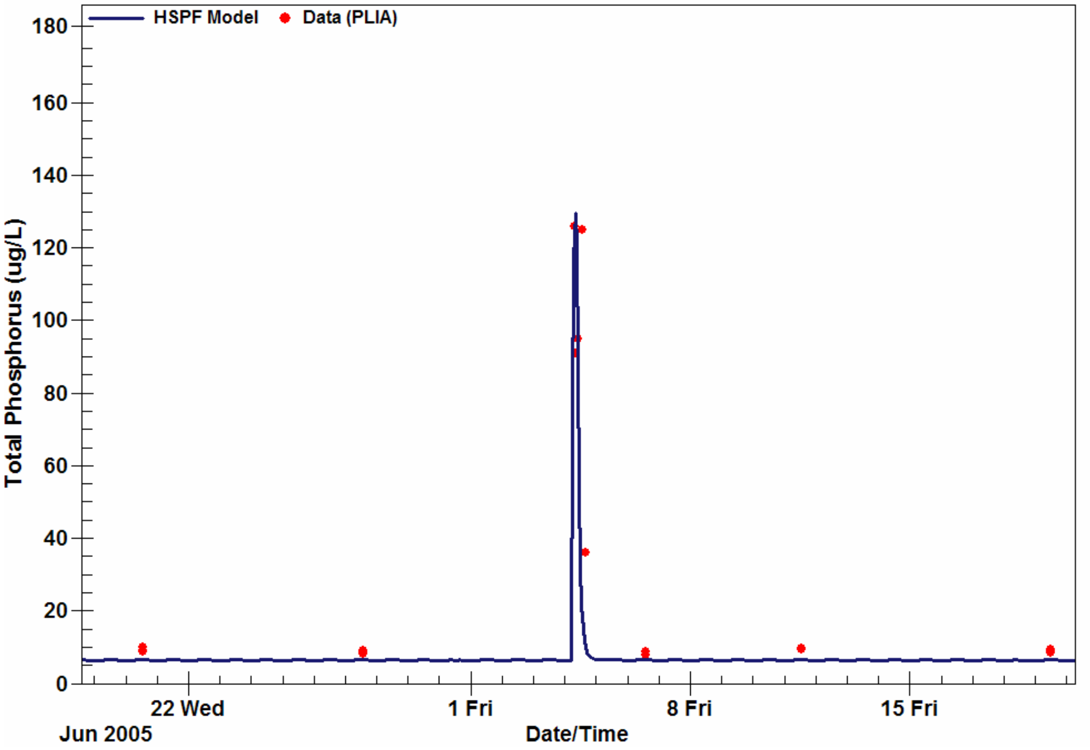


Figure 7b. Simulated and Observed TP Concentrations for Brundage Creek at Old Residence
(June 20 – July 20, 2005)

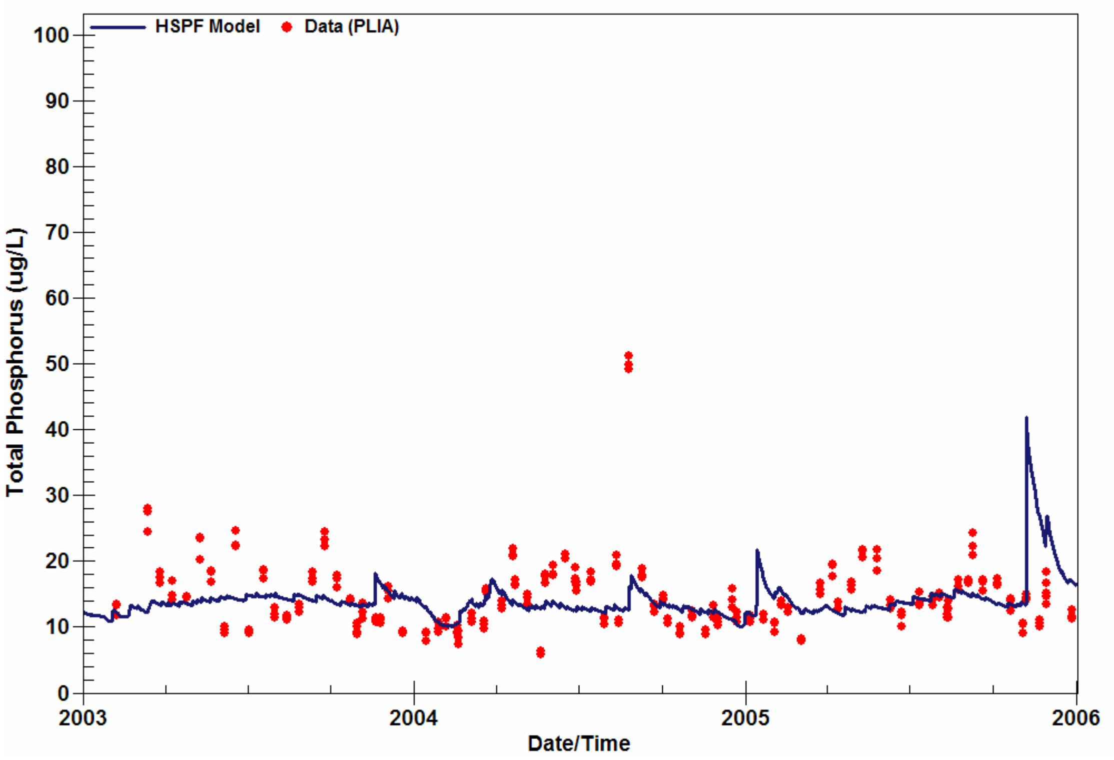


Figure 8. Simulated and Observed TP Concentrations for North Branch Platte River at Deadstream Road

An important additional check on the model calibration for total phosphorus is to ensure that the calibrated unit area load (UAL) rates are generally consistent with literature ranges available for individual land use types. Table 5 presents the average UAL rate (lb/acre/year) for each of the nine land use types included in the BASINS model for the Platte River watershed, as well as the range of annual UALs for the entire 1990-2005 period. Literature ranges are provided in the rightmost column of the table.

Although many of the data-based ranges are quite large, a review of the values in Table 5 suggests that the calibrated model UALs generally fall within, or very close to, the data-based ranges. It is also worth noting that the *relative* magnitude of UALs across land use types is similar between the model and data ranges. This comparison provides added confidence that the model simulation of watershed runoff flow, TP, and TSS is reasonable and provides results consistent with previous studies of watershed TP loading.

It should be noted that the UALs in Table 5 include TP loads delivered via groundwater flow in addition to TP loads delivered via direct watershed runoff. The groundwater TP loading rate is generally consistent across the various land use types. The hatchery TP contribution is not included as part of the UAL values, but is considered separately within the model as a true point source. As part of the calibration, it was assumed that interactions with the sediment bed do not result in any net gain or loss of TP from the river water. Therefore, the UAL values in Table 5, combined with the net hatchery point source loading, translate directly into the actual TP loadings from the watershed between the boundary at Fewins Road and Big Platte Lake. This correspondence is important because it allows the direct use of the UALs, subwatershed / land use areas, and the hatchery point source loads to predict potential changes in TP loading within the graphical user interface (GUI) tool.

Table 5. Total Phosphorus Calibrated Unit Area Loads & Literature Ranges

Land Use Type	Unit Area Loads (lb/ac/yr)		
	Average	Range	Literature Ranges
Forest	0.03	0.02-0.05	0.02-0.74 [a]
Barren	0.08	0.04-0.15	n/a
Orchards	0.05	0.03-0.10	n/a
Permanent Pasture / Open Land	0.07	0.04-0.16	0.04-0.09 [b]
Cropland	0.11	0.03-0.24	0.22-0.76 [a]
Low-Density Residential	0.25	0.16-0.39	0.41-0.57 [c]
Commercial	0.70	0.61-0.87	0.17-5.56 [a]
Wetland	0.03	0.02-0.04	n/a
Feeding Operation	2.61	2.02-4.17	19-709 [a]

[a] Reckhow, et al., 1980.
[b] Sonzogni, 1980.
[c] EPA, 1999.

Watershed Model Application

Application of the watershed model involved 1) the selection of representative “High”, “Low”, and “typical” years based on rainfall and flow information, 2) simulation of those representative years with the calibrated model, and 3) integration of the model results for each year into a graphical user interface (GUI) to facilitate evaluation of TP load scenarios. The following sections discuss the selection process for the High, Low, and typical years, the results of the model simulations for the selected years, and the GUI tool development.

Selection of High, Low, and Typical Years

For the Platte River watershed, the selection of a “High”, “Low”, and “typical” year can potentially be based on one or a combination of three different criteria:

- Model-predicted TP load to Big Platte Lake;
- Total annual rainfall at Frankfort; and/or
- Mean annual flow for the USGS gage at Honor.

Because TP loads to Big Platte Lake and at other points within the system represent the outcome of greatest interest from the model simulations, TP load was the primary consideration when selecting High, Low, and typical years. Annual rainfall and streamflow statistics were used to support the selection process. Table 6 provides a summary of the TP loads to Big Platte Lake, total rainfall, and mean daily streamflow for all years during the 1990-2005 period, with the years rank-ordered from largest to smallest annual TP load. The TP loads represented in this table are based on the watershed (including upstream) loads from the calibration period and use a constant hatchery net loading of 175 lb/yr for all years in place of the historical hatchery net loadings used for model calibration (Ray Canale, personal communication).

Table 6. Rank-Ordered Annual TP Loads to Big Platte Lake

Load Rank[1]	Year	TP Load (lb/yr)	Rainfall (inches)	Streamflow (cfs)[2]	Notes
1	1992	6,193	41.6	170	Selected as “High” year
2	2002	5,733	29.4	159	
3	1990	5,279	39.6	147	
4	1996	4,993	37.5	157	
5	2001	4,948	42.0	138	
6	1993	4,869	38.5	175	
7	1995	4,835	38.3	150	
8	2005	4,834	27.2	142	
9	1991	4,822	39.3	152	
10	2004	4,662	39.7	162	Selected as “typical” year
11	1994	4,423	34.9	157	
12	1998	3,991	38.2	137	
13	1997	3,932	29.3	150	
14	2003	3,883	31.3	135	
15	1999	3,481	32.2	131	
16	2000	3,273	30.3	116	Selected as “Low” year

Notes:

[1] Each year in the 1990-2005 period is rank-ordered based on largest to smallest model-predicted TP load to the lake. Loads assume a constant hatchery net TP load of 175 lb/yr.

[2] Represents model-simulated average annual flow from the Platte River to Big Platte Lake.

The final selections for the "High", "Low", and "typical" years are noted and highlighted in blue in Table 6. The rationale for the three selections is provided below:

- "High" Year: Year 1992 was selected as the High year because it has the highest TP load of any year within the 1990-2005 period. This year is also characterized by the second-highest rainfall totals and the second-highest streamflow to Big Platte Lake.

- "Low" Year: Year 2000 was selected as the representative Low year because it has the lowest TP load of any year. In addition, this year has the lowest streamflow to Big Platte Lake and the third-lowest rainfall total of any year.

- "Typical" Year: Year 2004 was selected as the representative typical year because the total TP load (4,662 lb/yr) was most similar to the average annual load across the entire 1990-2005 period (4,634 lb/yr).

The relative contributions of the upstream (i.e., above Fewins Road), watershed (between Fewins Road and Big Platte Lake), and the hatchery components to the overall TP load for each year are summarized in Table 7. The upstream and hatchery contributions comprise the highest fraction of the total TP load for the Low year and lowest fraction for the High year.

Table 7. Rank-Ordered Annual TP Loads to Big Platte Lake

Hydrologic Condition	TP Load (lb/yr)	Upstream Contribution	Watershed Contribution	Hatchery Contribution
High Year (1992)	6,194	36.1%	61.1%	2.8%
Typical Year (2004)	4,661	43.6%	52.6%	3.8%
Low Year (2000)	3,275	44.3%	50.4%	5.3%

Of the three selected years, it is anticipated that the "High" year (1992) would have a larger fraction of its total annual TP load delivered during watershed runoff events relative to the Low year (2000). An analysis of the daily rainfall and model-predicted TP load was conducted to confirm this hypothesis. To support this analysis, each day within each of the three years was classified as a "runoff" day if the total precipitation for that day exceeded 0.10-inch and the average air temperature was greater than or equal to 32 degrees Fahrenheit (i.e., snowfall was assumed to occur for temperatures less than 32 degrees). All days that did not meet these criteria were classified as "non-runoff" days. In general, the daily TP load to Big Platte Lake will be dominated by local runoff conditions on "runoff" days, while loads from the upstream lake systems and local baseflow will dominate the TP load on "non-runoff" days.

Table 8 provides the results of the runoff vs. non-runoff TP load analysis. The results in Table 8 confirm that the "High" year has a higher fraction of runoff load (45%) than the "typical" year (32%) and the "Low" year (28%).

Table 8. Runoff vs. Non-Runoff TP Load Contributions for Selected Years

Hydrologic Condition	TP Load (lb/yr)	"Runoff" Days		"Non-Runoff" Days	
		# of days	% TP Load	# of days	% TP Load
High Year (1992)	6,194	68	45%	298	54%
Typical Year (2004)	4,661	63	32%	303	68%
Low Year (2000)	3,275	54	28%	312	72%

Scenario Results & Discussion

The typical, High, and Low years were simulated using the calibrated Platte River watershed model. Land use and meteorological inputs (e.g., rainfall, air temperature) used for these simulations were identical to those used for the calibration. The only modification to the original simulation for the three years of interest was the use of a simplified net hatchery load to replace the time-variable TP intake and loading rates used in the calibration simulation. As indicated above, a constant daily net TP loading rate of 175 lb/yr (0.479 lb/day) was used for each of the scenario years (Ray Canale, personal communication). The TP loads at key points within the system are shown schematically in Figures 9a, 9b, and 9c for the High, typical, and Low years, respectively. It should be noted that because only the net hatchery load to the Platte River is considered in the scenarios, the Brundage Creek load represents its entire watershed load without any load "lost" to the hatchery intakes from the creek or Brundage Spring.

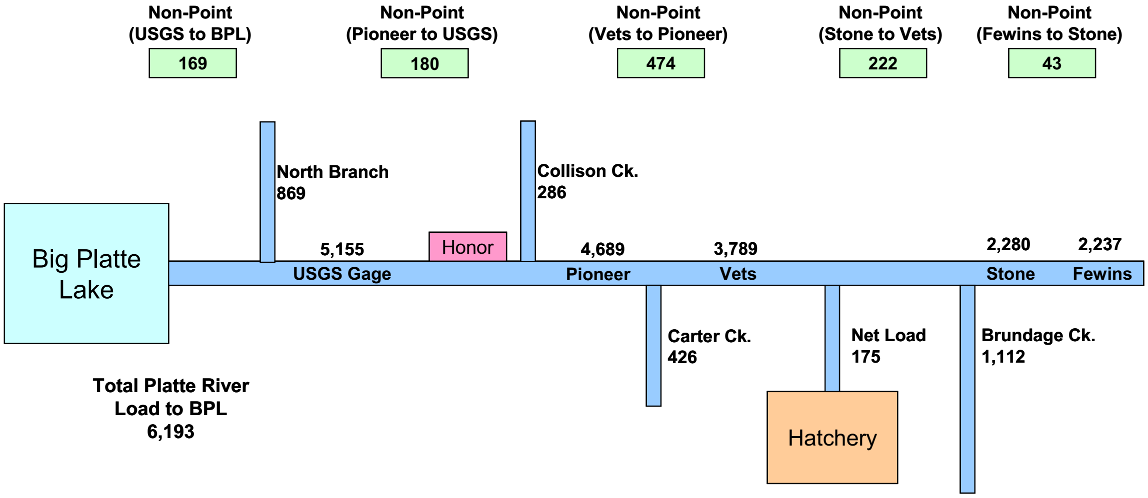


Figure 9a. TP Load Schematic for "High" Year (1992)

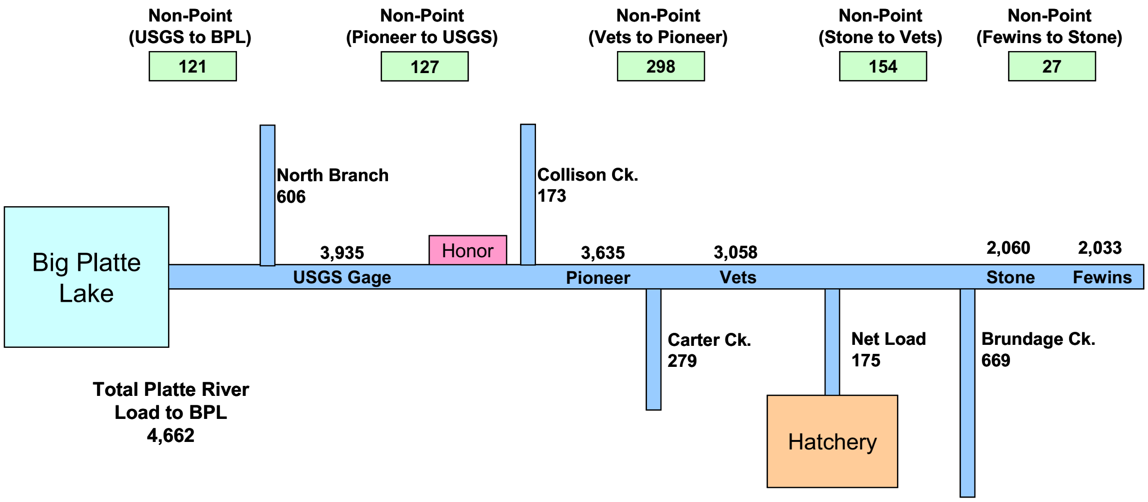


Figure 9b. TP Load Schematic for "Typical" Year (2004)

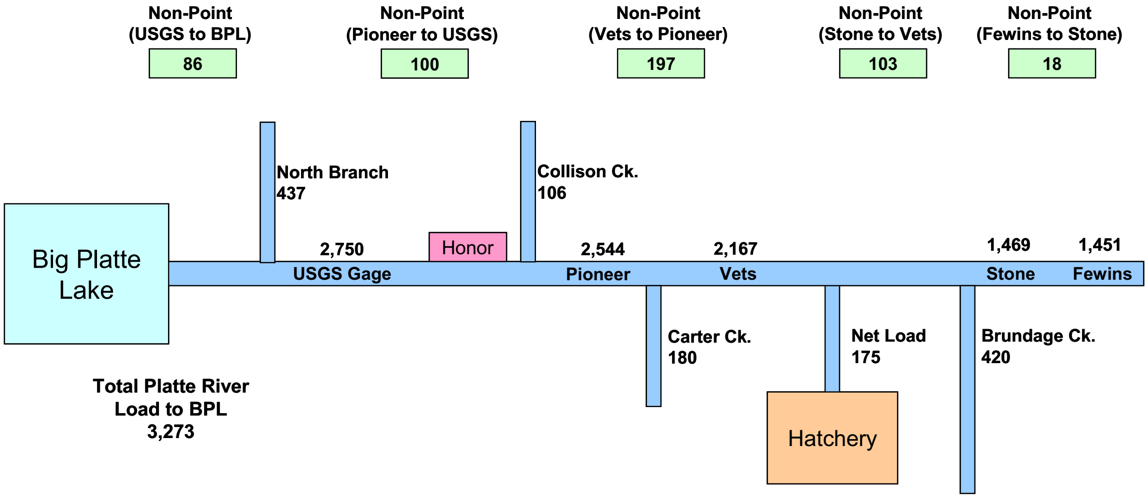


Figure 9c. TP Load Schematic for "Low" Year (2000)

Table 8 summarizes the UALs (lb/acre/year) by land use type for the typical, High, and Low years. As could be expected, the High year has the largest UALs and the Low year has the smallest UALs for each of the land uses.

Table 8. TP Unit Area Loads for the Selected High, Typical, and Low Years

Land Use Type	Area (acres)	Percent of Total Area	Unit Area Load (lb/ac/yr)		
			Low Year (2000)	High Year (1992)	Typical Year (2004)
Forest	23,858	65%	0.023	0.046	0.036
Barren	33	0%	0.038	0.139	0.071
Orchards	702	2%	0.027	0.101	0.054
Pasture	7,833	21%	0.036	0.120	0.071
Cropland	1,660	4%	0.033	0.236	0.079
Low-Density Residential	2,230	6%	0.164	0.388	0.219
Commercial	345	1%	0.654	0.773	0.688
Wetland	310	1%	0.018	0.039	0.039
Feeding Operation	0	0%	2.138	3.242	2.686

Platte River TP Load Scenario Analysis Tool

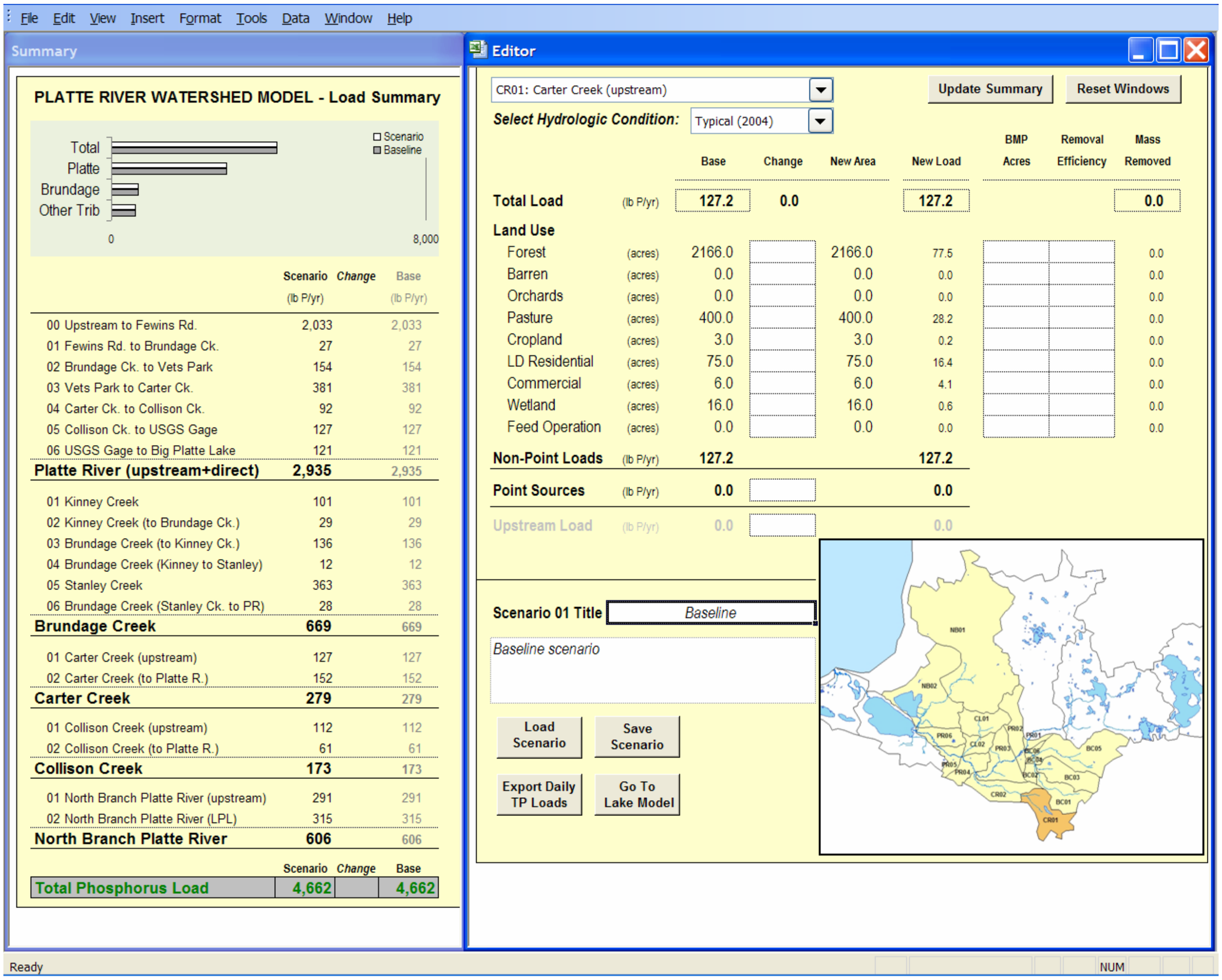
A graphical user interface (GUI) tool was developed in Microsoft Excel to allow the user to review and modify TP loads for each of the simulated subwatersheds for the "High", "typical", and "Low" years. The unit area loads presented in Table 8 above and the land use areas used for model calibration are used to drive the GUI calculations of TP load for each subwatershed. A screenshot of the GUI tool is provided in Figure 10.

The left pane within the GUI is a "Summary" window that shows the base and scenario (i.e., modified) TP load (lb/yr) contribution for each of the 18 subwatersheds between Fewins Road and Big Platte Lake, as well as the upstream contribution at Fewins Road for a selected hydrologic condition (i.e., typical, High, or Low). The subwatersheds are organized by major tributary or mainstem, including:

- Platte River (upstream and direct drainage);
- Brundage Creek;
- Carter Creek;
- Collison Creek; and
- North Branch Platte River.

TP load subtotals are provided for each of these tributary/mainstem reaches, and the grand total of all loadings to Big Platte Lake is also provided for the base and scenario conditions. The total TP load to Big Platte Lake and the contributions from individual tributaries and direct drainage areas closely match the values shown in Figures 9a, 9b, and 9c. It is important to keep in mind that a constant annual "point source" load of 139 lb/yr is applied to the "NB02: North Branch Platte River (LPL)" subwatershed, consistent with the TP load added as part of calibration for this tributary. The annual hatchery load (175 lb/yr) is included as a point source for the "PR03: Vets Park to Carter Ck" subwatershed.

Positioned to the right of the "Summary" window is the "Editor" window, which allows the user to select one of the three hydrologic conditions (typical, High, or Low) and modify the land use distribution, point source loading, and/or upstream loading for any of the subwatersheds. When a particular subwatershed is selected using the drop-down menu near the top of the window, the map in the lower right-hand corner is updated to highlight the selected area. The “Editor” window also allows the user to specify “best management practice” (BMP) areas for any subwatershed and the associated TP removal efficiency for those areas. Any user-defined scenario (with a maximum of 20 scenarios) can be saved within the GUI using the buttons and descriptions provided in the lower left-hand corner of the “Editor” window. The “Export Daily TP Loads” button allows the user to export a daily time series of flow and TP loads to Big Platte Lake for the three hydrologic conditions. The flows and phosphorus loads generated by the Editor and summarized on the Summary sheet are transferred to a water quality model for the lake by selecting the “Go to Lake Model” button. The model predicts the total phosphorus concentration in the lake and compares the results with water quality goals. This model was developed through an independent project and is described in detail in another report (Canale, et al., 2006).



