Platte River Watershed Baseline Calibration Report

Prepared for:

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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.

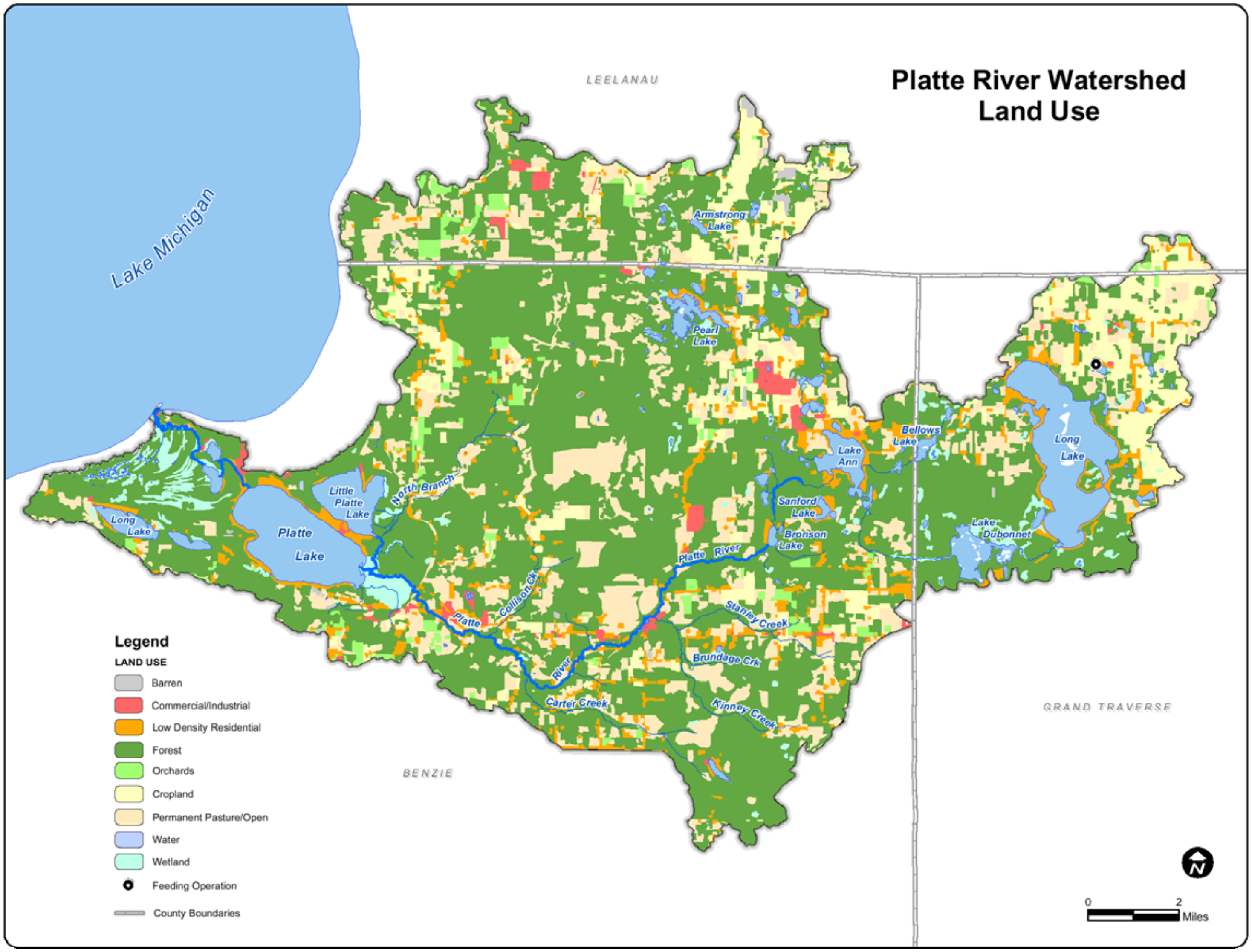

Figure 1. Current land use in the Platte River watershed

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.

<u>Soil information</u>
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.

