Pomme de Terre River Watershed TMDL Report

Minnesota Pollution Control Agency

January 2015

wq-iw7-36e

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Acronyms

ARM	Agricultural Runoff Model
AWQCP	Agricultural Water Quality Certification Program
BASINS	Better Assessment Science Integrating point and Non-point Sources
BMP	Best Management Practice
cf/L	Cubic Feet per Liter
cfs	Cubic Feet per Second
CRP	Conservation Reserve Program
CWA	Clean Water Act
CWLA	Clean Water Legacy Act
DNR	Minnesota Department of Natural Resources
EDA	Environmental Data Access
EQuIS	Environmental Quality Information System
HSPF	Hydrologic Simulation Program – FORTRAN
HUC	Hydrologic Unit Code
kg/ha	Kilograms per Hectare
LA	Load Allocation
lbs/day	Pounds per Day
LC	Loading Capacity
m	Meters
mg	Milligrams
mgd	Million Gallons per Day
mg/L	Milligrams per Liter
mg/ton	Milligrams per Ton
ml	Milliliters
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System
NCHF	North Central Hardwood Forest
NGP	Northern Glaciated Plains
NPDES	National Pollutant Discharge Elimination System
NPDES/SDS	National Pollutant Discharge Elimination System/State Disposal System
NPS	Non-Point Source
NTU	Nephelometric Turbidity Units
NTRU	Nephelometric Turbidity Ratio Units
org	Organisms
PdT	Pomme de Terre River
PdTRA	Pomme de Terre River Association
SDS	State Disposal System
SSTS	Subsurface Sewage Treatment System
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
µg/L	Micrograms per Liter
EPA	United States Environmental Protection Agency
VSS	Volatile Suspended Solids
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facilities

TMDL Summary Table

EPA/MPCA Required Elements	Summary	TMDL Page #
Location	The Pomme de Terre River watershed is in west-central Minnesota. The specific impaired water bodies addressed are the Pomme de Terre River from Barrett Lake to North Pomme de Terre Lake, Dry Wood Creek, North Turtle Lake, Lake Christina, Perkins Lake and Hattie Lake.	13
303(d) Listing Information	Total of 10 listings for *E. coli* bacteria (1), turbidity (1), low dissolved oxygen (1), aquatic macroinvertebrate bioassessments (1), fishes bioassessments (2)and excess nutrients (4); see Table 1.3	9
Applicable Water Quality Standards/ Numeric Targets	*See Section 1.1*	9
Loading Capacity (expressed as daily load)	The loading capacities for the stream impairments are provided in Section 4.2 and for the lake impairments in Section 5.2	30-31, 34-36
Wasteload Allocation	Wasteload allocations for the stream impairments are provided in Section 4.2 and for the lake impairments in Section 5.2	30-31, 34-36
Load Allocation	Load allocations for the stream impairments are provided in Section 4.2 and for the lake impairments in Section 5.2	30-31, 34-36
Margin of Safety	Turbidity, *E. coli*, Total Phosphorus, Dissolved Oxygen and Lakes, Excess Nutrients: Explicit MOS of 10% used; *See Section 3.2*	20
Seasonal Variation	Turbidity and *E. coli:* Load duration curve methodology accounts for seasonal variation; *See Section 4.3* Total Phosphorus: Proposed standard is developed for critical conditions; *See Section 4.3* Dissolved Oxygen: Standard is developed for critical conditions; *See Section 4.3* Excess Nutrients: Standard is developed for critical conditions; *See Section 5.3*	31, 36
Reasonable Assurance	Changes in the landscape and hydrology will need to occur if pollutant levels are going to decrease. The source reduction strategies detailed in the implementation section have been shown to be effective in improving water quality. Many of the goals outlined in this TMDL report run parallel to objectives outlined in the local Water Plans. Various	39

	programs and funding sources are currently being utilized in the watershed and will also be used in the future. Additionally, Minnesota voters have approved an amendment to increase the state sales tax to fund water quality improvements, which will help to fund many improvement initiatives.	
Monitoring	Intensive watershed monitoring will occur on a 10-year schedule. Long term load monitoring at watershed outlets is currently occurring. Long term intermediate scale load monitoring began in 2013.	36
Implementation	A summary of potential management measures is included as well as a rough approximation of the overall implementation cost to achieve the TMDL**.**	36
Public Participation	Public participation in the PdT has been ongoing for the past two years. With respect to this specific TMDL: A public comment period was open from August 18, 2014 to September, 17, 2014. There were two comment letters and one phone call received and responded to as a result of the public comment period.	41

Executive Summary

Section 303(d) of the Clean Water Act (CWA) provides authority for completing Total Maximum Daily Loads (TMDLs) to achieve state water quality standards and/or designated uses. The TMDL establishes the maximum amount of a pollutant a water body can receive on a daily basis and still meet water quality standards. The TMDL is divided into wasteload allocations (WLA) for point or permitted sources, load allocations (LA) for nonpoint sources, which includes natural background, and a margin of safety (MOS).

This TMDL report addresses one turbidity impairment, one turbidity stressor; one dissolved oxygen impairment and two dissolved oxygen stressors, one *E. coli* impairment, and four lake eutrophication impairments in the Pomme de Terre (PdT) River watershed. Addressing multiple impairments in one TMDL report is consistent with Minnesota's Water Quality Framework that seeks to develop watershed wide protection and restoration strategies rather than focus on individual reach impairments.

The PdT watershed covers 559,968 acres, spans the north central hardwood forest (NCHF) and northern glaciated plains (NGP) ecoregions and drains portions of six counties (Otter Tail, Grant, Douglas, Big Stone, Swift and Stevens) in the north-west Minnesota River basin.

This report used a variety of methods to evaluate current loading, contributions by the various pollutant sources as well as the allowable pollutant loading capacity (LC) of the impaired water bodies. These methods included the Hydrologic Simulation Program – FORTRAN (HSPF) model, the load duration curve approach and the BATHTUB lake eutrophication model.

A general strategy and cost estimate for implementation to address the impairments is included. Non-point sources will be the focus of implementation efforts. Non-point contributions in general are not regulated and will need to be addressed on a voluntary basis. Permitted point sources will be addressed through the Minnesota Pollution Control Agency's (MPCA) National Pollutant Discharge Elimination System (NPDES) Permit programs.

1 Introduction

The CWA Section 303(d) requires states to publish, every two years, a list of surface waters that do not meet water quality standards and do not support their designated uses. These waters are then classified as impaired. Once a water body is placed on the impaired waters list, a TMDL must be developed. The TMDL provides a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards.

The passage of Minnesota's Clean Water Legacy Act (CWLA) in 2006 provided a policy framework and resources to state and local governments to accelerate efforts to monitor assess, and restore impaired waters and to protect unimpaired waters. The result has been a comprehensive watershed approach that integrates water resource management efforts with local government and local stakeholders and develops restoration and protection studies for Minnesota's 81 major watersheds. For the entire PdT River major watershed (Figure 1.1), the intensive watershed monitoring work began in 2007 and subsequent assessment resulted in impairment listings, or proposed listings, on three separate reaches of the PdT River, Dry Wood Creek, an unnamed creek in Stevens County, and four lakes (North Turtle, Perkins, Christina, Hattie). Based on the results of stressor identification work and other factors, pollutant TMDL calculations were only completed for one reach of the PdT River, Drywood Creek, and the four impaired lakes. For the other two reaches of the PdT River, and the unnamed creek, combinations of nitrate, altered hydrology, and degraded habitat were determined to be the primary causes of impairment. Because insufficient information currently exists on appropriate nitrate thresholds for protecting biological communities, and because the other two stressors are not pollutants, TMDL calculations were not made for those reaches. Completion of this TMDL report, in conjunction with two prior completed PdT River TMDL studies (MPCA, 2007a; MPCA, 2011a), will address the majority of impaired waters in the PdT River watershed. The wetland and fish consumption impairments will not be covered directly in this report. The information gained and strategies developed in this process should serve to help improve the streams and wetlands for which TMDL calculations are not being made, and to protect unimpaired water bodies.

1.1 Applicable Water Quality Standards

The criteria used for determining stream reach and lake impairments are outlined in the MPCA's document Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment: 305(b) Report and 303(d) List (MPCA, 2011b). The applicable water body classifications and water quality standards are specified in Minn. R. ch. 7050. The Minn. R. ch. 7050.0470 lists water body classifications and Minn. R. ch. 7050.2222, lists applicable water quality standards. The impaired waters covered in this TMDL are classified as Class 2B or 2C, 3B, 3C, 4A, 5 and 6. Relative to aquatic life and recreation the designated beneficial uses for 2B and 2C waters are as follows:

Class 2B waters – The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable.

Class 2C waters – The quality of Class 2C surface waters shall be such as to permit the propagation and maintenance of a healthy community of indigenous fish and associated aquatic life, and their habitats. These waters shall be suitable for boating and other forms of aquatic recreation for which the waters may be usable.

The water quality standards that apply to the PdT stream reaches in this TMDL report are shown in Table 1.1. Lake water quality standards are specific to ecoregion and lake type (depth). The water quality standards that apply to the lakes in this TMDL report are shown in Table 1.2. For more detailed information refer to the MPCA TMDL protocols specific to the parameter of interest (MPCA, 2007b; MPCA, 2007c; MPCA, 2009).

In addition to meeting phosphorus limits, chlorophyll-a and Secchi transparency standards must also be met. In developing the lake nutrient standards for Minnesota lakes (Minn. R. 7050), the MPCA evaluated data from a large cross-section of lakes within each of the state's ecoregions (MPCA, 2005). Clear relationships were established between the causal factor total phosphorus (TP) and the response variables chlorophyll-a and Secchi transparency. Based on these relationships it is expected that by meeting the phosphorus target in each lake, the chlorophyll-a and Secchi standards will likewise be met.

Table 1.1: Surface water quality standards for PdT stream reaches addressed in this report.

Parameter	Water Quality Standard	Units	Criteria	Period of Time Standard Applies
Escherichia coli	Not to exceed 126	org/100 ml	Monthly geo mean	April 1 – October 31
	Not to exceed 1,260	org/100 ml	Upper 10th percentile	
Turbidity	Not to exceed 25	NTU	Upper 10th percentile	Year round
Dissolved Oxygen	Daily minimum of 5.0	mg/L	100 percent of days above 7Q10 flow; 50 percent of days at 7Q10 flow	Year round

Table 1.2: Lake water quality standards for PdT lakes addressed in this report.

Ecoregion/Type	Total Phosphorus Standard (µg/L)	Chlorophyll –a Standard (µg/L)	Secchi Depth (m)	Period of Time Standard Applies
NCHF/Shallow Lakes	< 60	< 20	>1.0	June 1 – September 30
NGP/Shallow Lakes	< 90	< 30	> 0.7	June 1 – September 30

NCHF = North Central Hardwood Forest
NGP = Northern Glaciated Plains

This TMDL report applies to 10 impairment listings for two stream reaches and four lakes in the PdT River Watershed - HUC 07020002 (Table 1.3, Figure 1.1). Supporting documentation of the impairments can be found in MPCA (2010), MPCA (2011c) and MPCA (2012a).

Table 1.3: Pomme de Terre watershed 303(d) impairments addressed in this report.

