Dissolved Oxygen TMDL for the Wintering River in McHenry and McLean Counties, North Dakota

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1.0 INTRODUCTION AND DESCRIPTION OF THE WATERSHED

Wintering River is located within the Mouse (Souris) River Watershed, in southwest McHenry and northeast McLean Counties, in north central North Dakota (Figures 1 and 2). The river is 207.8 miles long and its watershed has an area of 555,520 acres. The Wintering River and its watershed flow northward and empty into the Mouse (Souris) River. Table 1 summarizes some of the geographical, hydrological and physical characteristics of the Wintering River and its watershed.

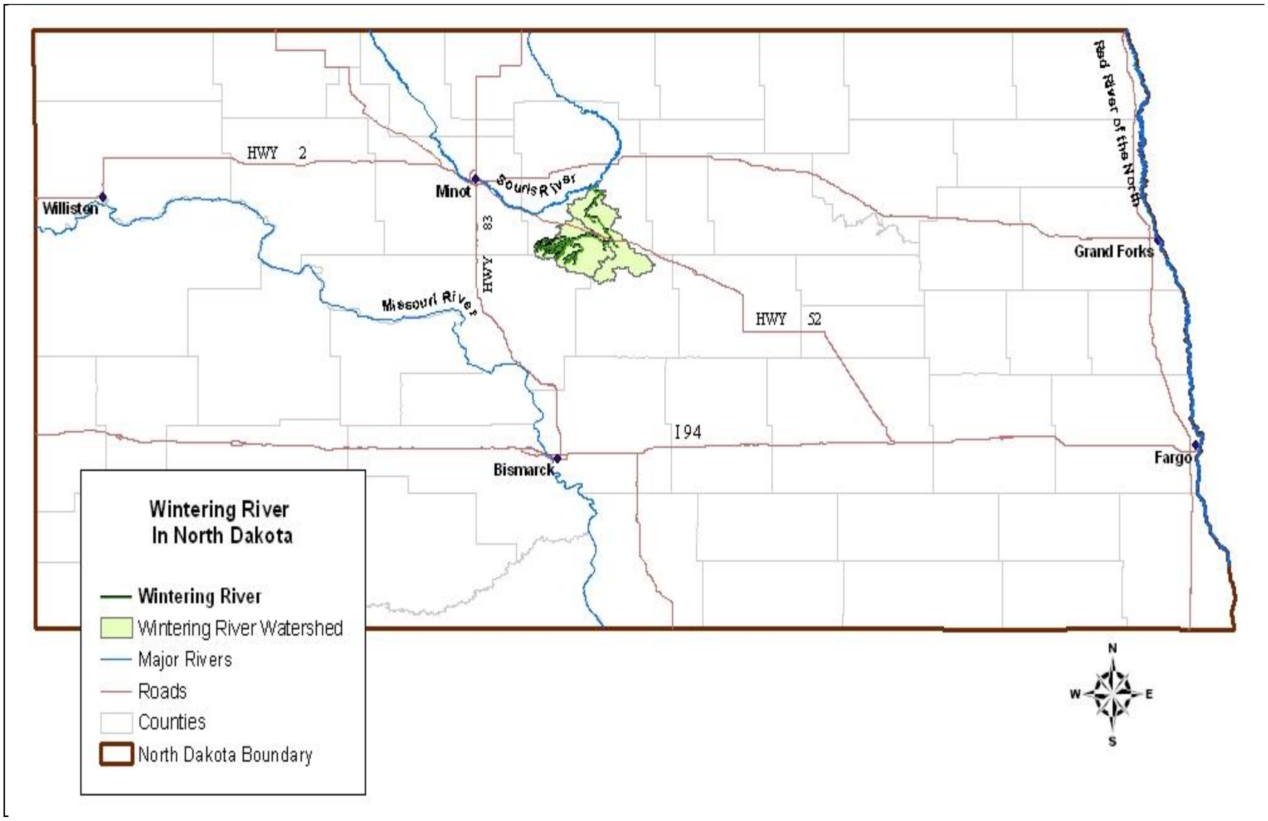


Figure 1. Location of Wintering River and its Watershed in North Dakota.

Table 1. General Characteristics of Wintering River and its Watershed.

Legal Name	Wintering River
Stream Classification	Class III
Major Drainage Basin	Mouse (Souris) River[1]
8 Digit HUC	09010003
Counties	McHenry and McLean Counties, ND
Eco-region	Level III: Northern Glaciated Plains (46) Level IV: Glacial Lake Deltas (46d) and Drift Plains (46i) [Small portion in Northwestern Glaciated Plains (42), Missouri Coteau (42a)]
Watershed Area	555,520 acres
River Miles	207.8 miles

[1] Recent local legislation passed that determined the river shall be called Mouse River on all identifiable signs. It is also known as the Souris River in Canada and to many state and federal agencies within North Dakota

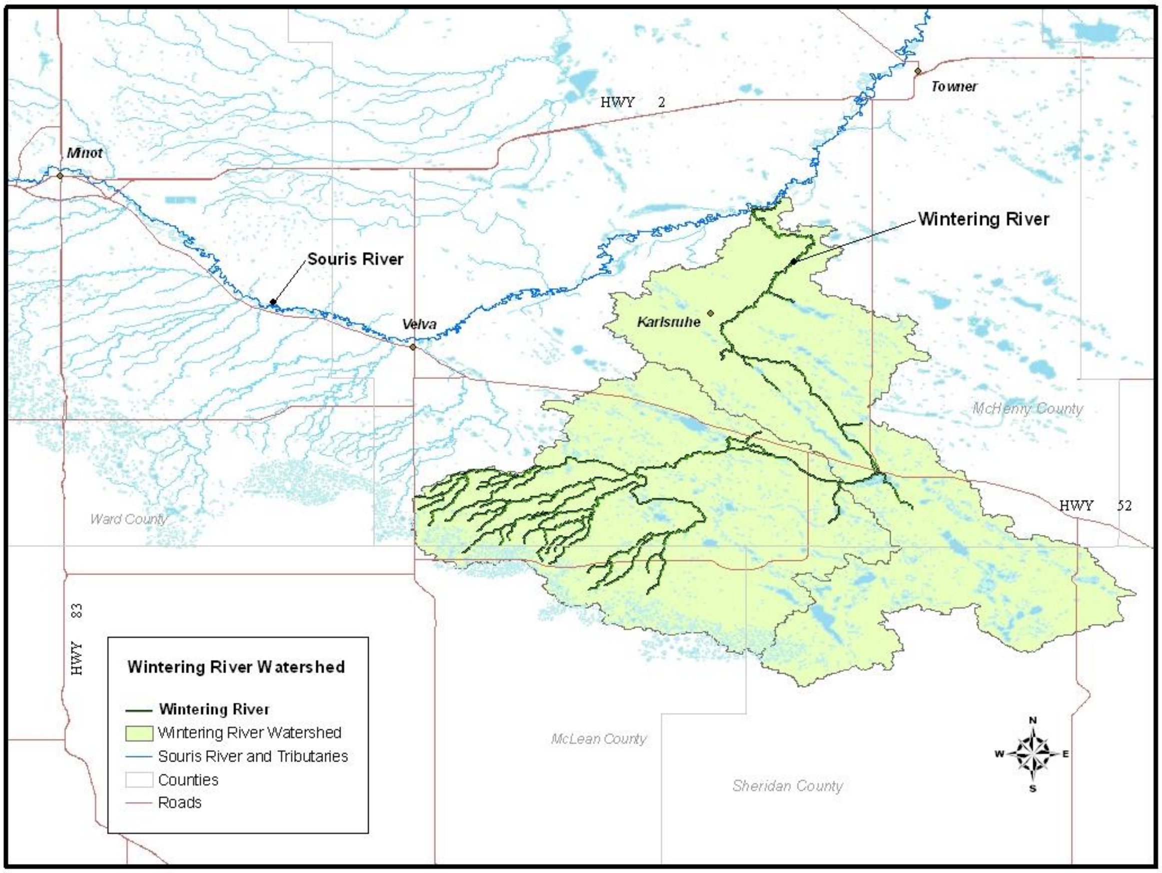


Figure 2. Location of Wintering River and its Watershed.

1.1 Clean Water Act Section 303(d) Listing Information

Based on the 2010 Section 303(d) list of impaired waters needing TMDLs, the North Dakota Department of Health (NDDoH) has identified the Wintering River as fully supporting, but threatened for fish and aquatic life beneficial use due to low dissolved oxygen levels.

Table 2. 2010 Section 303(d) TMDL Listing Information for the Wintering River.

Assessment Unit ID	ND-09010003-003-S_00
Waterbody Description	Wintering River, including all tributaries. Located in SW McHenry County and NE McLean County
Size	207.8 miles
Impaired Designated Uses	Fish and Aquatic Life
Use Support	Fully Supporting, but Threatened
Impairment	Low Dissolved Oxygen
Priority	High

1.2 Ecoregions

The Wintering River begins at Wintering Lake, southwest of Bergen, ND and flows east then north to the Souris River. Approximately 87 percent of the Wintering River watershed lies within the Drift Plains level IV ecoregion (46i), with ten percent in the Glacial Lake Deltas ecoregion (46d), and about three percent in the Missouri Coteau ecoregions (42a) (Figure 3).These all belong to the Northern Glaciated Plains (46) level III ecoregion.

The Drift Plains are characterized by generally flat to occasionally rolling topography with a thick layer of glacial till left behind by the Wisconsinan glaciers. Prior to cultivation, the Drift Plain grasslands were a mixture of tall grass and short grass prairie. There are a good proportion of temporary and seasonal wetlands throughout the watershed. The Glacial Lake Deltas were deposited by rivers entering glacial lake basins (e.g., Glacial Lake Souris). The heaviest sediments, mostly sand and fine gravel, formed delta fans at the river inlets. As the lake floors were exposed during withdrawal of the glacial ice, wind reworked the sand in some areas into dunes. In contrast to the highly productive, intensively tilled glacial lake plains, the dunes in the delta areas have a thin vegetative cover and a high risk for wind erosion. These areas are used mainly for grazing or irrigated agriculture. A small portion of the Missouri Coteau ecoregion is within the watershed. It consists of a glaciated, hummocky, rolling stagnation moraine. Stream drainage is absent or uncommon and there are numerous pothole wetlands between mounds of glacial till. Soils consist of thick glacial till over Tertiary sandstone and shale. Elevation in the watershed ranges from 1,080 to 2,000 ft (msl) (USGS, 2006).

The soils present belong to the Order Mollisols and are typically Barnes, Svea, Hamerly, and Parnell. Though the till soil is very fertile, agricultural success is subject to annual climatic fluctuations. (USEPA, et al. 1998)

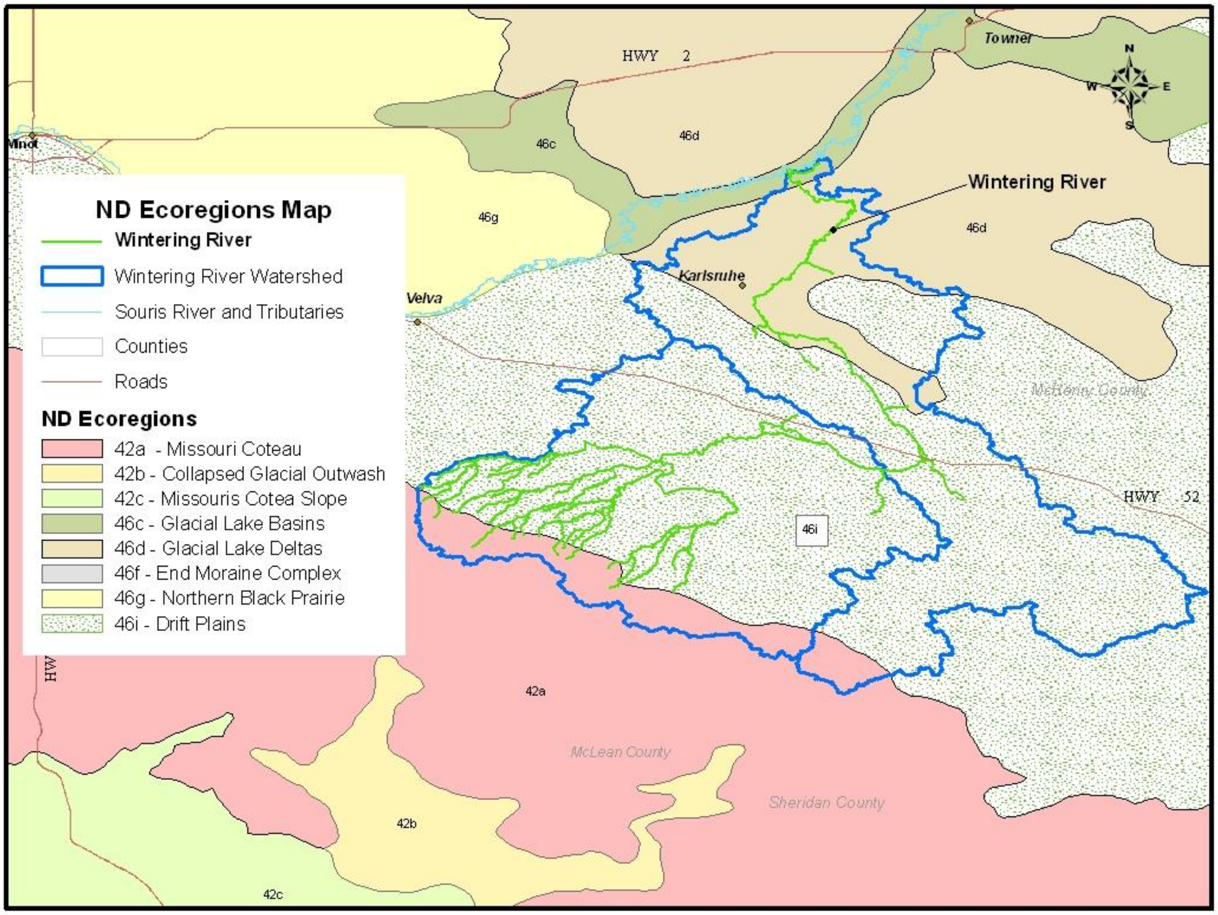


Figure 3. Level IV Ecoregions of the Wintering River Watershed.

1.3 Land Use

Land use data from the North Dakota Agricultural Statistics Service (NDASS, 2006) indicates that the watershed is primarily agricultural (84.6 percent), consisting of crop production and livestock grazing. Forty-three (43) percent of the agricultural land is actively cultivated, tilled mainly for durum, spring wheat, other small grains (e.g., rye, oats), and a variety of other crops (Table 4). Forty-one (41) percent of the watershed is pasture/range/haylands. Four (4) percent is low density urban development, while water and woods make up almost ten (10) percent of the watershed (Tables 3 and 4, Figure 4). There are no confined animal feeding operations (CAFOs) within the contributing drainage. There are 14 animal feeding operations (AFOs), of which two have undergone the State permitting process. While all CAFOs must obtain a permit, only those AFOs that have the potential to impact water quality are required to obtain a permit. For more details on operations requiring a permit, please refer to North Dakota State Century Code, Chapter 33-16-03.1-05.

Table 3. Major Land Use Categories in the Wintering River Watershed (based on 2006 NDASS data).

Major Category	Acres	Percent of Watershed
Agriculture/Cultivated	241,682.5	43.50
Pasture/Range/Hay	228,311.6	41.10
Urban/Barren	23,397.1	4.21
Water	46,507.2	8.37
Woods	9,683.5	1.74
No Data	5,938.1	1.07

Table 4. Land Use Types in the Wintering River Watershed (based on 2006 NDASS data).

Land Use Type	Acres	Percent of Watershed
Winter Wheat	804.62	0.15
Durum/SpringWheat	130,451.86	23.48
Rye/Oats/Other Small Grains	5,636.78	1.01
Beans/Peas/Lentils	62,195.10	11.20
Sunflowers	10,730.78	1.93
Corn	16,373.51	2.95
Potatoes	410.06	0.07
Mustard Seed	110.93	0.02
Flax	3,879.63	0.69
Canola/Safflower	11,149.20	2.01
Idle/CRP/Hayland	118,107.74	21.26
Pasture/Range	48,333.08	8.70
Alfalfa	61,870.83	11.14
Water	46,507.24	8.37
Woods	9,683.45	1.74
Urban	22,078.44	3.97
Barren	1,318.70	0.24
No Data	5,938.05	1.07
TOTAL	**555,520**	**100**

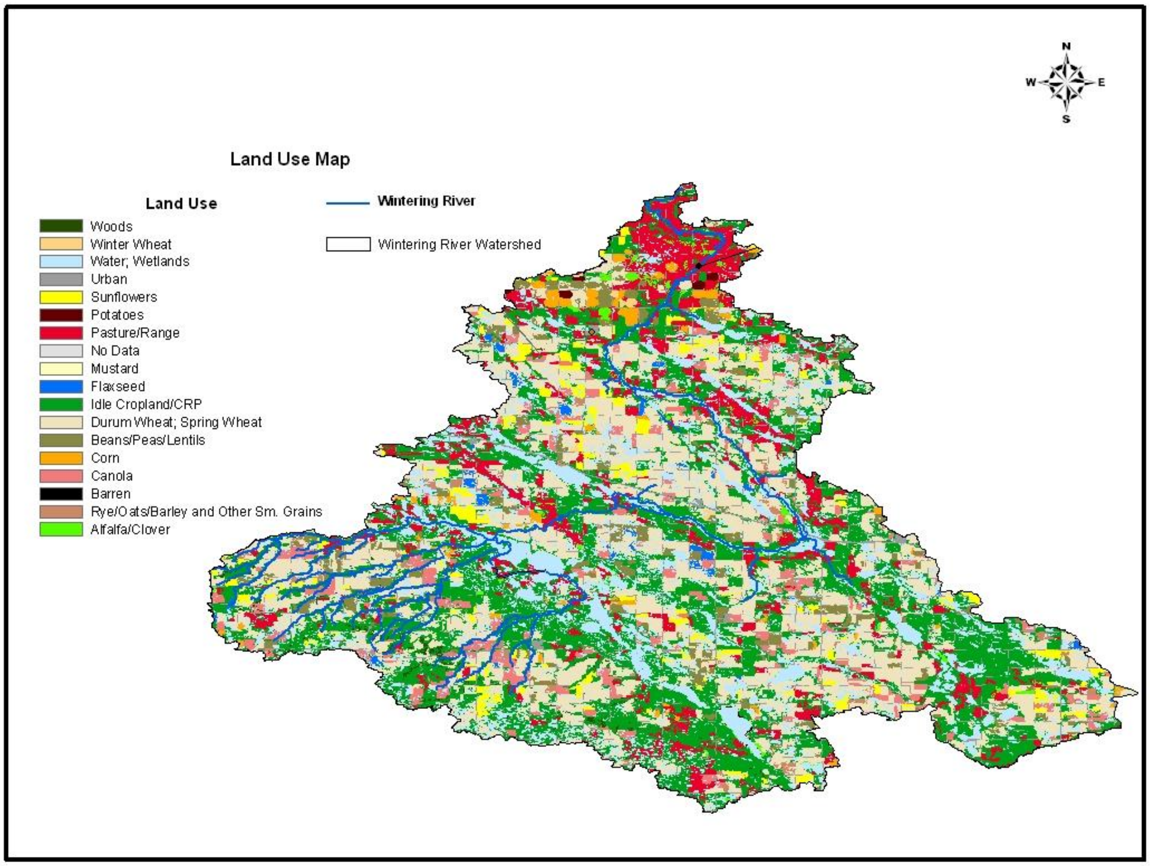


Figure 4. Land Use Map for the Wintering River Watershed (NDASS, 2006).

1.4 Climate and Precipitation

North Dakota's climate is characterized by large temperature variation across all time scales, light to moderate irregular precipitation, plentiful sunshine, low humidity, and nearly continuous wind. Its location at the geographic center of North America results in a strong continental climate, which is exacerbated by the mountains to the west. There are no barriers to the north or south so a combination of cold, dry air masses originating in the far north and warm humid air masses originating in the tropical regions regularly overflow the state. Movement of these air masses and their associated fronts causes near continuous wind and often results in large day to day temperature fluctuations in all seasons. The average last freeze in spring occurs in late May. In the fall, the first 32 degree or lower temperature occurs between September 10th and 25th. However, freezing temperatures have occurred as late as mid-June and as early as mid-August. About 75 percent of the annual precipitation falls during the period of April to September, with 50 to 60 percent occurring between April and July. Most of the summer rainfall is produced during thunderstorms, which occur on an average of 25 to 35 days per year. On the average, rains occur once every three or four days during the summer. Winter snowpack, although persistent from December through March, only averages around 15 inches (Enz, 2003). Historical average monthly precipitation data from the High Plains Regional Climate Center (HPRCC) can be seen for the Towner, ND station (about ten miles northeast of the watershed) in Figure 5.

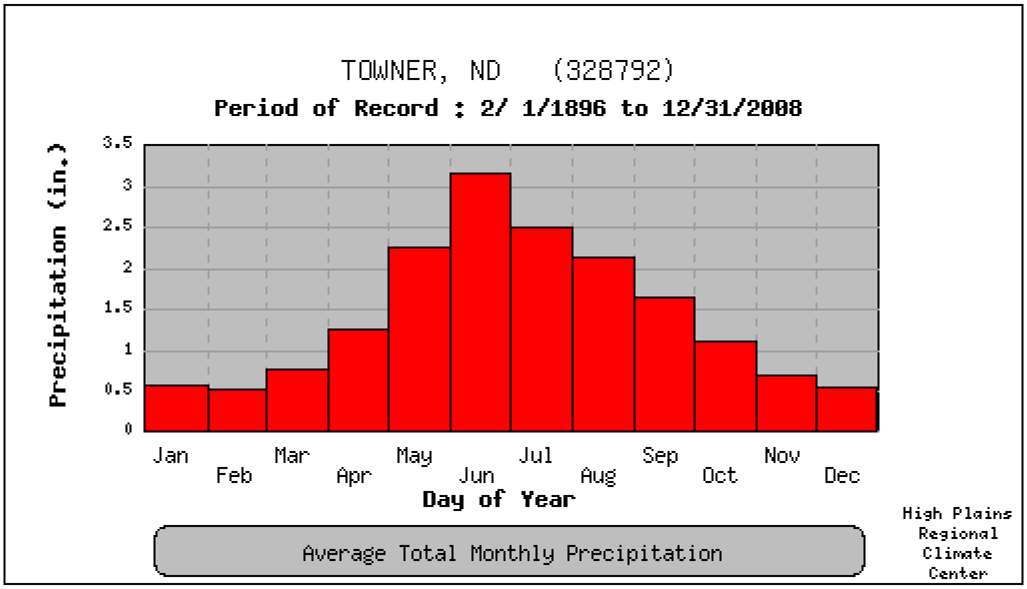


Figure 5. Average Total Monthly Precipitation Data for the HPRCC Station at Towner, North Dakota (328792), 1896 – 2008.

Average annual air temperatures at the Karlsruhe, ND North Dakota Agricultural Weather Network (NDAWN) station, located within the Wintering River watershed, were 44° F in 2006 and 46° F in 2007, with an average annual wind speed of 11.2 mph. Total annual precipitation was 10.27 inches in 2006 and 9.58 inches in 2007 (Figure 6). November through February averages about 0.50 inches of precipitation per month, occurring mostly as snow. Measurable precipitation (0.01 inch or more) occurs an average of 65 to 100 days during the year with over 50 percent of these events producing less than 0.10 inch (NDAWN, 2008).

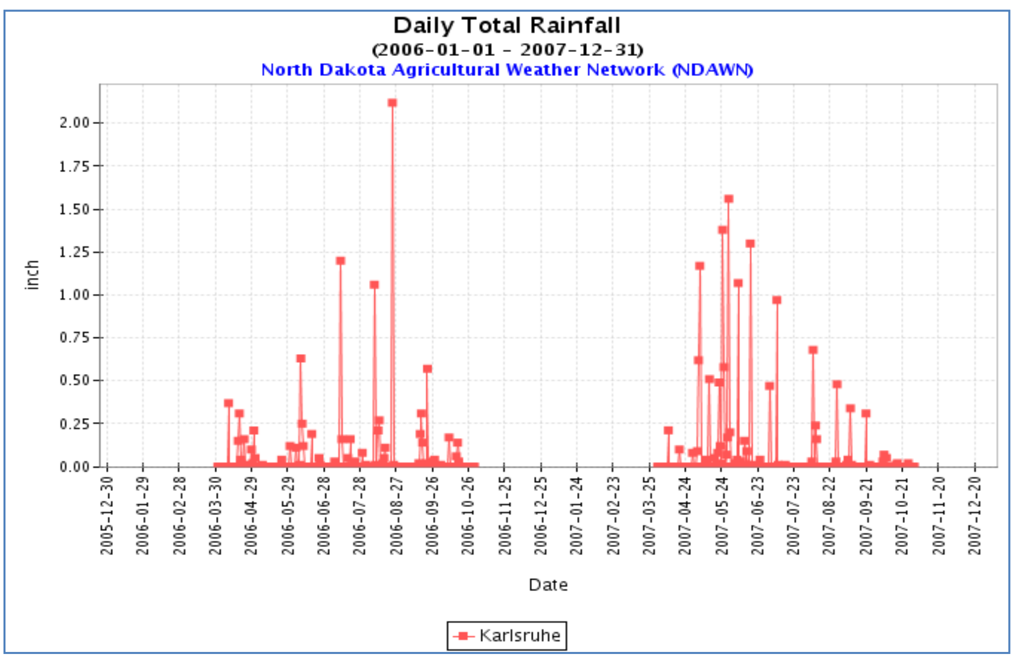


Figure 6. Rainfall Amounts at the Karlsruhe, ND NDAWN Weather Station, 2006-2007.

1.5 Available Data

The Wintering River has no major tributaries and very ephemeral flows. This is especially noticeable in the upstream reaches, which often have no flow by June. The river has three distinct regions (upstream, mid-river, and downstream). The upstream third of the river is very ephemeral and has flows only during spring runoff and large rainfall events. The middle third is functionally a large wetland with almost no flow, except for very large rain events. The downstream section functions as a typical stream and has springs which usually provide flow for portions of this section throughout the entire year.

For this project, four sites (385388, 384106, 385386, and 384107) were sampled for water quality and flow from April 2006 through August 2007 (Figure 7). By September of both years, the flow at all sites was zero, with the springs contributing no noticeable flow to the downstream portion. In 2007, monitoring was moved from site 385388 to site 384106. These sites are similar enough and spatially close enough to be considered comparable, so effectively data for this TMDL comes from three locations with sites 384388 and 384106 being combined into one reporting unit. The downstream –most site, 384107, is co-located with a USGS gauging station (05120500). Limited DO data from 1997 is also available for site 384107.

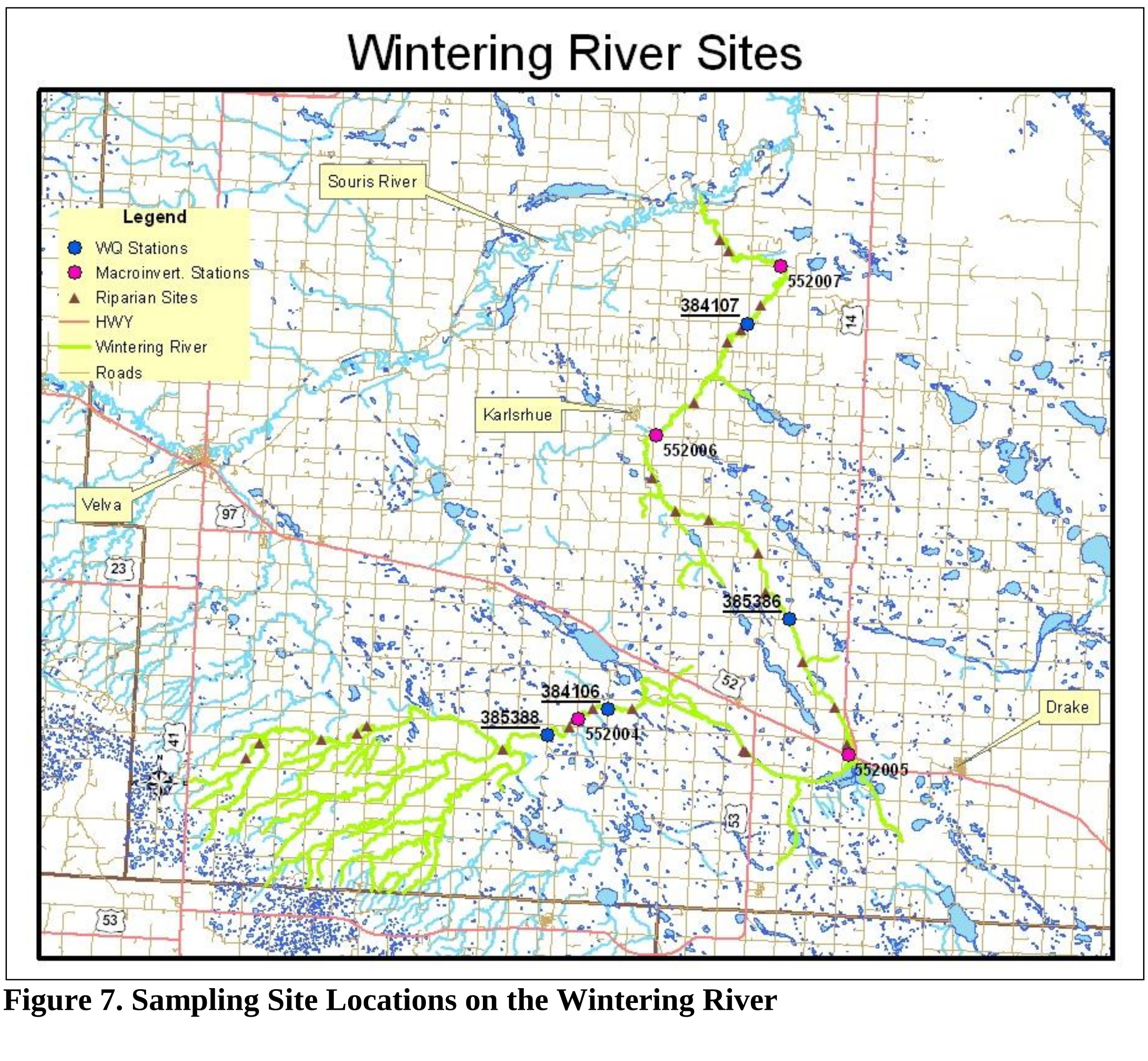


Figure 7. Sampling Site Locations on the Wintering River

1.5.1 Dissolved Oxygen Data

In 2006, extreme low flow conditions in the river prevented any intensive sampling. Three intensive sampling events in 2007 were conducted to characterize dissolved oxygen (DO) concentrations at the three stations. These included a 30-hour sampling period between May 9-10 with five samples collected, a five hour period on May 23rd with a range of three to five samples collected at staggered time intervals, and a four hour period on June 5th with four to seven samples collected at staggered time intervals. An additional sample was taken on June 6th after a 24-hour gap (Appendix A). Minimum daily DO concentrations are summarized in Table 5 (Houston Engineering, 2007).

