Deer Creek/Nemadji River Total Maximum Daily Load
Summary of Existing Water Quality Data

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1.0 Executive Summary

The purpose of this document is to provide a summary of the existing data for Deer Creek and the Nemadji River Basin in support of the Deer Creek/Nemadji River TMDL (Total Maximum Daily Load) study. Existing data on turbidity, TSS (total suspended solids), loads and sources will be used to assist in the quantification of the level of impairment, identification of sources, and recognition of data gaps. The compilation of past data will improve the efficiency of the TMDL study by providing easy access to data and aid with facilitation of an organized effort to collaborate with other professionals to analyze past data. Data will be collected through review of records from the Carlton County SWCD, MPCA, USGS, and other agencies with past involvement in the Nemadji River Basin. The information will be analyzed for usefulness via the methods described in the Data Use Criteria section of this document. After data is reviewed, it will be considered by a team of professionals for use in the load quantification. Additionally, data (or lack of data) will assist in the identification of future monitoring sites and the need for further information to complete the TMDL study.

The Data Summary section provides detail on the program descriptions and data collected. Review of these summaries reveals some apparent geographical data gaps. For example, little data has been gathered on some streams such as Nemadji Creek, Hunter's Creek, and Blackhoof River while there exists substantially more data on Deer Creek and the N. Fork Nemadji River. Existence of available data provides a means for explanation of listings for impairment. While some subwatersheds may be representative of other subwatersheds, listing for impairment is done so only with available data. Hence, streams may behave and resemble others that are listed, but may not be listed due to lack of data. Yet the recognition of similar subwatersheds may aid in using streams with data as a representative to another similar stream without data.

Due to the large size of the watershed and numerous study sites existing throughout the watershed, maps of past study sites and existing study sites are displayed in Appendix 2. In order to enhance collaboration with other professionals, maps have been developed as a visual display of data collections sites and will be used in consideration of monitoring sites for the 2009 monitoring plan. These maps will aid in the identification of geographical data gaps and help determine possible locations where past data collected can be expanded upon by further data collection.

2.0 Background

The Nemadji River Basin has approximately 433 square miles (277,400 acres) of drainage area and is located south of Duluth, Minnesota, straddling the Minnesota-Wisconsin border. (See Appendix A for map of watershed.) The basin area includes southeastern Carlton County and northeastern Pine County in Minnesota and northwestern Douglas County in Wisconsin. The land cover is 69 percent forest, 18 percent cropland and pasture, 11 percent wetlands and lakes, and two percent other categories. The majority of land ownership is non-industrial private land (55 percent). The remainder is county (22 percent), state (16 percent), railroad and industrial (6 percent), and Tribal, City, and Township (1 percent). Approximately 80% of the Minnesota portion of the Nemadji River Basin is located within Carlton County including all of the clay erosion prone areas and most of the headwater tributaries.

Deer Creek is a small perennial stream with a drainage area of 5,118 acres located entirely in Carlton County Minnesota and is a tributary to the Nemadji River. The land cover in the Deer Creek watershed is about a 60/40 mix of forest and open land. A majority (> 90%) is privately owned land with the remainder in state owned wildlife management area.

In December of 2003, Deer Creek (headwaters to Nemadji River) and the Nemadji River from the Minnesota – Wisconsin border upstream in Minnesota to the headwaters were listed on the Federal Clean Water Act's 303 (d) list of impaired waters for turbidity. In response to the listing, the state is required to conduct a TMDL study in order to define the load of sediment the water body can deliver while still meeting state standards. In 2008 a contract was drawn between the Minnesota Pollution Control Agency (MPCA) and the Carlton County Soil and Water Conservation District (SWCD) to carry out the Deer Creek/Nemadji River TMDL study. In the spring of 2008 the work began on the Deer Creek portion of the study. Upon completion of a monitoring plan (which this document will support), work will begin in 2009 on the greater Nemadji River Basin in order to quantify the sediment load of the Nemadji River.

3.0 Data Use Criteria

Each data set will be given a rank based on several factors. Consideration will be made about the type of data, number of data points, age of data, method of collection, and the existence of an EPA or MPCA approved QAPP (Quality Assurance Project Plan) when the data was collected. Usefulness of the data will be the primary determination of the ranking. The following questions will be used in the consideration of data utility:

- What are the primary causes of turbidity impairment in the Deer Creek and Nemadji River systems?

- Is the impairment a localized problem or a result of cumulative sources?

- What are the primary sources of sediment inputs to the Deer Creek and Nemadji River systems?

- Are there any natural background sources affecting the conditions of Deer Creek and Nemadji River?

- How do the TSS loads correspond to turbidity levels in Deer Creek and the Nemadji River?

- What is the maximum TSS or sediment load that Deer Creek and the Nemadji River systems can carry and not exceed their aquatic life uses?

- Are there any data gaps?

Data will be ranked for usefulness in the following manner:

1: Data in this category will be used directly in the TMDL study. A QAPP (Quality Assurance Project Plan) was in place for the project when the data was collected. Lab and field methods were carried out according to EPA requirements. Data may be used to develop the LDC (Load Duration Curve), wasteload and load allocations, identify water quality indicators such as development of a TSS and turbidity relationship, and assess and identify sources. Data found in STORET may be ranked in this category based on the number of data points and relative age of the data.

2: This data will be used as supportive data and not used directly for the LDC and load allocations. Data may have been collected in support of a peer reviewed scientific journal article with a QA plan or SOP (Standard Operating Procedures) but does not include an EPA or MPCA approved QAPP. This includes any other data that was collected with a QA plan but does not include an EPA or MPCA approved QAPP that will help in the determination of sediment loading. Data found in this category may have standard methods of data collection such as geomorphology work using stream metrics. This data may be used in modeling.

3: Data in this category will not be used to develop the LDC and allocations. Data may help in determining trends, identify needs for additional data, and assist in the identification of pollution sources. Data in this category may be quantitative data but may lack number of data points and/or may be older data. No QA or QAPP exists on the data, yet information was collected by an agency that has trained staff and SOP.

N/A: This data is worth noting and may provide some background on the history of data collection and studies done on the river. This data will not be used in the LDC and allocations and does not contain useful sediment loading data. Data in this category may be from broad data sources, old data, or may not be located.

4.0 Data Summary

4.1 Data Sources

Existing data for the Nemadji River Basin is found in many forms. Data collected through past projects was done so by various agencies and collected in various formats. In order to give an overview of data sources used, the following list displays data sources and access information.

Source	Type of database	Access information
STORET/EDA	Storage and Retrieval System managed by the MPCA	Some data can be accessed through the EDA (Environmental Data Access) link on the MPCA website: http://www.pca.state.mn.us/data/edaWater/index.cfm Full STORET summary was provided by MPCA STORET staff.
USGS/ NWIS	National Water Information System: acquisition, processing and long term storage of water data	http://waterdata.usgs.gov/mn/nwis/nwis
Carlton County SWCD	Paper and electronic files organized by program	Contact Carlton County SWCD contact@carltonswcd.org
MnDNR Fisheries	Data summary obtained at request	Temperature data can be accessed via EDA/STORET. Fish surveys and assessments were gathered by request.
WisDNR	SWIMS (Surface Water Integrated Monitoring Systems)	Data obtained by request.
St. Louis River Watch	Youth based water quality program. Excel spreadsheet and graphs available on website.	http://www.slriverwatch.org/graphselection.asp
State Climatology Office-DNR Waters	Website contains high density precipitation data.	http://climate.umn.edu/hidradius/HIDENbrowse.asp
WLSSD	Western Lake Superior Sanitary District website displays real-time precipitation data for the area, including Wrenshall.	http://extranet.wlssd.duluth.mn.us/plantoverview/rain.aspx
Cloquet Forestry Center-University of Minnesota	Precipitation information collected for NOAA. Evaporation information available upon request.	Monthly precipitation totals: http://cfc.cfans.umn.edu/weather/ Real-time precipitation data: http://www.weatherforyou.com/cgi-bin/hw3/hw3.cgi?forecast=wxhistory&icao=KCOQ

4.2 Past Reports

Listed below are reports produced for programs involving data collection that may be useful for this study. Descriptions of the reports and programs are found in the Data Summary section. The following list and rankings are used only as an initial inventory for the usefulness of data existing.

	Program/Reports	Predominant Data Type	Rank
1	**"The Nemadji River System"** by Eugene Surber (1925)	Stream and air temperature, flow measurements, other stream observations	N/A
2	**"1950 Nemadji River Survey"** by Jerome Huehn prepared for MN Dept. of Conservation (1950)	Water chemistry data (no turbidity or TSS), flow conditions, stream conditions, stream and air temperature, fish counts.	N/A
3	**"Blackhoof River Stream Improvement Project"** by O.M. Jarvepana, Minnesota Department of Conservation (1953)	Information on streambank stabilization and fish habitat improvement work on the Blackhoof River.	N/A
4	**"Report on Red Clay Deposits, Carlton County"** by Department of Iron Range Resources and Rehabilitation (1963)	Mineralogical and textural character of glacial clay samples from holes drilled in Carlton County.	N/A
5	**"Report on Classification and Establishment of standards of Water Quality and Purity for the Nemadji River and Tributaries Carlton and Pine Counties"** by MN Dept. Health prepared for MN Water Pollution Control Commission (1966)	Water chemistry data (includes turbidity and TSS), bottom fauna samples, physical observations, and bacteriological analysis.	3
Red Clay Project			
6	**"Nemadji River Erosion and Sedimentation Control Project"** prepared by the Onanegozie RC&D(MN) and the Pri-Ru-Ta RC&D (WI) sponsored by Carlton County SWCD and Douglas County SWCD	Project proposal seeking funds to develop a plan to correct or abate erosion issues in the Nemadji River basin.	N/A
7	**"Erosion and Sedimentation in the Lake Superior Basin"** reported by Red Clay Interagency Committee (1972)	Stream bank erosion surveys for WI portions of red clay area only. Other information on land use in WI portion of red clay area.	3
8	**"Second Annual Report, Red Clay Project"** reported by Soil Conservation Service (1976)	Soil survey, roadside erosion survey plans, flow monitoring, groundwater investigation, and daily sediment monitoring. Summary of report on effects of erosion on aquatic life in the Nemadji River and tributaries.	3
9	**"Impact of Non Point Pollution Control on Western Lake Superior-Red Clay Project Work Plan"** prepared for EPA(1976)	Erosion data collection on Skunk Creek and Balsam Creek (Wisconsin).	3
10	**"Red Clay-EPA Project"** by T.J. Weix and P.S. Whiteside, SCS presented at the 1977 Technical Conference, Northland College, Ashland, WI	Dutch Cone Pentrometer and Clay Flocculation Studies.	N/A
11	**"Five County Roadside/Streambank Red Clay Erosion Study-Phase I"** by Center for Lake Superior Environmental Studies-UW Superior (1978)	Includes erosion locations, dimensions, type, control needs and causes.	3
12	**"Five County Roadside/Streambank Red Clay Erosion Study-Phase II"** by Center for Lake Superior Environmental Studies-UW Superior (1978)	Maps of erosion locations and analysis of erosion data with additional data collection of target areas.	3
13	**"Red Clay and Its Transport to Lake Superior"** prepared for EPA (1979)	Use of Landsat imagery to determine relative magnitude of sediment sources. Includes suspended sediment data collected on the Nemadji River.	3
14	**"Red Clay Project: Impact of Nonpoint Pollution Control on Western Lake Superior-Final Part II"** prepared for EPA (1980)	Final reports on research conducted by UW-Superior, Center for Lake Superior Environmental Studies. Includes turbidity and stream velocity data. Also includes roadside and stream bank erosion report and vegetation analysis.	3
15	**"Red Clay Project: Impact of Nonpoint Pollution Control on Western Lake Superior-Final Part III"** prepared for EPA (1980)	Evaluation of erosion and sediment control project and monitoring reports for water quality, bedload transport and meteorological monitoring. Flow and suspended sediment data collected on Deer Creek, Skunk Creek, and Elim Creek.	3
16	**"Impact of Non Point Pollution Control on Western Lake Superior-Red Clay Project Final Report: Summary"** prepared for EPA(1980)	Presents findings, conclusions, and recommendations of study.	N/A
17	**"Best Management Practices-Pictorial Review"** prepared by D.S. Houtman, Wisc. BSWCD for EPA (no date)	Pictures and brief explanations of erosion control practices, includes Skunk Creek Hwy 103 structure and Hanson Dam.	N/A
18	**"The Red Clay Project in Minnesota"** by J.F.Ourada and W.L. Scheib, SCS presented at the 1983 Winter Meeting American Society of Agricultural Engineers	Technical discussion of Hansen and Elim dams and Skunk Creek Cty Rd 103 road stabilization project.	N/A
19	**"Results of 1992 Private Well Testing Program in the Nemadji River Watershed Carlton, County, MN"** reported by Carlton County SWCD	Wells tested for depth, coliform bacteria and nitrate levels.	N/A
20	**"Erosion-Sedimentation and Nonpoint Pollution in the Nemadji Watershed: Status of Our Knowledge"** by Gregory Banks and Kenneth Brooks (1992)	Assessment of success of Red Clay Project. Turbidity, TSS, and flow data collected at Deer Creek, Skunk Creek, and Elim Creek Data found in STORET.	2
21	**"Impacts of the Nemadji River Spill"** by Jopke and Patterson-Wisconsin DNR, Water Resources Management (1994)	Documentation of biological impacts in river and surrounding area, including animal deaths. Water chemistry data, including benzene concentrations.	N/A
22	**"Soil Mass Movement in the Nemadji River Watershed"** by Wayne Wold (1994)	Suspended sediment and discharge data Deer Creek. Correlation between turbidity and suspended sediment concentrations. Land cover characteristics. Assessed number of beaver dams and slumps.	3

