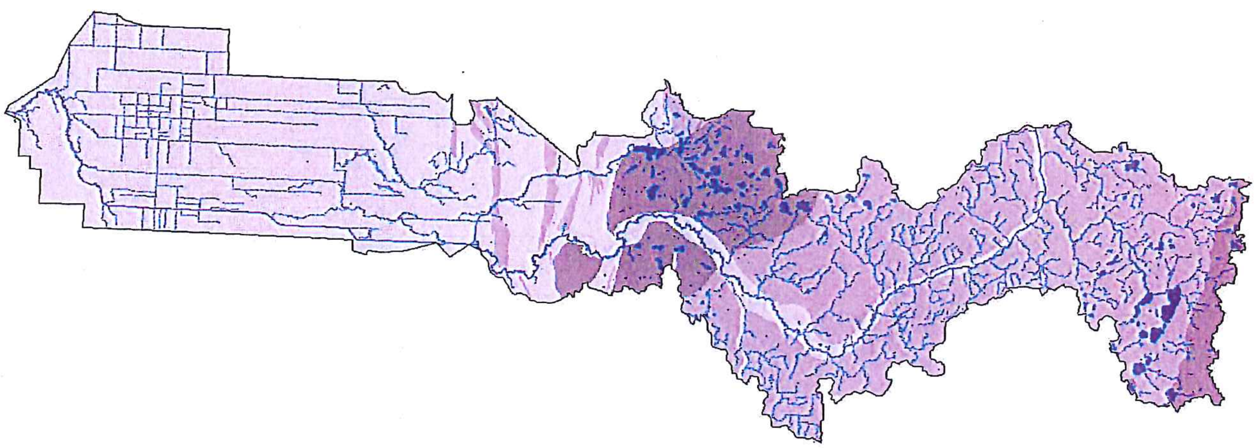
# APPENDIX I

# RED RIVER BASIN STREAM SURVEY REPORT

# SAND HILL RIVER

# Red River Basin Stream Survey Report

## *Sand Hill River Watershed 2006*



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## INTRODUCTION

The Red River of the North basin (Red River Basin) is a unique North American landscape with diverse terrestrial and aquatic natural resources. Since settlement, the landscape has been managed primarily to increase agricultural production (Stoner et al. 1993). The impacts of flooding have been a concern in Red River Basin since the early 1800's (Red River Basin Flood Damage Reduction Work Group Agreement 1998). Projects intended to lessen the impacts of flooding on agricultural lands, homes and properties have resulted in extensive development of drainage systems, modification of existing natural stream channels, and installation of various other "flood control" measures. These watershed-level changes have altered the natural hydrology and changed ecosystem function, which has generally reduced the quality of natural resources. Concern over the potential cumulative environmental effects of proposed flood control projects prompted an Environmental Impact Statement (EIS). The EIS was released in 1996 and disagreement over the outcome eventually led to the Minnesota Legislature funding a "mediation" process to resolve disputed issues. The product of this process was a 1998 agreement that details a new watershed-based management framework for both flood Damage reduction and natural resource enhancement in Red River Basin.

According to the mediation agreement, comprehensive watershed management plans that integrate flood damage reduction and natural resource enhancement are to be developed by each watershed district. Sound goals with measurable objectives will be needed for these plans. The present condition of resources must be known in order to develop and evaluate progress toward achieving natural resource enhancement goals and objectives. However, information necessary to describe present conditions exists on few streams in Red River Basin. In response to this lack of current data, the fisheries management section of the Minnesota Department of Natural Resources (MN DNR) proposed watershed-level stream sampling within streams found the Watershed Districts that were initiating new watershed plans.

This report presents the results of sampling efforts conducted in the year 2005 in streams and waterways that lie within the Sand Hill River watershed, Minnesota. Specifically this report describes the landscape setting, presents and discusses the results of current sampling, identifies factors impacting aquatic resources and outlines potential strategies to improve the condition of stream resources within the Sand Hill River watershed.

## Watershed Description

### Location and Size

The Sand Hill River watershed is located in the central part of the Red River Basin in northwest Minnesota (Figure 1). The Sand Hill River watershed encompasses approximately 432 square miles, the majority of which lies in Polk County with minor portions lying within Norman and Mahnomen counties (Figure 2).

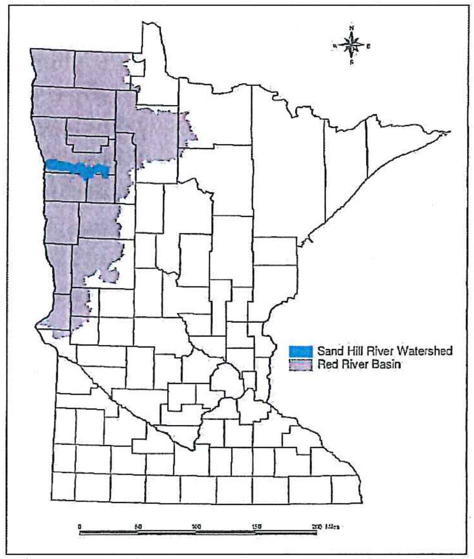



**Figure 1.** Location of the Sand Hill River watershed in Minnesota.

### Topography

The Red River Basin was shaped by the Red River Lobe of the Laurentide Ice Sheet, a continental glacier that occurred during the last two stages of the Wisconsin glacial age. Lake Agassiz was formed by the final melting of the continental ice sheet and disappeared from the area approximately 8,500 years ago. When Lake Agassiz receded it modified the surface topography leaving behind remnant lake bottom, beach ridge areas and upland till.

Much of the Sand Hill River watershed (47.1%) is relatively level (Figure 3) and is made up of lacustrine derived materials formed in the deeper waters of glacial Lake Agassiz. Rolling and undulating topography covers approximately 40% of the watershed including most of the eastern one-half. Hummocky topography comprised of glacial till from the Red River Lobe of the glacier, covers approximately 13% of the watershed. This topography is found along the extreme east edge of the watershed and in a six-mile wide band ranging east-west from Fertile to 6 miles east, and nort-south from the northern to the southern boundaries of the watershed. Beach ridges from Glacial Lake Agassiz are located within a narrow east-west band from Fertile to approximately 6 miles west, and running north-south through the watershed (Figure 3).