Table 5. Minimum Daily Dissolved Oxygen Concentrations (mg/L) During Intensive Sampling, 2007.

Station	May 9-10	May 23	June 5-6
384106 (upstream)	4.90	5.60	2.62
385386 (mid –river)	1.98	7.28	3.51
384107 (downstream)	5.58	9.42	6.65

[1] No flow in Wintering River during these months. No samples were collected.

Outside of the intensive sampling events, DO data was collected from April until there was no flow, usually between the end of June and beginning of August. Figures 8, 9, and 10 depict DO concentration data for 1997, 2006, and 2007 respectively. Biochemical oxygen demand (BOD) and chemical oxygen demand data (COD) were also collected for use in modeling. Summary tables for each sampling site can be found in Appendix A.

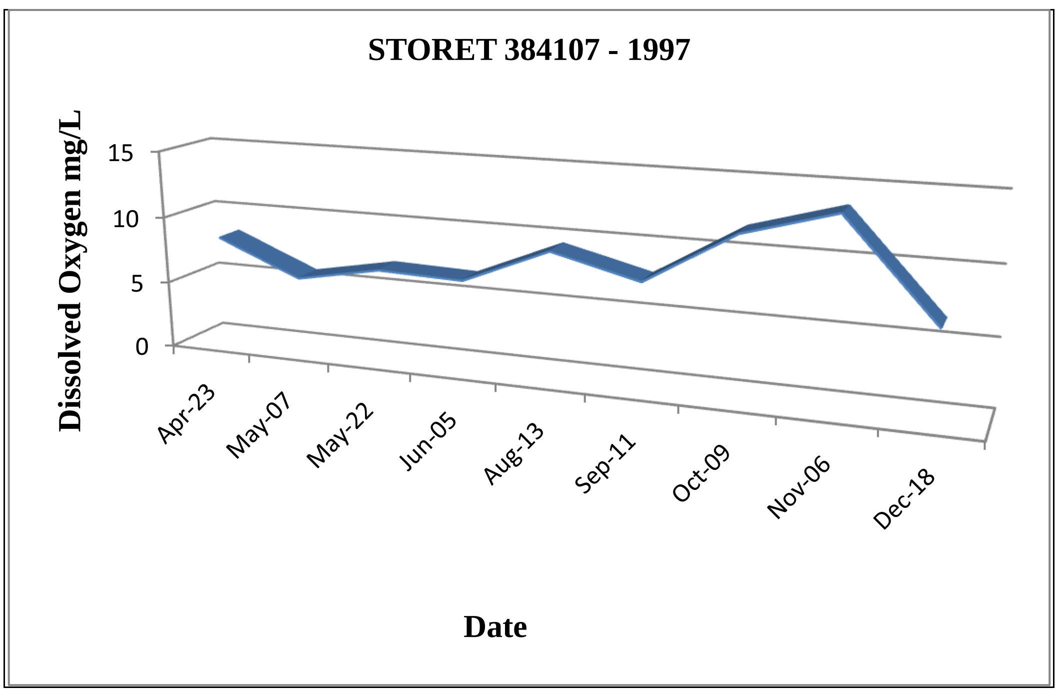


Figure 8. Dissolved Oxygen Concentrations for Site 384107 in 1997.

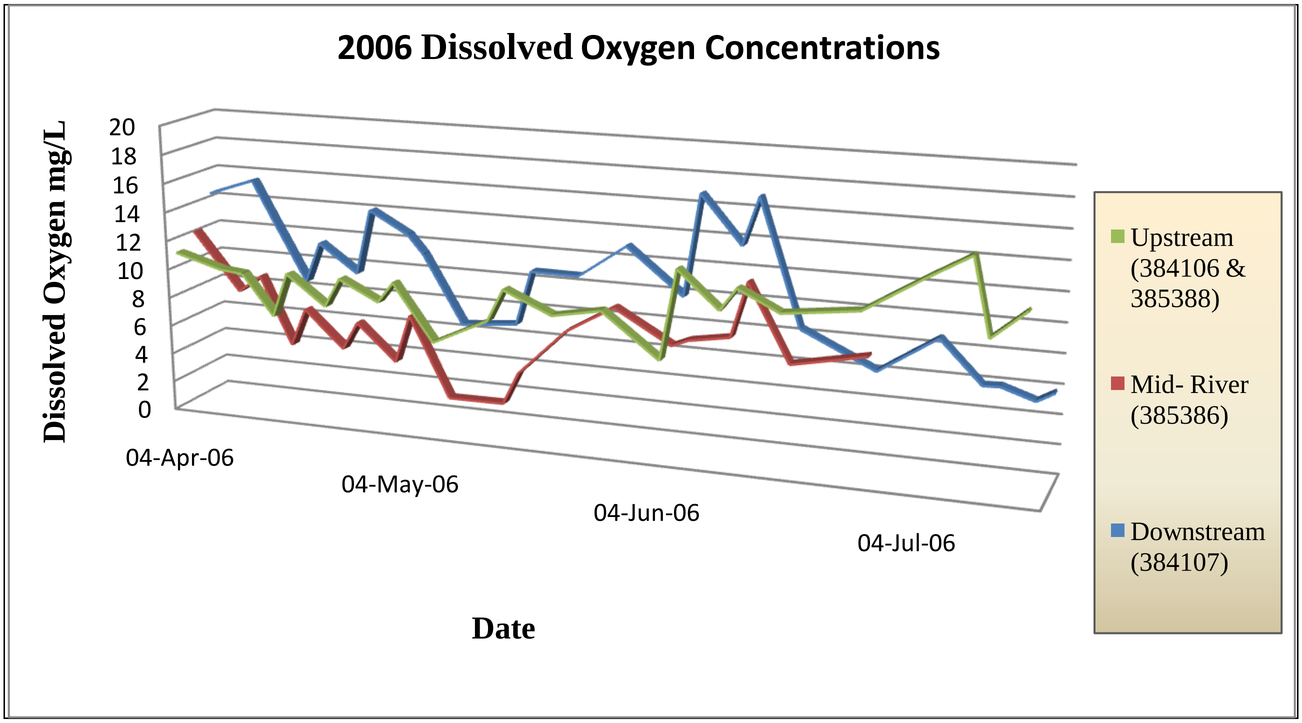


Figure 9. Dissolved Oxygen Concentrations for All Sites in 2006.

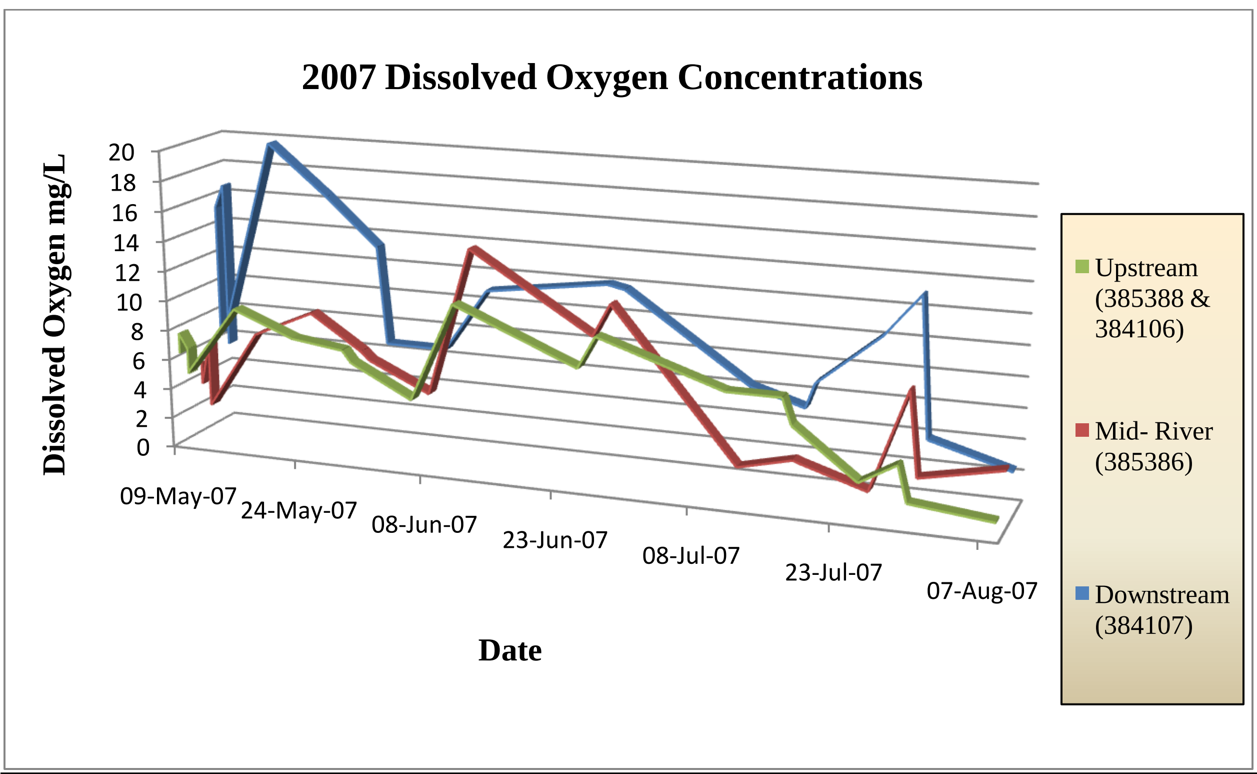


Figure 10. Dissolved Oxygen Concentrations for All Sites in 2007.

1.5.2 Hydraulic Discharges

For all sites except 384107, discharge data were estimate using stream velocity and stream stage measurements. Due to lack of flow readings, no rating curve could be developed for station 384106. A rating curve was developed for station 385388 based on limited data collected in 2006. This rating curve appears to have been influenced by a confounding factor, as data were noticeably variable. A rating curve was developed for station 385386 as paired discharge and stage data demonstrate a reasonable relationship (Appendix B). Site 384107 was co-located with a USGS gauging station (05120500), which provided continuous mean daily discharge data.

1.5.3 Other Data

Macroinvertebrate sampling was conducted at four sites along the Wintering River (Figure 7). In order to interpret these biological data and to develop a biological assessment methodology, the NDDoH has adopted the "multi-metric" index approach to assess biological integrity or aquatic-life use support for rivers and streams. The multi-metric index approach assumes that various measures of the biological community (e.g., species richness, species composition, trophic structure, and individual health) respond to human-induced stressors (e.g., pollutant loadings or habitat alterations). Each measure of the biological community, termed a "metric," is evaluated and scored on either a 1-, 3-, 5-point scale (fish) or on a scale of 0-100 (macroinvertebrates). The higher the score, the better will be the biological condition and, presumably, the lower the pollutant or habitat impact.

Currently the multi-metric IBI for the Northern Glaciated Plains (46) level III ecoregion is under development. However, enough data has been compiled and analyzed to allow a general interpretation of the IBI scores for the Wintering River watershed. Draft IBI scores with associated threshold condition and aquatic life beneficial use support are listed in Table 6.

As indicated in Table 7, scores have declined significantly since 1997 across all habitat types, with the greatest decline in scores associated with riffle/run habitat types. This is also an indication of riparian erosion and livestock directly in the river increasing erosion and deposition of sediment on the river bed, as well as a corresponding increase in organic matter and nutrients causing oxygen depletion. Macroinvertebrate species in the riffle/run habitat type are less tolerant to low DO/high temperature/high total suspended sediment conditions than are those species common to the glide pool habitat.

Table 6. Draft IBI Threshold Condition Values for the Northern Glaciated Plains Ecoregion (46).

Good – Fully Supporting	Fair – Fully Supporting But Threatened	Poor - Not Supporting
25^{th} Percentile or $\geq$ 70 IBI	$\leq$ 69 IBI and $\geq$ 59 IBI	10^{th} Percentile or $\leq$ 58 IBI

Table 7. IBI Scores for Wintering River, 1997 and 2007.

Station ID	Type	1997 IBI Score	Condition	2007 IBI Score	Condition	Aquatic Life Designated Use
552004	RR[1]	33	Poor	10	Poor	Not Supporting
552005	GP[2]	49	Poor	42	Poor	Not Supporting
552006	RR[1]	36	Poor	16	Poor	Not Supporting
552007	GP[2]	64	Fair	56	Poor	Not Supporting

[1]RR = Rifle/Run Habitat
[2]GP = Glide/Pool Habitat

A riparian assessment was conducted with the help of the Natural Resources Conservation Service using the Riparian Health Assessment Protocol (Appendix C). Twenty-three (23) sites were chosen based on a random sampling method provided by the US EPA. Each site was scored based on numerous ranking questions including those on stream bank vegetative cover and livestock caused bare ground/ hummocking. This tool is useful in determining where livestock may be contributing to the organic load (which increases BOD and therefore decreases the concentration of DO in the river). Total points possible are 57. A summary of the assessment is provided in Table 8. Of the 23 sites sampled (Figure 7), 17 scored in the Healthy range, five scored in the range of Healthy with Problems, and only one scored in the Unhealthy range. The sites closer to the Unhealthy range were mostly located in the downstream portion of the watershed.

Table 8. Riparian Health Assessment Summary for the Wintering River.

Points	Percent of Total	Conditions Status	Number of Sites
57/57	100	Healthy	3
52/57	91		7
46/57	80		7
40/57	70	Healthy with Problems	2
37/57	65		3
34/57	60		0
32/57	56	Unhealthy	1
29/57	51		0
23/57	40		0
17/57	30		0

A Rapid Geomorphic Assessment (Appendix D) was also conducted to determine stream channel stability and stage of channel evolution. Areas identified in this assessment as having high stream bank erosion and instability are good indicators of areas contributing to the organic load. The seven sites assessed corresponded to the three water quality sites and four macroinvertebrate sampling sites. Scores of 0-15 were ranked as stable, and 15-30 were ranked as unstable. Only one site (Site 552007) ranked as unstable at 23.5 points. This site is located furthest downstream in the watershed (Table 9).

Table 9. Rapid Geomorphic Assessment Summary for the Wintering River

Site	Score	Condition Status	Upstream
552004	14	Stable	
384106	8	Stable	
552005	7	Stable	
385386	8	Stable	
552006	7.5	Stable	
384107	8	Stable	
552007	23.5	Unstable	Downstream

2.0 WATER QUALITY STANDARDS

The Clean Water Act requires that Total Maximum Daily Loads (TMDLs) be developed for waters on a state's Section 303(d) list. A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. The purpose of a TMDL is to identify the pollutant load reductions or other actions that should be taken so that impaired waters will be able to attain water quality standards. TMDLs are required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis. Separate TMDLs are required to address each pollutant or cause of impairment (i.e., fecal coliform bacteria).

2.1 Narrative Water Quality Standards

The North Dakota Department of Health has set narrative water quality standards that apply to all surface waters in the State. The narrative general water quality standards are listed below (NDDoH, 2006).

- All waters of the State shall be free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations that are toxic or harmful to humans, animals, plants, or resident aquatic biota.

- No discharge of pollutants, which alone or in combination with other substances, shall:

    1. Cause a public health hazard or injury to environmental resources;

    2. Impair existing or reasonable beneficial uses of the receiving waters; or

    3. Directly or indirectly cause concentrations of pollutants to exceed applicable standards of the receiving waters.

In addition to the narrative standards, the NDDoH has set a biological goal for all surface waters in the State. The goal states that "the biological condition of surface waters shall be similar to that of sites or waterbodies determined by the department to be regional reference sites" (NDDoH, 2006).

2.2 Numeric Water Quality Standards

Wintering River is a Class III stream which carries the following definition:

Class III - The quality of the waters in this class shall be suitable for agricultural and industrial uses. Streams in this class generally have low average flows with prolonged periods of no flow. During periods of no flow, they are of limited value for recreation and fish and aquatic biota. The quality of these waters must be maintained to protect secondary contact recreation uses (e.g., wading), fish and aquatic biota, and wildlife uses.

Numeric criteria have been developed for Class III streams for DO (Table 10).

Table 10. North Dakota Dissolved Oxygen Standards for Class III Streams.

Parameter	Water Quality Standard (minimum value)
Dissolved Oxygen	5.0 mg/L[1]

[1] **Up to 10% of representative samples collected during any 3yr period may be less than this value provided lethal conditions are avoided.**

3.0 TMDL TARGET

A TMDL target is the value that is measured to judge the success of the TMDL effort. TMDL targets must be based on state water quality standards, but can also include site specific values when no numeric criteria are specified in the standard. The following TMDL target for the Wintering River is based on the North Dakota water quality standard for DO. If the target is met, the aquatic life beneficial use will be fully supported.

3.1 Dissolved Oxygen Target

The North Dakota State Water Quality Standard for DO is "5.0 mg/L as a daily minimum (up to 10 percent of representative samples collected during any three year period may be less than this value provided that lethal conditions are avoided)" and will be the DO target for the Wintering River.

4.0 SIGNIFICANT SOURCES

4.1 Point Sources

Within the Wintering River watershed there are no point sources permitted through the North Dakota Pollutant Discharge Elimination System (NDPDES) Program. Towns located within the watershed utilize septic waste systems.

There are no confined animal feeding operations (CAFOS) in the Wintering River watershed. There are two permitted AFOs in the watershed, however, they are zero discharge facilities and are not deemed a significant source for this report.

4.2 Nonpoint Sources

Land use data from the North Dakota Agricultural Statistics Service (NDASS, 2006) indicates that the watershed is primarily agricultural (84.6 percent), consisting of crop production and livestock grazing. Forty-one (41) percent of the watershed is pasture/range/haylands. Based on the 2006 NDASS data, an even larger percentage of the land area within an estimated 250 meter riparian buffer adjacent to the Wintering River is pasture/rangeland and grassland. With agriculture being the predominant land use, farms and ranches are located throughout the watershed. Livestock production is also exemplified as the dominant agricultural practice in McHenry and McLean Counties with an estimated livestock production of 113,000 cattle in the two counties combined (NASS, 2008).

While there are no large (>1000 cattle) CAFOs within the contributing drainage, there are 14 small (<300 cattle) animal feeding operations (AFOs), of which two have undergone the State permitting process (Figure 5). There may be other AFOs in the TMDL sub-watersheds; however their location and size are unknown.

These data indicate that the primary nonpoint sources creating an oxygen demand and lowering the DO concentrations in the Wintering River watershed are as follows:

- Nutrient runoff of from cropland and pasture;
- Runoff of manure from unpermitted animal feeding areas;
- Direct deposit of manure into Wintering River by livestock; and
- Background levels associated with wildlife

Failing septic systems or direct discharge sewage systems which contribute to nutrient loads and lower DO concentrations may also be located within the watershed. While their specific location and potential for nutrient and organic matter loading are unknown, these systems may be associated with isolated single-family dwellings and farmsteads located throughout the watershed or within small towns located within the watershed that do not have a centralized sewer system (e.g., Karlsruhe and Balfour).

5.0 TECHNICAL ANALYSIS

In TMDL development, the goal is to define the linkage between the water quality target and the identified source or sources of the pollutant to determine the load reduction needed to meet the target. To determine the cause-and-effect relationship between the water quality target and the identified source, Houston Engineering was contracted to develop a spreadsheet model that predicts biochemical oxygen demand (BOD) loads throughout the Wintering River. The model then relates varying BOD loads to predicted DO concentrations to determine the BOD load that is necessary to meet the DO State water quality standard of 5.0 mg/L. The loading capacity or TMDL is the amount of pollutant a waterbody can receive and still meet and maintain water quality standards and beneficial uses. The following technical analysis addresses the low DO impairment through a BOD load allocation and the BOD load allocation reductions necessary to achieve the water quality standards target of 5.0 mg/L DO minimum, plus a margin of safety.

5.1 Definition of Water Quality Terms

One of the most important parameters in aquatic ecosystems is dissolved oxygen (DO). Fish and macroinvertebrates require minimum levels of oxygen in order to grow, reproduce, and survive. Groundwater, the primary source of river flow during dry weather, or in this case low discharge from the upstream reservoirs, is naturally low in DO. Aquatic plant life serves as both a source (photosynthetic oxygen production) and a sink (respiration and decomposition). However, the measurement of oxygen concentrations does not directly measure the pollutants contributing to the impairment. Some analysis into interactions with other chemical processes as well as determining the relationship between them is required (Figure 11).

Biochemical oxygen demand (BOD) represents the amount of DO required by aerobic biological organisms in a body of water to break down (oxidize) organic matter present in a given water sample at a certain temperature over a specific period of time. The greater the BOD, the greater the oxygen depletion in a stream or lake.

Carbonaceous biochemical oxygen demand (CBOD) is the amount of oxygen required by bacteria to oxidize organic carbon material to carbon dioxide (its lowest energy state). In rural areas, sources of oxygen-demanding substances may include diffuse runoff of agricultural fertilizer and animal wastes (from manure application or grazing animals), soil erosion, and runoff from concentrated animal operations (Vellidis, 2006). Nutrient levels from runoff can sometimes cause enough eutrophication to generate CBOD loads from decaying algae. These may not occur locally, but instead downstream where velocities are slow and the algae populations collect (MPCA, 2008). This is part of the process in this impaired reach of the Wintering River as the wetland complex in the middle of the watershed slows the flow and allows nutrient buildup. Where the water velocities drop, excess algae growth is noted.

Nitrogenous biochemical oxygen demand (NBOD) is the amount of oxygen required by bacteria to oxidize ammonia to nitrite, then nitrite to nitrate (Tchobanoglous, 1985).

Sediment oxygen demand (SOD) is defined as the combination of several processes, primarily the aerobic decay of organic material that has settled to the bottom of the streambed. Examples of organic materials that can act as sources of SOD include leaf litter, particulate BOD in wastewater discharge, and algae or plant biomass.

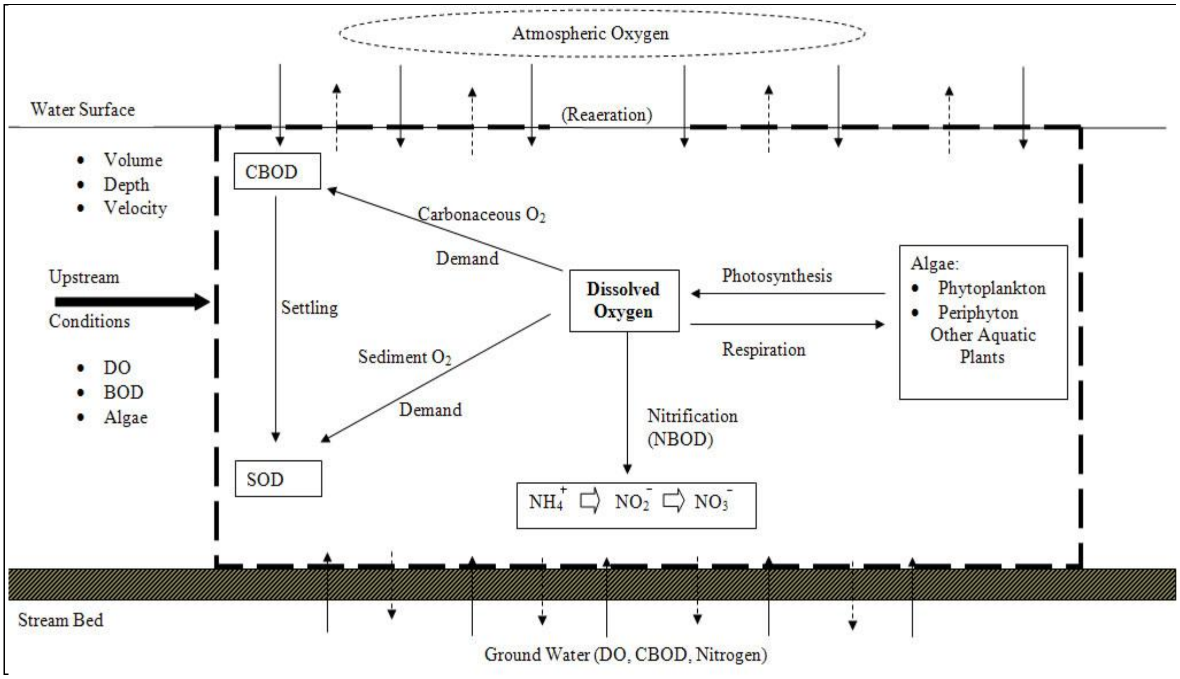


Figure 11. Schematic of the Major Processes Influencing DO in Rivers (MPCA, 2008).

5.2 Dissolved Oxygen Interactions

The amount of DO in a river at any point in time reflects the combination of physical, chemical, and biological sources and sinks of oxygen within the reach. Sources of oxygen include re-aeration, transport from upstream (flow), ground water, and photosynthetic production by algae and aquatic plants. Sinks for oxygen loss include the biochemical oxidation of suspended and dissolved organic material, oxygen demands from settled organic and inorganic materials, respiration of aquatic plants, and the conversion of nitrogen through nitrification (MPCA, 2008). When oxygen is consumed faster than it can be replenished, the DO levels decline.

The photosynthetic oxygen production (a source) and respiration (a sink) associated with aquatic plant life are important factors in the DO balance of natural waters. Of special concern are situations with an overabundance of free floating algae, attached algae, or larger submerged or emergent aquatic plants (MPCA, 2008). The middle section of the Wintering River system is dominated by cattails and other emergents, as well as many shallow pools where algae production is extensive. The greater the availability of light and nutrients, the greater the growth of aquatic plants and the more impact they have on oxygen resources. Photosynthetic rates respond to variations in sunlight intensity and water turbidity, which can decrease the light transmittance through the water column.

The quality of water downstream reflects the pollutant loads from upstream sources and tributaries in the watershed. Affected by natural and anthropogenic factors, this upstream water quality may exert a large influence on the DO balance of the downstream river segment (MPCA, 2008). Natural characteristics like lakes or wetlands, such as the one in the middle of this impaired river, affect downstream water quality much differently than a riffle-pool-run river would.

Direct discharge of pollutants from point and nonpoint sources into a river segment adds to its CBOD and NBOD, creating an oxygen demand that may depress DO below acceptable concentrations. High nutrient (nitrogen and phosphorus) levels can also cause the eutrophication process to generate CBOD loads from decaying algae (Vellidis, 2006). This may occur further downstream than where the pollutant enters the waterbody, such as pools where water velocities are low and the algae population can become extensive.

During the summer months, a high density of aquatic plants can cause oxygen levels to vary widely (Mulholland et al., 2005). Slow movement of water, high water temperature, high levels of nutrients, and strong solar radiation, such as that which occurs in the summer, increases photosynthesis and plant growth. During the night, plants undergo respiration, an oxygen dependant reaction, which creates an oxygen demand. Highly eutrophic conditions can occur, especially during low flow conditions when increased residence times are favorable for producing lots of algae, causing periods of active plant growth and respiration. When the growth factors change and become less favorable, plants will die and decompose, which uses up oxygen resources (Vellidis, 2006).

5.3 Correlating the Dissolved Oxygen Target with the TMDL Load Reduction Parameter.

To look specifically at the Wintering River, several conditions are related to the DO impairment. First of all there is nutrient loading occurring from nonpoint sources throughout the reach. This nutrient loading is leading to excessive algal growth during the summer months and large diurnal swings in DO (Figure 12).

The largest variation in DO levels occurred at the downstream- most site (384107), which is downstream from the large wetland site (385386) in the middle of the system. While idealized diurnal variation includes a change of only about 3 mg/L from high to low (Figure 13), the diurnal variation for site 384107 for the intensive sampling period in May, 2007 was greater than 9 mg/L. The algae then go through boom and bust cycles that create an oxygen deficit in the summer. Organic matter is also a result of manure runoff from livestock in the riparian area (red areas in Figure 4).

