Upper Mississippi Clearwater River: County Ditch #44 to Lake Betsy Dissolved Oxygen TMDL

Wenck File #0002-117

Prepared for:

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November 2010

wq-iw8-29e

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TMDL Summary Table

TMDL Summary Table		
EPA/MPCA Required Elements	**Summary**	**TMDL Report Section**
Location	Upper portion of the Clearwater River Watershed District, in Stearns and Meeker Counties Minnesota in the Upper Mississippi St. Cloud HUC 07010203. See Figure 2.1 on page 2-2.	Section 2
303(3) Listing Information	Clearwater River, Clear Lake to Lake Betsy 07010203-549 The Clearwater River was added to the 303(d) list in 1996 due to low dissolved oxygen concentrations which impair aquatic life, per Minnesota Rules 7050.0150. The TMDL for Clearwater River was prioritized to start in 2004 and be completed by 2009.	Section 1
Applicable Water Quality Standards/ Numeric Targets	Criteria set forth in Minn. R. 7050.0222 (4). The numeric target for the reach is in terms of dissolved oxygen: 5.0 mg/L as a daily minimum. This dissolved oxygen standard may be modified on a site-specific basis according to part 7050.0220, subpart 7, except that no site-specific standard shall be less than 5 mg/L as a daily average and 4 mg/L as a daily minimum. Compliance with this standard is required 50 percent of the days at which the flow of the receiving water is equal to the $7Q_{10}$.	Section 3
Loading Capacity	The loading capacity, the total maximum daily load expressed as pounds of C-BOD, N-BOD and SOD per day per MPCA submittal requirements. The loading capacity is provided for the critical condition where a DO violation was observed:	Section 5

Reach	Critical Condition	Waste Load (lb /day)	Load (lb /day)	Margin of Safety (lb /day)	TMDL (lb /day)
Clearwater River	downstream of Kingston Wetland, Late Summer, Q<10 cfs	0 lbs/day SOD	324.86 lbs/day SOD	Implicit	324.86 lbs/ day SOD
		2.18 lbs/day C-BOD	216.75 lbs/dayC-BOD	Implicit	218.93lbs/day C-BOD
		493.01 lbs/day N-BOD	58,548.16 lbs/day N-BOD	Implicit	59,041.17 lbs/day N-BOD

<table>
<tr><th colspan="3">TMDL Summary Table</th></tr>
<tr><th>EPA/MPCA Required Elements</th><th>Summary</th><th>TMDL Report Section</th></tr>
<tr><td>Wasteload Allocation</td><td>The Wasteload Allocation represents the WWTPs which operate using land application; potential future systems that have been evaluated for the area; and the NPDES Construction Permit. Only NPDES Construction is allowed a WLA greater than 0, as the MPCA, watershed and local residents have rejected other requests to discharge to area lakes in the past. There are no individual permitted sources in the watershed allowed to discharge to surface waters.
<table>
<tr><th>Source</th><th>Permit #</th><th colspan="2">Gross WLA (lbs/day) C-BOD/ N-BOD</th></tr>
<tr><td>NPDES Construction</td><td>MNR100001</td><td>2.18 lbs/ day C-BOD</td><td>493.01 lbs/ day N-BOD</td></tr>
<tr><td>Clearwater River Watershed District Future Systems</td><td>NA</td><td>0 lbs/ day C-BOD</td><td>0 lbs/ day N-BOD</td></tr>
<tr><td>City Watkins WWTP</td><td>MN0051365</td><td>0 lbs/ day C-BOD</td><td>0 lbs/ day N-BOD</td></tr>
</table></td><td>Section 5</td></tr>
<tr><td>Load Allocation</td><td>The portion of the loading capacity allocated to existing non-permitted sources. Proportional loads were derived by using the determined percentage contribution of each source.
<table>
<tr><th rowspan="2">Source</th><th colspan="3">Load Allocation (lbs/day)</th></tr>
<tr><th>C-BOD</th><th>N-BOD</th><th>SOD</th></tr>
<tr><td>Septic Systems (SSTS)</td><td>0 lbs/ day C-BOD</td><td>0 lbs/ day N-BOD</td><td>0 lbs/ day SOD</td></tr>
<tr><td>Watershed Load</td><td>215.09 lbs/ day C-BOD</td><td>48,808.43 lbs/ day N-BOD</td><td>0 lbs/ day SOD</td></tr>
<tr><td>Groundwater</td><td>0.85lbs/ day C-BOD</td><td>9,739.73 lbs/ day N-BOD</td><td>0 lbs/ day SOD</td></tr>
<tr><td>Wetland</td><td>0 lbs/ day C-BOD</td><td>0 lbs/ day N-BOD</td><td>324.86 lbs/ day SOD</td></tr>
<tr><td>Total</td><td>218.93 lbs/ day C-BOD</td><td>59,041.17 lbs/ day N-BOD</td><td>324.86lbs/ day SOD</td></tr>
</table></td><td>Section 5</td></tr>
<tr><td>Margin of Safety</td><td>The Margin of Safety is both an implicit and explicit and was established by using conservative approaches to set the TMDL (implicit) and conservative load reductions (explicit) and are described in section 5.4 of this report.</td><td>Section 5.4</td></tr>
</table>

TMDL Summary Table		
EPA/MPCA Required Elements	**Summary**	**TMDL Report Section**
Seasonal Variation	Seasonal variation is accounted for by using the critical condition, and in the linkages between sources and in-stream DO concentrations. The in-stream data used to link sources to in-stream concentrations represents an appropriate range of seasonal and annual variations in flow and conditions. Load reduction strategies in the implementation plan are based on the relationships developed using these data.	Section 5.5
Reasonable Assurance	Reasonable assurance is provided by the cooperative efforts of the Clearwater River Watershed District, a watershed based organization with statutory responsibility to protect and improve water quality in the water resources in the Clearwater River watershed which contains the listed reach and its tributary watershed.	Section 7
Monitoring	The Clearwater River Watershed District monitors water quality and flow in the listed reach annually through its baseline monitoring program which it started in 1981. The CRWD will continue this annual baseline program and add monitoring as recommended in Section 8.	Section 8
Implementation	This TMDL sets forth an implementation framework and load reduction strategies. These are proposed implementation strategies that will be refined in the final implementation plan. The final implementation plan is part of a program to address all TMDLs within the Clearwater River Watershed District. The estimated cost of implementation for all TMDLs in the CRWD over 10 years is $9.3 million.	Section 9
Public Participation	Public Comment period: Meeting location: Comments received:	Section 6

1.0 Executive Summary

The MPCA found that the Clearwater River between Clear Lake and Lake Betsy, reach ID 07010203-549 located in Meeker County, Minnesota, is impaired and does not meet Minnesota water quality standards for dissolved oxygen (DO). This reach was placed on the 303(d) list in 2004 because monitoring data have revealed that DO concentrations sometimes fall below the state standard of 5 milligrams per liter (mg/L) which can impair aquatic habitat.

Section 303(d) of the Clean Water Act requires states to set Total Maximum Daily Loads (TMDLs) for impaired waters and determine load reductions needed to achieve standards. This report presents the DO TMDL for the Clearwater River between Clear Lake and Lake Betsy, river miles 35.3 to 25.0. The goal of this TMDL study was to develop an implementation plan with sufficient BMPs to achieve the necessary load reductions to meet the State standard for DO. The Clearwater River Watershed District's (CRWD's) ultimate goal in doing TMDLs is improved water quality within the CRWD, specifically water quality that meets or exceeds state standards.

Through this study, the critical reach, critical flow regime, and critical time period for the DO impairment were each identified. Violations of the DO standard were found to occur exclusively in the reach between Kingston Wetland and Lake Betsy between river miles 29.0 and 25.0 located at the very downstream of the listed reach. Violations were observed only during late summer low flow conditions.

Measured in-stream concentrations of carbonaceous oxygen demand (C-BOD) and total phosphorus (TP) were close to the mean values observed in minimally impacted streams of the North Central Hardwood Forest Ecoregion or within the standard deviation, and concentrations of nitrogenous BOD (N-BOD) are low. This indicates that while there are documented anthropogenic impacts in the watershed based on the presence of other impairments, and the dominance of agricultural land uses, watershed contributions of C-BOD to the Clearwater River are not the sole cause of the impairment.

The combination of low in-stream C-BOD concentrations, the fact that occurrences of DO violations are limited to the area between Kingston Wetland and Lake Betsy and the lack of watershed individual permitted point sources, indicates that DO violations are the result of the combination of watershed loads, sediment oxygen demand (SOD) in the wetlands and existing channel morphometry in the downstream portion of the river. Modeling and data analysis supports this.

Though data analysis and modeling indicate that the impairment is due in part to conditions wetland SOD which *can* occur naturally in streams flowing through wetlands, the MPCA has determined that because there are documented anthropogenic impacts within the watershed, a TMDL is the appropriate tool to address the DO impairment. This reach of the Clearwater River is also impaired for bacteria, 1 lake upstream and 6 downstream lakes are impaired for nutrients. There are 11 lake nutrient impairments district wide.

In addition to the land use impacts and other impairments in the watershed, the channel and riparian wetland was altered from its pre-settlement condition. The main stem of the Clearwater River was straightened and made deeper through the Kingston Wetland to facilitate drainage of fields for agriculture. In the early 1980s, the CRWD undertook a project in the Kingston Wetland to restore the wetland's assimilative capacity for phosphorus. Specifically, a dike was constructed to route stream flow to the edges of the wetland to allow it to filter through the wetland and back into the channel, removing particulate phosphorus and restoring hydrology to the wetland. The project was successful in improving water quality in downstream lakes over the past 30 years. Today the wetland acts as a sink for particulate phosphorus and is protective of water quality in downstream lakes. However, the wetland sediments exert oxygen demand and reduce dissolved oxygen in the main channel and at times exports soluble phosphorus to downstream lakes.

There are no current individually permitted point sources to the Clearwater River, the Kingston wetland or to the downstream wetlands. Historical nutrient sources identified far upstream of the wetlands off the main stem of the Clearwater River near Watkins were mitigated through the Chain of Lakes Restoration Project.

Modeling results show that either watershed or SOD load reductions of 60% will bring modeled DO concentrations in the critical reach up from 3.59 mg/L to just over 5 mg/L. This improvement, while technically above the 5 mg/L standard, is within the level of uncertainty of the modeling and data collection efforts and therefore both watershed and SOD load reductions are required to provide a Margin of Safety to achieve the TMDL.

Modeling shows that simultaneous 60% reductions of both watershed oxygen demand and wetland SOD bring modeled DO concentrations in the critical reach up from 3.59 mg/L to 8.18 mg/L. This scenario brings modeled downstream DO concentrations in line with measured and modeled upstream concentrations, mitigating for the wetland SOD and existing channel morphometry. Given that the model slightly under-predicts main channel DO, and the required load reductions bring in-stream water quality above the state standard, a significant MOS is provided through this TMDL.

Watershed load reductions of similar magnitudes are required for the lake nutrient TMDLs in the upper watershed lakes which share a tributary watershed. Bacteria load reductions are also required to meet the Clearwater River Bacteria TMDL for the same reach. The transport mechanisms for nutrients, bacteria, and watershed oxygen demand are similar, so recommended watershed BMPs are the same.

Reducing wetland SOD is more complicated. Technologies to mitigate for the SOD are limited. The natural state of the channel and riparian wetland may have been a meandering low flow channel with flow accessing the riparian wetland during high flow/wet weather events. Such a flow regime would limit exposure to wetland SOD in critical conditions and may reduce export of soluble phosphorus, while still offering the wet weather/ high flow reduction in total phosphorus that benefits lakes downstream by allowing higher flows to access the floodplain wetland and its phosphorus assimilative capacity. The costs and benefits of such a restoration of the channel to a more natural state should be evaluated.

Other potential methods for reducing SOD include dredging existing wetland sediments in the 577 acres wetland complex, re-routing the Clearwater River around the wetland, or mitigating for SOD through other physical stream channel improvements like improving re-aeration, or adding an aeration system. In any case the original restoration Kingston Wetland project should be evaluated with new water quality goals and standards in mind.

2.0 Background

2.1 WATERSHED DESCRIPTION

The Clearwater River Watershed District is a predominantly agricultural 168-square mile watershed in central Minnesota (Figure 2.1). The Clearwater River and the Clearwater River Chain of Lakes are the predominant water features in the District. From upstream to downstream the Chain of Lakes along the Clearwater River includes Clear Lake, Lake Betsy, Union Lake, Scott Lake, Lake Louisa, Lake Marie, Caroline Lake, Lake Augusta, Pleasant Lake, Cedar Lake and Clearwater Lake.

The CRWD has been proactive in the protection and improvement of water quality and has made considerable improvements in water quality throughout the District. However, monitoring data has shown that a 9.7-mile stretch of Clearwater River between Clear Lake and Lake Betsy (ID 07010203-549) does not meet water quality standards for dissolved oxygen (DO). The impaired reach and its tributary watershed are shown in Figure 2.2.