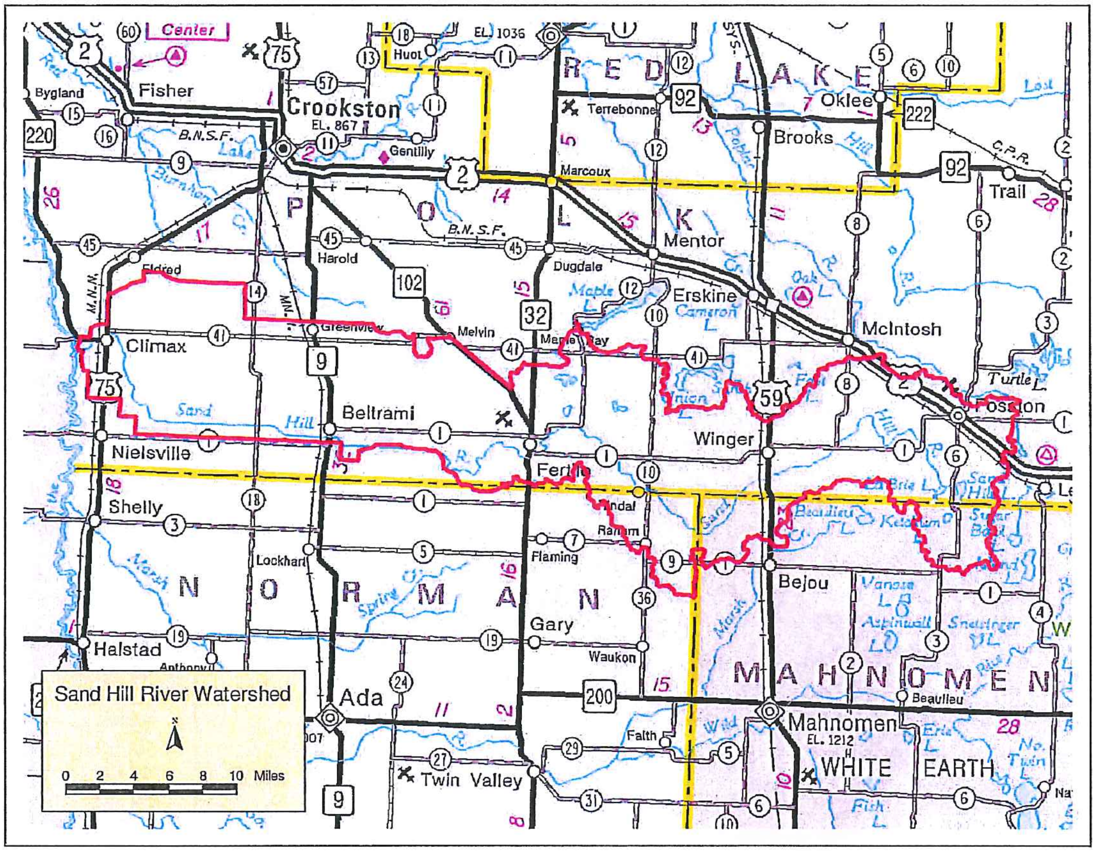


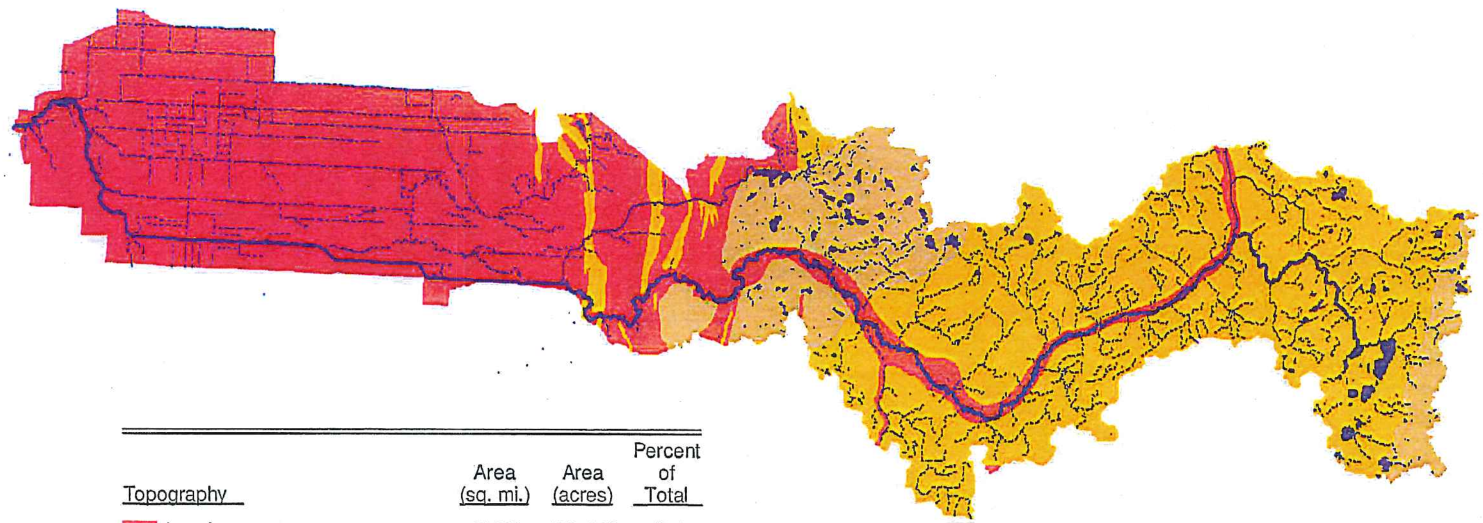

**Figure 2.** The Sand Hill River watershed (outlined in red) overlain on the Minnesota Department of Transportation highway map.

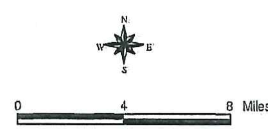
## Land use/land cover

Land use and cover in the Sand Hill River watershed has changed dramatically since the early 1900's. Around the turn of the century, prairie and wet prairie dominated landscape on the level lands in the western half of the watershed (Figure 4). Prairie and brush-prairie was prominent in the rolling and undulating lands in the eastern half of the watershed and aspen-oak covered the hummocky portions. Today cultivated crops, which now cover 81% of the watershed, have replaced most of the native vegetation and relatively few grasslands, approximately 5%, remain (Figure 5). Forest covers only 6% of the land and exists only in a relatively patchy distribution. Water and wetlands collectively cover approximately 5% of the watershed and exists primarily in the hummocky areas of the watershed and along waterways (Figures 5 and 3).

## Soils

Soils in the western part of the watershed are primarily fine and very fine (Figure 6), black, clayey and silty soils formed as lake bed deposits. Sandy soils are dominant in the hummocky and beach ridge area in the central portion of the watershed. Fine, loamy soils are found in the rolling and undulating land in the east (Figure 6).






| Topography | Area (sq. mi.) | Area (acres) | Percent of Total |
|---|---|---|---|
| Level<br>Areas of little relief relalive to adjacent topography. | 203.8 | 130,443 | 47.1 |
| Rolling to Undulating<br>Areas exhibiting variable relief over broad reaches. | 170.9 | 109,405 | 39.6 |
| Hummocky<br>Areas of highly variable relief relative to adjacent topography. | 57.4 | 36,752 | 13.3 |
| Total | 432.1 | 276,600 | 100 |

**Figure 3.** Topographic features of the Sand Hill River watershed (MN DNR GIS dataset 2005).

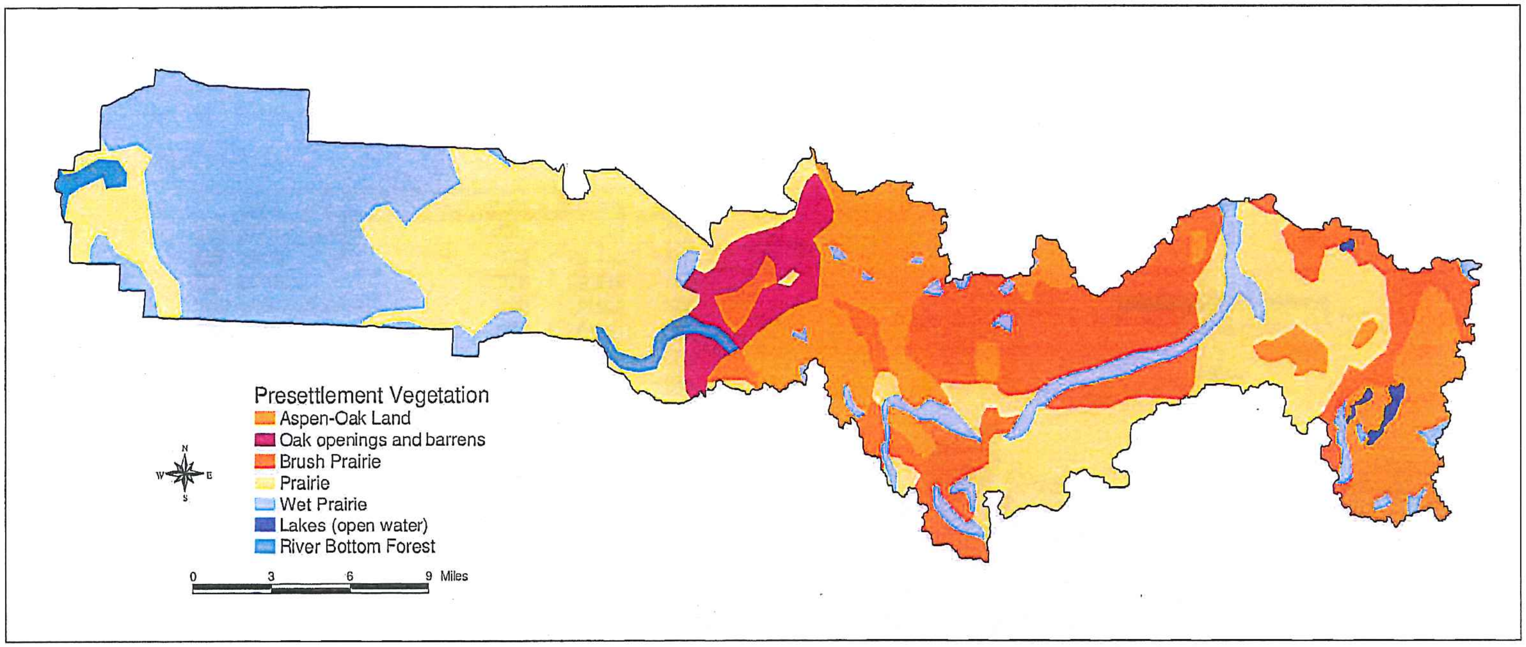
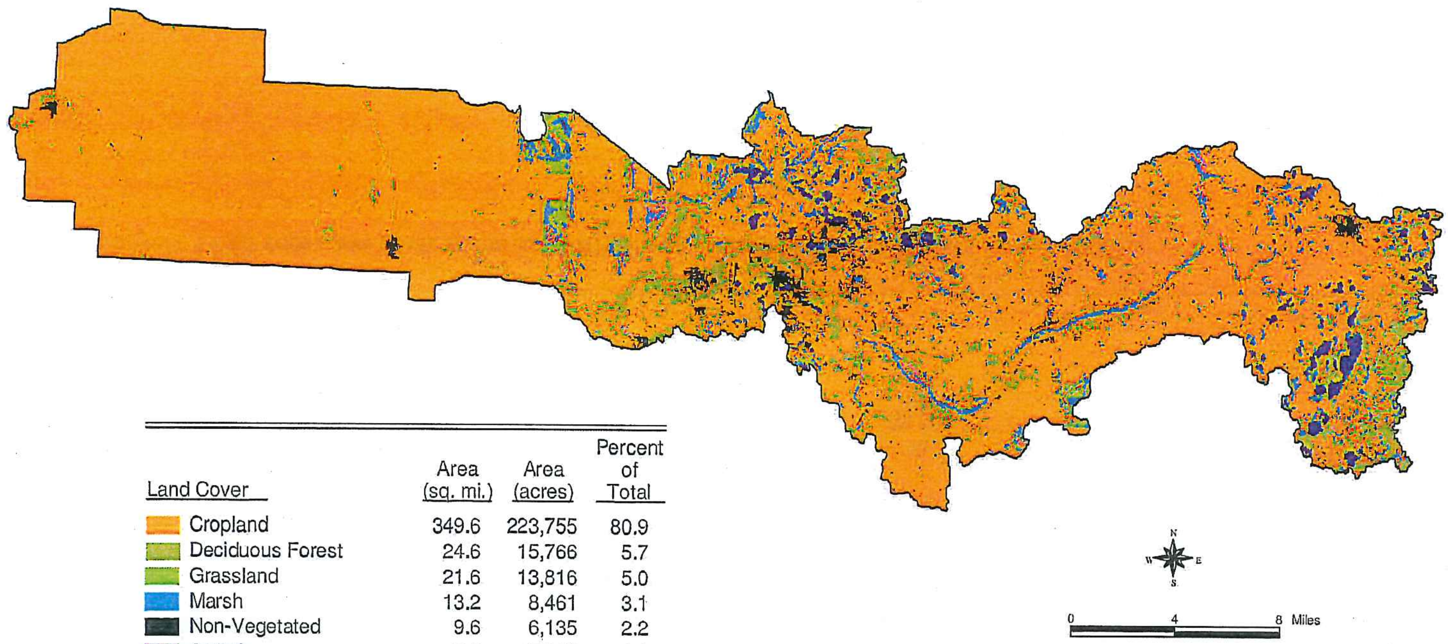