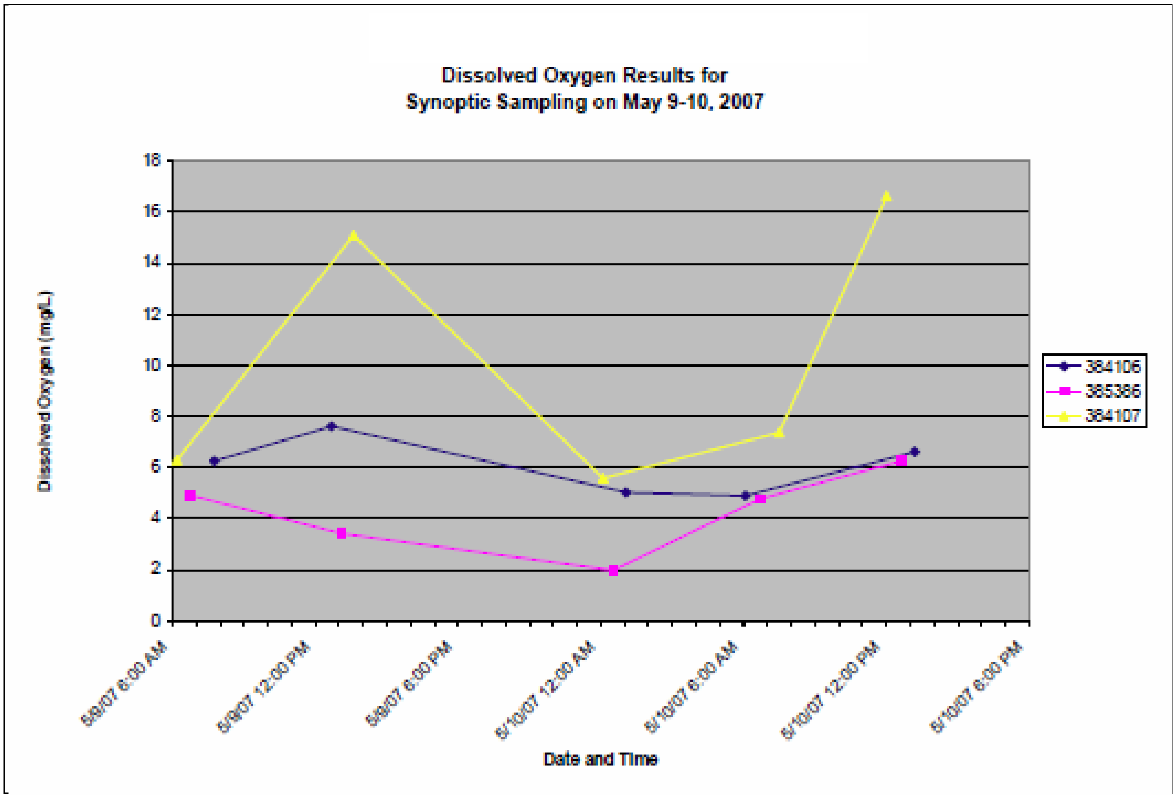


Figure 12. Diurnal Oxygen Swings in Wintering River (Houston Engineering, 2007).

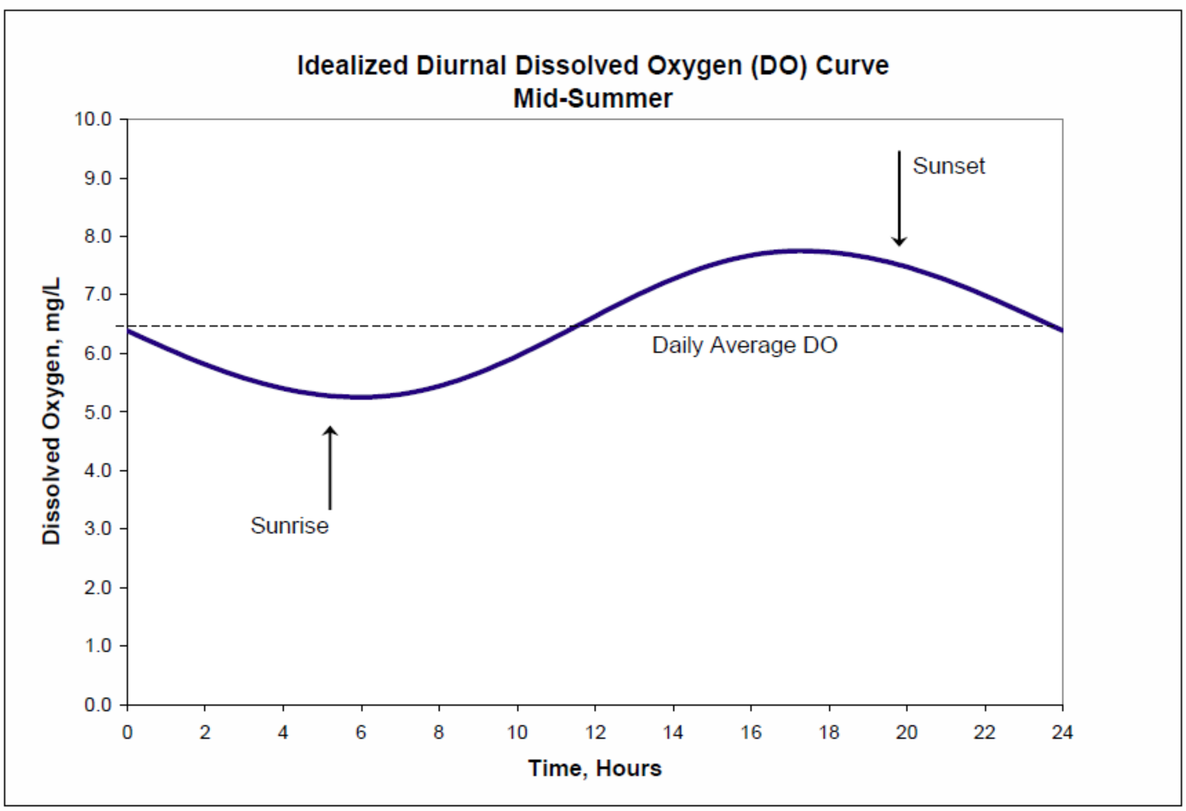


Figure 13. Idealized Diurnal Dissolved Oxygen Response to Photosynthetic Cycles. (MPCA, 2008).

When the pollutant load of oxygen demanding organics is large enough to overwhelm the oxygen resources of a water body, it creates an imbalance that destabilizes the stream environment and leads to aquatic life impairments (MPCA, 2008). Because these events occurred mostly in the summer months, indicating that photosynthetic processes were the primary cause, BOD was chosen as the loading parameter for the TMDL. A spreadsheet to model BOD loading was developed by Houston Engineering and was used to determine the TMDL load that would be predicted to result in meeting the 5.0 mg/L DO water quality standard.

5.4 Discharge Data

Dissolved oxygen concentrations across the years were pooled and plotted against river discharge values. The most complete record for discharge is at monitoring station 384107, which is co-located with USGS gauging station 05120500. Discharge and DO measurements are shown in Figures 15 and 16 for 2006 and 2007, respectively. Discharge data were also compiled for station 385386 and plotted against DO concentration values (Figures 17 and 18). Discharge records were not calculated for sites 385388 and 384106 due to lack of flow data.

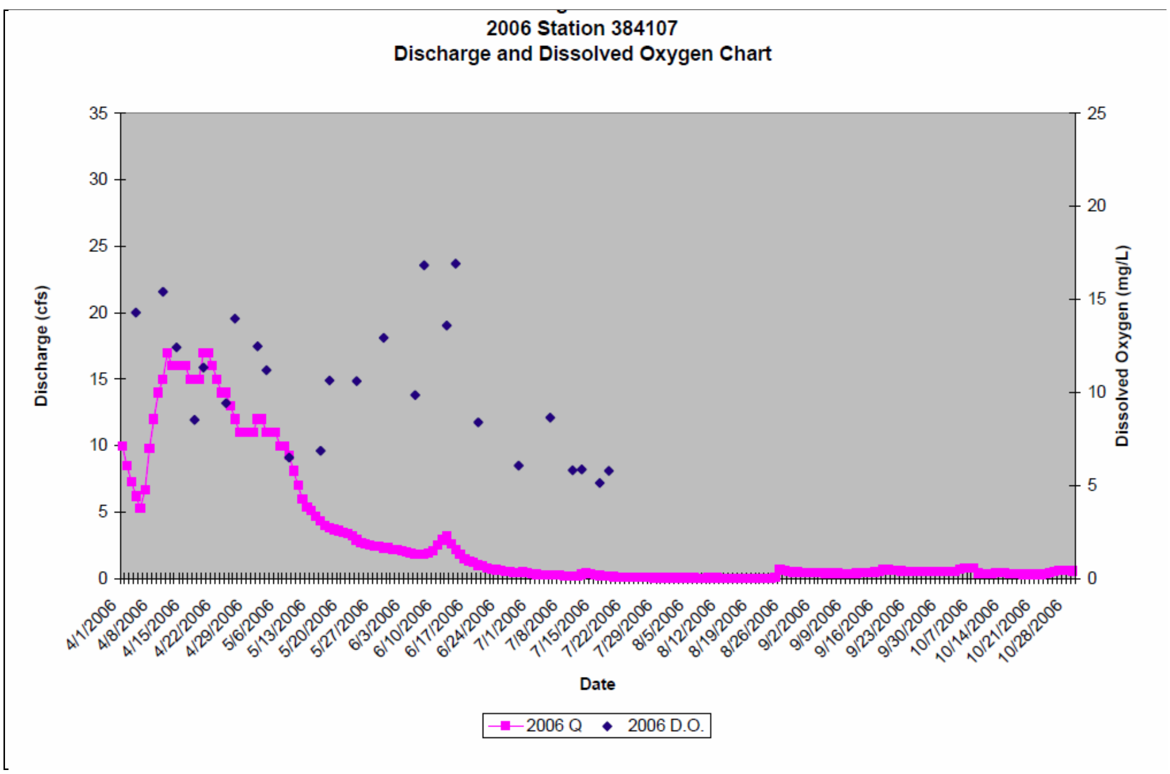


Figure 14. Discharge and Dissolved Oxygen for Site 384107 in 2006.

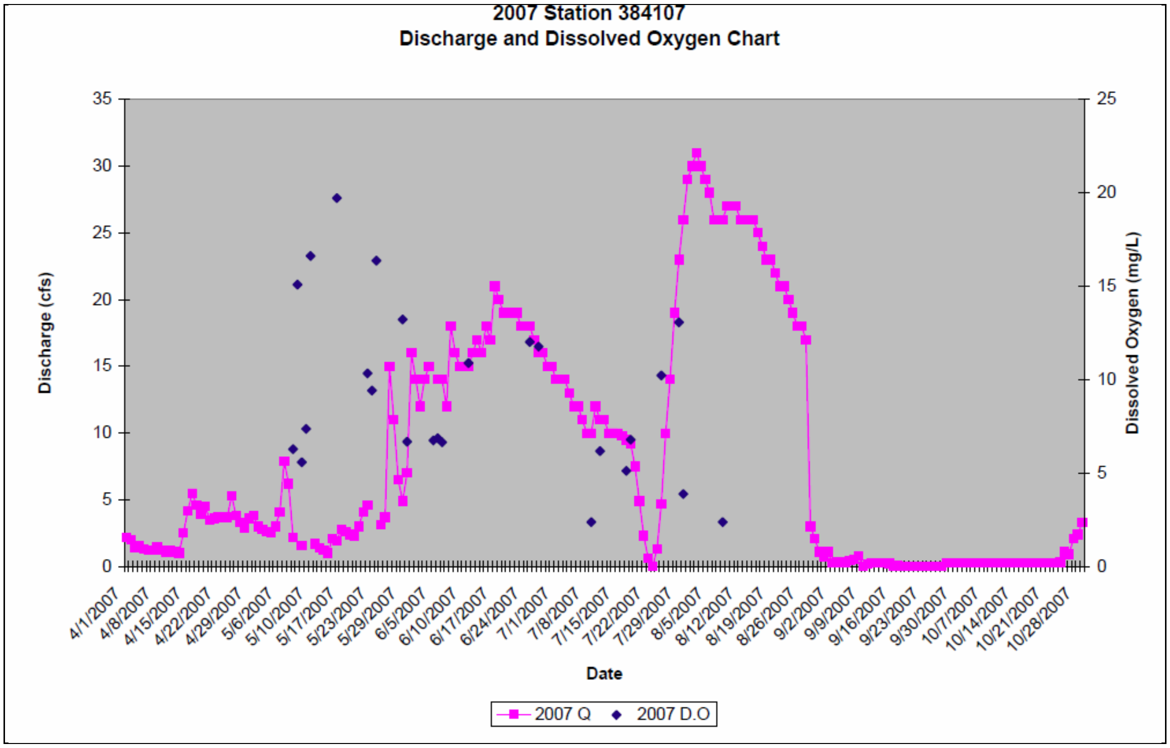


Figure 15. Discharge and Dissolved Oxygen for Site 384107 in 2007.

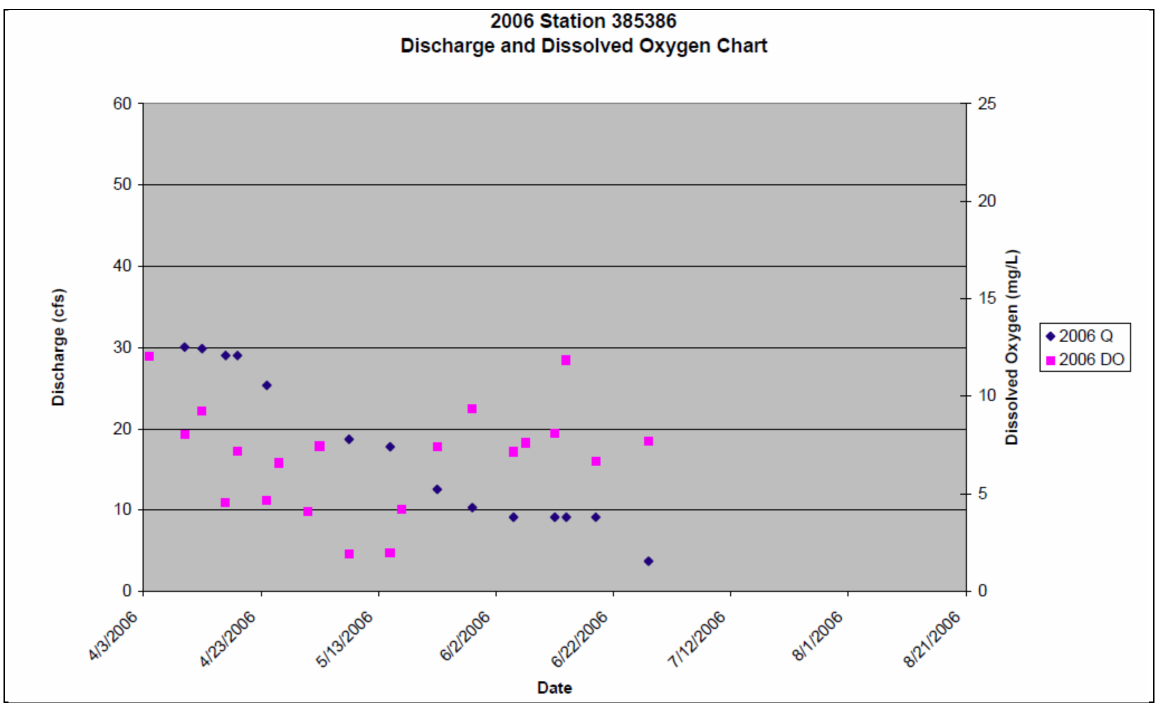


Figure 16. Discharge and Dissolved Oxygen for Site 385386 in 2006.

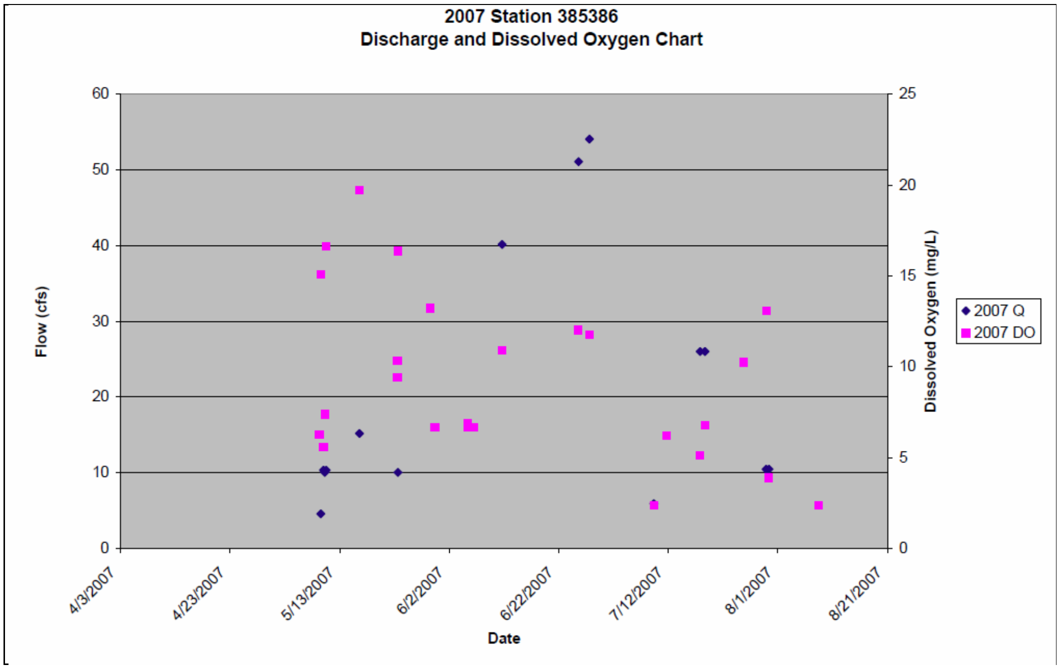


Figure 17. Discharge and Dissolved Oxygen for Site 385386 in 2007.

These figures generally support the critical time of year for low DO as being July and early August while there is still flow. The critical flow regime of less than 0.5 cfs does not appear to drive low DO conditions as anticipated. This may be a function of the time of day during which the sampling occurred (i.e. in-stream photosynthesis during daytime). Since the critical flow for low DO occurs during July, a median flow value for each reach was calculated. For site 384107 (reach 1), median flow was based on data from 12 years (1995-2007) of USGS July flow records, and was determined to be 14 cfs. For site 385386 (reach 2), July flow data from the sampling period of 2006 – 2007 was used, and the median flow was determine to be 11 cfs.

These median flow values for July were used for the calculation of BOD load based on three factors. First, low flow did not show a correlation to low DO concentration. Second, July was determined to be the critical month for DO impairment. Third, the BOD model requires a single flow value as input for each reach.

5.5 BOD Spreadsheet Model Analysis

A spreadsheet model was constructed by Houston Engineering to quantify current BOD loads within the river system, and related BOD loads to expected DO concentration conditions. The model framework allows a user to evaluate multiple scenarios using a range of potential values for input boundary conditions and to assess the impact downstream. The user is then able to apply the calculated BOD load as a total maximum daily load (TMDL) for the critical conditions identified. The TMDL represents an aggregate value of all potential sources and sinks within the watershed and river system (Houston Engineering 2007).

5.5.1 Overview

Water quality data was obtained at three different stations throughout the

Wintering River. The spreadsheet model was created as a tool to evaluate DO response to varying BOD loads through two of the three reaches of river. Reach 1 is the further downstream reach and is located between sites 384107 and 385386. Reach 2 is the furthest upstream reach and is located between water quality stations 385386 and 384106. The model separates the two reaches, so inputs and outputs are for each specific reach only. The middle reach was not modeled as this reach is more characteristic of a lake or reservoir than as a river.

The model is based on two fundamental equations. A BOD equation, represented as a first order loss reaction, is utilized to estimate BOD loss. A DO mass balance equation, which incorporated several terms, is also used. The DO mass balance equation incorporated the oxygen consumed during BOD loss as well as accounts for other losses and gains within the modeled reach. The DO mass balance predicts the minimum DO concentration in the modeled reach.

Conceptually, a Lagrangian model approach was used to assess minimum DO conditions in the model. This approach mathematically follows a “plug” of water as it moves downstream in the river system. A Lagrangian model uses a moving frame of reference as the plug moves from the upstream boundary condition downstream to the end of the reach.

The model has four inputs for each reach, which are the upstream boundary conditions. The inputs are temperature, DO, BOD, and flow. All four of these inputs can be modified and the outputs updated. The three outputs of the model are BOD load, resultant minimum DO based on the inputs, and the distance downstream where the minimum DO occurs. The BOD load is in pounds per day and is calculated from the inputs of flow multiplied by the BOD concentration The resultant minimum DO output is the lowest DO concentration found at any point downstream, given the upstream conditions that were provided. The minimum DO occurrence is related to the travel time for the plug of water (Houston Engineering, 2007).

5.5.2 Model Calibration

The model was calibrated to data collected on May 9th and 10th, 2007, where paired temperature, DO and BOD concentrations were collected at the three sampling stations. For model calibration and predictive modeling, BOD always refers to ultimate BOD rather than 5-day BOD. Using the upstream and downstream measured BOD concentrations, the BOD decay rate constant was calibrated in the BOD equation. The calibration was done by using measured upstream BOD, then varying BOD decay rate in the model until the predicted downstream BOD concentration until matched the measured downstream BOD concentration. The calibration was accomplished using an iterative process to determine the corrected decay rate constant. The calibrated reaction rate constant, k, is 0.50d^{-1} at 20 degrees Celsius.

A DO mass balance equation was used to predict a minimum in-stream DO concentration. A one-hour time step was used in the decay and mass balance equations. The DO mass balance equation was calibrated iteratively similar to the

BOD first order loss reaction equation. The measured upstream DO concentration was used as input to the model, and used to predict a downstream DO concentration until it matched the measured downstream value. The reaeration rate constant was the value that was iteratively varied in order for the downstream DO concentration to equal the measured value.

The terms that are in the equation are BOD loss, SOD loss, and reaeration loss/gain. A summary of these terms and the calibrated values based on the monitoring data are presented in Table 11. The calibration was performed based on site-specific minimum temperature, DO, and flow conditions.

Table 11. Summary of Calibration Terms for the Wintering River BOD Model.

	Calibration Terms (at 2cfs and adjusted to 20 degrees C.)		
Reach ID	BOD Decay Rate	Reaeration Rate	SOD
Reach 1	0.5 /day	12.43 /day	1 g / m^2 /day
Reach 2	0.5 /day	5.22 /day	1 g / m^2 /day

The equations and calibrations of the DO mass balance are as follows:

BOD: The measured upstream BOD concentration was input along with a calibrated decay rate constant *k* to determine the BOD losses. The difference in BOD concentrations between time steps was multiplied by the control volume.

$$BOD = BOD_{original} * e^{-k*t}$$

$$(BOD_t - BOD_{t+1}) * \text{Control Volume} = \text{BOD Loss (grams of BOD)}$$

SOD: A fixed SOD decay rate of 1 g/m^2/day was used to determine the SOD losses. This decay rate was multiplied by an exposed water surface area during the time step. The exposed water surface area was found using results from a HEC-RAS model created from the survey data. A key assumption is that exposed water surface area is equivalent to the effective bottom surface area which contributes to SOD.

SOD Decay Rate*Area*Time Step = SOD Loss

Reaeration: The reaeration term, like BOD, follows a first order reaction. The rate constant for reaeration was calibrated using the upstream and downstream measured DO levels. The amount of reaeration is based on the difference between the actual DO concentration and the saturation concentration.

$$(l-e^{-k*t})*(DO_{saturated} - DO_{actual})*\text{Control Volume} = \text{Reaeration Loss.}$$

The calibrated model used input values that were solved explicitly. The user model provides the ability to enter any range of flows and DO, and BOD conditions. Thus, the user model relies on regression equations to provide flexibility. Therefore, the regression equation outputs in the user model will always vary slightly from the actual calibrated model (Houston Engineering, 2007).

5.5.3 Reach 2 Calibration

Additional calibration was required for reach 2 as the upstream BOD concentration is lower than the downstream concentration. There is a large wetland located in the middle of the reach which likely contributes most or all of the BOD loading to the system. To account for this, another BOD mass input source was added to the DO mass balance equation. This added mass is a generic input and can reflect inputs from the wetland as well as any other nonpoint source contribution. In the spreadsheet, this source is added to the mass balance at a time equal to seventy-five (75) percent of the total travel time between the water quality stations, and assumes a steady state input.

The amount of mass added to the system was calibrated using the BOD equation, which was found to be 9,650 g/hr. During the calibration, the same decay rate was assumed for both reaches. The wetland is approximately 280 acres in size. Using this size, the BOD added to the system is estimated to be 0.17 g/m^2/day (Houston Engineering, 2007).

5.5.4 Determination of TMDL Loads for Each Reach

Because the large wetland in the center of the Wintering River system disjoins the river as a whole, and causes it to act as two separate systems, TMDL loads were calculated for each reach located upstream and downstream of the wetland independently.

Given a median monthly flow for the critical month of July of 14 cfs, the current BOD load for reach 1 (downstream) is 1,812 lb/day. Given a median monthly flow for the critical month of July of 11 cfs for reach 2, the current BOD load is 867 lb/day and the allowable load is 517 lb/day, requiring a 60 percent reduction in BOD load. Input values and output summaries are located in Appendix C. The allowable BOD load values ensure the DO minimum in the river is 5.0 mg/L.

5.6 Loading Sources

The load reductions can be generally allotted to nonpoint sources. Based on the data available, the general focus of BMPs and load reductions for the listed segment should be on unpermitted animal feeding areas, range/pastureland indicated in red in Figure 4, runoff from cropland near riparian areas with no buffer, and riparian areas that are highly disturbed as described in the two riparian surveys (Section 1.5.3). Higher priority should be given to the animal feeding areas rated higher or located in close proximity to the Wintering River.

Animals grazing in the riparian area contribute organic matter, nutrient loading, and increased turbidity which can increase water temperature, by eroding stream banks and depositing manure where it has an immediate impact on water quality. Due to the close proximity of manure to the stream or by direct deposition in the stream, riparian grazing

impacts water during all times of year when the livestock are present. Exclusion of livestock from the riparian area eliminates the potential of direct manure deposit and therefore is considered to be of high importance at all flows. However, intensive grazing in the upland creates the potential for manure accumulation and availability for runoff at high flows and a high potential for nutrient and organic matter contamination.
Since there are no point sources in the watershed (see Section 4.1), loading sources indicate nonpoint source pollution.

6.0 MARGIN OF SAFETY AND SEASONALITY

6.1 Margin of Safety

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) regulations require that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The margin of safety (MOS) can be either incorporated into conservative assumptions used to develop the TMDL (implicit) or added as a separate component of the TMDL (explicit).

To account for the uncertainty associated with known sources and the BOD load reductions necessary to reach the TMDL DO target of 5.0 mg/L, a ten percent explicit margin of safety was used for this TMDL. The MOS was calculated as ten percent of the TMDL. In other words ten percent of the TMDL is set aside from the load allocation as a MOS.

6.2 Seasonality

Section 303(d)(1)(C) of the Clean Water Act and associated regulations require that a TMDL be established with seasonal variations. The Wintering River TMDL addresses seasonality because the reduction of BOD is related to the period of the season when the greatest deficit of DO occurs.

7.0 TMDL

The TMDL can be described by the following equation**:**

TMDL = LC = WLA + LA + MOS where:

LC	=	loading capacity, or the greatest loading a waterbody can receive without violating water quality standards;
WLA	=	wasteload allocation, or the portion of the TMDL allocated to existing or future point sources;
LA	=	load allocation, or the portion of the TMDL allocated to existing or future nonpoint sources;

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

Table 12 provides an outline of the critical elements of the Wintering River fecal DO TMDL. The TMDLs are presented in Tables 13 and 14. These tables provide an estimate of the existing daily load and an estimate of the average daily loads necessary to meet the water quality target (i.e. TMDL load) for each reach. Each TMDL load includes a load allocation from known nonpoint sources and a ten percent margin of safety. It should be noted that the TMDL loads, load allocations, and the MOS are estimated based on available data and reasonable assumptions and are to be used as a guide for implementation. The actual reduction needed to meet the applicable water quality standards may be higher or lower depending on the results of future monitoring. The reduction in BOD load is modeled so that if the reduction is reached, the DO concentration will meet water quality standards.

Table 12. TMDL Summary for the Wintering River.

Category	Description	Explanation
Beneficial Use Impaired	Aquatic Life	Fish and other aquatic life impairments
Pollutant/Impairment	Low Dissolved Oxygen	See Section 2.1
TMDL Target	5.0 mg/L dissolved oxygen	Based on North Dakota water quality standards
WLA		No contributing point sources in the watershed.
LA	Nonpoint Source Contributions	Loads are a result of nonpoint sources (i.e., unpermitted AFOs, range and pasture land grazing, riparian grazing, failing septic systems, runoff from cropland)
Margin of Safety (MOS)	Explicit	10 percent

Table 13. Dissolved Oxygen TMDL Using BOD Loads for the Wintering River (ND-09010003-003-S_00) Reach 2 (headwaters to site 385386).

Reach 2: Site 384106 to 385386, headwaters to mid-river wetland	
Existing Load	867 lb/day BOD
TMDL	517 lb/day BOD
WLA	None
LA	465.3 lb/day BOD
MOS	51.7 lb/day BOD

Table 14. Dissolved Oxygen TMDL Using BOD Loads for the Wintering River (ND-09010003-003-S_00) Reach 1 (site 385386 to downstream end of reach).

Reach 1: Site 385386 to 384107, mid-river wetland to downstream end of reach	
Existing Load	1,812 lb/day BOD
TMDL	1,057 lb/day BOD
WLA	None
LA	951.3 lb/day BOD
MOS	105.7 lb/day BOD

8.0 ALLOCATION

There are no known point sources that could potentially impact the watershed. Therefore, all BOD loads for this TMDL are allocated to nonpoint sources in the watershed.

The entire nonpoint source load for each reach is allocated as a single load because there is not enough detailed source data to allocate the load to individual uses (e.g., animal feeding, cropland runoff, riparian grazing, upland grazing). To achieve the TMDL targets identified in the report, it will require the wide spread support and voluntary participation of landowners and residents in the immediate watershed as well as those living upstream. The TMDLs described in this report are a plan to improve water quality by implementing best management practices through non-regulatory approaches. “Best management practices” (BMPs) are methods, measures, or practices that are determined to be a reasonable and cost effective means for a land owner to meet nonpoint source pollution control needs,” (USEPA, 2001). This TMDL plan is put forth as a recommendation for what needs to be accomplished for Wintering River, its tributaries and associated watershed to restore and maintain its aquatic life uses. Water quality monitoring should continue to assess the effects of the recommendations made in this TMDL. Monitoring may indicate that BMP implementation and/or the loading capacity recommendations should be adjusted.