Figure 2.1. Clearwater River Watershed Location Map

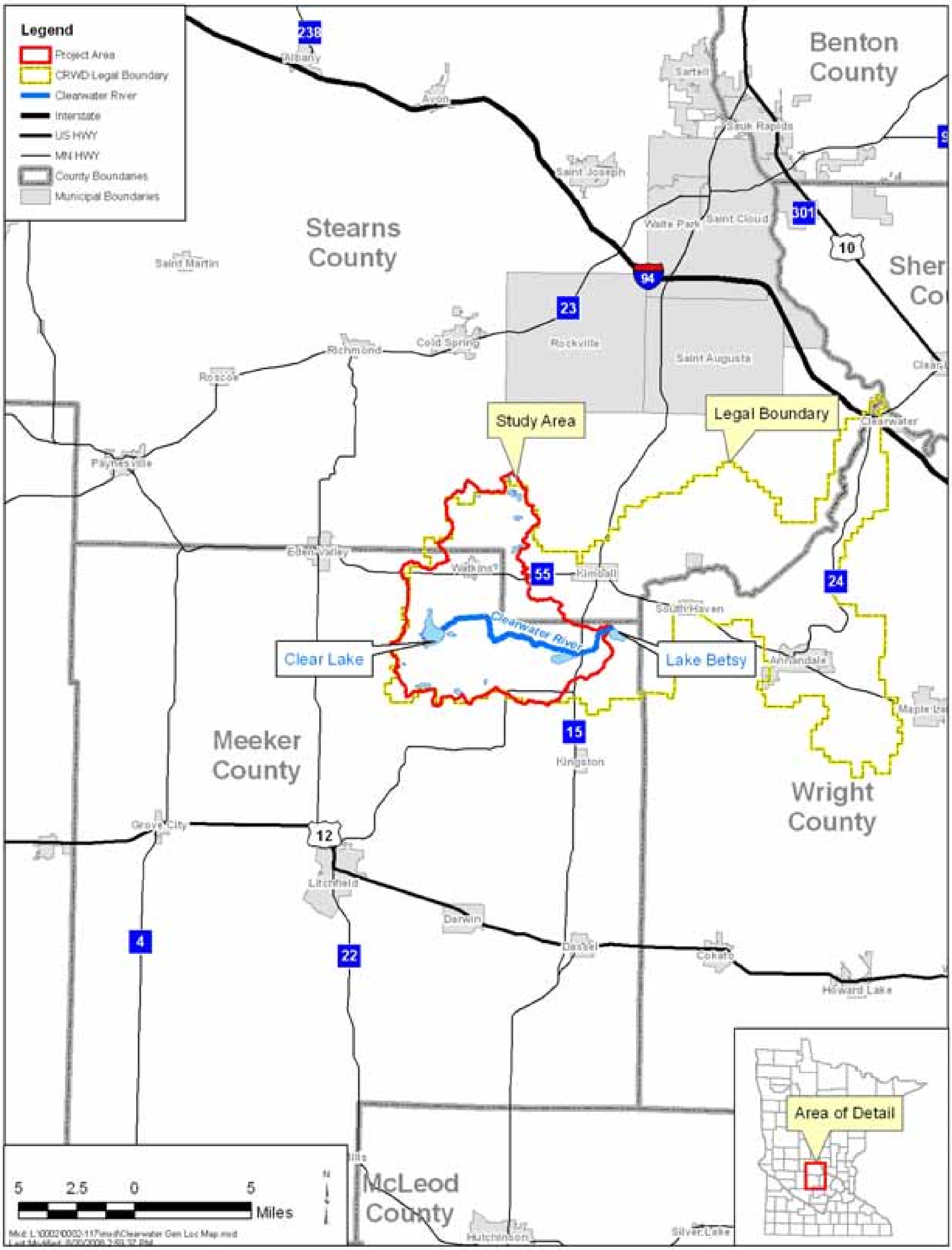
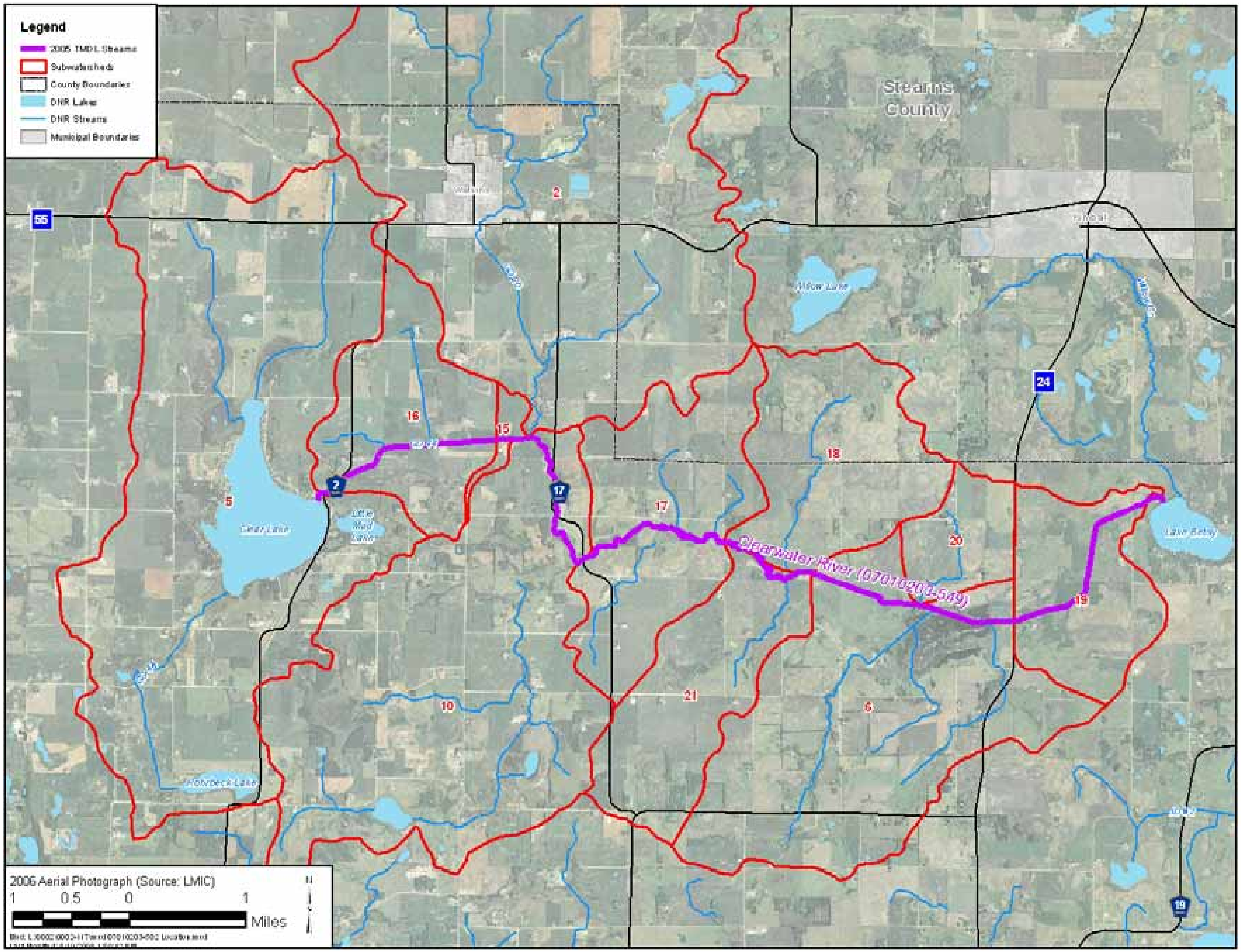


Figure 2.2. Clearwater River, Listed Reach from Clear Lake to Lake Betsy and Tributary Watershed



2.2 LAND USE

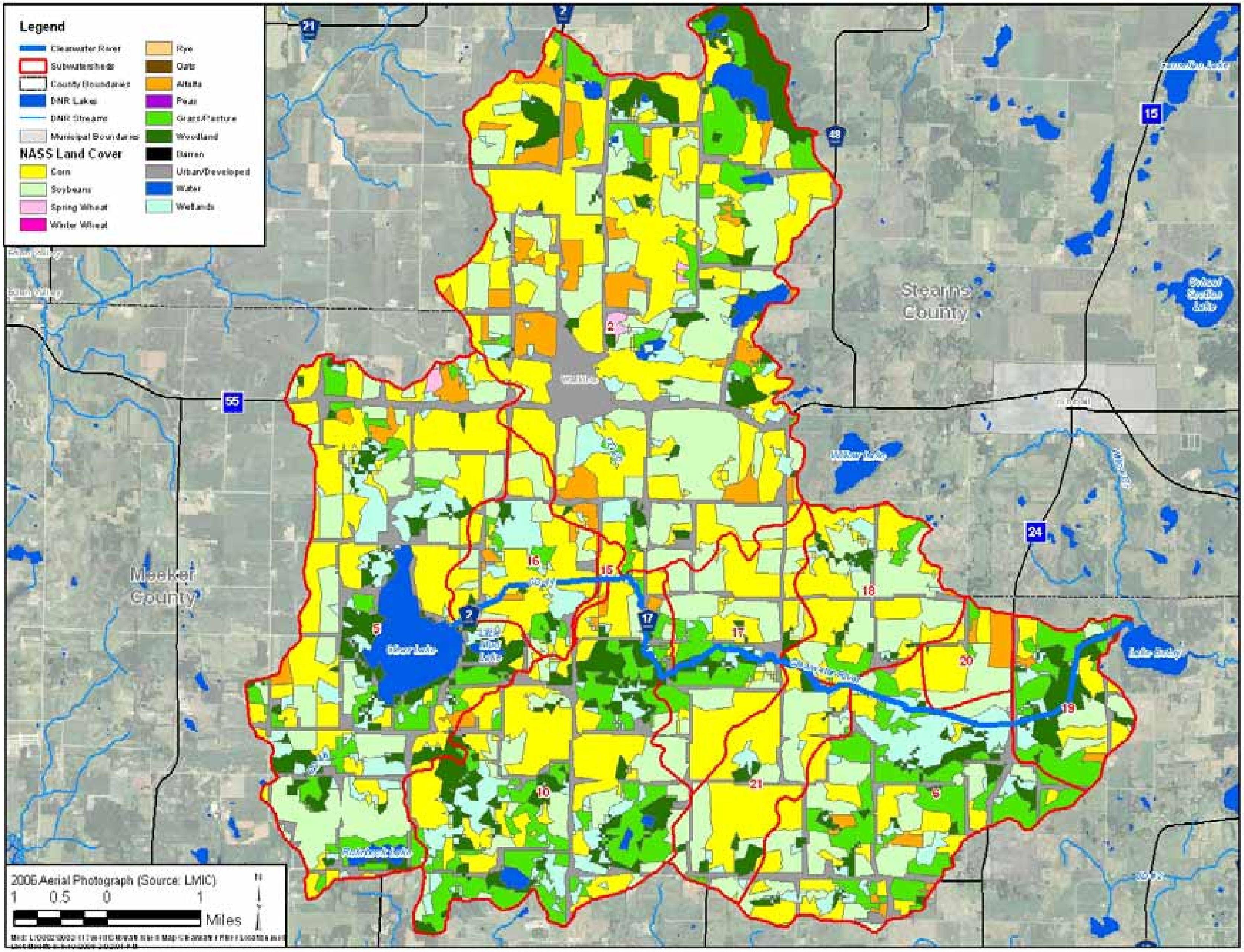
The Clearwater River watershed is comprised mainly of agricultural land uses. The National Agriculture Statistics Services (NASS) 2006 cropland data layer was used to determine land use within the sub-watersheds tributary to the listed reach. This data is an appropriate data set for large agricultural watersheds as the use categories within the data set are more specific in describing agriculture uses, such as separately classifying corn, soybeans and alfalfa. Other categories in the data set are more general such as urban, wetlands or woodlands.

Land use in the sub-watersheds tributary to the Clearwater River reach between Clear Lake and Lake Betsy is listed in Table 2.1. The land use data for each of these sub-watersheds is shown in Figure 2.3. Overall, corn is the most frequent land use covering 10,601 acres or 31.3 percent of the 33,875 acres of the area within the sub-watersheds between Clear Lake and Lake Betsy. Soybeans were the next most frequent land use, covering almost 7,700 acres or 22.7 percent of the total area. Grasslands and pasture (12%), woodland (9%), urban/developed (10%), and wetlands (8%) range between about 3,000 and 4,000 acres each.

Table 2.1 Land Use in the Sub-watersheds Tributary to the Listed Reach of the Clearwater River.

Land Use	Total (ac)	Percent
Corn	10,601.34	31.29%
Soybeans	7,665.40	22.63%
Spring Wheat	73.37	0.22%
Alfalfa	1,269.44	3.75%
Peas	0.49	0.00%
Grass/Pasture	3,932.62	11.61%
Woodland	3,002.73	8.86%
Urban/Developed	3,516.33	10.38%
Water	1,000.65	2.95%
Wetlands	2,813.19	8.30%
Total (acres)	33,875.55	100.00%

Figure 2.3 Land Use in the Sub-watersheds Tributary to the Listed Reach of the Clearwater River



2.3 STREAM PHYSICAL CHARACTERISTICS

The Clearwater River between Clear Lake and Lake Betsy extends between river miles CR 35.3 in the upstream end at Clear Lake and CR 25.6 at Lake Betsy (Figure 2.4). The channel in this 9.7 mile reach can be broken into three distinct sections based on channel characteristics such as slope, morphometry, channel bed and riparian land use. Table 2.2 summarizes the stream characteristics for each reach.

In the 1.7-mile upstream segment of the Clearwater River between Clear Lake and CR 33.6 the slope is 0. The channel is primarily ditched in this segment, sometimes draining large wetland complexes. The riparian land use is primarily pasture, wetland and agriculture (primarily row crop and pasture, see Table 2.1).

The next reach between CR 33.6 and CR 29.0 is steeper; in fact the maximum slope of 33 ft/ mile occurs between CR 33.6 and CR 31.8. Downstream of this, the slope ranges from 5 to 10 ft/ river mile. The portion of the river between CR 33.6 and CR 29.0 is more sinuous and the channel sediments are generally coarser. The channel in this segment is mostly flanked by a woody riparian buffer consisting of trees and grasses.

Between CR 29.0 and CR 25.0 the river flows through large wetlands. The first of these wetlands is the Kingston Wetland located between CR 29.0 and CR 27.2. Prior to 1985, the Clearwater River was straightened and ditched through the Kingston Wetland. In 1985 the CRWD undertook a project in the Kingston Wetland to restore the wetland's assimilative capacity for phosphorus. Specifically, a dike was constructed to route stream flow to the edges of the wetland to allow it to filter through the wetland and back into the channel, removing particulate phosphorus. The project was one of several in the Clearwater River Chain of Lakes Restoration (reports on this project are available at the District office) that all together reduced total phosphorus and sediment loading in the Clearwater River and downstream lakes by an order of magnitude. Today, thirty years after construction, the Project acts as a sink for particulate phosphorus and is protective of water quality in downstream lakes. However, the wetland sediments exert oxygen demand and reduce dissolved oxygen in the main channel and may at times export soluble phosphorus to downstream lakes. Restoration of the channel to its natural state should be evaluated.