**Figure 4.** Historic (year 1908) vegetative cover in the Sand Hill River watershed (MN DNR GIS dataset 2005).




| Land Cover | Area (sq. mi.) | Area (acres) | Percent of Total |
|---|---|---|---|
| Cropland | 349.6 | 223,755 | 80.9 |
| Deciduous Forest | 24.6 | 15,766 | 5.7 |
| Grassland | 21.6 | 13,816 | 5.0 |
| Marsh | 13.2 | 8,461 | 3.1 |
| Non-Vegetated | 9.6 | 6,135 | 2.2 |
| Aquatic | 8.2 | 5,246 | 1.9 |
| Shrub | 5.3 | 3,410 | 1.2 |
| Conifer Forest | <0.1 | 11 | <0.1 |
| Total | 432.1 | 276,600 | 100 |

**Figure 5.** Land use and land cover in the Sand Hill River watershed from the 1990's (MN DNR GIS dataset 2005).

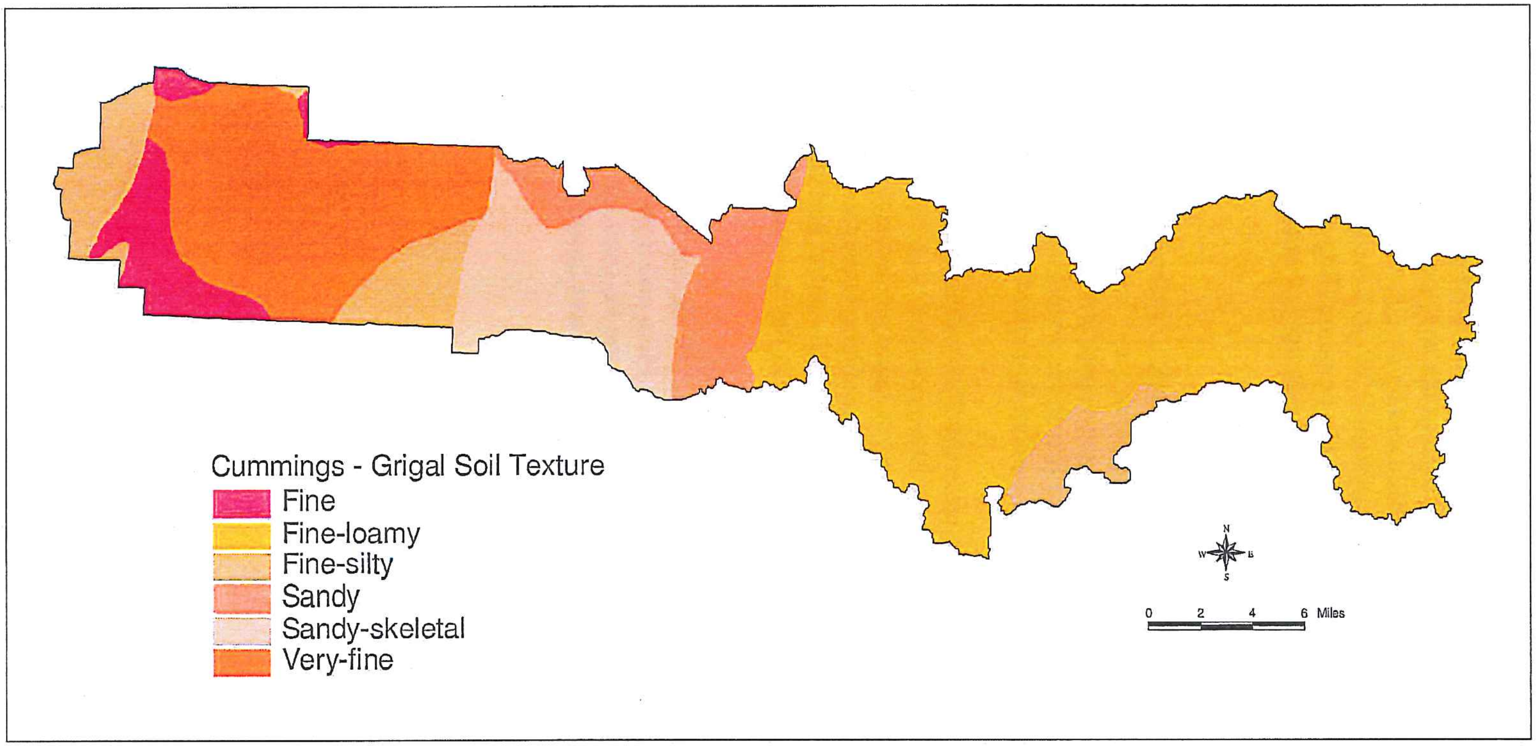



**Figure 6.** Soil textures in the Sand Hill River watershed (MN DNR GIS dataset 2005).

**Wetlands**

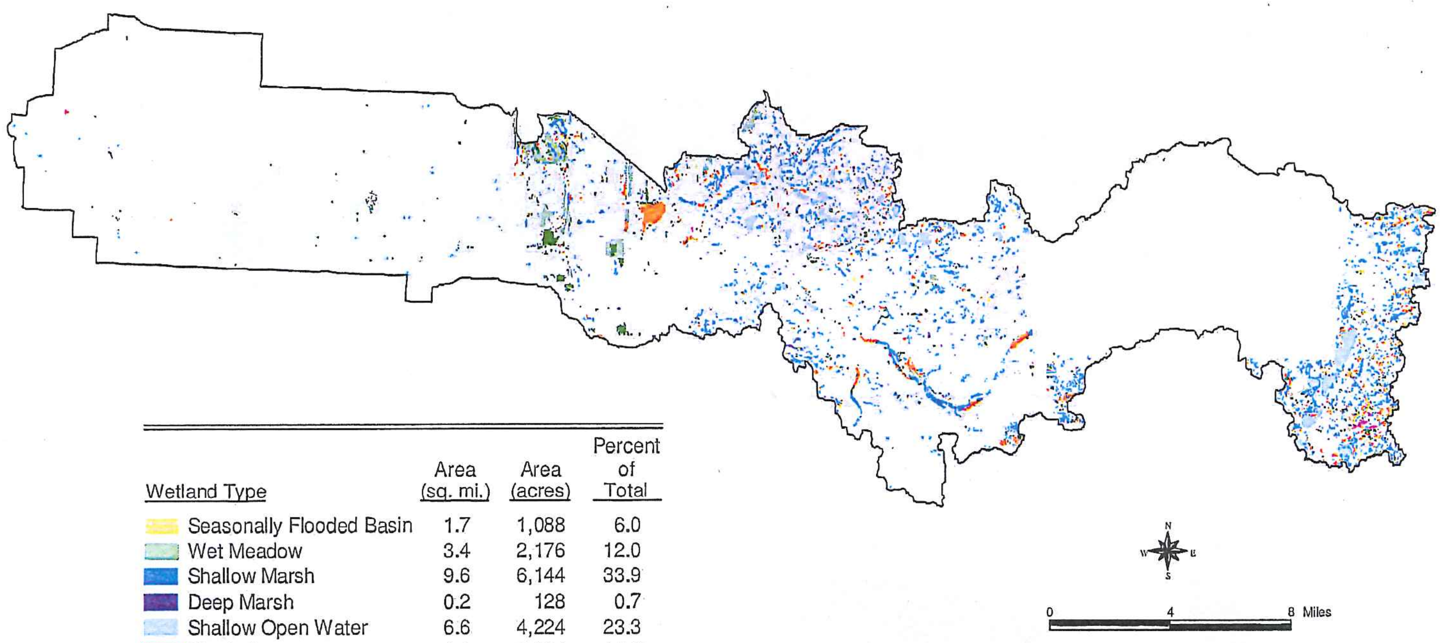
In the mid-1990s, wetlands covered 28 square miles, or 6.5%, of the Sand Hill River watershed (Figure 7). The majority of the wetlands were concentrated in the hummocky lands of central and far-eastern Sand Hill River watershed (Figure 7). The most abundant wetland type in the watershed was shallow marsh, which comprised 34% of the wetland types found. Shallow open water was the next most abundant habitat type followed by shrub swamp (Figure 7). Less than 1% of all wetland types identified were riverine systems. Most of the land that was historically covered by wet prairie (Figure 4) has been converted to cropland (Figure 5). Extensive ditching and agricultural practices has altered the function and hydrology of many of the existing wetlands.

**Ecological Classification System**

The Ecological Classification System used by the MN DNR is a hierarchical system that classifies areas into "provinces", "sections", "subsections", and "land type associations" based on climate, geology, hydrology, topography, soils, and vegetation (www.dnr.state.mn.us/ecs/index.html). The Sand Hill River watershed contains portions of the Prairie Parkland, Tallgrass Aspen Parklands and Eastern Broadleaf Forest provinces (Figure 8).

Most land in the western one-third half of the watershed lies within the Prairie Parkland province as does smaller portions in the south-central and eastern portions. Lands classified as Prairie Parkland province in the west are comprised of a mix of land type associations including Red River Alluvial Plain, Sand Hill Lake Plain, Anthony Lake Plain, Greenview Lake Plain, and Felton Lake Plain. Prairie Parkland province land in the south-central part of the watershed is made up entirely of Barnesville Beach Complex and those in the east are made up of Flom Till Plain.