Reach	Description	Year Listed	Assessment Unit ID/DNR Lake #	Affected Use	Impairment addressed
Pomme de Terre River	Barrett Lake to North Pomme de Terre Lake	2006	07020002-563	Aquatic Life	Fishes Bioassessments
Dry Wood Creek	Dry Wood Lake to Pomme de Terre River	2010	07020002-556	Aquatic Life	Turbidity
Dry Wood Creek	Dry Wood Lake to Pomme de Terre River	2010	07020002-556	Aquatic Recreation	*Escherichia coli*
Dry Wood Creek	Dry Wood Lake to Pomme de Terre River	2012	07020002-556	Aquatic Life	Aquatic Macroinvertebrate Bioassessments
Dry Wood Creek	Dry Wood Lake to Pomme de Terre River	2012	07020002-556	Aquatic Life	Aquatic Fishes Bioassessments
Dry Wood Creek	Dry Wood Lake to Pomme de Terre River	2012	07020002-556	Aquatic Life	Dissolved Oxygen
North Turtle	Lake or Reservoir	2012	56-0379-00	Aquatic Recreation	Nutrient/Eutrophication Biological Indicators
Christina	Lake or Reservoir	2010	21-0375-00	Aquatic Recreation	Nutrient/Eutrophication Biological Indicators
Perkins	Lake or Reservoir	2010	75-0075-00	Aquatic Recreation	Nutrient/Eutrophication Biological Indicators
Hattie	Lake or Reservoir	2012	75-0200-00	Aquatic Recreation	Nutrient/Eutrophication Biological Indicators

1.2 Priority Ranking

The MPCA's projected schedule for TMDL completions, as indicated on the 303(d) impaired waters list, implicitly reflects Minnesota's priority ranking of these TMDLs. Ranking criteria for scheduling the TMDL projects include, but are not limited to: impairment impacts on public health and aquatic life; public value of the impaired water resource; likelihood of completing the TMDL in an expedient manner, including a strong base of existing data and restorability of the waterbody; technical capability and willingness locally to assist with the TMDL; and appropriate sequencing of TMDLs within a watershed or basin.

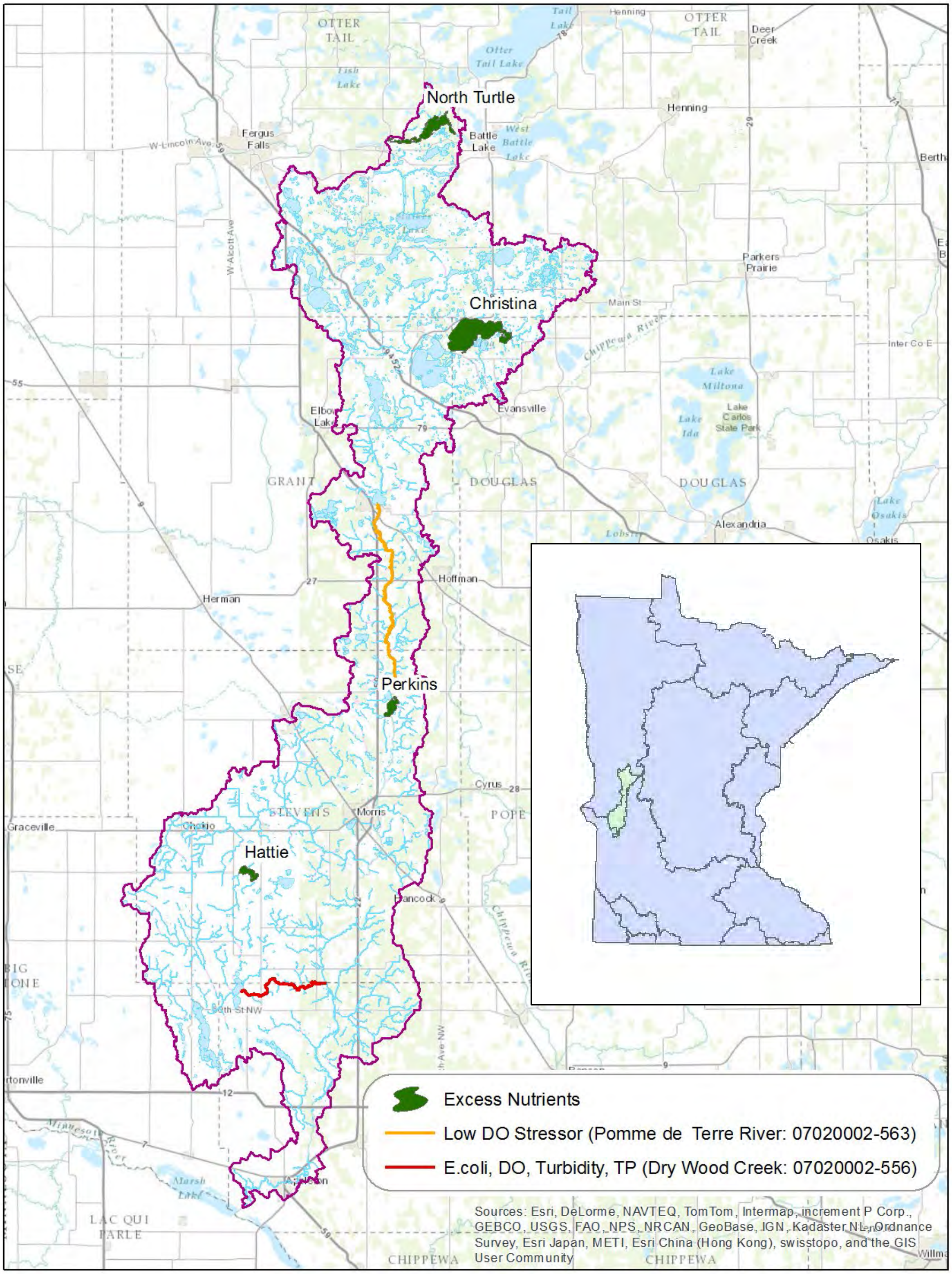

Figure 1.1: Map of Pomme de Terre indicating site and nature of impairments. The river flows from north to south.

2 Watershed Characteristics

2.1 Pomme de Terre River Watershed

The PdT River watershed is located in the west-central portion of Minnesota in the NCHF and NGP ecoregions. The PdT watershed covers 559,968 acres and drains portions of six counties (Otter Tail, Grant, Douglas, Big Stone, Swift and Stevens) in the north-west Minnesota River basin. Morris and Appleton are the largest towns in the largely rural watershed. The upper reach of the watershed is characterized by its relatively low gradient and prevalence of lakes and wetlands. Gradient increases moving downstream in the watershed as does the occurrence of development and row crop agriculture. Glacial sediments cover the entire PdT watershed. Land use statistics of the PdT watershed and some of its sub-watersheds are shown in Table 2.1. For more detailed information on characteristics of the PdT watershed, refer to the PdT River Watershed Monitoring and Assessment Report (MPCA, 2011c).

Table 2.1: Land use percentages in the Pomme de Terre watershed and some of its sub-watersheds. Land use statistics are based on the 2009 National Agricultural Statistics Service as determined by the United States Department of Agriculture.

Watershed/ Catchment	Percent Open Water	Developed	Percent Barren/Mining	Percent Forest/Shrub	Percent Pasture/ Hay/ Grassland	Percent Cropland	Percent Wetland
Pomme de Terre	8.9	7.6	< 1	6.9	17.1	52	7.5
Dry Wood Creek	7.1	6.3	< 1	1	6.6	69	9.9
North Turtle Lake	29.5	5.5	< 1	20.5	23.1	12.1	9.2
Lake Christina	18.7	6.2	< 1	20.2	40.8	7.9	6.3
Perkins Lake	14.8	7.2	< 1	13.2	23.5	34	7.2
Hattie Lake	15.0	6.6	0	1.0	5.7	64.1	7.5

2.2 Subwatersheds

Dry Wood Creek

Dry Wood Creek is one of a handful of major tributaries to the PdT River. The watershed is located in the NGP ecoregion and drains portions of Stevens, Big Stone and Swift counties in the southern reaches of the PdT watershed. The primarily rural watershed covers 61,778 acres, much of which has been converted to cropland. The riparian area in the downstream section of the river is heavily pastured. A few lakes including Artichoke, North Dry Wood, and South Dry Wood are located within the watershed. For more detailed information on the characteristics of the Dry Wood Creek watershed, refer to the PdT River Watershed Monitoring and Assessment Report (MPCA, 2011c).

North Turtle Lake Watershed

North Turtle Lake is located in the NCHF ecoregion in the northern most reaches of the PdT watershed. A catchment area of over 7,100 acres drains to the 1,500 acre lake. Land use in the watershed is a mix of cropland, forest and rangeland. Four feedlots are in relatively close proximity to the lake. North Turtle Lake outlets via a pump that directs water to a culvert running under County Road 122. The water makes its way through a series of wetlands to South Turtle Lake. For more detailed information on the characteristics of the North Turtle Lake watershed, refer to the Assessment Report of Selected Lakes within the PDT River Watershed (MPCA, 2010).

Lake Christina Watershed

Lake Christina is located in the NCHF ecoregion in the northeastern PdT watershed. A catchment area of over 38,000 acres drains to the 3,955 acre lake. Land use in the watershed is primarily rangeland with a mix of forest and cropland. Lake Christina is nationally recognized as a critical staging area for migrating waterfowl and is managed as such. Rotenone treatments have been used to control fish populations and the lake has alternated between a macrophyte dominated clear water state and a turbid phase dominated by phytoplankton. Currently, activities are underway to draw down the water level in Lake Christina as a means for controlling the rough fish population, harden bottom sediments and establish native macrophytes. Christina's status as a staging area for migrating waterfowl increases the relative importance of wildlife delivered phosphorus during certain parts of the year through surface runoff and direct deposition. It is difficult to quantify the amount of phosphorus migrating waterfowl deliver to Christina and this TMDL will not attempt to do so. Phosphorus loading derived from wildlife is accounted for in the LA of the TMDL. Management of the lake for waterfowl has and likely will continue to provide a net benefit to the water quality of Lake Christina through control of rough fish populations and establishment of macrophytes. For more detailed information on the characteristics of the Lake Christina watershed, refer to the Assessment Report of Selected Lakes within the PdT River Watershed (MPCA, 2010).

Perkins Lake Watershed

Perkins Lake is a small (504 acre), shallow, turbid lake on the PdT River mainstem in Stevens County. The lake is located in the NGP ecoregion, though most of its 266,000 acre catchment is located in the NCHF ecoregion. Nearly half of the land use in the catchment is cropland with a mix of rangeland and forest making up the bulk of the remaining land use. Perkins Lake has been characterized by poor water quality, a lack of submerged macrophytes and degraded aquatic habitat since the initial lake survey report in 1947. For more detailed information on the characteristics of the Perkins Lake watershed, refer to the Assessment Report of Selected Lakes within the PdT River Watershed (MPCA, 2010).

Hattie Lake Watershed

Hattie Lake is a shallow, turbid, hypereutrophic lake located in the southern reaches of the PdT watershed within the NGP ecoregion. The 454 acre lake has a catchment area in excess of 8,800 acres resulting in a large catchment to surface area ratio (19:1). Gorder Lake (493 acres) is included in the Hattie Lake watershed. Cropland is the dominant land use in the watershed. Hattie Lake was used as a NGP reference lake in the 1980s. The data collected in the 1980s coupled with more recent data indicates Hattie Lake has exhibited poor water quality for a fairly long time. For more detailed information on the characteristics of the Hattie Lake watershed, refer to the Assessment Report of Selected Lakes within the PdT River Watershed (MPCA, 2010).

2.3 NPDES Permitted Facilities

The NPDES Permits (Permits) are issued by the MPCA under a delegation agreement from the U.S. Environmental Protection Agency (EPA). These Permits are issued to a range of facilities or industries, for which most, but not all, have point source discharges. The Permits define the conditions that a facility must meet in order to discharge wastewater to surface or groundwater (EPA, 2002). Effluent limits are set on pollutant discharges based on water quality standards and the receiving water's designated use (EPA, 2002). The effluent limits most relevant to this TMDL report are for TP. Applicable Permits are listed in Section 3.