23	**"Analysis of Soil Mass Wasting in the Nemadji River Watershed"** by Wayne Wold, Lloyd Queen, and Kenneth Brooks (1994)….followup report**"Assessing Cumulative Effects in the Nemadji River Basin, Minnesota"** by Wayne Wold, Lloyd Queen, and Kenneth Brooks (1995)(summarizes 1994 report)	Continuation of previous report. Includes GIS database for nine subwatershed.	N/A
24	**"Land Use Impacts on Stream Channel Processes in the Nemadji Watershed"** by Mark Reidel (1998)	Stream flow, channel hydraulics, slump inventory, and land use.	2
Nemadji River Basin Project (NRBP): PHASE I			
25	**"Nemadji River Basin Project Executive Summary Report: Erosion and Sedimentation in the Nemadji River Basin"** completed by Natural Resources Conservation Service and U.S. Forest Service (1998) (Summary of 1999 final document.) **"Erosion and Sedimentation in the Nemadji River Basin-Nemadji River Basin Project Final Report"** completed by Natural Resources Conservation service and U.S. Forest Service (1999) (Phase I)	Document includes STORET data review. Summarizes and interprets past data and establishes goals of Phase II.	N/A
26	**"EPA 319 Final Report"** submitted by Carlton County SWCD (2003) (May relate to 1999 work plan if funded separately and prior to Phase II)	Outlines accomplishments of 1999-2000 workplan. Completed forest inventory GIS project. Delay in funding resulted in no monitoring in 2000.	N/A
Nemadji River Basin Project (NRBP): PHASE II			
27	**"Nemadji River Watershed Workplan for 319 Grant"** completed by Carlton County Water Plan Coordinator, Brian Hayden (1999) (likely Phase II application per Greg Johnson)… **"Nemadji River Basin Project Phase II Workplan"** sponsored by Carlton County Water Plan Advisory Committee (2000-2002) project workplan for actual phase II	Workplan for 319 grant outlines objective of workplan for 2000-2002. Phase II workplan includes monitoring plan for 2000-2002. Four types of monitoring: hydraulic, water quality, macro invertebrate, and fisheries/biological monitoring. Includes QAPP.	N/A
28	**"Nemadji River Basin Project Final Report for 2001 319 Parntership Grant"** submitted by Carlton County Water Management Plan Coordinator	Outlines accomplishments of NRBP 2001. Completed GIS project inventorying Red Clay dam sites. Flow and water quality monitoring (found in STORET) includes TSS data for Deer Creek and N. Fork Nemadji River.	1
29	**"319A 2003 Final Report"** submitted by Carlton County Water Management Plan Coordinator	Outlines accomplishments of NRBP 2002. Flow and water quality monitoring (found in STORET) includes TSS data for Deer Creek, N. Fork Nemadji River, and Rock Creek.	1
30	**"Nemadji River Basin Plan Clean Water Partnership Phase II Continuation Work Plan"** sponsored by Carlton County Soil and Water Conservation District (2004-2006)	Outlines plan for project for the years 2004-2006. Includes monitoring plan for Oct. 2003-Sept. 2006 and QAPP.	N/A
31	**"Nemadji River Basin Project Final Report for the CWP Continuation Project 2007"** submitted by Carlton County SWCD (2007)	Outlines accomplishments of NRBP 2003-2007. Includes flow and water quality monitoring for various years of reporting period (found in STORET) includes TSS and some turbidity data for Rock Creek, Clear Creek (no turbidity data), Deer Creek, and N. Fork Nemadji River.	1
32	**"Nemadji River Basin Sediment Transport Modeling for Two Subwatersheds"** by Biard and Associates completed for US Army Corps of Engineers (2000)	Surface water model providing sediment budget information for the Nemadji River Basin based on data from Deer Creek and Skunk Creek.	3
33	**"Land Use Impacts on Fluvial Processes in the Nemadji River Watershed"** by Mark Reidel, Sandy Verry, and Kenneth Brooks (2002)	Stream metric evaluation. Study sites were N. Fork Nemadji River, Deer Creek, Skunk Creek, and Blackhoof River. Four study sites for channel metrics were chosen for each stream.	2
34	**"Nemadji Watershed Erosion Survey 2001/2002"** completed by MN DNR	Helicopter photos of stream erosion sites on Blackhoof River, N. Fork Nemadji River, Net Creek, Little Net Creek, and S. Fork Nemadji River hotlinked to aerial photo base map.	3
35	**"Lake Superior Basin Plan-Examining the Relative Health of Watersheds"** reported by MPCA (2003)	General characteristics of watersheds in Lake Superior Basin.	N/A
36	**"Channel Stability Across Scale in the Nemadji River Basin"** by Joe Magner (2004)	Study established new study sites in addition to Reidel's work (see **"**Land Use Impacts on Stream Channel Processes in the Nemadji Watershed" by Mark Riedel (1998) above).	2
37	**"LakeSuperiorStreams: Community Partnerships For Understanding Water Quality and Stormwater Impacts at the Head of the Great Lakes"** (http://lakesuperiorstreams.org). University of Minnesota-Duluth, Duluth, MN 55812 Authors: Axler, R., M. Lonsdale, C. Hagley, G. Host, J. Reed, J. Schomberg, E. Ruzycki, N. Will, B. Munson, and C. Richards (2005)	Provides river description, maps, pictures, and links to data and other related websites.	N/A

38	**"Deer Creek Groundwater Seepage"** by Howard Moores and Nigel Wattrus (UMD) (2005)	Groundwater seepage investigation on Deer Creek.	3
39	**"Stream Bank Stability Assessment in Grazed Riparian Areas"** by Mark Reidel, Kenneth Brooks, and Elon Verry (2006)	Assesses stream bank stability in grazed riparian areas along Deer Creek using Pfankuch method and mechanical estimates.	2
40	**"Predicting stream channel erosion in the lacustrine core of the upper Nemadji River, Minnesota (USA) using stream geomorphology metrics"** by Joe Magner and Kenneth Brooks (2007)	Use of stream geomorphology metric information obtained at past study locations to predict stream channel erosion in the upper portion of the Nemadji River.	2
41	**MnDNR Survey and Population Assessment History Report and Interview**-Minnesota DNR-Fisheries (7/16/08)	Fish counts, temperature data, some chemistry monitoring, stream sediment source information and physical stream information on all subwatersheds of the Nemadji River Basin within the last 60 years.	N/A
42	**WisDNR SWIMS Report for the Nemadji River and Interview** -Wisconsin DNR-Superior Office (10/3/08)	Chemistry and flow information for Nemadji River, Wisconsin	2
43	**Precipitation data sources:** State Climatology Office-DNR Waters, Western Lake Superior Sanitary District, Cloquet Forestry Center	Precipitation data available in several areas within and surrounding watershed.	2

4.3 Data Summary

In order to give a timeline of data, summaries are listed by project reports, beginning with the oldest projects on record. This will give a logical illustration of the programs that drove the means for the data collection throughout the years. The following table describes each project or paper found in relation to the Nemadji River Basin that contains some data on the water conditions. Anything reported under "Available TSS or Turbidity Data" is in regards to TSS, turbidity, or other related sediment load information for the listed rivers only (Deer Creek and the main stem of the N. Fork Nemadji River, Minnesota).

Program/Paper and Summary		**Available TSS or Turbidity Data**		**Period of Record**	**Data Rank**	**Recommended use in developing TMDL and explanation of ranking**
		Stream	**Type/#**			
1	**"The Nemadji River System"** by Eugene Surber (1925) Map of river system with trout waters, air and water temp readings, land and forest descriptions, shading of stream, siltation occurrences, bottom types, fauna notes, and fish observations.	N/A	N/A	1925	N/A	Historical comments on conditions of watershed can be used as general background information.

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
		Stream	**Type/#**			
2	**"1950 Nemadji River Survey"** by Jerome H. Huehn, prepared for Mn Dept. of Conservation, Division of Game and Fish (1950) Stream surveys done by walking length of streams and station monitoring. Includes information on stocking history, fish distribution and counts (lbs/acre), water chemistry (Sulfate, Total Phosphorous, Chloride, Total Nitrogen, and Total Alkalinity), flow conditions (cfs), stream dimensions, air and water temperatures, general stage conditions, and stocking and improvement recommendations. (N. Fork Nemadji River, Clear Creek, Mud Creek, Stateline Creek, Net River, Little Net River, Silver Creek, Anderson Creek, Stony Brook, Clear Creek, Pleasant Valley Creek, Deer Creek, Blackhoof River, Skunk Creek, Spring Creek, North Fork Creek (Nemadji), Bear Creek, Canutrup Creek, Mary Brook, Dry Tibutaries) Data summaries available on printed copy of report in Carlton County SWCD files.	N/A	N/A	1950	N/A	Historical comments on conditions of watershed can be used as general background information. Ranking based on age of data.
3	**"Blackhoof River Stream Improvement Project"** by O.M. Jarvepana, Minnesota Department of Conservation (1953) Approximately 6 miles of stream was worked beginning in June 1950 and ending in November 1952. Area was from NE1/4NE1/4 Section 17 to State Aid 6 in SW1/4NW1/4 Section 26. Improvement work was mainly bank erosion control through creation of cover and pools with channel devices and providing better fishing conditions through selective brushing. Work included tree plantings, channel dams, deflectors, digging logs, shelters, log jam removals, fencing away cattle, stream and trail brushing.	N/A	N/A	1953	N/A	Provides historical information on past erosion control practices on the Blackhoof River.
4	**"Report on Red Clay Deposits, Carlton County"** by Department of Iron Range Resources and Rehabilitation in cooperation with the Mines Experiment Station University of Minnesota(1963) Drill samples of glacial clay deposits were examined and differentiated between red till and gray-green laminated clays. Clay-sized content of gray-green laminated clays was generally less than 30 percent and the clay-sized fraction of the red till ranged as high as 70 percent. Study determined no need for further work by the Mines Experiment Station on additional exploration samples for economic evaluation.	N/A	N/A	1963	N/A	Provides historical information on clay deposits and economic evaluation of clays.
5	**"Report on Classification and Establishment of Standards of Water Quality and Purity for the Nemadji River and Tributaries Carlton and Pine Counties"** by Mn Dept of Health, prepared for Minnesota Water Pollution Control Commission (1966) Two field surveys done December 1965 and	Nemadji R. Hwy 23 Nemadji R. Cty Rd 6A	Suspended Solids and Turbidity (2 samples) Suspended Solids and Turbidity (2 samples)	1965, 1966 1965, 1966	3	Low number of sampling points and age of data result in designation of 3. Data may be used in rough comparisons and understanding of history of rivers.

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
		Stream	**Type/#**			
	March 1966. Physical observations, bottom fauna samples, and water samples collected for bacteriological and chemical analysis (temp., coliform, total solids, total volatile matter, suspended solids, susp. volatile matter, turbidity value, color, hardness, alk, pH, chlorides, D.O., 5-day biochemical oxygen demand, ammonia, surfactant, phenols, copper, cadmium, nickel, zinc radioactivity, pesticides) Sampling stations identified for Nemadji River (Hwy23), Nemadji River (Cty Rd 6A), Clear Creek (Hwy23), Mud Creek (Hwy23), S. Fork Nemadji river (Hwy23), State Line Creek (State Aid Rd 8), Net River (S.A. Rd 8), Little Net River (S.A. Rd8), Rock Creek (Hwy23), Deer Creek (Hwy23), Blackhoof River (Cty Rd 6A), Nemadji River (Wisc. Border), S. Fork Nemadji River (Wisc. Border)	Deer Creek Hwy 23	Suspended Solids and Turbidity (2 samples)	1965, 1966		
Red Clay Project						
6	**"Nemadji River Erosion and Sedimentation Control Project"** prepared by the Onanegozie RC&D(MN) and the Pri-Ru-Ta RC&D (WI) sponsored by Carlton County SWCD and Douglas County SWCD (1971) Project proposal was seeking funds to develop a plan to correct or abate the erosion issues in the Nemadji River basin. Discussion of impacts of erosion and slippage including deposition of sediments in Duluth-Superior harbor and consequential dredging of harbor for ship passage. Also discusses impacts to high cost of road repairs due to erosion and slippage, aesthetics, sediment in a water line, property values, and hampering of industrial expansion.	N/A	N/A	1971	N/A	Background information regarding beginning efforts of the Red Clay Project
7	**"Erosion and Sedimentation in the Lake Superior Basin"** reported by Red Clay Inter-agency Committee (1972) Review and report of existing data of the sediment problems of the Lake Superior Basin. Includes information on stream banks, erosion sources and biological effects of erosion. Cost estimates and agency responsibility information.	N/A	N/A	1972	3	Erosion information may be useful for historical sediment source information.
8	**"Second Annual Report, Red Clay Project"** reported by Soil Conservation Service (1976) Summary of work completed in the Red Clay Project area by SCS personnel and compilation of reports relating to project. Includes ½ page summary of Nemadji Basin soil survey and roadside erosion control plans. Includes USGS summary of flow monitoring on Skunk Creek and groundwater investigation in Nemadji Basin. Discussion of daily sediment monitoring at Nemadji River near South Superior. Center for Lake superior Environmental Studies report of vegetative cover in Nemadji Basin and report on effects of erosion control on aquatic life in Nemadji River and tributaries**.**	N/A	N/A	1975-1976	3	Continuous flow monitoring and sediment monitoring may be used for historical record of stream conditions. Ranking based on age of data. Soil survey and erosion control comments may also be used for historic record.