<u>Current land use</u>
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

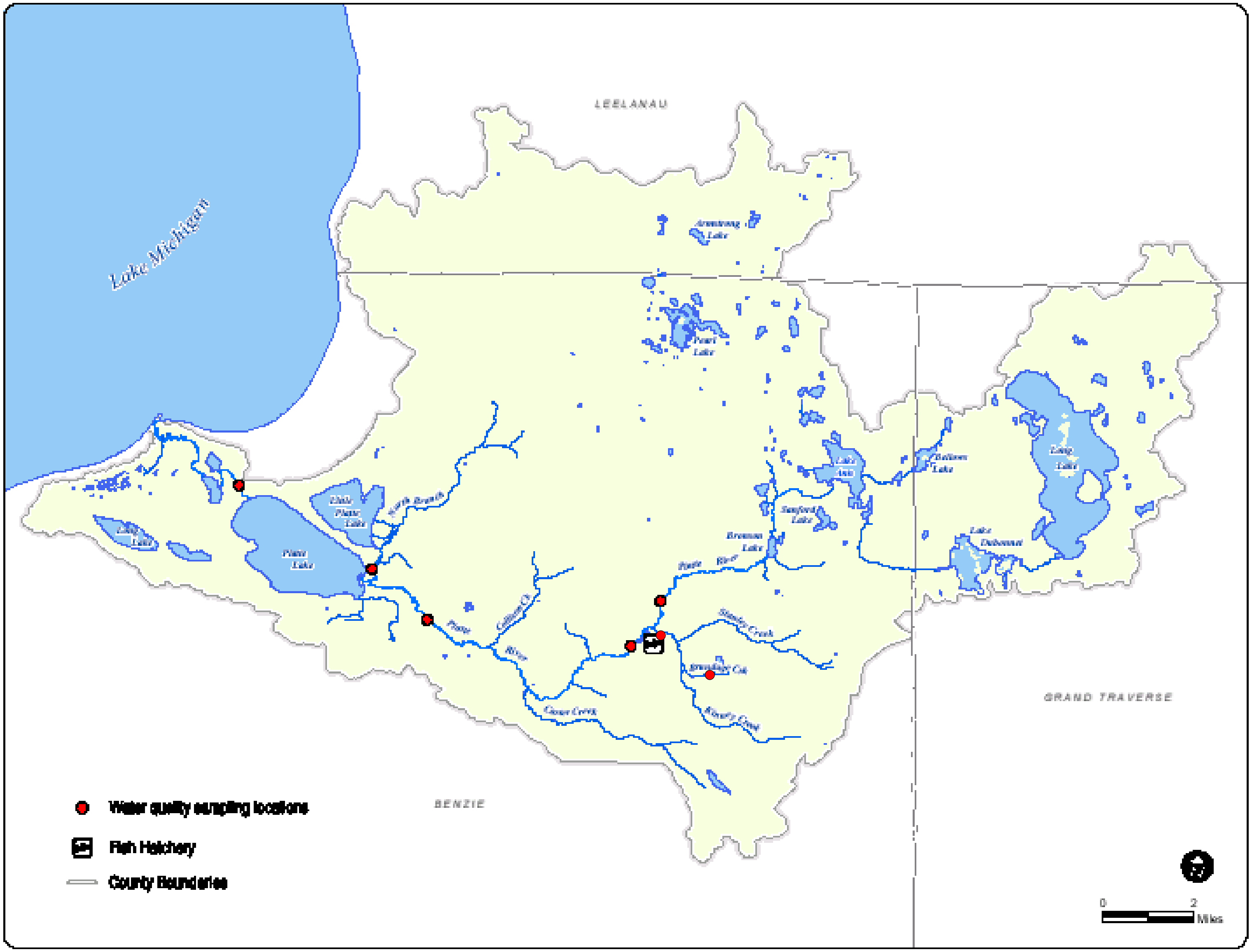

Figure 2. Sampling station locations

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.

<u>Hydrology</u>
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.

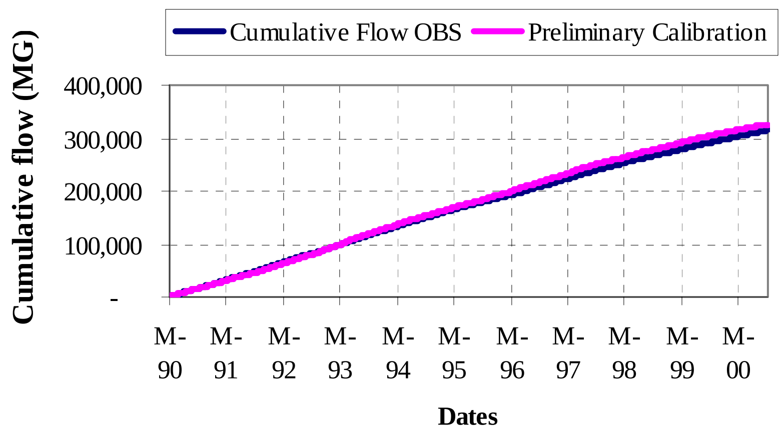

Figure 3. Comparison of cumulative flow during calibration period

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.

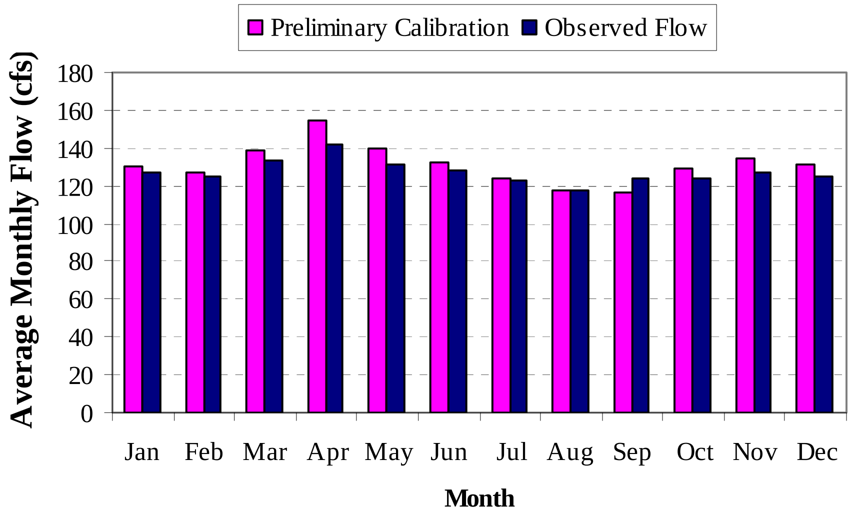

Figure 4. Comparison of monthly average flows during calibration period

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.