3 Methodology for Estimating TMDL Components

A TMDL for a waterbody that is impaired as a result of excessive loading of a particular pollutant can be described by the following equation:

$$\textbf{TMDL = LC = } \sum \textbf{WLA + } \sum \textbf{LA + MOS + RC}$$

Where:

LC = loading capacity, or the greatest pollutant load a waterbody can receive without violating water quality standards;

WLA = wasteload allocation, or the portion of the TMDL allocated to existing or future permitted point sources of the relevant pollutant;

LA = load allocation, or the portion of the TMDL allocated to existing or future nonpoint sources of the relevant pollutant;

MOS = margin of safety, or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality. The MOS can be provided implicitly through analytical assumptions or explicitly by reserving a portion of LC (EPA, 1999);

RC = reserve capacity, or the portion of the LC attributed to growth of existing and future load sources;

An explicit RC has not been defined for the impairments in this TMDL report. Land use in the watershed is not expected to change significantly in the next 20 years, nor is development likely to result in new regulated point sources. Refer to Section 3.5 for discussion on how future growth will be managed in the context of the TMDL. Per Code of Federal Regulations (40CFR 130.2(1)) TMDLs can be expressed in terms of mass per time, toxicity or other appropriate measures. For the PdT impairments addressed in this report, the TMDLs, allocations and margins of safety are expressed in mass per day. Each of the TMDL components is discussed in greater detail below.

Data Sources

Hydrologic Simulation Program – FORTRAN (HSPF)

HSPF is a comprehensive package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants. HSPF incorporates watershed-scale Agricultural Runoff Model (ARM) and Non-Point Source (NPS) models into a basin-scale analysis framework that includes fate and transport in one dimensional stream channels. It is the only comprehensive model of watershed hydrology and water quality that allows the integrated simulation of land and soil contaminant runoff processes with in-stream hydraulic and sediment-chemical interactions. The result of this simulation is a time history of the runoff flow rate, sediment load, and nutrient and pesticide concentrations, along with a time history of water quantity and quality at the outlet of any subwatershed. HSPF simulates three sediment types (sand, silt, and clay) in addition to a single organic chemical and transformation products of that chemical.

The HSPF watershed model contains components to address runoff and constituent loading from pervious land surfaces, runoff and constituent loading from impervious land surfaces, and flow of water and transport/transformation of chemical constituents in stream reaches. Primary external forcing is provided by the specification of meteorological time series. The model operates on a lumped basis within subwatersheds, meaning that within a delineated subwatershed, areas with similar land uses are aggregated and a uniform set of parameter values are applied to that land category. Upland responses within a subwatershed are simulated on a per-acre basis and converted to net loads on linkage to stream reaches. Within each subwatershed, the upland areas are separated into multiple land use categories.

Within the PdT River watershed, dissolved oxygen, runoff, phosphorus and flow simulated output were used for analysis and TMDL calculations.

EQuIS

The MPCA uses a system called EQuIS (Environmental Quality Information System) to store water quality data from more than 17,000 sampling locations across the state. EQuIS contains information from Minnesota streams and lakes dating back to 1926.

All discreet water quality sampling data utilized for assessments and data analysis for this report are stored in this database and are accessible through the MPCA's EDA (Environmental Data Access) website: http://www.pca.state.mn.us/index.php/data/environmental-data-access.html.

3.1 Loading Capacity

Turbidity

The duration curve approach was utilized to address the turbidity impairment (EPA, 2007). A flow duration curve was developed using 1996-2009 daily average flow data provided by the PdT River Watershed HSPF model (MPCA, 2012e). Flow zones were determined for very high, high, mid, low and very low flow conditions. The mid-range flow value for each flow regime was then multiplied by the Total Suspended Solid (TSS) surrogate standard of 52 mg/L to calculate the LC. Thus, for the "very high flow" zone, the LC is based on the flow value at the 5th percentile. Conversion factors are shown in Table 3.1.

Table 3.1: Converting flow and concentration to sediment load

Load (tons/day) = TSS surrogate (mg/L) * Flow (cfs) * Factor			
For **each** flow zone			
Multiply **flow** (cfs) by **28.31** (cf/L) and **86,400** (sec/day) to convert	cfs	à	L/day
Multiply **TSS surrogate** (52 mg/L)by **L/day** to convert	L/day	à	mg/day
Divide **mg/day** by **907,184,740** (mg/ton) to convert	mg/day	à	tons/day

Use of a TSS surrogate for turbidity

Turbidity is a measurement of the clarity of water, determined by how much light is absorbed and scattered in a water sample. Suspended organic matter, inorganic sediment and dissolved organic matter all can affect turbidity. It is not a direct measure of pollutant mass. However, because light scatter and absorption is strongly affected by particles suspended in the water, there is a strong relationship between turbidity and the commonly used mass-based water quality parameter TSS. For this reason, and because mass loads are needed for TMDL calculations and allocations, TSS is commonly used as a surrogate for turbidity.

A regression analysis was completed in the PdT River Turbidity TMDL and found that in the watershed, 52 mg/L TSS was equivalent to 25 Nephelometric Turbidity Units (NTU). Regressions were performed on both NTU data (Figure 3.1) and NTRU data (Figure 3.2), both resulting in the same surrogate value. Additional information about the surrogate determination can be found in the Turbidity TMDL Assessment for the PdT River Final Report (MPCA, 2011a). Due to the limited amount of data in other areas of the watershed, 52mg/L will be used as the surrogate for the entire watershed.

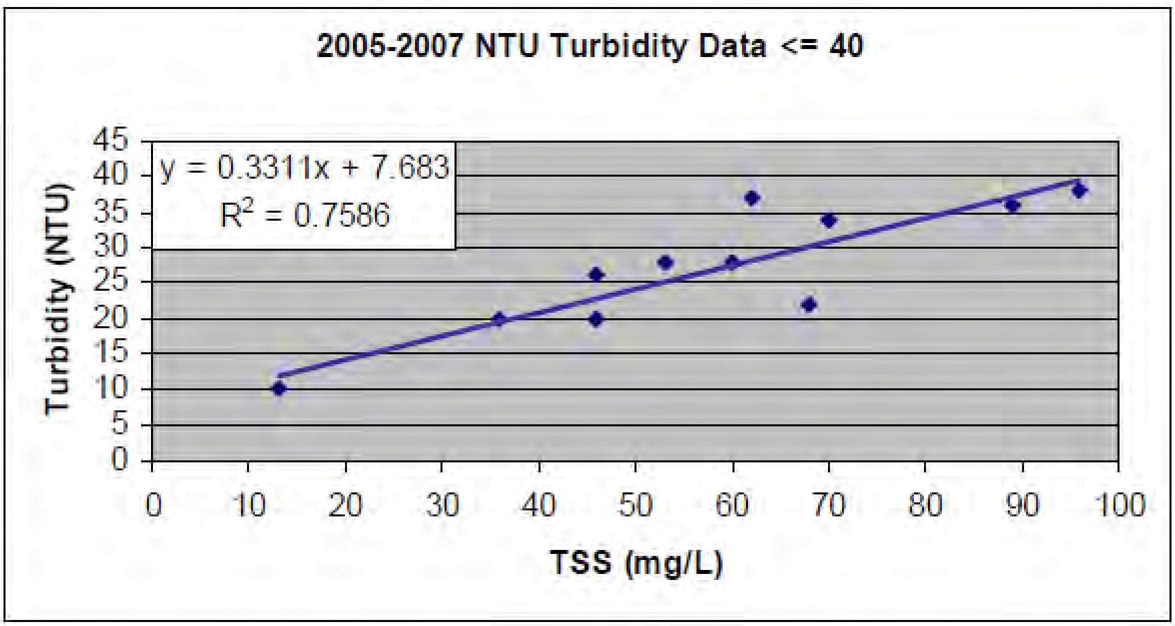

Figure 3.1: Pomme de Terre River at Appleton; relationship between TSS and Turbidity (NTU)

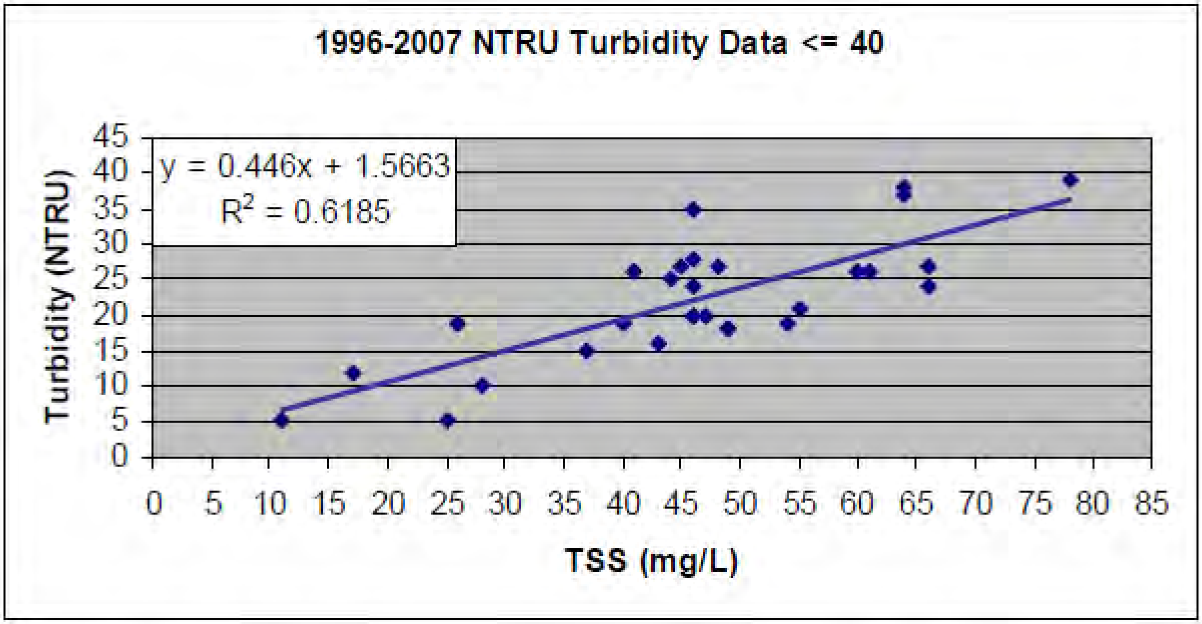

Figure 3.2: Pomme de Terre River at Appleton; relationship between TSS and Nephelometric Turbidity Ratio Units

E. coli

The duration curve approach was also utilized to address the *E. coli* impairments (EPA, 2007). A flow duration curve was developed using April through October, 1996 through 2009 daily average flow data provided by the PdT River Watershed HSPF model (MPCA, 2012e). Flow zones were determined for very high, high, mid, low and very low flow conditions. The mid-range flow value for each flow zone was then multiplied by the standard of 126 org/100ml to calculate the LC. For example, for the "very high flow" zone, the LC is based on the flow value at the 5^{th} percentile. Conversions are shown in Table 3.2.

Table 3.2: How to convert flow and concentration into bacteria load (Cleland, 2006).

Load (org/day) = Concentration (org/100mL) * Flow (cfs) * Factor			
multiply by **3785.2** to convert	mL per gallon	à	org/100 gallon
divide by **100** to convert		à	org/gallon
multiply by **7.48** to convert	gallon per ft^3	à	org/ft^3
multiply by **86,400** to convert	seconds per day	à	ft^3/day
multiply by **24,462,688** to convert	(org/100mL) * ft^3 / sec	à	org/day
Divide by **1 billion** to convert	org/day	à	Bil org/day

Dissolved Oxygen

The calibrated PdT HSPF model was utilized to characterize the existing condition and identify the pollutant of concern resulting in low dissolved oxygen. Model scenarios demonstrate that dissolved oxygen is sensitive to phosphorus. Also, the PdT River Watershed Biotic Stressor Identification report (MPCA, 2012a) determined that excess phosphorus, through one or more stressor pathways, contributes to the dissolved oxygen and biological impairments in the impaired stream reaches addressed in this report.