The Tallgrass Aspen Parklands encompasses a smaller section located in the central part of the watershed and contains alternating bands of Gentilly Lake Plain and Beach Ridge land type associations. The Eastern Broadleaf Forest Province lies in the far south-central part of the watershed and is comprised of McIntosh Moraine and Erskine and Lengby Till Plain land type associations.




| Wetland Type | Area (sq. mi.) | Area (acres) | Percent of Total |
|---|---|---|---|
| Seasonally Flooded Basin | 1.7 | 1,088 | 6.0 |
| Wet Meadow | 3.4 | 2,176 | 12.0 |
| Shallow Marsh | 9.6 | 6,144 | 33.9 |
| Deep Marsh | 0.2 | 128 | 0.7 |
| Shallow Open Water | 6.6 | 4,224 | 23.3 |
| Shrub Swamp | 4.1 | 2,624 | 14.5 |
| Wooded Swamp | 2.6 | 1,664 | 9.2 |
| Bog | 0.1 | 64 | 0.4 |
| Other | <0.1 | <10 | <0.1 |
| Total wetlands | 28.3 | 18,112 | 100 |

**Figure 7.** Wetlands found in the Sand Hill River watershed (MN DNR GIS dataset 2005).

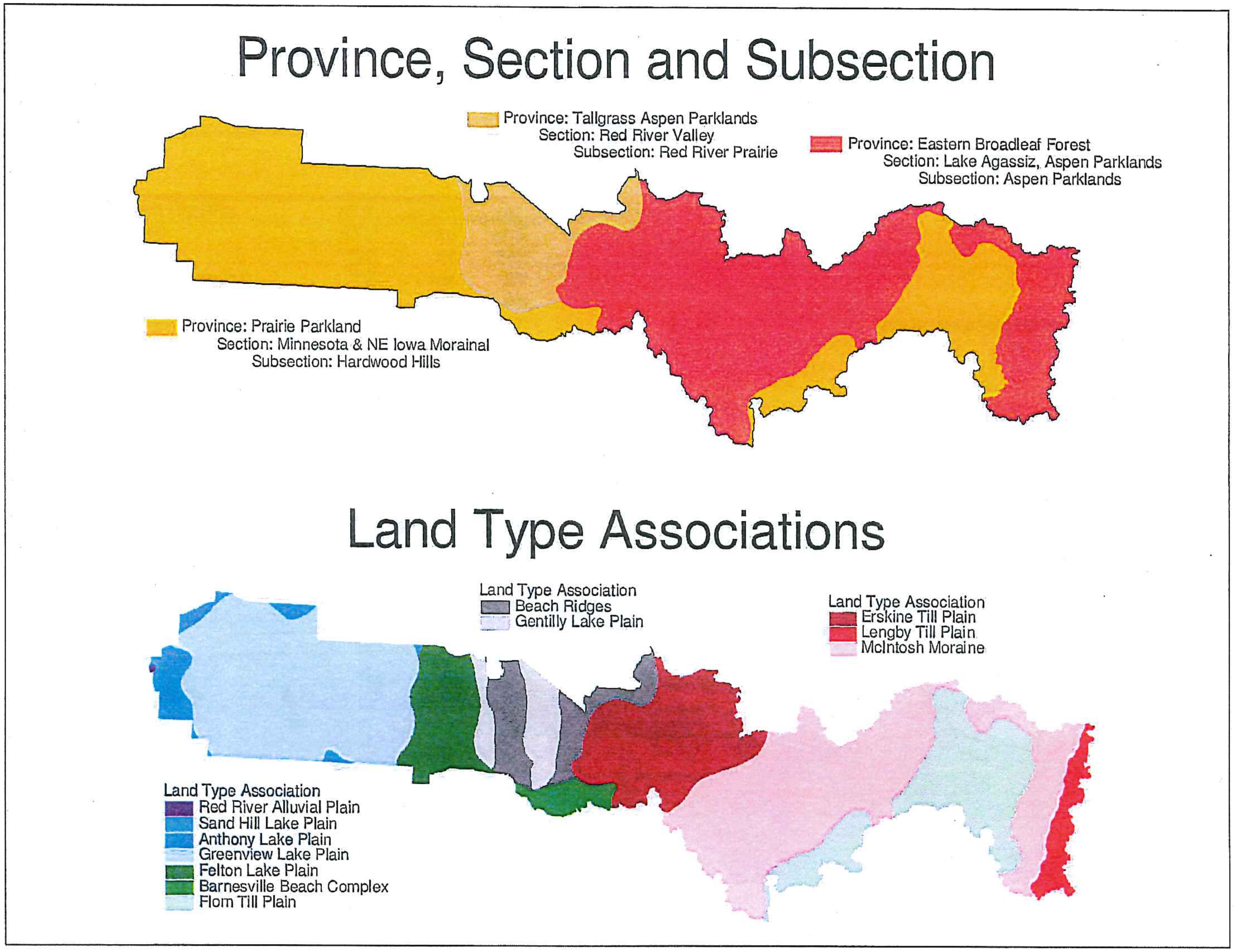



**Figure 8.** Ecological classification (MN DNR) of lands within the Sand Hill River watershed (MN DNR GIS dataset 2005).

## Hydrology

The United States Geological Survey (USGS) currently maintains one active stream flow recording gage station in the Sand Hill River watershed. Gage station #05069000 is located within the city limits of Climax, MN, and has a 420 square mile drainage area. Sand Hill River has a mean annual discharge of 85.3 cubic feet per second (cfs) for the period of record from 1943 through 2004 (Appendix A) as measured at the gage station. The highest instantaneous peak flow recorded at Climax was 4,560 cfs on April 14, 1965 and the annual seven-day minimum is 1.1, which was recorded in January 1962. The 90% exceedance discharge for the period of record at this gage station was 9.1 cfs and the 10% exceedance was 163 cfs (USGS 2004). Daily mean discharges are typically highest in mid-April and lowest in late December through late March (Figure 9).

Climate is likely the most significant variable that influences the hydrology of the watershed. However, human activities such as dam and road construction, stream channelization, ditching, converting land cover from native vegetation to cropland, and draining and filling wetlands have changed the landscape and significantly altered the natural hydrology in the Sand Hill River watershed. Streams in the watershed can be described as "flashy", where multiple peak flows occur (in addition to peak spring flows) along with periods of very low discharge.

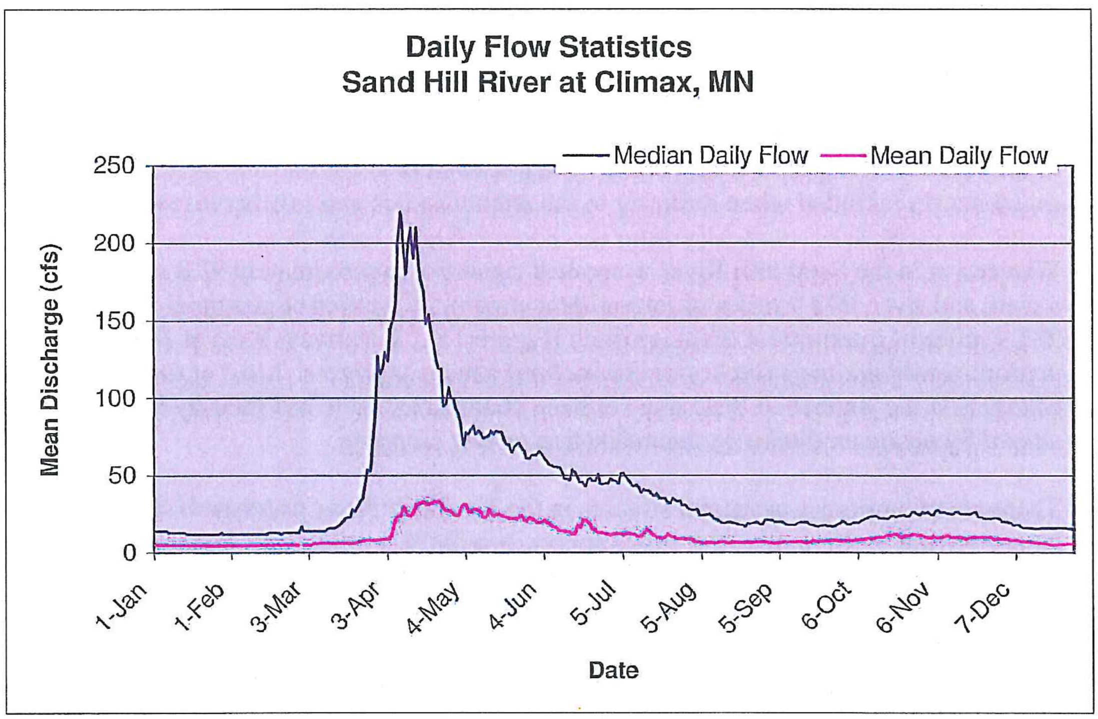



**Figure 9.** Mean and median daily mean discharges at USGS gage stations number 05069000 in Climax, MN.

The MN DNR is directed by Minnesota Statutes, section 103G.285 to limit consumptive appropriations of surface water under certain low flow conditions. The annual Q90 exceedance discharge for the period of record analyzed is currently used as the specified low flow value for suspending certain surface water appropriations (MN DNR Waters 2005). Sand Hill River has a protected stream flow of 9 cfs measured at the USGS gage station at Climax, MN (MN DNR Waters 2005).

**Dams and Fish Passage Barriers**

The USCOE National Inventory of dams (http://crunch.tec.army.mil/nid/webpages/nid.cfm) identifies three dams within the Sand Hill River watershed: 1) the Sand Hill Lake outlet dam owned by the State of Minnesota, 2) a privately owned dam located on an intermittent tributary to Sand Hill River which confluences to Sand Hill River Reach 3, and 3) a dam at an old mill site located on Sand Hill River immediately to the west of Fertile, MN (locally referred to as a "sloped culverts"). In addition, there are four dams, (locally referred to as "drop structures"), located in Reach 2 that are not listed on the USCOE dams list but are low head dams being used as grade control structures (Figure 10).

All dams alter stream hydrology to one extent or another and interrupt stream connectivity. One aspect of stream connectivity that is of special concern is fish passage. The four drop structures in Sand Hill River Reach 2 and sloped culverts in Reach 3 are barriers to fish passage at all flows as is the Sand Hill Lake outlet structure. In addition to these dams, there is a "Texas crossing" located in Sand Hill River Reach 2 that is also a fish passage barrier during low stream flows (Figure 10).

**Waterways**

For this report, waterways are referenced by the name listed on USGS 1:24,000 scale topographical maps. For streams within the Sand Hill River watershed that contain segments of named ditches along their watercourse from headwaters to confluence, the names of ditched segments are included when referring to the stream names unless otherwise stipulated.

Waterways in the Sand Hill River watershed consist of approximately 93.8 miles of perennial stream and river, 272.9 miles of intermittent stream, 26.3 miles of perennial drainage ditch and 281.9 miles of intermittent drainage ditch (Figure 11). Waterways west of Fertile are predominantly drainage ditches or channelized stream segments. Most of the natural stream channels in the watershed that have not been channelized have had their hydrologic regime altered by upstream ditching, channelization or row cropping.