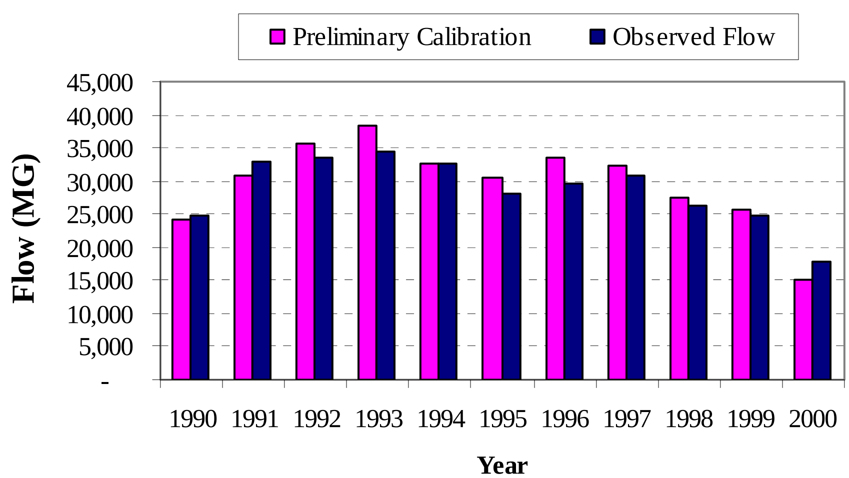

Figure 5. Comparison of annual flow volumes during calibration period

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.

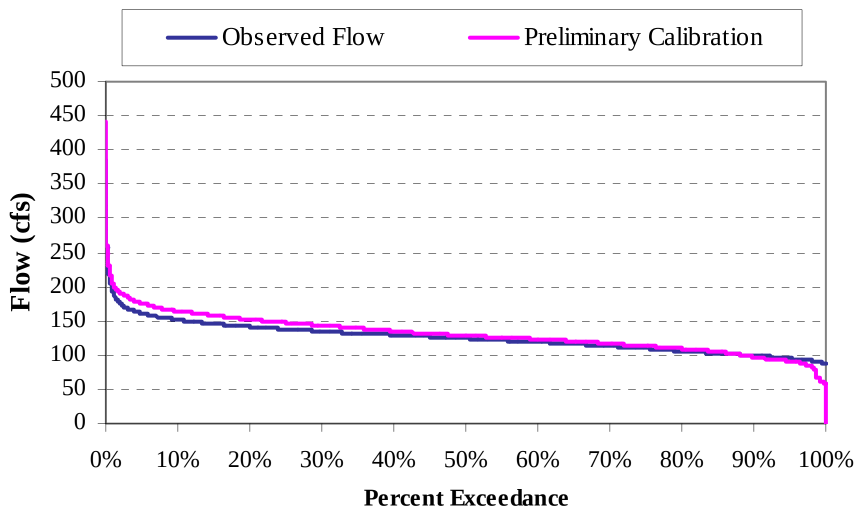

Figure 6. Percent exceedance comparison of daily average flows (3/90-12/00)

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.

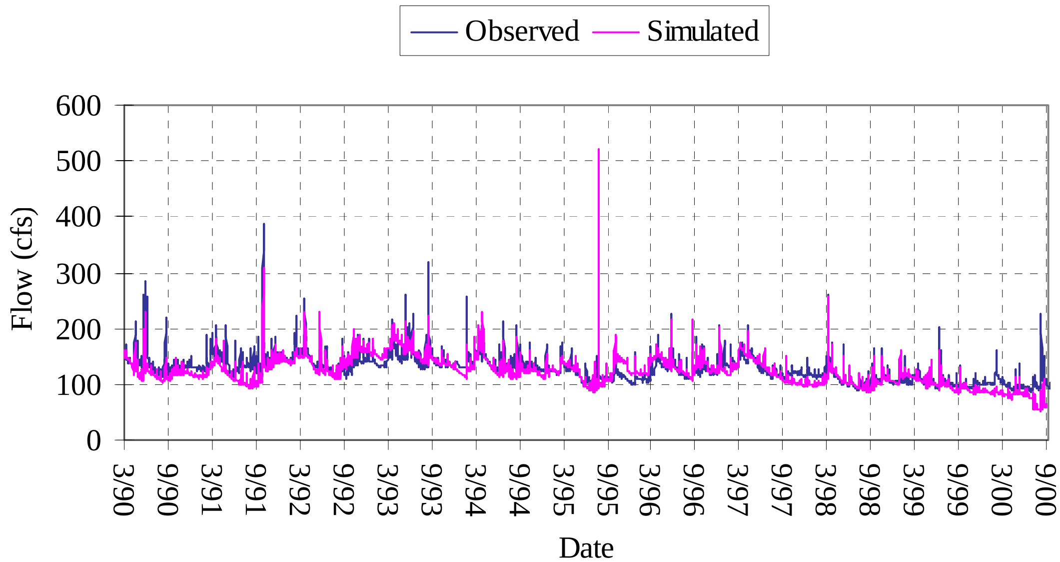

Figure 7. Daily average flow comparison at Platte River USGS gage 04126740.