Allocations were subsequently developed in consideration of model results. Continuous output for the 10 year period 2000 through 2009 from Dry Wood Creek and the mainstem of the PdT River from Barrett Lake to North PdT Lake were analyzed. The 7Q10 flows for each reach (seven-day consecutive low flow with a 10 year return frequency) were calculated using a statistical flow analysis tool named DFLOW, found in EPA's Better Assessment Science Integrating point and Non-point Sources (BASINS) package.

Under baseline conditions, the calibrated HSPF model predicts an average daily load from the Dry Wood Creek outlet to be 53.0 pounds per day (lbs/day) of TP for the period 2000 through 2009. When the simulated TP loading from the entire Dry Wood Creek watershed was reduced by 70%, the average daily load from the outlet was predicted to be 18.4 lbs/day. The model predicts that the daily dissolved oxygen minima were below 5 mg/L on 6% of the days on which the 7Q10 flow was exceeded. On days equal to the 7Q10, the model predicts that the daily dissolved oxygen minima were below 5 mg/L on 27% of the days.

Further reductions in TP did not result in further simulated improvements. At these concentrations, further TP reductions inhibit in-channel oxygen production via photosynthesis. Also the geometry of the stream channel is not conducive to significant re-aeration, which would support higher dissolved oxygen concentrations. Given reasonable modeling assumptions regarding algal growth, algal respiration, and in-stream re-aeration rate, the TP allocation was set at 18.4 lbs/day. If these conditions were met, the stream would no longer meet the requirements to be listed as impaired for dissolved oxygen, based on modeled results.

The PdT River Watershed Biotic Stressor Identification report (MPCA, 2012a) also lists other stressor pathways found to affect dissolved oxygen in Dry Wood Creek. These stressor pathways are impoundments, riparian condition, and source water pollution from North Drywood Lake. North Drywood Lake will likely be listed as impaired in the next PdT Watershed Assessment cycle. The TP allocations will be determined for the lake at that time.

In the PdT River from Barrett Lake to North PdT Lake, the calibrated HSPF model predicts an average daily load to be 53 lbs/day of TP for the period 2000 through 2009. Under these current baseline conditions, the model predicts that the daily dissolved oxygen minimum would fall below 5 mg/L 5.6% of the days when the flow is equal to or greater than the 7Q10 flow of 5.35 cfs. If the average daily TP loading is reduced to 45 lbs/day, then the dissolved oxygen standard is not violated.

Total Phosphorus

Excess TP was found to be a stressor to fish and macroinvertebrates in the Dry Wood Creek Watershed in the PdT River Watershed Biotic Stressor Identification report (MPCA, 2012a). HSPF model scenarios were used to determine the phosphorus load reductions necessary to meet the low dissolved oxygen standard and thereby support aquatic life.

Lakes, Excess Nutrients

The BATHTUB version 6.14 (Walker, 1999) model framework was used as a basis for modeling phosphorus and water loading for lakes within the PdT watershed. The watershed was subdivided into several segments based on lake assessment data, flow linkages and location of monitoring stations. Except for cases where segments (lakes) were hydrologically isolated from the rest of the PdT watershed, the segments were linked into a larger network that allowed for a more comprehensive model framework for the entire PdT watershed. This linkage made use of monitored flow and TP data that were available at the outlet of the PdT River as well as sites upstream.

Data requirements for development of the model framework included precipitation, evaporation, lake morphometry, lake water quality, animal units, watershed area, land use, flow and water quality, septic systems and NPDES dischargers.

The first order decay model within the BATHTUB framework provided relatively good agreement between predicted and observed TP, chlorophyll-a and Secchi depth for the lakes modeled in the PdT watershed. For more detail on the PdT model framework including sources of the model data refer to BATHTUB Modeling to Support Watershed Protection and Restoration Strategy Development: PdT Watershed Pilot Study Working Paper (MPCA, 2012b). The model framework was refined for the lakes addressed in this report to better reflect individual catchment characteristics.

Observed TP concentrations in each of these lakes exceeds the ecoregion/lake type standard. The first order decay model provides estimates of the phosphorus load entering each lake that result in the excess phosphorus concentrations. In order to calculate the phosphorus LC of each lake, external phosphorus inputs were reduced within the model framework until the predicted in-lake concentration matched the appropriate standard (Table 3.3).

Table 3.3: Observed and modeled lake conditions as well as loading estimates for observed conditions and loading capacities to meet the phosphorus standards.

Lake	Observed Mean Total Phosphorus (µg/L)	Predicted Total Phosphorus (µg/L)	Estimated Annual Phosphorus Load (lbs)	Predicted Total Phosphorus (µg/L) calibrated to standard	Annual Phosphorus Load Capacity (lbs)	Percent Phosphorus Load Reduction to Achieve Standard (%)
North Turtle	79	76	2,237	60	1,771.1	20.8
Christina	74.7	86.7	6,286	60	4,344	30.9
Perkins	112	127.1	19,102.2	90	13,533.7	29.1
Hattie	363	263	3,229.5	90	1,106.5	65.7

3.2 Margin of Safety

The purpose of the MOS is to account for uncertainty that the allocations will result in attainment of water quality standards.

For the stream TMDLs, an explicit 10% MOS is applied. This MOS has been used by the MPCA in several previous TMDLs and is expected to provide an adequate accounting of uncertainty. Turbidity and *E.coli* TMDLs have a MOS determined for each flow regime.

For the lake TMDLs an explicit 10% MOS is also applied. Therefore, the load capacity that is calibrated to attain the in-lake phosphorus concentration standard is reduced by 10%. The result is the total annual phosphorus load the lake may receive and still meet water quality standards.

3.3 Wasteload Allocation

Wastewater Treatment Facilities

Wastewater treatment facilities (WWTF) are NPDES/SDS (State Disposal System) permitted facilities that process primarily wastewater from domestic sanitary sewer sources (sewage). These include city or sanitary district treatment facilities, wayside rest areas, national or state parks, mobile home parks and resorts. Table 3.4 shows the relevant WWTFs for this TMDL report.

Table 3.4: Relevant WWTF permits in the TMDL

Facility*	Permit number	Watershed	City	System Type
Ashby WWTF	MNG580087	Perkins Lake	Ashby	Pond
Barrett WWTF	MNG580173	Perkins Lake	Barrett	Pond
Dalton WWTF	MN0023141	Perkins Lake	Dalton	Spray irrigation system
Underwood WWTF[1]	MN0025071	Perkins Lake	Underwood	Rapid Infiltration Basin
TWF Industries Inc. [2]	SIU000137	Perkins Lake	Barrett	NA

1 No discharge to surface water
2 Discharges to Barrett WWTF

***Morris WWTF does not discharge to reaches included in this TMDL.**

The Dalton WWTF operates a spray irrigation disposal system. The tile drain associated with the spray field is not a wastewater outfall and does not require a WLA. The tile line is monitored to evaluate the performance of the spray field and ensure that there is not breakthrough of inadequately treated wastewater. The facility permit will be reissued as an SDS Permit upon expiration.

The Underwood WWTF is an SDS permitted facility that does not discharge to surface waters. Therefore, the Underwood WWTF does not require a WLA.

TWF Industries Inc. is a metal finisher that discharges to the Barrett WWTF so it does not require a separate WLA.

For WWTFs with pond systems, WLAs are based on the facilities' average wet weather design flow in millions of gallons per day (mgd) and 2.0 mg/L phosphorus effluent concentration. Annual loading limits equivalent to the WLAs will be incorporated into the facility permits upon reissuance in 2015. The TMDL is based on annual time increment BATHTUB modeling and NPDES permits for these WWTFs will establish annual phosphorus loading limits consistent with the assumptions of the model (Table 3.5).

Table 3.5: Annual and daily wasteload allocations for Ashby and Barrett WWTFs.

	A	B	C	D	E	F
Facility	**Design Flow (mgd)**	**Concentration Assumption (mg/L)**	**Liters per Gallon**	**Days per Year**	**Kg/Yr (A*B*C*D)**	**lbs/day (A*B*8.34)**
Ashby WWTF	0.1011	2.0	3.785	365.25	280	1.69
Barrett WWTF	0.106	2.0	3.785	365.25	293	1.77

The Ashby and Barrett WWTF permits include maximum daily effluent flow rate restrictions of 6 inches per day from the secondary cells, equivalent to 0.78 and 0.91 mgd respectively. Assuming a phosphorus effluent concentration of 2.0 mg/L, Ashby WWTF could discharge up to 13 lbs/day and Barrett WWTF could discharge up to 15.2 lbs/day for any particular day and still be in compliance so long as they do not exceed the annual loads that will be specified in their permits. The TMDL is based on 1/365 of the annual permitted load, though as described, the facilities could exceed this load periodically without violating their permits. The Ashby and Barrett WWTFs are only authorized to discharge from March 1 to June 30 and from September 1 to December 31.

Minn. R. ch. 7053, subp. 3 require that facilities discharging directly to or affecting the trophic status of a lake, shallow lake or reservoir reduce phosphorus effluent concentrations to 1.0 mg/L. The Ashby WWTF and Barrett WWTF discharge approximately 42 and 16 river miles upstream of Perkins Lake respectively. BATHTUB modeling indicates the Ashby WWTF contributes 304 lbs and the Barrett WWTF contributes 67 lbs of the 19,102 lbs of phosphorus to Perkins Lake on an annual basis. Removing the Ashby and Barrett WWTFs from the model framework results in an estimated in-lake phosphorus concentration of 125.9 and 126.7 µg/L respectively versus 127.1 µg/L when both WWTFs are included. Therefore, there is no indication that the WWTFs are significantly affecting the trophic status of Perkins Lake and a WLA based on a 2.0 mg/L effluent concentration is appropriate.

Industrial process wastewater

Three sand and gravel operations are located within the areas of the PdT addressed in this TMDL report. These operations are covered by the Construction Sand and Gravel, Rock Quarrying and Hot Mix Asphalt Production facilities general permit (MNG490000). Phosphorus at these sites can be delivered by wind erosion, dust from mining activities and pit dewatering. Stormwater discharges from sand and gravel operations are expected to be consistent with the WLA in this TMDL when operations properly select, install and maintain all Best Management Practices (BMPs) required under the general permit.

Stormwater

Urban and suburban stormwater runoff, both from developing and built-out areas, carries pollutant loads that can match or exceed agricultural run-off on a per-acre basis. This runoff also contributes to channel instability and streambank erosion. Pollutants from stormwater runoff can include pesticides, fertilizer, oil, metals, pathogens, salt, sediment, litter and other debris. The MPCA has three categories for stormwater permits: municipal, construction and industrial.

Municipal

In 1987, the CWA was amended to include provisions for a two-phase program to address stormwater runoff. In March of 2003 the second phase of the program began. Phase II includes permitting and regulation of smaller construction sites, municipalities with Municipal Separate Storm Sewer Systems (MS4s) and industrial facilities. Although approximately 40 acres of Fergus Falls is within the PdT watershed, there is no stormwater conveyance system in the watershed. Therefore, Fergus Falls will not be given an MS4 WLA for this TMDL report.

Construction

The MPCA issues construction permits for any construction activities disturbing:

- One acre or more of soil
- Less than one acre of soil if that activity is part of a “larger common plan of development or sale” that is greater than one acre
- Less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources

Construction stormwater permit application records indicate approximately 0.04% of land use in the study area has been subject to construction over the last 10 years. The WLA for stormwater discharges from sites where there is construction activities reflects the number of construction sites less than one acre expected to be active in the watershed at any one time, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at construction sites are defined in the State's NPDES/SDS General Stormwater Permit for Construction Activity (MNR100001). If a construction site owner/operator obtains coverage under the NPDES/SDS General Stormwater Permit and properly selects, installs and maintains all BMPs required under the permit, including those related to impaired waters discharges and any applicable additional requirements found in Appendix A of the Construction General Permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. It should be noted that all local construction stormwater requirements must also be met.