Controlling nonpoint sources is a difficult undertaking requiring extensive financial and technical support. Provided that technical and financial assistance is available to stakeholders, these BMPs have the potential to significantly reduce organic and nutrient loading to the Wintering River. The following describe in detail those BMPs that will reduce organic and nutrient loading in the Wintering River, thus allowing an increase in dissolved oxygen so that beneficial uses can be met.

8.1 Livestock Management Recommendations

Livestock management BMPs are designed to promote healthy water quality and riparian areas through management of livestock and associated grazing land. Organic matter and nutrients from livestock and erosion from poorly managed grazing land and riparian areas can be a significant source of loading to surface water. Precipitation, plant cover, number of animals, and soils are factors that affect the amount of a pollutant delivered to a waterbody as a result of livestock. These specific BMPs are known to reduce NPS pollution from livestock.

Livestock exclusion from riparian areas - This practice is established to remove livestock from grazing riparian areas and watering in the stream. Livestock exclusion is accomplished through fencing. A reduction in stream bank erosion can be expected by minimizing or eliminating hoof trampling. A stable stream bank will support vegetation that will hold banks in place and serve a secondary function as a filter from nonpoint source runoff. Added vegetation will create aquatic habitat and shading for macroinvertebrates and fish. Direct deposit of fecal matter, and therefore nutrients and organic matter, into the stream and stream banks will be eliminated as a result of livestock exclusion by fencing.

Water well and tank development - Fencing animals from stream access requires an alternative water source, installing water wells and tanks satisfies this need. Installing water tanks provides a quality water source and keeps animals from wading and defecating in streams. This will reduce the transfer of nutrients and organic matter to the stream.

Prescribed grazing – This practice provides increased ground cover and ground stability by rotating livestock throughout multiple fields. Grazing with a specified rotation minimizes overgrazing and resulting erosion. The Natural Resources Conservation Service (NRCS) recommends grazing systems to improve and maintain water quality and quantity. Duration, intensity, frequency, and season of grazing can be managed to enhance vegetation cover and litter, resulting in reduced runoff, improved infiltration, increased quantity of soil water for plant growth, and better manure distribution and increased rate of decomposition, (NRCS, 1998).

Waste management system - Waste management systems can be effective in controlling up to 90 percent of the loading originating from confined animal feeding areas. A waste management system is made up of various components designed to control NPS pollution from concentrated animal feeding operations (CAFOs) and animal feeding operations (AFOs). Diverting clean water around the feeding area and containing dirty water from the feeding area in a pond are typical practices of a waste management system. Manure handling and application procedures are also integral to the waste management system. The application of manure is designed to be adaptive to environmental, soil, and plant conditions to minimize the probability of nutrient contamination of surface water.

8.2 Other Recommendations

Vegetative Filter Strip – Vegetated filter strips are used to reduce the amount of sediment, particulate organics, dissolved contaminants, and nutrients to streams. The effectiveness of filter strips and other BMPs in removing nutrients is quite successful. Results from a study by Pennsylvania State University (1992) as presented by USEPA (1993), suggest that vegetative filter strips are capable of removing up to 85 percent of phosphorus loading to rivers and streams (Table 15). The ability of the filter strip to remove contaminants is dependent on field slope, filter strip slope, erosion rate, amount and particulate size distribution of sediment delivered to the filter strip, density and height of vegetation, and runoff volume associated with erosion producing events (NRCS, 2001).

Septic System – Septic systems provide an economically feasible way of disposing of household wastes where other means of waste treatment are unavailable (e.g., public or private treatment facilities). The basis for most septic systems involves the treatment and distribution of household wastes through a series of steps involving the following:

1. A sewer line connecting the house to a septic tank
2. A septic tank that allows solids to settle out of the effluent
3. A distribution system that dispenses the effluent to a leach field
4. A leaching system that allows the effluent to enter the soil

Septic system failure occurs when one or more components of the septic system do not work properly and untreated waste or wastewater leaves the system. Wastes may pond in the leach field and ultimately run off directly into nearby streams or percolate into groundwater. Untreated septic system waste is a potential source of nutrients (nitrogen and phosphorus), organic matter, suspended solids, and fecal coliform bacteria. Land application of septic system sludge, although unlikely, may also be a source of contamination.

Failure of septic systems can occur for several reasons, although the most common reason is improper maintenance (e.g. age and inadequate pumping). Other reasons for failure include improper installation, location, and choice of system. Harmful household chemicals can also cause failure by killing the bacteria that digest the waste. While the number of systems that are not functioning properly is unknown, it is estimated that 28 percent of the systems in North Dakota are failing (USEPA, 2002).

Table 15. Relative Gross Effectiveness of Confined Livestock Control Measures (Pennsylvania State University, 1992).

Practice[b] Category	Runoff[c] Volume	Total[d] Phosphorus Percent	Total[d] Nitrogen Percent	Sediment Percent	Fecal Coliform Bacteria Percent
Animal Waste System[e]	-	**90**	**80**	**60**	**85**
Diversion System[f]	-	**70**	**45**	**NA**	**NA**
Filter Strips[g]	-	**85**	**NA**	**60**	**55**
Terrace System	-	**85**	**55**	**80**	**NA**
Containment Structures[h]	-	**60**	**65**	**70**	**90**

NA = **Not Available**
a **Actual effectiveness depends on site-specific conditions. Values are not cumulative between practice categories.**
b **Each category includes several specific types of practices.**
c **- = reduction; + = increase; 0 = no change in surface runoff.**
d **Total phosphorus includes total and dissolved phosphorus; total nitrogen includes organic-N, ammonia-N, and nitrate-N**
e **Includes methods for collecting, storing, and disposing of runoff and process-generated wastewater.**
f **Specific practices include diversion of uncontaminated water from confinement facilities.**
g **Includes all practices that reduce contaminant losses using vegetative control measures.**
h **Includes such practices as waste storage ponds, waste storage structures, and waste treatment lagoons.**

9.0 PUBLIC PARTICIPATION

To satisfy the public participation requirement of this TMDL, a hard copy of the TMDL for Wintering River and request for comment was mailed to participating agencies, partners, and to those who requested a copy. Those included in the hard copy mailing were:

- South McHenry County Soil Conservation District;
- South McLean County Soil Conservation District;
- McHenry County Water Resource Board;
- McLean County Water Resource Board;
- US EPA - Region VIII; and
- USDA-NRCS (State Office).

In addition to the mailed copies, the TMDL for Wintering River was posted on the North Dakota Department of Health, Division of Water Quality web site at http://www.ndhealth.gov/WQ/SW/Z2_TMDL/TMDLs_Under_PublicComment/B_Under_Public_Comment.htm .

A 30 day public notice soliciting comment and participation was also published in the following newspapers:

- Mouse River Journal; and
- McLean County Independent.

As part of its normal review, a public notice review was received from the US EPA Region VIII (Appendix F). No comments were received from any other agency, organization or individual. The Department's response to comments received from the US EPA Region VIII are provided in Appendix G.

10.0 MONITORING

As stated previously, it should be noted that the TMDL loads, load allocations, and the MOS are estimated based on available data and reasonable assumptions and are to be used as a guide for implementation. The actual reduction needed to meet the applicable water quality standards may be higher or lower depending on the results of future monitoring.

To ensure that the implementation of BMPs will reduce BOD loading and therefore increase DO concentrations to the necessary levels, water quality monitoring will be conducted in accordance with an approved Quality Assurance Project Plan (QAPP).

Specifically, monitoring will be conducted for all variables that are currently causing impairments to the beneficial uses of the waterbody. These include, but are not limited to DO and nutrients. Once a watershed restoration plan (e.g. Section 319 Nonpoint Source Project Implementation Plan [PIP]) is implemented, monitoring will be conducted in the watershed beginning two years after implementation and extending five years after the implementation project is complete.

11.0 TMDL IMPLEMENTATION STRATEGY

Implementation of TMDLs is dependent upon the availability of Section 319 NPS funds or other watershed restoration programs (e.g. USDA Environmental Quality Incentive Program), as well as securing a local project sponsor and required matching funds. Provided these three requirements are in place, a project implementation plan (PIP) is developed in accordance with the TMDL and submitted to the ND Nonpoint Source Pollution Task Force and US EPA for approval. The implementation of the BMPs contained in the NPS PIP is voluntary. Therefore, success of any TMDL implementation project is ultimately dependant on the ability of the local project sponsor to find cooperating producers.

Monitoring is an important and required component of any PIP. As a part of the PIP, data are collected to monitor and track the effects of BMP implementation as well as to judge overall project success. Quality Assurance Project Plans (QAPPs) detail the strategy of how, when, and where monitoring will be conducted to gather the data needed to document the TMDL implementation goal(s). As data are gathered and analyzed, watershed restoration tasks are adapted to place BMPs where they will have the greatest benefit to water quality.

Also, as part of any implementation plan for this TMDL, it is recommended that the permitted point sources (i.e., CAFOs, AFOs) in the watershed be inspected to ensure that they are being operated in compliance with their permit conditions, and to verify that they aren’t significant nutrient and organic matter sources. Currently, it is the policy of the NDDoH that all permitted CAFOs (greater than or equal to 1000 animal units) be inspected annually. Permitted AFOs (<1000 animal units) in the Wintering River watershed are inspected on an as needed basis.

12.0 REFERENCES

Chambers, P., Brown, S., Culp, J.M., Lowell, R.B., and Pietroniro, A. 2000. Dissolved oxygen decline in ice-covered rivers of northern Alberta and its effects on aquatic biota. Journal of Aquatic Ecosystems Stress and Recovery, 27-38.

Chapra, S., 1997. Surface Water-Quality Monitoring. The McGraw Hill Companies, Inc.

Chapra, S., Pelletier, G.J., and Tao, H. 2008. QUAL2K: A Modeling Framework for Simulating River and Stream Water Quality, Version 2.11: Documentation and Users manual. Civil and Environmental Engineering Dept., Tufts University, Medford, MA.

Chu R., and Jirka H. 2003. Wind and Stream Flow Induced Re-aeration. Journal of Environmental Engineering, 129-1136

Cleland. 2003. *TMDL development from the "Bottom Up" - Part III: Duration Curves and Wet-Weather Assessments.* America's Clean Water Foundation, Washington, DC.

Dodds, W. K. 2002. Freshwater Ecology: Concepts and Environmental Applications. Academic Press, San Diego, California.

Enz, John W. 2003. *North Dakota Topographic, Climate, and Agricultural Overview*. North Dakota State University. Available at http://www.soilsci.ndus.nodak.edu?Enz/enz/reports/ndclimate.htm

MPCA. 2008. Dissolved Oxygen TMDL Protocols and Submittal Requirements. Minnesota Pollution Control Board Minneapolis: MPCA.

Mulholland. 2005. Stream diurnal dissolved oxygen profiles as indicators of in-stream metabolism and disturbance effects: Fort Benning as a case study. Ecological Indicators 5:243-252

NASS. 2008. *National Agricultural Statistics Service*. Available at **http://www.nass.usda.gov/Statistics_by_State/North_Dakota/index.asp.**

NDASS. 2006. *North Dakota Agricultural Statistics Service Land Use CD.* Provided by the North Dakota Agricultural Statistic Service, Grand Forks, ND.

NDAWN. 2008. *Karlsruhe, North Dakota Weather Station.* North Dakota Agricultural Weather Network. North Dakota State University, Fargo, North Dakota. Available at: http://ndawn.ndsu.nodak.edu/index.html

NDDoH. 2004. *Quality Assurance Project Plan for the Wintering River Watershed TMDL Water Quality Monitoring Project*. North Dakota Department of Health, Division of Water Quality, Bismarck, North Dakota. Revised 2007.

NDDoH. 2006. *Standards of Water Quality for the State of North Dakota.* Chapter 33-16-02 of the North Dakota Century Code. North Dakota Department of Health, Division of Water Quality, Bismarck, North Dakota.

NDDoH. 2010. *North Dakota 2010 Integrated Section 305(b) Water Quality Assessment and Section 303 (d) List of Waters Needing Total Maximum Daily Loads.* North Dakota Department of Health, Division of Water Quality, Bismarck, North Dakota.

NRCS. 1998. *Natural Resource Conservation Service Practice Specification 528.* USDA - Natural Resources Conservation Service, North Dakota. Available at http://efotg.nrcs.usda.gov

NRCS. 2001. *Natural Resources Conservation Service Practice Specification 393* – Filter Strip(Acres) [Online]. USDA – Natural Resources Conservation Service, North Dakota. Available at http://www.nd.nrcs.usda.gov/resources/section4/standards/Section4.html.

Parr LB, M. C. (2004). Causes of low oxygen in a lowland, regulated eutrophic river in Eastern England. Science of the Total Environment 321: 273-286.

Pennsylvania State University. 1992. Non-point Source Database. Pennsylvania State University, Department of Agricultural and Biological Engineering, University Park, PA.

Tiedemann, A.R., D.A. Higgins, T.M. Quigley, H.R. Sanderson, and C.C. Bohn. 1988. *Bacterial Water Quality Responses to Four Grazing Strategies - Comparison with Oregon Standards*.

Tchobanoglous, G. a. (1985). Water Quality. Reading, Massachusetts: Addison-Wesley.

USEPA. 1993. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.* EPA 840-B-92-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA, NDDoH, et. al. 1998. *Ecoregions of North Dakota and South Dakota.* Poster.

USEPA. 2001. *Protocol for Developing Pathogen TMDLs*. EPA 841-R-00-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2002. Onsite Wastewater Treatment Systems Manual. EPA/625/R-00/008. U. S. Environmental Protection Agency. Office of Water, Office of Research and Development

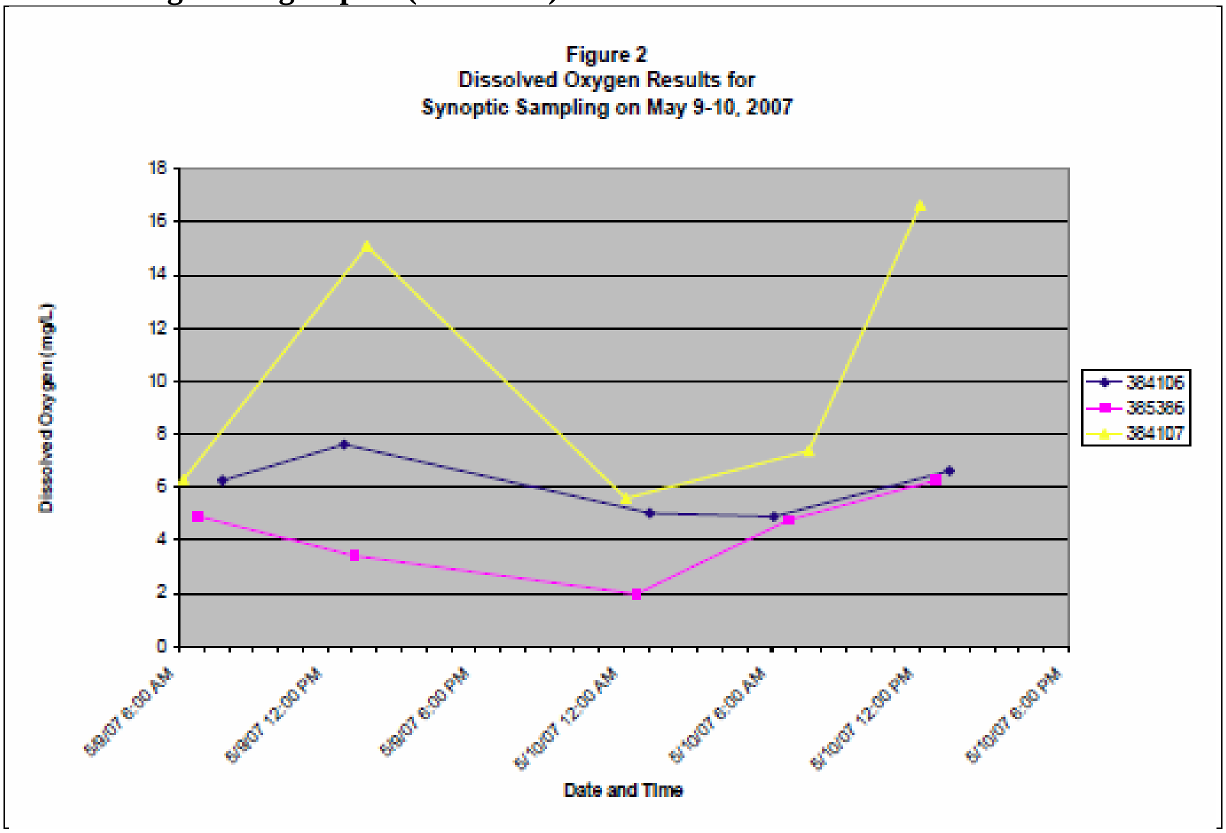
USEPA. 2007. An Approach for Using Load Duration Curves in the Development of TMDLs. EPA-841-B-07-006. U.S. Environmental Protection Agency, Office of Water, Washington, DC. Available at http://www.epa.gov/owow/tmdl/techsupp.html

USGS. 2006. *Ecoregions of North Dakota and South Dakota*. United States Geological Survey. Available at http://www.npwrc.usgs.gov/resource/habitat/ndsdeco/nodak.htm

Vellidis, G. (2006). Mathematical Simulation Tools for Developing Dissolved Oxygen TMDLs. American Society of Agricultural and Biological Engineers 49(4): 1003-1022.

Appendix A
Wintering River Water Quality Data

Intensive Sampling Results, 2007
Houston Engineering Report (Dec. 2007)



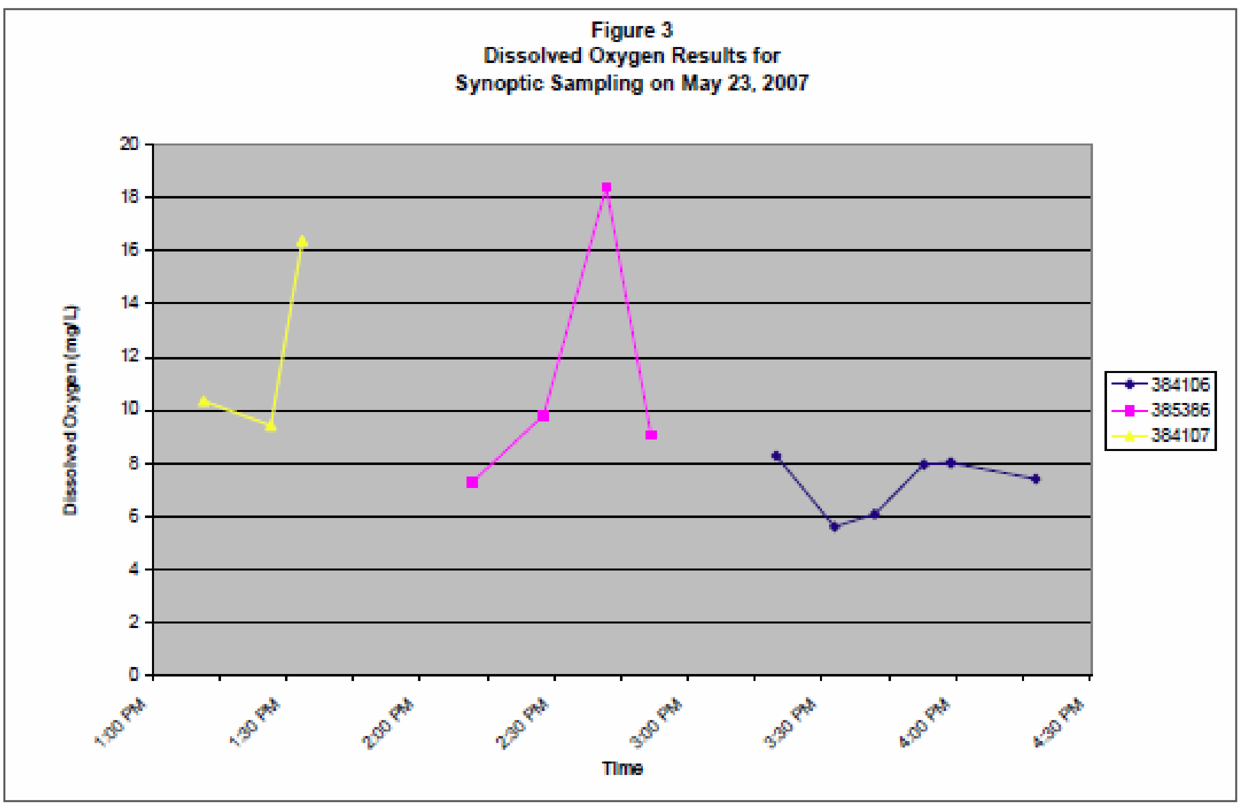
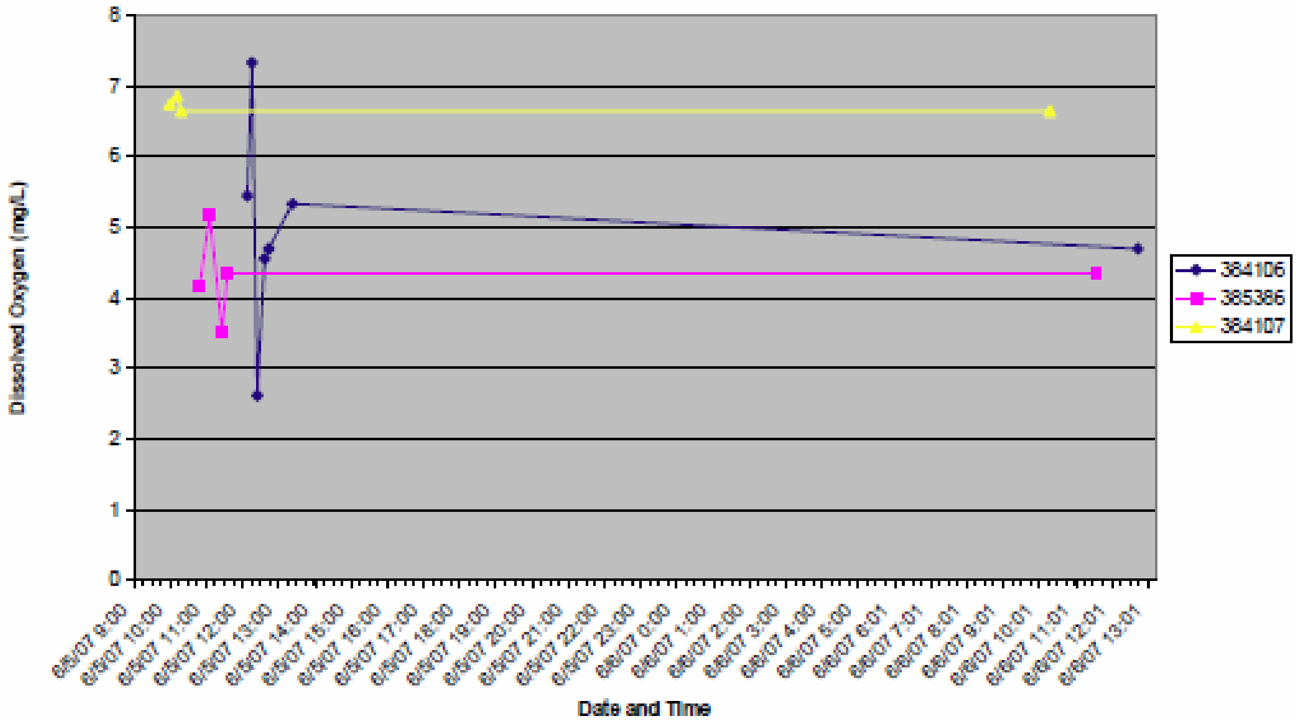


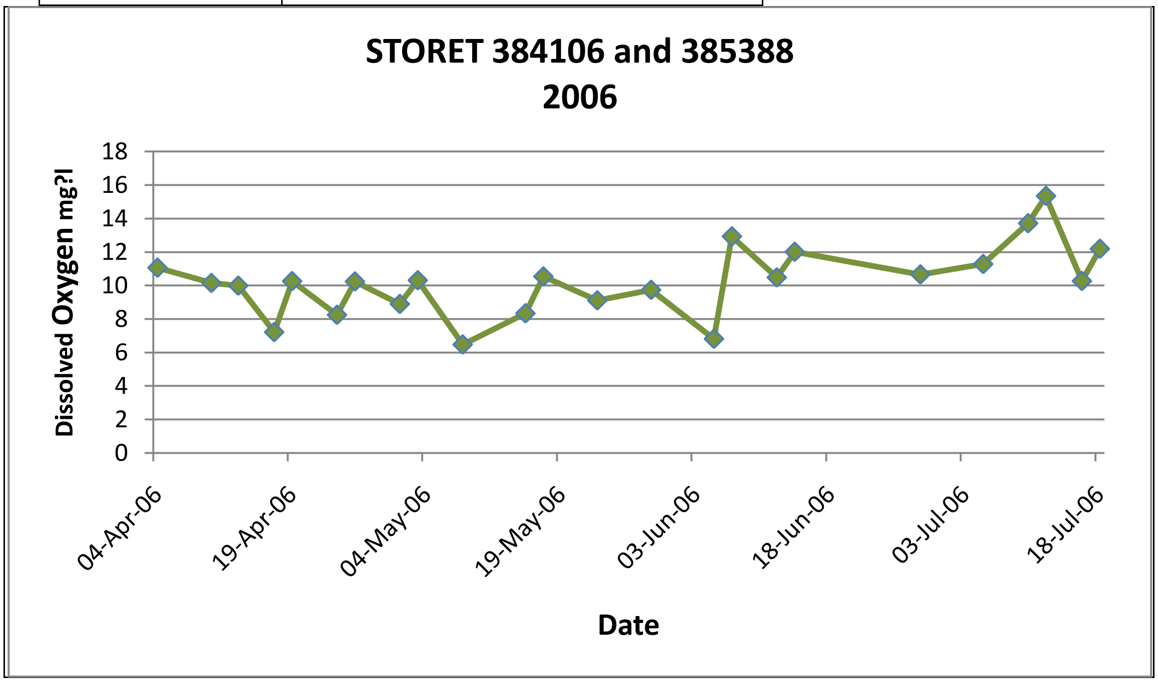
Figure 4
Dissolved Oxygen Results for
Synoptic Sampling on June 5-6, 2007



Dissolved Oxygen Data for Sites 384106 & 385388 (Upstream)

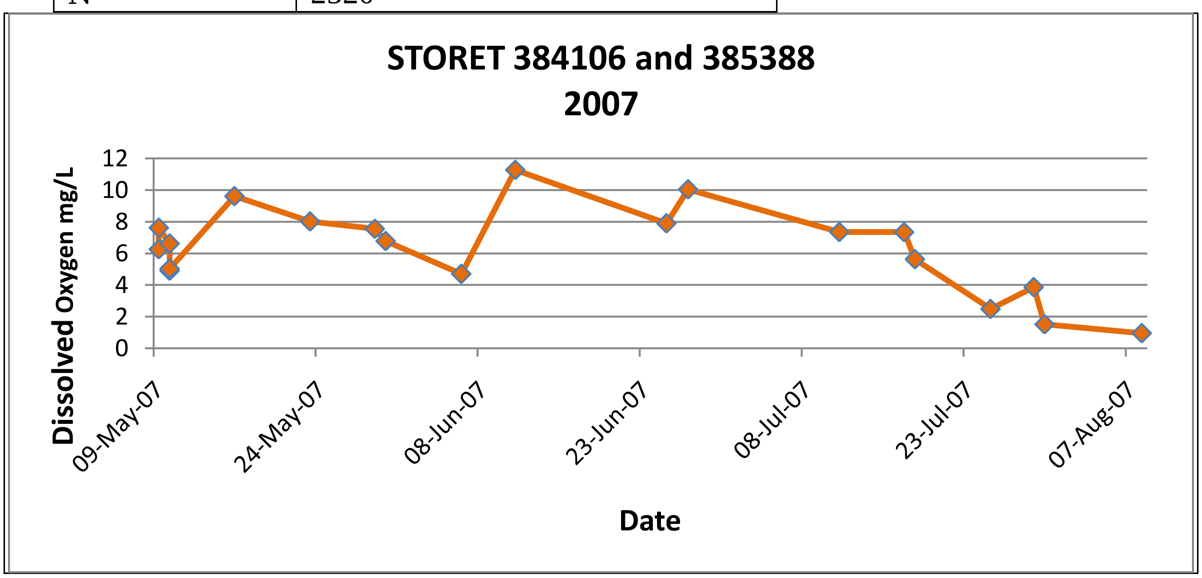
2006

Minimum	6.48
Maximum	15.34
Mean	10.26
N	24



2007

Minimum	0.95
Maximum	16.911.283
Mean	10.396.27
N	2520



BOD and COD data for Site 385106 (none collected at 385338)

Table 1. Corrected BOD (384106)