There are two primary perennial streams in the Sand Hill River watershed. Sand Hill River, the largest stream in the watershed, flows approximately 98.5 miles long from its origin at Sand Hill Lake to its confluence with Red River. Sand Hill River has a drainage area of 432.2 square miles and an average slope of 0.00088 (Figure 12). Kittleson Creek is a smaller perennial stream that originates in Kittleson Lake and flows southwesterly approximately 12.4 miles until it empties into Sand Hill River at the upstream boundary of the channelized segment west of Fertile. Numerous smaller natural or ditch tributaries to Sand Hill River also exist and, even though most of these are intermittent, they cumulatively have a large impact on the hydrology and morphology of Sand Hill River. Following is a more detailed description of Sand Hill River.

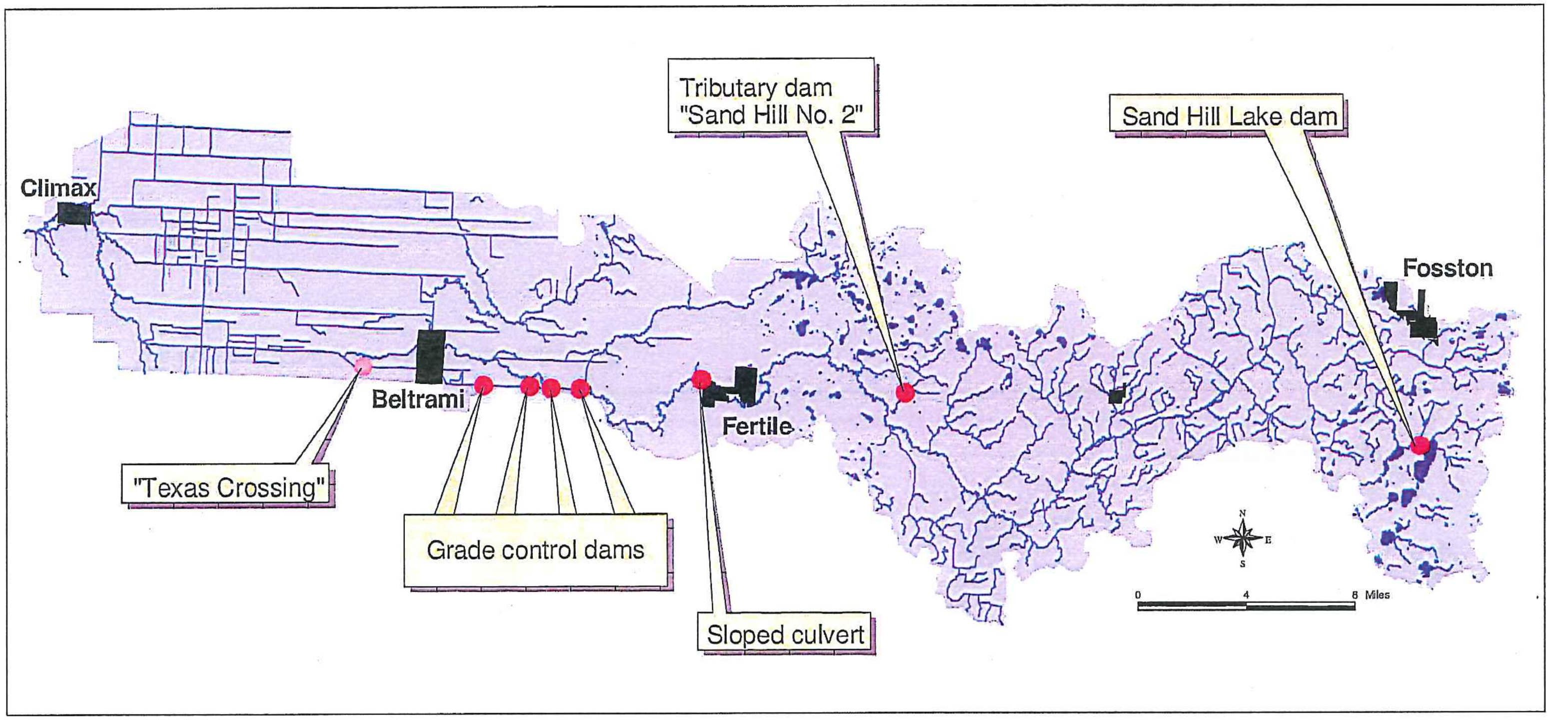
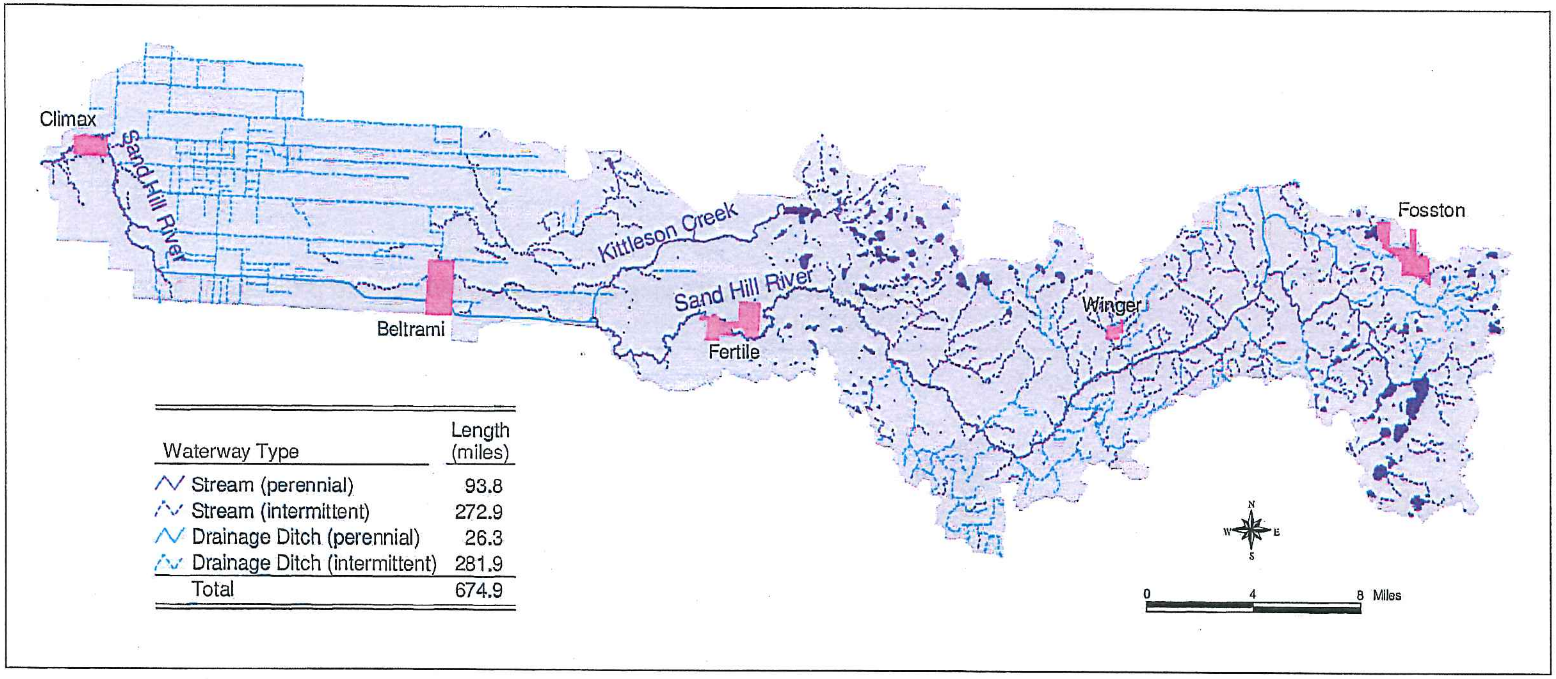



**Figure 10**. Location of dams and fish passage barriers in the Sand Hill River watershed.




| Waterway Type | Length (miles) |
|---|---|
| Stream (perennial) | 93.8 |
| Stream (intermittent) | 272.9 |
| Drainage Ditch (perennial) | 26.3 |
| Drainage Ditch (intermittent) | 281.9 |
| Total | 674.9 |