Downstream of CR 25.6, the slope of the river is small, and in fact there is backflow from Lake Betsy into the Clearwater River from time to time.

Photos of the stream, along with assessment of the sediments, and riparian cover are presented in Phase II TMDL Report (Wenck 2007) which is available on file with the MPCA, and will be posted on the CRWD web site after EPA approval.

Figure 2.4 Monitoring Stations in the Clearwater River between Clear Lake and Lake Betsy

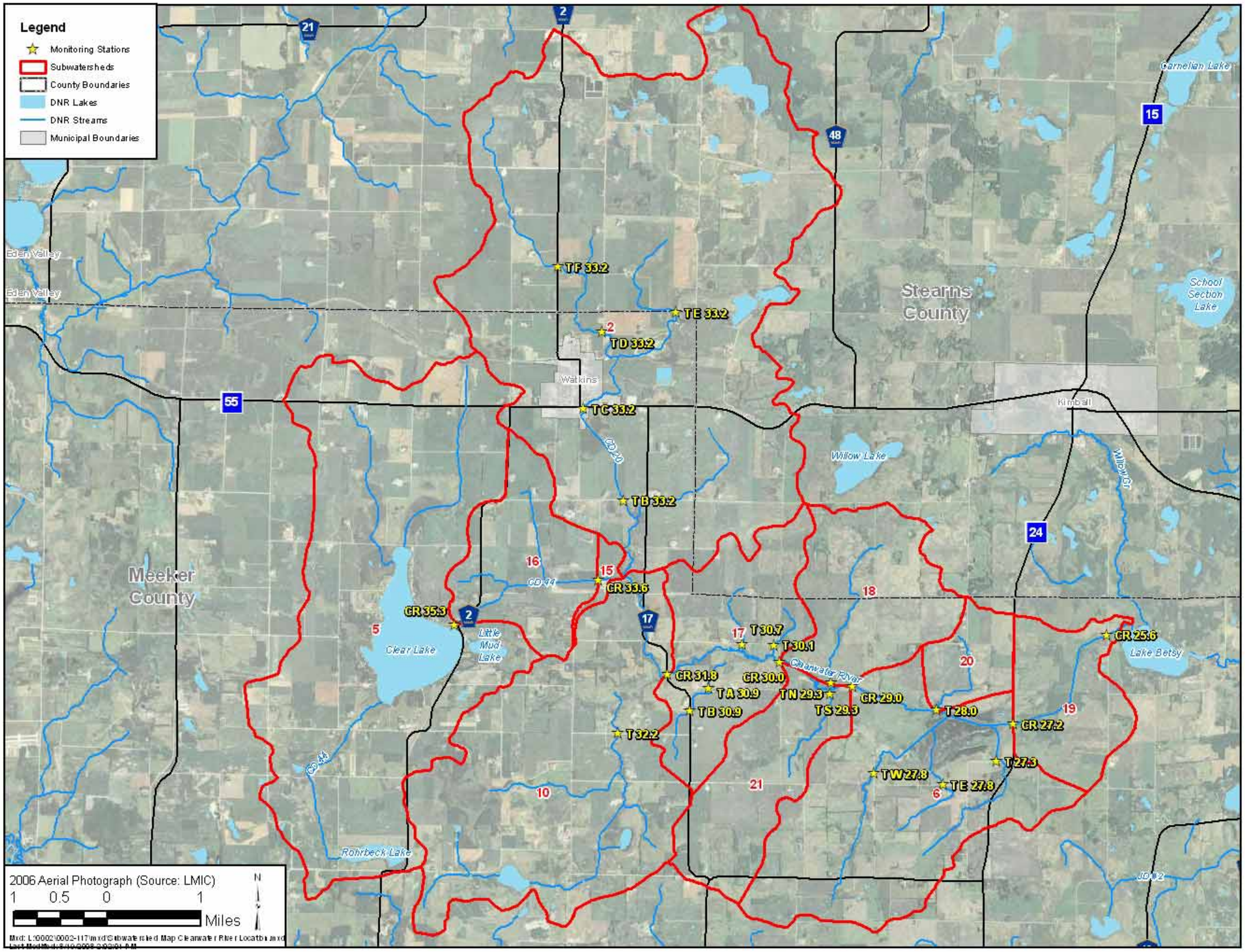


Table 2.2 Stream Characteristics of the Clearwater River between Clear Lake and Lake Betsy

River Mile	Drainage Area (acres)	Elevation (ft NGVD)	Slope (ft/ mile)	Stream Width (ft)	Tree Canopy	Sediment Description	Description
CR 35.3	6,801	1,129	--	12	Mowed turf grass riparian, 75% upstream, 25% downstream	gravel and cobbles, medium to coarse sand	Clear Lake Outlet
CR 33.6	8,214	1,129	0	12	20% upstream, 100% downstream	medium to coarse sandy clay upstream; coarser sand, some gravel and cobble.	Straight narrow ditch with steep banks upstream, flowing through agricultural land. Downstream, channel has more meanders and is heavily forested. Channel widens and sediment is coarser graied.
CR 31.8	23,679	1,070	33	14	75% in the area	Fine to medium sand, layers of gravel, some cobble and boulders	Meandering channel, undercut banks, braided, sediment deposits
CR 30.0	25,602	1,060	6	14	100% upstream, 90% downstream	clean medium to coarse sand, organic material at surface	Meandering channel, undercut banks, braided, sediment deposits
CR 29.0	28,633	1,050	10	18	60% upstream, 90% downstream	Medium to coarse sand, some gravel	Meandering channel, undercut banks, braided, sediment deposits, Kingston Wetland downstream
CR 27.2	32,704	1,040	6	43	10% upstream, 60% downstream	Wetland soils, organic muck	County Road 15, ditched and dredged channel
CR 25.6	33,877	1,032	5	35	90% upstream, 20% downstream	Sandy edges, organic muck	Ditched, straight channel with undercut banks. Forested banks upstream. Cow pasture on the northbank downstream.
CR 25.0	33,976	1,032	0	--			Lake Betsy Inlet

T:\ 0002\75_TMDL Ph2\Report\[Rpt Outline.xls]Table4.1

2.4 FIELD MONITORING

Field monitoring for the Clearwater River DO TMDL for the reach between Clear Lake and Lake Betsy was conducted between August 2005 and October 2006. Field data collection was conducted to determine the spatial and temporal extent of the DO impairment on the Clearwater River and to quantify the sources of oxygen demand. The TMDL study included a field survey, bi-weekly water quality sampling as well as two synoptic surveys, continuous and discrete flow measurements, and a time of travel study. The findings of this study are presented in the Phase II Report (Wenck 2007).

Data were collected during wet and dry weather and over a range of flow conditions. The findings of these studies that are relevant to the TMDL are summarized in the sections that follow.

2.5 WATER QUALITY

Table 2.3 compares water quality in the Clearwater River in 2005 and 2006 to that of minimally impacted streams in the North Central Hardwood Forest Ecoregion.

Table 2.3 Water Quality in the Clearwater River and Minimally Impacted Streams of the North Central Hardwood Forest Ecoregion

	Water Quality of Minimally Impacted Streams in NCHF, Annual 1970-1992*				2005-2006 Clearwater River, Clear Lake to Lake Betsy			
Parameter	Mean	SD	MAX	MIN	Mean	SD	MAX	MIN
Conductivity (µmhos/cm)	298	83	840	40	826	262	1,716	442
pH (SU)	8.1	0.3	8.9	7.2	7.7	0.8	9.0	5.6
TSS (mg/L)	13.7	22.5	330	0.5	20	51	387	2
Ammonia-N (mg/L)	0.2	0.2	1.3	0.02	0.1	0.1	0.6	0.1
NO2+NO3 (mg/L)	0.16	0.15	0.65	0.01	3.7	6.6	48	0.20
TP (mg/L)	0.13	0.15	1.6	0.01	0.21	0.13	0.72	0.04
Fecal Coliform (#/100mL)	920	3,277	27,000	4	621	12,609	60,000	10
BOD5 (mg/L)	2.7	2.1	17	0.3	2.9	1.3	7.0	2.0

*McCollar & Heiskary, 1993

T:\0002\75_TMDL Ph2\Report\[RAK FINAL DATA.xls]Table 4.2

Mean concentrations of in-stream indicators of anthropogenic impacts collected in 2005 and 2006 are generally close to Ecoregion means or within the standard deviation. Conductivity, NO2 +NO3, TSS, and total phosphorus show the greatest differences from Ecoregion means, but of those only Conductivity and NO2 +NO3 are outside the standard deviation of the mean of minimally impacted streams. The data indicates some anthropogenic impacts to this reach of the Clearwater River which is also impaired for bacteria. Further, Clear Lake and Lake Betsy, the lakes which bracket this reach of Clearwater River are both impaired for nutrients, as well as 3 other lakes directly downstream of Lake Betsy on the Clearwater Chain of Lakes. Land use in the watershed clearly demonstrates potential anthropogenic impacts, and opportunities for load reductions.

The high mean conductivity in the Clearwater River relative to the mean conductivity measured in minimally impacted streams in the ecoregion indicates that the stream has a groundwater contribution in this reach, this is supported by flow measurements and the hydrologic atlas of Water Resources of the Mississippi and Sauk Rivers Watershed (Helgesen 1975).

Water quality data in the listed reach of the Clearwater River along with the dominant land use in the tributary watershed point to agricultural land uses as the primary watershed sources of oxygen demand, though all watershed sources require consideration. Concentrations of NO2+NO3 are an order of magnitude higher in the Clearwater River compared to those of minimally impacted streams; NO2+ NO3 is a key component of agricultural runoff because of its use as fertilizer. Nitrogen fertilizers may be over-applied in cultivated areas leading to high concentrations in waters with agricultural watersheds. In further support of this conclusion, 55% of the land area tributary to the listed reach is row crops.

Total phosphorus concentrations are low relative to minimally impacted streams, likely due to the Clearwater Chain of Lakes Restoration Project, which targeted phosphorus reductions in the watershed.

Discrete measurements of DO along the profile of the Clearwater River in 2005 and 2006 show that the DO sag and the DO impairment is limited to the area between the Kingston Wetland and Lake Betsy in low flow, high-temperature conditions. Otherwise, DO concentrations are fairly consistent upstream to downstream (Figure 2.5). The longitudinal concentrations of C-BOD and TKN in the listed reach are shown in Figures 2.6 and 2.7. The concentrations of TKN are shown because they represent a measurement of N-BOD. Figures 2.5 through 2.7 are based on the discrete measurements collected during 2005 and 2006, including the synoptic surveys.

The consistent measurements of DO from upstream to downstream indicate the river is generally in equilibrium. This is supported by in-stream C-BOD-5 and TKN concentrations (Figures 2.6 and 2.7).