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.

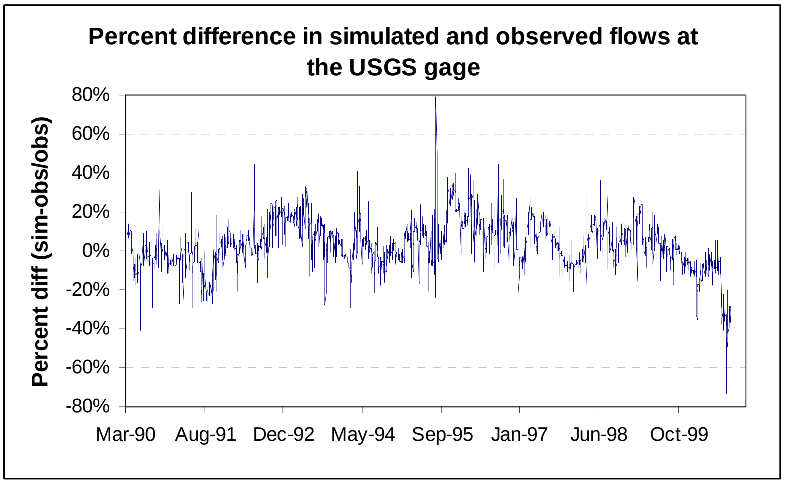

Figure 8. Percent difference in simulated and observed flows at the USGS gage

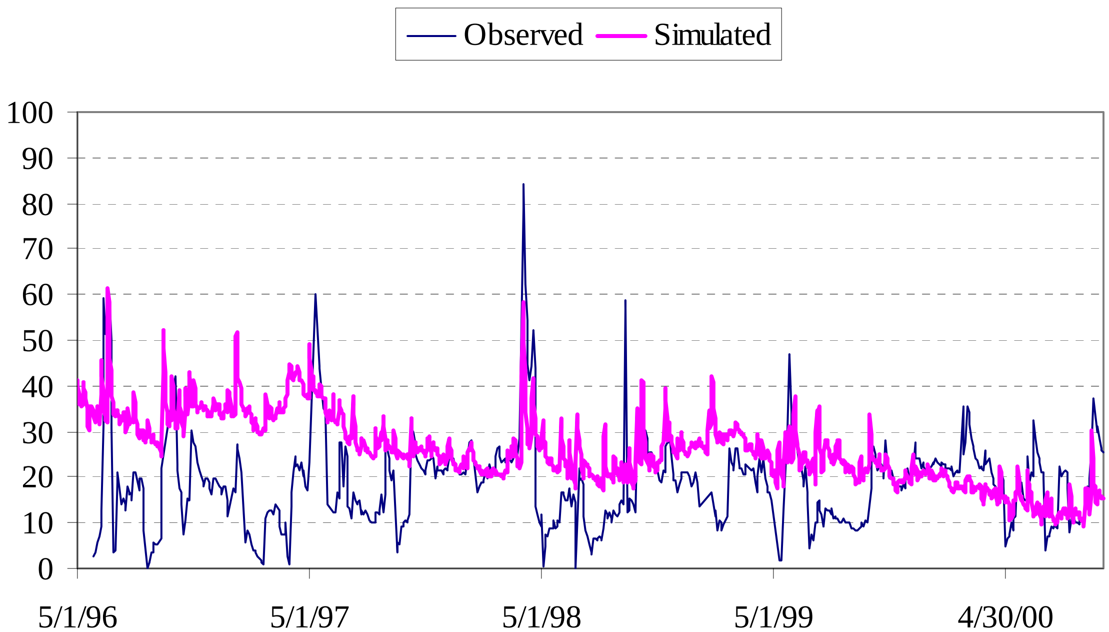

Figure 9. Daily average flow comparison for North Branch Platte River at Dead Stream Rd.