**Figure 11.** Waterways in the Sand Hill River watershed.

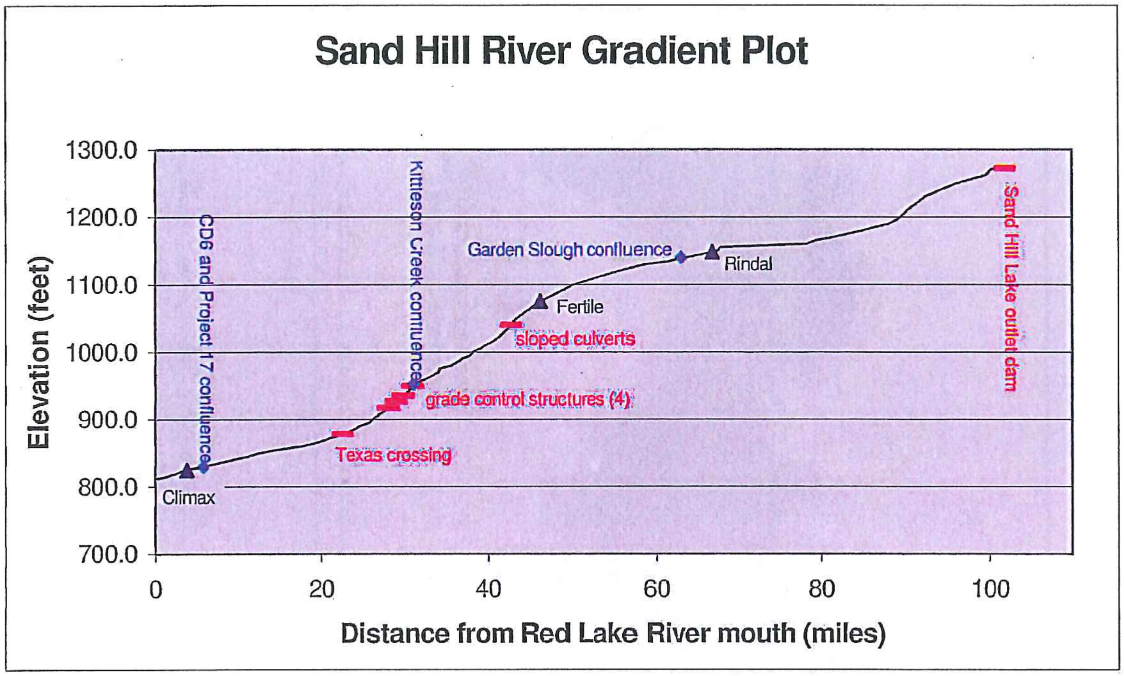
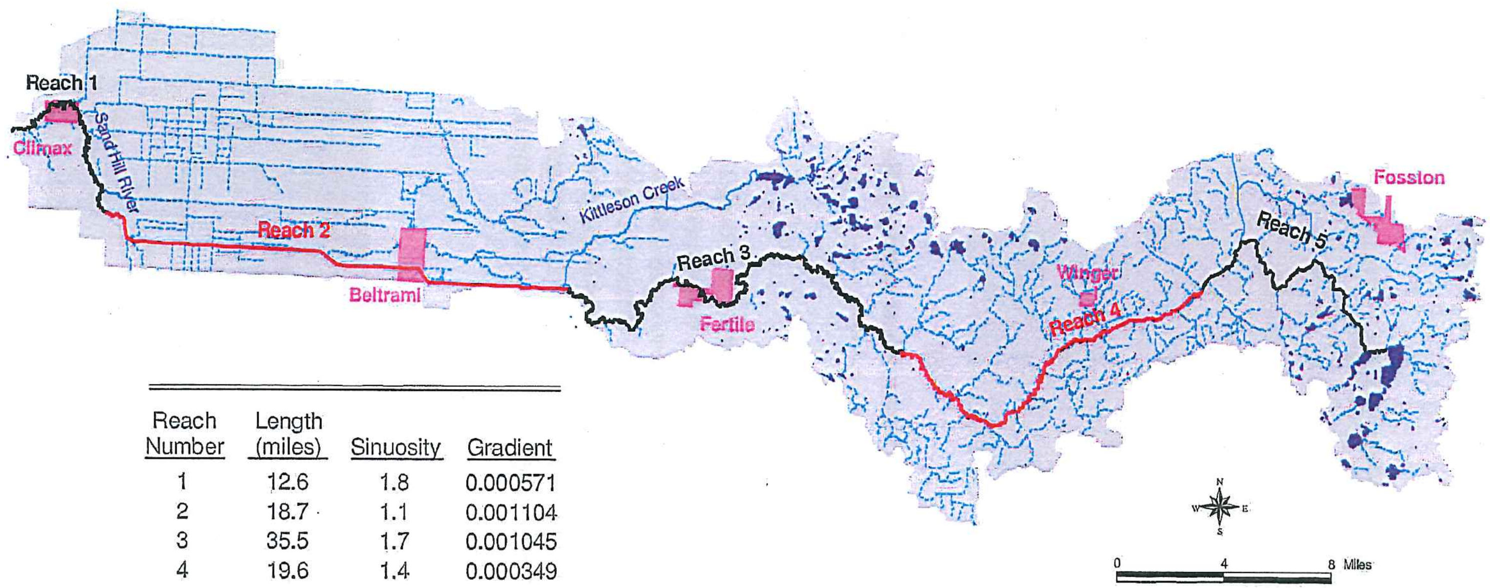



**Figure 12.** Sand Hill River gradient plot.

***Sand Hill River.*** Sand Hill River originates at the Sand Hill Lake outlet control structure and ends at its confluence with Red River of the North 1.4 miles southwest of Climax, MN.. Huberty (1994) divided Sand Hill River into five Reaches and these same delineated Reaches were used in this survey (Figure 14). For the purpose of this report, a Reach is defined as a segment of stream with relatively consistent morphological characteristics (e.g., gradient, sinuosity, cross-section morphology) and instream habitat is assumed to be similar throughout a Reach. Reach numbering began with the farthest downstream Reach and progressed sequentially upstream.

Sand Hill River Reach 5 is a relatively high gradient, low sinuosity stream segment that begins at the outlet to Sand Hill Lake and flows through rolling and undulating agricultural lands (Figure 13). Scattered small lakes and wetlands are common, especially in the upstream half of the Reach. Stream channelization is common throughout this Reach. Major impacts to this Reach include: stream channelization, ditching, and increased sedimentation and accelerated runoff resulting primarily from agricultural land use practices.


**Figure 13.** Example of Sand Hill River in Reach 5.




| Reach Number | Length (miles) | Sinuosity | Gradient |
|---|---|---|---|
| 1 | 12.6 | 1.8 | 0.000571 |
| 2 | 18.7 | 1.1 | 0.001104 |
| 3 | 35.5 | 1.7 | 0.001045 |
| 4 | 19.6 | 1.4 | 0.000349 |
| 5 | 13.6 | 1.2 | 0.001080 |

**Figure 14**. Delineated reaches of Sand Hill River.

Reach 4 is a low gradient, moderately sinuous stream segment that flows through gently rolling and undulating agricultural lands. Most of this segment meanders through broad wetlands, so there is very little timbered corridor (Figure 15). However, the wetlands are moderately effective at stabilizing the stream banks and reducing flood impacts in the immediate area. Major impacts to this Reach include: increased sedimentation and an altered hydrograph from ditching, channelization and agricultural land uses.


**Figure 15**. Examples of Sand Hill River in Reach 4.

Reach 3 is a relatively high gradient, highly sinuous stream segment. This Reach flows through hummocky and remnant beach ridge topographies, which produce some of the more complex instream habitat in Sand Hill River (Figure 16). Agricultural lands dominate the landscape, however, a timbered stream buffer exists through much, but not all, of this Reach. Major impacts to this Reach include: agricultural impacts, an altered hydrograph, stream connectivity impacts (e.g., fish passage barriers) from the "sloped culverts", and urban impacts associated with the city of Fertile.

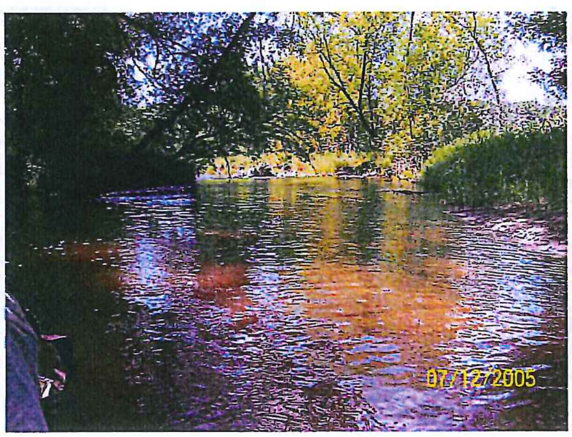
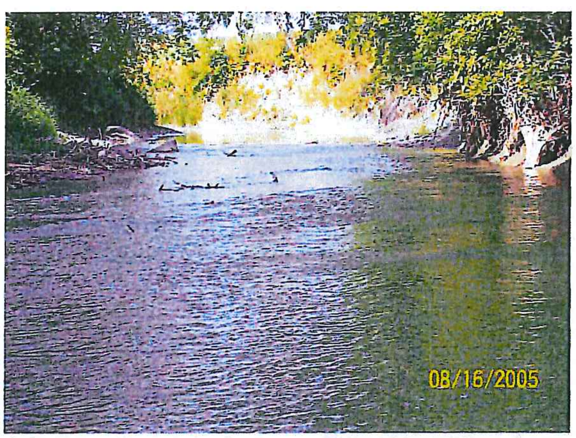



**Figure 16**. Examples of Sand Hill River in Reach 3.

Reach 2 is a relatively high gradient, channelized stream segment flowing through the glacial Lake Agassiz plain (Figure 17). Agricultural lands dominate the landscape surrounding this Reach and row cropping is prominent. Instream habitat consists primarily of run habitat and very little timbered stream buffer exists. Major impacts to this Reach include: stream channelization, hydrologic impacts due to altered hydrograph, stream connectivity impacts caused by the "Texas crossing" and the four grade control structures described earlier, and agricultural impacts.


**Figure 17.** Examples of Sand Hill River Reach 2.

Reach 1 is a low gradient, highly sinuous stream segment that meanders through the glacial Lake Agassiz plain (Figure 18). Agricultural lands dominate the landscape and row cropping is prominent. The stream buffer in the downstream half of Reach 1 is generally timbered and wide on both sides of the stream, however, the upstream half is generally narrow and ineffective at slowing surface runoff, stabilizing stream banks, or filtering runoff. Major factors impacting this Reach include: urban impacts associated with the city of Climax, hydrologic alterations and agricultural impacts (e.g., increased runoff and sedimentation).



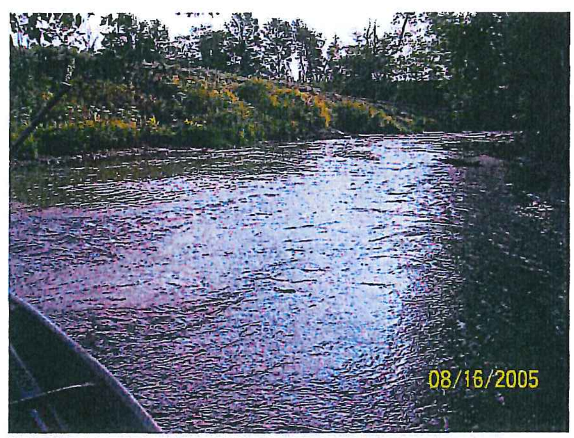



**Figure 18.** Examples of Sand Hill River Reach 1.

# METHODS

## Sample Stations

Sampling was conducted at 16 stations in streams within the Sand Hill River watershed in the summer 2005 (Table 1, Figure 19).