Date	Time	Parameter	Value (mg/L)
09-May-07	07:45	Corrected BOD Day 11	4.04
09-May-07	12:41	Corrected BOD Day 11	3.39
10-May-07	13:13	Corrected BOD Day 11	4.08
09-May-07	07:45	Corrected BOD Day 14	4.04
09-May-07	12:41	Corrected BOD Day 14	3.49
10-May-07	13:13	Corrected BOD Day 14	4.21
09-May-07	07:45	Corrected BOD Day 18	4.46
09-May-07	12:41	Corrected BOD Day 18	4.15
10-May-07	13:13	Corrected BOD Day 18	5.03
09-May-07	07:45	Corrected BOD Day 21	5.01
09-May-07	12:41	Corrected BOD Day 21	4.69
10-May-07	13:13	Corrected BOD Day 21	5.55
09-May-07	07:45	Corrected BOD Day 25	5.57
09-May-07	12:41	Corrected BOD Day 25	5.16
10-May-07	13:13	Corrected BOD Day 25	5.94
09-May-07	07:45	Corrected BOD Day 28	5.72
09-May-07	12:41	Corrected BOD Day 28	5.47
10-May-07	13:13	Corrected BOD Day 28	6.25
09-May-07	07:45	Corrected BOD Day 3	1.78
09-May-07	12:41	Corrected BOD Day 3	0.25
10-May-07	13:13	Corrected BOD Day 3	1.81
09-May-07	07:45	Corrected BOD Day 32	5.93
09-May-07	12:41	Corrected BOD Day 32	6.10
10-May-07	13:13	Corrected BOD Day 32	6.88
09-May-07	07:45	Corrected BOD Day 39	6.71
09-May-07	12:41	Corrected BOD Day 39	6.46
10-May-07	13:13	Corrected BOD Day 39	7.37
09-May-07	07:45	Corrected BOD Day 46	7.52
09-May-07	12:41	Corrected BOD Day 46	7.17
10-May-07	13:13	Corrected BOD Day 46	8.16
09-May-07	07:45	Corrected BOD Day 5	2.56
09-May-07	12:41	Corrected BOD Day 5	2.14
10-May-07	13:13	Corrected BOD Day 5	2.62
09-May-07	07:45	Corrected BOD Day 53	7.95
09-May-07	12:41	Corrected BOD Day 53	7.45
10-May-07	13:13	Corrected BOD Day 53	8.48
09-May-07	07:45	Corrected BOD Day 60	8.67
09-May-07	12:41	Corrected BOD Day 60	7.93
10-May-07	13:13	Corrected BOD Day 60	9.10

Table 1. (Cont.) Corrected BOD (384106)

09-May-07	07:45	Corrected BOD Day 67	8.75
09-May-07	12:41	Corrected BOD Day 67	8.04
10-May-07	13:13	Corrected BOD Day 67	9.25
09-May-07	07:45	Corrected BOD Day 7	2.90
09-May-07	12:41	Corrected BOD Day 7	2.42
10-May-07	13:13	Corrected BOD Day 7	2.96
09-May-07	07:45	Corrected BOD Day 74	9.00
09-May-07	12:41	Corrected BOD Day 74	8.30
10-May-07	13:13	Corrected BOD Day 74	9.59
09-May-07	07:45	Corrected BOD Day 81	10.2
09-May-07	12:41	Corrected BOD Day 81	8.53
10-May-07	13:13	Corrected BOD Day 81	9.74
09-May-07	07:45	Corrected BOD Day 88	9.40
09-May-07	12:41	Corrected BOD Day 88	8.77
10-May-07	13:13	Corrected BOD Day 88	9.90
09-May-07	07:45	Corrected BOD Day 95	9.50
09-May-07	12:41	Corrected BOD Day 95	8.86
10-May-07	13:13	Corrected BOD Day 95	10.1

Table 2. Ultimate BOD (384106)

Date	Time	Parameter	Value (mg/L)
09-May-07	07:45	Ultimate BOD 11th Day	4.14
09-May-07	12:41	Ultimate BOD 11th Day	3.45
10-May-07	13:13	Ultimate BOD 11th Day	4.15
09-May-07	07:45	Ultimate BOD 14th Day	4.56
09-May-07	12:41	Ultimate BOD 14th Day	3.82
10-May-07	13:13	Ultimate BOD 14th Day	4.56
09-May-07	07:45	Ultimate BOD 18th Day	5.61
09-May-07	12:41	Ultimate BOD 18th Day	5.01
10-May-07	13:13	Ultimate BOD 18th Day	5.99
09-May-07	07:45	Ultimate BOD 21st Day	6.21
09-May-07	12:41	Ultimate BOD 21st Day	5.66
10-May-07	13:13	Ultimate BOD 21st Day	6.61
09-May-07	07:45	Ultimate BOD 25th Day	6.85
09-May-07	12:41	Ultimate BOD 25th Day	6.22
10-May-07	13:13	Ultimate BOD 25th Day	7.09
09-May-07	07:45	Ultimate BOD 28th Day	7.04
09-May-07	12:41	Ultimate BOD 28th Day	6.59
10-May-07	13:13	Ultimate BOD 28th Day	7.44
09-May-07	07:45	Ultimate BOD 32nd Day	7.76
09-May-07	12:41	Ultimate BOD 32nd Day	7.30
10-May-07	13:13	Ultimate BOD 32nd Day	8.17

Table 2. (Cont.) Ultimate BOD (384106)

09-May-07	07:45	Ultimate BOD 39th Day	8.28
09-May-07	12:41	Ultimate BOD 39th Day	7.82
10-May-07	13:13	Ultimate BOD 39th Day	8.81
09-May-07	07:45	Ultimate BOD 3rd Day	1.83
09-May-07	12:41	Ultimate BOD 3rd Day	1.53
10-May-07	13:13	Ultimate BOD 3rd Day	1.91
09-May-07	07:45	Ultimate BOD 46th Day	9.22
09-May-07	12:41	Ultimate BOD 46th Day	8.63
10-May-07	13:13	Ultimate BOD 46th Day	9.74
09-May-07	07:45	Ultimate BOD 53rd Day	9.83
09-May-07	12:41	Ultimate BOD 53rd Day	9.08
10-May-07	13:13	Ultimate BOD 53rd Day	10.3
09-May-07	07:45	Ultimate BOD 5th Day	2.57
09-May-07	12:41	Ultimate BOD 5th Day	2.17
10-May-07	13:13	Ultimate BOD 5th Day	2.66
09-May-07	07:45	Ultimate BOD 60th Day	10.6
09-May-07	12:41	Ultimate BOD 60th Day	9.63
10-May-07	13:13	Ultimate BOD 60th Day	11.0
09-May-07	07:45	Ultimate BOD 67th Day	10.8
09-May-07	12:41	Ultimate BOD 67th Day	9.83
10-May-07	13:13	Ultimate BOD 67th Day	11.2
09-May-07	07:45	Ultimate BOD 74th Day	11.1
09-May-07	12:41	Ultimate BOD 74th Day	10.2
10-May-07	13:13	Ultimate BOD 74th Day	11.6
09-May-07	07:45	Ultimate BOD 7th Day	3.00
09-May-07	12:41	Ultimate BOD 7th Day	2.53
10-May-07	13:13	Ultimate BOD 7th Day	3.09
09-May-07	07:45	Ultimate BOD 81st Day	11.3
09-May-07	12:41	Ultimate BOD 81st Day	10.5
10-May-07	13:13	Ultimate BOD 81st Day	11.8
09-May-07	07:45	Ultimate BOD 88th Day	11.6
09-May-07	12:41	Ultimate BOD 88th Day	10.8
10-May-07	13:13	Ultimate BOD 88th Day	12.0
09-May-07	07:45	Ultimate BOD 95th Day	11.8
09-May-07	12:41	Ultimate BOD 95th Day	11.0
10-May-07	13:13	Ultimate BOD 95th Day	12.3

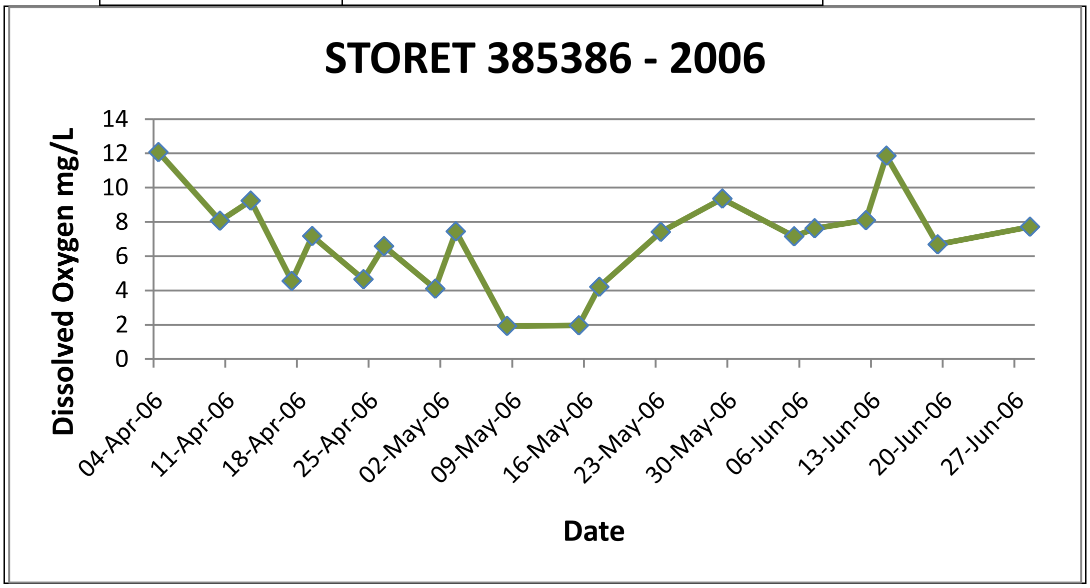
Table 3. Chemical Oxygen Demand Site (384106)

Date	Time	Parameter	Value (mg/L)
09-May-07	07:45	Chemical Oxygen Demand	22.
09-May-07	12:41	Chemical Oxygen Demand	23.
10-May-07	13:13	Chemical Oxygen Demand	25.
10-May-07	06:06	Chemical Oxygen Demand	24.
10-May-07	01:04	Chemical Oxygen Demand	24.
23-May-07	15:59	Chemical Oxygen Demand	46.
06-Jun-07	12:44	Chemical Oxygen Demand	130.
11-Jul-07	15:30	Chemical Oxygen Demand	138.
18-Jul-07	15:30	Chemical Oxygen Demand	100.
25-Jul-07	15:00	Chemical Oxygen Demand	80.
08-Aug-07	07:30	Chemical Oxygen Demand	100.

Dissolved Oxygen Data for Site 385386 (Mid-River)

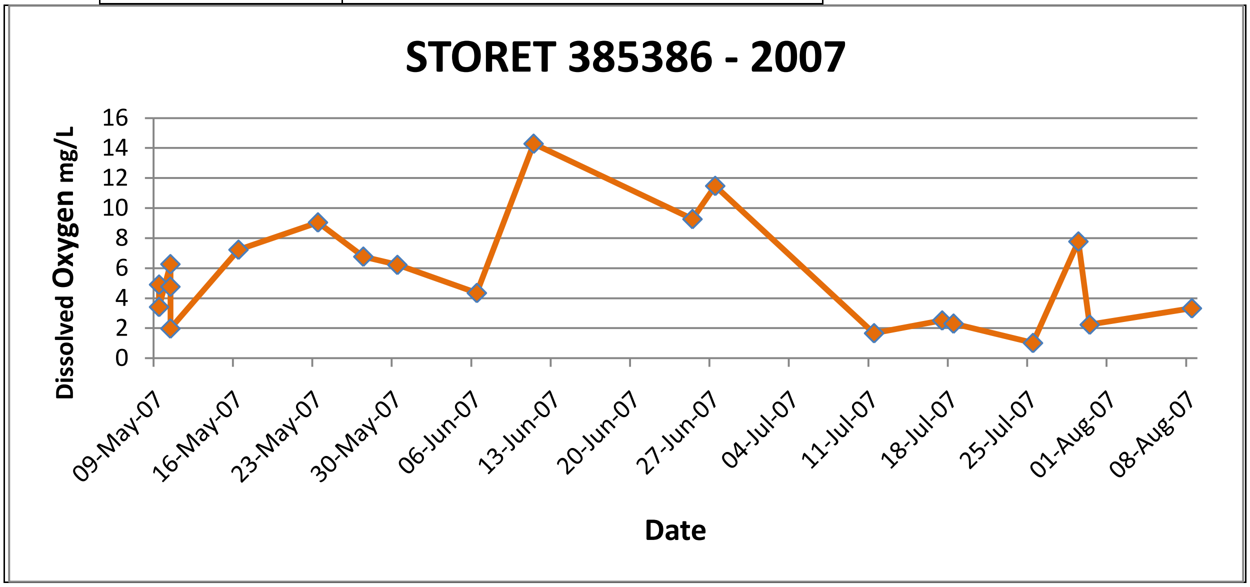
2006

Minimum	1.93
Maximum	12.06
Mean	6.89
N	20



2007

Minimum	1.02
Maximum	14.29
Mean	5.54
N	20



BOD and COD Data for Site 385386

Table 1. Corrected BOD (385386)

Date	Time	Parameter	Value (mg/L)
09-May-07	06:45	Corrected BOD Day 11	7.32
09-May-07	13:06	Corrected BOD Day 11	6.91
10-May-07	12:41	Corrected BOD Day 11	8.40
09-May-07	06:45	Corrected BOD Day 14	8.24
09-May-07	13:06	Corrected BOD Day 14	7.66
10-May-07	12:41	Corrected BOD Day 14	8.70
09-May-07	06:45	Corrected BOD Day 18	10.1
09-May-07	13:06	Corrected BOD Day 18	9.45
10-May-07	12:41	Corrected BOD Day 18	10.5
09-May-07	06:45	Corrected BOD Day 21	11.4
09-May-07	13:06	Corrected BOD Day 21	10.8
10-May-07	12:41	Corrected BOD Day 21	12.0
09-May-07	06:45	Corrected BOD Day 25	12.9
09-May-07	13:06	Corrected BOD Day 25	12.3
10-May-07	12:41	Corrected BOD Day 25	13.7
09-May-07	06:45	Corrected BOD Day 28	13.9
09-May-07	13:06	Corrected BOD Day 28	13.3
10-May-07	12:41	Corrected BOD Day 28	17.1
09-May-07	06:45	Corrected BOD Day 3	1.85
09-May-07	13:06	Corrected BOD Day 3	2.45
10-May-07	12:41	Corrected BOD Day 3	3.26
09-May-07	06:45	Corrected BOD Day 32	15.3
09-May-07	13:06	Corrected BOD Day 32	14.9
10-May-07	12:41	Corrected BOD Day 32	16.5
09-May-07	06:45	Corrected BOD Day 39	17.6
09-May-07	13:06	Corrected BOD Day 39	16.9
10-May-07	12:41	Corrected BOD Day 39	18.5
09-May-07	06:45	Corrected BOD Day 46	20.0
09-May-07	13:06	Corrected BOD Day 46	19.4
10-May-07	12:41	Corrected BOD Day 46	20.4
09-May-07	06:45	Corrected BOD Day 5	4.06
09-May-07	13:06	Corrected BOD Day 5	3.83
10-May-07	12:41	Corrected BOD Day 5	4.73
09-May-07	06:45	Corrected BOD Day 53	21.6
09-May-07	13:06	Corrected BOD Day 53	21.2
10-May-07	12:41	Corrected BOD Day 53	21.6
09-May-07	06:45	Corrected BOD Day 60	23.7
09-May-07	13:06	Corrected BOD Day 60	23.0
10-May-07	12:41	Corrected BOD Day 60	23.5

Table 1. (Cont.) Corrected BOD (385386)

Date	Time	Parameter	Value (mg/L)
09-May-07	06:45	Corrected BOD Day 67	24.9
09-May-07	13:06	Corrected BOD Day 67	24.4
10-May-07	12:41	Corrected BOD Day 67	24.7
09-May-07	06:45	Corrected BOD Day 7	4.95
09-May-07	13:06	Corrected BOD Day 7	4.74
10-May-07	12:41	Corrected BOD Day 7	5.71
09-May-07	06:45	Corrected BOD Day 74	26.2
09-May-07	13:06	Corrected BOD Day 74	25.9
10-May-07	12:41	Corrected BOD Day 74	25.9
09-May-07	06:45	Corrected BOD Day 81	27.1
09-May-07	13:06	Corrected BOD Day 81	27.1
10-May-07	12:41	Corrected BOD Day 81	27.2
09-May-07	06:45	Corrected BOD Day 88	28.0
09-May-07	13:06	Corrected BOD Day 88	28.5
10-May-07	12:41	Corrected BOD Day 88	28.3
09-May-07	06:45	Corrected BOD Day 95	28.8
09-May-07	13:06	Corrected BOD Day 95	29.4
10-May-07	12:41	Corrected BOD Day 95	29.1

Table 2. Ultimate BOD (385386)

Date	Time	Parameter	Value (mg/L)
09-May-07	06:45	Ultimate BOD 11th Day	7.87
09-May-07	13:06	Ultimate BOD 11th Day	7.30
10-May-07	12:41	Ultimate BOD 11th Day	8.54
09-May-07	06:45	Ultimate BOD 14th Day	9.58
09-May-07	13:06	Ultimate BOD 14th Day	8.79
10-May-07	12:41	Ultimate BOD 14th Day	10.2
09-May-07	06:45	Ultimate BOD 18th Day	11.8
09-May-07	13:06	Ultimate BOD 18th Day	11.0
10-May-07	12:41	Ultimate BOD 18th Day	12.3
09-May-07	06:45	Ultimate BOD 21st Day	13.2
09-May-07	13:06	Ultimate BOD 21st Day	12.5
10-May-07	12:41	Ultimate BOD 21st Day	14.0
09-May-07	06:45	Ultimate BOD 25th Day	14.9
09-May-07	13:06	Ultimate BOD 25th Day	14.2
10-May-07	12:41	Ultimate BOD 25th Day	15.9
09-May-07	06:45	Ultimate BOD 28th Day	16.0
09-May-07	13:06	Ultimate BOD 28th Day	15.3
10-May-07	12:41	Ultimate BOD 28th Day	17.2
09-May-07	06:45	Ultimate BOD 32nd Day	17.6
09-May-07	13:06	Ultimate BOD 32nd Day	17.1

Table 2. (cont.) Ultimate BOD (385386)

Date	Time	Parameter	Value (mg/L)
10-may-07	12:41	Ultimate BOD 32nd Day	19.0
09-May-07	06:45	Ultimate BOD 39th Day	20.1
09-May-07	13:06	Ultimate BOD 39th Day	19.4
10-May-07	12:41	Ultimate BOD 39th Day	21.4
09-May-07	06:45	Ultimate BOD 3rd Day	2.86
09-May-07	13:06	Ultimate BOD 3rd Day	2.52
10-May-07	12:41	Ultimate BOD 3rd Day	3.36
09-May-07	06:45	Ultimate BOD 46th Day	22.8
09-May-07	13:06	Ultimate BOD 46th Day	22.2
10-May-07	12:41	Ultimate BOD 46th Day	23.6
09-May-07	06:45	Ultimate BOD 53rd Day	24.8
09-May-07	13:06	Ultimate BOD 53rd Day	24.5
10-May-07	12:41	Ultimate BOD 53rd Day	25.2
09-May-07	06:45	Ultimate BOD 5th Day	4.13
09-May-07	13:06	Ultimate BOD 5th Day	3.86
10-May-07	12:41	Ultimate BOD 5th Day	4.79
09-May-07	06:45	Ultimate BOD 60th Day	27.0
09-May-07	13:06	Ultimate BOD 60th Day	26.5
10-May-07	12:41	Ultimate BOD 60th Day	27.2
09-May-07	06:45	Ultimate BOD 67th Day	28.5
09-May-07	13:06	Ultimate BOD 67th Day	28.0
10-May-07	12:41	Ultimate BOD 67th Day	28.6
09-May-07	06:45	Ultimate BOD 74th Day	30.0
09-May-07	13:06	Ultimate BOD 74th Day	29.6
10-May-07	12:41	Ultimate BOD 74th Day	29.9
09-May-07	06:45	Ultimate BOD 7th Day	5.11
09-May-07	13:06	Ultimate BOD 7th Day	4.86
10-May-07	12:41	Ultimate BOD 7th Day	5.87
09-May-07	06:45	Ultimate BOD 81st Day	31.1
09-May-07	13:06	Ultimate BOD 81st Day	30.9
10-May-07	12:41	Ultimate BOD 81st Day	31.3
09-May-07	06:45	Ultimate BOD 88th Day	32.1
09-May-07	13:06	Ultimate BOD 88th Day	32.5
10-May-07	12:41	Ultimate BOD 88th Day	32.6
09-May-07	06:45	Ultimate BOD 95th Day	33.2
09-May-07	13:06	Ultimate BOD 95th Day	33.8
10-May-07	12:41	Ultimate BOD 95th Day	33.7

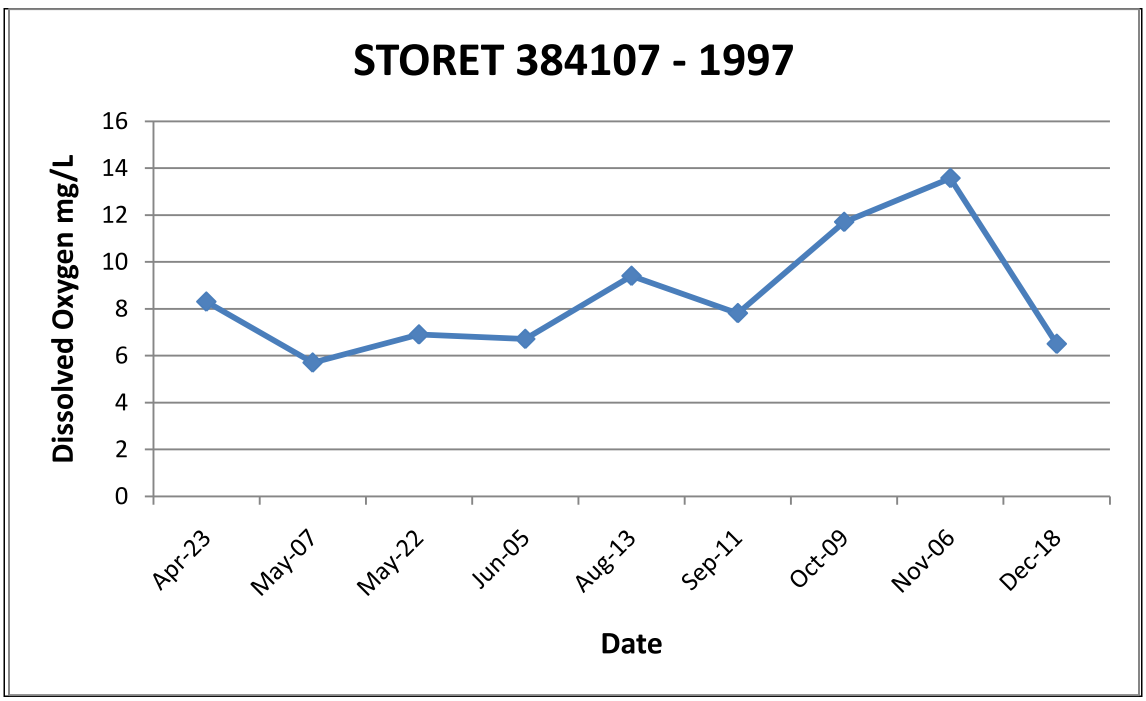
Table 3. Chemical Oxygen Demand (385386)

Date	Time	Parameter	Value (mg/L)
09-May-07	06:45	Chemical Oxygen Demand	116.
09-May-07	13:06	Chemical Oxygen Demand	108.
10-May-07	12:41	Chemical Oxygen Demand	118.
10-May-07	06:42	Chemical Oxygen Demand	108.
10-May-07	00:32	Chemical Oxygen Demand	116.
23-May-07	14:52	Chemical Oxygen Demand	122.
06-Jun-07	11:35	Chemical Oxygen Demand	130.
11-Jul-07	16:30	Chemical Oxygen Demand	128.
18-Jul-07	16:15	Chemical Oxygen Demand	110.
25-Jul-07	16:00	Chemical Oxygen Demand	105.
08-Aug-07	08:30	Chemical Oxygen Demand	168.

Dissolved Oxygen Data for Site 384107 (Downstream)

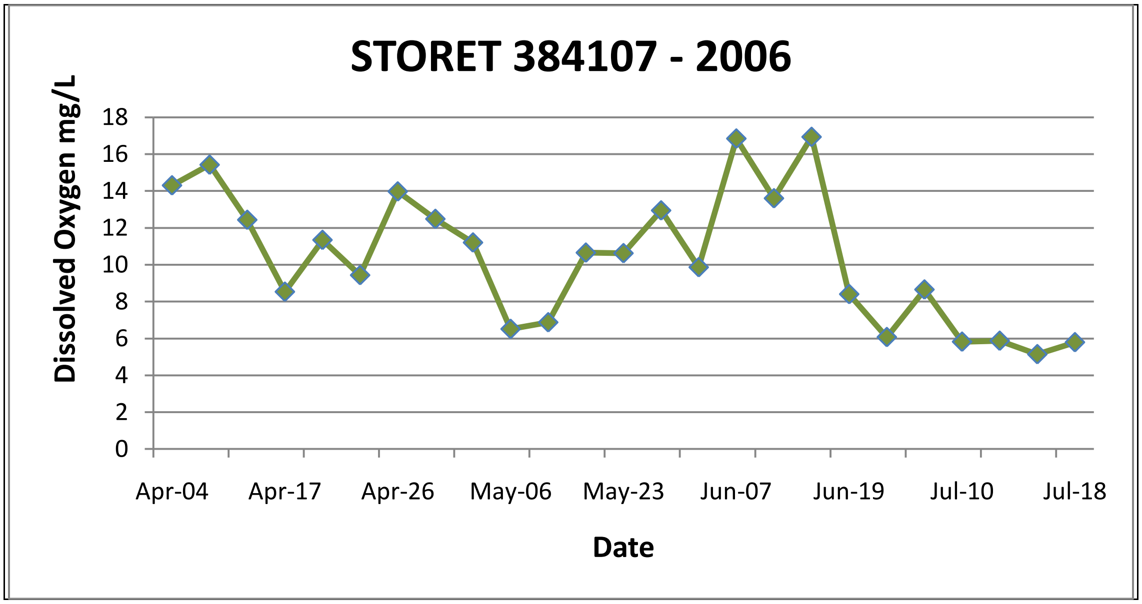
1997

Date	Dissolved Oxygen (mg/L)
04/23/1997	8.3
05/07/1997	5.7
05/22/1997	6.9
06/05/1997	6.71
08/23/1997	9.4
09/11/1997	7.81
10/09/1997	11.7
11/06/1997	13.57
02/18/1998	6.5
Minimum	5.7
Maximum	13.57
Mean	8.51
N	9



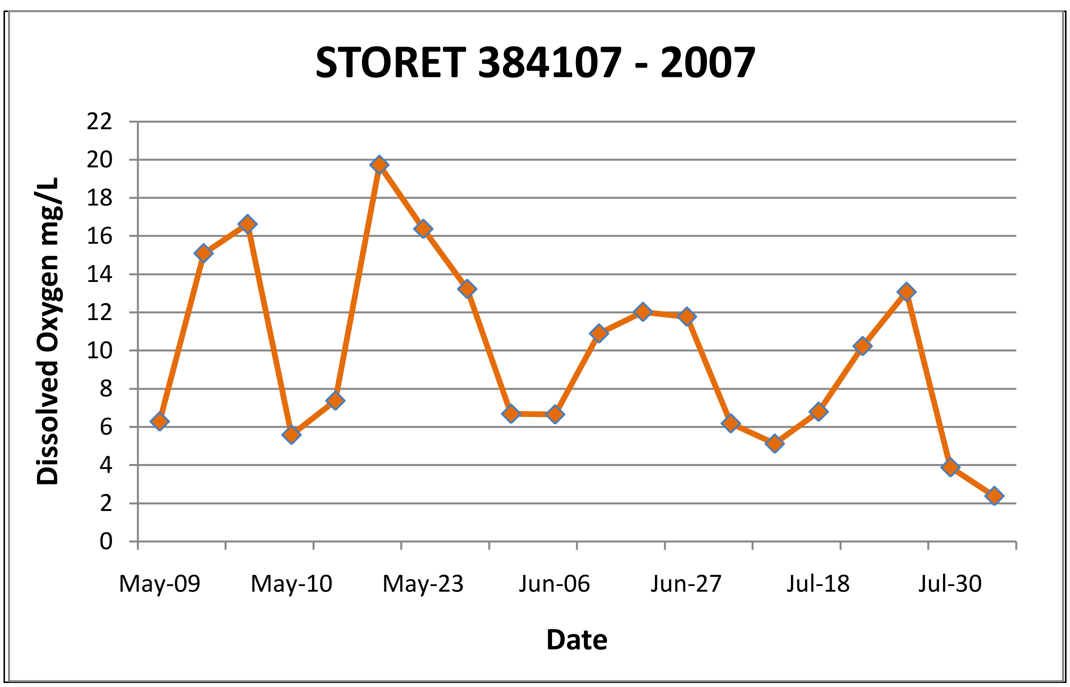
2006

Minimum	5.14
Maximum	16.93
Mean	10.39
N	25



2007

Minimum	2.38
Maximum	19.72
Mean	9.79
N	20



BOD and COD Data for Site 384107

Table 1. Corrected BOD (384107)