PLATTE RIVER WATERSHED MODEL - Load Summary

	Scenario (lb P/yr)	Change	Base (lb P/yr)
00 Upstream to Fewins Rd.	2,033		2,033
01 Fewins Rd. to Brundage Ck.	27		27
02 Brundage Ck. to Vets Park	154		154
03 Vets Park to Carter Ck.	381		381
04 Carter Ck. to Collison Ck.	92		92
05 Collison Ck. to USGS Gage	127		127
06 USGS Gage to Big Platte Lake	121		121
Platte River (upstream+direct)	**2,935**		2,935
01 Kinney Creek	101		101
02 Kinney Creek (to Brundage Ck.)	29		29
03 Brundage Creek (to Kinney Ck.)	136		136
04 Brundage Creek (Kinney to Stanley)	12		12
05 Stanley Creek	363		363
06 Brundage Creek (Stanley Ck. to PR)	28		28
Brundage Creek	**669**		669
01 Carter Creek (upstream)	127		127
02 Carter Creek (to Platte R.)	152		152
Carter Creek	**279**		279
01 Collison Creek (upstream)	112		112
02 Collison Creek (to Platte R.)	61		61
Collison Creek	**173**		173
01 North Branch Platte River (upstream)	291		291
02 North Branch Platte River (LPL)	315		315
North Branch Platte River	**606**		606
	Scenario	Change	Base
Total Phosphorus Load	**4,662**		**4,662**

CR01: Carter Creek (upstream)

Select Hydrologic Condition: Typical (2004)

		Base	Change	New Area	New Load	BMP Acres	Removal Efficiency	Mass Removed
Total Load	(lb P/yr)	**127.2**	**0.0**		**127.2**			**0.0**
Land Use								
Forest	(acres)	2166.0		2166.0	77.5			0.0
Barren	(acres)	0.0		0.0	0.0			0.0
Orchards	(acres)	0.0		0.0	0.0			0.0
Pasture	(acres)	400.0		400.0	28.2			0.0
Cropland	(acres)	3.0		3.0	0.2			0.0
LD Residential	(acres)	75.0		75.0	16.4			0.0
Commercial	(acres)	6.0		6.0	4.1			0.0
Wetland	(acres)	16.0		16.0	0.6			0.0
Feed Operation	(acres)	0.0		0.0	0.0			0.0
Non-Point Loads	(lb P/yr)	**127.2**			**127.2**			
Point Sources	(lb P/yr)	**0.0**			**0.0**			
Upstream Load	(lb P/yr)	0.0			0.0			

Scenario 01 Title *Baseline*

Baseline scenario

Figure 10. Platte River Watershed TP Load Analysis Tool

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List of Appendices

Appendix A – Watershed Model Flow Calibration Graphics

Appendix B – Watershed Model Total Phosphorus (TP) Calibration Graphics

Appendix C – Watershed Model Total Suspended Solids (TSS) Calibration Graphics

Appendix D – Memorandum: "Comparison of Platte River Watershed Precipitation and Streamflow Datasets"

Appendix A

Watershed Model Flow Calibration Graphics

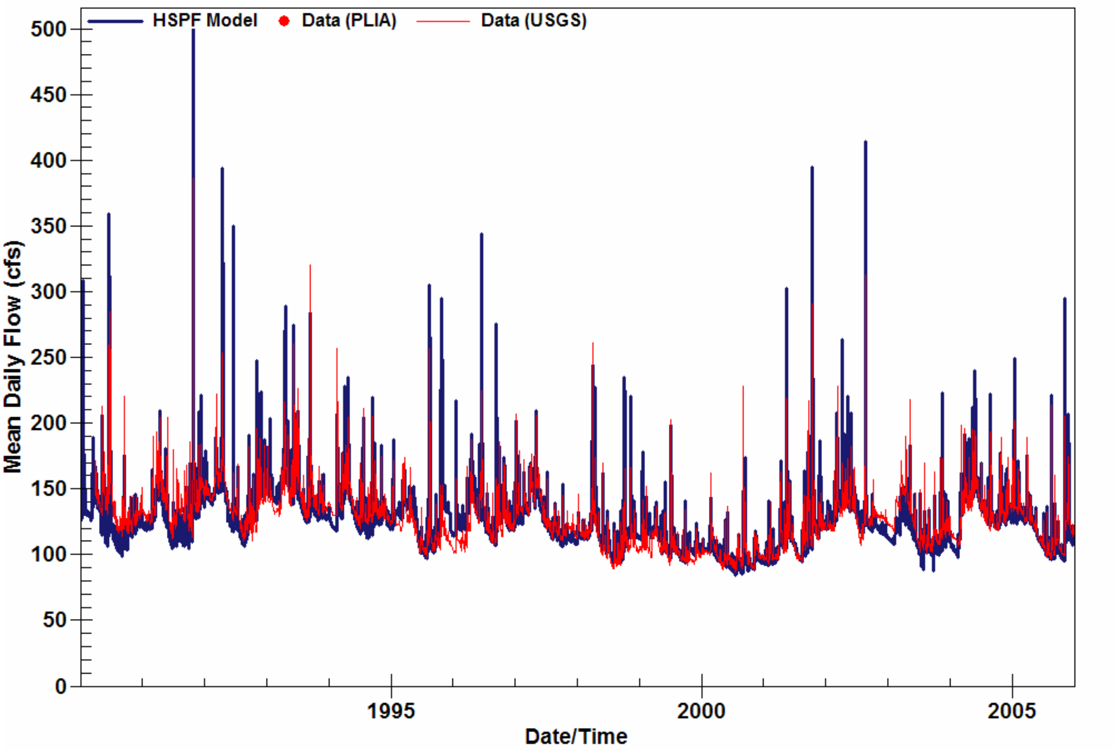

Figure A-1. Model-Predicted vs. Observed Flow for Platte River at USGS Station (1990-2005)

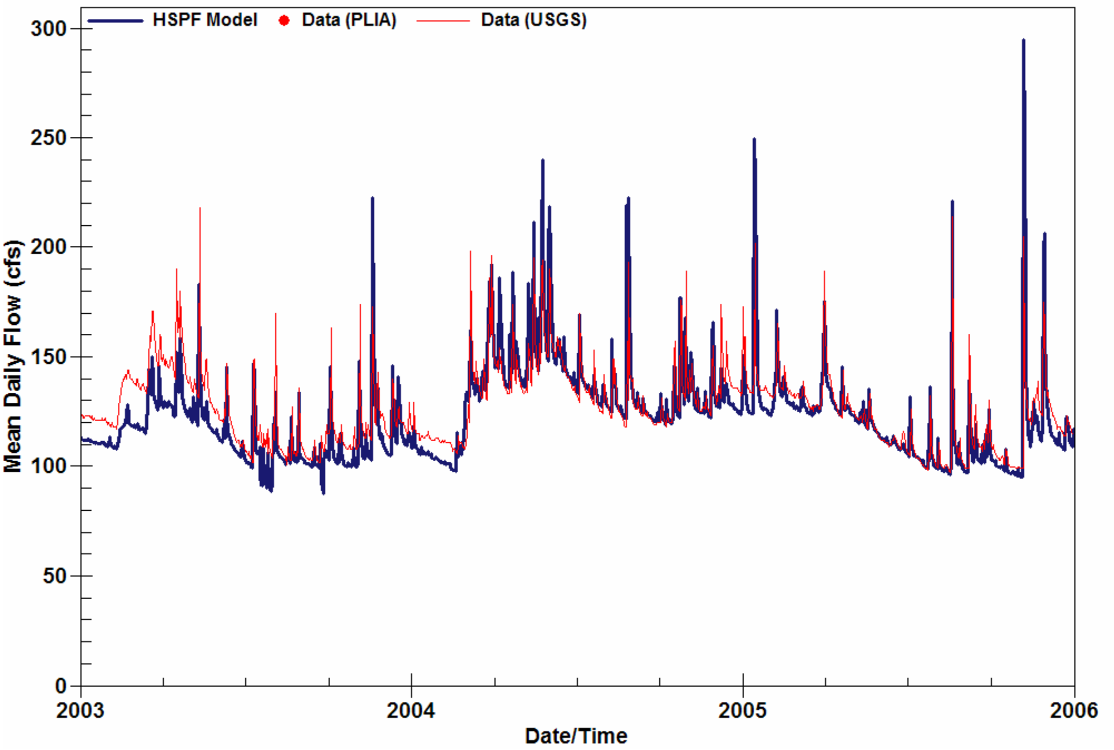

Figure A-2. Model-Predicted vs. Observed Flow for Platte River at USGS Station (2003-05)

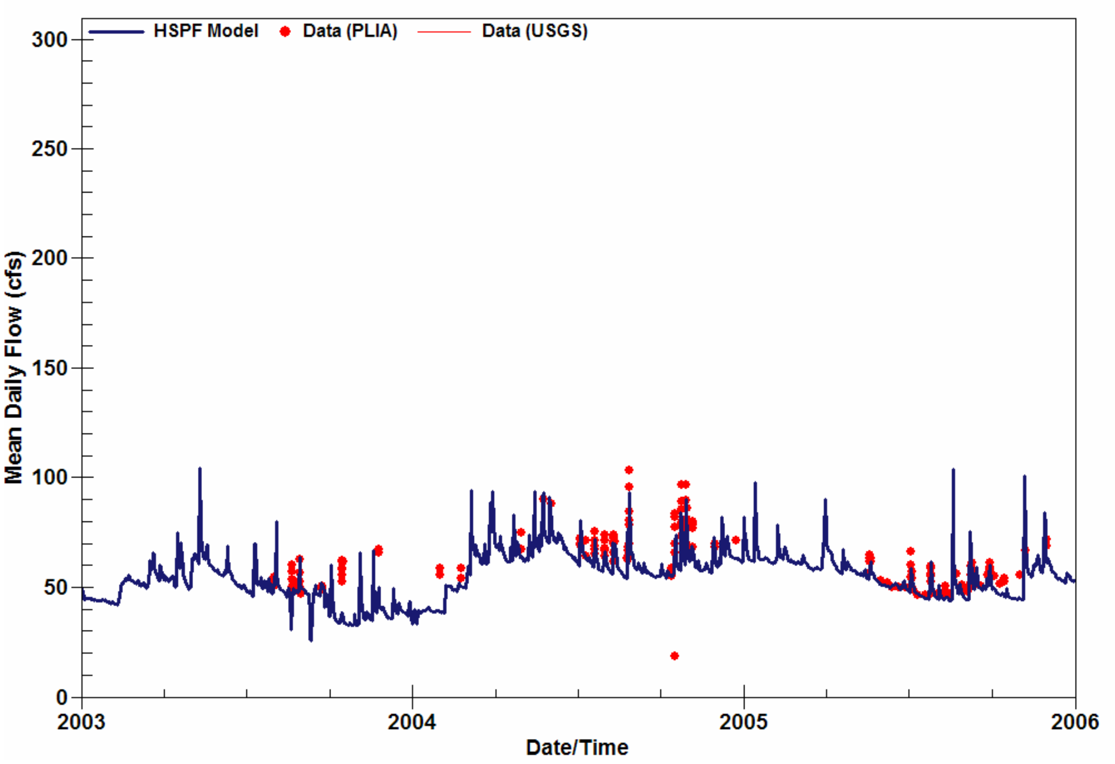

Figure A-3. Model-Predicted vs. Observed Flow for Platte River at Stone Bridge

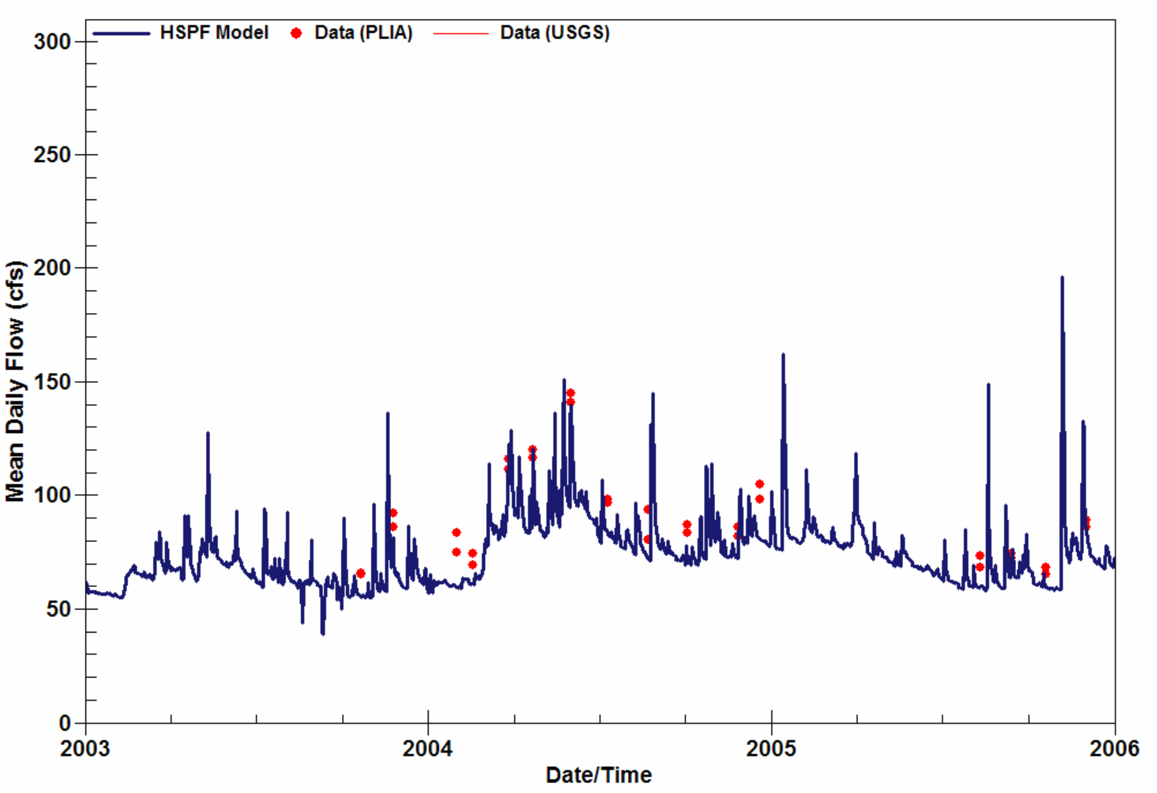

Figure A-4. Model-Predicted vs. Observed Flow for Platte River at Veteran's Park

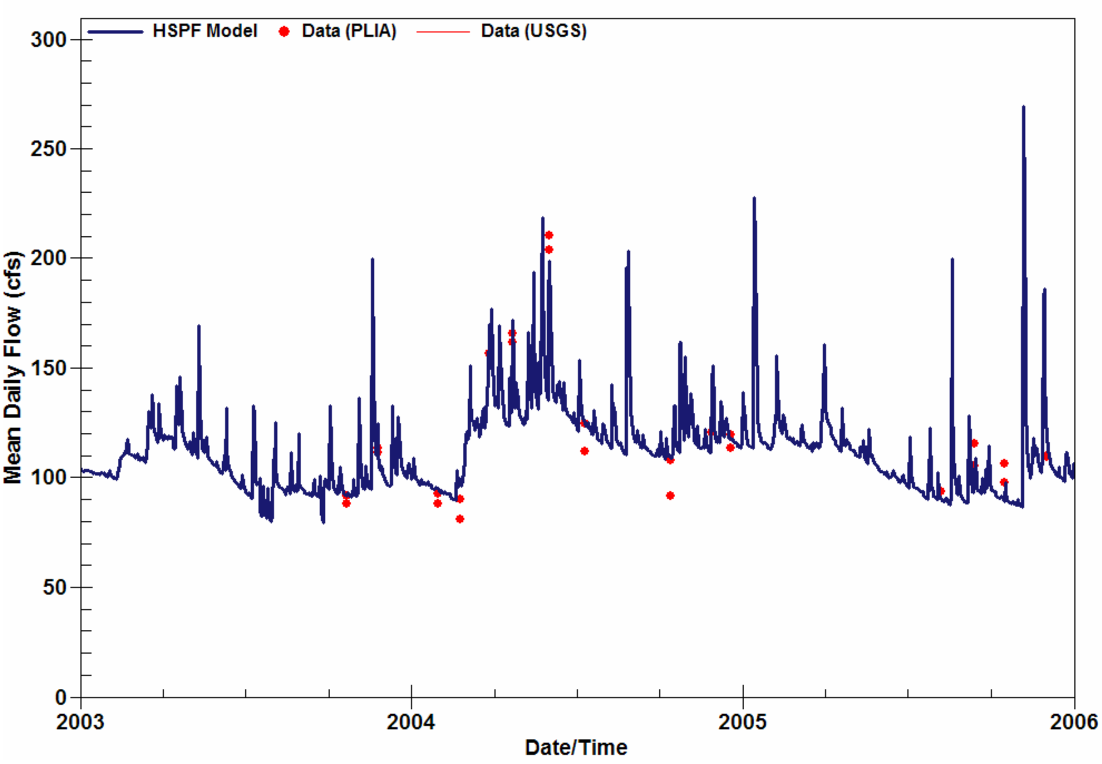

Figure A-5. Model-Predicted vs. Observed Flow for Platte River at Pioneer Road

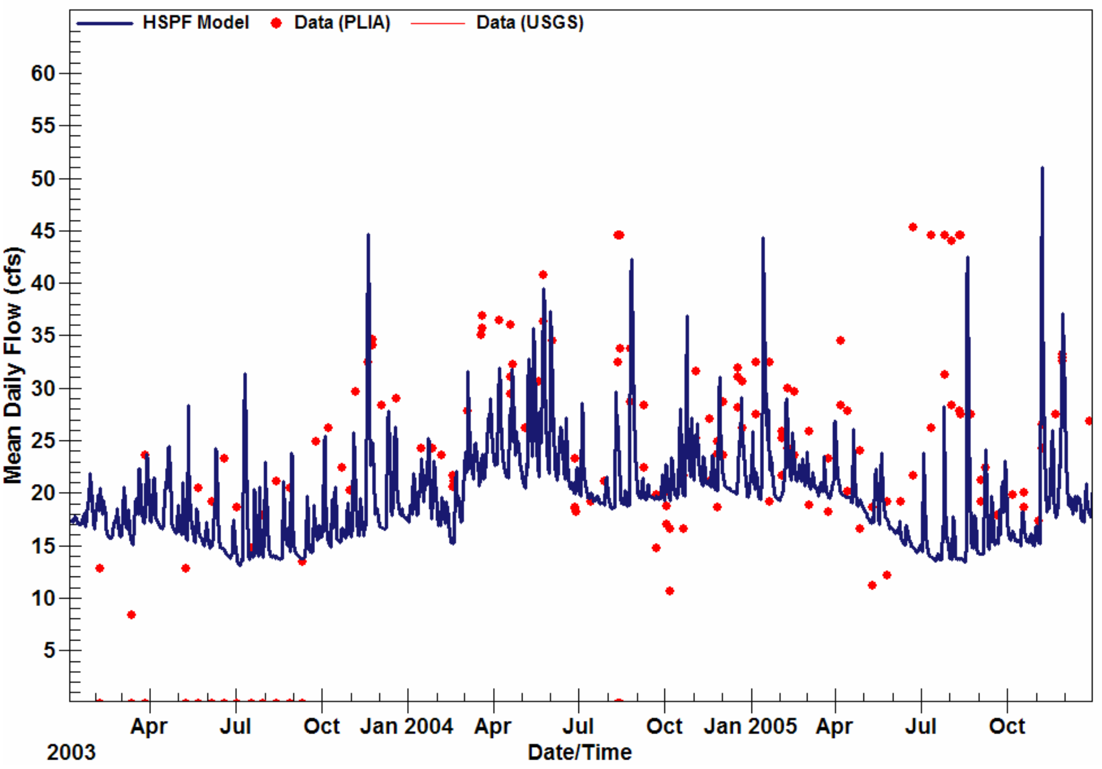

Figure A-6. Model-Predicted vs. Observed Flow for North Branch Platte River at Deadstream Road