Physical and biological stream characteristics investigated at various stations included:

- ***Fish community assessment***: Fish community assessments provide quantitative information describing the species and numbers of fish at locations throughout the watershed. The condition of fish communities reflects the condition of a stream.
- ***Stream morphology and classification***: Stream morphology descriptions provide information that can be used to assess current stream condition and stability, monitor changes over time and allow comparisons to other streams.
- ***Stream channel stability assessment***: Stream bank stability reflects whether or not a stream is functioning naturally. A stable stream will maintain a consistent dimension, pattern and profile over time and the stream bank stability assessment provides information to determine if these characteristics are consistent or if they are changing.
- ***Fish habitat evaluation***: The characteristics of instream habitat play a key role in determining the numbers, sizes, and species of fish that a stream can support. Information on fish habitat is vital to stream fisheries management.

## Fish Community Assessment

Fish communities were sampled at six stations during low flow conditions (Table 1, Figure 19). Station lengths were 35 times the mean stream width. Backpack or tow barge electrofishing gear was used depending on stream width and water depth at the time of sampling. After capture, fish were identified, measured for length, weighed, examined for diseases and anomalies (e.g., tumors) and released. Fish species that could not be identified in the field were preserved and identified in the laboratory. Fisheries data for each station was summarized into species composition and species catch per unit of effort tables.

Fish species index of biotic integrity (IBI) scores were calculated for each station using methods developed for the Lake Agassiz Plain (Niemela et al. 1998). Two different sets of twelve metrics were used: one a set for stations with drainage areas less than 200 square miles and the other was a set for stations with drainage areas of 200 to 1500 square miles. Metrics used were related to species richness and composition, trophic composition, reproductive guild, functional guild, and fish abundance and condition. According to Niemela et al. (1998), stream stations with scores from 12 through 20 are considered to have "very poor" biotic integrity, scores of 21 through 30 have "poor" integrity, scores of 31 through 40 have "fair" integrity, scores of 41-50 have "good" integrity and scores greater than 50 are determined to have "excellent" biotic integrity.

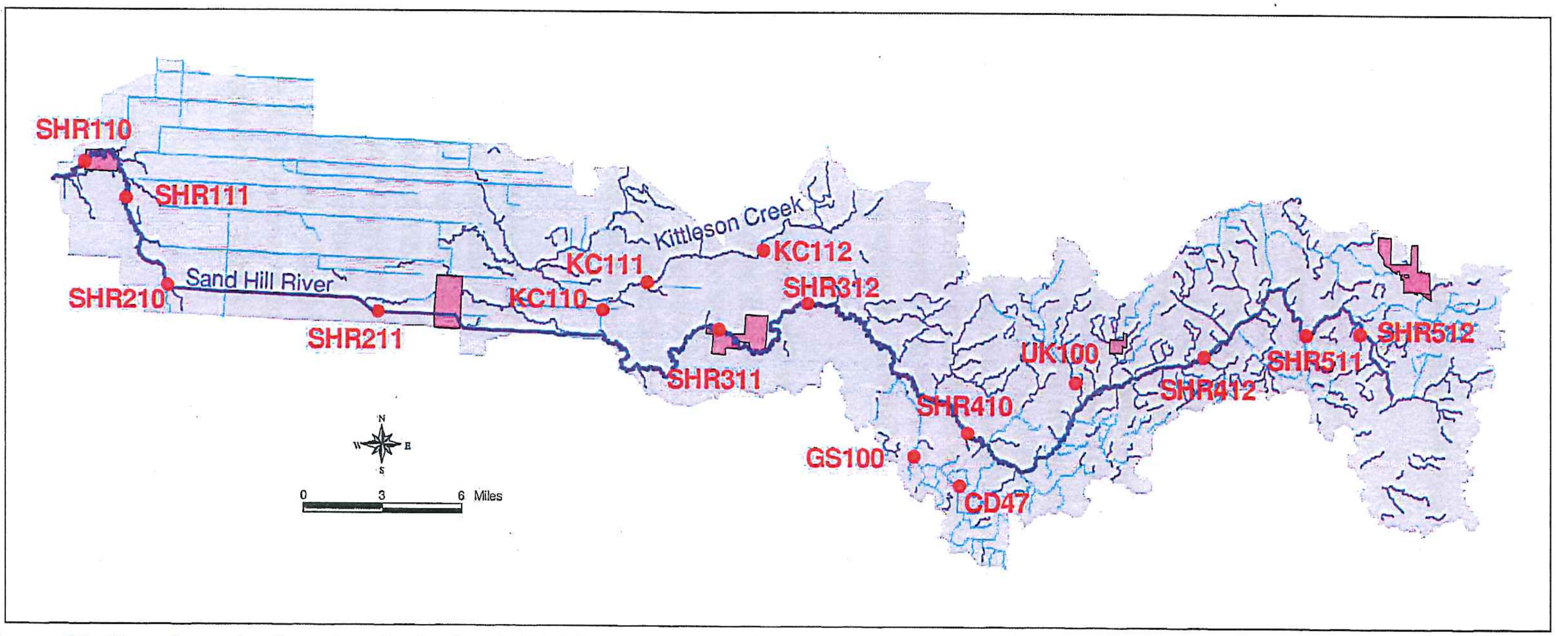



**Figure 19.** Sample station locations in the Sand Hill River watershed during the summer of 2005.

**Table 1.** Types of sampling completed at stations in the Sand Hill River watershed in 2005.

| Station | Stream/Waterway | Fish Community Assessment | Fish Habitat Evaluation | Stream Morphology | Stream Bank Stability |
|---|---|---|---|---|---|
| SHR110 | Sand Hill River | | X | X | X |
| SHR111 | Sand Hill River | | X | X | X |
| SHR210 | Sand Hill River | | X | X | X |
| SHR211 | Sand Hill River | | X | X | X |
| SHR311 | Sand Hill River | | X | X | X |
| SHR312 | Sand Hill River | X | X | X | X |
| SHR410 | Sand Hill River | | X | X | X |
| SHR412 | Sand Hill River | X | X | X | X |
| SHR511 | Sand Hill River | | X | X | X |
| SHR512 | Sand Hill River | X | X | X | X |
| GS100 | Garden Slough | | | X | X |
| CD47 | County Ditch 47 | | | X | X |
| KC110 | Kittleson Creek | | X | X | X |
| KC111 | Kittleson Creek | X | X | X | X |
| KC112 | Kittleson Creek | X | X | X | X |
| UK100 | Unnamed tributary | X | X | X | X |

## Stream Morphology and Classification

Stream morphology evaluation procedures were conducted on 16 stations (Table 1) following methods described in Rosgen (1996). Channel cross-section, longitudinal profile and substrate particle composition were surveyed at each sample stations. Survey data were used to estimate bankfull cross sectional areas and dimensionless ratios (i.e., width to depth ratio, slope, sinuosity, riffle: pool ratio, etc.) needed to describe stream morphology and classify the stream segments according to Rosgen (1996). Surveys were conducted using laser levels, and cross-sections and site boundaries were geo-referenced using Garmin XL12 global positioning receivers.

## Stream Channel Stability

Sixteen sample stations were evaluated for stream channel stability (Table 1). Methods to evaluate channel stability followed those described in Pfankuch (1975) with modifications recommended in Rosgen (1996). Station lengths of 35 times the mean stream width were used to rate 15 data categories describing various characteristics of the stream bottom (wetted width), lower stream bank (water's edge to the bankfull height) and upper banks (bankfull height to flood prone height). Pfankuch's stream channel rating system was developed before stream classifications were introduced and originally returned an average stability rating regardless of the stream type to which it was applied. Rosgen (1996) developed a conversion that, when applied to the Pfankuch system, adjusted the rating system to account for different stream types.

**Fish Habitat Evaluation**
Instream fish habitat evaluations were conducted at all 16 stations (Table 1).

*Mesohabitats.* Mesohabitat (i.e., pool, riffle, run) availability was determined using longitudinal profile data. At a minimum, the distance from the upstream boundary of the station and thalweg elevation readings were recorded at the upstream end, midpoint and downstream end of each mesohabitat type while conducting the longitudinal profile. Distance measurements were used to calculate the percentage of a station comprised of each mesohabitat type.

*Thalweg Depth.* Thalweg (the deepest point within the wetted width along any given cross-section) water depth distribution was determined using longitudinal profile data. During the longitudinal survey, stream bottom elevation readings were taken along the thalweg at a sufficient number of points to adequately describe the shape of the streambed including all mesohabitat types present. At a minimum, thalweg elevations were taken at the upstream and downstream boundaries of each mesohabitat type as well as the deepest point in each mesohabitat type. Water surface elevation was also taken along the longitudinal profile.

*Substrate Composition*
The Wolman (1954) pebble count method was used to collect substrate particle data. Substrate particles were sampled in a zig-zag pattern through the length of the longitudinal profile collecting data up to bankfull elevation. In order to get a representative sample proportioned to available mesohabitat units, every effort was made to follow a zig-zag pattern that traversed all habitat units within the profile in an unbiased manner.

*Cover for Larger Fishes*
Cover for larger fishes was defined as an object that provided instream shelter for a fish that is at least eight inches total length. Only objects a minimum of one foot long, measured upstream to downstream, and one foot wide, measured perpendicular to stream flow were counted as cover for larger fishes. The cover type and dimensions of each cover object encountered were recorded, as well as the mesohabitat type in which the object was located.

The following general instream cover definitions outlined by Simonson et al. (1994) were used. Much of the text was taken directly from the article.

Undercut banks – Banks that overhang the water (horizontally) by at least 0.30 m. To be considered cover the bottom of the undercut bank was no more than 0.10 m above the water surface. Instream habitat improvement structures, such as lunker structures, were included in this category.

Overhanging vegetation – Thick vegetation overhanging the water (horizontally) by at least 0.3 m. To be considered cover, the bottom of the overhanging vegetation was no more than 0.10 m above the water surface.

Woody debris - Individual or aggregations of wood (e.g., logs, tree branches, root wads, sticks) located in, or in contact with, the water.