Figure 2.5 Longitudinal Dissolved Oxygen Concentrations in the Clearwater River

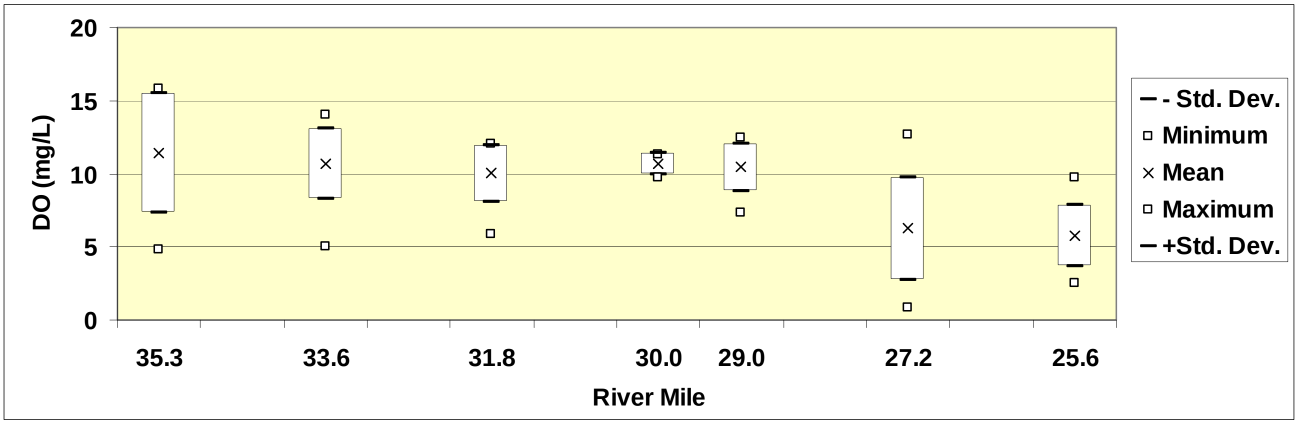


Figure 2.6 Longitudinal C-BOD-5 Concentrations in the Clearwater River

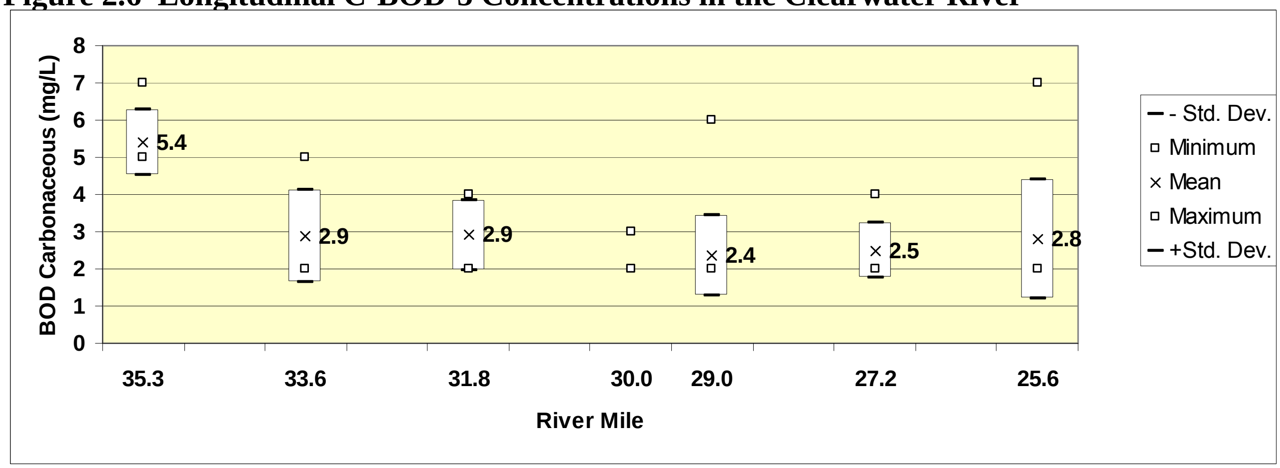
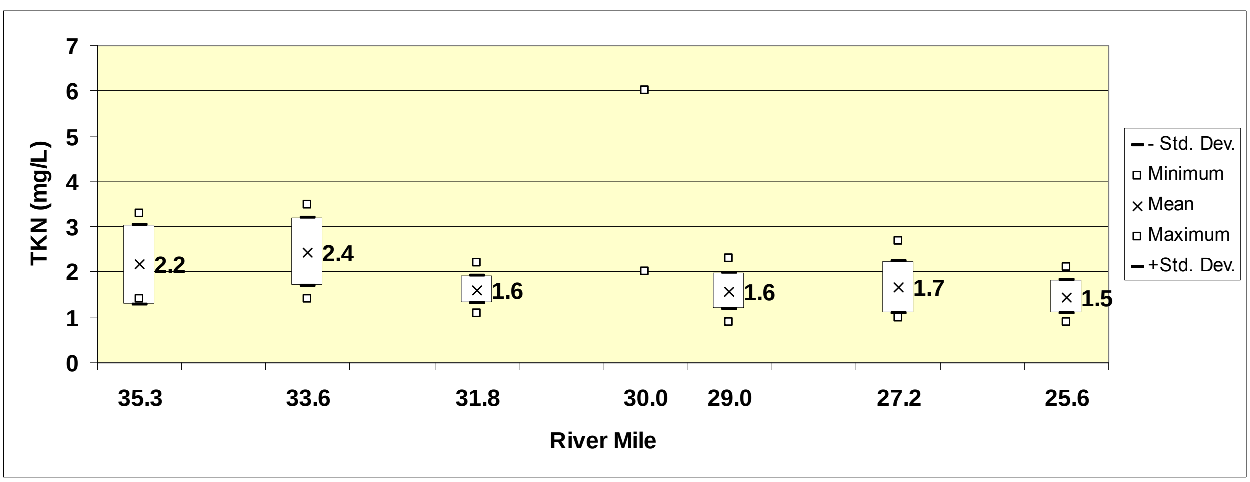


Figure 2.7 Longitudinal TKN Concentrations in the Clearwater River



The comparatively higher average C-BOD-5 concentrations in the upstream reach are likely due to organic material in the outflow of Clear Lake, a highly eutrophic lake with nuisance algae blooms.

Dissolved oxygen, temperature, conductivity and pH were measured continuously upstream and downstream of Kingston Wetland during 2005, and at CR 31.8 during late summer 2005 and 2006. Measurements were also collected at CR 25.6 during late summer of 2006.

Continuous measurements of dissolved oxygen showed that DO concentrations were consistently below the state DO standard of 5 mg/L downstream of Kingston Wetland throughout the monitoring in 2005, and occasionally dipped below the state DO standard at the upstream edge of Kingston wetland at the low point of the diurnal DO cycle. The occurrences of low DO at the upstream end of the Kingston Wetland corresponded with low or zero flows. This part of the channel is flat and subject to backwater conditions. It is possible that low DO water flowed upstream out of Kingston Wetland causing the low DO concentrations at the upstream edge of the wetland. Continuous data is included as Appendix A.

The upstream-most part of the channel is fed by outflow from Clear Lake, as such flow in this part of the channel is zero during late summer when lake outflows stop and there is no precipitation. Dissolved oxygen concentrations were measured at CR 31.1 in the upstream end of the listed reach during these zero flow to very low flow events. Continuously measured concentrations dipped below the state standard at the low point of the diurnal cycle on 6 of 17 days measured in 2005 and 3 of 28 days in 2006. However these measurements were taken during times when the channel flow was zero (Clear Lake was not discharging) indicating that they are characteristic of pools of standing water, not a flowing stream. Daily maximum DO concentrations were above the state standard for all measurements collected. The different between daily maximum and minimum DO is called delta DO, which is a measure of primary productivity in the stream. The average delta DO over the period of continuous record at CR 31.8 was high, 5 mg/L in 2005 and 3.5 in 2006. Because chlorophyll-a concentrations in the stream are typically low, this indicates that macrophytes and/or attached algal productivity are high.

Daily maximum DO concentrations near the downstream end of the listed reach at CR 26.1 in 2005 were consistently below the state standard. Daily minimum DO concentration at CR 25.6 dipped below the state standard 6 of 28 days measured in 2006, and the daily DO maximum fell below the state standard on 2 days. Average diurnal DO variation was 2.7 in 2006.

3.0 Applicable Water Quality Standards and Numeric Targets

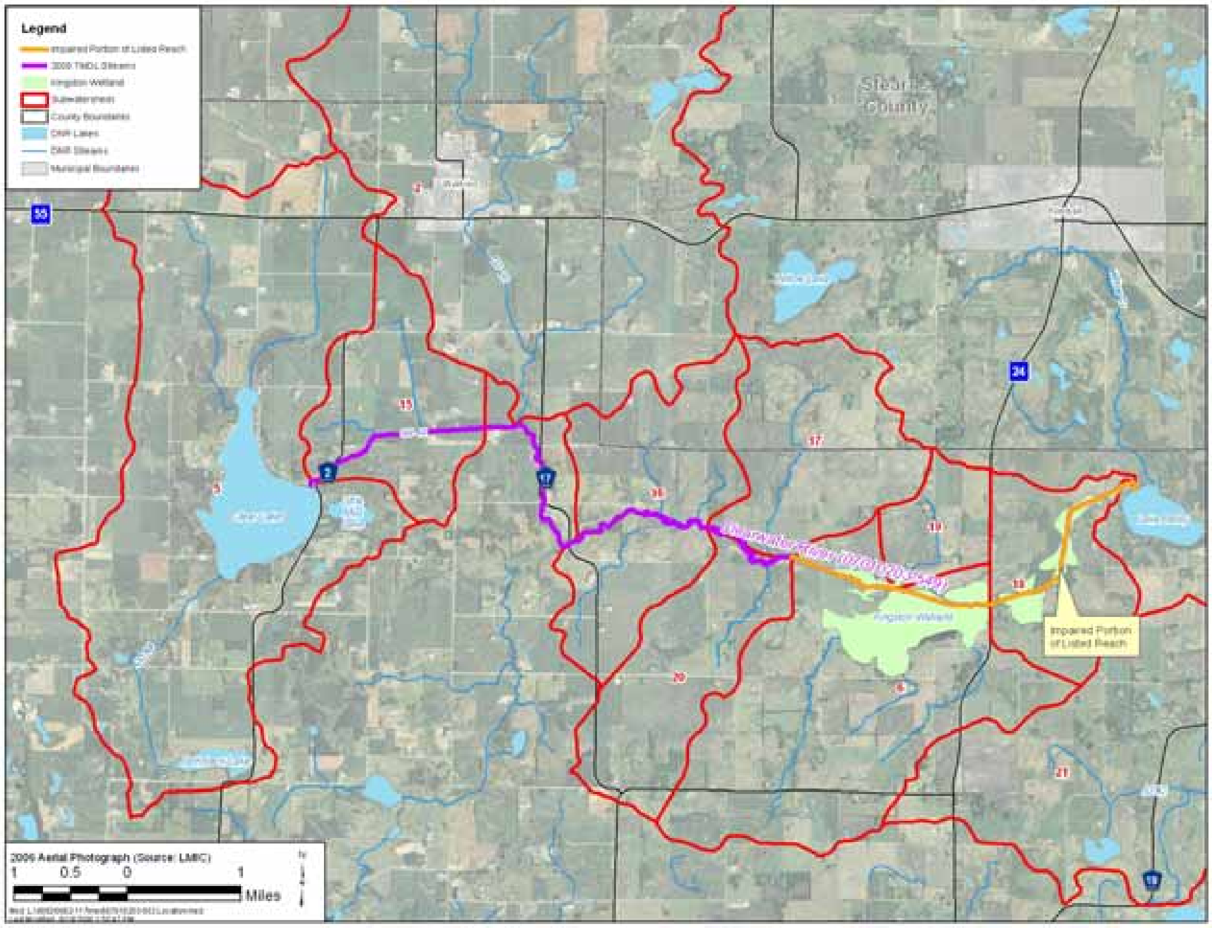
This Clearwater River reach is classified as a Class 2B, 3C, 4A, 4B, 5 and 6 water and is protected for aquatic life (warm and cool water fisheries and associated biota) and recreation (all water recreation activities including bathing). The Minnesota standard for class 2B waters is as follows:

Minn. R. ch. 7050.0222 subp. 4: Dissolved oxygen concentrations of 5.0 mg/L as a daily minimum. This dissolved oxygen standard may be modified on a site-specific basis according to part 7050.0220, subpart 7, except that no site-specific standard shall be less than 5 mg/L as a daily average and 4 mg/L as a daily minimum. Compliance with this standard is required 50 percent of the days at which the flow of the receiving water is equal to the $7Q_{10}$.

The 7Q10 for the downstream end of the listed reach, CR 25.0, is about 0.4 cfs. At this low flow rate, there is no flow in most of the channel, and backwater conditions are generally experienced in the downstream end of the channel (where the DO violations occur) due to the topography and elevation of the downstream lake, Lake Betsy. Further, at 7Q10 flows to the channel are limited to ground-water inflow, non-point source loading is zero, so no achievable load reductions could be assigned there.

The critical condition was determined from monitoring data to be during late summer with high temperatures and low flows between 0 and 10 cfs at the downstream end of the channel. Further, the critical condition and therefore the DO TMDL is set only for the portion of the channel over which the impairment was observed between the outlet of Kingston Wetland and Lake Betsy Inlet (Figure 3.1, CR 29.0 to CR 25.0).

Figure 3.1 Impaired Portion of Listed Reach



4.0 Source Assessment

An assessment of sources of oxygen demand in the watershed is discussed in this section. The sources are exclusively non-point source in nature. There are no known point sources within the entire tributary watershed of the Clearwater River listed for DO. This is to say the whole drainage area of the river is clear of point sources. Oxygen demand sources in the watershed tributary to the listed reach of the Clearwater River include wetland sediment oxygen demand (SOD), agriculture and associated land practices including feedlots and pasturing, crop farming and drain tiles, as well as residential and urban storm water runoff, and septic systems.

4.1 SOURCE DESCRIPTIONS AND RESULTS

4.1.1 Wetland SOD

The downstream portion of the Clearwater River between CR 29.0 and CR 25.0 (Kingston Wetland to Lake Betsy) is wide and flat in slope, forming a 577-acre wetland complex. The 439-acre Kingston Wetland is located between CR 29.0 and CR 27.2. The 138-acre wetland between 27.2 and 25.0 is unnamed.

Hydraulically, flow velocities through the wetlands are lower and residence time is longer than in the upstream narrower parts of the channel, allowing phytoplankton and other nutrient rich material to settle out. These wetlands also support a thick growth of macrophytes, and most likely support healthy communities of benthic organisms and attached filamentous bacteria. The wetland habitants and their annual die-off contribute organic material to the sediments which requires oxygen for stabilization. These factors combine to make SOD a natural phenomenon in wetlands.

In agricultural areas of Minnesota, it is common to find channels ditched through wetlands where the stream flow only interacts with the wetland soils in high-flow conditions and otherwise is confined to a low flow main channel. In these cases, the stream may not be subject to SOD from riparian wetlands at low flow. This is the case in the wetland located between 27.2 and 25.0, downstream of Kingston Wetland.

The Clearwater River and riparian wetlands in the downstream reach were altered from pre-settlement condition on two separate occasions. First, the main stem of the Clearwater River was straightened and made deeper through the Kingston Wetland, and downstream wetland to facilitate drainage of fields for agriculture. The date(s) of these changes is not known. Then, in the early 1980s, the CRWD undertook a project in the Kingston Wetland to restore the wetland's assimilative capacity for phosphorus. Specifically, a dike was constructed to route stream flow to the edges of the wetland to allow it to filter through the wetland and back into the channel, removing particulate phosphorus and restoring hydrology to the wetland. The project was successful in improving water quality in downstream lakes over the past 30 years. Today the wetland acts as a sink for particulate phosphorus and is protective of water quality in downstream lakes. However, the wetland sediments exert oxygen demand and reduce dissolved oxygen in the main channel and at times exports soluble phosphorus to downstream lakes.

The un-named wetland downstream of Kingston is more like a traditional agricultural ditched system, however it is in connection with the main channel, more so at high flows.

Historic wastewater inputs can also be a source of nutrients to wetland sediments which can exacerbate natural SOD in wetlands. No historical sources to the Kingston wetland or downstream wetland were identified. Phosphorus sources to a wetland in the upper watershed near Watkins were identified during the Clearwater Chain of Lakes Restoration Project. This wetland historically was tributary to the very upstream reach of County Ditch 44 which eventually drains to the upstream-most portion of the impaired reach. However, the wetland was isolated during the Watkins Wetland Isolation Project which occurred in 1987 and is no longer in hydraulic connection with County Ditch 44. There are no current or relevant historic sources to these wetlands, indicating that the condition is natural or background.