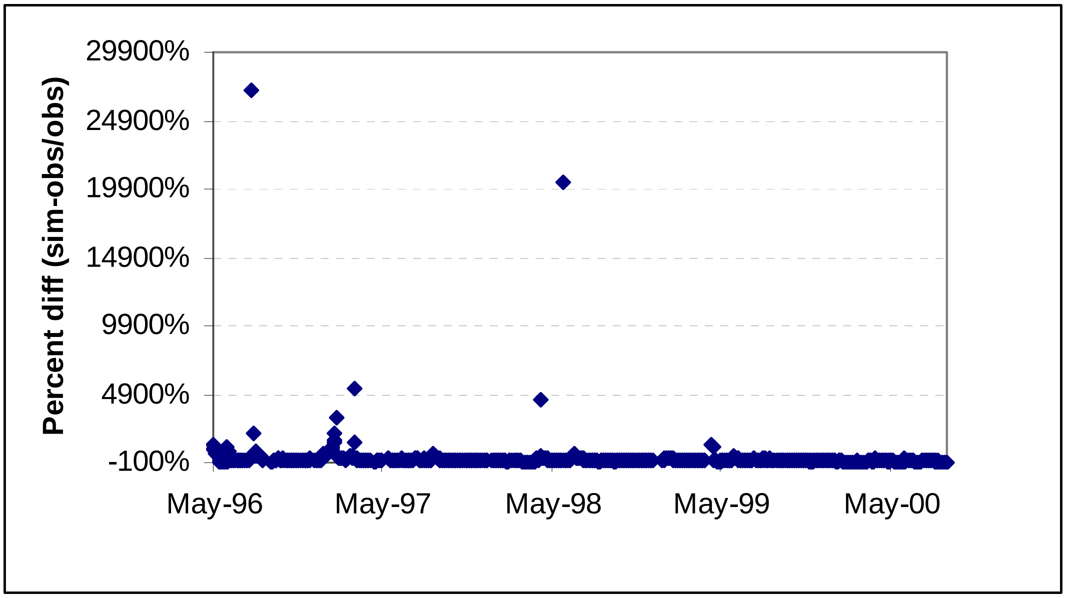

Figure 10. Percent difference in simulated and observed North Branch Platte R. flows

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.

<u>Total Phosphorus</u>
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.

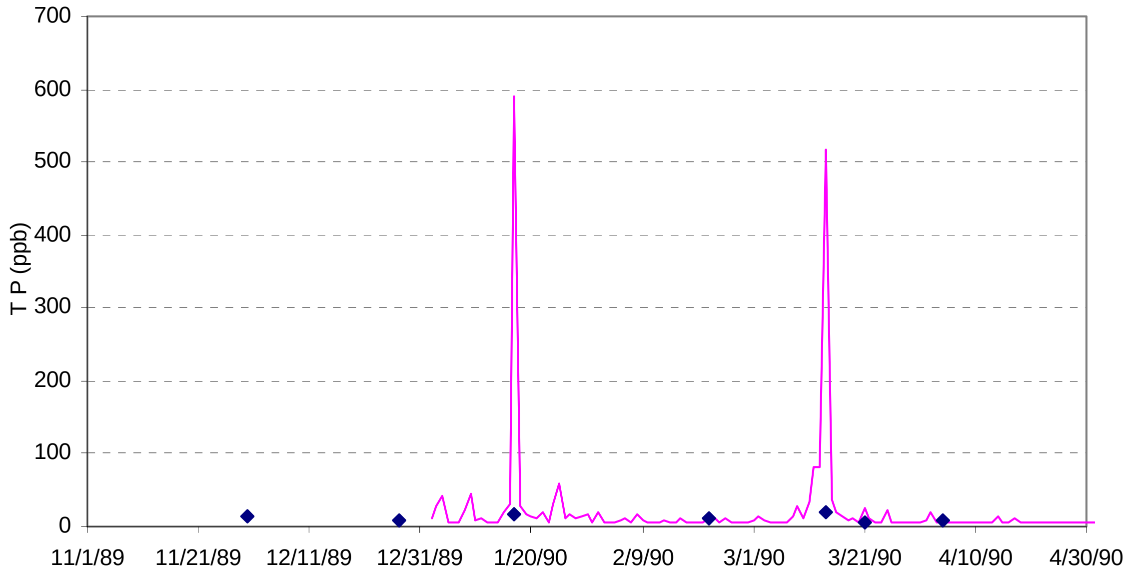

Figure 11. Simulated and observed total phosphorus at station 1, Platte River above the hatchery January 1990 – April 1990