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
		Stream	**Type/#**			
9	**"Impact of Non Point Pollution Control on Western Lake Superior-Red Clay Project Work Plan"** prepared for USEPA (1976) Final plan for research and demonstration project to evaluate structural and non-structural methods and techniques of controlling erosion and sedimentation. Includes section on Nemadji River Basin (pp7-61). Outlines study to be done on Skunk Creek Watershed and Little Balsam Creek Watershed within the Nemadji Basin. "**Skunk Creek Watershed Study Area"**-(pp26-43) (outlines plan for monitoring on Skunk Creek 1975-1978 and includes erosion inventory completed on Skunk Creek)	N/A	N/A	1976	N/A	Provides background and plans for Red Clay Project.
10	**"Red Clay-EPA Project"** by T.J. Weix and P.S. Whiteside, SCS presented at the 1977 Technical Conference, Northland College, Ashland, WI Discussion of Dutch Cone investigation of Little Balsam Creek and flocalulation behavior of clays from the Elim Creek Watershed in Carlton County.	N/A	N/A	1977	N/A	Provides overview of studies done on two streams in the Nemadji River watershed. Information should be captured in final report.
11	**"Five County Roadside/Streambank Red Clay Erosion Study-Phase I"** by Center for Lake Superior Environmental Studies-UW Superior for the EPA (1978) Completed five stages of work: 1) Established a 5 county base map of scale 2) Establish as an overlay the extent of known red clay sedimentation 3) Search regional and state records and collect copies of all that pertains to past surveys of subject area roadside and stream bank erosion 4) Compile such records into an uniform format 5) Establish overlay and in cartographic code, the pertinent and relevant information obtained in stage 4. Includes erosion locations, dimensions, type, control needs and causes.	N/A	N/A	1978	3	Erosion data may be used for historical record of sediment sources.
12	**"Five County Roadside/Streambank Red Clay Erosion Study-Phase II"** by Center for Lake Superior Environmental Studies-UW Superior for the EPA(1978) Four targeted areas were chosen for additional erosion data collection: 1) All remaining stretches of roadside erosion. 2) A sector of a red clay basin that has been subjected principally to recreation usage. 3) A sector of a red clay basin that has been utilized principally for agricultural purposes. 4) A sector of a red clay basin that has been maintained basically in a virgin state. Includes maps of erosion locations and analysis of erosion data.	N/A	N/A	1978	3	Erosion data may be used for historical record of sediment sources.

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
		Stream	**Type/#**			
13	**"Red Clay and Its Transport to Lake Superior"** prepared for EPA (1979) Use of Landsat imagery (1972-1975) to determine relative magnitude of three sources 1) erosion along red clay banks of Lake Superior in Wisconsin, 2) resuspension of sediments 3) runoff from streams flowing into lake. Study indicated that 75% of the turbidity in Lake Superior is from lakeshore erosion in Douglas Co., 5% is from river runoff mainly from the Nemadji River University of Minnesota-Duluth collected data on discharge and suspended sediment in several rivers including the Nemadji River at the "bridge near the Nemadji Gulf Club" in south Superior.	Nemadji River (south Superior)	Suspended Sediment (ukn no. of samples)	1975	3	Data used to estimate sediment load delivery to lake superior for the years 1970-1975. Data may be used for comparison.
14	**"Red Clay Project-Impact of Nonpoint Pollution Control on Western lake Superior-Final Part II"** prepared for USEPA (1980). Final reports on research conducted by UW-Superior, Center for Lake Superior Environmental Studies. The following studies are found in this document: **"Red Clay Slope Stability Factors"** by J.T. Mengel and B.E. Brown" (study area is Little Balsam Creek Drainage of the Nemadji River basin in Douglas Co. WI); **"Effects of Red Clay Turbidity and Sedimentation on Aquatic Life in the Nemadji River System"** by P.S. Devore, L.T. Brooke, and W.A. Swenson (study area includes Nemadji River, Little Balsam Creek, Empire Creek, Skunk Creek, and Elim Creek); **"Vegetation and Red Clay Soils Stability"** by L.A Kapustka, D.W. Davidson, and R.G. Koch (study area Skunk Creek and Little Balsam); **"Vegetational Cover Analysis"** by R.G. Koch, S.H. Stackler, L.M. Koch, and L. Kapustka (study area Skunk Creek subwatershed and Little Balsam Creek subwatershed); **"Effect of Vegetation Cover on Soil Water Content of Red Clay Soils and Erosion Control"** by L.A. Kapustka and R.G. Koch (study area Little Balsam Creek subwatershed); **"Role of Plant Roots in Red Clay Erosion"** by L.A. Kapustka and D.W. Davidson (study area Little Balsam Creek subwatershed and Skunk Creek subwatershed); **"Evaluation of Red Clay Interagency Committee Works Project"** by G. Tenpas and W. Briggs (evaluation of past Red Clay projects beginning in 1955); **"Five County Roadside/Streambank Red Clay Erosion Survey" and "Field Analysis of Red Clay Streambank and Highway Erosion"** by D.R. Bray, P.L. Webster and A.B. Dickas Turbidity and stream velocity data found in "Effects of Red Clay Turbidity and Sedimentation on Aquatic Life in the Nemadji River System."	Nemadji River (0.5 miles upstream of mouth)	Turbidity (12 samples)	1975-1977	3	Ranking based on age of data. May be used for historical comparison.
		Nemadji River (5 miles upstream of mouth)	Turbidity (5 samples)	1975		
		Nemadji River (18 miles upstream of mouth)	Turbidity (6 samples)	1975		
		Nemadji River (22 miles upstream of mouth)	Turbidity (20 samples)	1975-1977		
		Nemadji River (29 miles upstream of mouth)	Turbidity (19 samples)	1975-1977		
		Nemadji River (50 miles upstream of mouth, Hwy 103)	Turbidity (5 samples)	1975		

	Program/Paper and Summary	Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
		Stream	**Type/#**			
15	**"Red Clay Project-Impact of Nonpoint Pollution Control on Western lake Superior-Final Part III"** prepared for USEPA (1980). Includes report titled, **"Hydrologic Characteristics of Elim, Skunk, and Deer Creeks, Upper Nemadji River Basin, Minnesota"** by E.G. Giacomini, R.J. Wolf, G.A. Payne, and D.G Adolphson Evaluation of erosion and sediment control project and monitoring reports for water quality, bedload transport and meteorological monitoring. Includes technical appendices, including methods of sampling, data analysis, and specific information on sampling locations beginning on page 329. Includes data summaries and refers to annual USGS report for complete data set. Data from Deer Creek summarized in this paper is from USGS station 04024098.	Deer Creek USGS 75 ft upstream Hwy 23	Turbidity (22 samples)	1976-1978	3	Ranking based on age of data. May be used for historical comparison.
		Deer Creek USGS 75 ft upstream Hwy 23 Turbidity	Susp. Sediment Conc. (7 samples)	1977-1979		
		Deer Creek USGS 75 ft upstream Hwy 23 Turbidity	Susp. Sediment Dis. (8 samples)	1977-1979		
16	**"Impact of Non Point Pollution control on Western Lake Superior-Red Clay Project Final Report: Summary"** prepared for EPA (1980) Presents the project's findings, conclusions and recommendations. Includes summary of bedload study in the Nemadji River in Douglas County and groundwater study in Carlton County.	N/A	N/A	1976-1978	N/A	Comments may be used for background information. Data collected during project captured in preceding document.
17	**"Best Management Practices-Pictorial Review"** prepared by D.S. Houtman, Wisc. BWSR for EPA (no date) Pictures and brief explanations of erosion control practices, includes Skunk Creek Hwy 103 structure and Hanson Dam.	N/A	N/A	No date	N/A	Pictures and comments may be used for background information of past erosion control practices applied in the watershed.
18	**"The Red Clay Project in Minnesota"** by J.F.Ourada and W.L. Scheib, SCS presented at the 1983 Winter Meeting American Society of Agricultural Engineers Discussion of building of two floodwater regarding dams and one major slide stabilization measure (Hansen Dam, Elim Dam, and Skunk Creek Cty Rd 103 crossing stabilization. Includes recommendations and future construction considerations.	N/A	N/A	1983	N/A	Comments may be used to for background information on project.
19	**"Results of the 1992 Private Well Testing Program in the Nemadji River Watershed Carlton County, Minnesota"** Reported by the Carlton County SWCD 162 wells were tested in the Nemadji Watershed for measurements of depth, coliform bacteria and nitrate levels.	N/A	N/A	1992	N/A	Data may be used for background information of ground water.
20	**"Erosion-Sedimentation and Nonpoint Pollution in the Nemadji Watershed: Status of Our Knowledge"** by Gregory Banks and Kenneth Brooks (1992) Reassesses the conclusions of the Red Clay	Deer Creek at USGS station 04024098, reported by U of M	Turbidity (16 samples)	1991	2	Data is found in STORET and may be used for comparison. Ranking based on small time frame of data collection.

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
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	Project. Summarizes past research of the red clay area. Flow and chemistry data was collected on three tributaries (Skunk Creek, Deer Creek, and Elim Creek) and compared to 1970's data near similar sampling sites. Results found on pages 43-44. Comments from data summary: "Comparisons are also complicated by the fluctuations in annual precipitation. The Red Clay project experienced two drought years compared to the relatively wet 1991. Similarly there are questions about whether sampling locations, seasons, and methodologies are comparable. Nonetheless the data show no significant changes in water quality parameters, TSS excepted. A valuable product of this summer's sampling was the development of sediment rating curves for Skunk and Deer Creek. The value of reducing upland runoff through vegetative management is apparent, although vegetation has only a limited effect on storm flow of large events…"	Deer Creek at USGS station 04024098, reported by U of M	TSS (16 samples)	1991		
21	**"Impacts of the Nemadji River Spill"** by Peter Jopke and Dale Patterson-Wisconsin DNR, Water Resources Management (1994) Documentation of biological impacts in river and surrounding area, including animal deaths. Water chemistry data, including benzene concentrations. Heavy winds and rain followed by the rise in the river flow made delayed sampling efforts yet helped disperse the chemical cloud and dilute the spilled material.	N/A	N/A	1994	N/A	May provide useful background information.
22	**"Soil Mass Movement in the Nemadji River Watershed"** by Wayne Wold (1994) Project funded by Carlton SWCD. Study correlates the watershed characteristics of nine representative subwatersheds (Mud Creek, Rock Creek, **Deer Creek**, Skunk Creek, Clear Creek, Silver Creek, Noname Creek, Little Net Creek, and State Line Creek examining the occurrence of soil mass movement in stream valleys using simple linear regression models. Study found that the number of slumps increased as the percentage of non-forested area in the subwatersheds increased. Site-specific activities such as road construction and logging would appear to have the greatest effect on steeper slopes in red clay soils. Includes land cover characteristics including Deer Creek subwatershed. Includes number of beaver dams and slumping banks on creek stretches. Includes suspended sediment/discharge data and turbidity data. Correlation between turbidity and Suspended Sediment concentrations. Data found on p. 35 of this report or p. 109 of 1994 report.	Upper Deer Creek (Cty Rd 3)	Turbidity (3 samples)	1993-1994	3	Although turbidity and suspended solids correlation was made, sampling only covered three points in time and no storm events. Data not found in STORET. Data may be useful background information
		Upper Deer Creek (Cty Rd 3)	TSS (3 samples)	1993-1994		
		Lower Deer Creek (Hwy23)	Turbidity (3 samples)	1993-1994		
		Lower Deer Creek (Hwy23)	TSS (3 samples)	1993-1994		

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
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23	**"Analysis of Soil Mass Wasting in the Nemadji River Watershed"** by Wayne Wold, Lloyd Queen, and Kenneth Brooks (1994) and **"Assessing Cumulative Effects in the Nemadji River Basin, Minnesota"** by Wayne Wold, Llyod Queen, and Kenneth Brooks (1995) (Brief summary of previous study.) Report with supporting GIS database of watershed variables for nine subwatersheds (Mud Creek, Rock Creek, **Deer Creek**, Skunk Creek, Clear Creek, Silver Creek, Noname Creek, Little Net Creek, and State Line Creek). Examines cause and effect relationships between mass soil movement sites and various watershed characteristics. Continued analysis from previous study where data was collected in 1993-1994. Use of helicopter platform photos (1:5000) to provide stereo coverage of the mainstem for eight of the nine subwatersheds. Seven of nine subwatersheds were field checked for slump location and number. Concluded that only relationship that is clearly a factor in determining the number of slumps on a subwatershed scale is the amount of forested versus non-forested area. (Conclusions p.112) Suggestion for further need for study on hillslope hydrology.				3	Same data as previous report.
24	**"Land Use Impacts on Stream Channel Processes in the Nemadji Watershed"** by Mark Riedel (1998) Report Objective: 1. Identify relationships between stream hydraulics and mass wasting, stream type and mass wasting, and land use and stream type in the Nemadji Watershed. 2. Determine applicability of river classification techniques for clay bed rivers. 3. Improve understanding of stream dynamics and generation of suspended sediments in the clay channel systems of the Nemadji River Watershed. Sampling reaches installed on Skunk Creek, Deer Creek, and Blackhoof River. Includes data on stream flow, channel hydraulics, slump inventory, and land use. Results of project provided strong correlations between land use and bankfull discharge and between bankfull discharge and slump occurrence.			1998	2	Results of this study have provided strong basis for ongoing study.