The contribution of wetland SOD to the DO impairment in this listed reach is supported by the following findings:

- Data collected shows that DO violations only occur between CR 27.2.0 and CR 25.0, the area where the Clearwater River runs through large wetlands, during late summer low flow conditions
- The naturally flat topography of this reach, and wide channel provide low flow velocities and allow for settling of organics further enriching bottom sediments.
- The high residence time in this area (relative to residence time in other areas of the channel which are more narrow) and enriched sediments that naturally occur in wetlands increases SOD
- The bacteria impairment in this reach, coupled with the other impairments in the watershed, previous alterations to the wetland and main stem and the dominance of agricultural land use in the watershed suggest that though SOD can be a natural occurrence, in this case a TMDL is necessary to address DO concentrations.

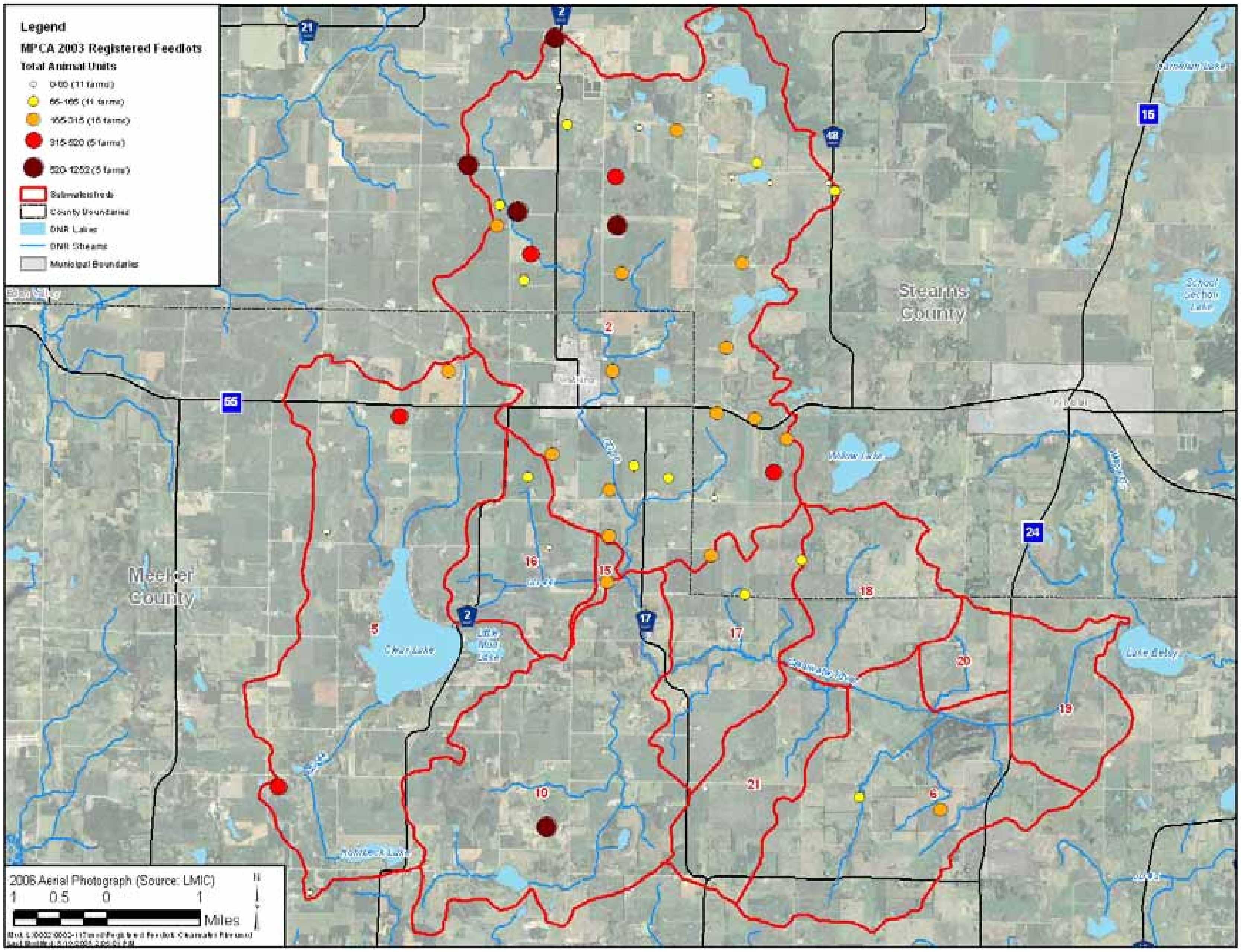
4.1.2 Livestock

Sources of oxygen demand from livestock include several categories such as feedlots, overgrazed pastures, surface application of manure and incorporated manure. There are 48 registered feedlot operations within the watershed, their locations within the watershed and associated animal units are presented in Figure 4.1.

Livestock were determined to be a source of bacteria identified in the bacteria TMDL. Livestock in the stream and the riparian corridor were shown to be driving exceedances of the acute fecal coliform standard of 2,000 CFU/mL, while manure spreading and distributed livestock throughout the watershed were linked to exceedances of the chronic standard of 200 CFU/ mL.

Transport mechanisms are similar for oxygen demand and bacteria, this indicates that organic matter from livestock operations is entering the stream and may be impacting DO in the stream. This indicates that through the bacteria TMDL, livestock are a source of oxygen demand.

Figure 4.1 Registered Feedlots in the Watershed Tributary to the Listed Reach of the Clearwater River between Clear Lake and Lake Betsy



4.1.3 Crop Farming

Corn and soy bean rotation are the primary row crops in the watershed tributary to the portion of the Clearwater River between Clear Lake and Lake Betsy. The high in-stream concentrations of $NO_2 + NO_3$ indicate that crop farming is a source of nutrients, bacteria and oxygen demand to the stream. Organic and ammonia nitrogen in animal waste also contributes to $NO_2 + NO_3$ through the process of nitrification. In areas where surface manure is applied to crop fields, open tile inlets can serve as a transport mechanism to deliver nutrients, bacteria and oxygen demand to the Clearwater River and its tributaries.

4.1.4 Surface Manure Application

Manure from animal feedlots is applied to the landscape through one of two methods, surface application or liquid incorporation. Large hog, beef or dairy feedlot operations typically have a liquid manure pit and these operations use liquid incorporation to apply manure. However, there are very few of these large feedlot operations within the Clearwater River watershed between Clear Lake and Lake Betsy. The vast majority of feedlot operations in the listed portion of the watershed are small to medium sized beef, dairy and hog operations. These farms surface apply manure, typically starting in mid to late fall after harvesting is complete with surface manure applications continuing through the winter. Surface applied manure is worked into the soil with agriculture tillage equipment, which may take place immediately after application but may be delayed until the spring immediately prior to planting.

No specific information on application rates is available other than to say that local farmers report no hauling of manure to farms outside the drainage area. Animal waste produced in the drainage area, stays in the drainage area.

4.1.5 Subsurface Sewage Treatment Systems (SSTS) and Human Waste

Failing or nonconforming septic systems can be an important source of oxygen demand especially during dry periods when these sources continue to discharge and runoff driven sources are not active. No homes, and therefore no septic systems, are located close enough (within 1,000 feet) to the Clearwater River to be a source of bacteria to the Clearwater River in the impaired reach.

Wastewater from the City of Watkins and most of the homes ringing Clear Lake are routed to the waste water treatment plant (WWTP) at Watkins and land-applied north of the City outside of the area tributary to Clearwater River and is therefore not a source of oxygen demand.

Seven homes on the southeast portion of Clear Lake are not connected to the sanitary sewer in this area and are reported to be using newly installed SSTS. These homes are not thought to be a source of oxygen demand to the Clearwater River. These assumptions are supported by the absence of optical brighteners (a florescent white dye added to laundry soap) in the Clearwater

River. The dye indicates the presence of household washwater, a primary component of septic system discharge, in surface waters. The absence of the dye in the Clearwater River, coupled with low C-BOD, N-BOD, bacteria concentrations, and lack of DO violations in this reach of the river over the flow period indicate that septic systems around Clear Lake are not a contributor to the DO impairment on the Clearwater River.

4.1.6 Urban and Residential Stormwater Runoff

There is relatively little urban and residential area in the portion of the Clearwater River watershed tributary to the listed reach. Urban and developed lands comprise approximately 10 percent of the total area. Consequently, urban and residential stormwater is a relatively small proportion of oxygen demand in this watershed.

One urban area, Watkins, lies within the watershed tributary to the Clearwater River between Clear Lake and Lake Betsy. The City of Kimball lies within the CRWD, however it is located within a subwatershed that drains into Lake Betsy via Willow Creek which enters the lake downstream of the listed reach of the Clearwater River. Therefore runoff from the City of Kimball is not a contributing source of oxygen demand considered in this TMDL.

Watkins storm water enters the Clearwater River via County Ditch 20, between monitoring stations at CR 33.8 and CR 31.8.

4.2 LINKING WATER QUALITY TARGETS AND SOURCES

A key aspect of a TMDL is the linkage between the pollutant sources and the selected water quality target or instream loads. Establishment of this linkage provides for the quantification of the assimilative capacity of the stream while still supporting state water quality standards. This linkage allows for loads or load reductions to be allocated among the sources that will ultimately result in the water body meeting standards. The linkages can be obtained through intensive modeling and/or through the use of qualitative assumptions backed by a sound understanding of pollutant dynamics in the watershed. Both techniques require significant professional judgment and selection of terms based on assumptions.

4.3 SELECTION OF MODEL AND TOOLS

Watershed sources of oxygen demand were quantified through measurement and data collection. An extensive hydrologic, hydraulic and water quality monitoring program was implemented in 2005 and 2006 to quantify these sources.

The remaining oxygen sources and sinks for the river, such as SOD were quantified through modeling in-stream water quality using the EPA’s QUAL2K (Version 2.07) modeling framework. The QUAL2K model is a windows version of the EPA’s QUAL 2E model and is widely accepted for simulating DO in rivers and for setting DO TMDLs. It is a one-dimensional, longitudinal, steady state model. The QUAL2K model was selected to:

- Quantify the SOD contribution in downstream wetlands
- Determine the steady state assimilative capacity of the Clearwater River during low flow condition to determine necessary load reductions

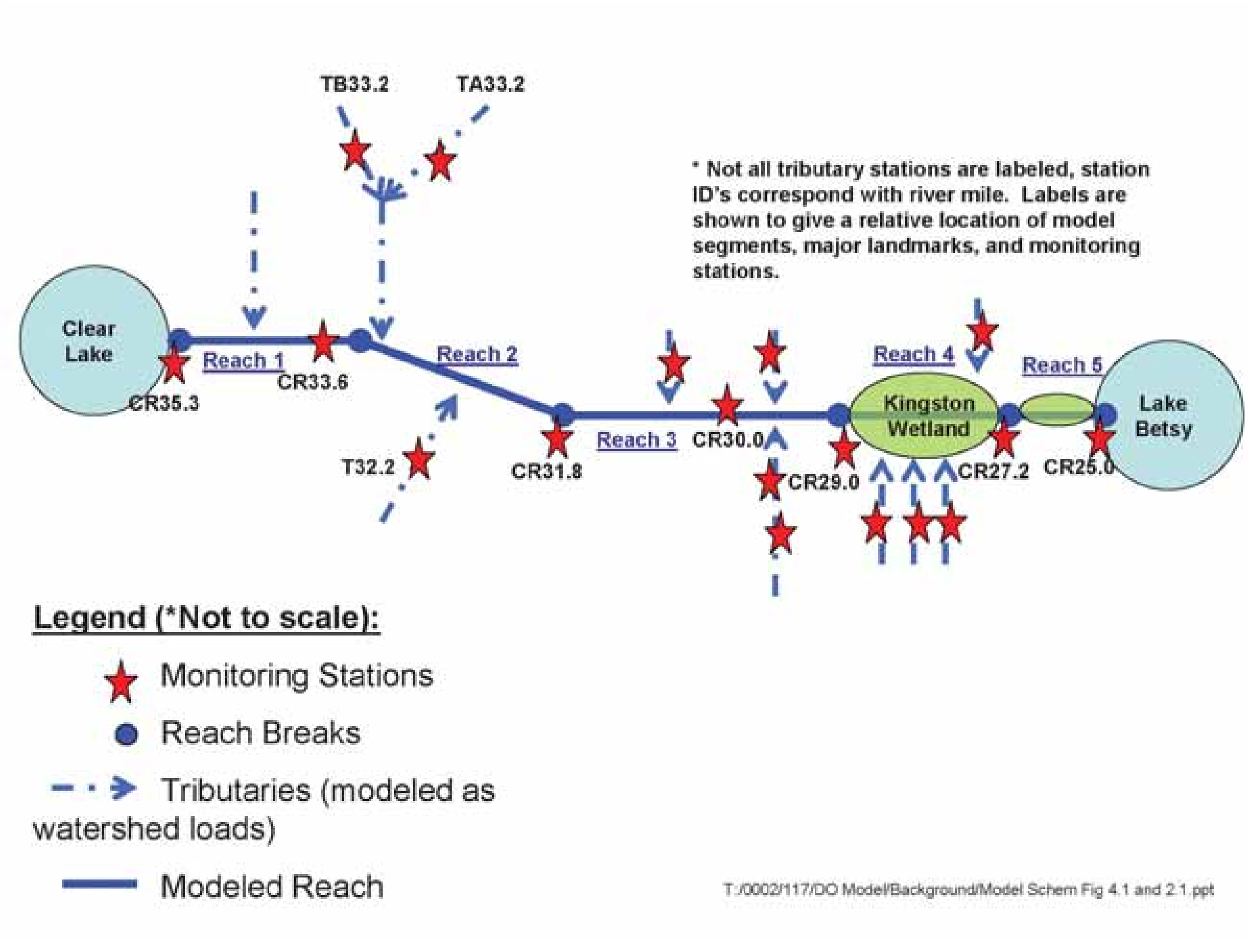
A general discussion of model input, calibration, and results is presented in Section 4.3.1 of this report. A more detailed description of the modeling effort is included with supplemental information such as tables, figures, model input/ output and other attachments are included as Appendix A to this report.