Industrial

Industrial sites might contribute to stormwater pollution when water comes in contact with pollutants such as toxic metals, oil, grease, de-icing salts and other chemicals from rooftops, roads, parking lots and from activities such as storage and material handling. Examples of exposed materials that would require a facility to apply for an industrial stormwater permit include: fuels, solvents, stockpiled sand, wood dust, gravel, metal and a variety of other materials. As part of the permit requirements, the facilities are required to develop and implement a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP uses BMPs designed to eliminate or minimize stormwater contact with significant materials that might result in polluted stormwater discharges from the industrial site.

Industrial stormwater permit application records indicate less than 0.01% of the land use in the subwatersheds addressed in this TMDL have been subject to permitted industrial activity over the last 10 years. The WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES industrial stormwater permit coverage is required, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at the industrial sites are defined in the State's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or NPDES/SDS General Permit for Construction Sand & Gravel, Rock Quarrying and Hot Mix Asphalt Production facilities (MNG490000). If a facility owner/operator obtains coverage under the appropriate NPDES/SDS General Stormwater Permit and properly selects, installs and maintains all BMPs required under the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. It should be noted that all local stormwater management requirements must also be met.

Industrial wastewater, construction stormwater and industrial stormwater are lumped together into a categorical WLA based on an approximation of the land area covered by those activities. To account for these sources as well as allowing for the potential of higher rates of construction and additional industrial facilities, this TMDL assumes 0.1% of the land area for an industrial wastewater, construction and industrial stormwater category. The allocation to this category is made after the MOS is subtracted from the total LC.

Livestock Facilities

The NPDES livestock facilities are zero discharge facilities and therefore are given a WLA of zero and should not impact water quality in the watershed as a point source. Two facilities with NPDES permits are located within the Perkins Lake subwatershed. One facility is covered under Minnesota's General Feedlot Permit, MNG440000 and the other facility has an individual permit, MN0066690. Runoff of phosphorus and bacteria from fields where manure has been land-applied might occur at times. Such discharges are covered under the LA portion of the TMDLs, provided the manure is applied in accordance with the permit.

Straight Pipe Septic Systems

Straight pipe septic systems are illegal and therefore receive a WLA of zero. According to Minn. Stat. 115.55, subd. 1, a straight pipe "means a sewage disposal system that includes toilet waste and transports raw or partially settled sewage directly to a lake, a stream, a drainage system, or ground surface".

3.4 Load Allocation

Once the WLA and MOS were determined for each watershed, the remaining LC was considered the LA. The LA includes nonpoint pollution sources that are not subject to NPDES permit requirements, as well as “natural background” sources. Natural background as defined in Minn. R. 7050.0150, subp. 4, refers to the multiplicity of factors that determine the physical, chemical or biological conditions that would exist in a waterbody in the absence of measurable impacts from human activity or influence. Anthropogenic sources of stress are not a component of natural background as it has been defined by Minnesota rule.

Ideally, the LA could be broken down into distinct sub-categories such as natural background, cropland erosion, manure and fertilizer application, atmospheric deposition, inadequate human wastewater treatment, non-MS4 stormwater runoff and internal loading. However, current understanding of the different source contributions to impairments of concern in these lakes and streams is not sufficient for such precise numerical breakdowns, and attempting to do so is impractical.

3.5 Consideration of Growth on TMDL

Potential changes in population and land use over time in the PdT Watershed could result in changing sources of pollutants. Possible changes and how they may or may not impact TMDL allocations are discussed below.

Load Transfer

Future transfer of watershed runoff loads in this TMDL may be necessary if any of the following scenarios occur within the project watershed boundaries:

1. New development occurs within a regulated MS4. Newly developed areas that are not already included in the WLA must be given additional WLA to accommodate the growth. This will involve transferring LA to WLA.
2. One regulated MS4 acquires land from another regulated MS4. Examples include annexation or highway expansions. In these cases, the transfer is WLA to WLA.
3. One or more non-regulated MS4s become regulated. If this has not been accounted for in the WLA, then a transfer must occur from the LA.
4. Expansion of an urban area encompasses new regulated areas for existing permittees. An example is existing state highways that were outside an urban area at the time the TMDL was completed, but are now inside a newly expanded urban area. This will require either a WLA to WLA transfer or a LA to WLA transfer.
5. A new MS4 or other stormwater-related point source is identified. In this situation, a transfer must occur from the LA.

Load transfers will be based on methods consistent with those used in setting allocations in the TMDL. In cases where WLA is transferred from or to a regulated MS4, the permittees will be notified of the transfer.

Wasteload Allocation

There are currently no un-sewered communities in the subwatersheds addressed in this TMDL. It is unlikely that any new communities will develop in the future.

Currently permitted discharges can be expanded and new NPDES discharges can be added while maintaining water quality standards provided the permitted NPDES effluent concentrations remain below the surface water targets. Given this circumstance, a streamlined process for updating TMDL WLA for turbidity and *E. coli* to incorporate new or expanding discharges will be employed. The following process will apply to the non-stormwater facilities and any new wastewater or cooling water discharge in the PdT River watershed:

1. A new or expanding discharger will file with the MPCA permit program a permit modification request or an application for a permit reissuance. The permit application information will include documentation of the current and proposed future flow volumes and pollutant loads.
2. The MPCA permit program will notify the MPCA TMDL program upon receipt of the request/application, and provide the appropriate information, including the proposed discharge volumes and the pollutant loads.
3. The TMDL Program staff will provide the permit writer with information on the TMDL WLA to be published with the permit's public notice.
4. The supporting documentation (fact sheet, statement of basis, effluent limits summary sheet) for the proposed permit will include information about the pollutant discharge requirements, noting that the effluent limit is below the in-stream target and the increased discharge will maintain water quality standards. The public will have the opportunity to provide comments on the new proposed permit, including the pollutant discharge and its relationship to the TMDL.
5. The MPCA TMDL program will notify the EPA TMDL program of the proposed action at the start of the public comment period. The MPCA permit program will provide the permit language with attached fact sheet (or other appropriate supporting documentation) and new pollutant information to the MPCA TMDL program and the EPA TMDL program.
6. The EPA will transmit any comments to the MPCA permits and TMDL programs during the public comment period, typically via e-mail. The MPCA will consider any comments provided by EPA and by the public on the proposed permit action and WLA and respond accordingly, conferring with EPA if necessary.
7. If following the review of comments, the MPCA determines that the new or expanded effluent discharge, with a concentration below the in-stream target, is consistent with applicable water quality standards and the above analysis, the MPCA will issue the permit with these conditions and send a copy of the final effluent information to the EPA TMDL program. The MPCA's final permit action, which has been through a public notice period, will constitute an update of the WLA only.
8. The EPA will document the update to the WLA in the administrative record for the TMDL. Through this process, the EPA will maintain an up-to-date record of the applicable WLA for permitted facilities in the watershed.

Load Allocations

The amount of land in agricultural land use in the PdT Watershed is likely to remain constant. While the majority of the landscape is likely to remain in an agricultural land use, it is possible a shift from pasture/hay land to row crops could occur. However, the loading capacities are estimated using a long term data set and slight shifts in land use would likely not substantially increase or decrease annual flows or loads. Larger shifts in land use could very well make meeting the TMDL more difficult over time.

4 Dry Wood Creek and Pomme de Terre River Impairments

4.1 Sources and Current Contributions

A summary of sources and current contributions is provided in this section for the pollutants causing impairments in the Dry Wood Creek watershed downstream of North Drywood Lake (AUID# 07020002-556) and the section of the PdT River from Barrett Lake to North PdT Lake (AUID#07020002-563). A more in depth discussion of biological stressors and pollutant sources and causal pathways, excluding *E. coli*, can be found in the PdT River Watershed Biotic Stressor Identification report (MPCA, 2012a).

Turbidity/total suspended solids – Dry Wood Creek

At least one sample was collected in each year for 2007 and 2009 through 2011 within the impaired reach. For TSS, 40% of the 72 samples collected exceed the surrogate value of 52 mg/L. The data collected show a minimum value of 1.6 mg/L, a maximum value of 188 mg/L and a mean value of 54 mg/L. On average Volatile Suspended Solids (VSS) make up 29% of TSS in Dry Wood Creek. The minimum percentage of VSS/TSS was 12% and the maximum was 75%.

The PdT River Watershed Biotic Stressor Identification report (MPCA, 2012a) indicated several stressor pathways for turbidity. The riparian condition of the creek is decreased in some areas due to minimal buffers and increased livestock trampling and decreased riparian and bank vegetation. Lack of adequate buffers can allow more overland flow. Channelization of reaches throughout the watershed has led to changes in the hydrological and geomorphological condition of the stream. This has led to changes in erosion rates that have led to an increase in turbidity. North Drywood Lake contributes sestonic (suspended) algae and high phosphorus concentrations that may cause increased algae blooms in the stream. Impoundments in Dry Wood Creek have led to instability creating increased erosion around impoundments as well as channel alteration to regain stability.

E. coli – Dry Wood Creek

Bacteria data were collected in Dry Wood Creek in 2007-2008 and 2010-2011. For 2007, fecal coliform data were collected. These values were converted to an *E. coli* equivalent by multiplying by 0.63 (126/200=0.63). In the months of April through October of monitored years, a total of 85 samples were collected, with a computed geometric mean of 216 org/ml. Individual results ranged from 4 to 3,339 org/ml. The geometric means for each month are presented in Table 4.1.

Table 4.1: Dry Wood Creek *E. coli* geometric means for all data 2007-2008 and 2010-2011.

Month	Number of Samples	Geometric Mean
April	12	15
May	13	109
June	17	467
July	17	252
August	12	535
September	9	1206
October	4*	176

*Fewer than five data points are generally not a reliable geometric mean

Likely sources of bacteria in the Dry Wood Creek watershed include livestock and inadequate subsurface sewage treatment systems (SSTS). Both are described in more detail below. Wildlife may also be contributing some bacteria to the system.

Livestock – Both feedlots and pasture are present in the Dry Wood Creek Watershed. Livestock can contribute bacteria to the watershed through runoff from poorly managed feedlots as well as direct loading if allowed access to streams or lakes. Additional runoff can occur through manure applications.

Inadequate SSTS –Without individual inspections it is difficult to know for certain the rate of compliance for septic systems in the watershed. Estimates made by each individual county in the PdT River Watershed range from 25%-75% compliance.

It has been suggested that *E. coli* bacteria have the ability to reproduce naturally in water and sediment, which should be taken into account when identifying bacteria sources. Two Minnesota studies describe the presence and growth of "naturalized" or "indigenous" strains of *E. coli* in watershed soils (Ishii et al, 2006) and ditch sediment and water (Sadowsky et al, 2010). The latter study was conducted in the agriculture dominated Seven Mile Creek watershed located in south-central Minnesota. As much as 36% of *E. coli* strains found in the Seven Mile study was represented by multiple isolates, suggesting persistence of specific *E. coli*. While the primary author of the study suggests 36% might be used as a rough indicator of "background" levels of bacteria during this study, this percentage is not directly transferable to the concentration and count data of *E. coli* used in water quality standards and TMDLs. Additionally, because the study is not definitive as to the ultimate origins of these bacteria, it would not be appropriate to consider them as "natural" background (MPCA, 2012c). Caution should be used before extrapolating the results of the Seven Mile Creek study to other watersheds.

Total phosphorus – Dry Wood Creek

Phosphorus levels in Dry Wood Creek are indicative of an excessive nutrient problem. Nuisance algal blooms have also been observed and documented in several years in the stream. TP levels are exceeding the draft MPCA standard of 0.15 mg/L as a June through September mean value and the NGP ecoregion annual mean of 0.218 mg/L. The data collected show a minimum value of 0.12 mg/L, a maximum value of 1.13 mg/L and a mean value of 0.52 mg/L. On average, 62% of this phosphorus is orthophosphorus, which is readily available for algal uptake, causing moderate to severe blooms, which were noted throughout the data collection period. Phosphorus in this system is likely to be directly contributing to the dissolved oxygen and turbidity impairments also present in this system. Reducing phosphorus levels in the HSPF model increases the amount of dissolved oxygen in the reach, indicating that in this system, excess phosphorus is a driver for high dissolved oxygen flux. Large (greater than 4 mg/L) diurnal swings in dissolved oxygen were measured in Dry Wood Creek on several occasions in 2008 and 2009 (MPCA, 2012a).