Appendix B

Watershed Model Total Phosphorus (TP) Calibration Graphics

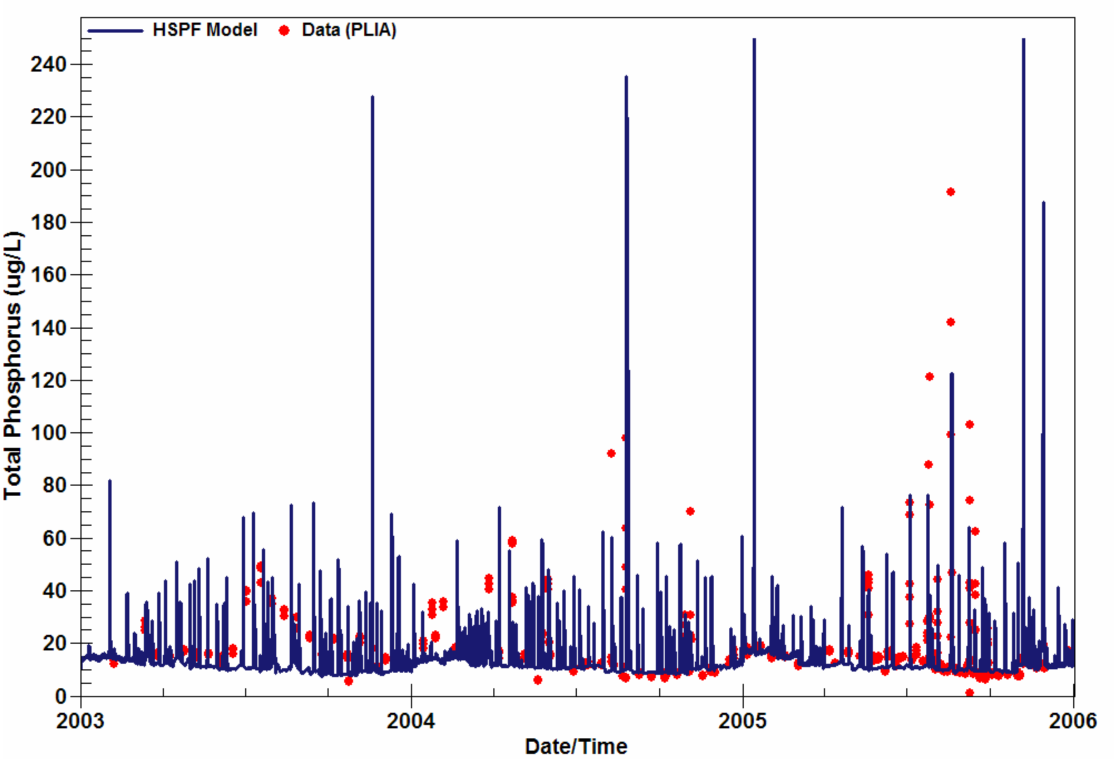

Figure B-1. Model-Predicted vs. Observed TP for Platte River at USGS Station

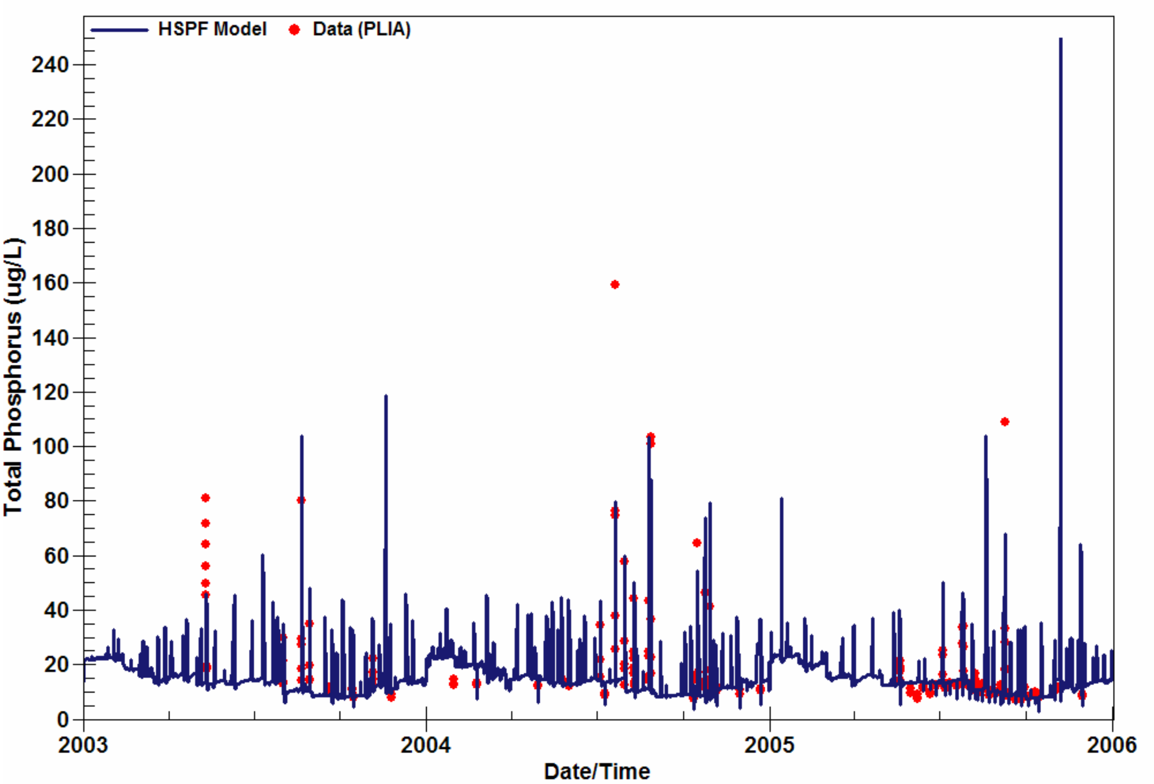

Figure B-2. Model-Predicted vs. Observed Flow for Platte River at Stone Bridge

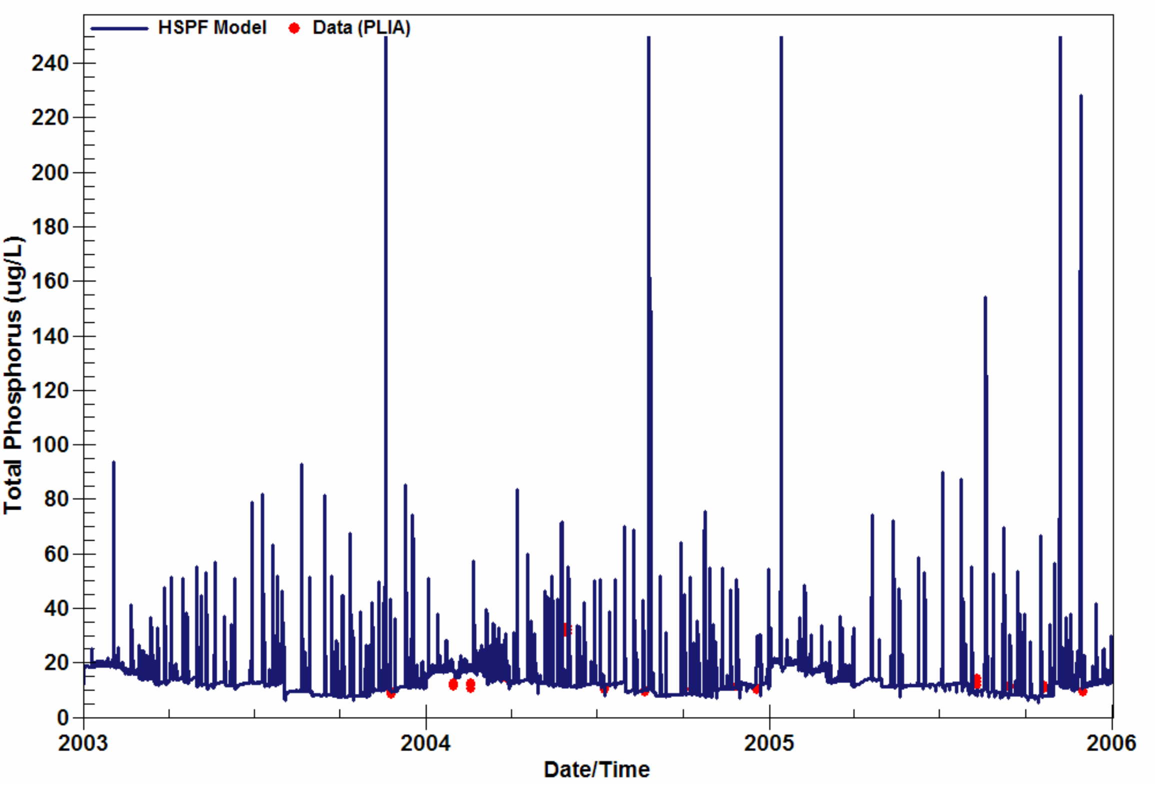

Figure B-3. Model-Predicted vs. Observed Flow for Platte River at Veteran’s Park

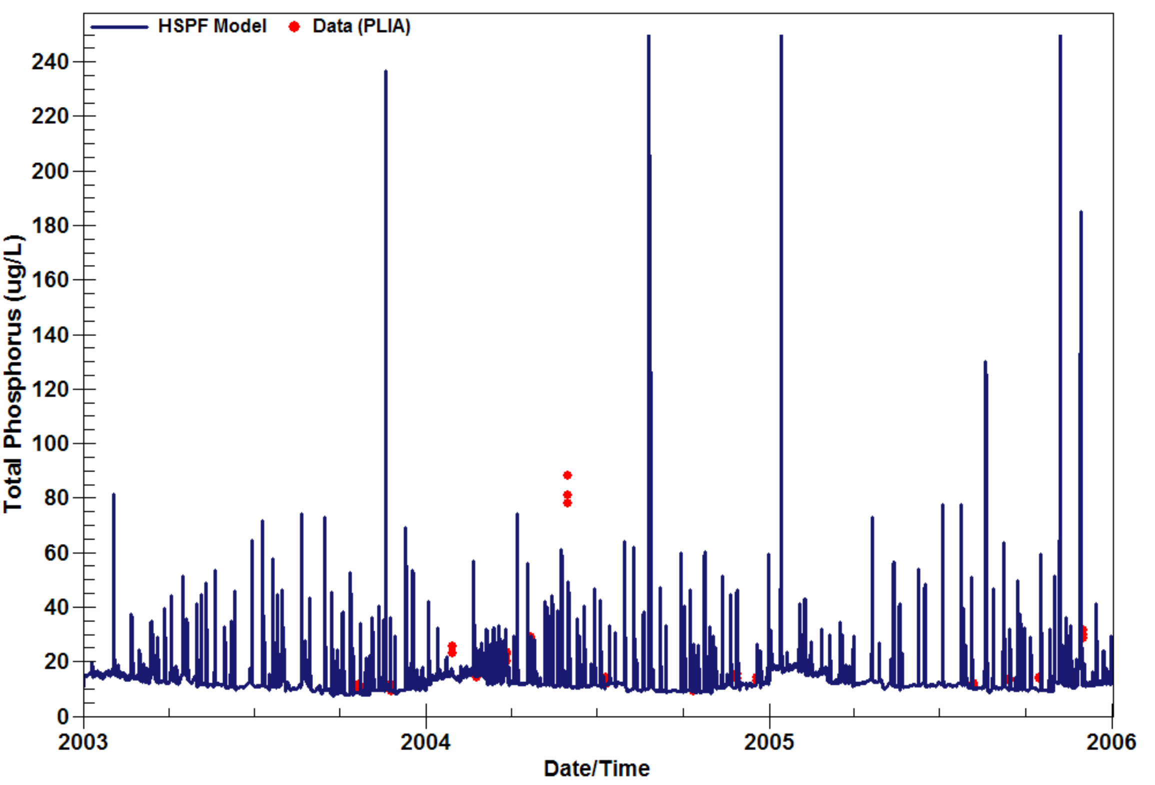

Figure B-4. Model-Predicted vs. Observed Flow for Platte River at Pioneer Road

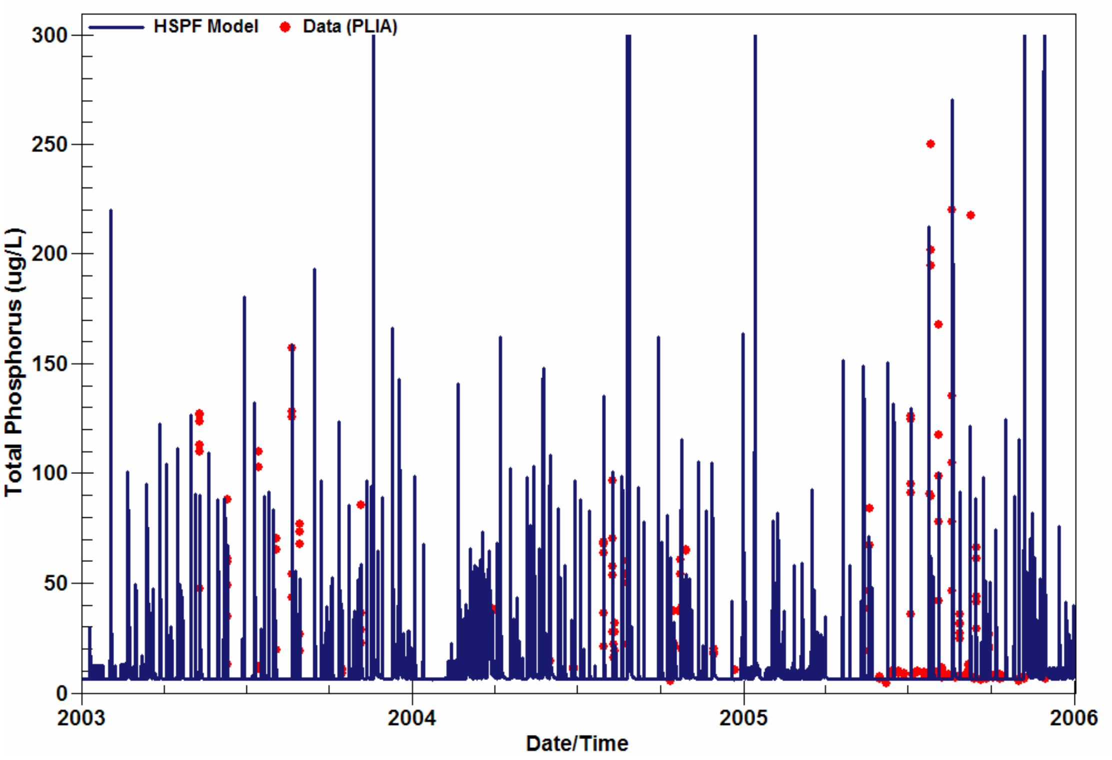

Figure B-5. Model-Predicted vs. Observed Flow for Brundage Creek at Old Residence

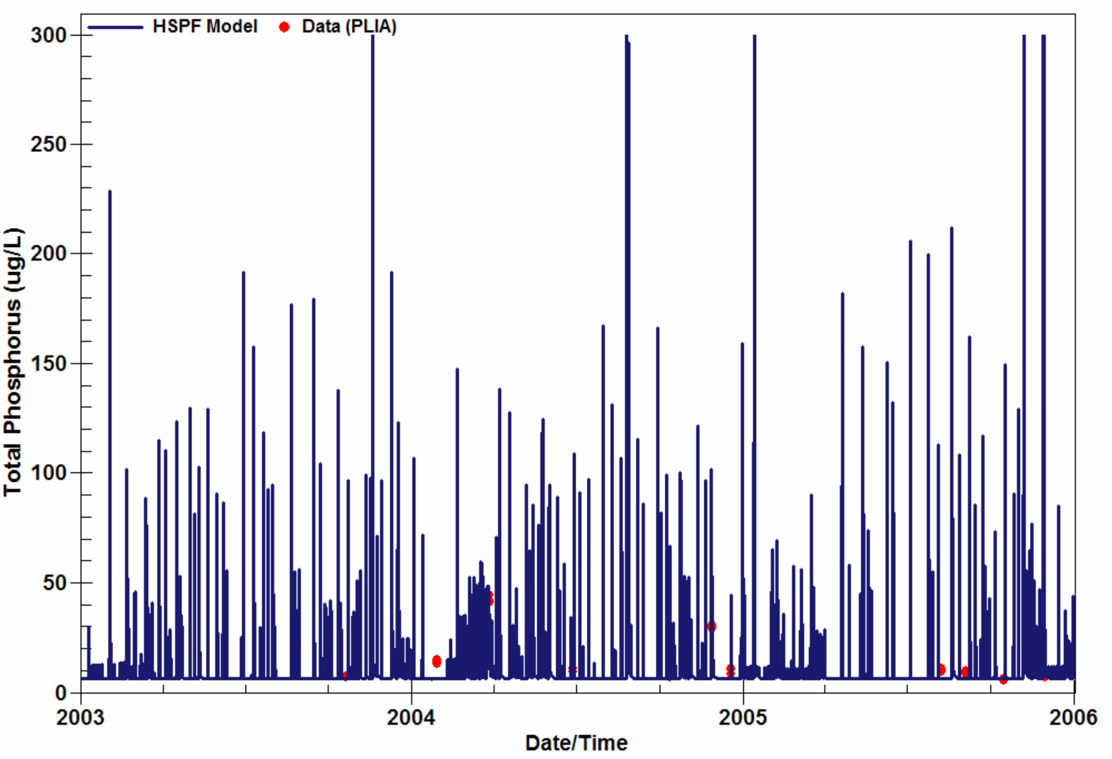

Figure B-6. Model-Predicted vs. Observed Flow for Carter Creek

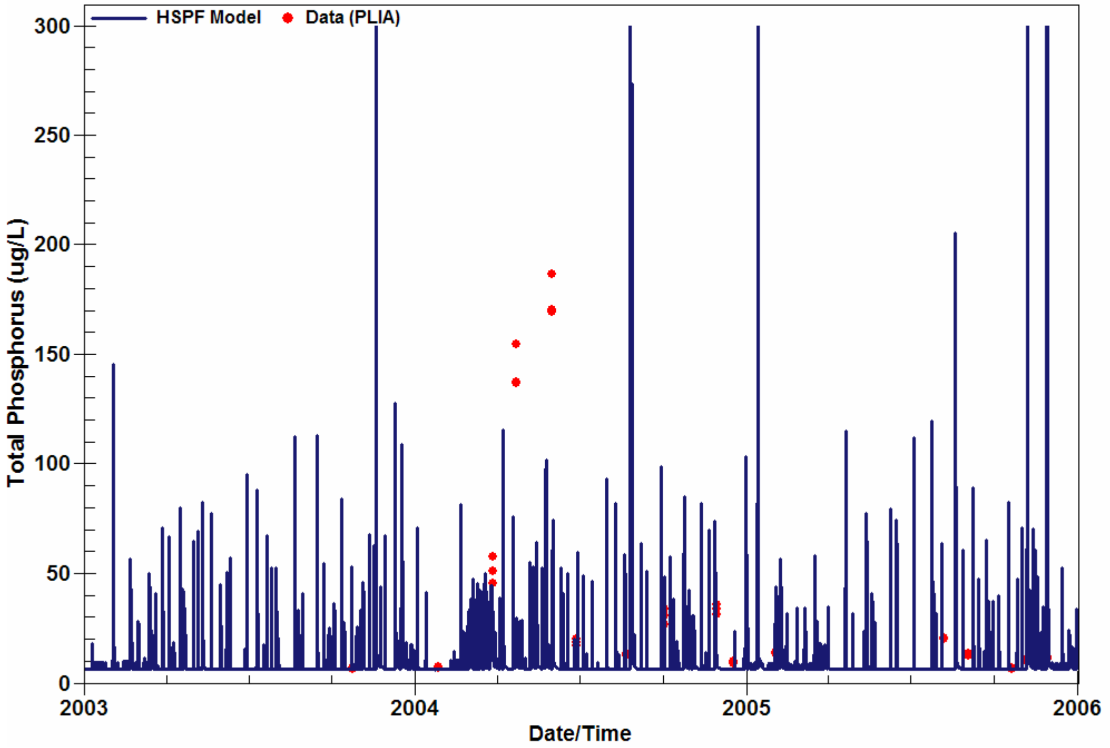

Figure B-7. Model-Predicted vs. Observed Flow for Collison Creek

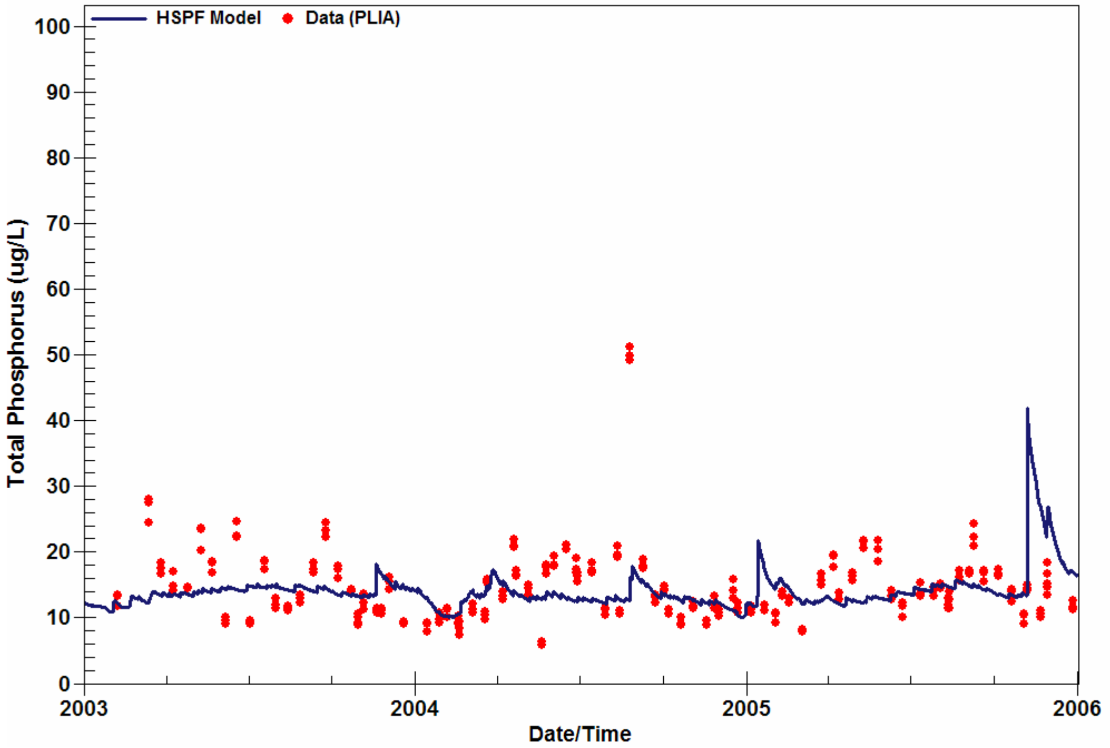

Figure B-8. Model-Predicted vs. Observed Flow for North Branch Platte River at Deadstream Road

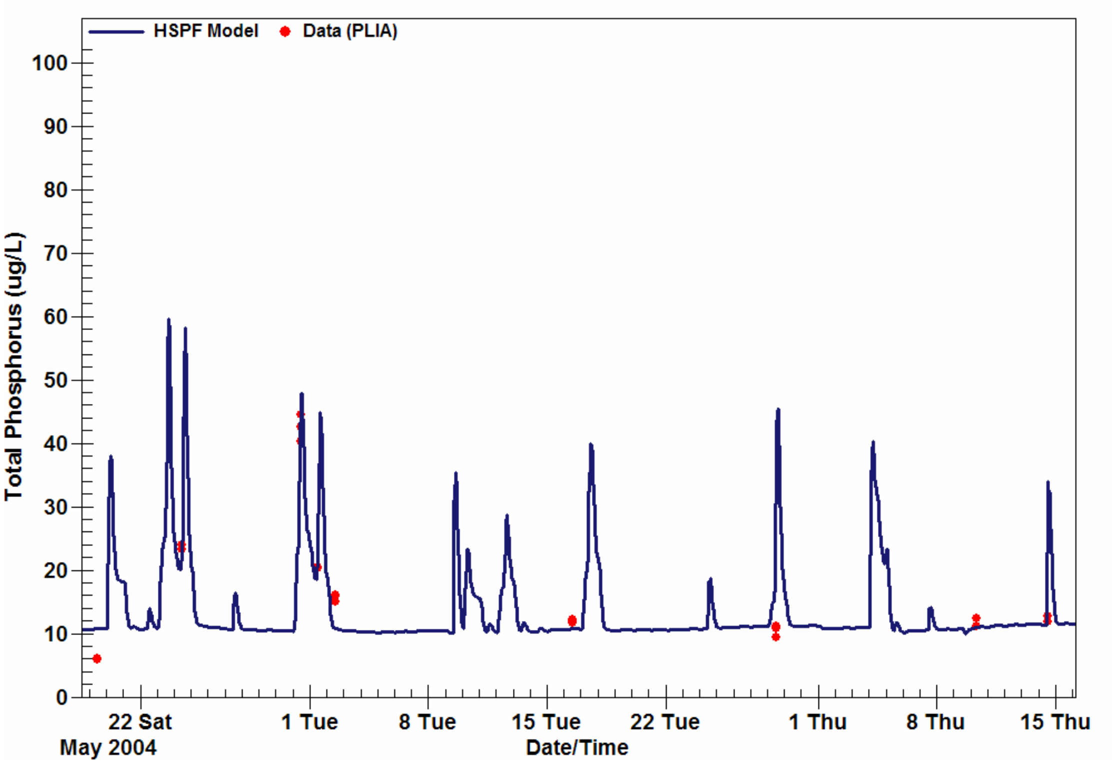

Figure B-9. Model-Predicted vs. Observed TP for Platte River at USGS Station (May 18 – July 15, 2004)

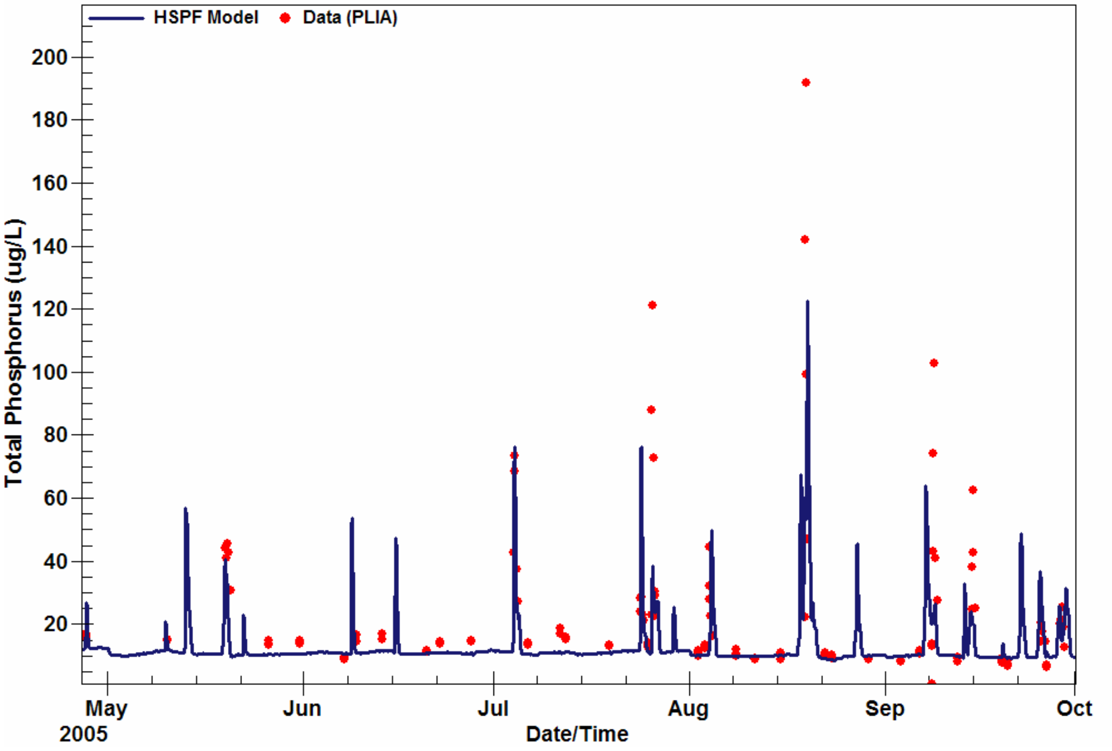

Figure B-10. Model-Predicted vs. Observed TP for Platte River at USGS Station (May-September, 2005)

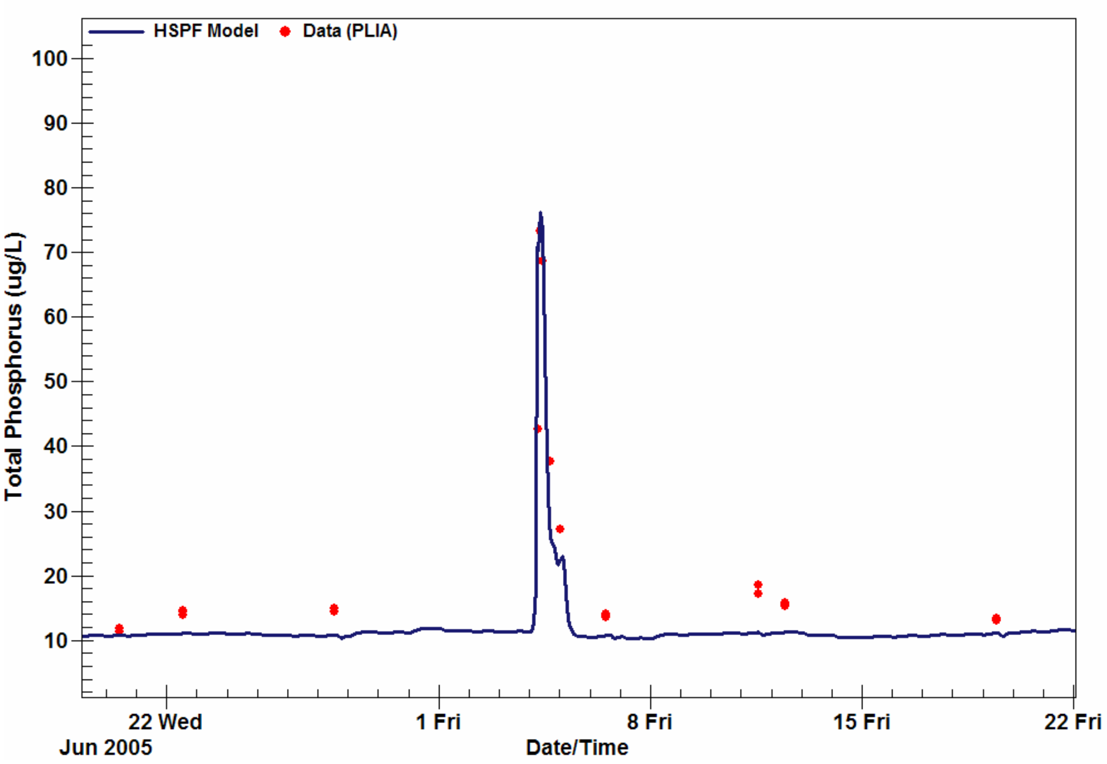

Figure B-11. Model-Predicted vs. Observed TP for Platte River at USGS Station (June 19 – July 22, 2005)

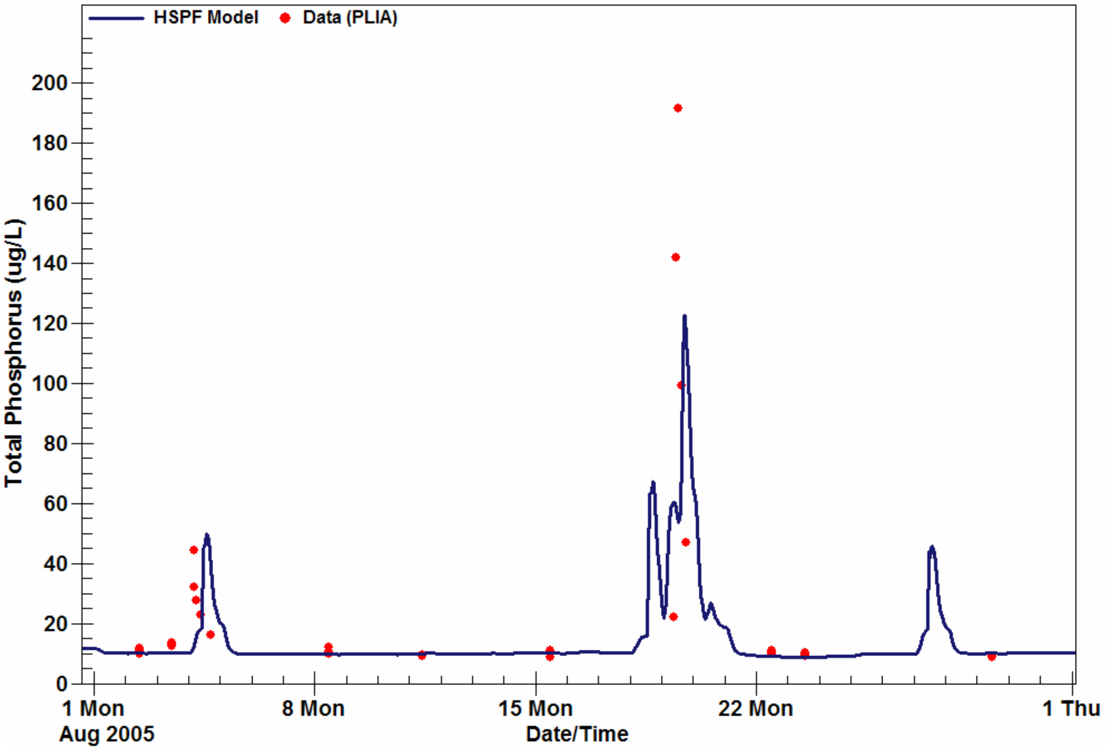

Figure B-12. Model-Predicted vs. Observed TP for Platte River at USGS Station (August, 2005)