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
		Stream	Type/#			
Nemadji River Basin Project (NRBP): PHASE I						
25	**Nemadji River Basin Project: "Executive Summary Report: Erosion and Sedimentation in the Nemadji River Basin"** completed by Natural Resources Conservation Service and U.S. Forest Service (1998) (Summarizes the 1999 NRBP document.) **"Erosion and Sedimentation in the Nemadji River Basin-Nemadji River Basin Project Final Report"** completed by Natural Resources Conservation Service and U.S. Forest Service (1999) (Phase I) In 1978, the St. Louis system (including the Nemadji River Basin) was designated an "area of concern" (AOR) by the Great Lakes Water Quality Agreement (WQA) between The United States and Canada. Several impaired uses were recognized at that time. In 1987, Remedial Action Plans (RAPs) were developed for implementing provisions of the WQA and restoring beneficial uses of this area. In 1993, the Citizen's Advisory Committee of the RAP requested the Natural Resources Conservation Service (NRCS) to identify methods for reducing sedimentation in the Nemadji River. Under the authority of Public Law-566 Watershed Protection and Flood Prevention Act, the NRCS began work on the Nemadji River Basin Project in January 1994. The Carlton County Board of Commissioners, several Wisconsin agencies and the Metropolitan Interstate Committee served as sponsors to provide local support and input. The mission of the Nemadji River Basin Project at that time was to recommend remedial actions and treatments to implement restoration to beneficial uses to the Nemadji River Basin. The result of this NRCS effort was a report entitled "Erosion and Sedimentation in the Nemadji River Basin." This report established the goals that became the basis of the initial Clean Water Partnership Phase II implementation project funded by the MPCA in 2000 and the Clean Water Partnership Phase II Continuation project begun in 2004. Two EPA Section 319 grants focused on implementing the 1998 NRCS reports recommendations have also been completed in the Nemadji River Basin. NRBP reported a sediment yield of 127,000 tons of per year, which is far smaller than the 1979 estimate of 562,000 tons per year as reported by the EPA. The large difference is attributed to the greater availability of data in the more recent report. Includes STORET data review on p. 20 of appendix section. Appendix also includes: Sediment Budget Process section beginning on p. 67 which includes estimations of sediment contribution of all tributaries in the Nemadji River Basin.	N/A	N/A	2000-2002	N/A	Document provides background information of project. Data from STORET review captured in previous listed studies.

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
		Stream	**Type/#**			
26	**"EPA 319 Final Report"** submitted by Carlton SWCD (2003) Outline fulfillment of 1999-2000 workplan. Includes GIS project. Summary follows: The *Community GIS* Consultant has completed development of the Land SAT maps of the Nemadji Basin to assist in the coordination of forest harvesting and reforestation. Forest inventory maps produced as large display maps, binder, for use with ARC GIS. Also includes details of monitoring during 2001. Water samples are taken from May through September or June through October, depending on the ice melt. The delay in receiving funding from the 1999-2000 319 delayed the monitoring program until 2001. Deer Creek, Clear Creek, and Rock Creek are monitored with funding from the CWP grant.	N/A	N/A	2001	N/A	2001 Data results captured in 2003 final report listed below.
Nemadji River Basin Project (NRBP): PHASE II						
27	**"Nemadji River Watershed Workplan for 319 Grant"** completed by Carlton County Water Planner, Brian Hayden (1999) (Outlines objective of workplan for 2000-2001) **"Nemadji River Basin Project Phase II Workplan"** sponsored by Carlton County Water Plan Advisory Committee (2000-2002) Document outlines specific implementation goals for the NRBP project for the years 2000-2002. Water quality goals include: 1. Develop an inventory and communication strategy useful to watershed timber harvest/restoration. 2. Initiate selected restoration projects as demonstration sites to determine their effectiveness or to eliminate immediate erosion concerns. 3. Develop an effective water quality sedimentation monitoring plan for the long term. Fisheries goals include: 1. Improve the essential habitats for salmonid species by reducing turbidity and sedimentation and restore fish migratory access to previously inaccessible areas. 2. Measure success by habitat assessments and invertebrate counts. Document includes Nemadji River Sediment Concentrations on graph for 1974-1978 (in attachments and references section). Includes feedlot inventory 1998. Monitoring plan is found in document and outlines plan for four types of monitoring: hydrologic (collected by MPCA), water quality (collected by SWCD), macro invertebrate (collected by DNR, MPCA), and fisheries or biological monitoring (collected by DNR, River Watch, MPCA). QAPP included.	N/A	N/A	2000-2002	N/A	Document discusses past data collected captured in previous studies listed.

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
		Stream	**Type/#**			
28	**"Nemadji River Basin Project Final Report for 2001 310 Partnership Grant"** Submitted by Carlton County Soil and Water Conservation District Summarizes accomplishments of project 2001. Completed tasks: 1) Inventory and assessed condition of water retention devices (dams) constructed during 1970s NRCS Nemadji Red Clay Project. 2) Wetland Restoration attempt yet this portion of the grant abandoned. 3) Riparian Restoration: 8 acres of tree plantings along tributaries within the Nemadji basin. 4) Project management: technical advisory meetings held. 5) Project education and promotion. 5) Geologic Evaluation: Contract with UMD Geology Dept. to analyze stratigraphy and hydrology of portion of watershed near mud volcanoes included shallow seismic line analysis to assess feasibility of reducing sediment input to Deer Creek. Also, plan for contract with UM to begin geologic atlas in 2005. 7) Plan for future water quality monitoring.	See #18	See #18	2001	N/A	GIS inventory of retention devices may be useful information regarding implementation practices and sediment sources. Note 2001 data captured in following report due to the STORET report lumping 2001-2003 data together.
29	**"319A 2003 Final Report"** submitted by Carlton County Water Management Plan Coordinator Summarizes accomplishments of NRBP 2002. Accomplishments include DNR erosion inventory (see details below), fluvial processes assessment and planning (see report by Reidel, Verry, and Brooks below), newsletter distribution, technical advisory meetings, forest inventory GIS project. Flow and water quality monitoring data found in STORET under this project name.	N. Fork Nemadji at Hwy23 (S000-110)	TSS (27 samples)	2001-2003	1	Data may be useful in calculation of sediment loads or as comparative data.
		Deer Creek at Hwy 23 (S003-250)	TSS (28 samples)	2001-2003		
30	**"Nemadji River Basin Plan Clean Water Partnership Phase II Continuation Work Plan"** sponsored by Carlton County Soil and Water Conservation District (2004-2006) Outlines plan for project for the years 2004-2006. The following summary is taken directly from the Statement of Project Goals and Objectives portion of the workplan: The primary goal of this Clean Water Partnership Phase II Continuation is to positively affect hydrology in the identified small hydrologic units within the 11 subwatersheds of the Nemadji River Basin, as recommended in the Phase I report. Work towards this goal will include projects in education, BMP installation, and water monitoring. With information established in previous watershed projects, efforts in all three of these areas can begin at an advanced stage. Secondary goals include work in fish habitat and wildlife habitat improvement All short-term goals and objectives will ultimately enhance and support the main long-term objective of restoring beneficial uses to the Nemadji River Basin. Includes monitoring plan for 2003-2006 and QAPP.	N/A	N/A	2004-2006	N/A	Project plans may be useful in understanding goals of projects.

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
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31	**"Nemadji River Basin Project Final Report for the CWP Continuation Project 2007"** submitted by Carlton County SWCD (2007) Outlines accomplishments of NRBP 2003-2007. The following are the listed accomplishments as summarized in the report: 1. Awareness of the issues in the Nemadji River Basin were elevated and discussed with public and agency stakeholders. 2. Nemadji Turbidity issues were documented leading to an Impaired Waters listing. 3. Fish habitat improvement projects were completed. 45 acres of reforestation projects were completed. Note that tributary issues documented included monitoring efforts. Flow and water quality monitoring for various years within reporting period (found in STORET) includes TSS and some turbidity data for Rock Creek, Clear Creek (no turbidity data), Deer Creek, and N. Fork Nemadji River.	Nemadji River Hwy 23	Turbidity (33 Samples)	2004-2005	1	Data may be used in final calculations and/or as comparative data. Data in this time period were used in impaired listing determination.
		Nemadji River Hwy 23	TSS (42 Samples)	2002-2005		
		Deer Creek Hwy 23	Turbidity (33 Samples)	2004-2005		
		Deer Creek Hwy 23	TSS (32 Samples)	2004-2005		
32	**"Nemadji River Basin Sediment Transport Modeling for Two Subwatersheds"** by Biard and Associates for US Army Corps of Eng. (2000) A comprehensive sediment budget completed as part of the Nemadji River Basin Project (1998) determined that 98% of the sediment yield from the Nemadji Basin is derived from the erosion of the valley walls. In addition, the sediment delivery ratio (SDR) was found to be almost 98% – indicating almost all of the sediment that is eroded along the Nemadji Basin tributaries is transported to the mouth of the river. Forestry and timber harvesting practices may have had an impact upon this erosion. The turbidity in the river and dredging in the mouth have an impact on fishing and other recreational uses. A tool to assess the implication of land use planning and the merits of remedial measures is required. This report describes the development of a watershed based sediment transport model and addresses this requirement. It consists of hydrologic, hydrodynamic, erosion and sediment delivery models. Deer Creek and Skunk Creek were used for the models.	N/A	N/A	2000	3	Sediment transport model created for Deer Creek may be used as a comparison in sediment load, usefulness of model questioned by team at time of release. Note model comes with separate user manual and a workshop was held to train potential users of the model. Model uses data from 1976-1978 Deer Creek Gage 04024098 (data collected during Red Clay Project). Sediment data reported from model may be useful comparison for sediment source determinations.

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
		Stream	**Type/#**			
33	**"Land Use Impacts on Fluvial Processes in the Nemadji River Watershed"** by Mark Reidel, Sandy Verry, and Kenneth Brooks (2002) Researched land use history across upper 520 km2 of Nemadji River Watershed, surveyed channel characteristics, identified relic channels and employed dendrochronology to date floodplains and terraces. Results indicate that two episodes of channel incision began propagating through the river and its tributaries. One associated with timber harvesting in the mid 1800s and another associated with a large fire in 1894. Historical increases in water yield, particularly bankfull discharge, initiated the channel incision. This occurred with the onset of basin scale land use conversion in 1850s. Forest fires in 1894 and 1918 and agricultural land use conversion during the early 1900s initiated additional episodes of channel incision. Study sites were N. Fork Nemadji River, Deer Creek, Skunk Creek, and Blackhoof River. Four study sites for channel metrics were chosen for each stream.	N/A	N/A	2002	2	Results of study may be useful in understanding system loads.
34	**"Nemadji Watershed Erosion Survey 2001/2002"** completed by MN DNR The erosion survey was completed on Blackhoof River, N. Fork Nemadji River, Net Creek, Little Net Creek, and S. Fork Nemadji River. Includes aerial photos of erosion points along riverbanks. Project is in htm format as an aerial photo map with erosion points and linked photos.	N/A	N/A	2001/ 2002	3	Record of erosion points many be useful in determining sediment sources.
35	**"Lake Superior Basin Plan-Examining the Relative Health of Watersheds"** reported by MPCA (2003) Nemadji and some tributaries in the Nemadji watershed are listed according to amount of public land ownership, number of dams, road density, tourism/recreation pressure, number of stream crossings, point and nonpoint pollution sources, and overall ranking of health relative to other watersheds. Ecological settings are also surveyed and discussed. Soils types are reported. It is important to note that broad data sources were used. 17 recommendations are made for Carlton County in a table at the end of the document.	N/A	N/A	2003	N/A	Comments on description of watershed can be used as general background information.