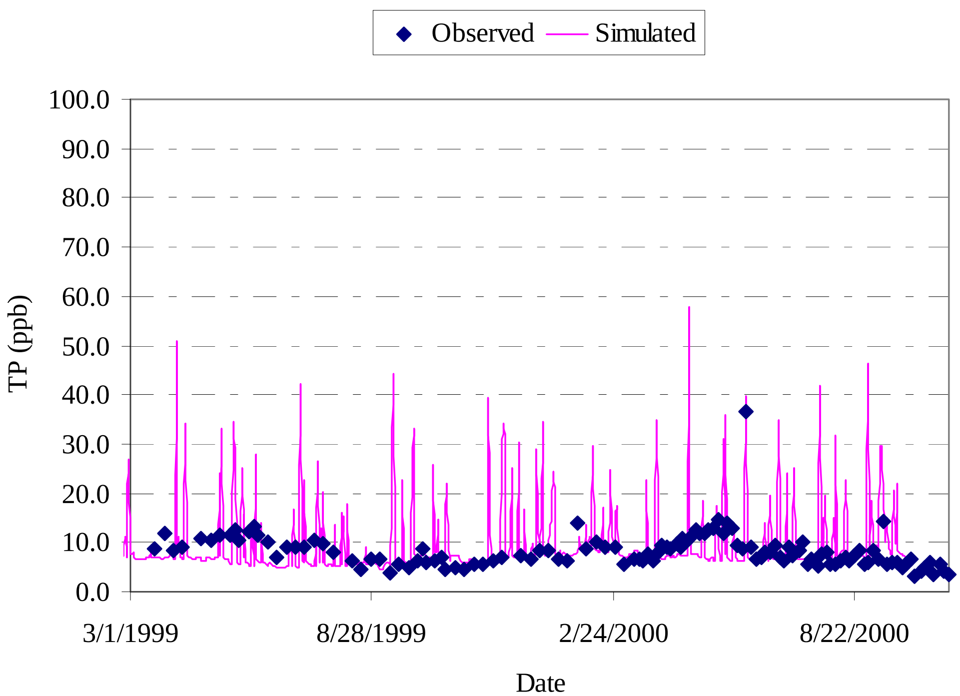

Figure 12. Simulated and observed total phosphorus at station 1, Platte River above hatchery, from March 1999 – September 2000

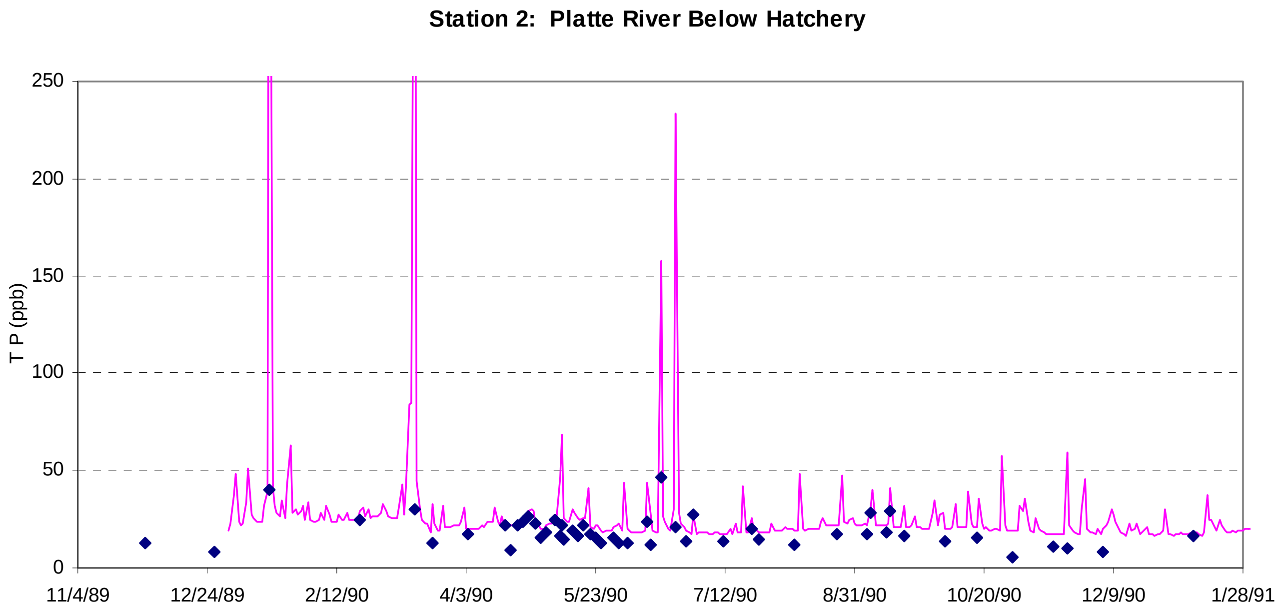

Figure 13. Simulated and observed total phosphorus at station 2, Platte River below hatchery