Date	Time	Parameter	Value (mg/L)
09-May-07	06:10	Corrected BOD Day 11	5.54
10-May-07	12:10	Corrected BOD Day 11	5.80
10-May-07	13:36	Corrected BOD Day 11	6.27
09-May-07	06:10	Corrected BOD Day 14	5.64
10-May-07	12:10	Corrected BOD Day 14	6.11
10-May-07	13:36	Corrected BOD Day 14	6.58
09-May-07	06:10	Corrected BOD Day 18	6.74
10-May-07	12:10	Corrected BOD Day 18	6.79
10-May-07	13:36	Corrected BOD Day 18	7.37
09-May-07	06:10	Corrected BOD Day 21	7.24
10-May-07	12:10	Corrected BOD Day 21	7.20
10-May-07	13:36	Corrected BOD Day 21	7.92
09-May-07	06:10	Corrected BOD Day 25	7.59
10-May-07	12:10	Corrected BOD Day 25	7.53
10-May-07	13:36	Corrected BOD Day 25	8.29
09-May-07	06:10	Corrected BOD Day 28	6.43
10-May-07	12:10	Corrected BOD Day 28	7.88
10-May-07	13:36	Corrected BOD Day 28	8.54
09-May-07	06:10	Corrected BOD Day 3	2.66
10-May-07	12:10	Corrected BOD Day 3	2.48
10-May-07	13:36	Corrected BOD Day 3	3.02
09-May-07	06:10	Corrected BOD Day 32	8.41
10-May-07	12:10	Corrected BOD Day 32	8.60
10-May-07	13:36	Corrected BOD Day 32	9.15
09-May-07	06:10	Corrected BOD Day 39	8.93
10-May-07	12:10	Corrected BOD Day 39	9.02
10-May-07	13:36	Corrected BOD Day 39	9.68
09-May-07	06:10	Corrected BOD Day 46	9.70
10-May-07	12:10	Corrected BOD Day 46	9.71
10-May-07	13:36	Corrected BOD Day 46	10.5
09-May-07	06:10	Corrected BOD Day 5	3.75
10-May-07	12:10	Corrected BOD Day 5	3.72
10-May-07	13:36	Corrected BOD Day 5	4.23
09-May-07	06:10	Corrected BOD Day 53	10.2
10-May-07	12:10	Corrected BOD Day 53	10.1
10-May-07	13:36	Corrected BOD Day 53	10.9
09-May-07	06:10	Corrected BOD Day 60	10.8
10-May-07	12:10	Corrected BOD Day 60	10.7

Table 1. (cont.) Corrected BOD (384107)

Date		Time	Parameter
10-May-07	13:36	Corrected BOD Day 60	11.4
09-May-07	06:10	Corrected BOD Day 67	10.9
10-May-07	12:10	Corrected BOD Day 67	10.7
10-May-07	13:36	Corrected BOD Day 67	11.5
09-May-07	06:10	Corrected BOD Day 7	4.35
10-May-07	12:10	Corrected BOD Day 7	4.39
10-May-07	13:36	Corrected BOD Day 7	4.85
09-May-07	06:10	Corrected BOD Day 74	11.2
10-May-07	12:10	Corrected BOD Day 74	10.9
10-May-07	13:36	Corrected BOD Day 74	11.8
09-May-07	06:10	Corrected BOD Day 81	11.3
10-May-07	12:10	Corrected BOD Day 81	11.1
10-May-07	13:36	Corrected BOD Day 81	12.0
09-May-07	06:10	Corrected BOD Day 88	11.6
10-May-07	12:10	Corrected BOD Day 88	11.3
10-May-07	13:36	Corrected BOD Day 88	12.1
09-May-07	06:10	Corrected BOD Day 95	11.7
10-May-07	12:10	Corrected BOD Day 95	11.4
10-May-07	13:36	Corrected BOD Day 95	12.3

Table 2. Ultimate BOD (384107)

Date	Time	Parameter	Value (mg/L)
09-May-07	06:10	Ultimate BOD 11th Day	5.86
10-May-07	12:10	Ultimate BOD 11th Day	5.81
10-May-07	13:36	Ultimate BOD 11th Day	6.43
09-May-07	06:10	Ultimate BOD 14th Day	6.49
10-May-07	12:10	Ultimate BOD 14th Day	6.23
10-May-07	13:36	Ultimate BOD 14th Day	6.94
09-May-07	06:10	Ultimate BOD 18th Day	7.76
10-May-07	12:10	Ultimate BOD 18th Day	7.08
10-May-07	13:36	Ultimate BOD 18th Day	8.57
09-May-07	06:10	Ultimate BOD 21st Day	8.33
10-May-07	12:10	Ultimate BOD 21st Day	8.00
10-May-07	13:36	Ultimate BOD 21st Day	9.29
09-May-07	06:10	Ultimate BOD 25th Day	8.81
10-May-07	12:10	Ultimate BOD 25th Day	8.54
10-May-07	13:36	Ultimate BOD 25th Day	9.77
09-May-07	06:10	Ultimate BOD 28th Day	9.15
10-May-07	12:10	Ultimate BOD 28th Day	8.93
10-May-07	13:36	Ultimate BOD 28th Day	10.1
09-May-07	06:10	Ultimate BOD 32nd Day	9.93

Table 2. (cont.) Ultimate BOD (384107)

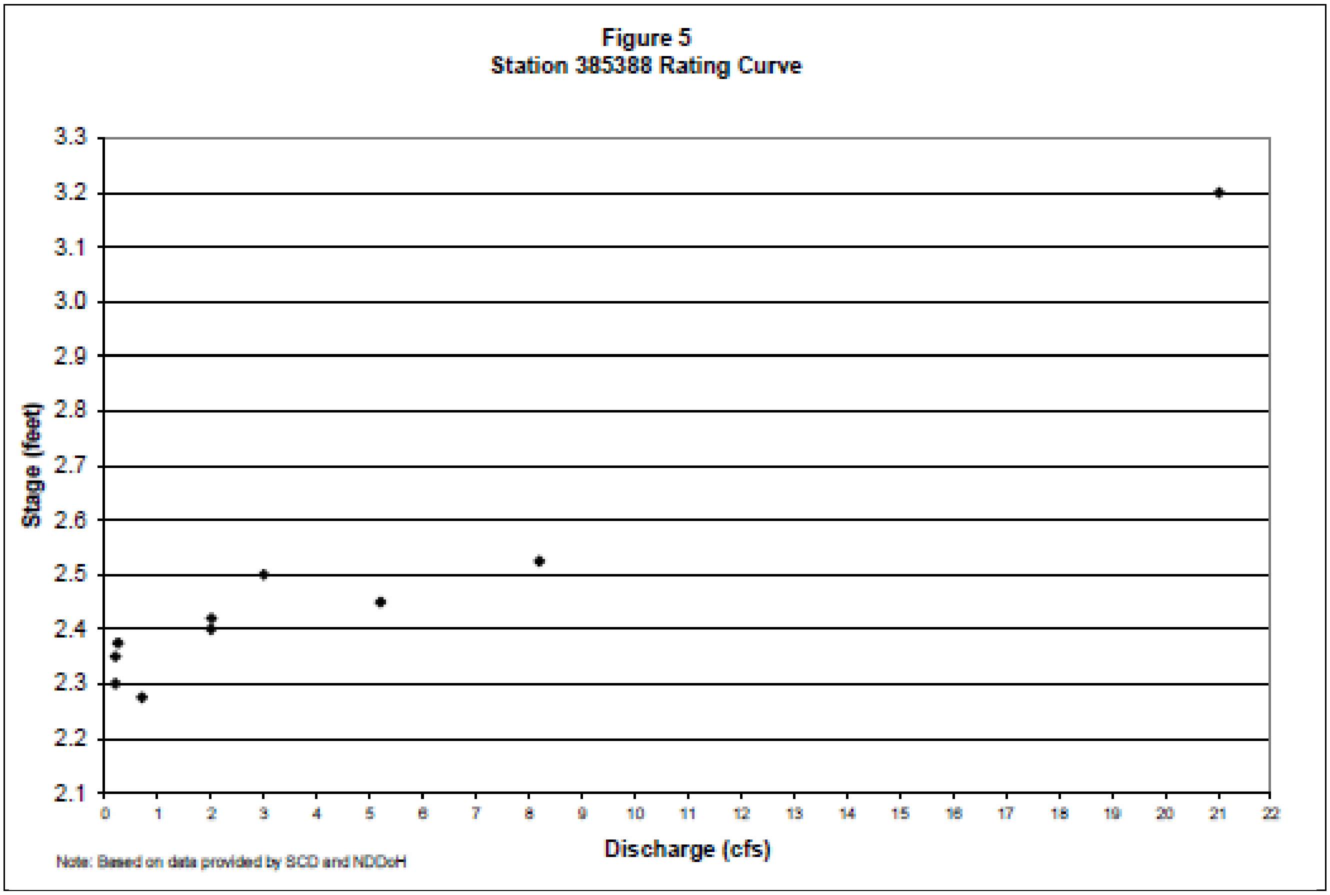
Date	Time	Parameter	Value (mg/L)
10-May-07	12:10	Ultimate BOD 32nd Day	9.75
10-May-07	13:36	Ultimate BOD 32nd Day	10.8
09-May-07	06:10	Ultimate BOD 39th Day	10.6
10-May-07	12:10	Ultimate BOD 39th Day	10.3
10-May-07	13:36	Ultimate BOD 39th Day	11.5
09-May-07	06:10	Ultimate BOD 3rd Day	2.74
10-May-07	12:10	Ultimate BOD 3rd Day	2.52
10-May-07	13:36	Ultimate BOD 3rd Day	3.19
09-May-07	06:10	Ultimate BOD 46th Day	11.5
10-May-07	12:10	Ultimate BOD 46th Day	11.1
10-May-07	13:36	Ultimate BOD 46th Day	12.4
09-May-07	06:10	Ultimate BOD 53rd Day	12.2
10-May-07	12:10	Ultimate BOD 53rd Day	11.7
10-May-07	13:36	Ultimate BOD 53rd Day	13.0
09-May-07	06:10	Ultimate BOD 5th Day	3.80
10-May-07	12:10	Ultimate BOD 5th Day	3.72
10-May-07	13:36	Ultimate BOD 5th Day	4.34
09-May-07	06:10	Ultimate BOD 60th Day	12.8
10-May-07	12:10	Ultimate BOD 60th Day	12.4
10-May-07	13:36	Ultimate BOD 60th Day	13.6
09-May-07	06:10	Ultimate BOD 67th Day	13.0
10-May-07	12:10	Ultimate BOD 67th Day	12.5
10-May-07	13:36	Ultimate BOD 67th Day	13.8
09-May-07	06:10	Ultimate BOD 74th Day	13.3
10-May-07	12:10	Ultimate BOD 74th Day	12.8
10-May-07	13:36	Ultimate BOD 74th Day	14.2
09-May-07	06:10	Ultimate BOD 7th Day	4.51
10-May-07	12:10	Ultimate BOD 7th Day	4.44
10-May-07	13:36	Ultimate BOD 7th Day	5.06
09-May-07	06:10	Ultimate BOD 81st Day	13.5
10-May-07	12:10	Ultimate BOD 81st Day	13.0
10-May-07	13:36	Ultimate BOD 81st Day	14.4
09-May-07	06:10	Ultimate BOD 88th Day	13.8
10-May-07	12:10	Ultimate BOD 88th Day	13.3
10-May-07	13:36	Ultimate BOD 88th Day	14.6
09-May-07	06:10	Ultimate BOD 95th Day	14.0
10-May-07	12:10	Ultimate BOD 95th Day	13.5
10-May-07	13:36	Ultimate BOD 95th Day	14.9

Table 3. Chemical Oxygen Demand Site

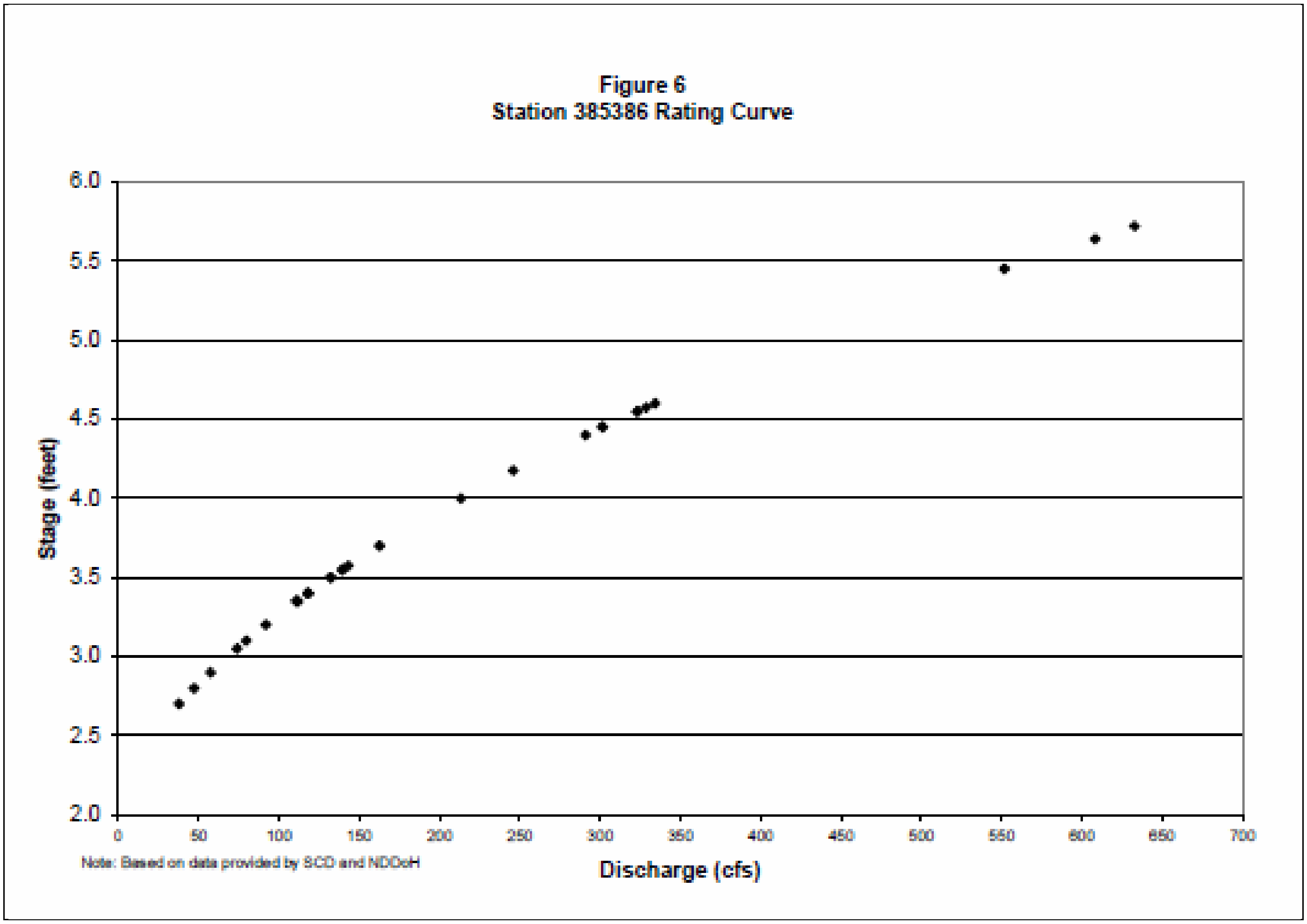
Date		Time	Parameter	Value (mg/L)
09-May-07		06:10	Chemical Oxygen Demand	27.
09-May-07		13:36	Chemical Oxygen Demand	28.
10-May-07		12:10	Chemical Oxygen Demand	30.
10-May-07		13:36	Chemical Oxygen Demand	31.
10-May-07		07:31	Chemical Oxygen Demand	28.
23-May-07		13:34	Chemical Oxygen Demand	26.
06-Jun-07		10:18	Chemical Oxygen Demand	70.
11-Jul-07		17:15	Chemical Oxygen Demand	108.
18-Jul-07		17:00	Chemical Oxygen Demand	75.
25-Jul-07		17:00	Chemical Oxygen Demand	70.
08-Aug-07		09:30	Chemical Oxygen Demand	86.

Appendix B
Wintering River Hydraulic Discharge Data
And Surveyed Cross-Sections

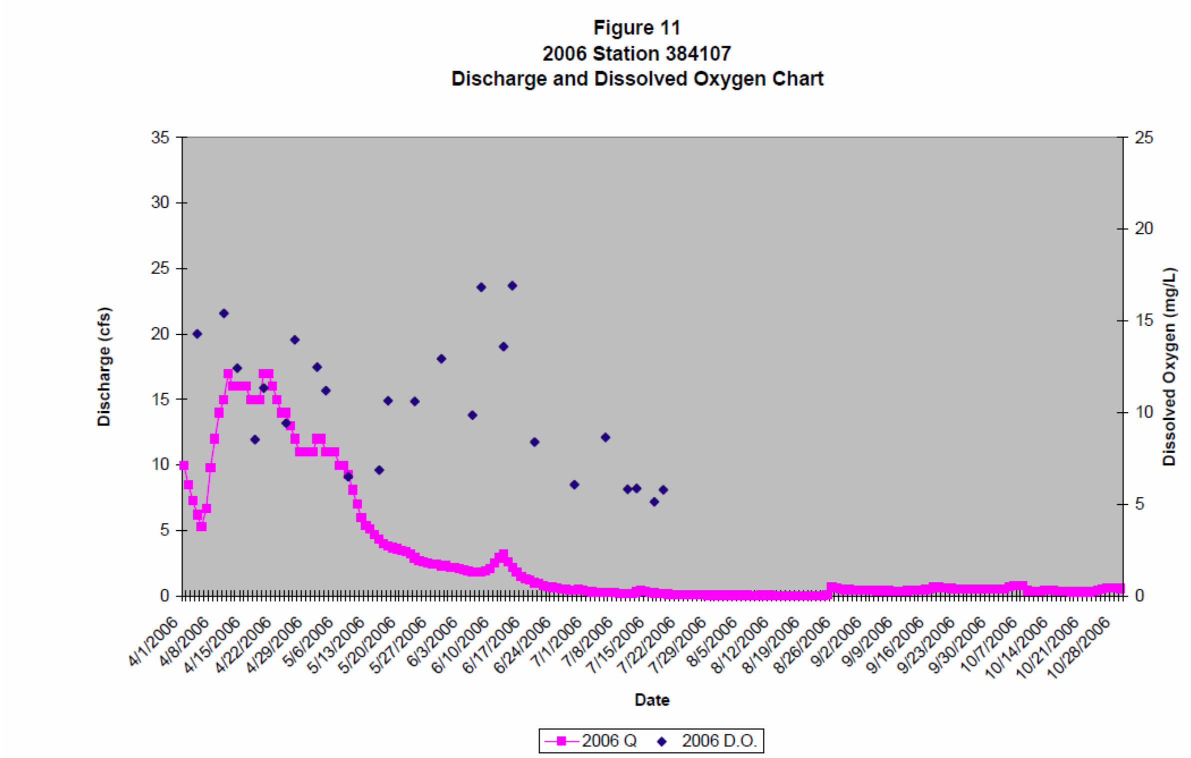
Rating Curve for Site 385388, 2006
Houston Engineering (2007)



Rating Curve for Site 385386, 2006-2007
Houston Engineering (2007)



Houston Engineering
Discharge vs. Dissolved Oxygen
TMDL Report 2007



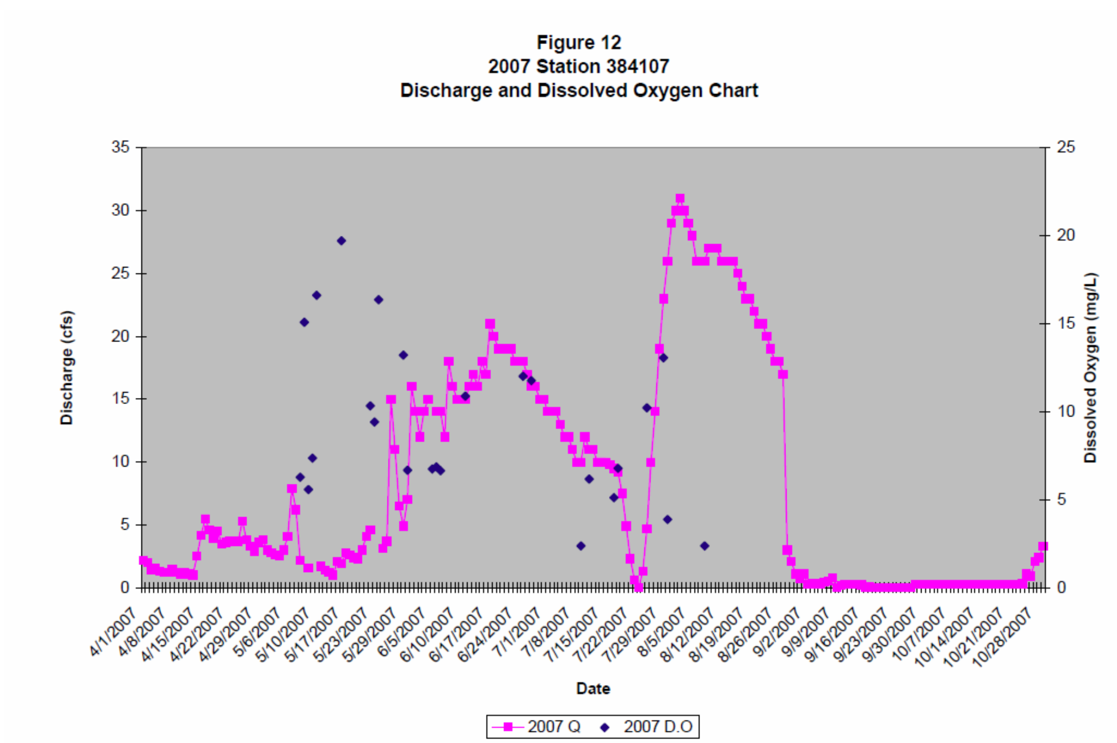


Figure 13
2006 Station 385386
Discharge and Dissolved Oxygen Chart

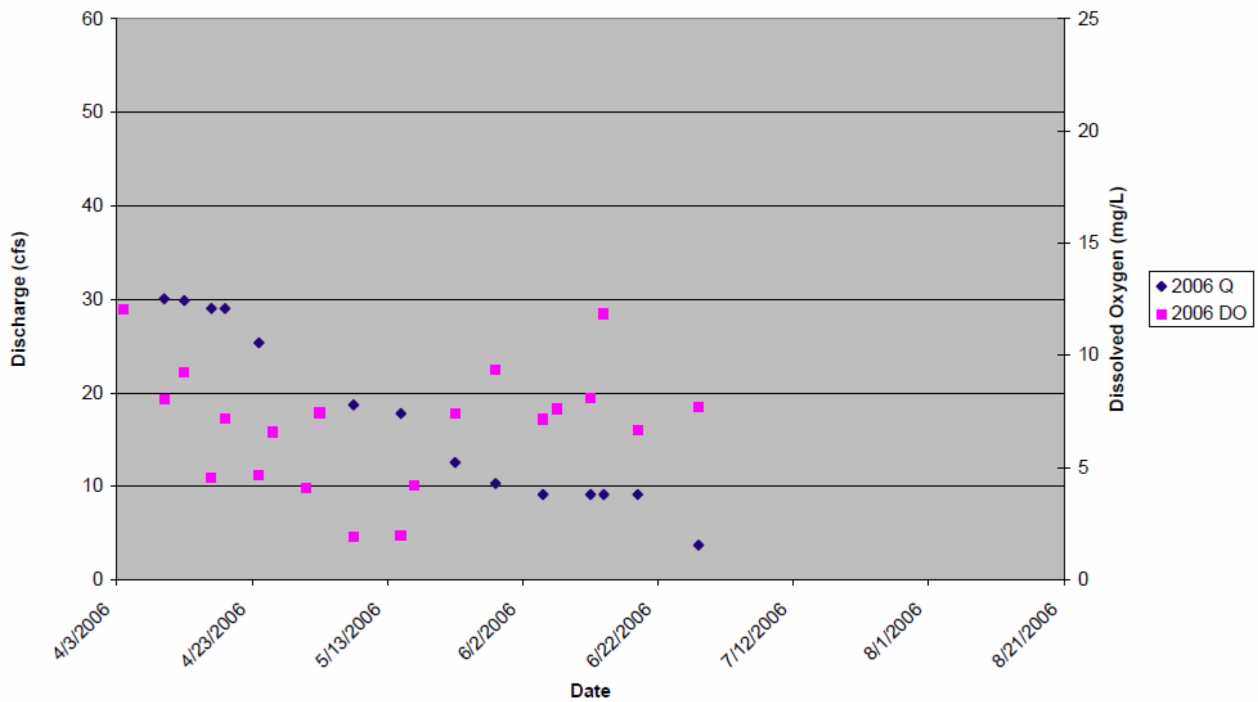
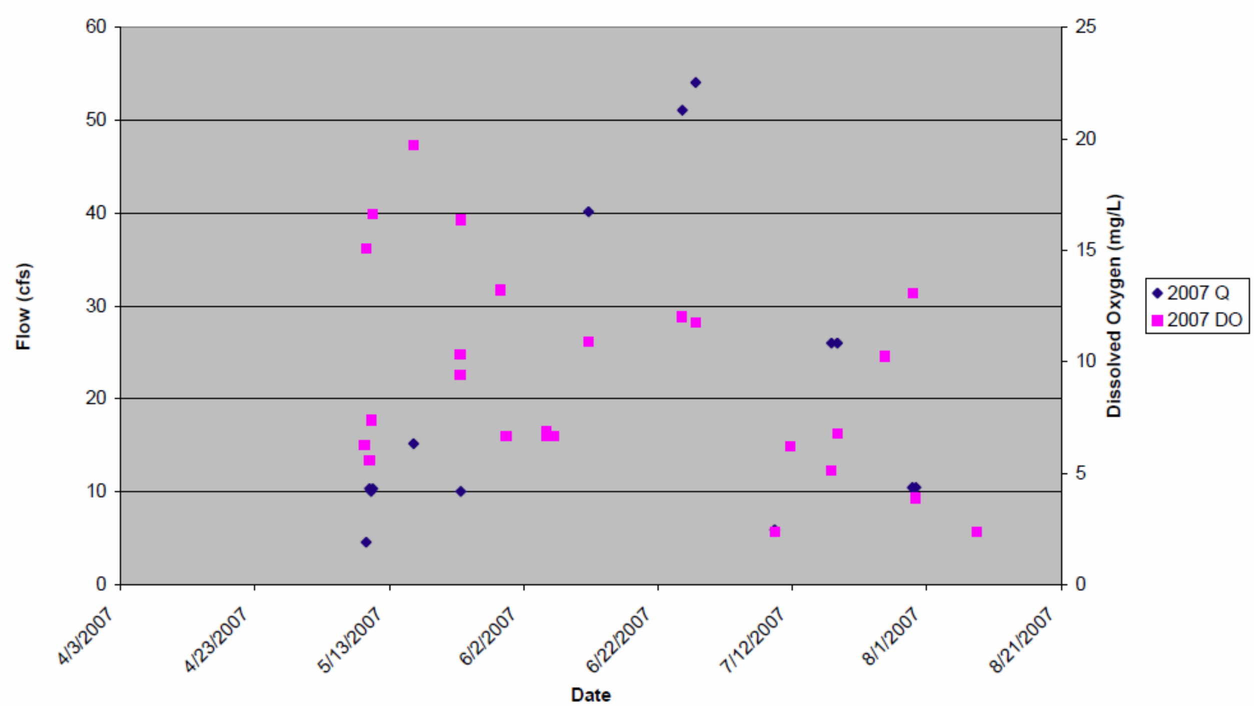
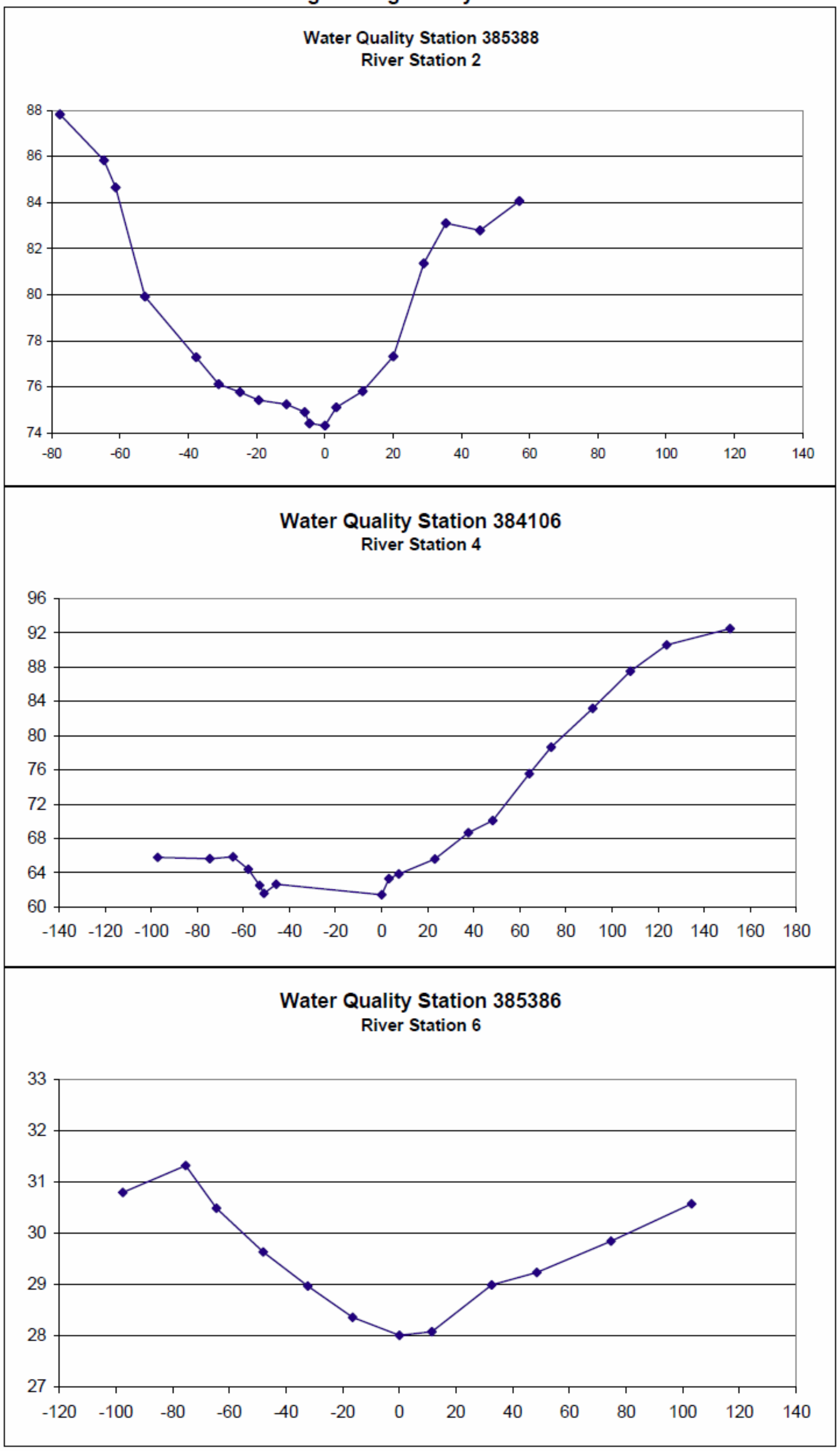


Figure 14
2007 Station 385386
Discharge and Dissolved Oxygen Chart



Surveyed Cross-Sections
Houston Engineering (2007)

Figure 7
Houson Engineering Surveyed Cross-sections



NOTE - a relative scale is used for each river station to enhance the display of local stream geometry.