4.3.1 QUAL2K Model Configuration, Boundary Conditions and Initial Conditions

The QUAL2K model includes one main stem reach extending between Clear Lake and Lake Betsy with five segments (Figure 4.2). Model segments were selected based on natural breaks in channel slope, topography, and other characteristics (Section 2.3 Table 2.2). The many small tributary inflows along the listed reach were modeled as distributed non-point sources representative of the watershed load for each segment, i.e. no tributaries were explicitly modeled.

The upstream most portion of the listed Reach (Reach 1), is not represented in the fall calibration model run representing critical condition because there is no flow in this section during critical condition, and QUAL models cannot simulate that condition. This reach is modeled in the spring model validation run representing the spring synoptic survey.

Figure 4.2 Model Configuration



State variables in the QUAL2K model include DO, C-BOD, nitrogen series and phosphorus. Model processes include C-BOD decay, nitrification, reaeration, and SOD. Model inputs include flow rates and concentrations from distributed non-point sources, headwater inflows and groundwater inflows. The inputs were derived from data collected during the synoptic survey and in the case of groundwater inflow concentrations, literature values and well records.

The model was calibrated and validated to the main stem of the Clearwater River using data collected during the 2005 and 2006 synoptic surveys. The model simulated the critical flow period as identified by the data collected, this was late summer low flow where flows were less than 10 cfs.

First, the models were calibrated to match time of travel, depth and flow measurements in the synoptic survey. Then the nutrients and BOD were calibrated. Kinetic coefficients used were either literature values, or determined using in-stream DO, BOD and N concentrations. Equations are used to estimate reaeration rates, the DO exchanged between the atmosphere and water column, from measured, reach specific hydraulic data.

The key assumption for this modeling effort is that the system is in equilibrium, everywhere except for the area between the outlet of Kingston Wetland and Lake Betsy. Equilibrium is assumed in the system because no point sources contribute to oxygen demand, and data collected during Phase II show that C-BOD, TKN and DO concentrations are similar from upstream to downstream (Figures 2.5- 2.7). The reach between Kingston Wetland and Lake Betsy is not in equilibrium due to SOD in the 577-acre wetland complex.

In agricultural areas of Minnesota, it is common to find channels ditched through wetlands where the stream flow only interacts with the wetland soils in high-flow conditions and otherwise is confined to a low flow main channel. In these cases, the stream may not be subject to SOD from riparian wetlands at low flow. That is not the case for the critical reach of the impaired stream. The main stem of the Clearwater River through Kingston Wetland is routed around the wetland complex and fed into the wetland, so stream flow is routed over the entire wetland area and the hydrology of the wetland is restored to a pre-settlement condition.

The wetland between Kingston wetland and Lake Betsy has slightly less channel water/ wetland than the Kingston wetland. The exposure to wetland sediments and SOD generally appears to correlate to flow (less flow = less interaction) unless there is a backwater condition where the level of Lake Betsy is higher and prevents discharge from this wetland. Saturated conditions were observed in this wetland during all Phase II site visits.

Because data shows that SOD in the downstream wetland complexes is the driver of the impairment, and that the impairment is limited to the downstream section of the river, the primary role of the model is to quantify wetland SOD implicitly, given that watershed sources were quantified through field data collection, and no point sources exist. The model was then used to determine assimilative capacity.

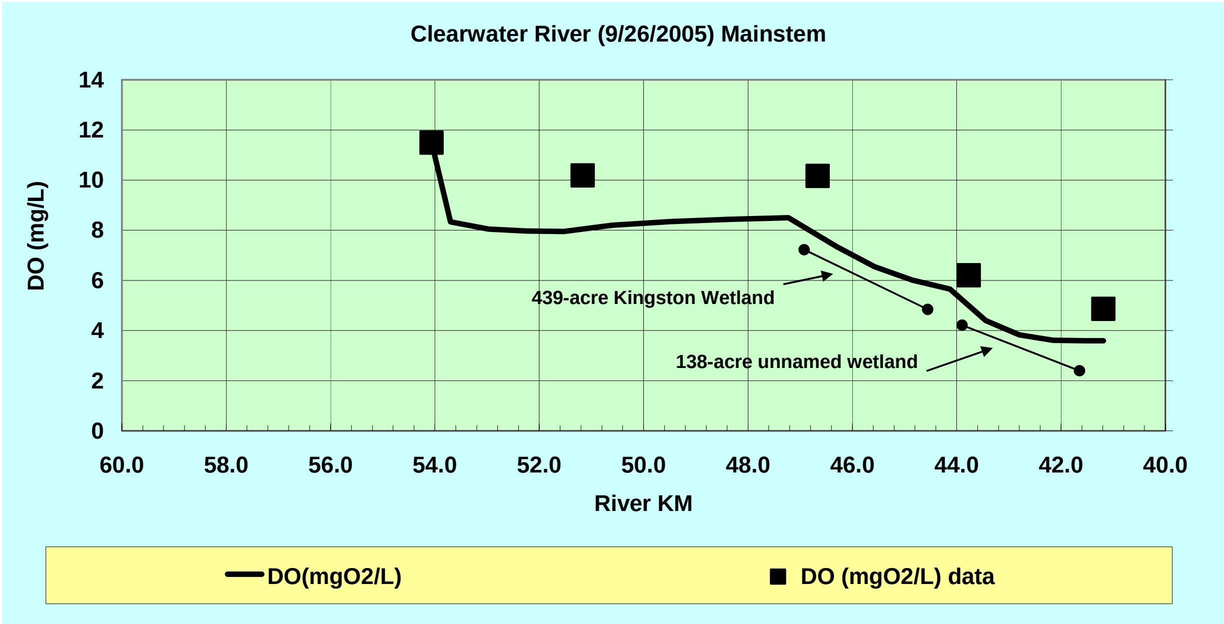
To quantify SOD, the upstream portion of the model was first calibrated to data collected during the fall synoptic survey. The SOD in the wetland area was then adjusted upwards to match observed DO concentrations downstream of the wetland.

Model inputs were derived from synoptic surveys, special studies, and in limited cases, literature values. The origins of model inputs are described in Appendix A. Model input and results were compared with historical data, export coefficients to check the realism and reasonableness.

4.3.2 Model Calibration and Validation

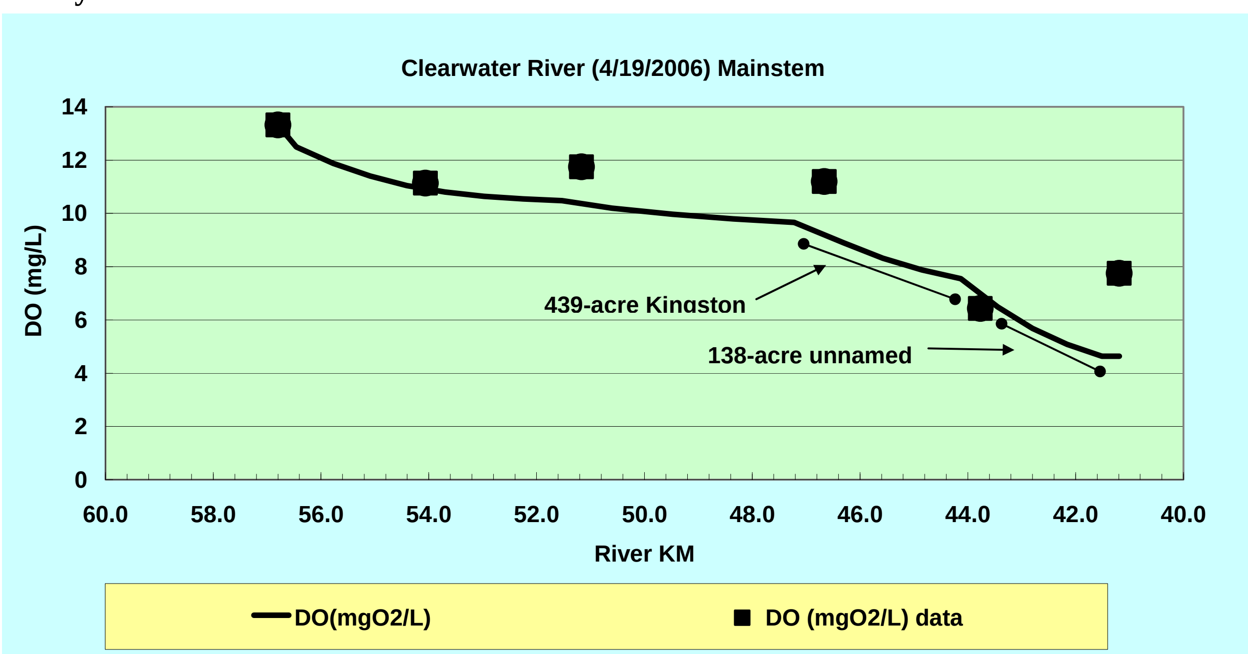
The model was calibrated to the critical condition late summer low flow synoptic survey conducted in September 2005. Modeled and measured DO concentrations are shown in Figure 4.3. The model calibration fit well to measured data. Data fit extremely well in the downstream reach, and slightly under-predicted DO concentrations in the upstream reach. In terms of a DO TMDL and the load allocations, the under prediction in the low flow critical condition is conservative.

Figure 4.3 Modeled vs. Measured DO Concentrations for Model Calibration- September 2005 Survey



The model was validated using the spring synoptic survey conducted in April 2006. Figure 4.4 compares modeled and measured DO from the model validation run. The model results from the validation run also fit well to measured data, better in the upstream reach than the downstream reach. The combination of the calibration and validation results indicate a good model fit.

Figure 4.4 Modeled vs. Measured DO Concentrations for Model Validation- April 2006 Survey



5.0 Load and Wasteload Allocations

The DO TMDL for the Clearwater River between Clear Lake and Lake Betsy will be expressed in the form of C-BODu, N-BOD (decay of both ammonia and organic nitrogen), and SOD. The N-BOD loads were calculated as 4.33 times the sum of ammonia nitrogen (NH3-N) plus organic nitrogen (ON). The assumption is that all ON ultimately decays to NH3-N. The factor 4.33 is the stoichiometric ratio (mass basis) of oxygen to nitrogen that was used in the QUAL2K modeling. The SOD component was integrated over the stream bed area of the wetland reaches and reflects temperature correction for the ambient conditions of the projection simulation.

The linkage of the impairment to the source, as well as the load and wasteload allocations are based on thorough evaluation of data collected during synoptic surveys and regular seasonal monitoring, as well as through the QUAL2K modeling effort. The data and the model show that:

- ❖ The DO impairment is limited to the area between Kingston Wetland Outlet and the inlet of Lake Betsy, CR 27.2 and CR 25.0
- ❖ The Clearwater River in the area of the Kingston Wetland has been altered from its natural state, first to facilitate agricultural land uses, and again to restore the wetlands phosphorus assimilative capacity
- ❖ The DO impairment is the result of multiple sources including:
    - SOD in the wetlands riparian to the downstream section of the Clearwater River
    - Existing channel morphometry, specifically the flat grade of the downstream end of the river and occasional backwater conditions
    - Documented anthropogenic impacts in the watershed as demonstrated by the presence of other impairments in the reach and the surrounding watershed and the dominance of agricultural land use.
- ❖ Mitigating the DO impairment requires addressing both SOD and watershed sources of OD.
- ❖ There are no individually permitted point sources in the watershed; however the MPCA requires that a WLA greater than 0 be provided for NPDES construction, and WLA’s of 0 be designated for present and future waste water treatment facilities which currently rely on land application.

5.1 EXISTING LOADS

The existing loads to the river under late summer, low flow critical conditions were determined using the September 2005 model calibration and are tabulated in terms of C-BOD, N-BOD, and SOD in Table 5.1.

Table 5.1 Existing Daily Oxygen Demand Loads to the Clearwater River between Clear Lake and Lake Betsy during Late Summer, Low Flow Critical Condition

	CBOD (lbs/day)	NBOD (lbs/day)	SOD (lbs/day)
Watershed Load	545	123,254	--
Groundwater	2	24,349	--
SOD	--	--	812
Total	547	147,603	812

T:\0002\117\DO Model\Background Data\[Eq. SOD calculation.xls]Existing Load Assim Cap

5.2 ASSIMILATIVE CAPACITY

To determine the assimilative capacity, existing oxygen demand during the September 2005 critical condition was adjusted downwards until in stream DO concentrations downstream of Kingston Wetland met standards. As discussed previously, the DO violations are limited to a portion of the listed reach between CR 29.0 and CR 25.0. The DO concentration at the critical station, CR 25.6, was 4.31 mg/ L at 10:30 AM on September 26, 2005 and 5.41 mg/L at 10:45 AM on September 27, 2005 for an average concentration of 4.86 mg/L (the calibration event is based on average conditions for data collected over those two days).

First, watershed non-point source C-BOD and N-BOD were simultaneously reduced by 20%, 40%, 60% and 80%. Then watershed loads were set back to existing conditions and SOD was reduced by 20%, 40%, 60% and 80%. The resulting modeled DO concentrations at the critical location, CR 25.6 were then compared to the standard and are tabulated in Table 5.2.