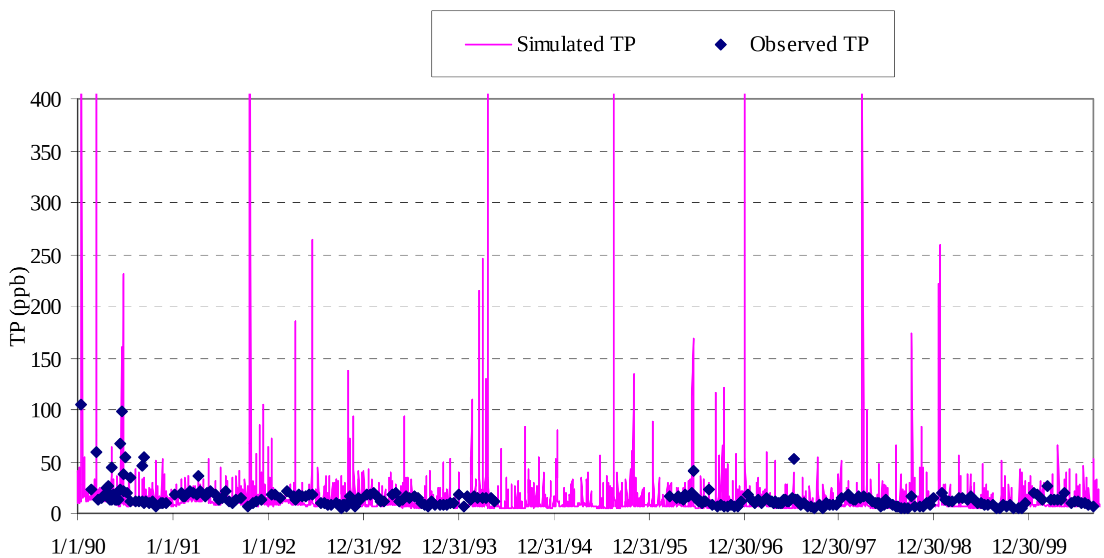

Figure 14. Simulated and observed total phosphorus at station 3, USGS gage

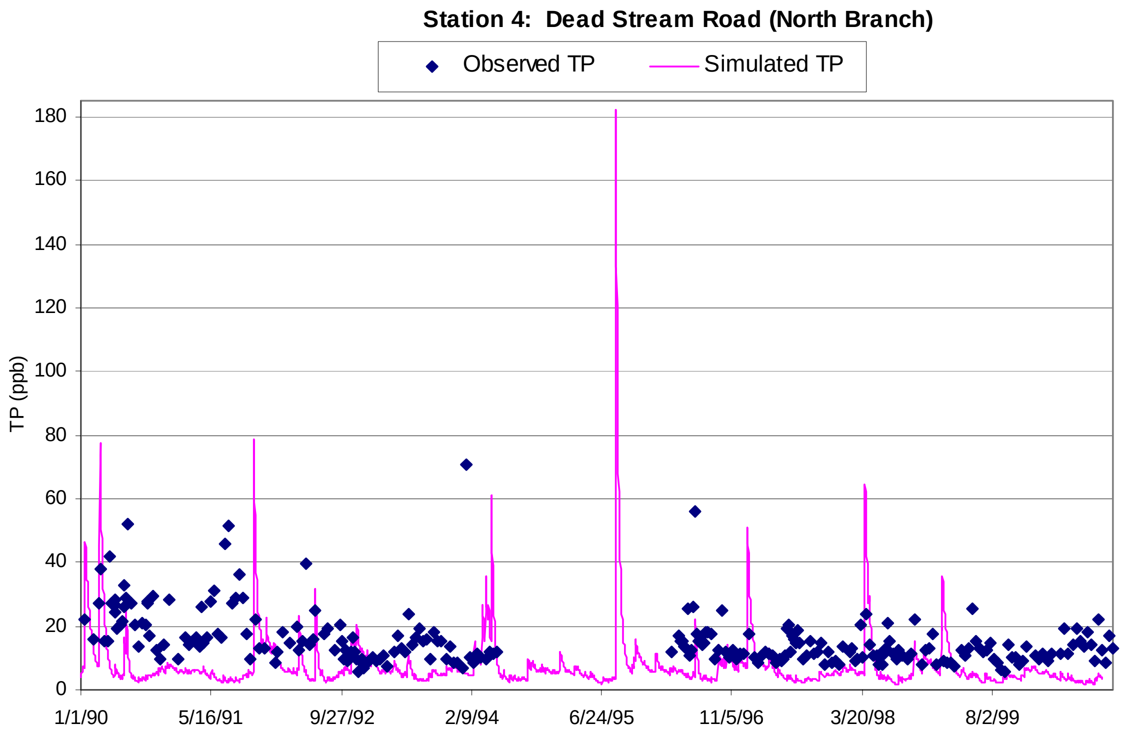

Figure 15. Simulated and observed total phosphorus at station 4, North Branch of the Platte River at Dead Stream Rd.