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
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36	**"Channel Stability Across Scale in the Nemadji River Basin"** by Joe Magner (2004) Study established new study sites in addition to Reidel's work (see **"**Land Use Impacts on Stream Channel Processes in the Nemadji Watershed" by Mark Riedel (1998) above). Conclusions drawn about current system disequilibrium: "1. The cohesive nature of the red clay will resist erosion except where fractures or other weak shear zones exist due to ground water discharge. 2. The mass wasting of bank soil will need to occur until the valley beltwidth becomes several times larger than the bankfull channel width (Rosgen, 1994). Based on data in table 1, streams will need to erode 6-to-10 times their current bankfull width, assuming the base elevation remains stable and the climate does not change. 3. Additionally, a supply of aggradeable sediment (not clay size particles) will need to accumulate in the overwidened streambeds to build new active floodplains."	N/A	N/A	2004	2	Information may be used in modeling and further understanding of stream characteristics.
37	**"LakeSuperiorStreams: Community Partnerships For Understanding Water Quality and Stormwater Impacts at the Head of the Great Lakes"** (http://lakesuperiorstreams.org). University of Minnesota-Duluth, Duluth, MN 55812 Authors: Axler, R., M. Lonsdale, C. Hagley, G. Host, J. Reed, J. Schomberg, E. Ruzycki, N. Will, B. Munson, and C. Richards (2005) Provides river description, maps, pictures, and links to DNR/MPCA data, City of Superior website, Nemadji River Basin Project, and Great Lakes Commission Tributary Model (Nemadji Sediment Transport Modeling)	N/A	N/A	2005	N/A	Provides public access for much of the data presented in this document.
38	**"Deer Creek Groundwater Seepage"** by Howard Moores and Nigel Wattrus (UMD) (2005) The following is a portion of the report summary: "This report summarizes the results of an investigation of groundwater seepage along a reach of Deer Creek, Carlton County, Minnesota. The groundwater seepage is causing excessive turbidity, which affects all aspects of stream ecology and contributes large amounts of sediment to the Nemadji River." Recommendations include possibility of pumping water around targeted study site in order to lower potentiometric surface, yet disposal of pumped water would be an issue. Installation of French Drains (method of redirecting water away from an area) is another possible solution but expensive. Final recommendation emphasized is to leave the system alone and allow for natural process of reaching equilibrium.	N/A	N/A	2005	3	Study contains valuable information about geological processes and groundwater sediment information but will not be used in final calculations.

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39	**"Stream Bank Stability Assessment in Grazed Riparian Areas"** by Mark Reidel, Kenneth Brooks, and Elon Verry (2006) Grazed riparian stretches were investigated along Deer Creek under a variety of cattle traffic scenarios over a three-year period. Study concluded that stream bank stability was significantly reduced in grazed riparian areas. The "Pfankuch" method of rating stream bank stability in the field was very consistent with mechanistic estimates and measured values of stream bank stability."	N/A	N/A	2006	2	May be used for information regarding sediment source.
40	**"Predicting stream channel erosion in the lacustrine core of the upper Nemadji River, Minnesota (USA) using stream geomorphology metrics"** by Joe Magner and Kenneth Brooks (2007) The following is an excerpt from the paper conclusions: "we can draw some conclusions about the current system disequilibrium. First, a limited supply of aggradable sediment (larger than clay size particles) will need to be transported from the beach ridge and moraine and accumulate in widened streambeds to reconnect channels to active floodplains. Second, high risk streams will need to erode from their current mean bankfull width, measured in 2001, 5-to-10 times assuming the base elevation of the channel remains stable and climate does not change. Third, mass wasting of bluff and bank material will need to occur until the valley beltwidth becomes several times larger than bankfull channel width. Fourth, the cohesive nature of the lacustrine clay-rich sediment will resist erosion except where fractures/conduits exist due to ground water discharge. Ground water discharge via factures will create weak zones of shear and the formation of a friction angle (the friction angle is a failure plane angle within the bluff/bank). Time and associated weathering, change in soil moisture content, increased bluff/bank height, and the gravitational forces of vegetative weight will cause bank failure. This suggests that mass wasting may always occur in the Nemadji River basin because pore pressures associated with ground water discharge will spatially change with mass wasting. In summary, the Nemadji River basin may very likely remain in fluvial disequilibrium well into the 22nd century."	N/A	N/A	2007	2	Information may be used in modeling and further understanding of stream characteristics.

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41	**DNR Survey and Population Assessment History Report and Interview-**Minnesota DNR-Fisheries (7/16/08) Summary of 1) fish surveys, 2) population assessments, and 3) 3-year temperature studies conducted and to be conducted in the Nemadji River Basin. Summary data provided by DNR Fisheries in excel spreadsheet. Includes 24 streams of Nemadji River Basin including the main stem. 7/16/08 interview clarifies data contained in summary. Survey streams include in depth study including pollution sources, sediment information, and physical information. Recent surveys include Rosgen classification methods. Population assessments primarily include fish data with some discrete d.o., temperature, alkalinity, and conductivity data. Three-year temperature data include continuous temperature data collection throughout season. Last recorded surveys conducted on N. Fork Nemadji River and Deer Creek were done in 1950 (see "1950 Nemadji River Survey" by Jerome Huehn above) Last recorded population assessment conducted on Deer Creek and N. Fork Nemadji was done in 1993. Note: no trout present for both streams. 3-year temperature assessments have not been done on either stream. GIS layers of trout stocking, trout abundance, and temperature data collection sites are on file at Carlton SWCD.	N/A	N/A	1950-present	N/A	Historical data on conditions of watershed can be used as general background information.
42	**WisDNR SWIMS Report for the Nemadji River, WisDNR lab reports, and WisDNR State of Wisconsin Surface Water Quality Monitoring Data (books)** -Wisconsin DNR-Superior Office (10/3/08 visit) TSS and Turbidity data for Nemadji River at Cty C, WI, found in SWIMS database. WisDNR lab reports (prior to entry into SWIMS database) indicate data for TSS at Nemadji River, Finn Road Crossing, WI. Water Quality Monitoring Data (books) detail water chemistry information for Nemadji River Cth C, WI, no reports of turbidity or TSS.	Nemadji River at Cth C, near south Superior, Wisconsin	TSS (191samples)	1974-2007	3	Data found in these records may be incorporated into study when looking at the system as a whole.
		Nemadji River at Cth C, near south Superior, Wisconsin	Turbidity (39 samples)	1974-1976, 2006, 2007		
		Nemadji River 50 yards above Finn Road Crossing, Wisconsin	TSS (10 samples)	2007-2008		

Program/Paper and Summary		Available TSS or Turbidity Data		Period of Record	Data Rank	Recommended use in developing TMDL and explanation of ranking
		Stream	**Type/#**			
43	**Precipitation data sources:** State Climatology Office-DNR Waters: Monthly rainfall totals for 6 locations in Carlton County, 5 locations in Pine County. Western Lake Superior Sanitary District: Real-time rainfall amounts for Wrenshall, MN Cloquet Forestry Center-University of Minnesota: 1 hour, 3 hour, and 6 hour current rainfall totals and monthly totals available for Cloquet Forestry Center location. USGS: daily precipitation totals available for Nemadji River-South Superior station (04024430) for the years 1997-2008	N/A	N/A	N/A	2	Historical precipitation data may be used for comparison of climatologically trends.

4.4 Turbidity and TSS Data Tables

Turbidity and TSS data listed in the previous section is broken down into further detail in the following tables. This section is organized by station locations, beginning with Nemadji River stations and ending with Deer Creek stations.

Turbidity and TSS Data for N. Fork Nemadji River at Hwy 23 (STORET Station S000-110)

Turbidity Data

Lab or Field Measurement	Units	Number of Measurements	Turbidity Test Method/Procedure	Period of Record	Source
Lab	NTRU	33	180.1	4/7/2004-11/14/2005	STORET
Lab	JCU	7	LEG_P00071	5/26/1967-5/20/1968	STORET
Lab	None	31	LEG_P00076	7/23/1973-6/16/1975	STORET

TSS Data

Lab or Field Measurement	Units	Number of Measurements	TSS Test Method/Procedure	Period of Record	Source
Lab	Mg/l	27	160.2	4/10/2001-10/22/2003	STORET
Lab	Mg/l	36	160.4	5/22/2002-10/30/2004	STORET
Lab	Mg/l	16	13765	3/31/2005-11/14/2005	STORET
Lab	Mg/l	38	LEG_P00530	5/26/1967-6/16/1975	STORET

Note: Corresponding colors have same years of data, possibly useful for TSS/Turbidity relationship

Nemadji River Suspended Solids and Turbidity Data With Unknown Exact Station Locations

Suspended Solids and Turbidity data taken from
"Red Clay Turbidity and Its Transport in Lake Superior" report to EPA

Lab or Field Measurement	Units	Monitoring Location	Number of Measure-ments	Test Method/Procedure	Period of Record	Source
Field	Mg/l	Nemadji River at the bridge near the Nemadji Golf Club in south Superior	ukn	US DH-48 integrating sampler	April 1975	Red Clay Turbidity document

Turbidity data taken from "Red Clay Project Impact of Nonpoint Pollution Control on Western Lake Superior Final Part II" report to EPA

Lab or Field Measurement	Units	Monitoring Location	Number of Measure-ments	Turbidity Test Method/Procedure	Period of Record	Source
Field	Formazin Turbidity Units (FTU)	0.5 miles upstream of mouth	12	Ecolab Model 104 Turbidimeter (Ecologic Instruments, Inc.)	8/19/1975-4/21/1977	Red Clay Project Final Part II document
Field	FTU	5 miles upstream of mouth	5	Ecolab Model 104 Turbidimeter (Ecologic Instruments, Inc.)	8/19/1975-12/8/1975	Red Clay Project Final Part II document
Field	FTU	18 miles upstream of mouth	6	Ecolab Model 104 Turbidimeter (Ecologic Instruments, Inc.)	9/4/1975-12/8/1975	Red Clay Project Final Part II document
Field	FTU	22 miles upstream of mouth	20	Ecolab Model 104 Turbidimeter (Ecologic Instruments, Inc.)	9/4/1975-10/26/1977	Red Clay Project Final Part II document
Field	FTU	29 miles upstream of mouth	19	Ecolab Model 104 Turbidimeter (Ecologic Instruments, Inc.)	9/11/1975-10/26/1977	Red Clay Project Final Part II document
Field	FTU	50 miles upstream of mouth (Mn. Cty Rd 103)	5	Ecolab Model 104 Turbidimeter (Ecologic Instruments, Inc.)	9/11/1975-11/19/1975	Red Clay Project Final Part II document

Turbidity and TSS for Deer Creek at Hwy 23
(STORET Station S003-250)

Turbidity Data

Lab or Field Measurement	Units	Number of Measurements	Turbidity Test Method/Procedure	Period of Record	Source
Lab	NTRU	33	180.1	4/7/2004-11/14/2005	STORET

TSS Data

Lab or Field Measurement	Units	Number of Measurements	TSS Test Method/Procedure	Period of Record	Source
Lab	Mg/l	28	160.2	4/10/2001-10/22/2003	STORET
Lab	Mg/l	32	USGS I-3765-85	4/7/2004-11/14/2005	SWCD (ERA lab sheets on file)

Turbidity and TSS for Deer Creek at
75 Feet Upstream From Hwy 23 (S002-602)

Turbidity Data

Lab or Field Measurement	Units	Number of Measurements	Turbidity Test Method/Procedure	Period of Record	Source
Ukn	JTU	22	ukn	1976-1978	USGS: National Water Information System (04024098)
Lab	NTU	16	LEG_P82079	1991	STORET

TSS Data

Lab or Field Measurement	Units	Number of Measurements	Turbidity Test Method/Procedure	Period of Record	Source
Lab	NTU	16	LEG_P00530	1991	STORET

Suspended Sediment and Suspended Sediment Discharge Data for Deer Creek at 75 ft Upstream Hwy 23 (STORET station S002-602, USGS 04024098)

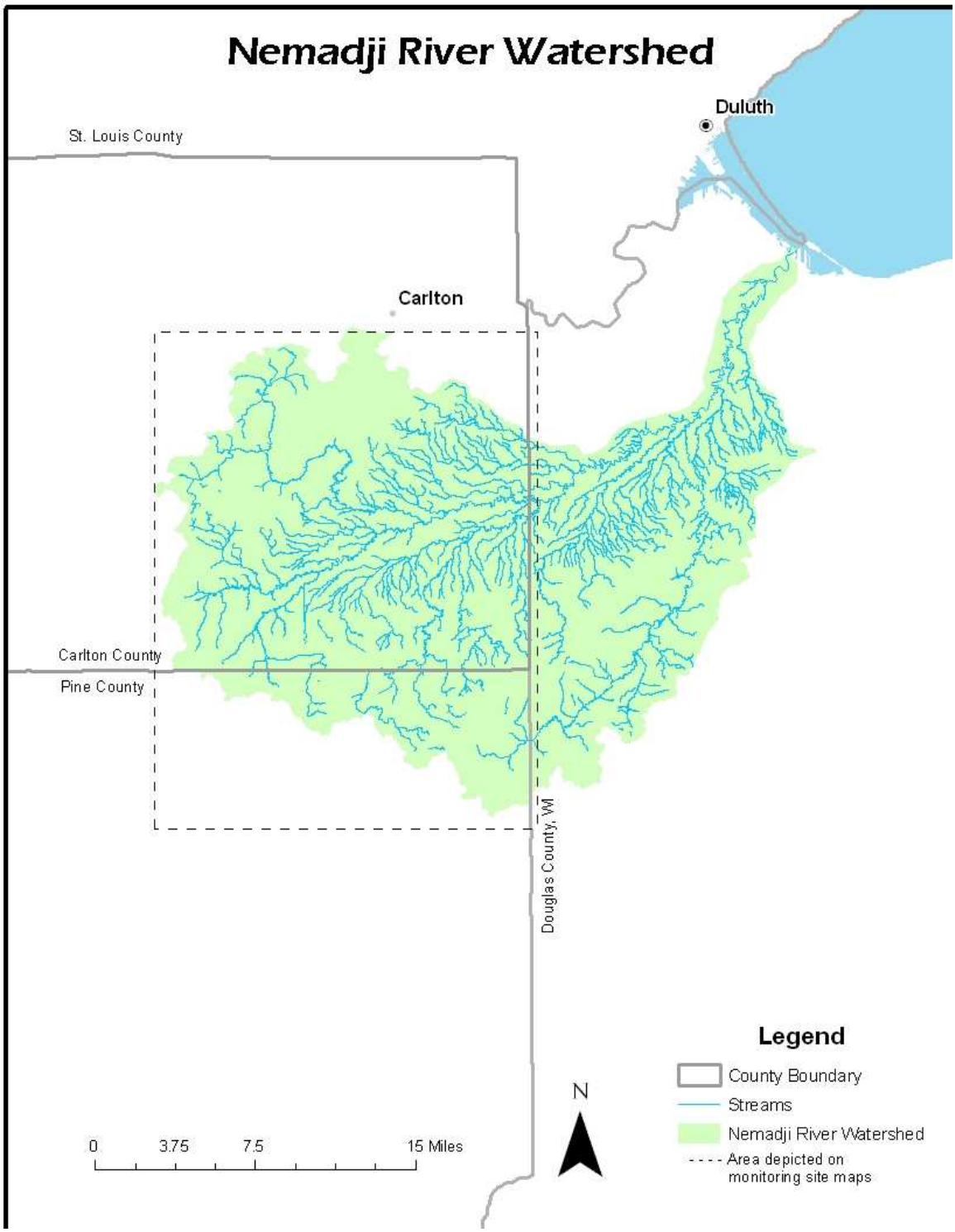
Suspended Sediment Concentration Data

Lab or Field Measurement	Units	Number of Measurements	Test Method/Procedure	Period of Record	Source
Ukn	Mg/l	7	ukn	03/14/1977-05/10/1979	USGS: National Water Information System (04024098)