Appendix C
BOD Spreadsheet Model Output

Reach1 Current BOD Load

Reach 1
From Water Quality Station 385386 to 384107

Inputs:		
Temperature:	19.4	degrees Celcius
Upstream DO:	4.2	mg/L
Upstream BOD:	24	mg/L
Flow:	14	cfs
Outputs:		
Minimum DO:	4.12	mg/L
Distance Downstream:	2.72	miles
BOD Load:	1,812	lb/d

Notes:
1.Documentation for this spreadsheet is in report "Wintering River TMDL Dissolved Oxygen Modeling" by Houston Engineering Inc., dated 12/31/07
2.Assumptions and computations for this spreadsheet are located below.
3. BOD concentration and load reflects ULTIMATE BOD.

Reach 1 Allowable BOD Load

Reach 1
From Water Quality Station 385386 to 384107

Inputs:		
Temperature:	19.4	degrees Celcius
Upstream DO:	5	mg/L
Upstream BOD:	14	mg/L
Flow:	14	cfs
Outputs:		
Minimum DO:	5.00	mg/L
Distance Downstream:	0.68	miles
BOD Load:	1,057	lb/d

Reach 2 Current BOD Load

Reach 2
From Water Quality Station 384106 to 385386

Inputs:		
Temperature:	15	degrees Celcius
Upstream DO:	8	mg/L
Upstream BOD:	6	mg/L
Flow:	11	cfs
Outputs:		
Minimum DO:	4.20	mg/L
Distance Downstream:	32.99	miles
Total BOD Load:	867	lb/d
Upstream BOD Load:	356	lb/d
Wetland BOD Load:	511	lb/d

Reach 2 Allowable BOD Load

Reach 2
From Water Quality Station 384106 to 385386

Inputs:		
Temperature:	15	degrees Celcius
Upstream DO:	5	mg/L
Upstream BOD:	3	mg/L
Flow:	11	cfs
Outputs:		
Minimum DO:	5.00	mg/L
Distance Downstream:	32.99	miles
Total BOD Load:	517	lb/d
Upstream BOD Load:	6	lb/d
Wetland BOD Load:	511	lb/d

Appendix D
Riparian Health Assessment

The following is an excerpt from the Riparian Health Assessment for Streams and Small Rivers. The full document can be found at http://www.cowsandfish.org/pdfs/StreamsFieldWkbk2005.pdf (5.14MB):

Riparian Health Assessment for Streams and Small Rivers

FOREWORD

This workbook describing riparian health assessment has been written for those people who can most effectively influence riparian areas with their management - landowners, livestock producers, farmers, agency staff and others who use and value these green zones. Riparian health assessment blends many fields of science and undergoes periodic additions and modifications. In addition, the language describing the method of assessing riparian health undergoes continual evision, to clarify, expand and increase understanding. This printing of the Field Workbook incorporates the feedback from dozens of training workshops involving hundreds of participants. Riparian health assessment forms part of a larger package of awareness about riparian areas, leading to choices on managing these vital landscapes. When used as part of the Cows and Fish program, it provides a starting point for future plans and management decisions.

Why Develop Riparian Health Assessment?
Some History and Uses

Riparian areas are the focus of attention because of their agricultural benefits, the biodiversity values they represent and for concerns about water quality. Some riparian areas have declined in their ability to perform the ecological functions that relate directly to these benefits and values. Often, the health of these valuable landscapes has changed over time, even though that decline isn't readily apparent. We need to understand the current status of riparian areas so that we can improve or maintain their health. The first step is to determine the condition or health of the site. Once we know the health of a site, we have a mechanism to link management actions to improving or maintaining ecological function.

In response to many concerns in the United States, the University of Montana, through its Riparian and Wetland Research Program, devised a system to survey and measure the overall health or condition of a riparian site. Many scientific disciplines participated to determine what the key ecological functions of riparian areas were and how these could be measured with a relatively quick and easy assessment technique. This method was initially used to evaluate riparian health on approximately 8,000 km of rivers and streams in Montana, Idaho, Wyoming, North Dakota and South Dakota. The testing and refinement of the method was expanded to include Alberta, British Columbia and Saskatchewan. With this experience, the method has evolved into the present riparian health assessment. It has been adapted to include riparian situations that will be encountered in Alberta and may be useful for other jurisdictions.

RIPARIAN HEALTH ASSESSMENT QUESTIONS (1-11)

1. How much of the riparian area is covered by vegetation?

Vegetation cover of the floodplain and streambanks

Vegetation reduces the erosive forces of raindrop impacts and the velocity of water moving over the floodplain or along the streambanks. Vegetation cover also:

- traps sediment and stabilizes banks;
- absorbs and recycles nutrients;
- reduces the rate of evaporation; and
- provides shelter and forage values.

Vegetation cover is visually estimated using the canopy cover method. Use the illustrations to help you estimate canopy cover on the reach.

- Sediment deposited on the reach is considered "bare ground" for this question.

Scoring:

6 = More than 95% of the reach soil surface is covered by plant growth (less than 5% bare soil).
4 = 85% to 95% of the reach soil surface is covered by plant growth (5-15% bare soil).
2 = 75% to 85% of the reach soil surface is covered by plant growth (15-25% bare soil).
0 = Less than 75% of the reach soil surface is covered by plant growth (greater than 25% bare soil).

Scoring Tip: Soil not covered by plants, litter, moss, downed wood, or rocks larger than 6 cm (2.5 in) is considered bare ground. Count standing rooted, dead or living plants as vegetative cover.

5. Is Woody Vegetation Being Used?

Utilization of preferred trees and shrubs

Because woody species have such an important role to play in riparian health, measurements of the level of use helps us understand whether they will persist in the reach. Livestock will often browse woody plants, especially in late summer and fall. Wildlife, including beaver, make use of woody plants year-round. Woody plants can sustain low levels of use but heavier browsing can:

- deplete root reserves;
- inhibit establishment and regeneration;
- lead to replacement by less desirable woody species;
- cause the loss of preferred woody species; and
- lead to invasion by disturbance or weed species.

Not all woody species are palatable or used by animals. Some species do not contribute significantly to riparian condition and stability although some utilization may occur. Other species may persist under high use but are not good indicators to evaluate the effect of utilization. These species are excluded from this evaluation of utilization. See the table on the next page for a list of these species. To establish the amount of utilization:

- first, randomly pick 2 to 3 plants of each of the preferred woody species found on the reach;
- for each plant, select a branch that would be available or accessible to browsing animals;
- count the total number of leaders (twigs) on the branch;
- now count only the older leaders (2nd year growth and older) that have been clipped off by browsing;
- determine the percentage of utilization by comparing the number of leaders browsed with the total number of leaders available on the branch; and
- do not count current year's use since an estimate in mid-season does not accurately reflect actual use, because browsing can continue year-round.

Riparian Health Assessment – Field Sheet

Landowner/Lessee: ______________________ Date:________Reach No.:___________

Stream/River:____

Site Description:____

						Scores or N/A Actual	Possible
1. Vegetative Cover of Floodplain and Streambanks							
	6	**4**	**2**	**0**		____	____
2. Invasive Plant Species							
	3	**2**	**1**	**0**	**(cover)**	____	____
	3	**2**	**1**	**0**	**(density)**	____	____
3. Disturbance-Increaser Undesirable Herbaceous Species							
	3	**2**	**1**	**0**		____	____
4. Preferred Tree and Shrub Establishment and Regeneration							
	6	**4**	**2**	**0**		____	____
5. Utilization of Preferred Trees and Shrubs							
	3	**2**	**1**	**0**		____	____
6. Standing Decadent and Dead Woody Material							
	3	**2**	**1**	**0**		____	____
7. Streambank Root Mass Protection							
	6	**4**	**2**	**0**		____	____
8. Human-Caused Bare Ground							
	6	**4**	**2**	**0**		____	____
9. Streambank Structurally Altered by Human Activity							
	6	**4**	**2**	**0**		____	____
10. Pugging, Hummocking and/or Rutting							
	3	**2**	**1**	**0**		____	____
11. Stream Channel Incisement (vertical stability)							
	9	**6**	**3**	**0**		____	____
					TOTAL	____	____

Appendix E
Rapid Geomorphic Assessment

Rapid Geomorphic Assessments: RGA’s

To evaluate channel-stability conditions and stage of channel evolution of a particular reach, a Rapid Geomorphic Assessment (RGA) will be carried out using the Channel-Stability Ranking Scheme. RGAs utilize diagnostic criteria of channel form to infer dominant channel processes and the magnitude of channel instabilities through a series of nine questions. Granted, evaluations of this sort do not include an evaluation of watershed or upland conditions; however, stream channels act as conduits for energy, flow and materials as they move through the watershed and will reflect a balance or imbalance in the delivery of sediment. RGA’s provide a rapid characterization of stability conditions.

The RGA procedure consists of four steps to be completed on site:

1. Determine the ‘reach’. The ‘reach’ is described as the length of channel covering 6-20 channel widths, thus is scale dependent and covers at least two pool-riffle sequences.
2. Take photographs looking upstream, downstream and across the reach; for quality assurance and quality control purposes. Photographs are used with RGA forms to review the field evaluation
3. Make observations of channel conditions and diagnostic criteria listed on the channel-stability ranking scheme.
4. Sample bed material.

Channel-Stability Index

A field form containing nine criteria (Figure J.1) will be used to record observations of field conditions during RGAs. Each criterion was ranked from zero to four and all values summed to provide an index of relative channel stability. The higher the number the greater the instability: sites with values greater than 20 exhibit considerable instability; stable sites generally rank 10 or less. Intermediate values denote reaches of moderate instability. However, rankings are not weighted, thus a site ranked 20 is not twice as unstable as a site ranked 10. The process of filling out the form enables the final decision of ‘Stage of Channel Evolution’.

CHANNEL-STABILITY RANKING SCHEME

River__________________________ Site Identifier_______________________________________

Date _____________ Time_______ Crew _______________ Samples Taken_________________________

Pictures (circle) U/S D/S X-section Slope__________ Pattern: Meandering / Straight / Braided

1. Primary bed material

	Bedrock	Boulder/Cobble	Gravel	Sand	Silt Clay	
	0	1	2	3	4	______

2. Bed/bank protection

	Yes	No	(with)	1 bank protected	2 banks	
	0	1	2	3		______

3. Degree of incision (Relative elevation of "normal" low water; floodplain/terrace @ 100%)

	0-10%	11-25%	26-50%	51-75%	76-100%	
	4	3	2	1	0	______

4. Degree of constriction (Relative decrease in top-bank width from up to downstream)

	0-10%	11-25%	26-50%	51-75%	76-100%	
	0	1	2	3	4	______

5. Stream bank erosion (Each bank)

	None	Fluvial	Mass wasting (failures)	
Left	0	1	2	______
Right	0	1	2	______

6. Stream bank instability (Percent of each bank failing)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	0	0.5	1	1.5	2	______
Right	0	0.5	1	1.5	2	______

7. Established riparian woody-vegetative cover (Each bank)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	2	1.5	1	0.5	0	______
Right	2	1.5	1	0.5	0	______

8. Occurrence of bank accretion (Percent of each bank with fluvial deposition)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	2	1.5	1	0.5	0	______
Right	2	1.5	1	0.5	0	______

9. Stage of channel evolution

	I	II	III	IV	V	VI	
	0	1	2	4	3	1.5	______

Figure L.1 - Channel stability ranking scheme used to conduct rapid geomorphic assessments (RGA's). The channel stability index is the sum of the values obtained for the nine criteria.

1. Primary bed material

Bedrock	The parent material that underlies all other material. In some cases this becomes exposed at the surface. Bedrock can be recognized by appearing as large slabs of rock, parts of which may be covered by other surficial material.
Boulder/Cobble	All rocks greater than 64 mm median diameter.
Gravel	All particles with a median diameter between 64.0 – 2.00 mm
Sand	All Particles with a median diameter between 2.00 – 0.63 mm
Silt Clay	All fine particles with a median diameter of less than 0.63 mm

2. Bed/bank protection

Yes	Mark if the channel bed is artificially protected, such as with rip rap or concrete.
No	Mark if the channel bed is not artificially protected and is composed of natural material.
1 bank protected	Mark if one bank is artificially protected, such as with rip rap or concrete.
2 banks	Mark if two banks are artificially protected.

3. Degree of incision (Relative elevation Of "normal" low water; floodplain/terrace @ 100%)

Calculated by measuring water depth at deepest point across channel, divided by bank height from bank top to bank base (where slope breaks to become channel bed). This ratio is given as a percentage and the appropriate category marked.

4. Degree of constriction (Relative decrease in top-bank width from up to downstream)

Often only found where obstructions or artificial protection are present within the channel. Taking the reach length into consideration, channel width at the upstream and downstream parts of the reach are measured and the relative difference calculated.

5. Stream bank erosion (Each bank)

The dominant form of bank erosion is marked separately for each bank, left and right, facing in a downstream direction.

If the reach is a meandering reach, the banks are viewed in terms of ‘Inside, Outside’ as opposed to ‘Left, Right’ (appropriate for questions 5-8). Inside bank, being the inner bank of the meander, if the stream bends to the left as you face downstream, this would be the left bank. Outside bank, being the outer bank, on your right as you face downstream in a stream meandering left.

None	No erosion
Fluvial	Fluvial processes, such as undercutting of the bank toe, cause erosion.
Mass Wasting	Mass movement of large amounts of material from the bank is the method of bank erosion. Often characterized by high, steep banks

with shear bank faces. Debris at the bank toe appears to have fallen from higher up in the bank face. Includes, rotational slip failures and block failures.

6. Stream bank instability (Percent of each bank failing)
If the bank exhibits mass wasting, mark percentage of bank with failures over the length of the reach. If more than 50% failures are marked, the dominant process is mass wasting (see question 5).

7. Established riparian woody-vegetative cover (Each bank)
Riparian woody-vegetative cover is the more permanent vegetation that grows on the stream banks, distinguished by its woody stem, this includes trees and bushes but does not include grasses. Grasses grow and die annually with the summer and thus do not provide any form of bank protection during winter months whilst permanent vegetation does.

8. Occurrence of bank accretion (Percent of each bank with fluvial deposition)
The percentage of the reach length with fluvial deposition of material (often sand, also includes fines and gravels) is marked.

9. Stage of channel evolution
Stage of channel evolution are given by Simon and Hupp, 1986 (see diagram below). All of the above questions help lead to an answer to this question. Refer bank to previously answered questions for guidance. See Table 2 for guidelines of what features are often found with each stage of channel evolution.

Total Score Total up the responses to the 9 questions.

Stages of Channel Evolution

The channel evolution framework set out by Simon and Hupp (1986) is used to assess the stability of a channel reach (Figure L.2; Table L.1). With stages of channel evolution tied to discrete channel processes and not strictly to specific channel shapes, they have been successfully used to describe systematic channel-adjustment processes over time and space in diverse environments, subject to various disturbances such as stream response to: channelization in the Southeast US Coastal Plain (Simon, 1994); volcanic eruptions in the Cascade Mountains (Simon, 1999); and dams in Tuscany, Italy (Rinaldi and Simon, 1998). Because the stages of channel evolution represent shifts in dominant channel processes, they are systematically related to suspended-sediment and bed-material discharge (Simon, 1989a; Kuhnle and Simon, 2000), fish-community structure, rates of channel widening (Simon and Hupp, 1992), and the density and distribution of woody-riparian vegetation (Hupp, 1992).

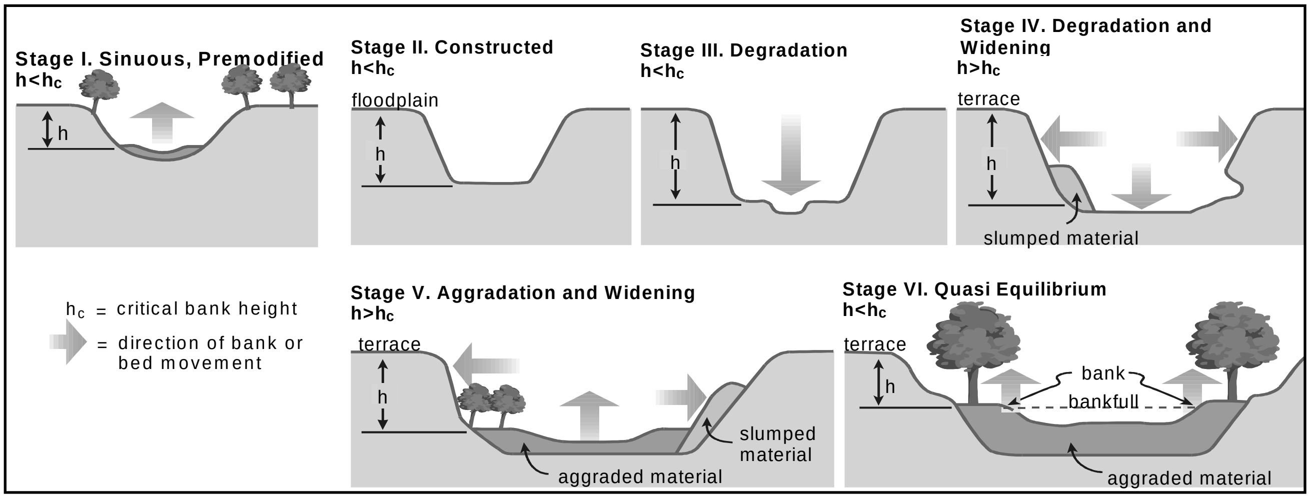


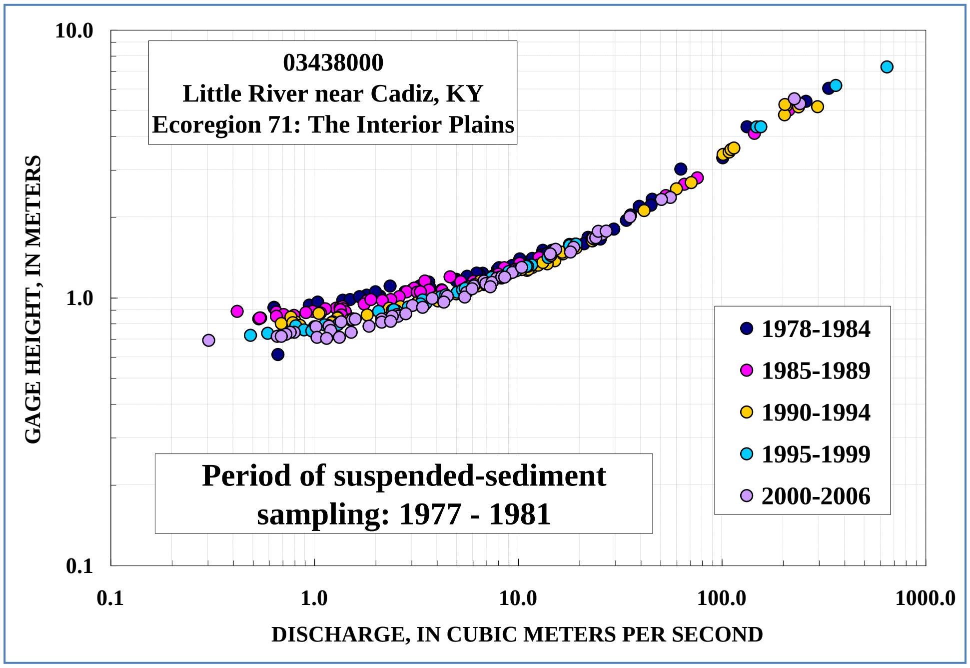
Figure L.2 - Six stages of channel evolution from Simon and Hupp (1986) and Simon (1989b) identifying Stages I and VI as "reference" conditions for given Ecoregions

Table L.3 – Summary of conditions to be expected at each stage of channel evolution.

Stage	Descriptive Summary
I	*Pre-modified* – Stable bank conditions, no mass wasting, small, low angle bank slopes. Established woody vegetation, convex upper bank, and concave lower bank.
II	*Constructed* – Artificial reshaping of existing banks. Vegetation often removed, banks steepened, heightened and made linear.
III	*Degradation* – Lowering of channel bed and consequent increase of bank heights. Incision without widening. Bank toe material removed causing an increase in bank angle.
IV	*Threshold* – Degradation and basal erosion. Incision and active channel widening. Mass wasting from banks and excessive undercutting. Leaning and fallen vegetation. Vertical face may be present.
V	*Aggradation* – Deposition of material on bed, often sand. Widening of channel through bank retreat; no incision. Concave bank profile. Filed material re-worked and deposited. May see floodplain terraces. Channel follows a meandering course.
VI	*Restabilization* – Reduction in bank heights, aggradation of the channel bed. Deposition on the upper bank therefore visibly buried vegetation. Convex shape. May see floodplain terraces.

An advantage of a process-based channel-evolution scheme is that Stages I and VI represent true "reference" conditions. In some cases, such as in the Midwestern United States where land clearing activities near the turn of the 20th Century caused massive changes in rainfall-runoff relations and land use, channels are unlikely to recover to Stage I, pre-modified conditions. Stage VI, a re-stabilized condition, is a much more likely target under present regional land use and altered hydrologic regimes (Simon and Rinaldi, 2000) and can be used as a "reference" condition. Stage VI streams can be characterized as a 'channel-within-a-channel', where the previous floodplain surface is less frequently inundated and can be described as a terrace. This morphology is typical of recovering and re-stabilized stream systems following incision. In pristine areas, where disturbances have not occurred or where they are far less severe, Stage I conditions can be appropriate as a reference.

Unfortunately it is not uncommon that suspended-sediment sampling was carried out over twenty years ago. It may also be the case that the stage of channel evolution relevant to a given site now, was not relevant at the time of suspended-sediment sampling. As we cannot readily create a rating equation to fit the current stability of a given site, plotting certain stream morphology characteristics against a range of discharges over time can help us to establish the stability of the channel at the time of suspended-sediment sampling



Appendix F
US EPA Public Notice Review and Comments

EPA REGION VIII TMDL REVIEW

TMDL Document Info:

Document Name:	**Dissolved Oxygen TMDL for the Wintering River in McHenry and McLean Counties, North Dakota**
Submitted by:	**Mike Ell, North Dakota Department of Health**
Date Received:	**September 10, 2010**
Review Date:	**October 10, 2010**
Reviewer:	**Vern Berry, EPA**
Rough Draft / Public Notice / Final?	**Public Notice Draft**
Notes:	

Reviewers Final Recommendation(s) to EPA Administrator (used for final review only):

- ☐ Approve
- ☐ Partial Approval
- ☐ Disapprove
- ☐ Insufficient Information

Approval Notes to Administrator:

This document provides a standard format for EPA Region 8 to provide comments to state TMDL programs on TMDL documents submitted to EPA for either formal or informal review. All TMDL documents are evaluated against the minimum submission requirements and TMDL elements identified in the following 8 sections:

1. Problem Description
   - 1.1. TMDL Document Submittal Letter
   - 1.2. Identification of the Waterbody, Impairments, and Study Boundaries
   - 1.3. Water Quality Standards
2. Water Quality Target
3. Pollutant Source Analysis
4. TMDL Technical Analysis
   - 4.1. Data Set Description
   - 4.2. Waste Load Allocations (WLA)
   - 4.3. Load Allocations (LA)
   - 4.4. Margin of Safety (MOS)
   - 4.5. Seasonality and variations in assimilative capacity
5. Public Participation
6. Monitoring Strategy
7. Restoration Strategy
8. Daily Loading Expression

Under Section 303(d) of the Clean Water Act, waterbodies that are not attaining one or more water quality standard (WQS) are considered “impaired.” When the cause of the impairment is determined to be a pollutant, a TMDL analysis is required to assess the appropriate maximum allowable pollutant loading rate. A TMDL document consists of a technical analysis conducted to: (1) assess the maximum pollutant loading rate that a waterbody is able to assimilate while maintaining water quality standards; and (2) allocate that assimilative capacity among the known sources of that pollutant**.** A well written

TMDL document will describe a path forward that may be used by those who implement the TMDL recommendations to attain and maintain WQS.

Each of the following eight sections describes the factors that EPA Region 8 staff considers when reviewing TMDL documents. Also included in each section is a list of EPA's minimum submission requirements relative to that section, a brief summary of the EPA reviewer's findings, and the reviewer's comments and/or suggestions. Use of the verb "must" in the minimum submission requirements denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable.

This review template is intended to ensure compliance with the Clean Water Act and that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Problem Description

A TMDL document needs to provide a clear explanation of the problem it is intended to address. Included in that description should be a definitive portrayal of the physical boundaries to which the TMDL applies, as well as a clear description of the impairments that the TMDL intends to address and the associated pollutant(s) causing those impairments. While the existence of one or more impairment and stressor may be known, it is important that a comprehensive evaluation of the water quality be conducted prior to development of the TMDL to ensure that all water quality problems and associated stressors are identified. Typically, this step is conducted prior to the 303(d) listing of a waterbody through the monitoring and assessment program. The designated uses and water quality criteria for the waterbody should be examined against available data to provide an evaluation of the water quality relative to all applicable water quality standards. If, as part of this exercise, additional WQS problems are discovered and additional stressor pollutants are identified, consideration should be given to concurrently evaluating TMDLs for those additional pollutants. If it is determined that insufficient data is available to make such an evaluation, this should be noted in the TMDL document.

1.1 TMDL Document Submittal Letter

When a TMDL document is submitted to EPA requesting formal comments or a final review and approval, the submittal package should include a letter identifying the document being submitted and the purpose of the submission.

Minimum Submission Requirements.

☒ A TMDL submittal letter should be included with each TMDL document submitted to EPA requesting a formal review.

☒ The submittal letter should specify whether the TMDL document is being submitted for initial review and comments, public review and comments, or final review and approval.

☐ Each TMDL document submitted to EPA for final review and approval should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute**.** The submittal letter should contain such identifying information as the name and location of the waterbody and the pollutant(s) of concern, which matches similar identifying information in the TMDL document for which a review is being requested.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The draft Wintering River dissolved oxygen TMDL was submitted to EPA for review during the public notice period via an email from Mike Ell, NDDoH on September 10, 2010. The email included the draft TMDL document and a public notice announcement requesting review and comment.

COMMENTS: None

1.2 Identification of the Waterbody, Impairments, and Study Boundaries

The TMDL document should provide an unambiguous description of the waterbody to which the TMDL is intended to apply and the impairments the TMDL is intended to address. The document should also clearly delineate the physical boundaries of the waterbody and the geographical extent of the watershed area studied. Any additional information needed to tie the TMDL document back to a current 303(d) listing should also be included.

Minimum Submission Requirements:

☒ The TMDL document should clearly identify the pollutant and waterbody segment(s) for which the TMDL is being established. If the TMDL document is submitted to fulfill a TMDL development requirement for a waterbody on the state's current EPA approved 303(d) list, the TMDL document submittal should clearly identify the waterbody and associated impairment(s) as they appear on the State's/Tribe's current EPA approved 303(d) list, including a full waterbody description, assessment unit/waterbody ID, and the priority ranking of the waterbody. This information is necessary to ensure that the administrative record and the national TMDL tracking database properly link the TMDL document to the 303(d) listed waterbody and impairment(s).

☒ One or more maps should be included in the TMDL document showing the general location of the waterbody and, to the maximum extent practical, any other features necessary and/or relevant to the understanding of the TMDL analysis, including but not limited to: watershed boundaries, locations of major pollutant sources, major tributaries included in the analysis, location of sampling points, location of discharge gauges, land use patterns, and the location of nearby waterbodies used to provide surrogate information or reference conditions. Clear and concise descriptions of all key features and their relationship to the waterbody and water quality data should be provided for all key and/or relevant features not represented on the map

☐ If information is available, the waterbody segment to which the TMDL applies should be identified/geo-referenced using the National Hydrography Dataset (NHD). If the boundaries of the TMDL do not correspond to the Waterbody ID(s) (WBID), Entity_ID information or reach code (RCH_Code) information should be provided. If NHD data is not available for the waterbody, an alternative geographical referencing system that unambiguously identifies the physical boundaries to which the TMDL applies may be substituted.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Wintering River its tributaries are a stream system located in McHenry and McLean Counties, in north central North Dakota. The Wintering River is part of the larger Souris (Mouse[1]) River basin in the Lower Souris sub-basin (HUC 0901003). The Wintering River and tributary segments flow approximately 207.8 miles, with a total drainage area of 555,520 acres. There is one 303(d) listed segment of the Wintering River covered by this TMDL document: 1) Wintering River, including all tributaries, located in SW McHenry and NE McLean Counties (ND-10160004-035-S_00). The segment is listed as high priority for TMDL development.