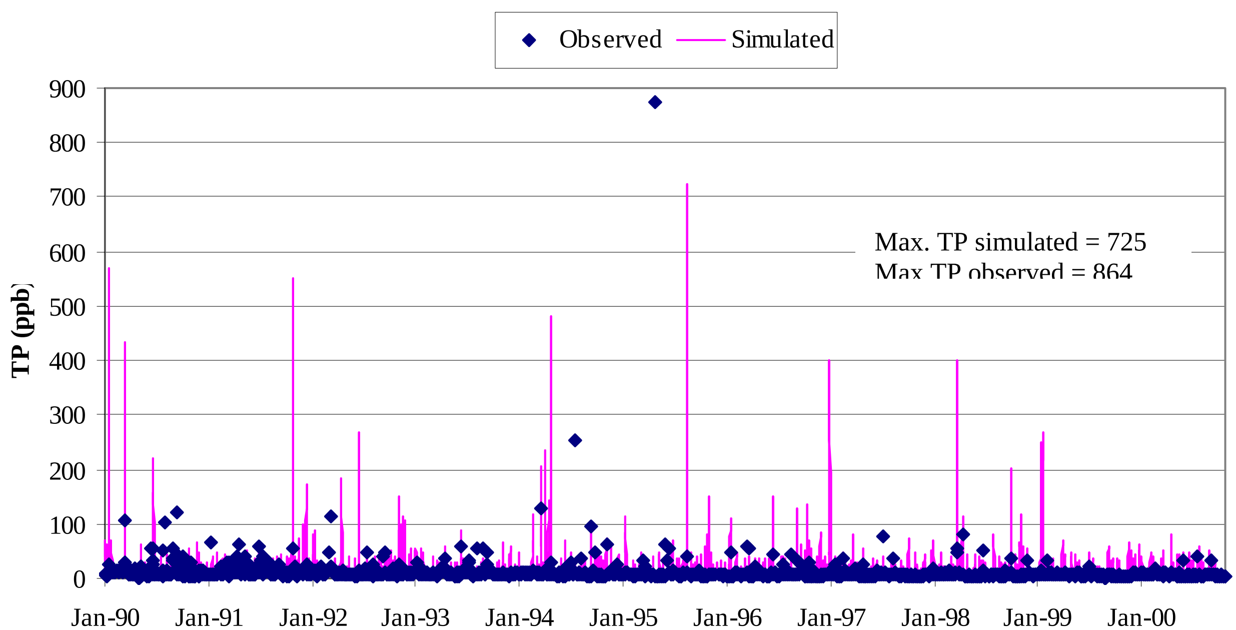

Figure 16. Simulated and observed total phosphorus at station 6, Brundage Creek at hatchery intake

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

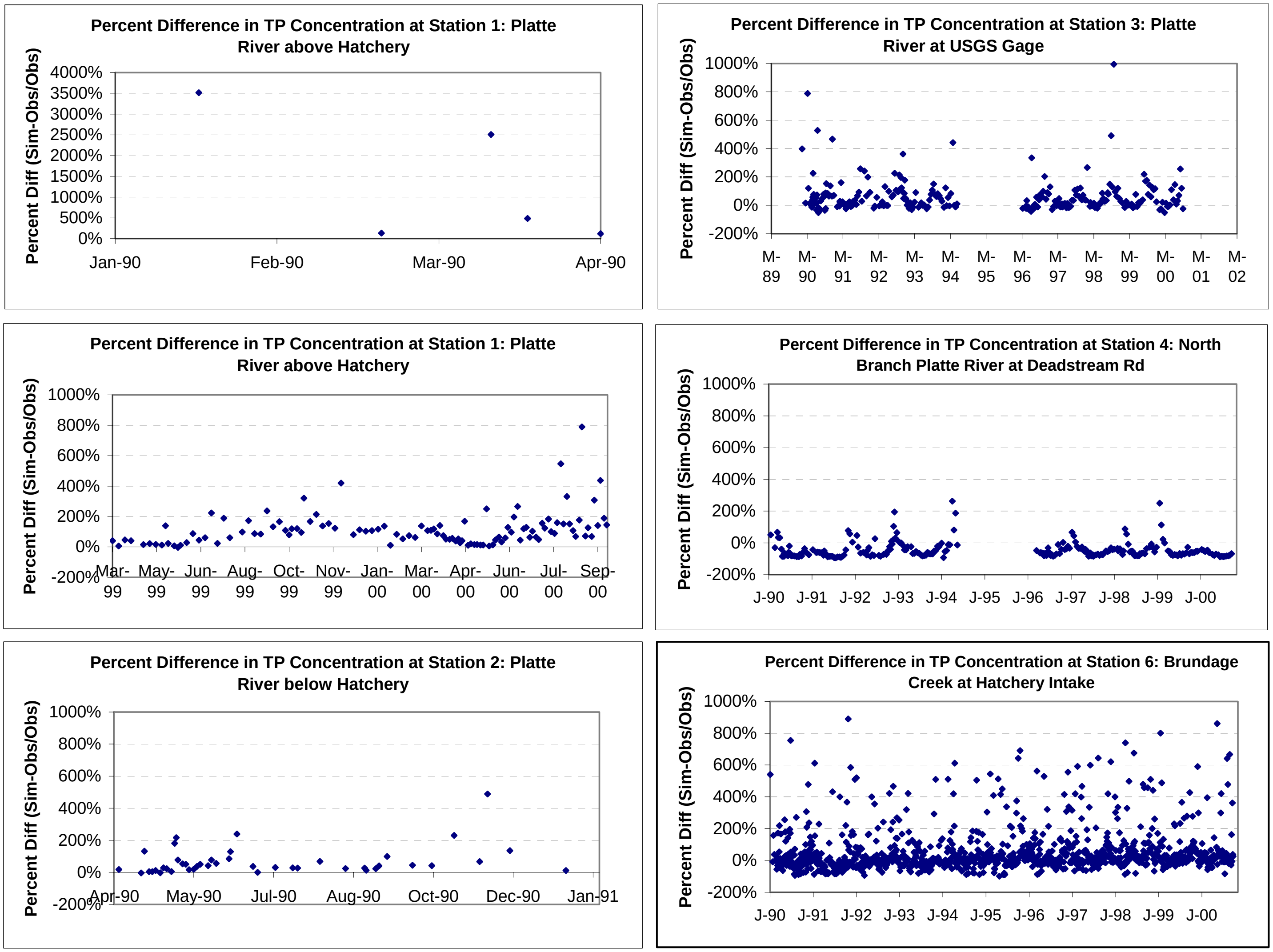

Figure 17. Percent difference in predicted and observed total phosphorus concentrations

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