Table 5.2 Load Reduction Scenarios

	DO at CR 25.6 for each Scenario	
DO Reduction (%)	**Watershed Load Reduction**	**SOD Load Reduction**
No reduction	Measured: 4.31 mg/L DO Modeled: 3.59 mg/L DO	Measured: 4.31 mg/L DO Modeled: 3.59 mg/L DO
20% Reduction	Modeled: 4.06 mg/L DO	Modeled: 4.25 mg/L DO
40% Reduction	Modeled: 4.64 mg/L DO	Modeled: 4.86 mg/L DO
60% Reduction	Modeled: 5.42 mg/L DO	Modeled: 5.63 mg/L DO
80% Reduction	Modeled: 6.12 mg/L DO	Modeled: 6.37 mg/L DO

Continuous DO meters installed at the outlet of Kingston Wetland during late August showed that average diurnal DO fluctuations downstream of the wetland were 2.7 mg/L in 2006. It is necessary to account for these diurnal DO variations in the TMDL to ensure the daily low DO concentration does not violate the DO standard of 5 mg/L. However, the model does not incorporate macrophytes, which, based on chlorophyll-a concentrations, account for the majority of diurnal DO variations in this system.

The DO at the Kingston Wetland outlet measured during the synoptic survey was something close to the lowest concentration of the day but not the daily low based on the time of day the sample was collected. Concentrations of in stream DO are typically at their lowest daily value shortly after sunrise which occurred at 7:09 AM during the September 2005 survey, data was collected between 10:30 and 10:45 AM. The highest daily DO concentrations during this period are measured in late afternoon, 5:00- 7:00 PM.

To account for diurnal DO variations in determining assimilative capacity, watershed and load reductions were made until DO concentrations at the critical location downstream of Kingston Wetland met or exceeded the 5 mg/L standard. While modeling shows that individual reductions in watershed load OR wetland SOD produce DO concentrations over 5 mg/L in the critical reach, the relative difference between model results and the state standard is within the uncertainty of the model and data collection efforts. As such, the simultaneous 60% reduction of watershed and SOD load was modeled.

Model results show that simultaneous 60% reductions of both watershed oxygen demand and wetland SOD bring modeled DO concentrations in the critical reach up from 3.59 mg/L to 8.18 mg/L. This scenario brings modeled downstream DO concentrations in line with measured and modeled upstream concentrations, mitigating for the wetland SOD and natural channel morphometry.

Watershed load reductions of similar magnitudes are required for the lake nutrient TMDLs in the upper watershed lakes which share a tributary watershed. Bacteria load reductions are also required to meet the Clearwater River Bacteria TMDL for the same reach. The transport mechanisms for nutrients, bacteria, and watershed oxygen demand are similar, so recommended watershed BMPs are the same.

Reducing wetland SOD is more complicated. Technologies to mitigate for the SOD are limited. The natural state of the channel and riparian wetland may have been a meandering low flow channel with flow accessing the riparian wetland during high flow/wet weather events. Restoring the channel to such a flow regime would limit exposure to wetland SOD in critical conditions and may reduce export of soluble phosphorus, while still offering the wet weather/ high flow reduction in total phosphorus that benefits lakes downstream by allowing higher flows to access the floodplain wetland and its phosphorus assimilative capacity. The costs and benefits of such a restoration of the channel to a more natural state should be evaluated.

Other potential methods for reducing SOD include dredging existing wetland sediments in the 577 acres wetland complex, re-routing the Clearwater River around the wetland, or mitigating for SOD through other physical stream channel improvements like improving re-aeration, or adding an aeration system. In any case the original restoration Kingston Wetland project should be evaluated with new water quality goals and standards in mind.

The assimilative capacity was determined to be 40% of existing total loads to provide a Margin of Safety (Table 5.3).

Table 5.3 Assimilative Capacity (Includes MOS)

	CBOD (lbs/day)	NBOD (lbs/day)	SOD (lbs/day)
Total	218.93	59,041.17	324.86

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5.3 TMDL ALLOCATION

Table 5.4 summarizes modeling results that show modeled DO concentrations in the critical reach improving from a modeled 3.59 mg/L to over 6 mg/L for an 80% reduction in either watershed or watershed SOD. While technically above the DO standard of 5 mg/L, the relative difference in modeled results the difference is within the uncertainty of model and data collection efforts. Therefore, large watershed reductions alone do not fully mitigate for the wetland SOD and channel morphometry and therefore may not achieve the standard.

Removing wetland SOD from the model entirely brings modeled DO concentrations at CR 25.6 up to 7.13 mg/L indicating that based on the change in channel morphometry which governs re-aeration and the watershed loads, there would still be a decrease in DO in this channel segment. This indicates that SOD, channel morphometry and watershed non-point sources each play a role in the impairment.

Therefore, to achieve the TMDL, simultaneous 60% reductions in watershed and wetland SOD required. The load allocation, shown in table 5.4, represents load reductions of 60% in watershed oxygen demand and 60% wetland SOD which would together result in DO concentrations at CR 25.6 of 9.12 mg/L. This concentration puts the stream back into equilibrium, in other words it brings downstream DO concentrations in line with concentrations observed upstream.

Though there are no permitted point sources in the watershed, the MPCA requires that a WLA greater than zero is provided to account for NPDES construction. The MPCA also requires WLA’s of zero be designated to existing and future waste water treatment plants in the area.

Table 5.4 TMDL Allocation

	CBOD (lbs/day)	NBOD (lbs/day)	SOD (lbs/day)
Waste Load Allocation			
NPDES Construction	2.18	493.01	0
Other	0	0	0
WLA	**2.18**	**493.01**	**0.00**
Load Allocation			
Watershed Load	215.90	48,808.43	0.0
Groundwater	0.85	9,739.73	0.0
SOD	--	--	324.9
LA	**216.75**	**58,548.16**	**324.86**
MOS- Implicit	--	--	--
RC	0.0	0.0	0.0
TMDL	**218.93**	**59,041.17**	**324.86**

T:\0002\117_2\[Copy of Eq. SOD calculation.xls]Existing Load Assim Cap

Options for reducing SOD include:

- ❖ Restoring the natural channel/ riparian wetland hydrology which presumably was comprised of a low flow meandering channel and riparian wetland which was flooded during wet weather. Such a system likely avoided both the issue of SOD reducing DO in the main channel and the release of soluble phosphorus, while maintaining the particulate phosphorus assimilative capacity of the wetland.
- ❖ Rerouting the Clearwater River to circumvent the wetlands in this reach. This would eliminate the natural nutrient trap and buffer the wetlands provide to downstream lakes that are currently impaired, namely Lake Betsy, Scott Lake, Lake Louisa, Lake Marie, Lake Augusta and Lake Caroline. Further it would destroy the hydroperiod of the wetlands.
- ❖ Dredging the existing wetland sediments to remove organic material is not feasible due to the large size of the wetlands. Also, deeper wetlands soils may also exert oxygen demand which may leave the same problem or make it worse.
- ❖ Channel re-aeration opportunities are limited in this section of the river due to the naturally occurring flat topography.

These options should be evaluated in a feasibility and design study. Whatever option is chosen to restore the Kingston Wetland, it is critical to maintain the phosphorus assimilative capacity in the wetland to protect downstream lakes.

5.4 MARGIN OF SAFETY (MOS)

The MOS is established to account for variability and uncertainty in the relationship between load and wasteload allocations and water quality. This MOS can be established through explicit quantification of variability or through implicit conservative assumptions in the analysis. In this TMDL an implicit margin of safety has been used based on conservative assumptions, and an explicit MOS in terms of the requiring conservative load reductions.

Conservative modeling and conservative load reductions for this TMDL are listed below:

- First, measured flows and water quality data was used to quantify watershed sources of oxygen demand. SOD was calculated through quantification of other sources, and the total OD. The use of literature values was minimized, and there were no calibration factors used. Using actual data instead of literature values reduces the uncertainty in the quantification.
- The model calibration and validation each fit the data well, though slightly under-predicted DO concentrations, therefore providing conservative over-predictions of the required load reductions.
- Though the model showed that reducing either watershed *or* SOD loads were sufficient to meet the state standard, reductions in both watershed and wetland SOD were identified to provide significant MOS. The model predicts that that these reductions will bring modeled DO concentrations in the critical reach up from 3.58 mg/L to 8.18 mg/L, which is greater than the 5 mg/L standard.
- Monitoring and adaptive management will be used both to evaluate watershed reductions and track effectiveness towards meeting the TMDL as well as for evaluating new

possible methods to reduce the wetland SOD. It is also recommended that the impact of the DO impairment on biota be evaluated in the stream to determine if capital improvements to the stream may improve aquatic habitat for refuge during low DO periods.

5.5 SEASONAL VARIATION

Seasonal variation was addressed by using the critical period in terms of flow regime, and temperature with the assumption that if the load allocations necessary to maintain DO concentration at the critical flow regime (which occurs rarely) can be achieved, DO concentrations will be maintained above state standards at all other seasons/ flow regimes as well.

5.6 FUTURE GROWTH

The population and land use practices within the listed portion of the Clearwater River watershed are not anticipated to change significantly. The City of Watkins is the only urban area that contributes directly to the listed portion of the Clearwater River. The City of Kimball is located in a sub-watershed that drains to the Clearwater River just below the listed reach, but is presented here to quantify general growth patterns expected in the area. The population within the City of Watkins in 2000 was 880 residents (Table 5.5).

Table 5.5 Population Growth Estimates for Urban Areas in the Clearwater River Watershed

Urban Populations 2000	2000	2008 (estimated)	Percent Change
Watkins	880	950	+8%
Rural Population	1077	1142	+6%
Kimball*	635	673	+6%

* The City of Kimball is located is a subwatershed that drains to the Clearwater River just below the listed reach.

Based on estimates received from the City of Watkins, the State of Minnesota Demographer estimates the 2008 population at approximately 950. This represents approximately eight percent growth since the year 2000. The 2000 population census data from the US Census Bureau reveals that the rural population in the listed watershed was 1,077 residents and the population of the City of Kimball was 635 residents.

Stearns County has recently completed its 2030 Comprehensive plan. Based on the plan, growth in Stearns County has been approximately six percent since the year 2000. The plan also estimates the population in the county in 2030, with an estimated growth rate of approximately

25 percent. However, the majority of growth in Stearns County is anticipated to be with the growth corridor along I-94, near the City of St. Cloud. The rural areas in Stearns County are anticipated to grow less, in the range of five to ten percent. Additionally the City of Watkins and Kimball anticipate similar growth over the next 10 to 20 years to that which has occurred over the last 20 years, which is approximately five to ten percent.

Land use changes in urban and rural areas can increase watershed export of oxygen demand, this can be addressed through development regulations. Changes in the human population should not change the load allocations provided in this TMDL because loads from septic systems are not allowed under current law and it is unlikely that future sources will be permitted to discharge into the listed reach. Consequently no provisions for changes in human population have been identified in this TMDL.

6.0 Public Participation

The CRWD sees public participation as critical to the process of implementing the TMDL to meet water quality standards. The public participation efforts for this TMDL study are summarized below. The work described below is collective for all the on-going TMDL studies in the CRWD.

6.1 TECHNICAL ADVISORY COMMITTEE

This TMDL study has proceeded in Phases: Phase I was a review of existing data, Phase II was collection of data to fill gaps, and Phase III is setting the load allocation. The decision to proceed in phases was made to ensure that the most efficient and technically sound path was taken towards completion of the TMDL. Workplans and reports from each phase received review and approval from the Technical Advisory Committee comprised of the MPCA technical staff in the Brainerd/Baxter and St. Paul offices, the CRWD, and the project consultant. This group met formally only once at the Brainerd/ Baxter office, but was effectively coordinated by the MPCA project manager Margaret Leach throughout the project.

6.2 STAKEHOLDER MEETINGS

Since the beginning of the TMDL process in 2003 District Administrator Merle Anderson has actively sought engagement from and communication with city, county, township, lake association, and individuals alike. His efforts took the form of attendance of the regular meetings of these groups, calls to group leaders, organizing special meetings of these groups for the purpose of making presentations, and preparation of materials for distribution (Appendix C). Presentations are available on the CRWD web site.

Administrator Anderson updated the members of these groups on the status of the TMDL and provided information on the cause of the impairments and on their roles in the conceptual implementation plan. The goal of these efforts was to leverage existing regulatory framework, and relationships to generate support for TMDL implementation efforts. Using existing governmental programs and services for TMDL implementation should provide a significant cost savings and efficiency. This work on the part of Administrator Anderson is an ongoing CRWD tradition to work with other government agencies and provide them with the support they need to protect water resources. Specific examples of this work in the recent past are listed:

- CRWD funded municipal stormwater studies for the Cities of Annandale, Kimball and Watkins wherein several opportunities for stormwater improvements were identified.

- CRWD funded design of a road pavement project in Maine Prairie Township to ensure protection of the near-by School Section Lake.
- Development review and comment for major cities and counties.
- CRWD offers additional incentives for riparian buffers, rain gardens and CRP on top of what is offered by other government agencies.

6.3 PUBLIC MEETINGS

Additionally, seven public meetings have been held to date. At each stakeholder meeting, the District Administrator and project consultant updated the stakeholders on the status of the TMDL and provided information on the cause of the impairment and on conceptual implementation plans. The results of the public participation meetings are summarized below:

February 18, 2003 in Annandale
Watershed District Managers, the District Administrator, the MPCA Project Manager, and the Wenck Project Manager presented information about the TMDL process and the Clearwater River and Lake Louisa TMDL Project specifically. A question and answer session followed the presentation. County Soil and Water Conservation District Representatives from Wright, Meeker and Stearns Counties were invited, along with representatives from the Cities of Kimball and Watkins. Citizen advisory group members were also invited. Wright and Meeker County representatives attended.

December 17, 2003 in Annandale
The Wenck Project Manager presented information about the TMDL process and the Clearwater River and Lake Louisa TMDL Project specifically. An analysis of existing data was presented. A question and answer session followed the presentation. County Soil and Water Conservation District Representatives from Wright, Meeker and Stearns Counties were invited, along with representatives from the Cities of Kimball and Watkins. Citizen advisory group members, and lake associations were also invited. A Meeker County representative attended, along with members of the Citizen Advisory Group, and Clearwater Lake Association.