The designated use for the listed segment of the Wintering River and its tributaries is based on the Class III stream classification in the ND water quality standards (NDCC 33-15-02.1-09). The segment was included on the ND 2008 303(d) list for dissolved oxygen and fecal coliform bacteria. This document

[1] Recent local legislation passed that determined that the river shall be called the Mouse River on all identifiable signs. It is still known as the Souris River in Canada and to many State and Federal agencies.

addresses the dissolved oxygen impairment. The fecal coliform impairment was addressed in a separate TMDL document.

COMMENTS: None.

1.3 Water Quality Standards

TMDL documents should provide a complete description of the water quality standards for the waterbodies addressed, including a listing of the designated uses and an indication of whether the uses are being met, not being met, or not assessed. If a designated use was not assessed as part of the TMDL analysis (or not otherwise recently assessed), the documents should provide a reason for the lack of assessment (e.g., sufficient data was not available at this time to assess whether or not this designated use was being met).

Water quality criteria (WQC) are established as a component of water quality standard at levels considered necessary to protect the designated uses assigned to that waterbody. WQC identify quantifiable targets and/or qualitative water quality goals which, if attained and maintained, are intended to ensure that the designated uses for the waterbody are protected. TMDLs result in maintaining and attaining water quality standards by determining the appropriate maximum pollutant loading rate to meet water quality criteria, either directly, or through a surrogate measurable target. The TMDL document should include a description of all applicable water quality criteria for the impaired designated uses and address whether or not the criteria are being attained, not attained, or not evaluated as part of the analysis. If the criteria were not evaluated as part of the analysis, a reason should be cited (e.g. insufficient data were available to determine if this water quality criterion is being attained).

Minimum Submission Requirements:

☒ The TMDL must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the anti-degradation policy. (40 C.F.R. §130.7(c)(1)).

☒ The purpose of a TMDL analysis is to determine the assimilative capacity of the waterbody that corresponds to the existing water quality standards for that waterbody, and to allocate that assimilative capacity between the significant sources. Therefore, <u>all TMDL documents must be written to meet the existing water quality standards</u> for that waterbody (CWA §303(d)(1)(C)).

Note: In some circumstances, the load reductions determined to be necessary by the TMDL analysis may prove to be infeasible and may possibly indicate that the existing water quality standards and/or assessment methodologies may be erroneous. However, the TMDL must still be determined based on existing water quality standards. Adjustments to water quality standards and/or assessment methodologies may be evaluated separately, from the TMDL.

☒ The TMDL document should describe the relationship between the pollutant of concern and the water quality standard the pollutant load is intended to meet. This information is necessary for EPA to evaluate whether or not attainment of the prescribed pollutant loadings will result in attainment of the water quality standard in question.

☒ If a standard includes multiple criteria for the pollutant of concern, the document should demonstrate that the TMDL value will result in attainment of all related criteria for the pollutant. For example, both acute and chronic values (if present in the WQS) should be addressed in the document, including consideration of magnitude, frequency and duration requirements.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Wintering River segment addressed by this TMDL is impaired based on dissolved oxygen concentrations impacting the fish and aquatic life uses. Wintering River and its tributaries are Class III streams that must be protected for agricultural and industrial uses. Class III streams generally have low flow and prolonged dry periods and hence secondary contact recreational uses and standards are applied. Numeric criteria for dissolved oxygen in Class III streams have been established and are presented in the excerpted Table 10 shown below. Discussion of additional applicable water quality standards for Wintering River can be found on pages 13 and 14 of the TMDL.

Table 10. North Dakota Dissolved Oxygen Standards for Class III Streams.

Parameter	Water Quality Standard (minimum value)
Dissolved Oxygen	5.0 mg/L[1]

[1] **Up to 10% of representative samples collected during any 3yr period may be less than this value provided lethal conditions are avoided.**

COMMENTS: None.

2. Water Quality Targets

TMDL analyses establish numeric targets that are used to determine whether water quality standards are being achieved. Quantified water quality targets or endpoints should be provided to evaluate each listed pollutant/water body combination addressed by the TMDL, and should represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the water quality target. For pollutants with narrative standards, the narrative standard should be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include a variety of targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

Minimum Submission Requirements:

☒ The TMDL should identify a numeric water quality target(s) for each waterbody pollutant combination. The TMDL target is a quantitative value used to measure whether or not the applicable water quality standard is attained.

Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. Occasionally, the pollutant of concern is different from the parameter that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as a numerical dissolved oxygen criterion). In such cases, the TMDL should explain the linkage between the pollutant(s) of concern, and express the quantitative relationship between the TMDL target and pollutant of concern. In all cases, TMDL targets must represent the attainment of current water quality standards.

☐ When a numeric TMDL target is established to ensure the attainment of a narrative water quality criterion, the numeric target, the methodology used to determine the numeric target, and the link between the pollutant of concern and the narrative water quality criterion should all be described in the TMDL document. Any additional information supporting the numeric target and linkage should also be included in the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The water quality target for this TMDL is based on the numeric water quality standards for dissolved oxygen based on the fish and aquatic life beneficial use for the Wintering River. The target for the Wintering River segment included in the TMDL document is the dissolved oxygen standard expressed as daily minimum of 5.0 mg/L (up to 10 percent of representative samples collected during any three year period may be less than this value provided that lethal conditions are avoided).

COMMENTS: None.

3. Pollutant Source Analysis

A TMDL analysis is conducted when a pollutant load is known or suspected to be exceeding the loading capacity of the waterbody. Logically then, a TMDL analysis should consider all sources of the pollutant of concern in some manner. The detail provided in the source assessment step drives the rigor of the pollutant load allocation. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source (or source category) when the relative load contribution from each source has been estimated. Therefore, the pollutant load from each significant source (or source category) should be identified and quantified to the maximum practical extent. This may be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach may be appropriate. The approach should be clearly defined in the document.

Minimum Submission Requirements:

☒ The TMDL should include an identification of all potentially significant point and nonpoint sources of the pollutant of concern, including the geographical location of the source(s) and the quantity of the loading, e.g., lbs/per day. This information is necessary for EPA to evaluate the WLA, LA and MOS components of the TMDL.

☒ The level of detail provided in the source assessment should be commensurate with the nature of the watershed and the nature of the pollutant being studied. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of both the natural background loads and the nonpoint source loads.

☒ Natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g. measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified, characterized, and properly quantified.

☒ The sampling data relied upon to discover, characterize, and quantify the pollutant sources should be included in the document (e.g. a data appendix) along with a description of how the data were analyzed to characterize and quantify the pollutant sources. A discussion of the known deficiencies and/or gaps in the data set and their potential implications should also be included.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The TMDL document includes the landuse breakdown for the watershed based on the 2006 National Agricultural Statistics Service data. In 2006, the Wintering River watershed was predominantly agricultural (84.6 percent). Approximately 43 percent of the landuse in the watershed was cropland under active cultivation, 41 percent was pasture/rangeland and the remainder was water, roads or low density development. Based on the 2006 NDASS data, an even larger percentage of the land area within an estimated 250 meter riparian buffer adjacent to the Wintering River is pasture/rangeland and grassland. Livestock production is also exemplified as the dominant agricultural practice in McHenry and McLean Counties with an estimated livestock production of 113,000 cattle in the two counties combined.

The following nonpoint sources were found to be the primary sources for dissolved oxygen depletion in the watershed:

- Runoff of manure from cropland and pastureland;
- Runoff of manure from unpermitted animal feeding areas;
- Direct deposit of manure into Wintering River by grazing livestock; and
- Background levels associated with wildlife.

Failing septic systems or direct discharge sewage systems which contribute to nutrient loads and lower DO concentrations may also be located within the watershed. While their specific location and potential for nutrient and organic matter loading are unknown, these systems may be associated with isolated single-family dwellings and farmsteads located throughout the watershed or within small towns located within the watershed that do not have a centralized sewer system.

There are no municipal wastewater treatment plant discharges in the watershed. Towns that are located in the watershed (e.g., Balfour, Drake, and Karlsruhe) all utilize septic systems for their domestic waste. There are two permitted animal feeding operations (AFOs) in the watershed. However, these permits require no discharge so they are not considered significant point sources in the TMDL document.

COMMENTS: None.

4. TMDL Technical Analysis

TMDL determinations should be supported by a robust data set and an appropriate level of technical analysis**.** This applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader.

A TMDL analysis determines the maximum pollutant loading rate that may be allowed to a waterbody without violating water quality standards. The TMDL analysis should demonstrate an understanding of the relationship between the rate of pollutant loading into the waterbody and the resultant water quality impacts. This stressor → response relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and load allocations needs to be clearly articulated and supported by an appropriate level of technical analysis. Every effort should be made to be as detailed as possible, and to base all conclusions on the best available scientific principles.

The pollutant loading allocation is at the heart of the TMDL analysis. TMDLs apportion responsibility for taking actions by allocating the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways, such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or division of responsibility.

The pollutant loading allocation that will result in achievement of the water quality target is expressed in the form of the standard TMDL equation:

$$TMDL = \sum LAs + \sum WLAs + MOS$$

Where:

TMDL = Total Pollutant Loading Capacity of the waterbody

LAs = Pollutant Load Allocations

WLAs = Pollutant Wasteload Allocations

MOS = The portion of the Load Capacity allocated to the Margin of safety.

Minimum Submission Requirements:

☒ A TMDL must identify the loading capacity of a waterbody for the applicable pollutant, taking into consideration temporal variations in that capacity. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

☒ The total loading capacity of the waterbody should be clearly demonstrated to equate back to the pollutant load allocations through a balanced TMDL equation. In instances where numerous LA, WLA and seasonal TMDL capacities make expression in the form of an equation cumbersome, a table may be substituted as long as it is clear that the total TMDL capacity equates to the sum of the allocations.

☐ The TMDL document should describe the methodology and technical analysis used to establish and quantify the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

☒ It is necessary for EPA staff to be aware of any assumptions used in the technical analysis to understand and evaluate the methodology used to derive the TMDL value and associated loading allocations. Therefore, the TMDL document should contain a description of any important assumptions (including the basis for those assumptions) made in developing the TMDL, including but not limited to:

(1) the spatial extent of the watershed in which the impaired waterbody is located and the spatial extent of the TMDL technical analysis;
(2) the distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) a presentation of relevant information affecting the characterization of the pollutant of concern and its allocation to sources such as population characteristics, wildlife resources, industrial activities etc…;
(4) present and future growth trends, if taken into consideration in determining the TMDL and preparing the TMDL document (e.g., the TMDL could include the design capacity of an existing or planned wastewater treatment facility);
(5) an explanation and analytical basis for expressing the TMDL through surrogate measures, if applicable. Surrogate measures are parameters such as percent fines and turbidity for sediment impairments; chlorophyll *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

☒ The TMDL document should contain documentation supporting the TMDL analysis, including an inventory of the data set used, a description of the methodology used to analyze the data, a discussion of strengths and weaknesses in the analytical process, and the results from any water quality modeling used. This information is necessary for EPA to review the loading capacity determination, and the associated load, wasteload, and margin of safety allocations.

☒ TMDLs must take critical conditions (e.g., steam flow, loading, and water quality parameters, seasonality, etc…) into account as part of the analysis of loading capacity (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable critical conditions and describe the approach used to determine both point and nonpoint source loadings under such critical conditions. In particular, the document should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

☐ Where both nonpoint sources and NPDES permitted point sources are included in the TMDL loading allocation, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document must include a demonstration that nonpoint source loading reductions needed to implement the load allocations are actually practicable [40 CFR 130.2(i) and 122.44(d)].

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The technical analysis should describe the cause and effect relationship between the identified pollutant sources, the numeric targets, and achievement of water quality standards. It should also include a description of the analytical processes used, results from water quality modeling, assumptions and other pertinent information. To determine the cause-and-effect relationship between the water quality target and the identified sources, a spreadsheet model was developed by Houston Engineering to predict the biochemical oxygen demand (BOD) loads throughout the Wintering River. The technical analysis addresses the low dissolved oxygen impairment through a BOD load allocation, and the BOD load allocation reductions necessary to achieve the dissolved oxygen water quality standards target of $\geq$ 5.0 mg/L, plus a margin of safety. The BOD loads were derived to meet the dissolved oxygen water quality standards for the 303(d) impaired stream segment.

The amount of DO in a river at any point in time reflects the combination of physical, chemical, and biological sources and sinks of oxygen within the reach. Sources of oxygen include re-aeration, transport from upstream (flow), ground water, and photosynthetic production by algae and aquatic plants. Sinks for oxygen loss include the biochemical oxidation of suspended and dissolved organic material, oxygen demands from settled organic and inorganic materials, respiration of aquatic plants, and the conversion of nitrogen through nitrification. When oxygen is consumed faster than it can be replenished, the DO levels decline.

Fish and macroinvertebrates require minimum levels of dissolved oxygen (DO) in order to grow, reproduce, and survive. Groundwater, which often flows into streams during dry weather, is naturally low in DO. Aquatic plant life serves as both a source (photosynthetic oxygen production) and a sink (respiration and decomposition) for DO in aquatic ecosystems. However, the measurement of dissolved oxygen concentrations does not directly measure the pollutants contributing to the impairment. Some analysis into interactions with other chemical processes as well as the need to determine the relationship between them is required.

Biochemical oxygen demand (BOD) represents the amount of dissolved oxygen required by aerobic biological organisms in a body of water to break down (oxidize) organic matter present in a given water sample at a certain temperature over a specific period of time. The greater the amount of BOD; the greater the oxygen depletion in a stream or lake. Carbonaceous biochemical oxygen demand (CBOD) is the amount of oxygen required by bacteria to oxidize organic carbon material to carbon dioxide (its lowest energy state). In rural areas, sources of oxygen-demanding substances may include diffuse runoff of agricultural fertilizer and animal wastes (from manure application or grazing animals), soil erosion, and runoff from concentrated animal operations. Excessive nutrient levels from runoff can sometimes cause enough eutrophication to generate CBOD loads from decaying algae. The accumulation and decomposition of organic matter may not occur at the pollutant load source, but may show up downstream where velocities are slow and the algae populations collect. This is part of the process in this lower part of the impaired reach of the Wintering River as the shallow reaches upstream contain high nutrient concentrations. Where the water velocities drop, excess algae growth may occur. In addition to CBOD, nitrogenous biochemical oxygen demand (NBOD) can also be a significant source of oxygen depletion in surface waters.

Sediment oxygen demand (SOD) is a combination of several processes, primarily the aerobic decay of organic material that has settled to the bottom of a streambed or lake bottom. Examples of organic materials that can act as sources of SOD include leaf litter, particulate organic matter from point or nonpoint sources, and algae or plant biomass.

Direct discharge of pollutants from point and nonpoint sources into a river segment adds to its CBOD and NBOD, creating an oxygen demand that may depress DO below acceptable concentrations. High nutrient (nitrogen and phosphorus) levels can also cause the eutrophication process to generate CBOD loads from decaying algae. This may occur further downstream than where the pollutant enters the waterbody, such as pools where water velocities are low and the algae population can become extensive. During the summer months, a high density of aquatic plants can cause oxygen levels to vary widely. Slow movement of water, high water temperature, high levels of nutrients, and strong solar radiation, such as that which occurs in the summer, increases photosynthesis and plant growth. During the night, plants undergo respiration, an oxygen dependant reaction, which creates an oxygen demand. Highly eutrophic conditions can occur, especially during low flow conditions when increased residence times are favorable for producing lots of algae, causing periods of active plant growth and respiration. When the growth factors change and become less favorable, plants will die and decompose, which uses up oxygen resources.

When the pollutant load of oxygen demanding organics is large enough to overwhelm the oxygen resources of a water body, it creates an imbalance that destabilizes the stream environment and leads to aquatic life impairments. To look specifically at the Wintering River, several conditions are related to the DO impairment. First of all there is nutrient loading occurring from nonpoint sources throughout the reach. This nutrient loading is leading to excessive algal growth during the summer months and large diurnal swings in DO. Because the low DO values occurred mostly in the summer months, indicating that photosynthetic processes were the primary cause, BOD was chosen as the loading parameter for the TMDL.

The spreadsheet model developed by Houston Engineering quantified the current BOD loads within the river system, and related BOD loads to expected DO concentration conditions. The model framework allows a user to evaluate multiple scenarios using a range of potential values for input boundary conditions and to assess the impact downstream. The TMDL represents an aggregate value of all potential sources and sinks within the watershed and river system. Because the large wetland in the center of the Wintering River system disjoins the river as a whole, and causes it to act as two separate systems, TMDL loads were calculated for each reach located upstream and downstream of the wetland independently.

Given a median monthly flow for the critical month of July of 14 cfs, the current BOD load for reach 1 (downstream) is 1,812 lb/day. Given a median monthly flow for the critical month of July of 11 cfs for reach 2, the current BOD load is 867 lb/day and the allowable load is 517 lb/day, requiring a 60 percent reduction in BOD load. Input values and output summaries are located in Appendix C of the TMDL document. The allowable BOD load values ensure the DO minimum in the river is 5.0 mg/L.

COMMENTS: Section 5.1 (page16) mentions "…this impaired reach of the Souris River…" and flows from Canada. This needs to be revised to be applicable to the Wintering River.

4.1 Data Set Description

TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis. An inventory of the data used for the TMDL analysis should be provided to document, for the record, the data used in decision making. This also provides the reader with the opportunity to independently review the data. The TMDL analysis should make use of all readily available data for the waterbody under analysis unless the TMDL writer determines that the data are not relevant or appropriate. For relevant data that were known but rejected, an explanation of why the data were not utilized should be provided (e.g., samples exceeded holding times, data collected prior to a specific date were not considered timely, etc…).

Minimum Submission Requirements:

☒ TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and appropriate water quality criteria.

☒ The TMDL document submitted should be accompanied by the data set utilized during the TMDL analysis. If possible, it is preferred that the data set be provided in an electronic format and referenced in the document. If electronic submission of the data is not possible, the data set may be included as an appendix to the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Wintering River TMDL data description and summary are included tables throughout the document and in the data tables in Appendix A and B. The recent water quality monitoring was conducted over the period from April 2006 to August 2007. The data set also includes the information collected for and resulting from the BOD spreadsheet modeling.

COMMENTS: None.

4.2 Waste Load Allocations (WLA):

Waste Load Allocations represent point source pollutant loads to the waterbody. Point source loads are typically better understood and more easily monitored and quantified than nonpoint source loads. Whenever practical, each point source should be given a separate waste load allocation. All NPDES permitted dischargers that discharge the pollutant under analysis directly to the waterbody should be identified and given separate waste load allocations. The finalized WLAs are required to be incorporated into future NPDES permit renewals.

Minimum Submission Requirements:

☒ EPA regulations require that a TMDL include WLAs for all significant and/or NPDES permitted point sources of the pollutant. TMDLs must identify the portion of the loading capacity allocated to individual existing and/or future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit. If no allocations are to be made to point sources, then the TMDL should include a value of zero for the WLA.

☒ All NPDES permitted dischargers given WLA as part of the TMDL should be identified in the TMDL, including the specific NPDES permit numbers, their geographical locations, and their associated waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: There are no permitted municipal wastewater treatment facilities in the watershed. There are two permitted animal feeding operations in the watershed. The permits require no discharge so they are not considered significant point sources in the TMDL document. Therefore, the WLA for this TMDL is zero.

COMMENTS: None.

4.3 Load Allocations (LA):

Load allocations include the nonpoint source, natural, and background loads. These types of loads are typically more difficult to quantify than point source loads, and may include a significant degree of uncertainty. Often it is necessary to group these loads into larger categories and estimate the loading rates based on limited monitoring data and/or modeling results. The background load represents a composite of all upstream pollutant loads into the waterbody. In addition to the upstream nonpoint and upstream natural load, the background load often includes upstream point source loads that are not given specific waste load allocations in this particular TMDL analysis. In instances where nonpoint source loading rates are particularly difficult to quantify, a performance-based allocation approach, in which a detailed monitoring plan and adaptive management strategy are employed for the application of BMPs, may be appropriate.

Minimum Submission Requirements:

☒ EPA regulations require that TMDL expressions include LAs which identify the portion of the loading capacity attributed to nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Load allocations may be included for both existing and future nonpoint source loads. Where possible, load allocations should be described separately for natural background and nonpoint sources.

☒ Load allocations assigned to natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g., measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified and given proper load or waste load allocations.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The TMDL document includes the landuse breakdown for the watershed based on the 2006 National Agricultural Statistics Service data. In 2006, the Wintering River watershed was predominantly agricultural (84.6 percent). Approximately 43 percent of the landuse in the watershed was cropland under active cultivation, 41 percent was pasture/rangeland and the remainder was water, roads or low density development.

The entire nonpoint source load for each reach is allocated as a single load because there is not enough detailed source data to allocate the load to individual uses (e.g., animal feeding, cropland runoff, riparian grazing, upland grazing). To achieve the TMDL targets identified in the report, it will require the wide spread support and voluntary participation of landowners and residents in the immediate watershed as well as those living upstream. The Allocation section of the TMDL describes the best management practices that are recommended for the control of organic loading to the Wintering River and its tributaries.

COMMENTS: The Allocation section (page 28) mentions that the recommended BMPs will reduce fecal coliform levels in the Wintering River. While that may be true, the intent of this TMDL document is to reduce BOD, nutrient and organic loading in the River to meet the DO target. Please check and revise this section as needed.

4.4 Margin of Safety (MOS):

Natural systems are inherently complex. Any mathematical relationship used to quantify the stressor → response relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty and error. To compensate for this uncertainty and ensure water quality standards will be attained, a margin of safety is required as a component of each TMDL. The MOS may take the form of a explicit load allocation (e.g., 10 lbs/day), or may be implicitly built into the TMDL analysis through the use of conservative assumptions and values for the various factors that determine the TMDL pollutant load → water quality effect relationship. Whether explicit or implicit, the MOS should be supported by an appropriate level of discussion that addresses the level of uncertainty in the various components of the TMDL technical analysis, the assumptions used in that analysis, and the relative effect of those assumptions on the final TMDL. The discussion should demonstrate that the MOS used is sufficient to ensure that the water quality standards would be attained if the TMDL pollutant loading rates are met. In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

Minimum Submission Requirements:

☒ TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

- ☐ If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS should be identified and described. The document should discuss why the assumptions are considered conservative and the effect of the assumption on the final TMDL value determined.
- ☒ If the MOS is explicit, the loading set aside for the MOS should be identified. The document should discuss how the explicit MOS chosen is related to the uncertainty and/or potential error in the linkage analysis between the WQS, the TMDL target, and the TMDL loading rate.
- ☐ If, rather than an explicit or implicit MOS, the TMDL relies upon a phased approach to deal with large and/or unquantifiable uncertainties in the linkage analysis, the document should include a description of the planned phases for the TMDL as well as a monitoring plan and adaptive management strategy.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Wintering River TMDL includes an explicit MOS for the listed segment derived by calculating 10 percent of the loading capacity. The explicit MOS for the listed segment of the Wintering River are included in Tables 12 and 13 of the TMDL document.

COMMENTS: None.

4.5 Seasonality and variations in assimilative capacity:

The TMDL relationship is a factor of both the loading rate of the pollutant to the waterbody and the amount of pollutant the waterbody can assimilate and still attain water quality standards. Water quality standards often vary based on seasonal considerations. Therefore, it is appropriate that the TMDL analysis consider seasonal variations, such as critical flow periods (high flow, low flow), when establishing TMDLs, targets, and allocations.

Minimum Submission Requirements:

☒ The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variability as a factor. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Wintering River TMDL addresses seasonality because the reduction of BOD is related to the period of the season when the greatest deficit of DO occurs.

COMMENTS: None.

5. Public Participation

EPA regulations require that the establishment of TMDLs be conducted in a process open to the public, and that the public be afforded an opportunity to participate. To meaningfully participate in the TMDL process it is necessary that stakeholders, including members of the general public, be able to understand the problem and the proposed solution. TMDL documents should include language that explains the issues to the general public in understandable terms, as well as provides additional detailed technical information for the scientific community. Notifications or solicitations for comments regarding the TMDL should be made available to the general public, widely circulated, and clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for approval, a copy of the comments received by the state and the state responses to those comments should be included with the document.

Minimum Submission Requirements:

☒ The TMDL must include a description of the public participation process used during the development of the TMDL (40 C.F.R. §130.7(c)(1)(ii)).

☐ TMDLs submitted to EPA for review and approval should include a summary of significant comments and the State's/Tribe's responses to those comments.

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The TMDL document includes a summary of the public participation process that has occurred. It describes the opportunities the public had to be involved in the TMDL development process. Copies of the draft TMDL document were mailed to stakeholders in the watershed during public comment. Also, the draft TMDL document was posted on NDoDH's Water Quality Division website, and a public notice for comment was published in two newspapers.

COMMENTS: None.

6. Monitoring Strategy

TMDLs may have significant uncertainty associated with the selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL document to articulate the means by which the TMDL will be evaluated in the field, and to provide for future supplemental data that will address any uncertainties that may exist when the document is prepared.

Minimum Submission Requirements:

☒ When a TMDL involves both NPDES permitted point source(s) and nonpoint source(s) allocations, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring.

☒ Under certain circumstances, a phased TMDL approach may be utilized when limited existing data are relied upon to develop a TMDL, and the State believes that the use of additional data or data based on better analytical techniques would likely increase the accuracy of the TMDL load calculation and merit development of a second phase TMDL. EPA recommends that a phased TMDL document or its implementation plan include a monitoring plan and a scheduled timeframe for revision of the TMDL. These elements would not be an intrinsic part of the TMDL and would not be approved by EPA, but may be necessary to support a rationale for approving the TMDL. http://www.epa.gov/owow/tmdl/tmdl_clarification_letter.pdf

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Wintering River watershed will be monitored according to an approved quality assurance project plan. Once a watershed restoration plan is developed and implemented (e.g., a Section 319 Project Implementation Plan), monitoring will be conducted on the Wintering River according to a future Quality Assurance Project Plan.

COMMENTS: None.

7. Restoration Strategy

The overall purpose of the TMDL analysis is to determine what actions are necessary to ensure that the pollutant load in a waterbody does not result in water quality impairment. Adding additional detail regarding the proposed approach for the restoration of water quality is not currently a regulatory requirement, but is considered a value added component of a TMDL document. During the TMDL analytical process, information is often gained that may serve to point restoration efforts in the right direction and help ensure that resources are spent in the most efficient manner possible. For example, watershed models used to analyze the linkage between the pollutant loading rates and resultant water quality impacts might also be used to conduct "what if" scenarios to help direct BMP installations to locations that provide the greatest pollutant reductions. Once a TMDL has been written and approved, it is often the responsibility of other water quality programs to see that it is implemented. The level of quality and detail provided in the restoration strategy will greatly influence the future success in achieving the needed pollutant load reductions.

Minimum Submission Requirements:

☒ EPA is not required to and does not approve TMDL implementation plans. However, in cases where a WLA is dependent upon the achievement of a LA, "reasonable assurance" is required to demonstrate the necessary LA called for in the document is practicable). A discussion of the BMPs (or other load reduction measures) that are to be relied upon to achieve the LA(s), and programs and funding sources that will be relied upon to implement the load reductions called for in the document, may be included in the implementation/restoration section of the TMDL document to support a demonstration of "reasonable assurance".

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The TMDL Allocation section of the TMDL document includes a list of BMPs that are recommended to meet the TMDL loads. NDDoH typically works with local conservation districts or other cooperators to develop and implement Watershed Restoration Projects after the TMDL has been developed and approved. Detailed project implementation plans are developed as part of this process if Section 319 money is used.

There are no significant permitted point sources in the watershed so it's not necessary to fully document reasonable assurance demonstrating that the nonpoint source loadings are practicable.

COMMENTS: None.

8. Daily Loading Expression

The goal of a TMDL analysis is to determine what actions are necessary to attain and maintain WQS. The appropriate averaging period that corresponds to this goal will vary depending on the pollutant and the nature of the waterbody under analysis. When selecting an appropriate averaging period for a TMDL analysis, primary concern should be given to the nature of the pollutant in question and the achievement of the underlying WQS. However, recent federal appeals court decisions have pointed out that the title TMDL implies a “daily” loading rate. While the most appropriate averaging period to be used for developing a TMDL analysis may vary according to the pollutant, a daily loading rate can provide a more practical indication of whether or not the overall needed load reductions are being achieved. When limited monitoring resources are available, a daily loading target that takes into account the natural variability of the system can serve as a useful indicator for whether or not the overall load reductions are likely to be met. Therefore, a daily expression of the required pollutant loading rate is a required element in all TMDLs, in addition to any other load averaging periods that may have been used to conduct the TMDL analysis. The level of effort spent to develop the daily load indicator should be based on the overall utility it can provide as an indicator for the total load reductions needed.

Minimum Submission Requirements:

☒ The document should include an expression of the TMDL in terms of a daily load. However, the TMDL may also be expressed in temporal terms other than daily (e.g., an annual or monthly load). If the document expresses the TMDL in additional “non-daily” terms the document should explain why it is appropriate or advantageous to express the TMDL in the additional unit of measurement chosen.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Wintering River dissolved oxygen TMDL document includes daily loads expressed as pounds per day of BOD load for the listed segment of the watershed. The daily TMDL loads are included in TMDL section (Section 7.0) of the document.

COMMENTS: None.

Appendix G
NDDoH Response to Comments

US EPA Region VIII Comment: Section 5.1 (page16) mentions "…this impaired reach of the Souris River…" and flows from Canada. This needs to be revised to be applicable to the Wintering River.

NDDoH Response to Comment:
This error was corrected

US EPA Region VIII Comment: The Allocation section (page 28) mentions that the recommended BMPs will reduce fecal coliform levels in the Wintering River. While that may be true, the intent of this TMDL document is to reduce BOD, nutrient and organic loading in the River to meet the DO target. Please check and revise this section as needed.

NDDoH Response to Comment:
This section was revised to more accurately reflect reductions to organic and nutrient loading which are causing the low dissolved oxygen.