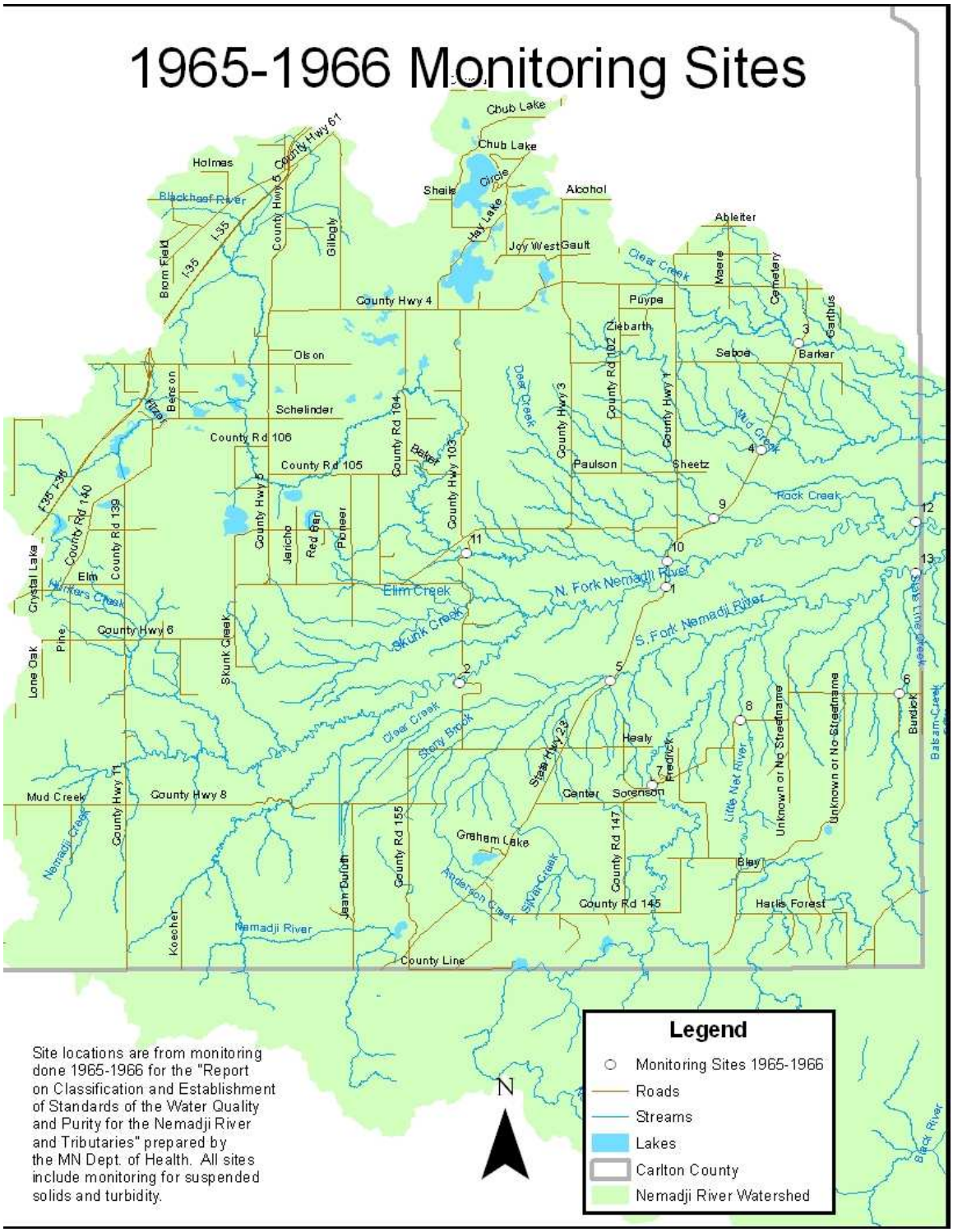
Suspended Sediment Discharge Data

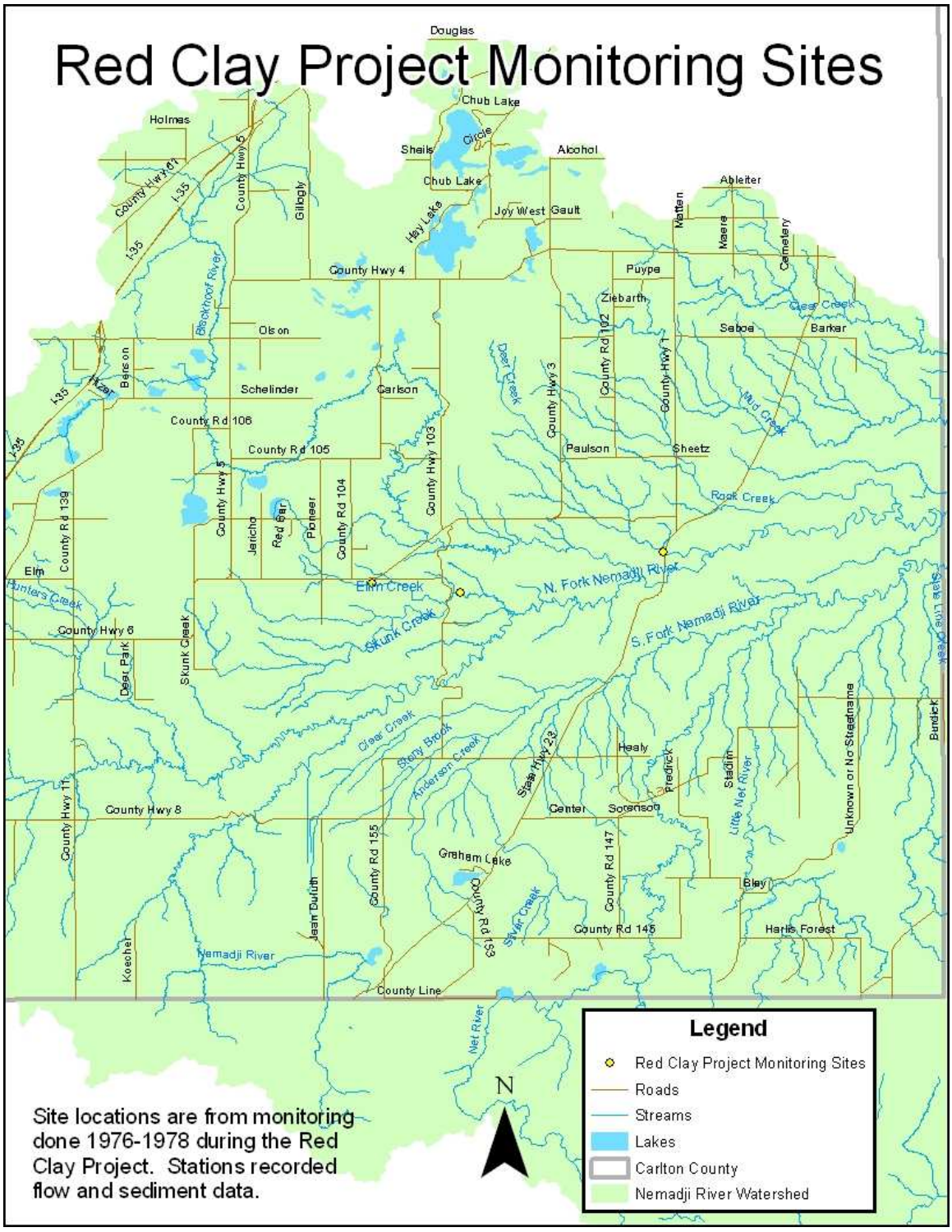
Lab or Field Measurement	Units	Number of Measurements	Test Method/Procedure	Period of Record	Source
Ukn	Tons/day	8	ukn	03/14/1977-05/10/1979	USGS: National Water Information System (04024098)