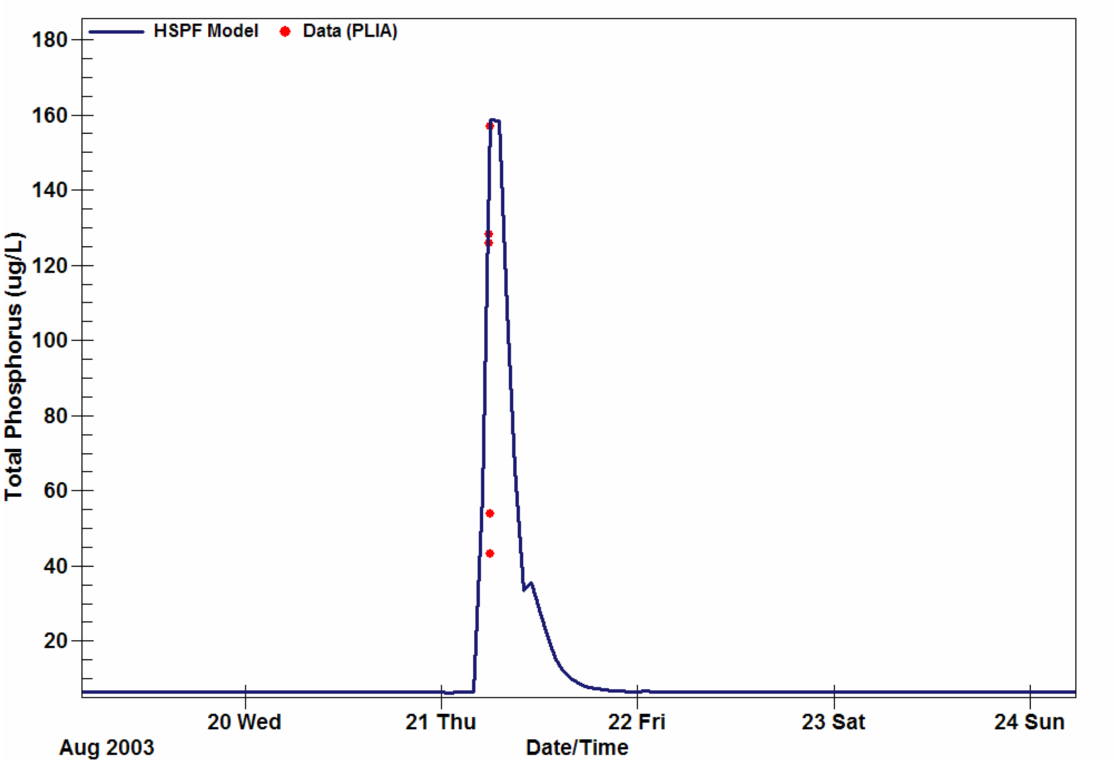

Figure B-13. Model-Predicted vs. Observed TP for Brundage Creek at Old Residence (August 20-24, 2003)

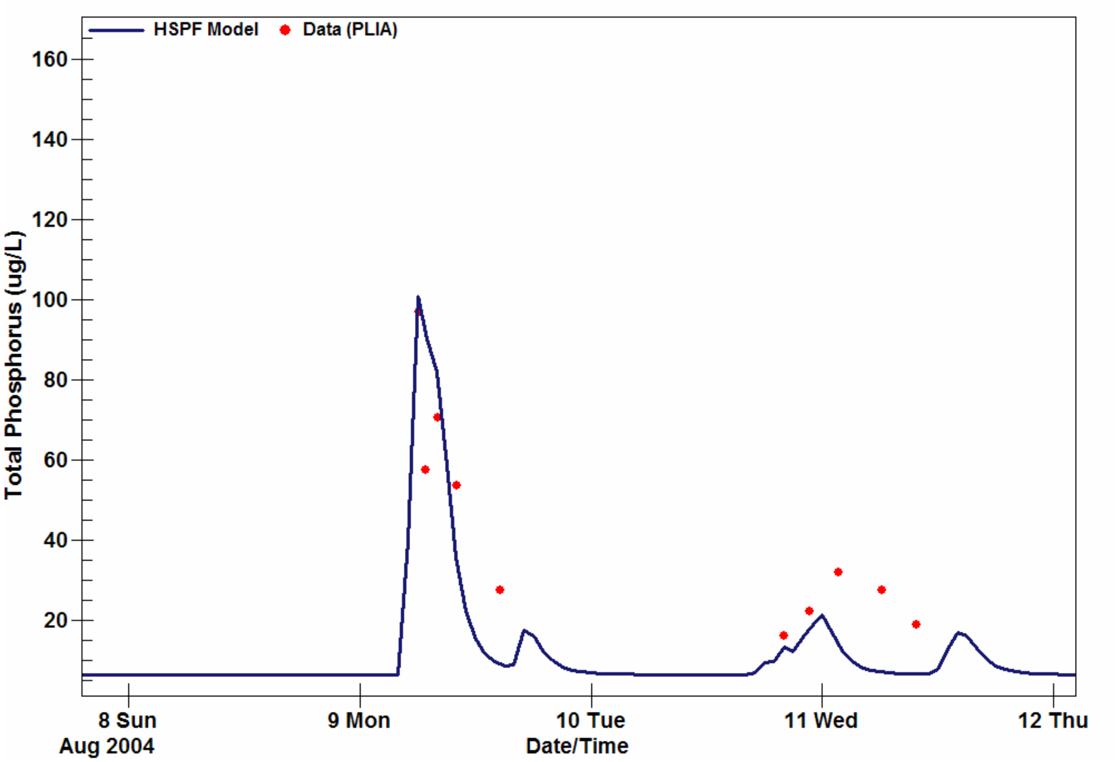

Figure B-14. Model-Predicted vs. Observed TP for Brundage Creek at Old Residence (August 8-12, 2004)

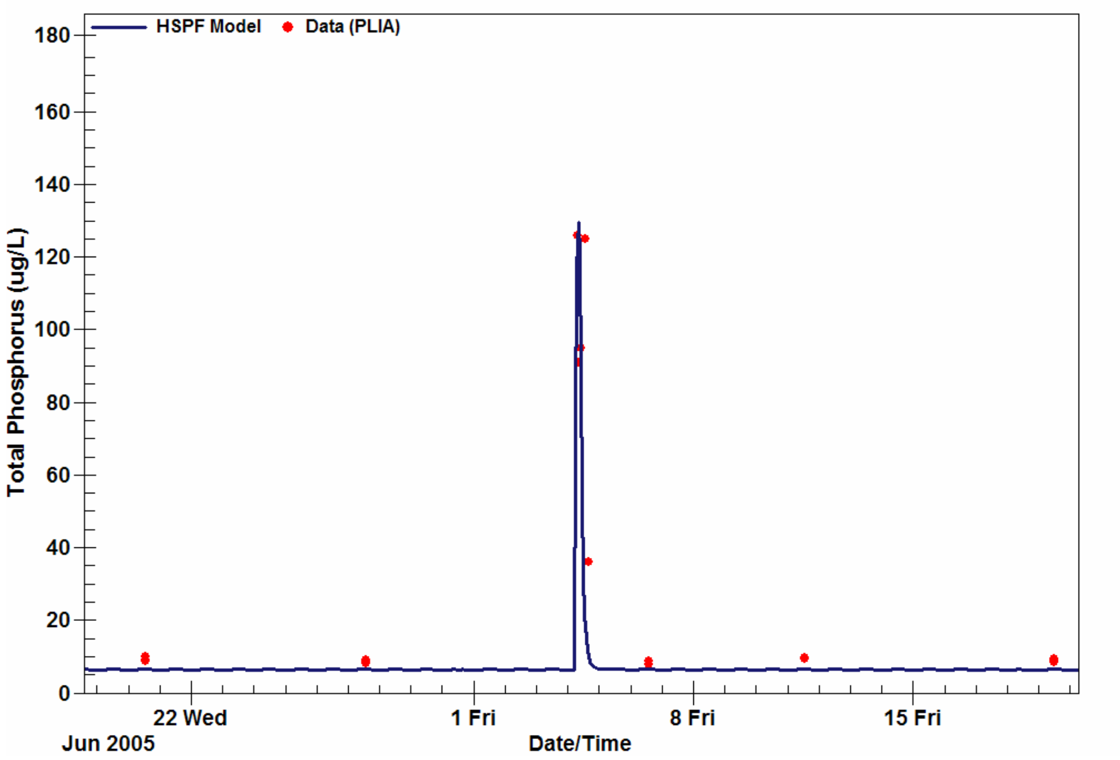

Figure B-15. Model-Predicted vs. Observed TP for Brundage Creek at Old Residence (June 17 – July 20, 2005)

Appendix C

Watershed Model Total Suspended Solids (TSS) Calibration Graphics

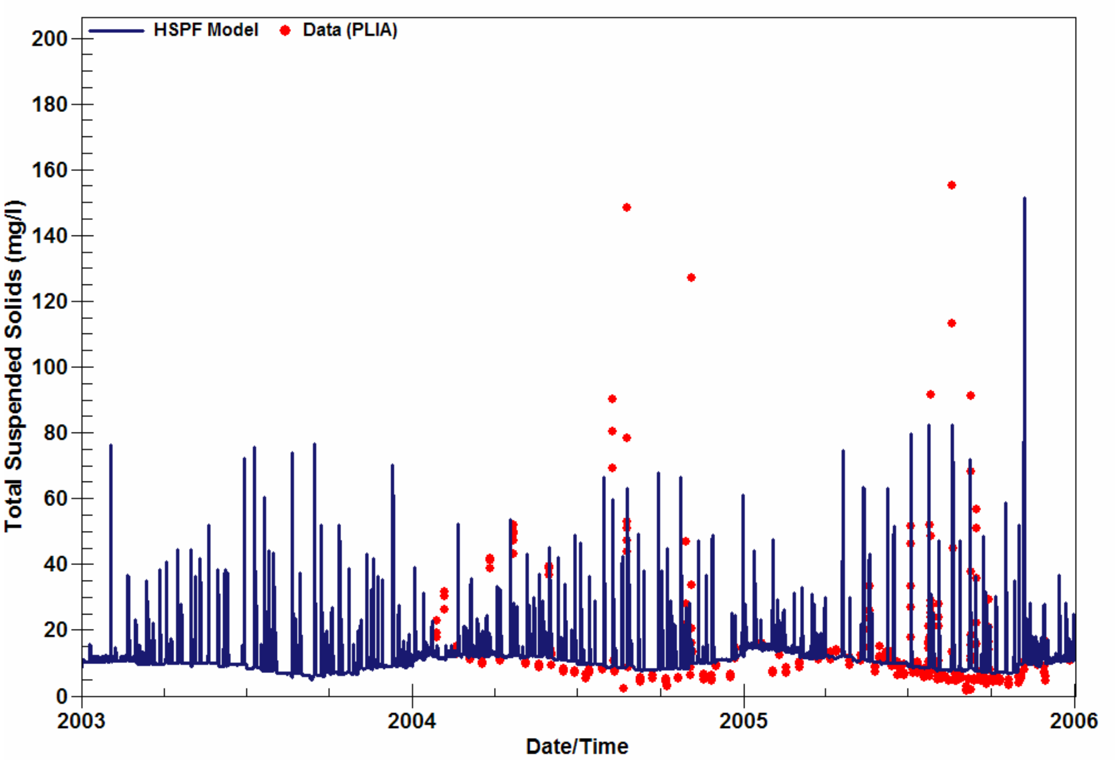

Figure C-1. Model-Predicted vs. Observed TP for Platte River at USGS Station (2003-05)

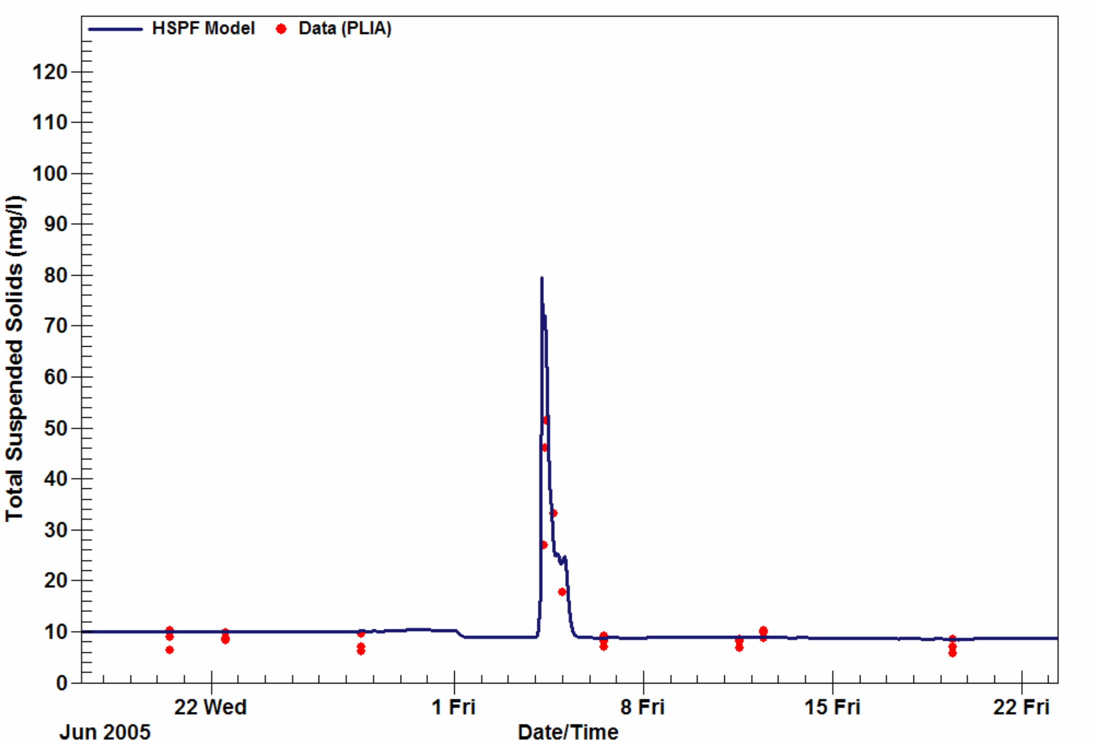

Figure C-2. Model-Predicted vs. Observed TP for Platte River at USGS Station (June 17 – July 23, 2005)

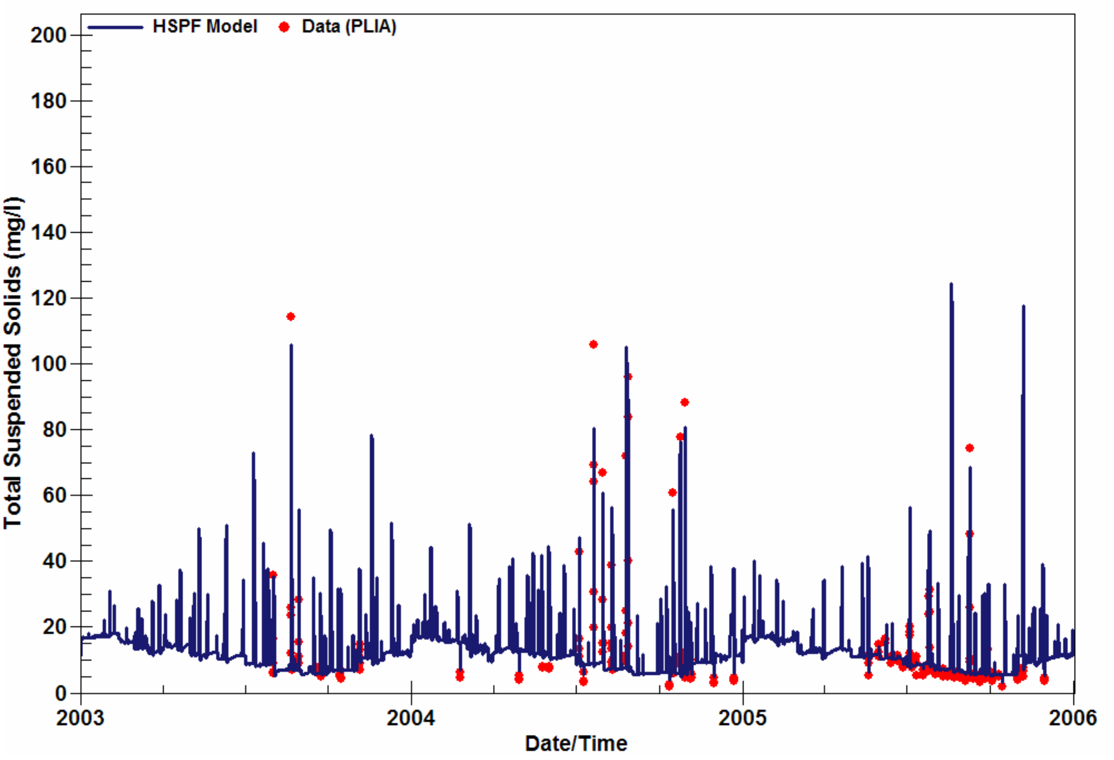

Figure C-3. Model-Predicted vs. Observed Flow for Platte River at Stone Bridge

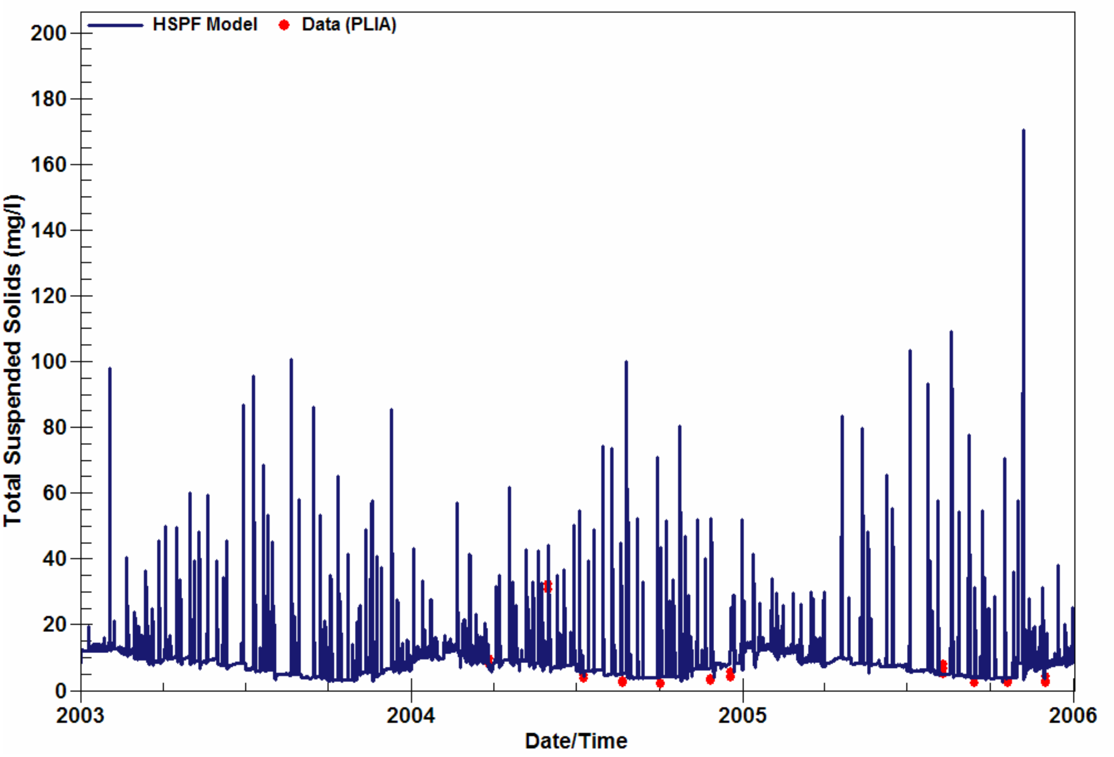

Figure C-4. Model-Predicted vs. Observed Flow for Platte River at Veteran's Park

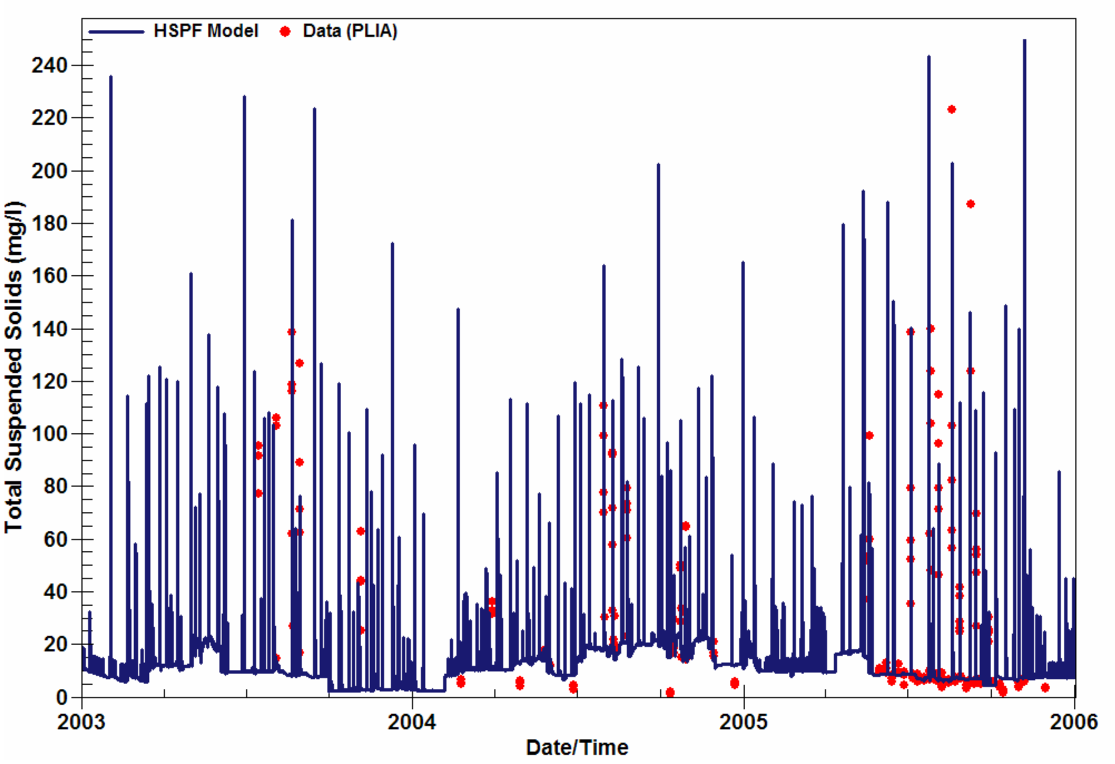

Figure C-5. Model-Predicted vs. Observed Flow for Brundage Creek at Old Residence

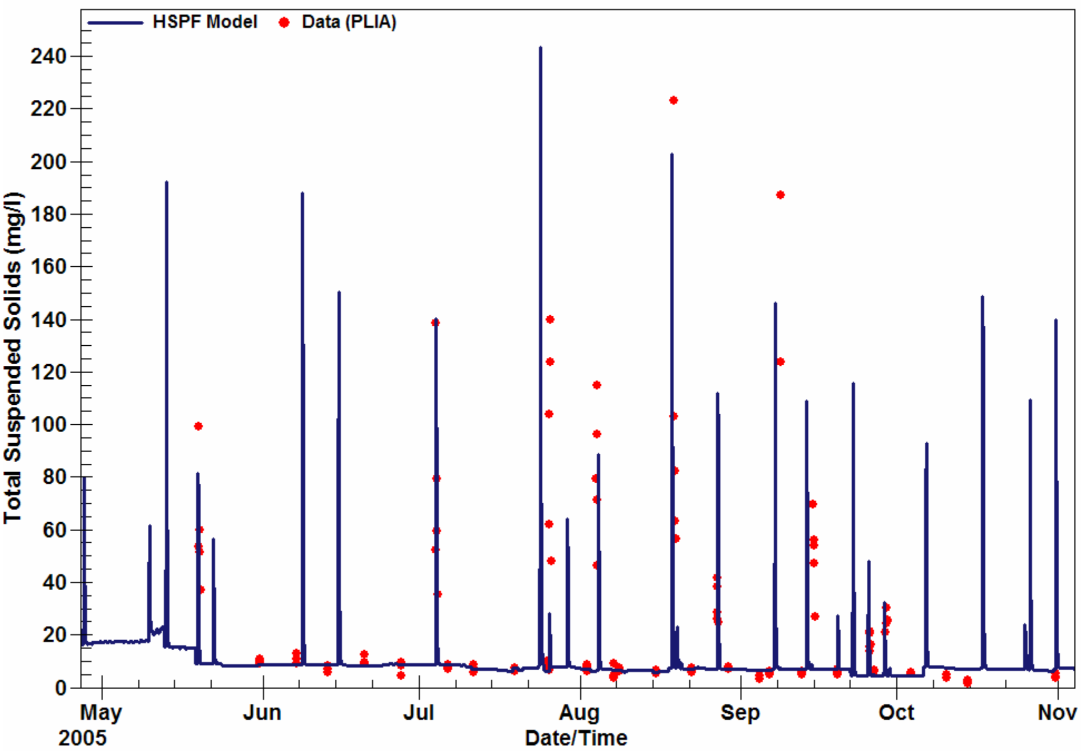

Figure C-6. Model-Predicted vs. Observed Flow for Brundage Creek at Old Residence (May-October, 2005)

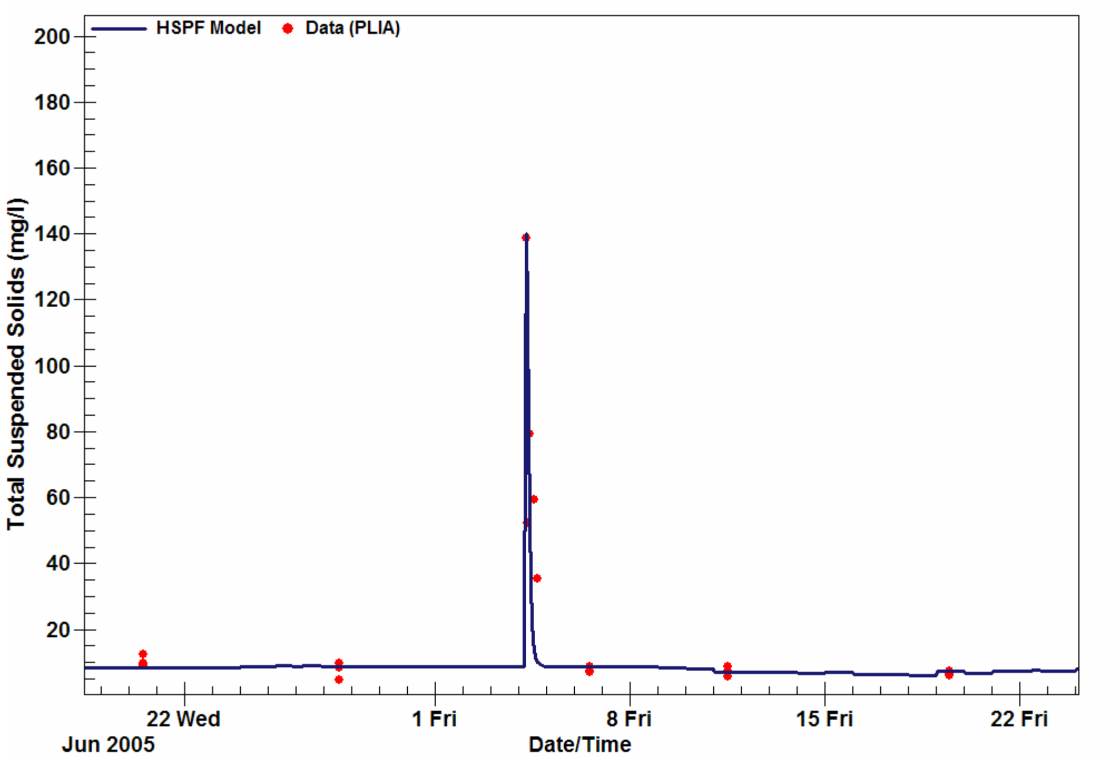

Figure C-7. Model-Predicted vs. Observed Flow for Brundage Creek at Old Residence (June 17 – July 23, 2005)

Limno-Tech, Inc.
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Memorandum

DATE: December 11, 2006
PROJECT: **PLATTE3**

TO:	**Wil Swiecki, Ray Canale, Gary Whelan**	**FROM:**	**Todd Redder, Dave Dilks**
SUBJECT:	**Comparison of Platte River Watershed Precipitation and Streamflow Datasets (final draft)**	**COPY:**	

Summary

LTI assessed the suitability of the available precipitation data to support watershed modeling efforts by analyzing available rainfall and streamflow data for the Platte River watershed. Major findings are:

- Observed Platte River runoff flows correlate very well with precipitation data from the Frankfort weather station.
- Preliminary calibration results for the BASINS flow model using Frankfort precipitation data show an extremely good comparison to observed stream flow data.
- For the above reasons, the Frankfort rainfall data are considered by LTI to be sufficient to support BASINS model application.