Both the PdT River Watershed Monitoring and Assessment Report (MPCA, 2011c) and the PdT River Watershed Biotic Stressor Identification report (MPCA, 2012a) point to source-water pollution from North Drywood Lake as a phosphorus pathway to Dry Wood Creek. Poor riparian condition was also determined to be a stressor pathway for phosphorus in the PdT River Watershed Biotic Stressor Identification report (MPCA 2012a). The riparian buffers along Dry Wood Creek are minimal in some areas. This can allow excessive amounts of nutrients, sediment and pesticides from fields to enter adjacent streams and rivers. Pasture land adjacent to the stream and cattle with direct stream access are also present in the impaired section of Dry Wood Creek and are another source of phosphorus to the system.

No point sources with direct discharge are present in the Dry Wood Creek subwatershed and can be eliminated as a source. Construction stormwater from housing or road construction projects near the stream or lake could be a minimal source of phosphorus to the system. Future industries could be sited in the watershed and could also be sources of phosphorus and sediment to the system.

Low dissolved oxygen – Dry Wood Creek and Pomme de Terre River

Dissolved oxygen concentrations in the PdT, like most streams, go through a diurnal cycle, generally reaching their maximum in late afternoon and minimum around sunrise. Aquatic plants and algae photosynthesize in the day, giving off oxygen. At night, bacterial, plant and animal respiration depletes oxygen. High phosphorus loads to the streams causes excessive production of algae, exacerbating this cycle and causing very extreme diurnal dissolved oxygen swings.

Dry Wood Creek

In Dry Wood Creek, low dissolved oxygen is a stressor to both fish and invertebrate communities throughout the creek. Dissolved oxygen data were collected in Dry Wood Creek in 2007 through 2011, both through discreet measurements and continuous sonde deployment. One measurement of dissolved oxygen was also made in each year for 2002 and 2003. Of 150 discreet dissolved oxygen measurements available in the impaired reach, 19 (13%) are below the 5 mg/L standard. Of the 23 samples collected before 9:00 AM, 13 (56%) are below the standard. Synoptic dissolved oxygen measurements and continuous sonde deployment in the reach during the summers of 2008 and 2009 indicate that during low flow summer periods dissolved oxygen daily minimum values are often below 5 mg/L. Dissolved oxygen flux is also high in the creek.

The PdT River Watershed Biotic Stressor Identification Report (MPCA, 2012a) lists impoundments, riparian condition and source-water pollution as stressor pathways for dissolved oxygen in Dry Wood Creek. Dissolved oxygen levels can be affected by impoundments by collecting nutrients and organic materials, causing decreased oxygen concentrations upstream. North Drywood Lake has an impoundment at its outlet and a large beaver dam is also often present on the stream. Minimal riparian buffers can allow for nutrients to runoff into the stream more readily during storm events. North Drywood Lake is the source of Dry Wood Creek and has both high phosphorus levels and a low winter dissolved oxygen profile.

PdT River, Barrett Lake to North PdT Lake

This reach is not currently listed for dissolved oxygen, but in the PdT River between Barrett and North PdT lakes, dissolved oxygen is a stressor for the fish impairment within the reach. Dissolved oxygen data were collected in 1995 and 2009 through 2011, both through discreet measurements and continuous sonde deployment. Of 160 discreet dissolved oxygen measurements available in the impaired reach, 12 (8%) are below the 5 mg/L standard. Of the 60 samples collected before 9:00 AM, 3 (5%) are below the standard. Continuous sonde deployment in the reach in the summers of 2009 and 2010 indicate that under certain conditions, the dissolved oxygen daily minimum values can drop below 5 mg/L.

The PdT River Watershed Biotic Stressor Identification report (MPCA, 2012a) lists riparian condition and riparian wetlands as stressor pathways for dissolved oxygen in this section of the PdT. Minimal riparian buffers can allow for nutrients to runoff into the stream more readily during storm events. Riparian wetlands may be flushing out low dissolved oxygen water into the PdT during rain events.

Table 4.3 includes loading capacities and allocations for this reach. Ashby WWTF effluent flows through PdT and Barrett Lakes before the impaired reach and is not considered a significant phosphorus contributor to this reach during the critical time periods, therefore it has no allocation related to the fishes bioassessments impairment. The Barrett WWTF discharges to the impaired reach and has the potential to contribute significant phosphorus loadings during the June portion of its permitted discharge window. It is recommended the Barrett WWTP permit be modified to prohibit discharge during the month of June. See section 5.2 for WLA for these facilities related to the Perkins Lake nutrient impairment. Figure 4.1 shows the relationship between the cities of Ashby and Barrett and the impaired reach.

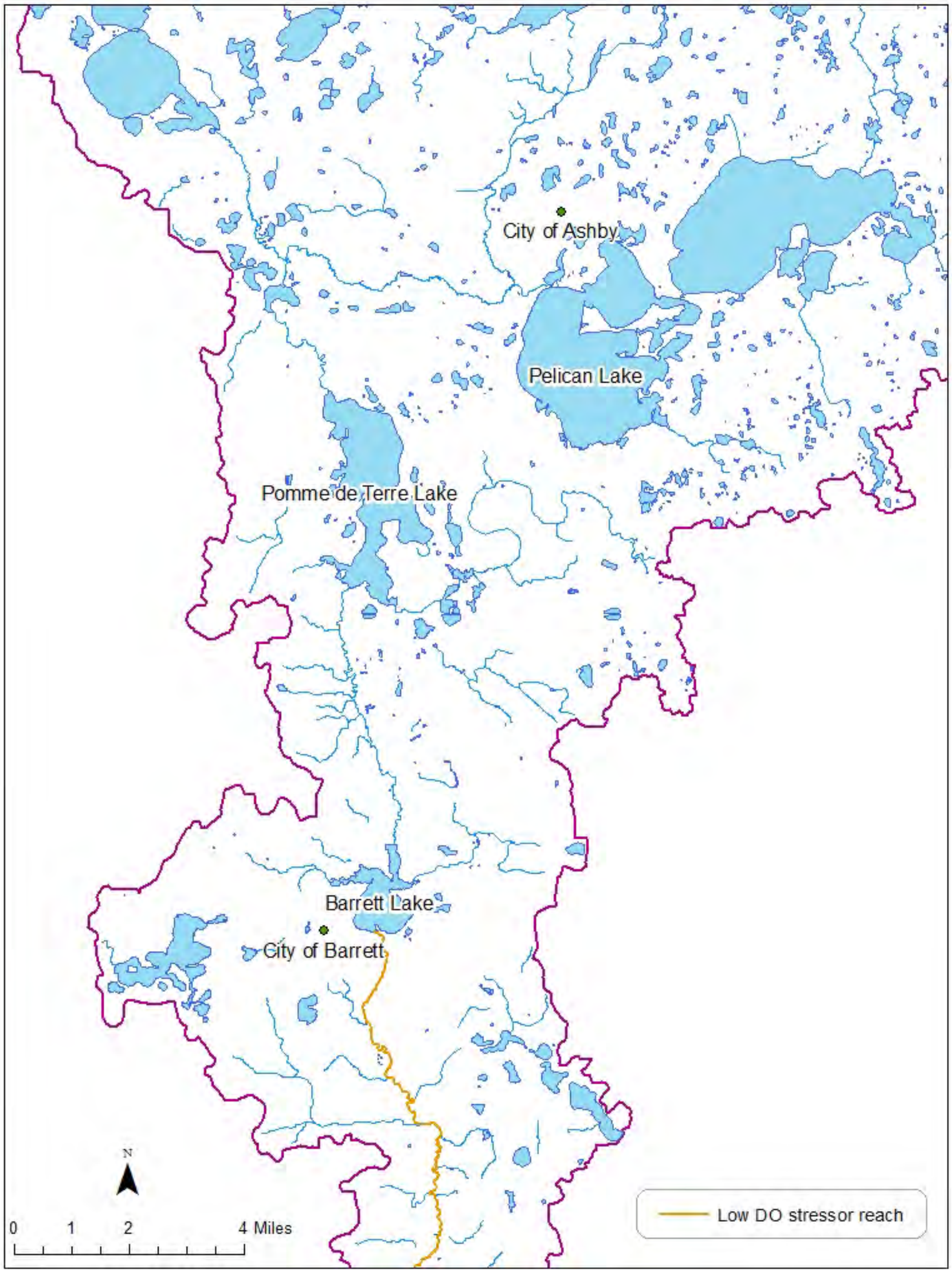

Figure 4.1: The relationship of the WWTF discharge locations of the cites of Ashby and Barrett to the PdT River and the Barrett Lake to North PdT Lake low dissolved oxygen stressor reach.

4.2 TMDL Allocations

TMDL allocations for all stream parameters can be found in Tables 4.2 and 4.3. Duration curves for total suspended solids and *E. Coli* can be found in Appendix A.

Table 4.2: Loading capacities and allocations for AUID#07020002-556. Dry Wood Creek – Drywood Lake to Pomme de Terre River

Total Suspended Solids	**Flow Zone**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	Tons per day				
Loading Capacity	14.91	3.12	1.19	0.40	0.027
Wasteload Allocation*					
Construction and Industrial Stormwater and Industrial Process Wastewater	0.015	0.003	0.001	0.0004	0.00003
Load Allocation	13.41	2.80	1.07	0.36	0.024
Margin of Safety	1.49	0.31	0.12	0.04	0.003
E. Coli	**Flow Zone**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	Billion organisms per day				
Average Daily Loading Capacity	378	96	37	13	1.6
Wasteload Allocation*					
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	340	86	33	12	1.5
Margin of Safety	38	10	3.7	1.3	0.16
Total phosphorus	**lbs per day**				
Loading Capacity	18.4				
Wasteload Allocation*					
Construction and Industrial Stormwater and Industrial Process Wastewater	0.02				
"Straight Pipe" Septic Systems	0				
Load Allocation	16.54				
Margin of Safety	1.84				

*No WWTF, NPDES Permitted Feedlots or Communities Subject to MS4 NPDES requirements are located in this reach.

Table 4.3: Loading capacities and allocations for AUID#07020002-563, Pomme de Terre River - Barrett Lake to North Pomme de Terre Lake

Total phosphorus	**lbs per day**
Loading Capacity	45.00
Wasteload Allocation*	
Wastewater treatment facilities Barrett WWTF	1.77**
Construction and Industrial Stormwater and Industrial Process Wastewater	0.033
Livestock facilities requiring NPDES permits	0
"Straight Pipe" Septic Systems	0
Load Allocation	40.47
Margin of Safety	4.5

*No Communities Subject to MS4 NPDES requirements are located in this reach.
** This facility is not permitted to discharge during the most critical (low flow, late summer) period for the dissolved oxygen stressor.

4.3 Critical Conditions and Seasonal Variation

Turbidity/total suspended solids

While the TSS data available for the PdT River Watershed Biotic Stressor Identification report (MPCA, 2012a) indicated that in 2007 at two locations in Dry Wood Creek (504PDT680 and 504PDT699) the pattern of TSS started high in spring and early summer and dropped to lower levels beginning in mid-summer, this pattern is not present in all years. The data from the Dry Wood Creek outlet site for 2010 and 2011 show that TSS is lowest in the spring and early summer and peaks in mid to late summer, with levels exceeding standards persisting through the fall. The reasons for this are likely differing sources contributing to the TSS in different years. The duration curve approach using multiple years of flow data helps to account for some of this variation and will provide adequate protection during the differing times of the year when the standard is exceeded.