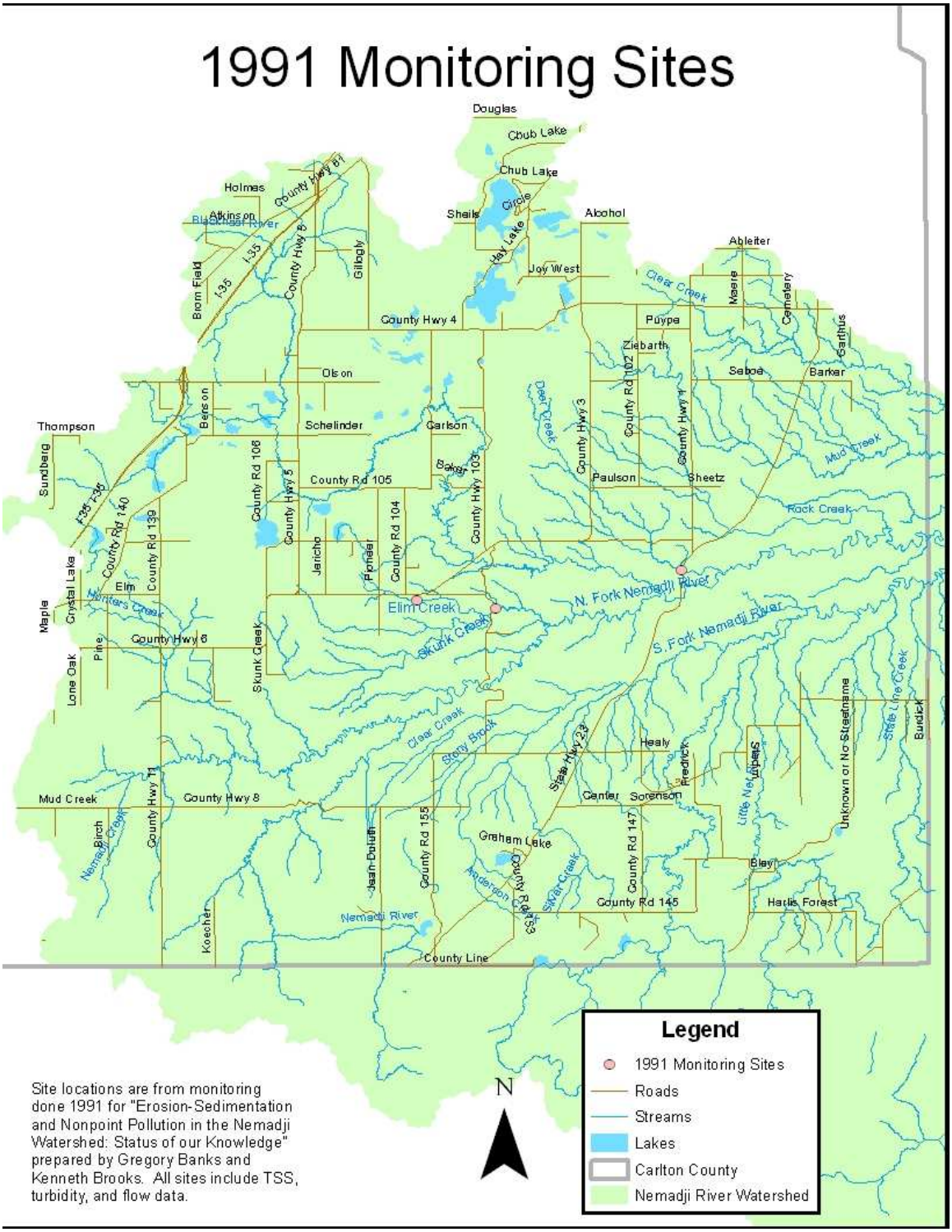
Appendix A-Area of study



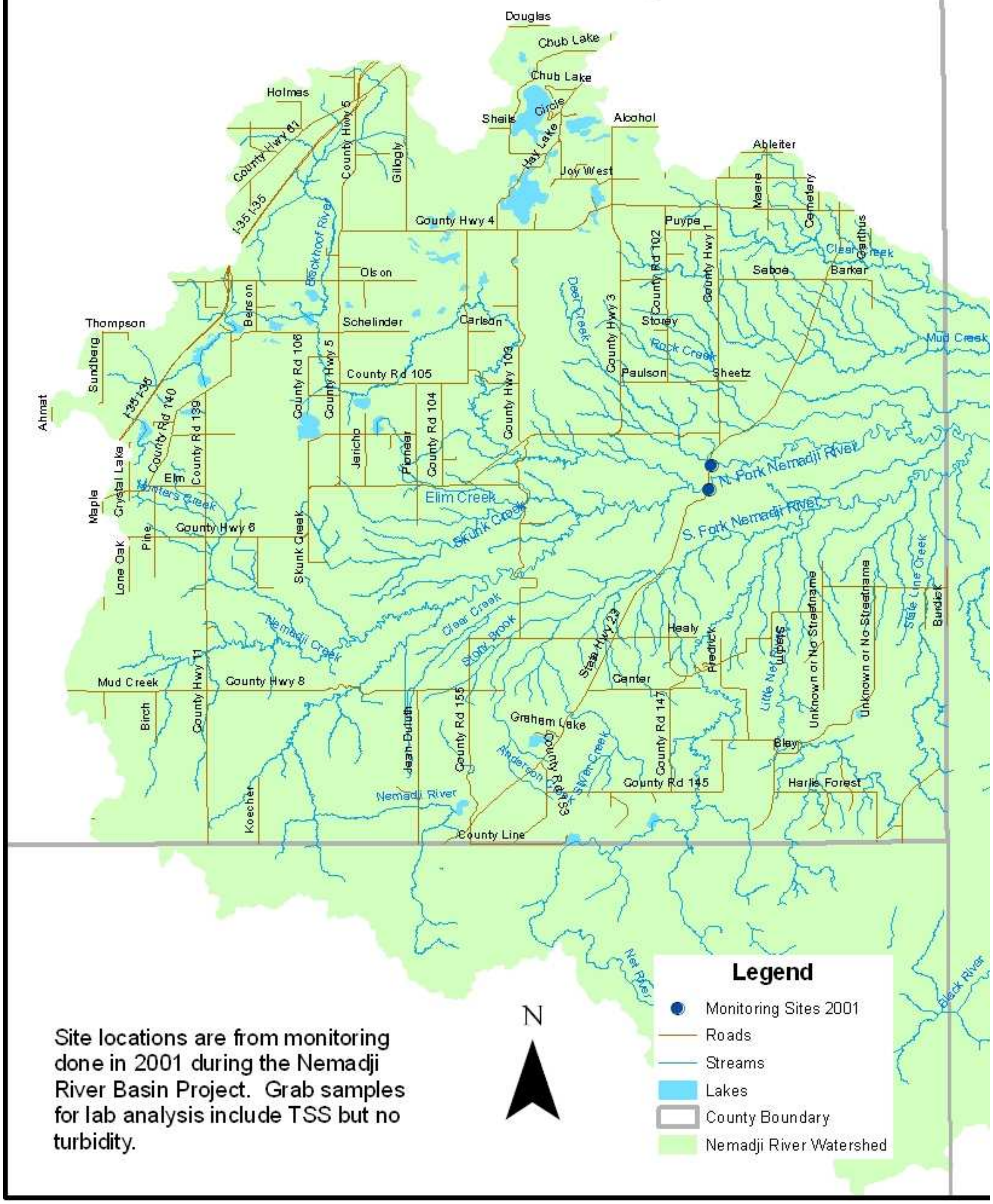
Appendix B-Past Monitoring Sites



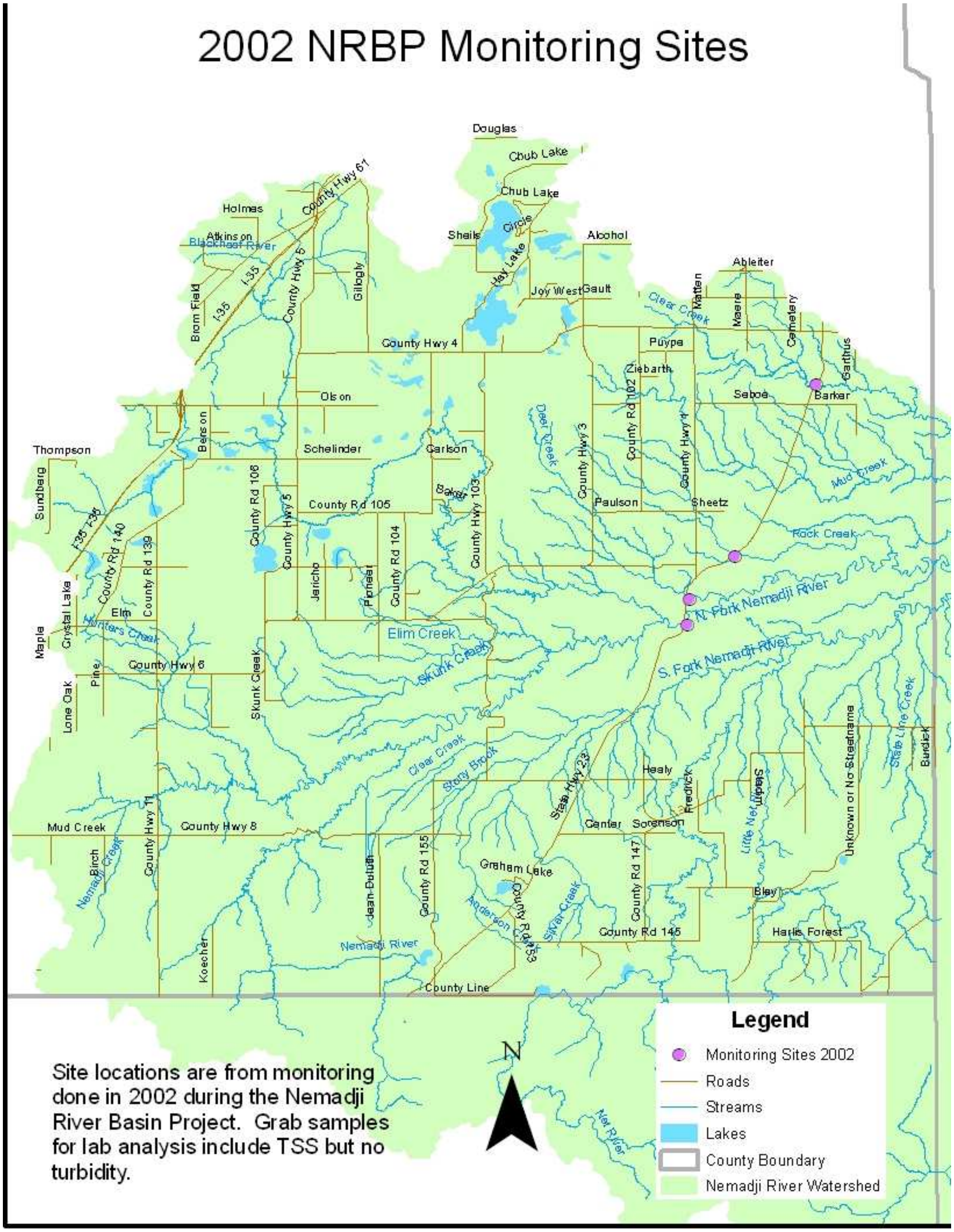

Red Clay Project Monitoring Sites
Douglas
Chub Lake
Holmes
Sheils
Circle
Alcohol
Chub Lake
Ableiter
Joy
West Gault
Hay Lake
Watten
Maere
Cemetery
County Hwy 4
Puype
Ziebarth
Clear Creek
Olson
Seboe
Barker
Schelinder
Carlson
Deer Creek
County Rd 102
County Hwy 1
Mud Creek
County Rd 106
County Rd 105
Paulson
Sheetz
County Hwy 103
County Hwy 3
Rock Creek
Elm
Elm Creek
N. Fork Nemadji River
Hunters Creek
Skunk Creek
S. Fork Nemadji River
County Hwy 6
Deer Park
Clear Creek
Stony Brook
Anderson Creek
Healy
Predrick
Stadim
Little Net River
Unknown or No Steadname
Bundick
County Hwy 8
Center
Sorenson
Graham Lake
County Rd 155
County Rd 147
Bley
Silver Creek
County Rd 145
Harris Forest
Nemadji River
County Line
Net River
Legend
Red Clay Project Monitoring Sites
Roads
Streams
Lakes
Carlton County
Nemadji River Watershed
N
Site locations are from monitoring done 1976-1978 during the Red Clay Project. Stations recorded flow and sediment data.

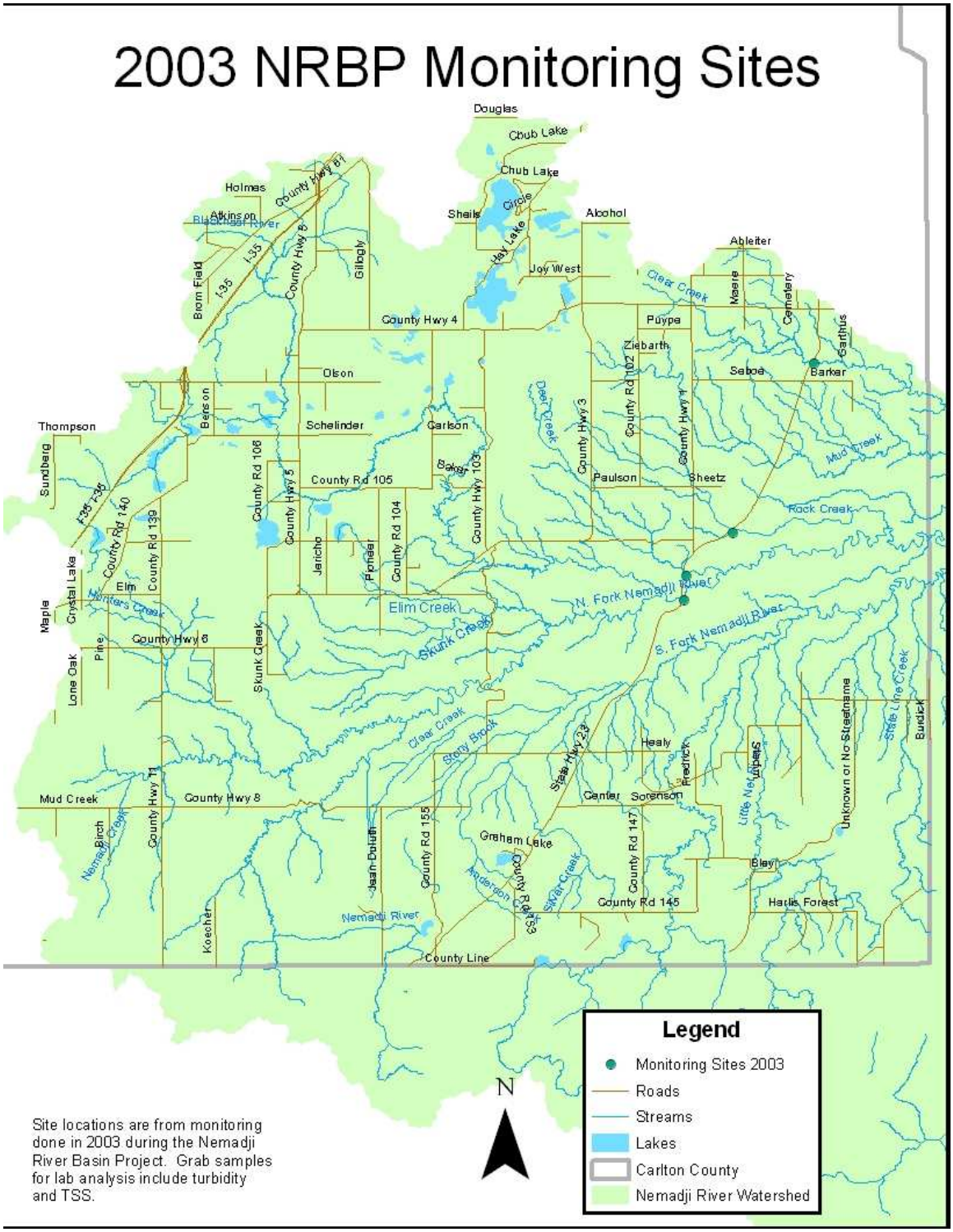

1991 Monitoring Sites
Douglas
Chub Lake
Chub Lake
Holmes
County Hwy 61
Atkinson
Blackhoof River
I-35
Brom Field
I-35
County Hwy 8
Gilbody
Sheils
Circle
Alcohol
Hay Lake
Joy West
Ableiter
Clear Creek
Maerie
Cemetery
County Hwy 4
Puype
Ziebarth
Carthus
Olson
Seboe
Barker
Deer Creek
County Rd 102
County Hwy 4
Thompson
Benson
Schelinder
Carlson
Sundberg
County Hwy 3
Mud Creek
County Rd 105
Baker
Paulson
Sheetz
County Hwy 5
County Rd 106
County Hwy 103
Rock Creek
I-35
I-35
County Rd 140
County Rd 139
Jericho
Pichael
County Rd 104
Crystal Lake
Elm
Winters Creek
Elim Creek
N. Fork Nemadji River
Maple
Skunk Creek
S. Fork Nemadji River
County Hwy 6
Pine
Lone Oak
Skunk Creek
Clear Creek
Story Brook
State Line Creek
Burdick
Healy
State Hwy 23
Predrick
Sherlin
Mud Creek
County Hwy 8
Center
Sorenson
Little Net River
Unknown or No Streetname
County Hwy 11
Nemadji Creek
Birch
Graham Lake
Jaam Bluff
County Rd 155
Anderson Creek
County Rd 147
Silver Creek
Bley
County Rd 145
Harlis Forest
Nemadji River
Koscher
County Line
Legend
1991 Monitoring Sites
Roads
Streams
Lakes
Carlton County
Nemadji River Watershed
N
Site locations are from monitoring done 1991 for "Erosion-Sedimentation and Nonpoint Pollution in the Nemadji Watershed: Status of our Knowledge" prepared by Gregory Banks and Kenneth Brooks. All sites include TSS, turbidity, and flow data.