Introduction

Observed precipitation data are an essential input to watershed models. Several precipitation monitoring stations exist in the vicinity of the Platte River watershed that are potentially suitable for supporting model calibration and application. The purpose of this memorandum is to assess the suitability of the various precipitation data sources to support watershed modeling efforts. The assessment is made by conducting a comparative analysis of the precipitation and streamflow datasets available for use in calibrating the BASINS model for the Platte River watershed for the 1990-2005 period. This assessment was conducted through the following steps:

- Review of data availability;
- Conducting hydrograph separation to differentiate between base flow and runoff flow;
- Analysis of the relationship between precipitation and runoff flow using linear regression techniques;
- Assessment of preliminary calibration of BASINS model; and
- Analysis of weather radar images.

Each step is discussed in detail below.

Data Availability

Two principal data types are required to calibrate and apply a watershed hydrology model: 1) daily/hourly precipitation and 2) daily average streamflow at one or more points within, or in the vicinity of, the subject watershed. Table 1 summarizes the precipitation datasets available for the Platte River watershed, including period of record and data frequency.

Table 1. Summary of Platte River Watershed Precipitation Datasets

Station ID	Station Description	Data Frequency	Period of Record
202984	Frankfort	Daily	11/1/1948 – 12/31/2005
200758	Beulah[1]	Daily	4/1/1999 - 12/31/2005[1]
208246	Traverse City	Hourly	3/1/1971 – 12/31/2005
208251 208252 208249	TC Cherry Capital TC Airport #2 TC Munson	Daily[2]	1/1/1897 – 1/31/1998 3/1/1999 – 8/31/2001 11/1/2001 – 12/31/2005

[1] The Beulah station is missing more than 50% of the days for 1999-2001 and ~30% of days for 2002.

[2] The three daily Traverse City datasets can be merged into a single dataset covering the majority of the 1990-2005 period.

In addition to actual rainfall measurements, weather radar data can also be processed to provide a more spatially detailed estimate of precipitation. The potential application of radar data will be discussed in another section of this report.

Streamflow data are collected by the United States Geological Survey (USGS) at the US-31 highway bridge near Honor, MI. Final approved estimates of mean daily streamflow for this gauge are published on the USGS website (http://waterdata.usgs.gov/nwis/dv/?site_no=04126740) for the period 3/27/1990 – 9/30/2006. Provisional data are also available beginning on 10/1/2006.

Hydrograph Separation

Stream flow consists of two major components, including direct runoff from rainfall and snowmelt events and "base flow", which is derived from direct and indirect shallow groundwater and inland lake flow contributions to a stream. Hydrograph separation refers to a common approach in which a software program is used to analyze the daily stream flow recession patterns for a given gauge location and estimate the fraction of total flow resulting from the distinct runoff and base flow components. The USGS distributes two software packages that can be used to conduct hydrograph separation – HYSEP (http://water.usgs.gov/software/hysep.html) and PART (USGS, 1998; http://water.usgs.gov/ogw/part/). LTI has applied both of these packages to other watersheds and has found that they generate comparable results. In general, the runoff and base flow estimates generated by these tools are very reliable on a monthly and annual scale. In addition to monthly estimates, HYSEP and PART also provide daily estimates of runoff and base flow, although there is greater uncertainty associated with the day-to-day estimates.

It is important to note that hydrograph separation techniques rely solely on observed streamflow data and do not consider precipitation data. For instance, the PART program scans the flows in a USGS daily record and identifies time periods where the flow patterns are consistent with typical groundwater recession behavior. The baseflow is assumed to be equal to the total flow for those periods, and linear interpolation is used to estimate the baseflow for days that do not exhibit recession behavior (e.g., during a runoff event). Similar techniques are used by HYSEP to estimate baseflow and runoff for each day in the period of record.

Both HYSEP and PART were used to conduct hydrograph separation for the Platte River USGS stream flow gauge operated at Honor. The purpose of the hydrograph separation was two-fold in this case:

1. To provide a quantitative breakdown of the base flow and runoff components to improve general conceptual understanding of watershed behavior; and

2. To allow correlations to be developed between the runoff component estimates and precipitation datasets.

The results of the two applications were very similar and confirm that base flow from groundwater and inland lake sources is the dominant contributor to total streamflow on a monthly and annual basis. Figure 1 summarizes the monthly results for 1990-2005 generated by the PART software package. These results indicate that base flow on average for the 16-year period contributes approximately 97% of the total Platte River flow at the gauge location. On a monthly basis, the contribution of base flow rarely falls below 90% and is typically in the 92-98% range. This range is similar to base flow estimates reported for other streams in northern lower Michigan of similar watershed size, including the Manistee River and the Little Manistee River (USGS, 1998), as shown in Table 2.

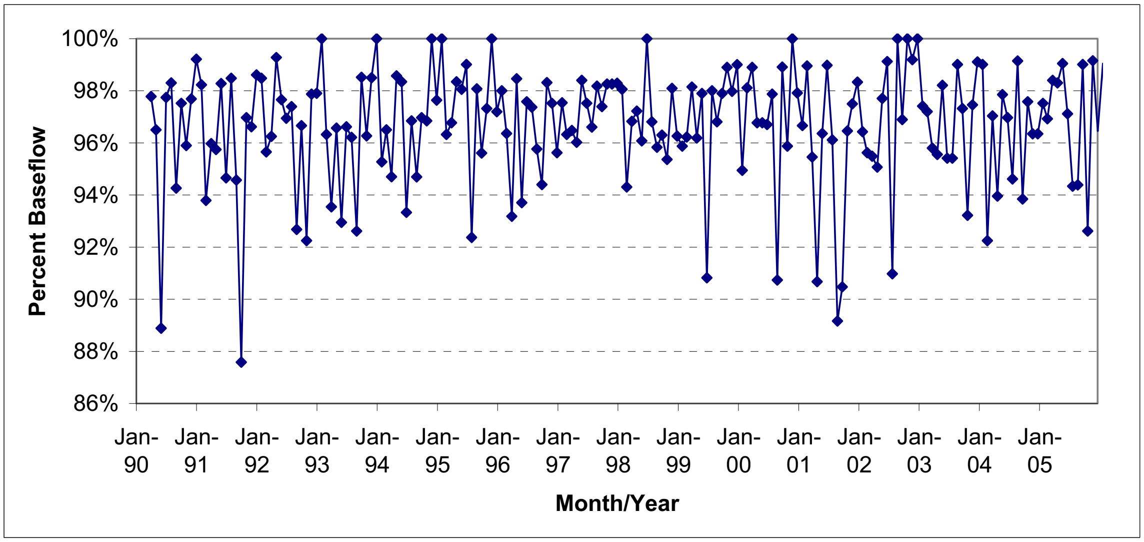

Figure 1. PART-Estimated Monthly Base Flow Percentages for the Platte River at Honor

Table 2. Monthly Flow Contributed by Base Flow for Selected Northern Michigan Streams

Station ID	Station Name	Drainage Area (mi^2)	% of Total Monthly Flow	Source
04126740	Platte River at Honor, MI	118	90-98	USGS and LTI analyses using the PART program.
04135500	Au Sable River at Grayling, MI	110	94.3	USGS, 1998
04123000	Big Sable River near Freesoil, MI	127	95.5	USGS, 1998
04123500	Manistee River near Grayling, MI	159	97.0	USGS, 1998
04126200	Little Manistee River near Freesoil, MI	200	94.5	USGS, 1998

An example of the daily base flow and runoff component time series estimated by HYSEP is provided in Figure 2. It should be noted that the runoff and base flow components always equal the total stream flow (in units of cubic feet per second) when added together. It is evident from Figure 2 that base flow is an important component of the flow even during and following rainfall / snowmelt events. Peak base flow "events" often occur following major runoff events because the soils in the Platte River watershed are predominantly sandy and are characterized by very high infiltration rates. As a result, a runoff event in the watershed will produce not only direct runoff flow, but measurable increases in base flow contributions to the stream network as well. A short (two to three day) lag time is often observed between precipitation and the subsequent increases in base flow, indicating the role of shallow groundwater.

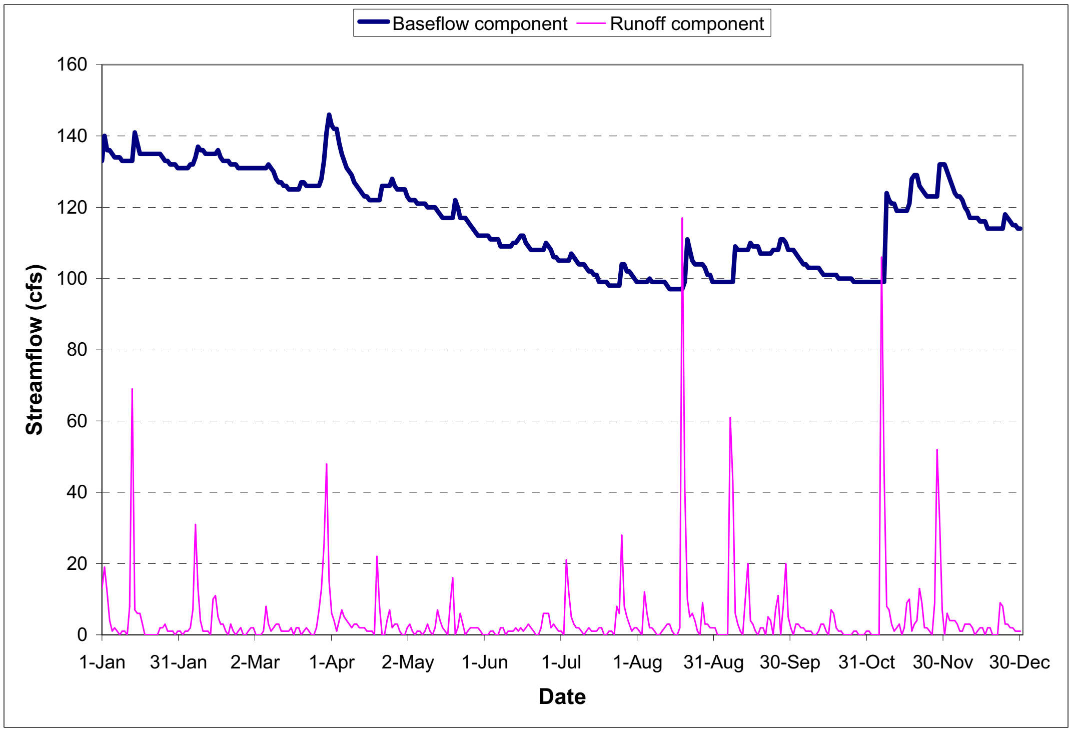

Figure 2. HYSEP Daily Hydrograph Separation Results for Year 2005

The United States Geological Survey (USGS) conducted an independent stream flow partitioning assessment and reached the virtually identical conclusion as LTI that 97% of the stream flow is due to base flow (Ray Canale, personal communication). A very minor discrepancy (96.6% vs. 96.7%) exists between the LTI and USGS results due to the fact that the LTI analysis considered only the final approved data up to 9/30/06 while the USGS analysis included additional data up to 11/7/06.

Comparison of Precipitation and Stream Flow Datasets

A comparative analysis of the available precipitation and stream flow datasets was conducted to explore and quantify the relationship between these variables in the context of BASINS model development, calibration, and eventual application. Specific stream flow-precipitation comparisons that are discussed in this section include:

- The relationship between annual stream runoff flow and annual precipitation; and
- The relationship between monthly stream runoff flow and monthly precipitation, including accounting for the effects of snow accumulation and melt dynamics.

Because surface runoff occurs in direct response to local precipitation / snowmelt, it is expected that it will be possible to directly correlate annual runoff flow quantities to observed precipitation for a representative station(s). This comparison was performed for available precipitation data for two different recent time periods, 2001-05 and 2003-05. A separate analysis for 2003-05 was conducted because the Beulah station only has data available for this period, and because the majority of the sampling data for total phosphorus and suspended solids falls within this period. Table 3 shows the correlation coefficient (R^2) generated by a least squares regression for runoff flow versus annual precipitation for the available precipitation stations. The R^2 value represents the fraction of the total variation in runoff flow that can be explained by the regression. An R^2 value of 1.00 would suggest a perfect linear relationship between annual runoff flow and precipitation.

Table 3. Linear Correlation Results (R^2) for Annual Runoff Flow Versus Precipitation

Station ID	2001-2005	2003-2005
Frankfort	0.98	0.99
Traverse City	0.65	0.77
Hatchery	0.16	0.50
Beulah	n/a[1]	0.51

[1] Data not available for Beulah from 2001-02.

The results in Table 3 show that the runoff flow at the USGS gauging station strongly correlates to the Frankfort precipitation dataset on an annual basis. Figure 3 illustrates this relationship and the linear regression fit for the 2001-05 period. This strong correlation does not mean that every precipitation event measured at Frankfort will also occur over the watershed (or vice versa); however, it does indicate that precipitation measured at Frankfort is representative of the actual event conditions experienced within the watershed during the 2001-05 period. The Traverse City station(s) has a reasonable correlation with runoff flow for the two time periods (i.e., $R^2 = 0.65$, 0.77); however, the correlations for the hatchery and Beulah stations are generally not as good. It is not immediately apparent why the correlations for the hatchery and Beulah precipitation stations are not as good; potential explanations include station locations not being representative of the entire watershed, monitoring equipment/staffing less rigorous than at the other stations, and/or missing data. Based on the results in Table 3, the Frankfort station was selected for the additional, more detailed analysis described below.

To build on the annual comparison presented in Figure 3, a monthly comparison of runoff flow and precipitation at Frankfort was conducted. Figure 4 shows the monthly runoff-precipitation relationship for all months during the period 2001-2005.

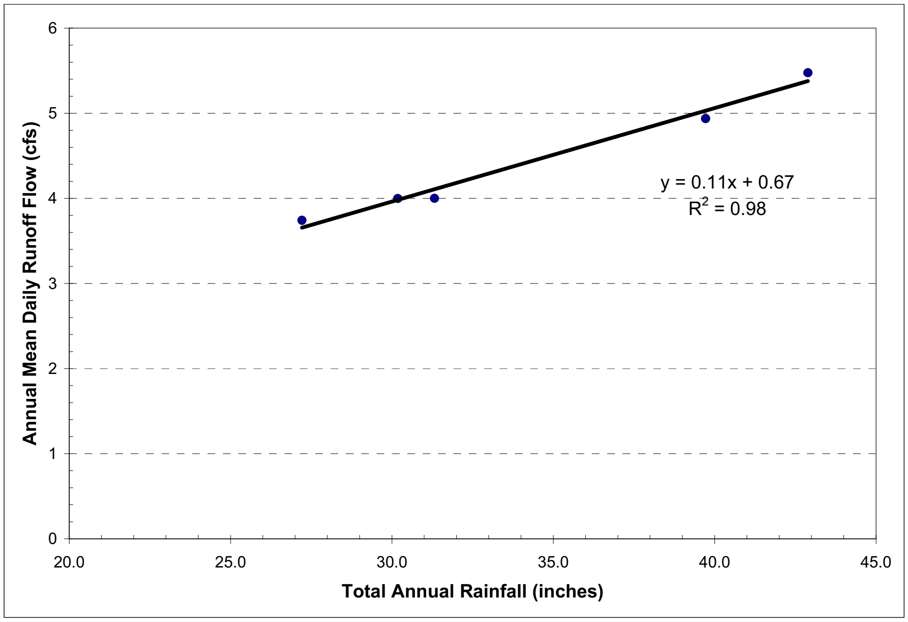

Figure 3. Comparison Annual Mean Daily Runoff Flow to Annual Precipitation at Frankfort (2001-2005)

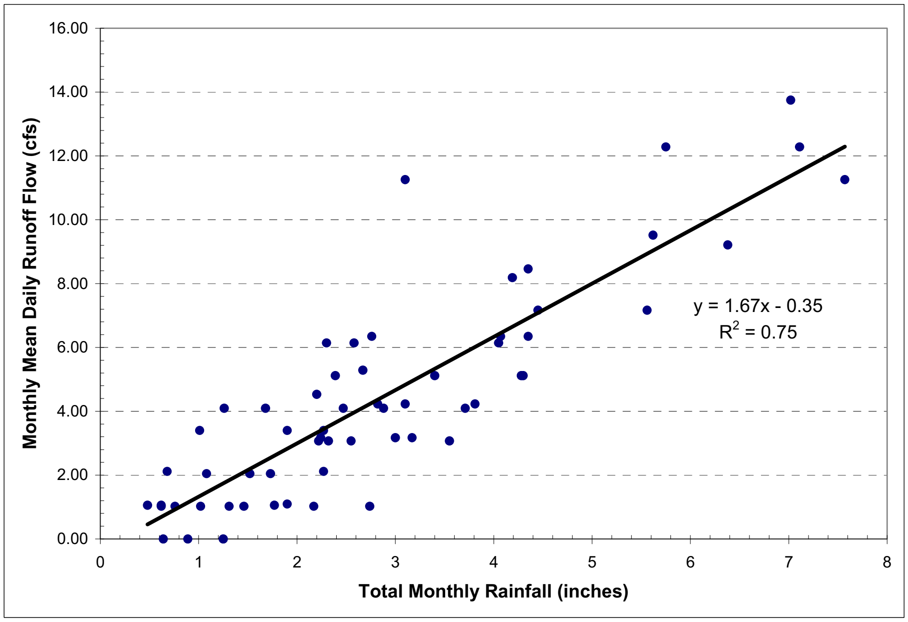

Figure 4. Linear Relationship for Monthly Runoff Flow versus Precipitation at Frankfort (January-December, 2001-2005)

Although the relationship between runoff flow and precipitation in Figure 4 is reasonably good ($R^2 = 0.75$), it is important to recognize that this relationship is affected by the periodic accumulation and subsequent melting of the snow pack that occurs during the winter months. In northern lower Michigan, snow accumulation and melt dynamics have the potential to significantly impact streamflow during November through April, with the final spring melt typically occurring in late March to mid-April. It is typical for snow that accumulates in January, for example, to melt sometime in February, March, or April. In that case, the effects of January precipitation on total streamflow and runoff will not be realized until later in the winter when the next significant snowmelt event occurs.

If the plot shown in Figure 4 is modified to only include the late spring, summer, and early fall months (i.e., May-October) when snow is not a factor, it is reasonable to expect that the correlation will improve. Figure 5 demonstrates that this is indeed the case; several of the outliers from Figure 4 are absent in Figure 5, and the R^2 correlation coefficient increases to 0.86.

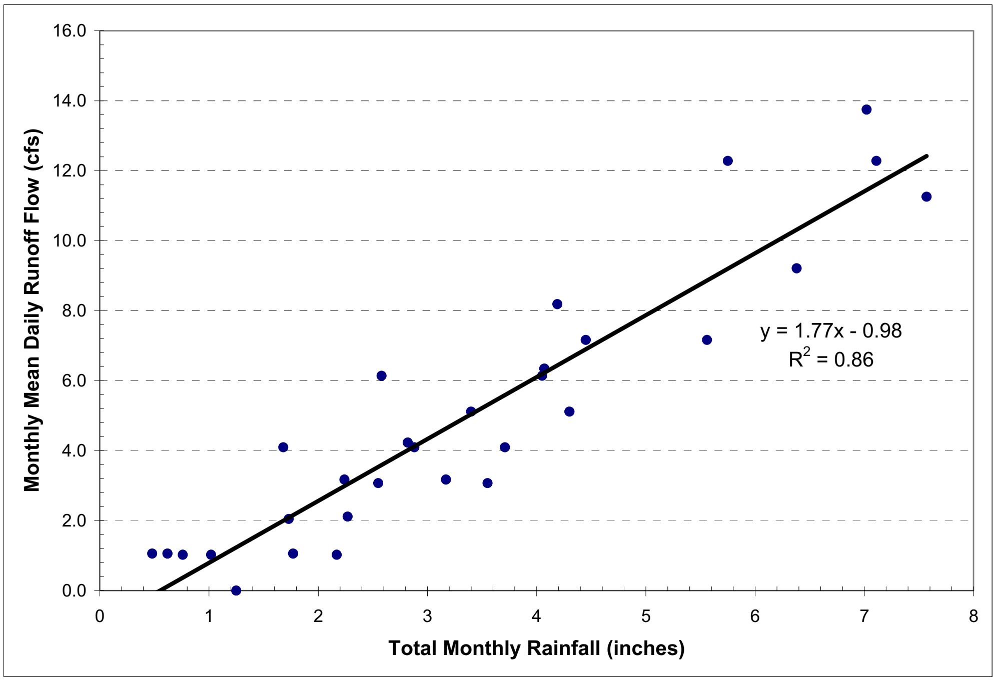

Figure 5. Linear Relationship for Monthly Runoff Flow versus Precipitation at Frankfort (May-October, 2001-2005)

Preliminary Hydrologic Calibration of BASINS Model

LTI further investigated the suitability of the Frankfort precipitation data via its ability to predict observed stream flows in the Platte River when used as input to the BASINS model. General performance targets have been established for streamflow calibrations conducted using the BASINS/HSPF model. These performance targets allow researchers to evaluate the success of a BASINS calibration for a particular watershed compared to results from other watersheds. The established calibration criteria are shown in Table 4 (Donigian, 2002). These targets are applicable when comparing annual and monthly model predictions of streamflow to mean annual and monthly data-based flows.

Table 4. General Calibration/Validation Targets or Tolerances for BASINS/HSPF Hydrology/Flow (Donigian, 2002)

% Difference Between Simulated and Recorded Values		
Very Good	Good	Fair
< 10	10 - 15	15 - 25

Annual and monthly results of the preliminary calibration at the USGS gage location are summarized in Figure 6. This comparison indicates that the mean absolute percent difference between simulated and observed stream flows is 4.3% on an annual basis and 5.7% on a monthly basis for the full calibration period (1990-2005). These results compare very favorably with the calibration performance targets generally associated with the BASINS/HSPF model (Table 4).

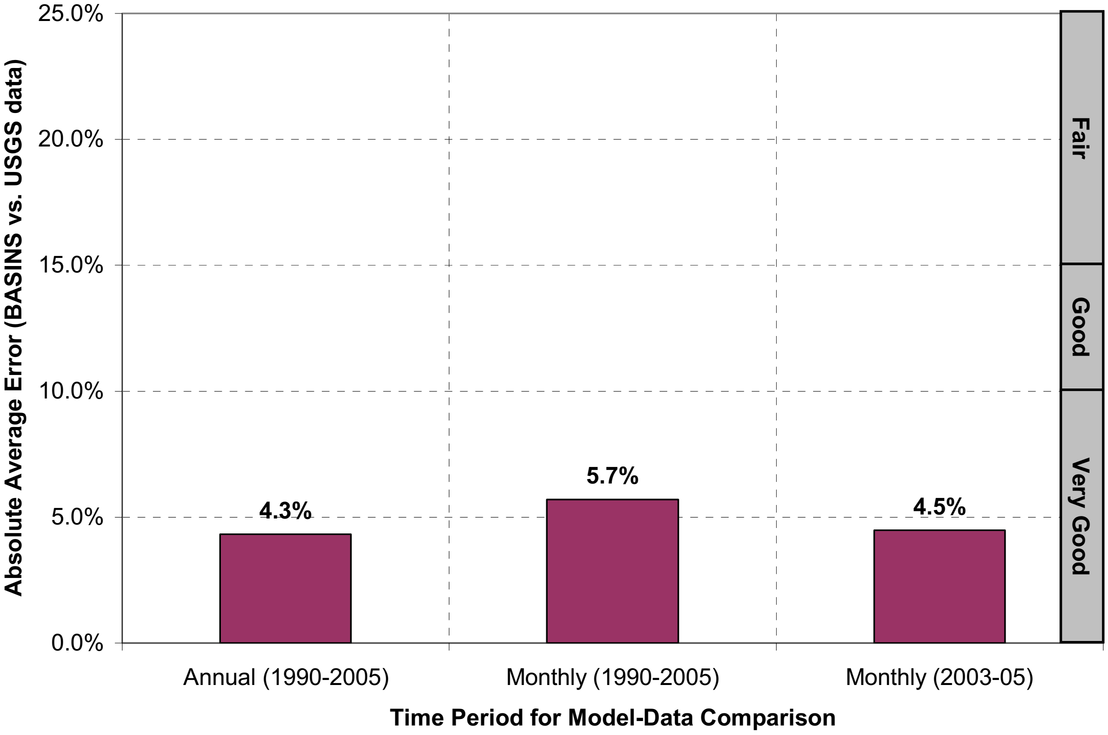

Figure 6. Annual and Monthly Mean Errors for BASINS-Predicted Flow Relative to USGS Data

LTI also used the USGS HYSEP program described previously to compute the base flow contribution to the daily flow time series simulated by the BASINS model. Based on this analysis, the monthly base flow component predicted by the BASINS model is 84-99%, which compares very well with the data-based estimates of monthly base flow shown in Figure 1 (88-99%).