E. coli

Concentrations of *E. coli* vary throughout the summer in Dry Wood Creek. While the standard is a monthly geometric mean from April through October, based on all available data in the impaired reach, it appears that June-October is the critical time period for exceedances of the *E. coli* standard in this watershed (Table 4.1). The duration curve approach using multiple years of flow data and the applicable time period of the standard will provide sufficient water quality protection during the critical summer period.

Total phosphorus

Water quality monitoring results indicate that TP in the Dry Wood Creek watershed is elevated at most times during the spring, summer and fall. TP patterns tend to follow TSS patterns fairly closely in this watershed. In some years, TP is highest in the spring and then falls through the rest of the year, but in others, the highest concentrations are found in the summer months. The reasons for this are likely differing sources contributing to the TP in different years.

Low dissolved oxygen

Daily minimum dissolved oxygen concentrations are at their lowest in the summer low flow season, both in the PdT and Dry Wood Creek.

5 North Turtle, Christina, Perkins and Hattie Lakes Excess Nutrients

5.1 Phosphorus Sources and Current Contributions

Non-point sources of phosphorus in the North Turtle, Christina, Perkins and Hattie watersheds are described below. TP delivery coefficients for each land use were based on literature and eco-region based values (Harmel et al, 2008). Assumed phosphorus concentrations were actually lower than measured concentrations from edge of field monitoring as phosphorus export per unit area tends to decline as watershed size increases (Prairie and Kalff, 1986).

Forest/Shrub – Forest and shrub land accounts for 1 - 20% of the land use in the lake catchment areas. Runoff from forested land can include decomposing vegetation and organic soils. A phosphorus delivery coefficient of 0.03 kg/ha-yr was used in the model.

Cropland – Cropland (land that is under annual cultivation) accounts for 8 - 64% of the land use in the lake catchment areas. Runoff from agricultural lands can include livestock wastes, fertilizers, soil particles and organic material from agronomic crops. A phosphorus delivery coefficient of 0.25 kg/ha-yr was used in the model.

Pasture/Hay/Grassland – This category combines several land uses including pasture, hay land, idle grasslands, CRP and any other state or federal program lands managed as grasslands. Between 6-42% of land use in these catchments is included in this category. Surface runoff can deliver phosphorus from manure deposited by livestock and wildlife. Runoff also includes phosphorus from vegetation and soil loss. A phosphorus delivery coefficient of 0.15 kg/ha-yr was used in the model.

Developed (low to high intensity) – Between 5.5% – 7.5% of the land use in these catchments falls under this category. Runoff from residences and impervious surfaces can include fertilizer, leaf and grass litter, pet waste and numerous other sources of phosphorus. A phosphorus delivery coefficient of 0.25 kg/ha-yr was used in the model.

Wetlands/Open Water – Wetlands and open water comprise 22% – 39% of the land use in these catchments. Wetlands and open water can export phosphorus through suspended solids as well as organic debris that flow through waterways. A phosphorus delivery coefficient of 0.015 kg/ha-yr was used in the model.

Advective Transport – Perkins Lake is the only lake in this report that is located on the mainstem of the PdT River. In the case of Perkins Lake, advective transport of upstream phosphorus that is not retained in the upstream river/lake complex is the primary source of phosphorus load.

Livestock – Livestock numbers are based on the MPCA record of registered feedlots in the immediate catchment area of each lake. A range of livestock produced phosphorus was calculated and a conservative delivery ratio of 10% was used. Livestock can contribute phosphorus to the watershed through runoff at feeding, holding and manure storage areas as well as direct loading if allowed access to streams or lakes. Additional runoff can occur through manure applications. Table 5.1 shows the livestock operations in each immediate lake catchment area and the estimated phosphorus load.

Table 5.1: Livestock operations in each lakeshed.

Immediate Lakeshed	Number of Facilities	Livestock Type	Animal Units	Estimate of Phosphorus Delivered (kg/yr)
North Turtle	4	Bovine	802	540
Christina	18	Bovine	1,200	720
Perkins	0	NA	0	0
Hattie	2	Cattle, Horses	242	145

Inadequate SSTS –Without individual inspections it is difficult to know for certain the rate of compliance for septic systems in the lake catchment areas. Individual county estimates range from 25%-75% compliance. Increasing septic compliance should be a focus of the lake restoration strategy, especially in shoreland areas. Phosphorus load from septics was applied to the model by estimating the number of homes in the shoreland areas, estimating the number of people per home and applying a soil retention coefficient of 0.7. The estimate of shoreland residences and phosphorus load is shown in Table 5.2.

Table 5.2: Estimate of phosphorus load from shoreland septic systems.

Lake	Estimate of shoreland residences	Estimate of Phosphorus Delivered (kg/yr)
North Turtle	45	36
Christina	20	16
Perkins	41	33
Hattie	8	6

Atmospheric Load – Direct atmospheric deposition to the surface of the lakes was based on regional values (Verry and Timmons, 1977). Sources of particulate phosphorus in the atmosphere may include pollen, soil erosion, oil and coal combustion and fertilizers. The atmospheric export coefficient used in the model was 0.3 kg/ha-yr.

Internal Load – Internal loading of phosphorus can come from a wide variety of sources including re-suspension of sediments due to wave action, rough fish, wildlife activity, boating and bio-chemical processes that release phosphorus. The nutrient retention models within the BATHTUB framework already account for nutrient recycling, so it is generally not advisable to add internal load without independent estimates or measurements (Walker, 1999).

Potential point source contributions include construction and industrial stormwater, WWTFs and industrial process wastewater. Industrial wastewater, construction and industrial stormwater are accounted for in the model through the "Developed" land use phosphorus delivery coefficient as described above. Only the Perkins Lake watershed contains WWTFs. The WWTF loads are applied to the model as separate "tributaries" using their 2009-2010 average discharge concentrations and flow.

The load assumptions for Hattie Lake resulted in an estimated in-lake phosphorus concentration (164 ppb) that was significantly different (T = 2.53; T > 2 indicates significant difference) than the observed mean value (363 ppb). This indicated phosphorus loads were under estimated for the Hattie Lake Watershed. Because of the discrepancy between the predicted and observed conditions, it was decided to use modeled phosphorus loads and flows from the PdT HSPF model rather than the landuse phosphorus concentrations and runoff values as shown above. The HSPF precipitation estimate average was nearly identical to the thirty year average, so the 30-year mean was used in the BATHTUB model. The PdT HSPF model broke the Hattie Lake watershed into two sub-watersheds: the Hattie Lake catchment and Gorder Lake catchment areas. The Gorder Lake catchment flows to the Hattie Lake catchment, thereby contributing phosphorus loading to Hattie Lake. The catchment area average flow and phosphorus loads for the period 1996-2009 as predicted by HSPF are shown below (Table 5.3).

Table 5.3: Average 1996-2009 HSPF load and flow estimates for catchments in the Hattie Lake watershed.

Lake Catchment	Area (km2)	1996-2009 Average Annual Total Phosphorus Load (kg/yr)	1996 – 2009 Average Annual Runoff (m/yr)
Hattie	18.47	963	0.117
Gorder	15.47	295.7	0.0736

Using these model inputs plus the septic and feedlot contributions, BATHTUB provided the following predictions (Table 5.4):

Table 5.4: Predicted Hattie Lake conditions using average HSPF flow and load values

	Observed lake conditions	Predicted lake conditions
Total Phosphorus (µg/L)	363	263

While still somewhat divergent, the HSPF loads and flows provide a better fit to the observed conditions. T-tests indicate the predicted and observed phosphorus values are not statistically different (T=1.24).

5.2 Total Phosphorus TMDL Allocations for Hattie, Christina, Perkins and North Turtle Lakes

Lake modeling was conducted and analyzed on an annual basis to establish annual load capacities necessary to attain and maintain applicable water quality standards. Daily load capacities were derived from these analyses to generate TMDLs. Non-daily WLAs are included for the two wastewater treatment plants in the Perkins Lake watershed to facilitate implementation of the daily WLAs as appropriate in NPDES permits.

Table 5.5: Total phosphorus loading capacities and allocations.

North Turtle Lake	TP lbs/day	
Loading Capacity	4.85	
Margin of Safety	0.485	
Wasteload Allocation*		
Construction and industrial stormwater and industrial process wastewater	0.0044	
Livestock facilities requiring NPDES permits	0	
"Straight pipe" septic systems	0	
Load Allocation	4.37	
Lake Christina	**TP lbs/day**	
Loading Capacity	11.9	
Margin of Safety	1.19	
Wasteload Allocation*		
Construction and industrial stormwater and industrial process wastewater	0.011	
Livestock facilities requiring NPDES permits	0	
"Straight pipe" septic systems	0	
Load Allocation	10.7	
Perkins Lake	**TP lbs/day**	**TP lbs/year**
Loading Capacity	37.08	13,534.2
Margin of Safety	3.71	1,353.4
Wasteload Allocation*		
Wastewater treatment facilities		
Ashby WWTF	1.69	616.9
Barrett WWTF	1.77	646.1
Construction and industrial stormwater and industrial process wastewater	0.033	12.05
Livestock facilities requiring NPDES permits	0	0

“Straight pipe” septic systems	0	0
Load Allocation	29.88	10,905.8

Hattie Lake	**TP lbs/day**
Loading Capacity	3.03
Margin of Safety	0.30
Wasteload Allocation*	
Construction and industrial stormwater and industrial process wastewater	0.003
Livestock facilities requiring NPDES permits	0
“Straight pipe” septic systems	0
Load Allocation	2.727

*No Communities Subject to MS4 NPDES requirements are located in these lake watersheds.

5.3 Critical Conditions and Seasonal Variation

Water quality monitoring in North Turtle, Christina, Perkins and Hattie Lakes suggests the in-lake TP concentrations vary over the course of the growing season (June through September), generally peaking in mid to late summer. The MPCA eutrophication water quality guideline for assessing TP is defined as the June through September mean concentration. The BATHTUB model was used to calculate the load capacities of each lake, incorporating mean growing season TP values. TP loadings were calculated to meet the water quality standards during the summer growing season, the most critical period of the year. Calibration to this critical period will provide adequate protection during times of the year with reduced loading.

6 Monitoring

Intensive watershed monitoring will occur in the PdT Watershed on a 10-year schedule. The monitoring and assessment work described in this report will be repeated beginning in 2017 or 2018. Long term load monitoring at watershed outlets is in place and additional long term intermediate scale load monitoring began in 2013.

7 Implementation

The monitoring, assessment and stressor ID work performed in the PdT Watershed have identified the practices and geographic areas that should be priorities for implementation. The implementation table that has been developed from this work can be found in the MPCA PdT River Watershed Report (MPCA 2012d). The restoration and protection strategies are outlined below:

- Focus conservation and land management on the floodplain of the PdT River and its major tributaries.
- Focus conservation and land management on the shoreland of lakes and wetlands.
- Promote short and long term water storage at different scales.

- Place special emphasis on comprehensive land and water management within the Dry Wood Creek subwatershed.
- Ensure free passage of fish throughout the watershed.
- Ensure that wastewater treatment plants discharge at or below permit limits.
- Feedlot inspections and BMP promotion.
- Urban BMPs. Encourage cities to enroll in GreenStep program.
- Industrial BMPs.
- Increase septic compliance, especially in shoreland areas.

Construction and Industrial Stormwater Discharges

The WLA for stormwater discharges from sites where there is construction activity reflects the number of construction sites greater than one acre expected to be active in the watershed at any one time, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at construction sites are defined in the State's NPDES/SDS General Stormwater Permit for Construction Activity (MNR100001). If a construction site owner/operator obtains coverage under the NPDES/SDS General Stormwater Permit and properly selects, installs and maintains all BMPs required under the permit, including those related to impaired waters discharges and any applicable additional requirements found in Appendix A of the Construction General Permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. It should be noted that all local construction stormwater requirements must also be met.

The WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES industrial stormwater permit coverage is required, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at the industrial sites are defined in the State's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or facility specific Individual Wastewater Permit (MN00XXXXX) or NPDES/SDS General Permit for Construction Sand & Gravel, Rock Quarrying and Hot Mix Asphalt Production facilities (MNG490000). If a facility owner/operator obtains coverage under the appropriate NPDES/SDS General Stormwater Permit and properly selects, installs and maintains all BMPs required under the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. It should be noted that all local stormwater management requirements must also be met.

Cost of Implementation

The CWLA requires that a TMDL include an overall approximation of implementation costs (Minn. Stat. 2007, § 114D.25). Based on cost estimates made for the previous PdT Turbidity TMDL (MPCA, 2011a), a reasonable estimate for reducing turbidity in the impaired reaches addressed in this report would be $5.5 to $6 million dollars over 10 years. These dollars would be spent primarily on practices such as pasture management, conservation tillage, vegetative practices, wetland restorations, rain gardens, urban BMPs and structural practices.

Phosphorus and bacteria reductions will also be needed to meet the targets of this TMDL. Residential practices would include those that reduce runoff from lakeshore homes and residences within the watershed. These practices could include shoreland buffers, rain gardens, lawn fertilizer reductions, vegetation management, and permeable pavement. Continued residential development of shoreland through construction and increased runoff, has the potential to add phosphorus to the system. Low impact practices and shoreland BMPs should be utilized for any new development. Practices on the homeowner scale often vary widely in cost (i.e. $500 for a small rain garden to $5,000 for permeable pavement). Assuming that 50% of homeowners are in need of BMPs, the cost to install could be as much as $325,000.

Non-compliant septic systems can be a significant source of phosphorus and bacteria, especially during low flow periods. Upgrading non-compliant septic systems should be a priority within the PdT Watershed. Compliance levels can be improved by increasing the rate at which systems are inspected and repaired. Another option would be to tie lakeshore waste into a local municipal WWTF. Although this is not a current option, it might be incorporated in the future.

Assuming 50% of septic systems are compliant, approximately sixty septic systems are in need of upgrading in the TMDL watersheds. Based on an average system cost of $10,000, the cost to upgrade shoreland homes could be as much as $600,000. In addition to septic system upgrades and residential practices, many of the BMPs associated with reducing turbidity would also be effective at reducing the phosphorus load to the impaired waters. Therefore, the $5.5 - $6 million dollar estimate to address the turbidity impairment serves as a reasonable estimate for the cost of phosphorus load reduction.

Internal loading reduction of phosphorus in lakes is often expensive, and if reductions in external loads are not realized, build-up of internal loading will likely reoccur. Long term goals to reduce internal loading must be paired with efforts to reduce loading from external sources. Management of fisheries resources to limit rough fish and management of in-lake vegetation has been successful in temporarily improving water quality in Lake Christina and could be considered in the other lakes. Treatment with alum has been used successfully on some lakes, though the feasibility and expense of such treatment on North Turtle, Christina, Perkins and Hattie Lakes would have to be further evaluated. Treatment with alum can be cost prohibitive and external sources would continue to 're-load' the lake if not reduced accordingly. Development and execution of long term lake management plans could easily exceed $500,000.

7.1 Adaptive Management

Adaptive management is an iterative implementation process that makes progress toward achieving water quality goals while using any new data and information to reduce uncertainty and adjust implementation activities. It is an ongoing process of evaluating and adjusting the strategies and activities that will be developed to implement the TMDL. The implementation of practicable controls should take place even while additional data collection and analysis are conducted to guide future implementation actions. Adaptive management does not include changes to water quality standards or LC. Any changes to water quality standards or LC must be preceded by appropriate administrative processes; including public notice and an opportunity for public review and comment.

Following EPA's approval of this TMDL, the restoration and protection strategies listed in Section 7 will be implemented through integration into local water planning activities. These strategies will utilize adaptive management (Figure 7.1) to evaluate project progress as well as to determine if the strategies should be amended. Implementation of TMDL related activities can take many years, and water quality benefits associated with these activities can also take many years. As the pollutant source dynamics within the watershed are more thoroughly understood, implementation strategies and activities will be adjusted and refined to efficiently meet the TMDL and lay the groundwork for de-listing the impaired reaches. The follow up water monitoring program outlined in Section 6 will be integral to the adaptive management approach, providing assurance that implementation measures are succeeding in attaining water quality standards.

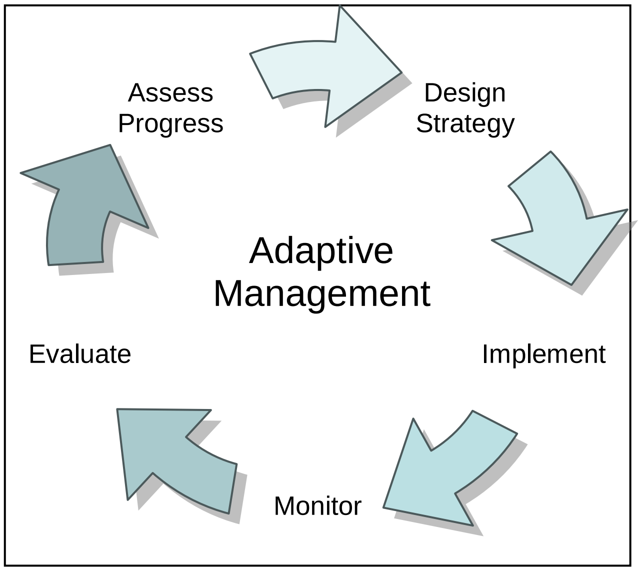

Figure 7.1: Adaptive management cycle.

8 Reasonable Assurance

Several agencies and non-profit groups have been and continue to work toward the goal of reducing pollutant loads in the PdT Watershed. Strong partnerships between the Pomme de Terre River Association (PdTRA), counties and soil and water conservation districts (SWCDs) have led to watershed wide implementation of conservation practices. Development of the Minnesota Agricultural Water Quality Certification Program (AWQCP) will strengthen the relationship between PdT landowners and state and federal agencies and provide additional incentives to attain water quality improvements.

Minnesota voters have approved an amendment to increase the state sales tax to fund water quality improvements. Subsequently, several state agencies have come together to focus on high level planning in order to best utilize these funds. The interagency Minnesota Water Quality Framework (Figure 8.1) as applied to Minnesota's 81 major watersheds clearly illustrates the cycle of assessment, watershed planning and implementation to which the state is committed. This is an iterative process that will provide feedback from implementation activities and inform an adaptive management approach to restoration and protection.

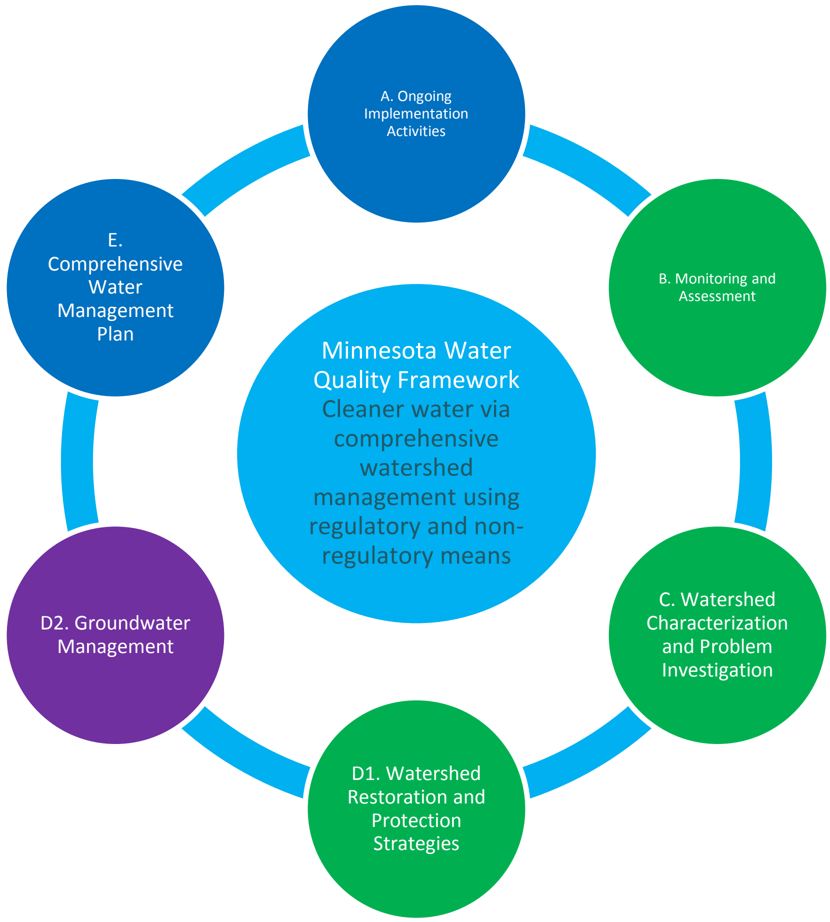

Figure 8.1: Minnesota Water Quality Framework.

The majority of pollutant reductions in the study areas will rely on voluntary adoption of conservation practices by an engaged citizenry. Through the PdT Watershed project, the PdTRA has been tasked with involving stakeholders in the watershed to devise protection and restoration strategies for water quality. Goals of civic engagement activities are to leverage opportunities within the watershed assessment and management process to promote active public participation, and craft protection and restoration strategies with input from local residents, businesses and organizations.

The PdTRA administered surveys and used input gleaned from previous meetings with watershed residents to develop an understanding of local engagement capacity and how information flows through the watershed.

The PdTRA has also been actively implementing BMPs in the watershed. In the past year alone through a federal 319 grant, four buffer projects were approved by the board totaling 111 acres including 71.5 acres along Dry Wood Creek. A prescribed grazing project was also completed through EQIP in Stevens County for 111 acres.

In addition to the federal 319 grant, the PdTRA received state implementation funds through the Minnesota Board of Water and Soil Resources. Over the past two years, these grants have resulted in the installation of rain gardens, shoreline stabilization and restoration projects, grassed waterways, alternative tile intakes, livestock exclusion fences, and water and sediment control basins. The PdTRA also obtained funding for a streambank repair project near a dam in a city park in Morris, Minnesota, a project which had widespread public interest and support.

The PdTRA technical staff maintains contact with landowners interested in installing water quality improvement projects in the watershed and keep them regularly updated on funding as it becomes available. Over the long term, active participation will help build and sustain local civic infrastructure and leadership for watershed stewardship initiatives.

9 Public Participation

The PdT River Association has completed two TMDLs (bacteria and turbidity) in the past five years, both of which had active stakeholder participation and numerous public meetings. In 2011, the PdTRA held several stakeholder meetings at their normal monthly Technical Advisory Committee meetings to gain feedback from the public with respect to impaired waters and implementation practices in the watershed.

Development of watershed TMDLs was discussed at a public impaired waters meeting in Benson in January 2012. Impairments in the neighboring Chippewa River watershed and the PdT River and the approach used to address them were the focus of the meeting.

An overview of the development of these TMDLs was given at the PdT River Association annual meeting in the spring of 2012. The TMDLs and restoration and protection strategies to address the TMDLs were the focus of group discussions, and input on the strategies was gathered from the participants.

The PdTRA also hosted a Citizen’s Watershed Academy in early 2012, where citizens of the watershed learned about water biology, impaired waters, and TMDLs. The PdTRA intends to host this academy again in the future to further increase citizen understanding of water quality topics. Through these activities, citizens in the watershed have gained an understanding of and provided input to the development of TMDLs in the watershed.

A public comment period was open from August 18, 2014, to September, 17, 2014. There were two comment letters and one phone call received and responded to as a result of the public comment period.

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Appendix A – Load Duration Curves