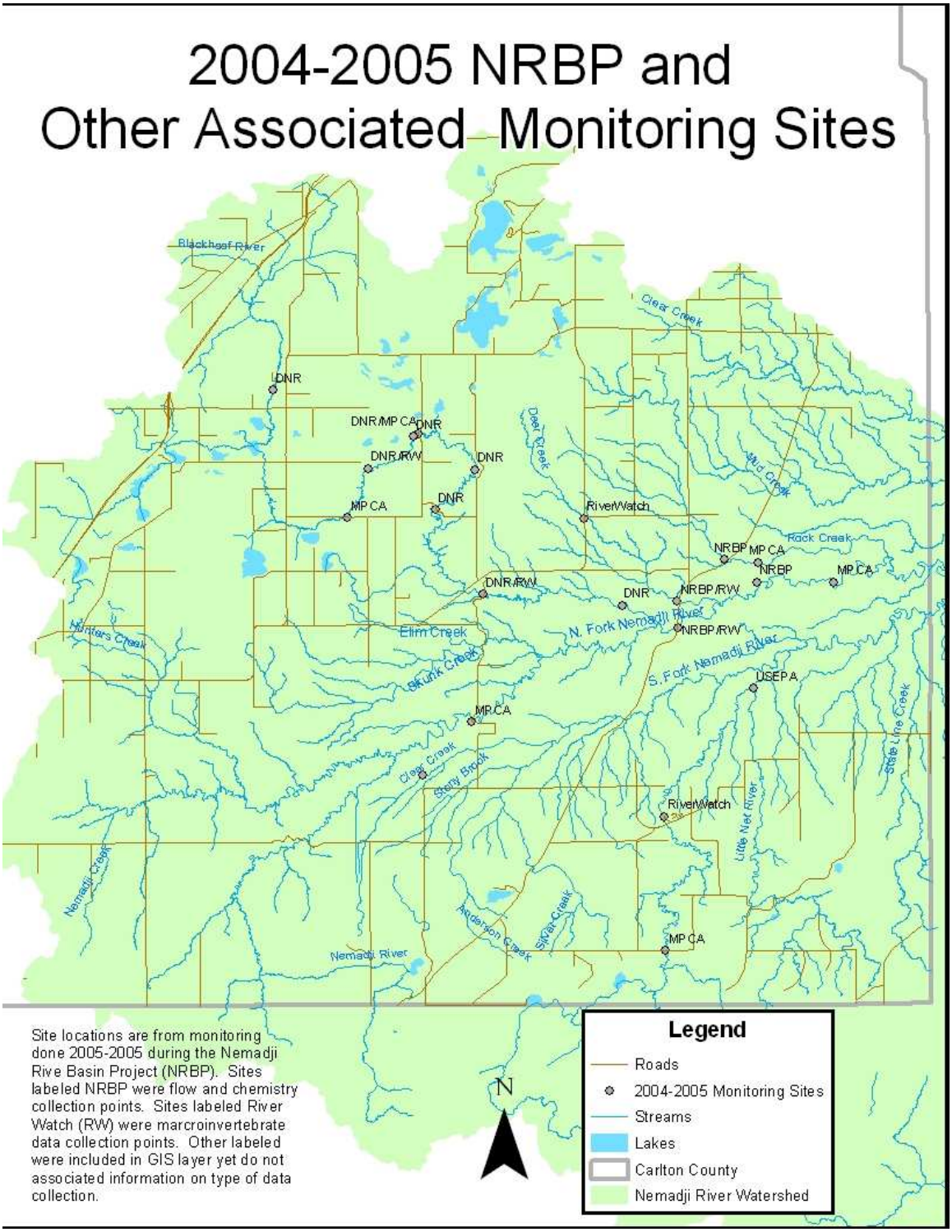
2001 NRBP Monitoring Sites

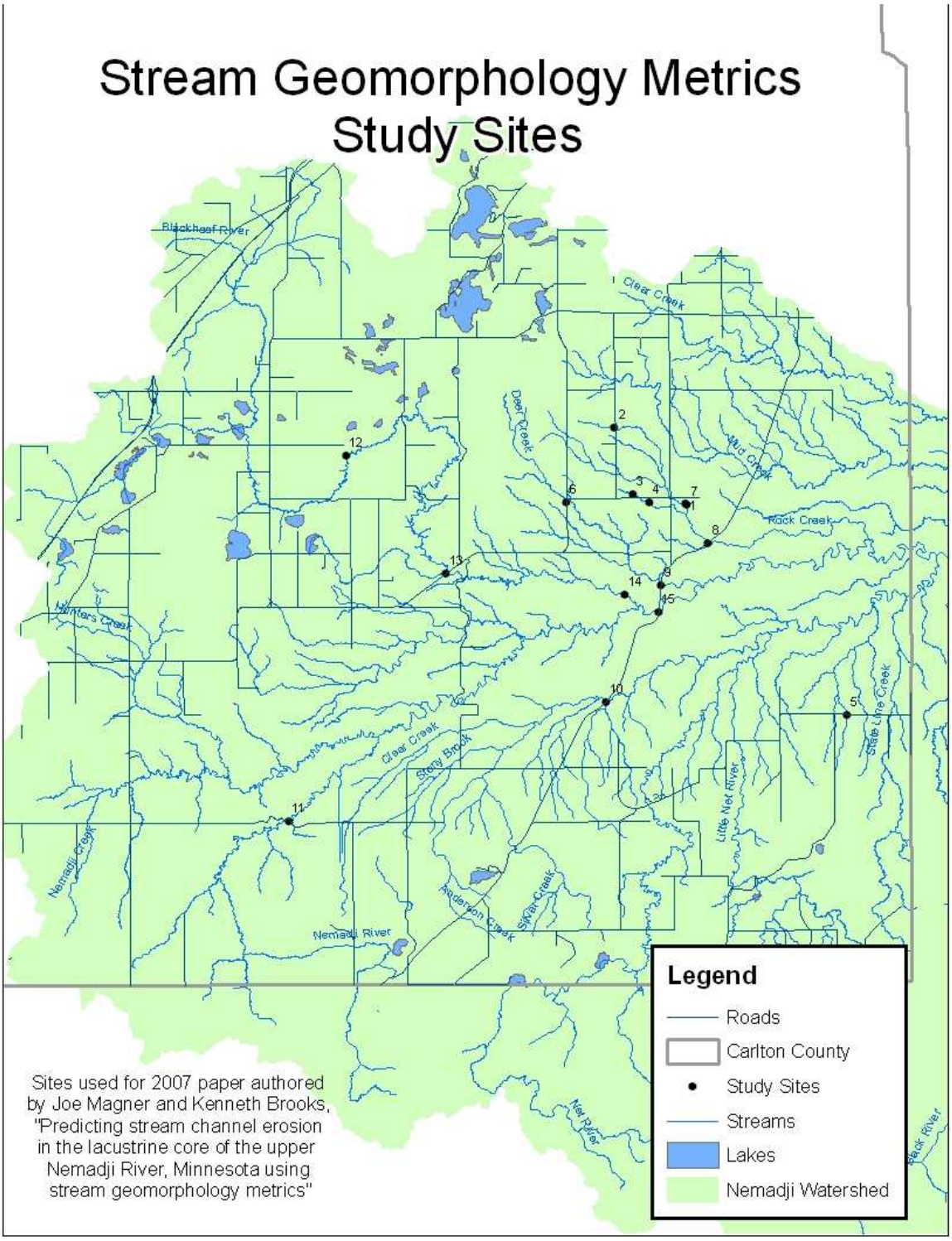


Site locations are from monitoring done in 2001 during the Nemadji River Basin Project. Grab samples for lab analysis include TSS but no turbidity.


2002 NRBP Monitoring Sites
Douglas
Chub Lake
Holmes
County Hwy 61
Atkinson
Blackhoof River
I-35
County Hwy 6
Gilbog
Shells
Circle
Hay Lake
Alcohol
Ableiter
Joy West
Gault
Brom Field
Clear Creek
Maerre
Cemetery
Puype
Garthus
County Hwy 4
Ziebarth
Olson
Sebo
Barker
Benson
Thompson
Schelinder
Carlson
Deer Creek
County Hwy 3
County Rd 102
County Hwy 4
Mud Creek
Sundberg
County Rd 106
County Rd 105
County Hwy 103
Paulson
Sheetz
Rock Creek
County Rd 140
County Rd 139
County Hwy 5
County Rd 104
Jericho
Pioneer
N. Fork Nemadji River
Crystal Lake
Elm
Hunters Creek
Elm Creek
Maple
Skunk Creek
S. Fork Nemadji River
County Hwy 6
Pine
Lone Oak
Clear Creek
Stony Brook
State Hwy 23
Healy
Fredrick
Little Net River
Unknown or No Streetname
State Line Creek
Burdick
Mud Creek
County Hwy 8
Center
Sorenson
Birch
Nemadji Creek
County Hwy 11
Jean-Duluth
County Rd 155
Graham Lake
County Rd 147
Bley
Anderson Creek
Silver Creek
County Rd 145
Harlis Forest
Nemadji River
Koecher
County Line
Legend
Monitoring Sites 2002
Roads
Streams
Lakes
County Boundary
Nemadji River Watershed
N
Net River
Site locations are from monitoring done in 2002 during the Nemadji River Basin Project. Grab samples for lab analysis include TSS but no turbidity.


2003 NRBP Monitoring Sites
Douglas
Chub Lake
Chub Lake
Holmes
County Hwy 61
Atkinson
Blackhawk River
I-35
Brom Field
I-35
County Hwy 8
Gilbody
Sheils
Circle
Alcohol
Hay Lake
Joy West
Ableiter
Clear Creek
Maerie
Cemetery
County Hwy 4
Puype
Ziebarth
Carthus
Seboe
Barker
Olson
Deer Creek
County Rd 102
County Hwy 3
County Hwy 4
Thompson
Benson
Schelinder
Carlson
Mud Creek
Sundberg
County Rd 105
Baker
County Hwy 103
Paulson
Sheetz
I-35
I-35
County Rd 140
County Rd 139
County Hwy 6
Jericho
Pichael
County Rd 104
Rock Creek
Crystal Lake
Elim
Winters Creek
Elim Creek
N. Fork Nemadji River
Maple
Skunk Creek
S. Fork Nemadji River
County Hwy 8
Pine
Lone Oak
Skunk Creek
Clear Creek
Story Brook
State Line Creek
Burdick
Healy
State Hwy 23
Fredrick
Sorenson
Center
Mud Creek
County Hwy 11
County Hwy 8
Little Net River
Unknown or No Streetname
Norway Birch Creek
Graham Lake
Jaam Bluff
County Rd 155
Anderson Creek
County Rd 147
Bley
Silver Creek
County Rd 145
Harlis Forest
Nemadji River
Kosche
County Line
Legend
Monitoring Sites 2003
Roads
Streams
Lakes
Carlton County
Nemadji River Watershed
N
Site locations are from monitoring done in 2003 during the Nemadji River Basin Project. Grab samples for lab analysis include turbidity and TSS.


2004-2005 NRBP and
Other Associated Monitoring Sites
Blackhoof River
Clear Creek
Deer Creek
Mud Creek
Rock Creek
Elim Creek
Skunk Creek
Winters Creek
N. Fork Nemadji River
S. Fork Nemadji River
Clear Creek
Shanty Brook
Little Net River
State Line Creek
Nemadji Creek
Anderson Creek
Silver Creek
Nemadji River
DNR
DNR/MPCA
DNR/RW
MPCA
RiverWatch
NRBP
USEPA
N
Site locations are from monitoring done 2005-2005 during the Nemadji Rive Basin Project (NRBP). Sites labeled NRBP were flow and chemistry collection points. Sites labeled River Watch (RW) were marcroinvertebrate data collection points. Other labeled were included in GIS layer yet do not associated information on type of data collection.
Legend
Roads
2004-2005 Monitoring Sites
Streams
Lakes
Carlton County
Nemadji River Watershed


Stream Geomorphology Metrics
Study Sites
Blackhawk River
Clear Creek
Deer Creek
Mud Creek
Rock Creek
Winters Creek
Clear Creek
Stony Brook
Nemadji Creek
Nemadji River
Anderson Creek
Silver Creek
Little Net River
State Line Creek
Net River
Black River
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Legend
Roads
Carlton County
Study Sites
Streams
Lakes
Nemadji Watershed
Sites used for 2007 paper authored by Joe Magner and Kenneth Brooks, "Predicting stream channel erosion in the lacustrine core of the upper Nemadji River, Minnesota using stream geomorphology metrics"

Appendix C-Current Monitoring Sites