Analysis of Weather Radar Data

The above section demonstrated that the Frankfort precipitation data and the BASINS model do a very good job of simulating flows in the Platte watershed. However, it is obvious that the Frankfort data cannot be used to develop 100% accurate flow predictions. Two possible indications that the precipitation data are the source of these deviations are:

1. A storm runoff event could be indicated by the stream flow data, but not reflected in the Frankfort precipitation data.
2. A rainfall event could be observed at Frankfort without a corresponding increase in stream flow.

A comparison of the BASINS-predicted daily flow using Frankfort precipitation data to USGS daily flow data is provided in Figure 7 for March-December, 2005. Overall, the model-data fit for this time period is excellent. Based on a review of the model-data daily flow comparison, no days were identified as matching case #1 (i.e., lack of rainfall at Frankfort during elevated streamflow). However, events occurring November 6 and November 29 in 2005 are similar to case #2 in that rainfall amounts observed at Frankfort result in model over prediction of streamflow at the USGS gage. It should be noted that the timing of response to the rainfall events is consistent with the streamflow data even though the absolute magnitudes of the model predictions do not exactly match the data.

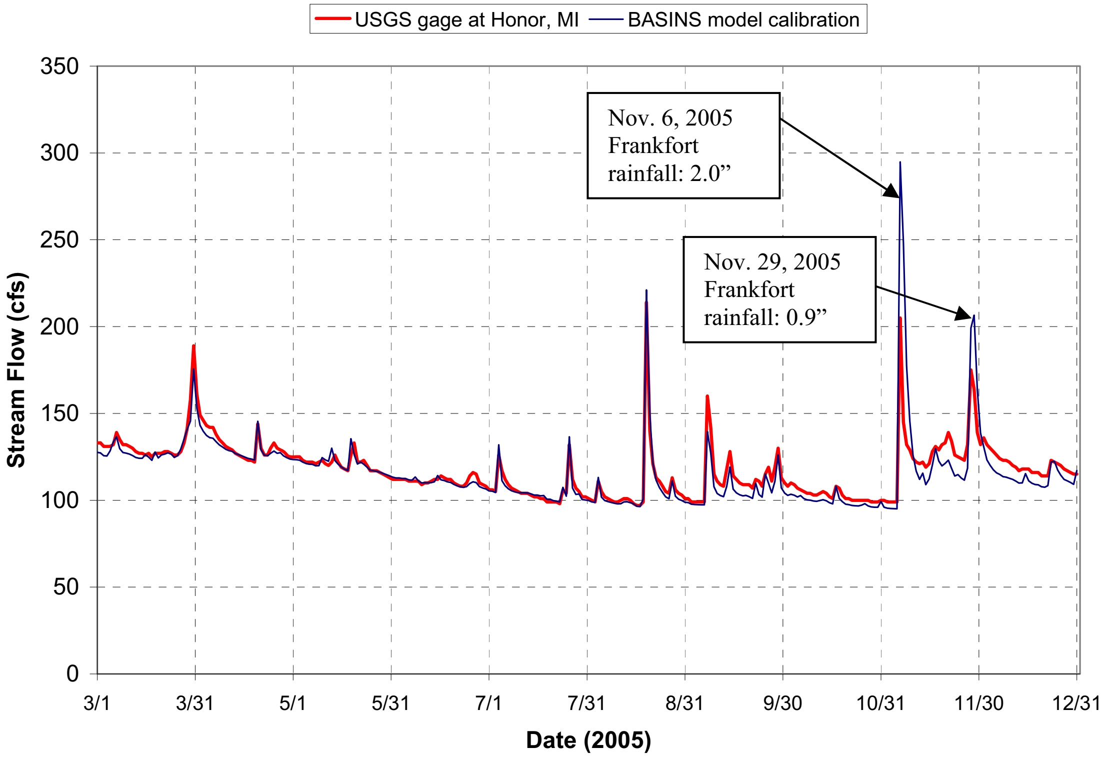

Figure 7. Comparison of BASINS Model-Predicted Flow and USGS Observed Streamflow at Honor, MI for March-December 2005

Therefore, LTI investigated daily weather radar images to determine whether the use of weather radar data has the potential to significantly improve the BASINS calibration for these days.

Daily rainfall radar images are available online from the National Weather Service. Figures 8a and 8b show the spatial regional distribution of rainfall on the November 6 and 29, 2005. These maps show that the rainfall in the far eastern part of the Platte watershed received less rainfall than the western part of the watershed. It is seen that Frankfort precipitation data therefore overestimates the average precipitation over the entire watershed on these days because the Frankfort weather station is located near the western part of the watershed. This results in BASINS over-estimating flow in the Platte River on these days as shown above in Figure 7.

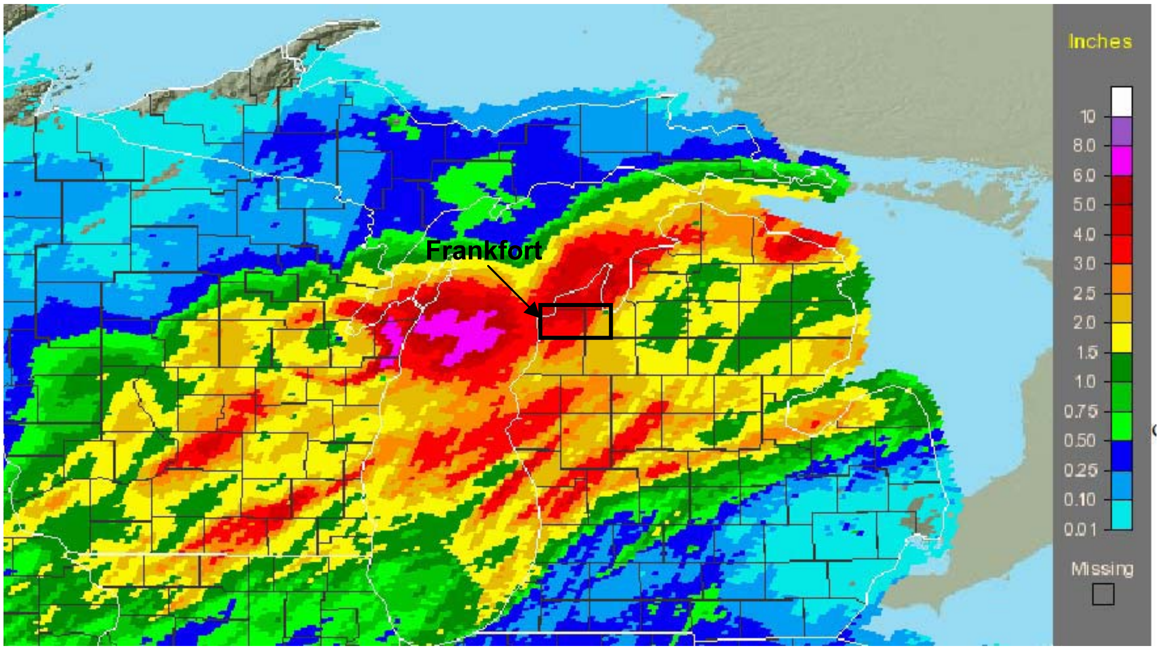

Figure 8a. Radar Map Illustrating Spatial Patterns for Rainfall on November 6, 2005

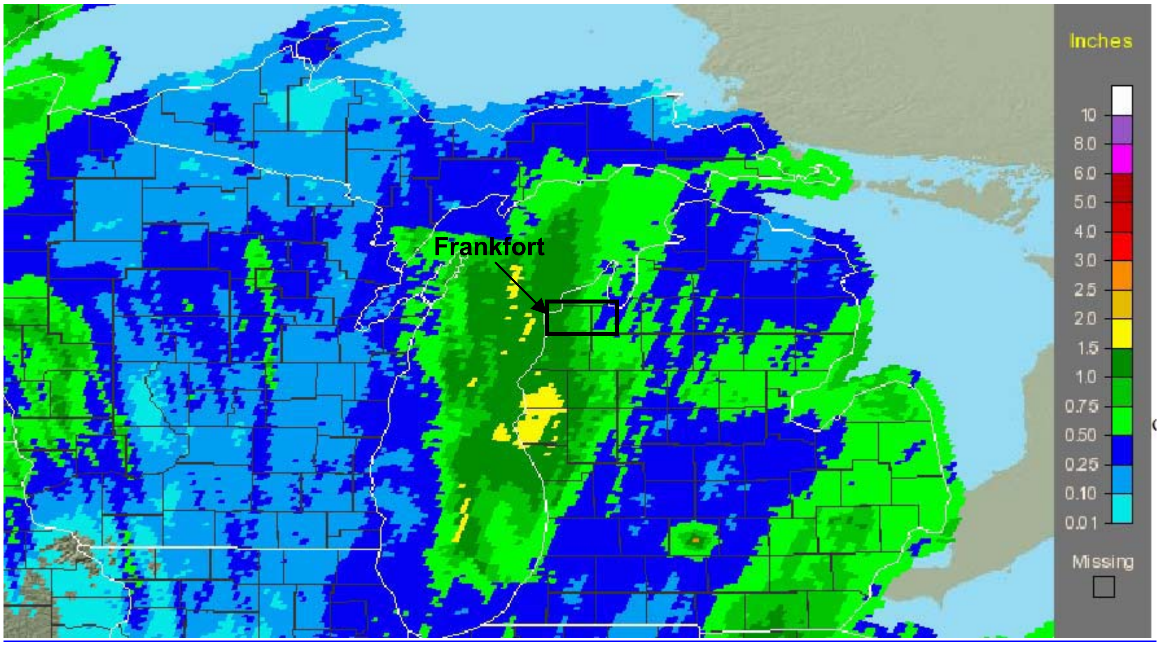

Figure 8b. Radar Map Illustrating Spatial Patterns for Rainfall on November 29, 2005

Suppose it were possible to spatially analyze the data from the local radar and determine the average amount of rainfall over the entire Platte River watershed as opposed to characterizing the watershed with Frankfort data alone. This might reduce the rainfall forcing function to 1.25 inches compared to the 2.0 inches measured at Frankfort and potentially improve the BASINS model flow prediction on November 6, 2005. A similar calculation could be made for November 29, 2005.

Conversion of the radar graphic images into such precipitation inputs for the model is not trivial and would therefore require significant effort and third-party costs. Discussions with a representative from “OneRain”, a company that specializes in processing of radar data, indicated that the costs would be $2,000 per storm event to convert the radar data into precipitation estimates for the watershed (L. Torrence, OneRain, personal communication, 10/20/06). Significant additional effort would be required to process this information into a form that could be used by the BASINS model.

Radar data are generally available for the northern Michigan area for the calibration period (1990-2005); however, these data would need to be calibrated against multiple local hourly rainfall gages, including the gage at Traverse City and other northern Michigan locations. The relative scarcity of hourly precipitation stations in the vicinity of the Platte River would likely limit the accuracy of radar-based hourly rainfall estimates for the watershed (L. Torrence, OneRain, personal communication, 10/20/06). Therefore, it is obvious that even local radar data cannot be used to develop 100% accurate flow predictions. The difficulties associated with use of local radar for driving stream flow models is further discussed by Stellman, et al. (2006).

The question becomes: is the extra effort required to incorporate the radar data to calibrate the BASINS model in a quantitative manner as described above worth the potential gain in accuracy and reliability? To address this question, return to the original purpose of the BASINS modeling project. The purpose is to simulate future phosphorus loading from the watershed as a function of <u>changes</u> in land use given existing soil and topographic conditions. The simulations will be performed for different hypothetical weather conditions, such as selected wet and dry years.

Is this goal and use of the model compromised if Frankfort weather data alone are used for model calibration as compared to incorporating local radar data? The answer depends on whether or not the radar data fundamentally improves our understanding of the basic mechanisms that define the connection between rainfall and stream response. The BASINS calibration using Frankfort precipitation data alone has been shown to far exceed the "very good" threshold (i.e., 10% relative error) described in the peer reviewed literature. Therefore, in our judgment the calibrated model using Frankfort data alone is sufficiently accurate and the basic mechanisms are sufficiently understood to be used for its intended application. Thus, it is recommended that Frankfort data be used to calibrate the model. Local radar data should be used in a qualitative manner to help explain deviations between model predictions of stream flow and USGS flow measurements.

Conclusions

The comparative analysis of the NCDC precipitation and USGS streamflow demonstrates that a strong relationship exists between Frankfort daily precipitation and USGS runoff flow at the Honor gauging station, both on a monthly and on an annual basis.

Overall, the BASINS-predicted daily flow at the USGS gage location compares very favorably to the USGS daily data across the variety of rainfall events observed at Frankfort during March-December, 2005. This comparison illustrates that although radar data has the potential to provide a more precise estimate of rainfall for a particular day(s), the Frankfort daily precipitation observations are sufficiently representative to support BASINS model calibration and application.

Preliminary model calibration efforts demonstrate that the Frankfort precipitation data, when used as input to BASINS, results in an extremely strong model calibration. The relationships between Frankfort precipitation and Platte River flow are considered by LTI to be sufficient to support a accurate, reliable, and legally defensible BASINS model development, calibration, and application.

References

Donigian, A. S., Jr., 2002. "Watershed Model Calibration And Validation: The HSPF Experience." WEF National TMDL Science and Policy 2002, November 13-16, 2002. Phoenix, AZ. WEF Specialty Conference.

Stellman, K., H. Fuelberg, R. Garza, and M. Mullusky, 2006. "Utilizing Radar Data to Improve Streamflow Forecasts." [Available online at: http://www.srh.noaa.gov/tlh/tlh/mm5/Radar/radarfinal3.html]

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APPENDIX C: BENZONIA ZONING OVERLAY

ARTICLE XXIII
PLATTE LAKES AREA MANAGEMENT PLAN OVERLAY DISTRICT

Section 23.1 ESTABLISHMENT OF OVERLAY DISTRICT; INTENT AND PURPOSE

This overlay district, the Platte Lakes Area Management Plan Overlay District, is hereby established and is intended to protect the health, safety and welfare of the Platte Lakes Area by promoting the preservation of natural features, protecting water quality and regulating development and the use of property which borders, encompasses or contacts the surface waters, watercourses and drainage ways to the Platte Lakes Area. The shape, size and character of the property located within this district may vary greatly due to circumstances imposed by the existing water bodies, watercourses, wetlands, drainage ways and varying slopes. Additionally, it is the intent of this ordinance to establish land management practices and procedures within the Platte Lakes Area that will help in the attainment and compliance with the court ordered Big Platte Lake water quality standard of 8.0 micro-grams per liter for phosphorus established in the Consent Judgment dated March 10, 2000 issued by the Ingham County Circuit Court in *Platte Lake Improvement Association vs. Michigan Department of Natural Resources,* File No. 86-57122 CE, particularly in Section 3 (Operation of the Hatchery), Paragraph F, sub-paragraph ii (Platte Lake Phosphorus Limit) thereof.

Section 23.2 PLATTE LAKES AREA

The Platte Lakes Area is defined as the property immediately surrounding the Platte Lakes. Boundaries may vary due to slopes and permeability of the soils, either of which may affect the distance of the boundary from the waters edge. The interpretation of the boundaries of this area shall be the responsibility of the Zoning Administrator, whose decision may be appealed to the Board of Appeals. In cases where a parcel is not entirely within the boundaries of the Platte Lakes Area only those portions within the Platte Lakes area are required to comply with the regulations of this Article.

Section 23.3 WATER RESOURCES SUBJECT TO ORDINANCE REGULATION

Navigable water bodies and watercourses, wetland areas 0.5 acre or larger in size, non-navigable waterways with tributaries from other non-navigable waterways whose origin is from surface run off, or springs and located within the Platte Lakes Area Management Plan Overlay District are subject to the regulations set forth in this Article XXIII.

Section 23.4 DISTRICT REGULATIONS

A. Dwelling and Accessory Structures.
  1. Only one dwelling per lot is permitted.
  2. Newly created building lots must be a minimum of one hundred (100) feet in width at the building line.

B. Impervious Surfaces.
  1. Impervious surfaces must be engineered and sloped in a manner that will not allow direct drainage into a water resource.
  2. Drainage of surface runoff from an impervious surface must be directed to a retention area or rock filled void large enough to allow natural absorption of storm water run off from a twenty-five (25) year storm event of three and one-half (3.5) inches of rain in a twenty-four (24) hour period.

C. Steep Slopes.
  1. Engineered slopes must be less than eighteen (18%) percent when located within one hundred (100) feet of a water resource. The surface must be maintained with a vegetative cover to minimize surface runoff.
  2. Natural slopes greater than eighteen (18%) percent must be maintained with a vegetative cover or retaining systems to minimize surface runoff.

D. Buffer Strips.

In order to protect water quality, preserve sensitive wildlife habitat and reduce soil erosion and sedimentation, any proposed development or redevelopment, as defined in this subsection, on properties subject to this overlay district shall be separated from the adjacent high water mark or bottom land of any subject water resource, by a buffer strip a minimum of twenty-five (25) feet in width as described below.

  1. For purposes of this district, construction, development or redevelopment shall include any of the following activities:
     a. The enlargement of the principle building square footage by more than two hundred (200) square feet.
     b. The demolition of an existing principle building and the building of a new principle building within the same footprint.

  2. The buffer strip shall consist of vegetation and or grass in living condition with the intent of minimizing sediment runoff into the adjacent water resource. A limited amount of

improvement may be permitted within the strip as described below:

a. Buffer Strip: The depth of the buffer strip shall measure twenty-five (25) feet from the ordinary high water mark of the water body. This area is extremely sensitive and must be treated carefully when considering vegetation removal. Specifically any <u>vegetative removal</u> that would cause or enhance erosion is prohibited unless approved measures to eliminate or reduce erosion are implemented simultaneously. Subsequently, any existing erosion within the buffer zone to the adjacent water body, when identified by the Soil Erosion Control Agent, must be corrected per approved soil erosion control measures.

b. Therefore, the <u>removal of any vegetation</u> within the buffer strip shall be limited to an area equal in width to twenty-five (25%) percent of the length of the water frontage of the parcel, or twenty-five (25) feet, whichever is greater. No contiguous area of clearance shall be wider than twenty-five (25) feet. Consistent with the spirit of the district's intent, as much as possible of the mature vegetation shall be preserved. Areas within this strip that do not include abundant native vegetation so as to permit relatively unimpeded pedestrian access to the water resource and/or to permit a virtually open view of the water from the principal structure, shall be included as a portion of the total clear area. Features permitted in the buffer strip may include footpaths constructed of permeable materials, stairways, fences and walls. The buffer strip may not be used for the dumping of brush, clippings, fill dirt, trash, debris or other materials. Under no circumstances shall the removal of vegetation be allowed where the slope is greater than eighteen percent (18%), except for poisonous plants, which may be removed by mechanical means only, not with herbicides.

c. The mowing and or cutting of the vegetation within the buffer strip is an appropriate phosphorus reduction measure as long as the mowing height is such as to enable continued plant growth and the clippings from the mowing are removed to an area outside of the buffer strip where their decay and re-entry to the buffer strip is prevented. In any case, this distance for deposition of organic debris from the water body is no less than the distance of the approved septic drain field from the water body for the property in question. If the property has a holding tank, the mowed clippings must be deposited at a location that meets the above criteria. If such a site cannot be arranged, then the buffer strip cannot be mowed. Under no circumstances can the mowed or cut vegetation be allowed to be deposited directly into the buffer strip or the adjacent water body.

d. Removal of trees and shrubs within the buffer strip must be replaced with vegetation possessing equal or greater soil retaining potential. Grasses are preferred over trees, as far as phosphorous control is concerned, as trees deposit leaves and or needles into the buffer zone and adjacent water body. Re-vegetation may be conducted per Natural Resources Conservation Service or Benzie County Soil Erosion Control Plans. The removed material must be properly disposed of as provided in subparagraphs b and c, above.

e. Removal of organic beach debris as well as tree leaves, etc. is encouraged as a phosphorus reduction measure so that phosphorus and other nutrients in the debris cannot decay and re-enter the water. The debris must be disposed of as provided in subparagraph c, above.

f. Fertilization of any type is prohibited within the twenty-five (25) foot buffer zone.

E. Redirection of Water Resources.

Redirection of a water resource, in part or in whole, may only be conducted in accordance with a permit issued by the Michigan Department of Environmental Quality (MDEQ) or its successor agency.

F. Construction within the Platte Lakes Area Management Plan Overlay District.

1. Construction activities within the district shall not encroach or impact the designated buffer strip.
2. A Soil Erosion Control permit is required for earth changes within five hundred (500) feet of a lake or stream or for any earth change amounting to one (1) acre or more.

G. Fertilization within the district.

All fertilization within the district for non-agricultural operations is limited to phosphate free fertilizer.

H. Agricultural Operations

1. No grazing of livestock shall be permitted within fifty feet (50) of the high water mark.
2. An agricultural operation may operate under an approved Natural Resources Conservation Service conservation plan that will allow agricultural activity within a buffer strip while maintaining protection of the water resource.

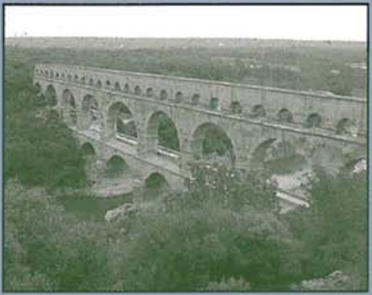
Section 23.5 CONFLICTS

If there is any conflict between any provision of this Article and any other provision of this Zoning Ordinance, the more restrictive provision shall take precedence over the less restrictive.

APPENDIX D: PHOSPHORUS BUDGET AND REMEDIATION PLAN FOR BIG PLATTE LAKE, MICHIGAN (ASCE PAPER- 2010)

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

September / October 2010 • Volume 136, Number 5
ISSN 0733-9496 • CODEN: JWRMD5



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Phosphorus Budget and Remediation Plan for Big Platte Lake, Michigan

Raymond P. Canale[1]; Todd Redder[2]; Wilfred Swiecki[3]; and Gary Whelan[4]

Abstract: This paper presents a phosphorus budget and modeling case study for Big Platte Lake Michigan and the Platte River watershed. These analyses are a necessary component of a credible total maximum daily load (TMDL) for Big Platte Lake and may be more broadly applicable to similar systems and other water quality management issues. A calibrated Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) model is used to simulate total phosphorus loads from the watershed. A nonsteady state lake model is developed to predict total phosphorus concentrations in both the water column and the sediments. Temperature and dissolved oxygen models are used to predict the anoxic periods in the lake hypolimnion to facilitate calculation of the internal phosphorus loading due to sediment release. Following calibration, the models were used to determine allowable total phosphorus loads for Big Platte Lake for typical hydraulic conditions. Current measured total phosphorus loads exceed model calculated allowable loads. Therefore various nonpoint remediation alternatives were evaluated as a means to reduce the excess loading. The credibility of the analyses was enhanced because of the availability of laboratory measurements of sediment phosphorus release rates and an extraordinarily comprehensive database of current and historical lake and tributary water quality measurements.

DOI: 10.1061/(ASCE)WR.1943-5452.0000071

CE Database subject headings: Phosphorus; Water quality; Hydraulic models; Lakes; Michigan.

Author keywords: Phosphorus; Nonpoint loading; TMDL; Water quality model; BASINS.

Background

The Platte River watershed is located in the northwest region of the Lower Peninsula of Michigan and has a total drainage area of approximately 495 km^2 (see Fig. 1). The drainage is dominated by deep glacial outwash deposits and the watershed soils are predominantly sand. Big Platte Lake (Lake) is the largest lake in the lower watershed. It has a volume of 83.5 million m^3, a mean depth of 8.2 m, a maximum depth of 28 m, and a mean hydraulic retention time of about 0.75 years. The Platte River (River) is the major source of water inflow to the Lake. The discharge of the River has been measured by the USGS (USGS Gauge #04126740) near Honor, Michigan since 1990 (see Fig. 1 for the location of the gauge station). The mean discharge of the River is 3.5 m^3/s over the period of measurement, and most of this flow is from groundwater sources. The largest tributary of the River is the North Branch, which enters the main tributary approximately 0.6 km upstream of the inlet to Big Platte Lake.

Phosphorus limits the growth of algae in Big Platte Lake. Phosphorus enters the Lake water column from point, nonpoint, and internal sources. The only significant point source of phosphorus in the watershed is the Platte River State Fish Hatchery (Hatchery) operated by the Michigan Department of Natural Resources (MI DNR). This facility produces Coho and Chinook salmon for the Great Lakes fishery. The Hatchery uses surface water to culture fish, and this water becomes enriched with phosphorus from fish fecal pellets, urine, and unconsumed feed. The outflow from the Hatchery discharges into the Platte River 17.7 km upstream of Big Platte Lake. The maximum Hatchery phosphorus loading was estimated to be 1,960 kg/year in 1974. Today, the mean net loading from the Hatchery is only about 79 kg/year. This reduction was attained by upgrading the solids handling technology at the facility and by using low phosphorus fish feed. The Hatchery contributes approximately 3% of the total phosphorus load that enters the Lake and is currently compliant with National Pollutant Discharge Elimination System (NPDES) requirements. Most of the remaining phosphorus load originates from nonpoint sources associated with groundwater flow, watershed runoff, and precipitation. The Lake also has internal phosphorus loads that result from release of phosphorus from the bottom sediments during anoxic periods and from the death and subsequent decay of migrating salmon.

The applicable water quality standard requires that the annual average volume-weighted total phosphorus concentration of Big Platte Lake be maintained below 8.0 mg/m^3 95% of the time. This standard is a court-ordered directive that was prescribed sub-

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Note. This manuscript was submitted on May 15, 2009; approved on December 15, 2009; published online on August 13, 2010. Discussion period open until February 1, 2011; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Water Resources Planning and Management***, Vol. 136, No. 5, September 1, 2010. ©ASCE, ISSN 0733-9496/2010/5-576–586/$25.00.

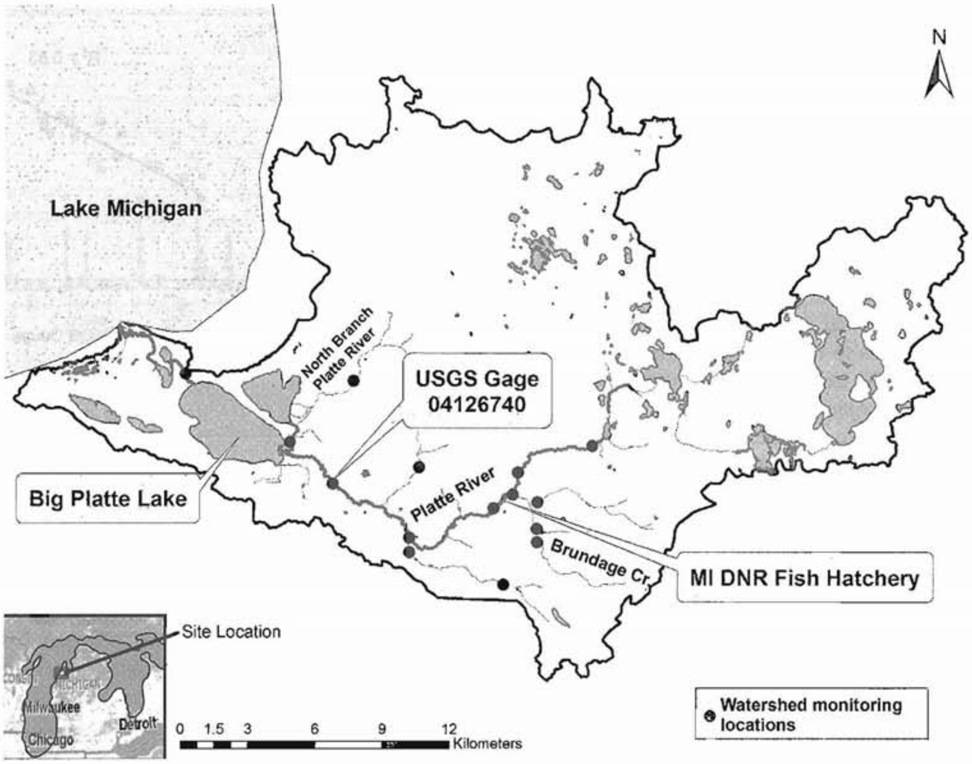


Fig. 1. Big Platte Lake and Platte River watershed

sequent to legal actions taken by residents of the Lake against the MI DNR as fully described in Canale et al. (2004). Currently the volume-weighted annual average Lake total phosphorus (TP) concentration typically varies between 7 and 9 mg/m^3 and has not complied with the water quality standard in recent years.