March 16, 2004 in Watkins
An additional meeting was held to solicit additional stakeholder involvement. The Wenck Project Manager presented information about the TMDL process and the Clearwater River and Lake Louisa TMDL Project specifically. An analysis of existing data was presented. A question and answer session followed the presentation.

Meeting invitations and a letter describing the TMDL Project were sent to resident’s homes. County Soil and Water Conservation District Representatives from Wright, Meeker and Stearns Counties, as well as representatives from the Cities of Kimball and Watkins were invited. Citizen advisory group members and lake associations were invited. The goal of the meeting was to establish a representative stakeholder group. These representative stakeholders met two more times.

July 15, 2007 Clearwater Chain of Lakes Association, Lake Louisa Working Group
District Administrator Merle Anderson met with members of the Clearwater Chain of Lakes Association (CCOLA) to spark interest in a Lake Louisa working group. This group of citizens heard a summary of the TMDL process and progress and agreed to discuss the Lake Louisa TMDL with residents to encourage interest and participation.

August 6, 2007, Clearwater Chain of Lakes Association, Lake Louisa Working Group
District Administrator Merle Anderson and Project Engineer Rebecca Kluckhohn met with 16 members of the Clearwater Chain of Lakes Association (CCOLA). This group is comprised of Lake Louisa and Lake Marie residents concerned with upstream water quality. Each resident expressed concern about the perceived deterioration of water quality in the entire Chain of Lakes. Most residents had moved to the area since the major improvements in water quality in the 1980s as the result of the Clearwater Chain of Lakes Improvement Project. Residents speculated that many septic systems around the lakes needed replacement, but that costs would be prohibitive for several residents. Residents also expressed concerns about livestock allowed to graze in and near the lakes and the Clearwater River.

August 10, 2007, Clear Lake Citizenship Dinner
The CRWD's 6^{th} Annual Citizenship Dinner was held at the Sportsman's Center at Clear Lake. Residents in the area of Clear Lake, the upstream boundary of the listed reach of the Clearwater River, attended this meeting. Manager Anderson and District Engineer Norm Wenck listened to residents and answered questions about water quality in Clear Lake.

October 3, 2007, Meeting with the Chain of Lakes Association
A meeting with the Chain of Lakes Association to go over Phase II Report and answer questions. Provided discussion topics for their next meeting.

April 16, 2008, Public Meeting
A public meeting to present the findings of the TMDL studies was held April 16, 2008 at Annandale Middle School. Representatives from all areas impacted by the TMDLs attended this meeting, including representatives of Lake Betsy, Union Lake and Scott Lake, two members of the Clear Lake Association, and members of the Chain of Lakes Association representing Lakes Louisa and Marie. The CRWD District Administrator, project consultant, MPCA project manager and Communication coordinator were also present to answer questions about the TMDL process and outcome.

August 2, 2008, CRWD Summer Tour
CRWD hosted a tour for 81 watershed residents to view watershed projects including rain gardens, buffers, sedimentation basins, fish migration barriers. Implementation of TMDLs were discussed.

7.0 Reasonable Assurance

When establishing a TMDL, reasonable assurances must be provided demonstrating the ability to reach and maintain water quality endpoints. Several factors control reasonable assurances including a thorough knowledge of the ability to implement BMPs as well as the overall effectiveness of the BMPs. Clearwater River Watershed District is best positioned to implement the TMDL and ultimately achieve water quality standards.

The Clearwater River Watershed District is the water management authority for the Clearwater River and its tributary watershed. The CRWD is uniquely qualified through its knowledge of the watershed to implement corrective actions to achieve TMDL goals.

Several of the implementation strategies are already part of the District's existing programs to improve water quality such as education, grants for pasture management, riparian buffers, and rain gardens, assistance to municipal partners for stormwater management, follow up water quality monitoring. The District's stable framework of existing programs provides funding for TMDL Implementation each year. Further, watershed BMPs recommended to meet bacteria and nutrient load reductions will provide benefit in terms of meeting the 60% watershed load reduction in oxygen demand goals.

8.0 Monitoring Plan

The CRWD measures lake water quality, precipitation, stream flow, stream water quality, and nutrient and sediment loads at three long-term monitoring stations and reports results annually. This monitoring program described in detail in Appendix B will continue, and is generally sufficient to track significant water quality trends, assess progress towards goals and make adjustments towards adaptive management.

Adaptive management is recommended here, monitoring and reporting conducted to support adaptive management will:

- Evaluate the aquatic habitat and the impacts of the DO impairment on aquatic wildlife, and periodically evaluate the options for mitigating wetland SOD,
- Track progress towards goals and effectiveness of BMPs,
- Prevent backsliding, and
- Monitor watershed sources of oxygen demand and other target parameters such as nutrients and bacteria.

In addition to the District's regular Annual Monitoring Program, the CRWD sometimes implements special monitoring to track success of individual projects, or to investigate specific water quality concerns. Supplemental monitoring of this nature is expected throughout the course of TMDL implementation. The following recommendations are made to supplement the annual monitoring plan (note that some of these items are in reference to other TMDL studies ongoing in the CRWD):

- Assess special monitoring needs annually based on implementation projects, report findings in the Annual Monitoring Reports. This is an important tool for adaptive management.
- Evaluate the aquatic habitat and the impacts of the DO impairment on aquatic wildlife and periodically evaluate the options for mitigating wetland SOD
- Add *E.* Coli to the parameter list for stream water quality samples to assess progress towards meeting bacteria TMDL. Consider adding two sampling stations along the impaired reach of the Clearwater River. This will require close coordination of District sampling technicians to ensure holding times are met.
- Install a continuous pressure transducer at the watershed outlet at the Clearwater Dam and either Fairhaven Dam or County Road 15 to measure flows and annual runoff.
- Increase sampling frequency for the station downstream of the Kingston Wetland. The site is currently sampled monthly. Increase frequency in early high flow spring conditions to weekly monitoring. Lower flow regimes can be sampled monthly with 2-4 rainfall sampling events through the season. Increased sampling provides better tracking of DO and bacteria concentrations ad loads in the listed reach of the river and better quantification of nutrient loads to downstream impaired lakes to track. Both of which will allow better evaluation of progress made towards watershed goals.

9.0 Implementation

9.1 IMPLEMENTATION FRAMEWORK

The implementation plan to address the DO impairment is the same as that to address the nutrient and bacteria TMDLs in that it relies on watershed BMPs. Wetland SOD is not addressed at this time because no feasible method exists for addressing it or for improving stream re-aeration.

It is a preliminary implementation plan that will be finalized as required by the TMDL process, and updated as new data is collected and progress towards goals is tracked through annual and special monitoring programs.

Implementing all the TMDLs within the CRWD will be a collaborative effort between state and local government, and individuals led by the CRWD. To meet water quality standards the CRWD will leverage the existing regulatory framework and relationships to generate support for TMDL implementation efforts, providing technical support, funding, coordination and facilitation when needed. Efficiency and cost savings are realized by using existing governmental programs and services for TMDL implementation to the maximum extent possible.

9.1.1 Clearwater River Watershed District

The mission of the Clearwater River Watershed District is to promote, preserve and protect water resources within the boundaries of the District in order to maintain property values and quality of life as authorized by MS103D. To this end, the Districts Comprehensive Plan approved July 23, 2003, documents the District's goals, existing policies and proposed actions. One of the Districts stated goals is to bring all of CRWD surface water into compliance with state water quality standards, through the TMDL process.

Because the primary goal and mission of the CRWD is in line with the goal of TMDL implementation, many of the implementation strategies are extensions of existing CRWD programs and projects and can be funded using existing CRWD budgets. However, additional outside funding will be necessary. The recommended implementation plan to meet lake water quality goals and associated cost is described in the following section.

9.1.2 Counties, Cities, Townships

Partnerships with counties, cities, townships and lake associations are one mechanism through which the CRWD protects and improves water quality. The CRWD will continue its strong tradition of partnering with state and local government to protect and improve water resources and to bring waters within the CRWD into compliance with State standards.

9.1.3 MPCA/ BWSR

The CRWD recognizes that public funding to set and implement TMDLs is limited, and therefore understands that leveraging matching funds as well as utilizing existing programs will be the most cost efficient and effective way to implement TMDLs within the CRWD. The CRWD does project a need for 50% cost-share support from the Board of Water and Soil Resources or other sources in the implementation phase of the TMDL process.

9.2 REDUCTION STRATEGIES

The findings of this study indicate that feasible load reduction strategies are limited to watershed BMPs at this time. The required reductions in wetland SOD are not presently feasible.

The CRWD's existing programs provide the framework for implementation, but they will require additional funding to reach the level of implementation required to meet state standards.

Existing CRWD programs are typically aimed at phosphorus load reduction, however since the delivery mechanisms for phosphorus, bacteria and oxygen demand to surface waters are often the same, the same programs work for all impairments. Current CRWD phosphorus reduction programs that also target oxygen demand and bacteria are described, along with the additional work that will be needed to meet state water quality standards:

1. CRWD provides incentives for shoreline and farm buffers including rain gardens, and tile intake buffers. The farm buffers provide an additional incentive to farmers who enroll land in CRP. County Soil Conservation Districts provide technical assistance for buffer installation. The CRWD will expand this program and focus heavily in subwatersheds tributary to the listed reach.
2. Education and funding to implement agricultural BMPs should be expanded. The CRWD's education and outreach is extensive as documented in the public involvement section. The success of the programs listed above hinges on participation which is fueled by education. This program should be extended providing a CRWD staff person devoted to TMDL implementation.
3. Animal feedlot upgrade incentives and pasture management plan grants. In a recent example of this program, the CRWD awarded a land owner a grant for construction to prevent grazing animals from entering the Clearwater River. This program should be expanded to include a study to identify parcels for upgrade and approach land owners with incentives and education. Activities should be focused in the subwatersheds tributary to the listed reach.
4. CRWD works collaboratively with cities, counties and townships to provide funds for stormwater management. The Watkins Area Stormwater Management Study funded by the CRWD is an example of such collaboration. The study identified several options for stormwater management in advance of development in the area.

The conceptual implementation plan to reduce bacteria concentrations in the Clearwater River is presented below (Table 9.1). Strategies are recommended based on their relative cost and effectiveness given the current level of understanding of the sources of bacteria in the watershed and their delivery potential. Recommendations take into account findings from stakeholder participation. Cost share breakdown is expected to be 50% from the state and federal funds, 25% from the individual, and 25% from watershed budgets.

Table 9.1 Conceptual Implementation Plan and Costs

Practice	TMDL	Unit Cost	Units	Note	Qty	Cost
Promote Ag BMPs (P Testing and fertilizer application)	Nutrient, DO	$75,000	ls		1	$75,000
Sedimentation Ponds/ Impoundments (weirs)	Nutrients	$100,000	ea	Use existing land options and evaluate oportuntites as they arise	5	$500,000
Replace Tile Intakes w/ Filters	Nutrient, DO, Bacteria	$500	per intake	*evaluate limestone/steel wool filter intakes to increase P removal	400	$200,000
Tile Intake Buffers	Nutrient, DO, Bacteria	$100	per intake		300	$30,000
Buffer Tributaries	Nutrient, DO, Bacteria	$350	ac		300	$105,000
Buffer Stream Banks	Nutrient, DO, Bacteria	$350	ac		200	$70,000
Address DO Impairment for Clearwater River	DO		lf	*design and construct, operation		$500,000
Tile Discharge Management	Nutrient, DO, Bacteria	$130,000	ls	* Inventory, FS, design construct	1	$130,000
Riparian Pasture/ Grazing Management Grants	Nutrient, DO, Bacteria	$10,000	ea		15	$150,000
Street Sweeping: Kimball, Southaven, Fairhaven & Watkins	Nutrient, DO, Bacteria	$40	per curb mile	* high efficiency, 55 curb miles for 15 years		$ 1,125,000
Lakeshore Septic Upgrade Grants	Nutrient	$7,500	ea	All Impaired Lakes	130	$975,000
Lake shore restoration grants (Shore land Erosion)	Nutrient	$300	ea	*grants	300	$90,000
Shallow Lakes Management Plans for Marie, Clear, Swartout, Albion & Henshaw Lakes	Nutrient	$15,000	ea		5	$75,000
Carp Control	Nutrient	$25,000	average per year per lake	*Fish trap already installed at Louisa, harvesting under way in several impaired lakes (5 lakes, 6 yrs)	30	$750,000
Curly Leaf Pondweed Control	Nutrient			*Lake association cost, some cost share		$300,000
Lake Aeration	Nutrient			2 Existing aerators re-installed		$600,000
Alum dosing of Cleawater River upstream of Kingston	Nutrient, DO					$600,000
Hypolimnetic withdrawl (Betsy)	Nutrient					$350,000
Kingston Wetland Enhancement/ Channel Re-meander Investigation	Nutrient, DO					$450,000
South Haven Stormwater Enhancement	Nutrient, DO, Bacteria					$75,000
City of Kimball Stormwater Enhancement Per 2004 Kimball Area Stormwater Management Study	Nutrient, DO, Bacteria					$500,000
City of Watkins Stormwater Enhancement per 2006 Watkins Area Stormwater Management Study	Nutrient, DO, Bacteria					$800,000
Public Outreach	Nutrient, DO, Bacteria	$10,000	per year		10	$100,000
Implementation Project Management and Administration	Nutrient, DO, Bacteria	$30,000	per year		10	$300,000
Implementation Performance Monitoring, Recommendations for Adaptive Management	Nutrient, DO, Bacteria	$25,000	per year		10	$250,000
Implementation Engineering	Nutrient, DO, Bacteria	$15,000	per year		10	$150,000
T:\0002\Implementation 2010\[TMDL Implementation_FINAL.xls]August 08					**TOTAL:**	**$9,250,000**

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