The Clean Water Act of 1972 mandates that analyses be performed to determine allowable phosphorus loads from point and nonpoint sources that are consistent with the water quality standards. This allowable loading is called a total maximum daily load (TMDL). The purpose of this paper is to present the results of technical analyses that are necessary to develop a credible TMDL for Big Platte Lake and may be more broadly applicable to similar systems. The approach uses a model for the phosphorus loading from the watershed and a model for the annual average total phosphorus concentration of Big Platte Lake. These two models will be applied to determine an allowable phosphorus loading to the Lake and quantify the annual average phosphorus load reduction needed to meet the water quality standards. This reduction most logically must be achieved exclusively through control of nonpoint sources because the Hatchery is currently a minor component of the overall loading. Finally, the models will be used to analyze the effectiveness of various nonpoint phosphorus control measures.

Sampling Program

The phosphorus loading reduction needed to meet the water quality standards for Big Platte Lake will affect public policy and expenditures, local zoning, and the attitudes and behaviors of private citizens. Thus, it is imperative that the calculations for the required phosphorus loading reduction be credible and defensible. This requires that the watershed phosphorus loading and lake water quality models be carefully calibrated using local water quality data. The Big Platte Lake and Platte River watershed monitoring program is quite comprehensive, and the details of the effort have evolved and expanded over time. The description below summarizes the current program.

Big Platte Lake has been sampled at the deepest location (approximately 28 m) at eight discrete depths every 2 weeks since 1993 except when ice conditions restrict access. Three replicate samples are taken at each depth and analyzed for total and dissolved phosphorus and turbidity. In addition, surface composite samples are collected using a 10 m vertical tube. Composite samples are analyzed for total and dissolved phosphorus, nitrate, nitrite, chlorophyll *a*, turbidity, alkalinity, phytoplankton, total dissolved solids, and calcium. Vertical net hauls are used to collect zooplankton. Other measurements include Secchi depth and vertical profiles of dissolved oxygen, temperature, pH, and light intensity.

Total phosphorus, nitrate, nitrite, turbidity, and flow have been measured at several Platte River and tributary locations every 2 weeks since 1990 (Fig. 1). The baseline flow data have been supplemented with measurements taken during more than 100 storm events between 2003 and 2007. Total phosphorus, turbidity, and flow were measured during these events using automated sampling equipment.

Hatchery discharge flow and phosphorus concentrations have been measured regularly since 1981. The current program collects samples two times per week from both the discharge and input locations to the Hatchery to permit calculation of the net loading as specified by NPDES regulations. Phosphorus concentrations are also obtained from the fish food used at the Hatchery and on sludge solids trucked away from the Hatchery. Periodic measurements of salmon tissue phosphorus also are taken to allow estimates of the amount of phosphorus in fish transported from the Hatchery. These measurements account for all of the inputs and outputs of phosphorus to and from the Hatchery and serve as the basis of a mass balance and bioenergetic model for fish production currently under development. The purpose of this model is to predict the phosphorus loading from the Hatchery as a function of the number and size of the fish produced and the efficiency of various facility waste treatment operations.

Other measurements complement the routine Lake, River, tributary, and Hatchery monitoring efforts. Rain water has been collected and analyzed for total phosphorus, nitrate, and nitrite concentrations over 40 times to facilitate estimation of the atmospheric loading to the Lake. A hydroacoustic survey was conducted to determine the density and percent coverage of macrophytes in Big Platte Lake in 2002. Macrophyte tissue phosphorus measurements were also taken to permit calculation of the mass of phosphorus associated with the plant biomass in the Lake. The phosphorus content of shoreline buffer zone plant material and debris was measured to permit estimates of the effectiveness of shoreline maintenance efforts. Migrating salmon are restricted from entering Big Platte Lake except during times when weir gates located downstream of the Lake are opened to allow upstream passage. All fish are individually counted as they enter the Lake and when they eventually arrive at an upstream collection facility located at the Hatchery. Fish counts at both the downstream and upstream locations, as well as size and tissue phosphorus measurements, allow calculation of the potential internal phosphorus loading to the Lake through the decay of spawning salmon biomass. Undisturbed sediment core samples were collected in 2004 and 2005 for laboratory measurement of sediment oxygen demand (SOD) and aerobic and anaerobic phosphorus sediment release rates. These measurements are the basis of estimates of the internal phosphorus loading from the sediments to the lake water column during periods of low bottom water dissolved oxygen concentrations. Finally, an ongoing study is being conducted to measure biologically available phosphorus from the Hatchery and various River and tributary locations using algal bioassay methodologies.

Watershed Phosphorus Loading Model

The purpose of the watershed model is to predict the flow and nonpoint loading of phosphorus into Big Platte Lake from the Platte River as a function of land use in the watershed for various hydrologic and hydraulic conditions. This task was accomplished by using the Hydrologic Simulation Program—FORTRAN (HSPF) model found within the overall EPA BASINS model framework (Bicknell et al. 2001). The HSPF framework has wide acceptability and is commonly used to simulate watershed hydrology, runoff, and instream nutrient transport. As a notable example, HSPF serves as the watershed component of the modeling framework developed to support the Chesapeake Bay Program (U.S. EPA, "Chesapeake Bay Phase 5 Community Watershed Model," in preparation, 2008). Recent and ongoing nutrient TMDL evaluations for the Minnesota River (MN) and the Truckee River (NV) are also based on HSPF model applications (Butcher et al. 2004; Peternel-Staggs et al. 2008). The model is capable of simulating daily stream flows, as well as instream total phosphorus and total suspended solids concentrations at various locations within the watershed. However, these impressive model capabilities alone do not guarantee credible predictions without careful calibration and validation using large amounts of local terrestrial, stream flow, water quality, and meteorological data.

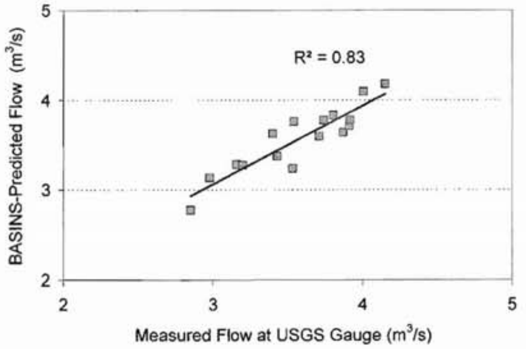


Fig. 2. Measured total annual flow of the Platte River at USGS gauge location compared to BASINS model predictions for various years

Hydrologic and hydraulic calibration of the BASINS-HSPF model was based on comparisons between model predictions and observed flows for the Platte River at the USGS gauge. Fig. 2 compares the measured and model-predicted annual average flows for 1990 through 2005 ($R^2=0.83$, slope=0.99). These results indicate that the model adequately simulates the long-term hydrologic response of the watershed and the variations in flow volume across dry and wet years. The model also closely matches observed trends in mean monthly flows ($R^2=0.77$, slope=0.94) and mean daily flows ($R^2=0.71$, slope=1.04) at the USGS gauge during the 16-year calibration period. Statistical error metrics, including RMS error (RMSE) and mean absolute relative error (MRE), also compare favorably for mean monthly (RMSE =8.9 cfs, MRE=5.4%) and mean daily (RMSE=14.4 cfs, MRE=6.4%) results during this period. Collectively, these statistical comparisons illustrate that the model accurately captures the seasonal and daily hydrologic response of the watershed. Overall, the annual, seasonal, and daily flow trends and patterns measured at the USGS location are consistent with model predictions as discussed in more detail in Canale et al. (2004).

The calibration of the BASINS-HSPF model for total phosphorus focused on comparisons between predicted and measured total phosphorus concentrations and estimated annual average loads at several River and tributary locations within the watershed. The total phosphorus calibration proceeded in a two-step iterative process. Model sediment and nutrient input parameters affecting total phosphorus runoff were configured to achieve unit area loads (UALs) consistent with ranges reported in the literature. Next, the model parameters were adjusted to compute diffuse loadings to match observed concentration and loading measurements at the USGS gauge station and other River and tributary locations. Fig. 3 shows an example of hourly model predictions compared to discrete measured total phosphorus concentrations in the Platte River at the USGS gauge station for 2005. The model results compare favorably to concentration measurements taken during both baseline and wet weather flow conditions ($R^2=0.62$ for 2005). Similar comparisons have been made for other locations and time periods as discussed in Canale et al. (2004). In addition, the model achieves good agreement with data-based estimates of the annual total phosphorus loading for the Platte River at the USGS gauge station (Fig. 4) (MRE =16%) and at various other locations in the watershed (Fig. 5). The favorable daily concentration and annual loading comparisons between the model output and data-based estimates provide

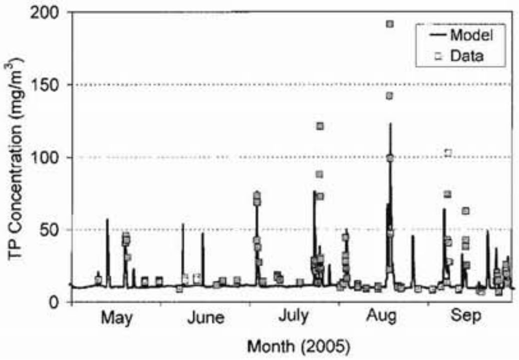


Fig. 3. Measured total phosphorus concentrations (squares) and BASINS model predictions (line) for 2005 at the Platte River USGS gauge location

confidence that the model can be used not only to reproduce recently measured watershed phosphorus loading, but also to reliably predict future loadings under various hydrologic and hydraulic conditions of interest.

Lake Water Quality Model

Overall Approach

The objective of this section is to develop reliable and practical models to predict long-term changes in total phosphorus concentrations in Big Platte Lake and to identify an allowable loading consistent with the water quality standards. Upon first consideration one might think that the preferred way to proceed would be to use a model that simulates a wide array of chemical and biological components of the ecosystem everywhere in the Lake and sediments at all times. Such a model would have several forcing functions such as flow, phosphorus loading, temperature, light intensity, and other meteorological variables. The model might have detailed horizontal and vertical resolution in the water column and sediments, dozens of dependent variables, and hundreds of coefficients to define the chemical and biological kinetics and the mass transport processes, perhaps on an hourly time scale to simulate diurnal changes.

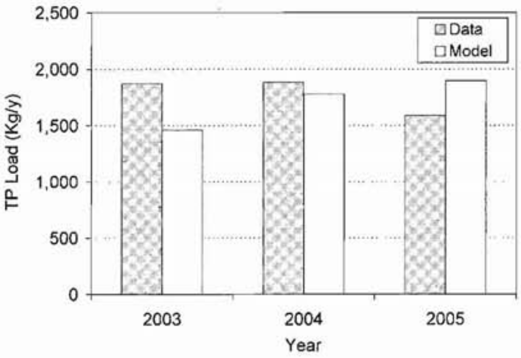


Fig. 4. Measured total annual total phosphorus loads (shaded bars) and BASINS model predictions (open bars) for various years at the Platte River USGS gauge location

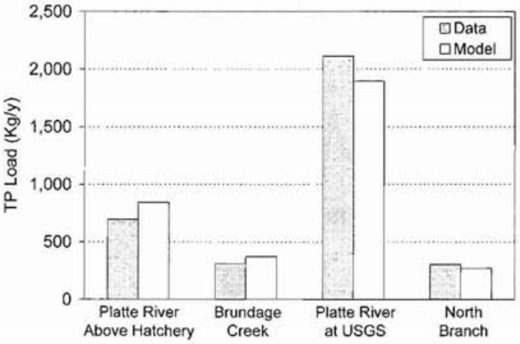


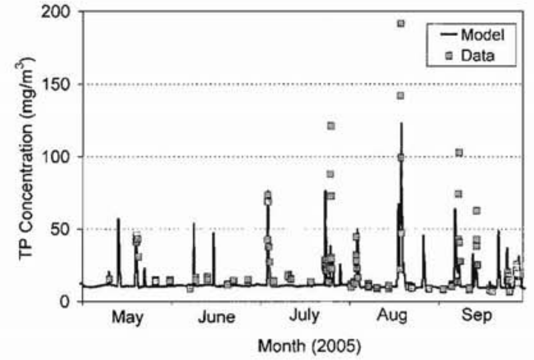
Fig. 5. Measured total annual total phosphorus loads (shaded bars) and BASINS model predictions (open bars) for 2005 at various watershed locations

However, as a practical matter, the coefficients and forcing functions of any model can never be known with exact certainty. Errors in the model coefficients and forcing functions propagate through the structure of the defining differential equations and expand in magnitude as the equations are integrated through space and time. As a result, the overall reliability of models can decrease as the number and uncertainty of the model variables, coefficients, and inputs increases. These issues have been extensively examined from both deterministic and stochastic perspectives (Seo and Canale 1996; Canale and Seo 1996). These analyses suggest that it may be most appropriate to use simple models for planning applications that are consistent with the availability of supporting lake and tributary water quality measurements. The downside of such an approach is that models with frameworks that are too simple may not be able to realistically simulate all of the important water quality parameters. Therefore, it is important to explore and test the effectiveness of models with an intermediate level of framework complexity because models that are either too simple or too complex may be unreliable and subject to scientific and legal challenge.

Two separate water quality modeling approaches are being developed simultaneously for Big Platte Lake to accommodate these considerations. The water quality standard for Big Platte Lake is based on whole lake volume-weighted annual average total phosphorus concentrations. Therefore, the primary approach as described here involves a model designed to predict annual average total phosphorus concentrations. This phosphorus model needs an associated seasonal dissolved oxygen model because the rate of phosphorus release from the lake bottom sediments depends on the hypolimnetic dissolved oxygen concentration. The overall model has relatively simple mechanisms and is easy to use, but it does not provide insight into the fine points of the chemical and biological dynamics of the Lake. The second approach uses a more complex ecosystem model that can provide more detailed information when needed. This latter model has multiple phosphorus components, dependent variables for the phytoplankton and zooplankton populations, and can simulate water clarity as described in more detail in Canale et al. (2004).

Model Description

Fig. 6 illustrates the total phosphorus model for Big Platte Lake and the lake bottom sediments used for this case study. The model has single water and sediment layers that are assumed to be completely mixed in both the horizontal and vertical directions. The



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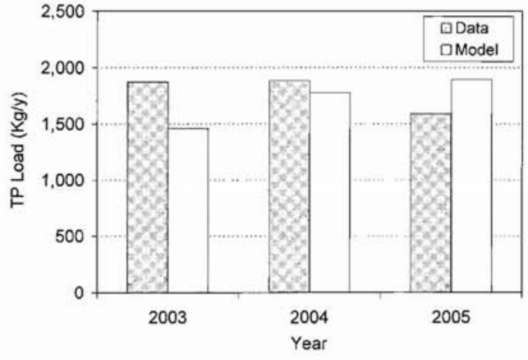

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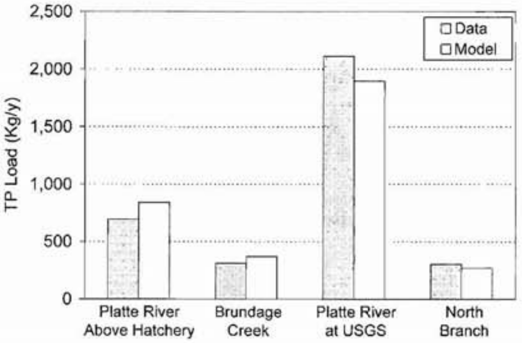

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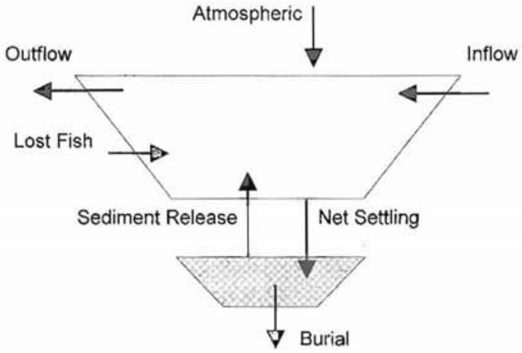

Fig. 6. Two-layer Big Platte Lake water and sediment model and components

phosphorus model mechanisms include point and nonpoint external loads, discharge through the lake outlet, settling losses to the bottom sediments, internal loading due to release from the sediments, and sediment burial. The nonsteady state mass balance equations are similar to those used by Chapra and Canale (1991) and Seo and Canale (1996) and are given by

$$V_w \frac{dP_w}{dt} = W - QP_w - \upsilon_s A_s P_w + \upsilon_r A_r P_s \tag{1}$$

$$V_s \frac{dP_s}{dt} = \upsilon_s A_s P_w - \upsilon_r A_r P_s - \upsilon_b A_r P_s \tag{2}$$

where A_r=phosphorus release area (m^2); A_s=settling area (m^2); P_s=sediment total phosphorus concentration (mg/m^3); P_w=water total phosphorus concentration (mg/m^3); Q=hydraulic flow rate (m^3/year); t=time (years); υ_b=sediment burial rate velocity (m/year); υ_r=phosphorus release rate velocity (m/year); υ_s=settling rate velocity (m/year); V_s=volume of lake sediments (m^3); V_w=volume of lake water (m^3); and W=total annual external phosphorus loading (mg/year).

Significant phosphorus release from the bottom sediment of Big Platte Lake occurs only when the sediments are anaerobic. These conditions occur when the average concentration of dissolved oxygen in the hypolimnion is less than about 2 mg/L (Michigan Department of Natural Resources 1990). Thus it is necessary to have a model that predicts the seasonal variation of the hypolimnetic dissolved oxygen concentrations to permit calculation of the fraction of the year when significant sediment release occurs. The hypolimnetic dissolved oxygen model mechanisms include hydraulic exchange between the epilimnion and hypolimnion and the hypolimnetic oxygen demand rate. Eq. (3) is the basis of the dissolved oxygen component of the Lake model.

$$V_h \frac{d\mathrm{DO}_h}{d\tau} = \upsilon_e A_e(\mathrm{DO}_e - \mathrm{DO}_h) - A_r(\mathrm{HOD}) \tag{3}$$

where A_e=area of the thermocline (m^2); DO$_e$=epilimnion dissolved oxygen concentration (mg/L); DO$_h$=hypolimnion dissolved oxygen concentration (mg/L); HOD=hypolimnetic oxygen demand rate (gm/m^2/day); τ=time (days); υ_e=exchange rate velocity between epilimnion and hypolimnion (m/day); and V_h=volume of hypolimnion (m^3).

Eqs. (1)–(3) represent a simple yet robust nonsteady state model that can simulate long-term changes in lake water and sediment total phosphorus. Similar models have been successfully used in a wide variety of applications (for example, Lung and Canale 1977; Seo and Canale 1999).

Calibration Procedure

The first step toward calibration of the model is to define the annual average hydraulic and total phosphorus loadings to the Lake. The flow rates into the Lake for 1990 through 2008 are based on USGS measurements extrapolated to include the entire watershed. Nonpoint phosphorus loads for the Platte River watershed were calculated using flow and total phosphorus measurements and results from the BASINS model. The Hatchery point load is based on direct measurements and estimates using fish production at the facility (Canale et al. 2004). An internal phosphorus load results from losses of fish that migrate through the Lake. The phosphorus loading is calculated as the difference between the fish that enter the Lake and those that are collected at the Hatchery multiplied by the percent phosphorus in the fish flesh. This estimated internal load is an upper bound because some fish may be taken by anglers before they reach the Hatchery. The atmospheric phosphorus loading (0.10 kg/ha/year) is estimated by multiplying the annual rainfall by the surface area of the Lake and the average of measured phosphorus concentrations. This estimate is roughly twice the wet deposition rate estimated by Miller et al. (2000) for Lake Michigan in 1994–1995, and it is similar to the total phosphorus deposition rate estimated by Delumyea and Petel (1978) for Lake Huron. Therefore, the calculated deposition rate of 0.10 kg/ha/year was taken to be representative of total atmospheric deposition of phosphorus for the purpose of calibrating the Lake model.

The model coefficients are the sediment release rate velocity, the settling velocity, the deep sediment burial rate velocity, the exchange rate between the epilimnion and hypolimnion, and the hypolimnetic oxygen demand rate. It is desirable to obtain approximate numerical values for each of these coefficients to the extent possible using independent data sets rather than performing multiple degree of freedom calibrations. The simple structure of the model and the robust field and laboratory data for Big Platte Lake allow such an approach in this case.

Holmes (M. Holmes, "Relationship between Phosphorus Release and Sediment Characteristics in Big Platte Lake, Benzie Co., MI," unpublished 2005 summary report, 2005) collected undisturbed cores from several bottom locations in Big Platte Lake and conducted laboratory experiments to measure sediment phosphorus release rates and SOD rates. These results, along with accompanying measurements of P_s, can be used to develop a first-cut estimate of υ_r. With this value for υ_r now available, Eq. (1) can be used to calculate υ_s because W is known from the BASINS model calibration, and extensive measurements are available for Q and P_w. With υ_r and υ_s known, Eq. (2) can be used to determine υ_b. Minor adjustments in the values of these coefficients can now be made following inspection of the long-term changes in model calculated and measured Lake water and sediment total phosphorus concentrations and the annual phosphorus release from the sediments.

The seasonal dynamics of the depletion of dissolved oxygen concentrations in the hypolimnion depend on the transfer of oxygen from the epilimnion to the hypolimnion, and the hypolimnetic oxygen demand rate. Oxygen transfer to the hypolimnion from the epilimnion depends on hydraulic exchange rates (υ_e) that vary seasonally with spring and fall mixing and summer thermal stratification. The exchange rates can be estimated by employing a

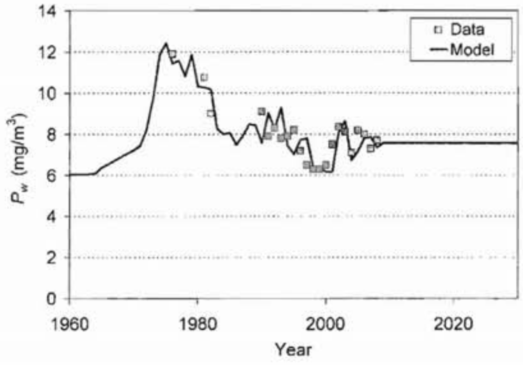

Fig. 7. Measured annual average total phosphorus concentrations (squares) for Big Platte Lake and model predictions (line) for various years

two-layer temperature model that uses the measured epilimnion temperature as a forcing function and the hypolimnion temperature as the dependent variable. With the exchange rates thus determined, the HOD is calculated from Eq. (3) using measured dissolved oxygen data.

Calibration Results

Figs. 7–9 show measured data and model output for the annual average water total phosphorus concentration (MRE=8.5%), sediment phosphorus concentration (MRE=5.0%), and the total annual release of phosphorus from the sediments (MRE=6.2%). The calculations beyond 2009 are projections that will be discussed in a subsequent section of this paper. Fig. 10 shows measured dissolved oxygen data and the model calibration for 2005 (MRE=7.2%). Note the winter oxygen depletion that is a consequence of ice cover that is present for the first 45 days of the year. The major role of the dissolved oxygen model is to provide the capability to determine the number of days of low hypolimnetic dissolved oxygen as a function of changes in the external phosphorus loading and the Lake water phosphorus concentration. Fig. 11 shows the measured number of days when the dissolved oxygen in the hypolimnion is less than 2 mg/L compared to model calculations for 1990–2008. The physical dimensions of the system and a summary of the final calibrated values of the model coefficients are shown in Table 1.

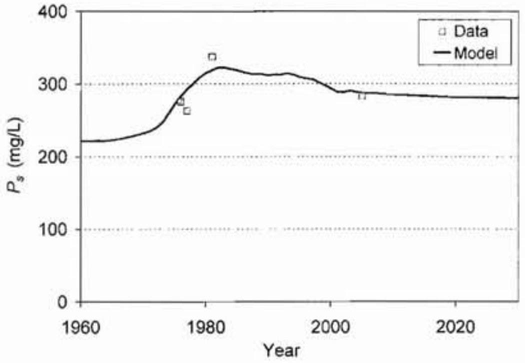

Fig. 8. Measured total phosphorus concentrations for Big Platte Lake sediments (squares) and model predictions (line) for various years

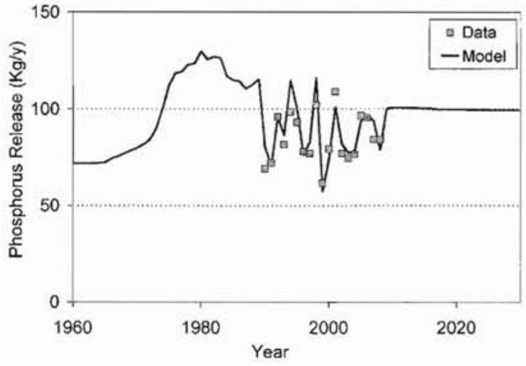

Fig. 9. Measured total annual release of total phosphorus from Big Platte Lake sediments (squares) and model predictions (line) for various years

The calibrated value for HOD is 0.89 $\text{gm}/\text{m}^2/\text{day}$ for 2005. Similar calibrations were performed for other years using measured temperature and dissolved oxygen vertical profiles. Fig. 12 shows a plot of calibrated HOD values as a function of the measured annual average volume-weighted water total phosphorus concentration for 1990–2008. A power function least-squares fit of the data are given by Eq. (4)

$$\text{HOD} = 0.41 P_w^{0.425} \quad (R^2 = 0.31) \tag{4}$$

Note the correlation is not strong and the curvilinear relationship is not apparent because the range in total phosphorus concentration is rather small. Despite these limitations, the exponent in the Eq. (4) is similar to other published values. Chapra and Canale (1991) gave the exponent as 0.478, and Rast and Lee (1978) gave 0.467. On the other hand, the overall magnitude of the HOD for Big Platte Lake is about five times larger than that in these previous studies. Note, however, that most published values for HOD are based on observed decreases of dissolved oxygen concentrations in the hypolimnion that implicitly include transfer across the thermocline. The HOD values determined here by model calibration recognize and account for oxygen transfer across the thermocline and are subsequently higher than HOD values determined simply by calculating the slope of the hypolimnetic dissolved oxygen depletion curve. In addition, it is important to note that the HOD of any lake depends on the volume and depth of the hypolimnion as well as the phosphorus concentration in the

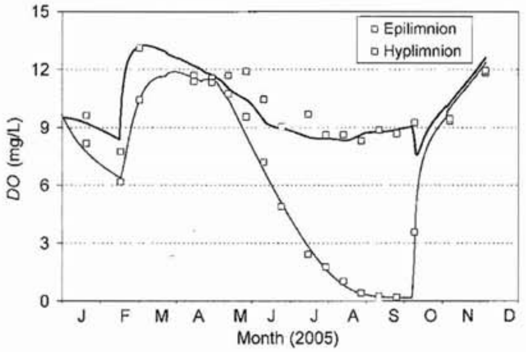

Fig. 10. Measured dissolved oxygen concentrations (squares) and model predictions (lines) for 2005 in the epilimnion and hypolimnion of Big Platte Lake

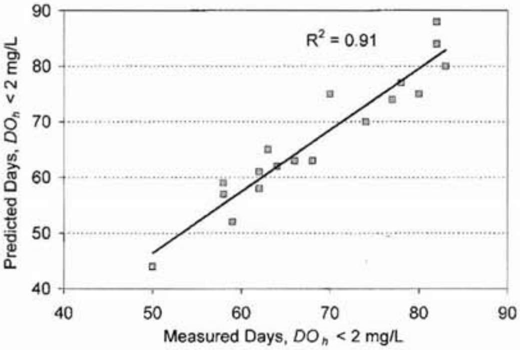

Fig. 11. Measured number of days the dissolved oxygen concentration in the hypolimnion of Big Platte Lake is less than 2 mg/L compared to model predictions for various years

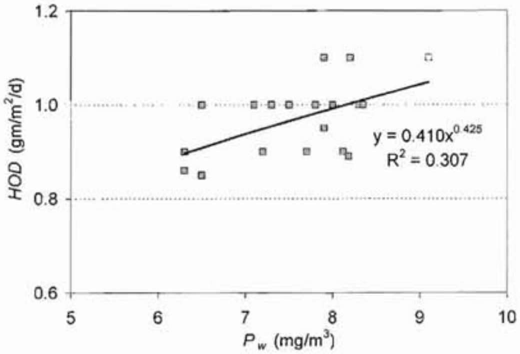

Fig. 12. Measured annual average total phosphorus concentration of Big Platte Lake versus model calibration values for HOD for various years

water column. The hypolimnion of Big Platte Lake is relatively small and is therefore expected to have a higher rate of oxygen depletion compared to a lake with a larger hypolimnion.

It is important to note that the empirical relationship between HOD and total phosphorus concentration has an implicit rational basis. The HOD is primarily a function of the SOD, bacterial respiration, and algal respiration that occurs under low light conditions in the hypolimnion. The algal and bacteria density and respiration are directly related to the phosphorus concentration of the water. SOD is related to the carbon deposition flux to the sediment, which is also proportional to the algal population. Complex mathematic models are available that can predict algal density and respiration rates in the hypolimnion, carbon deposition rates, and the resulting SOD (Di Toro et al. 1990; Chapra 1997) These models could certainly be used to circumvent the use of the empirical relationship given by Eq. (4). However, as discussed earlier in this paper, these complex models have important disadvantages associated with them, including greater resource requirements and the inclusion of model processes and coefficients that often cannot be parameterized using available data sets. Complex models are under development for Big Platte Lake and, when completed, will allow a quantitative evaluation and comparison of the merits and drawbacks of the empirical modeling approaches used here to estimate the HOD.

Holmes (M. Holmes, unpublished, 2005) determined that the average SOD of Big Platte Lake was 0.81 gm/m^2/day in 2005 using undisturbed bottom sediment cores collected at several locations and depths. The difference between the calibrated value of the HOD and the measured SOD can be attributed to algal respiration. The apparent magnitude of the respiration component of the HOD was about 0.08 gm/m^2/day in 2005. This estimate can be substantiated using 2005 measurements of hypolimnetic chlorophyll *a* and temperature. The average hypolimnetic chlorophyll *a* concentration was 2.0 mg/m^3 for 2005. An algal respiration rate of 0.07 per day was determined by preliminary calibration of the ecosystem model for the average measured hypolimnion temperature of 11 °C. These measurements were used to calculate an average algal respiration depletion rate of about 0.1 gm/m^2/day assuming a carbon to chlorophyll *a* ratio of 50. This value is close to the result estimated by subtracting the measured SOD from the calibrated value of the HOD. The above calculations indicate that the SOD is the dominant component of the HOD of Big Platte Lake and therefore would be a parameter of high priority in a more complex model.

Table 1. Calibration Values for Big Platte Lake Water Quality Model Coefficients

A_e	4.07×10^6	m^2
A_r	1.45×10^6	m^2
A_s	10.2×10^6	m^2
HOD (2005)	0.89	gm/m^2/day
v_b	0.0034	m/year
v_r (DO_h= <2 mg/L)	0.0011	m/year
v_e (summer)	0.0075	m/day
v_s	19.0	m/year
V_h	22.7×10^6	m^3
V_s	7.25×10^4	m^3
V_w	80.1×10^6	m^3

The annual amount of phosphorus released from the sediments is the product of the release rate velocity, the area of the sediment-water interface, the sediment phosphorus concentration, and the number of days of anoxia. The model calculations are compared to the measurements conducted by Holmes (M. Holmes, unpublished, 2005) in Fig. 9. This internal source is equivalent to an accumulation in the hypolimnion of about 3 mg/m^3 of phosphorus during the period of anoxia. This estimate is generally consistent with observations; however, the expected increase in concentration is relatively small, and the precision of the phosphorus measurements is limited in this low range. Therefore, any attempt to estimate the sediment release rate using increases in hypolimnetic total phosphorus concentrations in Big Platte Lake would be subject to unacceptably large errors. The anaerobic release rate velocity determined here is about 10 times smaller than that found in Shagawa Lake by Chapra and Canale (1991). This is not unexpected because the total phosphorus concentration of Shagawa Lake is an order of magnitude higher than Big Platte Lake. Furthermore, Big Platte Lake has high marl content and an alkalinity of about 150 mg/L compared to 25 mg/L for Shagawa Lake. These conditions suggest that the amount and mobility of the phosphorus in the sediments of Big Platte Lake is considerably less than that in Shagawa Lake.

Nürnberg (1994) developed an empirical correlation between anaerobic sediment phosphorus release rates and sediment total phosphorus concentrations. This relationship and sediment phosphorus concentrations measured by Holmes (M. Holmes, unpublished, 2005) can be used to calculate an anaerobic phosphorus release rate of about 3.4 mg/m^2/day for Big Platte Lake. This value is considerably higher than typical release rates of 0.85 $mg/m^2/day$ determined by Holmes (M. Holmes, unpublished, 2005) through field and laboratory measurements and model calibration. Sen et al. (2004) measured an average release rate of 0.57 $mg/m^2/day$ for eutrophic Beaver Lake (Arkansas), a value that is similar in magnitude to those determined for Big Platte Lake. On the other hand, Penn et al. (2000) measured sediment release rates in hypereutrophic Onondaga Lake (New York) that are about an order of magnitude larger than those measured in oligotrophic Big Platte Lake. It is apparent that the anaerobic sediment phosphorus release rate of a particular lake is dependent on both trophic status and sediment chemistry and is therefore not easily predicted from published studies for other systems. Therefore, it is recommended that sediment release rates be measured using intact cores as part of developing accurate phosphorus budgets for lakes where sediment-water interactions might be significant.

The sediment burial rate velocity determined by model calibration is 0.0034 m/year for Big Platte Lake (see Table 1). This is about five times higher than the rate found in Shagawa Lake by Chapra and Canale (1991). Again, this is not unexpected and is consistent with the differences in the hardness and alkalinity of the water in these lakes.

The annual average settling velocity for Big Platte Lake determined by model calibration is 19.0 m/year. The associated phosphorus retention is about 56%, an amount that is consistent with other oligotrophic lakes (Chapra 1997). Note, however, that the settling velocity is larger than the "apparent settling velocity" that would be estimated from models such as Vollenweider (1976) that do not explicitly include internal loading resulting from sediment release during anoxic periods. On the other hand, the settling velocity derived here acts on total phosphorus rather than on the particulate fraction alone. Only about 25% of the total phosphorus of Big Platte Lake is particulate; therefore, a settling velocity of 76 m/year would be required to deliver the same phosphorus and carbon flux to the sediments in a model that uses separate dependent variables for the dissolved and particulate components.

Practical Applications

Design Conditions

The water quality models will now be used to calculate an allowable annual average total phosphorus load that will insure that the total phosphorus concentration of Big Platte Lake is below 8 mg/m^3 95% of the time. The first step is to determine the annual average Lake phosphorus concentration consistent with this objective. Fig. 13 shows a plot of the percent of time the concentration of phosphorus in Big Platte Lake exceeds 8 mg/m^3 during the year as a function of the annual average volume-weighted total phosphorus concentration. This plot is based on approximately 7,000 discrete phosphorus measurements collected over a period of 17 years. A linear fit of the data indicates that an annual average concentration of 6.4 mg/m^3 will insure compliance with the Lake total phosphorus standard.

The baseline calculations employ typical nonpoint phosphorus loads and lake inflow rates based on 2004 measurements and BASINS model results. The baseline total phosphorus load is 2,539 kg/year and includes 2,197 kg/year from diffuse, nonpoint watershed sources, 71 kg/year for lost fish, and 101 kg/year from atmospheric deposition. The calculations use the NPDES limit for the Hatchery loading of 79 kg/year. The internal phosphorus loading from sediment release is about 90 kg/year and is calculated by the model. This loading gradually varies with time because P_w, P_s, and HOD, as well as the duration of anoxia, all vary in response to changes in the phosphorus loading to the Lake. The phosphorus model coefficients were unchanged from the calibration values reported in Table 1.

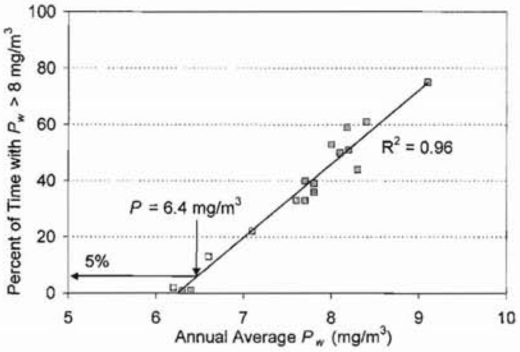

Fig. 13. Measured annual average total phosphorus concentration of Big Platte Lake versus the percent of the individual measurements that exceed 8 mg/m^3 for various years

The model projections beyond 2008 through 2030 shown in Figs. 7–9 were determined using the typical input conditions as described above. If no actions are taken to reduce phosphorus loading, the predicted annual average total phosphorus concentration of Big Platte Lake will be 7.6 mg/m^3, a value that violates the water quality standard (see Fig. 13). Simulations were performed using a series of stepwise reductions in phosphorus loading to determine an allowable total phosphorus load of 2,164 kg/year. These results show that the total phosphorus loading must be reduced by 375 kg/year to meet the water quality standards for the Lake. The projected total phosphorus concentrations and loading reduction requirements for other nonpoint loading and flow rate conditions are discussed in Canale et al. (2004).

Evaluation of Alternative Remedial Actions

The above model calculations have identified the need to reduce the nonpoint phosphorus loads to the lake, and now an action plan is needed to complete the task of attaining compliance with the water quality standards. This requires implementation of various watershed management practices that will reduce the nonpoint phosphorus loading. Although the BASINS and lake models discussed above cannot be used to determine the practicality or effectiveness of various abatement alternatives, the models can be used to determine incremental decreases in lake total phosphorus concentration if the functioning of these efforts can be estimated, prescribed, or specified as described below.

A local ordinance requires lakeside residents to construct retention basins to collect the runoff from all impervious surfaces to allow percolation into the groundwater. The calibrated BASINS model for the Platte River watershed estimates that the event mean concentration of such runoff has a total phosphorus concentration of approximately 250 mg/m^3 and that local groundwater has a concentration of about 6 mg/m^3. A maximum potential phosphorus reduction of about 86 kg/year could be attained if all 500 lakeside residents were to comply with the ordinance. This is equivalent to about 23% of the needed reduction in phosphorus loading to meet water quality standards.

Lake shore buffer zone ordinances are being considered to reduce the nonpoint phosphorus loads to the Lake. Although buffer zone vegetation reduces erosion, it is not considered effective for the removal of phosphorus over the long term because phosphorus retained by plants in the spring and summer is released with plant senescence in the fall. Therefore, lakeside residents have been asked to circumvent this natural recycling by collecting beach debris and cutting, harvesting, and removing excess buffer zone vegetation two to three times per year as suggested by Dillaha et al. (1986). Measurements indicate that typical shoreline debris material has a water content of about 75% and contains about 0.25% phosphorus by dry weight. Therefore, a total phosphorus loading reduction of about 70 kg/year could be attained if each lakeside property owner removed 225 kg of vegetative litter and beach debris (wet weight) from their property per year.

A typical 9 kg bag of lawn and garden fertilizer used in the area contains 10% phosphorus, or 0.9 kg per bag. A local ordinance is being considered that requires lakeside residents to use only phosphorus-free fertilizers. Detailed fertilizer sales volume and application rate data are not available for the local area; however, if 50% of the lakeside residences currently use one bag of fertilizer per year, a reduction of 227 kg of phosphorus loading could be attained through the use of phosphorus-free fertilizers.

It is important to note that the reductions in phosphorus loading estimated for the actions described above are a maximum because even without the remedial measures, some phosphorus from these sources would naturally percolate into the groundwater. It is not possible to quantitatively evaluate the actual phosphorus reduction achieved in practice compared to the potential reductions described in the previous paragraphs. In addition, note that the model calculations presented above do not account for increases in the nonpoint phosphorus loads that are expected from the future growth of population and commercial activities. Therefore, additional modeling and a long-term monitoring program should be carried out to confirm the effectiveness of the implemented corrective actions, to detect the effects of future watershed development, and to predict the benefits of future remedial efforts.

Discussion Items

TMDL applications of the watershed and lake phosphorus models developed in this paper require that a margin of safety (MOS) be established for load allocations to provide a degree of protection. The MOS can be expressed either explicitly by specifying unallocated assimilative capacity, or implicitly through the use of conservative assumptions in the TMDL analysis (Dilks and Freedman 2004). Various researchers have stressed the importance of defining an appropriate MOS based on modeling uncertainty analysis (Reckhow 2003; Walker 2003; Zhang and Yu 2002). The development of a meaningful MOS also requires that a desired level of protection be specified as a matter of policy. In practice, the MOS is often arbitrary in nature (Dilks and Freedman 2004).

Rigorous uncertainty analysis and development of a MOS for Big Platte Lake is beyond the scope of the present paper; however, some aspects of this issue will be discussed in this section. First, the internal phosphorus load due to bottom sediment release depends on the dissolved oxygen concentration in the hypolimnion, which is a function of the rate of mixing between the epilimnion and the hypolimnion. This mixing varies with wind speed and direction, both of which vary seasonally and annually. The allowable loads determined here are based on 2005 mixing conditions, which are more restrictive than typical mixing conditions. Fig. 9 shows that the projected sediment releases beyond 2009 are somewhat higher than the average of recent preceding years. Second, the loading requirements developed here assume that all fish not accounted for at the Hatchery constitute an internal phosphorus load. It is possible that some of the fish that enter the Lake are captured by anglers, but reliable estimates of the number of fish removed are not available. Finally, and most importantly, the water quality standard itself has an inherent safety factor because the allowable loads insure compliance with the Lake total phosphorus concentration standard 95% of the time. If no actions are taken to reduce the current total phosphorus loads, model calculations indicate that the Lake will attain a near steady state annual average total phosphorus concentration of 7.6 $\mathrm{mg/m^3}$. This concentration is equivalent to 65% compliance with the 8 $\mathrm{mg/m^3}$ standard rather than 95% as specified by the court order (see Fig. 13). Thus, the required nonpoint load reductions are a function of the statistical aspects of the numerical standard.

The intent of this case study was to demonstrate the utility of a model with an intermediate level of complexity to facilitate TMDL analyses and other planning applications for Big Platte Lake. It is also of interest to consider the utility of an even simpler approach. The nonpoint loads used to calibrate the above models were the result of dynamic simulations performed using the BASINS model. The calibrated BASINS model can also be used to derive site-specific UALs for each land-use type that characterizes the watershed. These UALs can be used in conjunction with the steady state solution of the model described by Eq. (1) to predict total phosphorus concentrations in Big Platte Lake and evaluate the effectiveness of alternative land-use assumptions and management options and scenarios. Field measurements can be used to estimate the number of days during the year when sediment release of phosphorus is significant. This steady state approach cannot reliably be used for cases where the sediment dynamics are important or where the nonpoint loads change in response to long-term watershed development. However, it can be a useful screening tool for cases where these long-term dynamic considerations are not important (for example, see case study by Litwack et al. 2006).

Conclusions

The experience gained through this case study indicates that a model with single water and sediment layers and one dependent variable (total phosphorus) can be used to perform reliable nutrient budget analyses for Big Platte Lake. The study suggests that this intermediate complexity model could be used to similar advantage for other lake systems. The model can be used with confidence when long-term sediment dynamics are significant or where long-term planning applications and projections are needed. The monitoring data for this study proved to be of critical importance to the efforts to achieve credible and defensible results. In addition to the typical components of a monitoring program such as stream flow, phosphorus loading, water total phosphorus concentrations, temperature, and dissolved oxygen concentrations; the laboratory measurements of sediment phosphorus release rates, SOD, and sediment total phosphorus concentrations proved to be particularly useful and are highly recommended to support other similar projects.

Additional insight into lake system dynamics may be provided by complex mechanistic models for HOD, but such efforts do not appear warranted for applications similar to Big Platte Lake.

Where additional analyses are necessary, SOD and algal respiration in the hypolimnion are the most important processes that must be quantified. However, care must be taken to avoid the propagation of large errors by minimizing the number and uncertainty of model coefficients and forcing functions.

UAL coefficients derived from the calibrated BASINS model and steady state versions of Eq. (1) may serve as a useful screening tool in cases for lakes where sediment dynamics and long-term trends are not important. In these cases, the internal loads due to sediment release may be considered constant with time, but sediment sampling and requisite laboratory measurements are necessary to correctly estimate their magnitude.

Acknowledgments

The writers wish to thank Jim Berridge of the Platte Lake Improvement Association (PLIA) for his efforts to develop and maintain the water quality database. Sylvia Heaton from the Michigan Department of Environmental Quality reviewed the manuscript and provided insights into the Michigan TMDL regulatory protocol. Steve Chapra from Tufts University and Mike Pattison (PLIA) reviewed the manuscript and provided useful comments and thoughtful suggestions.

Notation

The following symbols are used in this paper:

A_e = thermocline area (m^2);
A_r = phosphorus release area (m^2);
A_s = settling area (m^2);
DO_e = epilimnion dissolved oxygen concentration (mg/L);
DO_h = hypolimnion dissolved oxygen concentration (mg/L);
HOD = hypolimnetic oxygen demand rate ($\mathrm{gm/m^2/day}$);
P_s = sediment total phosphorus concentration ($\mathrm{mg/m^3}$);
P_w = water total phosphorus concentration ($\mathrm{mg/m^3}$);
Q = hydraulic flow rate ($\mathrm{m^3/year}$);
t = time (year);
V_h = volume of hypolimnion (m^3);
V_s = volume of lake sediments (m^3);
V_w = volume of lake water (m^3);
υ_b = sediment burial rate velocity (m/year);
υ_e = exchange rate velocity between epilimnion and hypolimnion (m/day);
υ_r = phosphorus release rate velocity (m/year);
υ_s = settling rate velocity (m/year);
W = total annual external phosphorus loading (kg/year); and
τ = time (days).

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Discussions and Closures

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS
1801 Alexander Bell Drive
RESTON, VA 20191-4400

0733-9496(201009/201010)136:5;1-4

APPENDIX E: SBDNL VISITOR EXPERIENCE AND RESOURCE PROTECTION (VERP) RESULTS FOR THE PLATTE RIVER

(3 day survey, 1 weekday and two weekends)

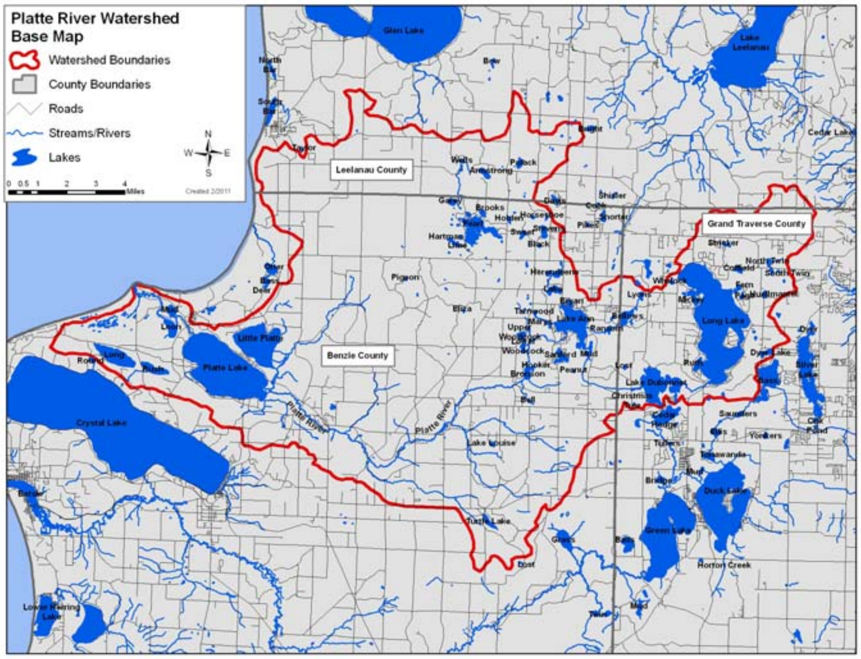
	2006	**2007**	**2008**	**2009**	**2010**	**2011**
Visitors (total)	3493	3890	2550	4130	4941	4617
Crafts (Total)	2408	2873	1933	3225	3941	3763
Kayaks	526	556	567	760	816	752
Canoes	611	599	511	533	422	442
Tubes/Rafts	1269	1718	855	1932	2703	2420
Rental Craft	1675	1634	1240	1624	2008	1511
% rentals	*70%*	*57%*	*64%*	*50%*	*51%*	*40%*
Private Craft	733	1239	693	1601	1933	2253
% private	*30%*	*43%*	*36%*	*50%*	*49%*	*60%*

APPENDIX F: PLATTE RIVER WATERSHED QUESTIONNAIRE

Platte River Watershed Questionnaire:

As part of the Platte River Watershed Protection Planning process the Watershed Steering committee *(Platte Lake Improvement Association, Benzie Conservation District, Sleeping Bear Dunes National Lakeshore, Michigan Department of Natural Resources –DNR and Michigan Department of the Environment DEQ*) is gathering valuable input from 'stakeholders' *(watershed residents and visitors*) on how they use the Platte River watershed, what they value about it and what they feel threatens it.

The fundamental purpose of watershed planning is to preserve the function and character of the watershed. A ***watershed*** is the total land area draining to a common body of water such as a lake, river or wetland or storm sewer. Surface water is confined within the boundaries of the watershed formed by surrounding hills and slopes.



Please take a few minutes to answer the following questions to help us better understand how the watershed is being used and what concerns users have for the watershed. You can submit completed surveys in person or mail them to the Benzie Conservation District

Mailing Address: P.O. Box 408

Beulah, MI 49617

Phone: (231) 882-4391 or (231) 882-5607

The survey is also available on the Benzie CD website and via the link to the right:

Physical Address:

280 S. Benzie Blvd.

Beulah, MI 49617

http://www.surveymonkey.com/s/N7VXX55

1. What is your 'residential' relationship to the Platte River watershed? ***(Circle One)***

   ARE YOU A:

   - *full time resident -seasonal resident -seasonal visitor -first time visitor*

2. How often do you enjoy the following activities in the Platte River watershed.

   Regularly (>2-3 times/week), **Fairly Often** (2-4 times/month), **Sometimes** (6 times/year), **Once a year, Never**

   Also, please rate the quality (Excellent, good, fair or poor) of those activities in the Platte River watershed.

	Frequency	Quality
- Boating (PWC included) -	_________	_________
- Swimming -	_________	_________
- Water skiing/wakeboarding -	_________	_________
- Tubing-	_________	_________
- Canoeing/kayaking	_________	_________
- Fishing (open water) -	_________	_________
- Ice Fishing -	_________	_________
- Hunting -	_________	_________
- Wildlife Observation -	_________	_________
- Other – (please describe)	_________	_________

3. Based on your experiences and knowledge of the watershed, please rank the following threats from most threatening (#1) to least threatening (#7).

   - Loss of natural habitat _____
   - Toxic Substances _____
   - Nutrients _____
   - Sediment _____
   - Exotic Species _____
   - Coliform bacteria (E.coli) _____
   - Other – (Please describe) _____

4. Please describe any conflicts (either ongoing or one-time) that you have had or continue to have with other watershed users.

5. Are there certain cultural, historic or environmental sites or resources that you think deserve special protection or specific management regulations?

6. What do you think of the condition of the the Platte River watershed TODAY compared to when you first remember it? (Circle one)

-Better *-Same (no real change)* *-Worse*

7. Imagine the Platte River watershed 50 years from now – What do you want it to look like?

(please use the back side if needed)

APPENDIX G: LIST OF RESOURCES FOR THE PLATTE RIVER WATERSHED

Platte Lake Improvement Association

(http://www.platte-lake.org/)

Lake Data

http://www.platte-lake.org/Lake_Data.html

Benzie Conservation District

http://benziecd.org/

Conservation Resource Alliance

http://www.rivercare.org/

Platte River Watershed- Road and Stream Crossing Report

http://www.northernmichiganstreams.org/platteriverrsx.asp

Grand Traverse Regional Land Conservancy

http://www.gtrlc.org/

Leelanau Conservancy

http://leelanauconservancy.org/

Sleeping Bear Dunes National Lakeshore

http://www.nps.gov/slbe/index.htm

Michigan Department of Environmental Quality

http://www.michigan.gov/deq

Michigan Department of Natural Resources

http://www.michigan.gov/dnr

Benzie Leelanau Health Department

http://www.bldhd.org/

The Watershed Center

Http://www.gtbay.org

Midwest Invasive Species Information Network

http://www.misin.msu.edu/