Boulders – Rocks greater than 10 inches long and located in, or in contact with, the water. Large pieces of concrete and other artificial rocky aggregates were included in this category.

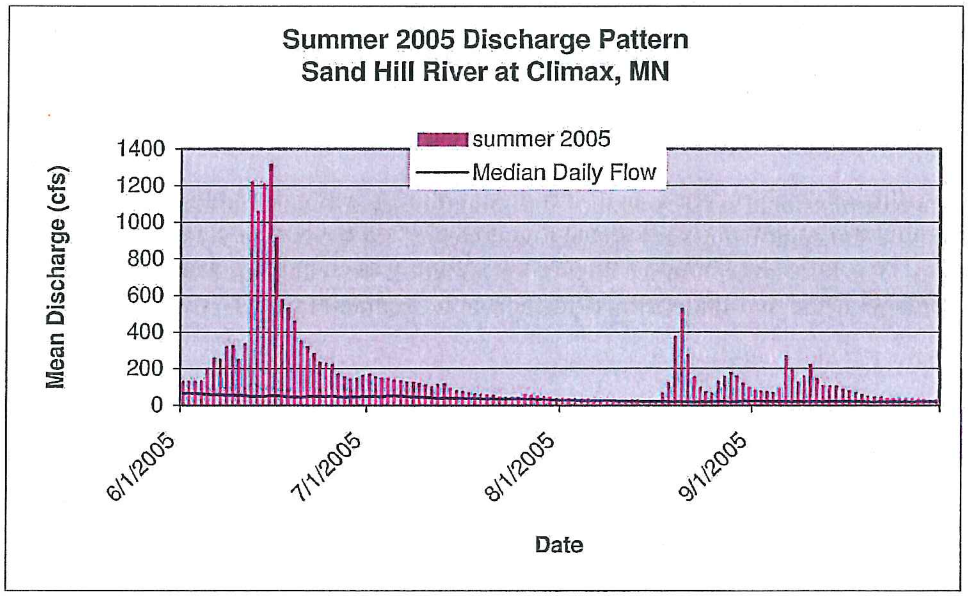
Submerged macrophytes – Vascular plants that normally have all, or nearly all, of their biomass below the surface of the water. To count as cover, submerged macrophytes were thick or dense enough to provide shelter or visual isolation for fishes.

Emergent macrophytes - Vascular plants that normally have a significant portion of their biomass above the surface of the water. To count as cover, emergent macrophytes were thick or dense enough to provide shelter or visual isolation for fish.

The two dimensional surface area of individual objects was calculated, and these were used to determine the cumulative two-dimensional area of each cover type throughout each sample station. The total water surface area of each station was calculated and used to determine the percentage of the two-dimensional surface area occupied by each cover type.

## RESULTS

Stream flows through most of the summer of 2005 were substantially above median flows at the USGS gage station on Sand Hill River in Climax, MN (Figure 20). Stream flows were not monitored on other streams in the watershed. However, stream flows ranging from bankfull flows to extreme low flow were observed on most of these streams.



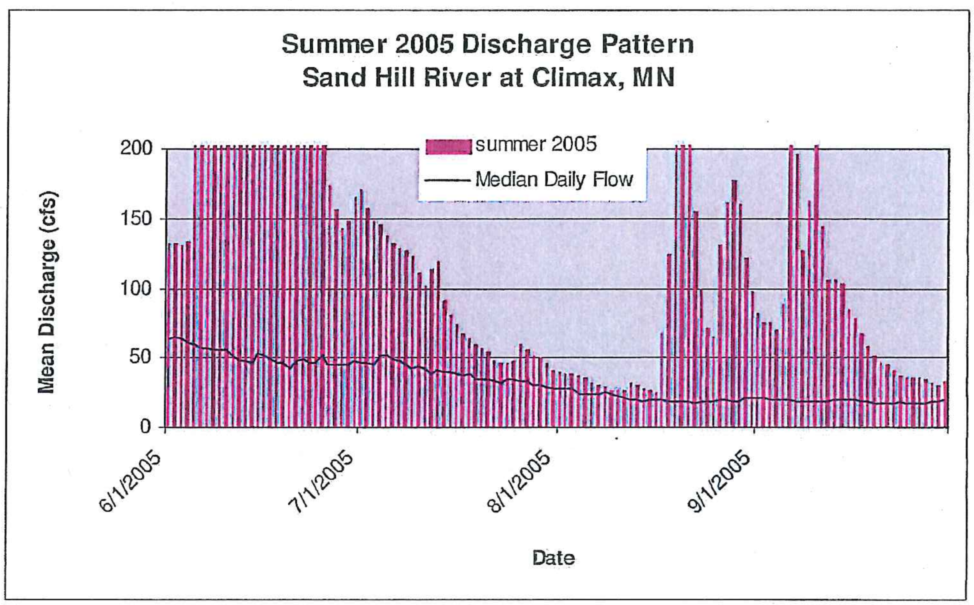




**Figure 20.** Sand Hill River stream discharge pattern from June 1, 2005 to September 30, 2005. Values on the lower graph were limited to those 200 cfs and less in order to facilitate comparison of discharges to historical median flows

**Fish Community**

The higher than normal streamflows throughout the summer of 2005 restricted fish community collection efforts to six stations, all located upstream from the fish passage barriers in Reaches 2 and 3. Nineteen fish species were sampled in the Sand Hill River watershed in the summer of 2005 (Table 2). Species richness was similar among the three stations on Sand Hill River and KC111. Species richness was good at all stations compared to reference stations established in the Red River basin by Niemela et al. (1998). Four species were found at all six fish sample stations including: fathead minnow, creek chub, white sucker and central mudminnow. Four species were sampled at only one station including pearl dace at station SHR412, golden shiner at station KC112, longnose dace at station SHR312 and blackside darter at station SHR312.

Eleven fish species that are considered to be sensitive to environmental disturbances, such as water quality and habitat degradation (Niemela et al. 1998) are known to occur in the Sand Hill River watershed (Appendix B, Table B2). Three of these 10 sensitive species were sampled in the summer of 2005 including: northern redbelly dace, finescale dace, and longnose dace. At least one environmentally sensitive species was sampled at each station. Longnose dace were only found in Sand Hill River station SHR312.

Thirteen fish species considered to be highly tolerant to environmental disturbances including water quality and habitat degradation (Niemela et al. 1998) are known to occur in the Sand Hill River watershed (Appendix B, Table B3). Of these 13 tolerant species, seven were sampled in the summer of 2005 including: golden shiner, fathead minnow, western blacknose dace, creek chub, white sucker, central mudminnow and brook stickleback. Tolerant fish species were found at all stations and comprised more than 50% of the individual fishes sampled at all six stations. The fish community at station UK100 was comprised of 98% tolerant fish species. Sixty-seven percent (67%) of all fishes sampled in the summer of 2005 were of a tolerant species.

No piscivorous or game fishes were sampled at any of the sample stations. No Minnesota State or Federally listed endangered or threatened fish species are known to inhabit streams in the Sand Hill River watershed.

***Fish Abundance.*** A total of 3,490 fish were sampled in 2005. Fathead minnow was the most numerically abundant species found comprising 28.2% of all fish sampled in 2005, followed by central mudminnow (13.0%) and northern redbelly dace (10.9%). Less than 10 individual golden shiner, longnose dace, black bullhead and blackside darter were sampled.

The relative abundance of fish within a sample station, expressed as the number of fish caught per hour of effort (CPUE), ranged from 2,330 fish/hr at Sand Hill River station SHR412 to 140 fish/hr at Kittleson Creek stations KC112 (Appendix C, Table C9).

***Fish Biomass.*** The total fish biomass in the watershed was dominated by white sucker, which accounted for 34.1% (8.9kg) of the total biomass sampled, most (8.1kg) of which were sample at station SHR412. Creek chub dominated the biomass at station SHR312, KC11 and KC112, while white sucker was dominant at SHR412, northern redbelly dace was dominant at SHR512, and fathead minnow was dominant at UK100.

**Table 2.** Fish species and total number of individuals sampled at stations in Sand Hill River (SHR), Kittleson Creek (KC), and an unnamed tributary to Sand Hill River (UK).

| | Station ID | | | | | | |
|---|---|---|---|---|---|---|---|
| **Species** | **SHR312** | **SHR412** | **SHR512** | **KC111** | **KC112** | **UK100** | **Total** |
| Common shiner | 26 | 29 | 3 | 33 | 1 | | 92 |
| Pearl dace | | 74 | | | | | 74 |
| Golden shiner | | | | | 6 | | 6 |
| Bigmouth shiner | 136 | 3 | 45 | 14 | | | 198 |
| Northern redbelly dace | 35 | 3 | 332 | 9 | | 1 | 380 |
| Finescale dace | | 17 | 18 | 2 | 2 | 2 | 41 |
| Fathead minnow | 272 | 300 | 310 | 6 | 7 | 89 | 984 |
| Western blacknose dace | 41 | | 27 | 37 | | | 105 |
| Longnose dace | 3 | | | | | | 3 |
| Creek chub | 170 | 76 | 4 | 80 | 14 | 9 | 353 |
| White sucker | 16 | 178 | 1 | 20 | 3 | 26 | 244 |
| Black bullhead | | 1 | 2 | 1 | | | 4 |
| Brown bullhead | 26 | | 1 | 1 | | | 28 |
| Central mudminnow | 31 | 369 | 38 | 11 | 5 | 1 | 455 |
| Brook stickleback | 6 | 1 | 169 | | 5 | 39 | 220 |
| Iowa darter | | 1 | 10 | | 4 | | 15 |
| Johnny darter | 51 | 17 | 3 | 3 | | | 74 |
| Yellow perch | 4 | 188 | 1 | 8 | 4 | | 205 |
| Blackside darter | 9 | | | | | | 9 |
| Total Number of Species | 14 | 14 | 15 | 13 | 10 | 7 | 19 |
| Total Number of Individuals | 826 | 1,257 | 964 | 225 | 51 | 167 | 3,490 |

Summaries of fish sampling efforts can be found in Appendix C, Table C1. Summaries of fish species composition and species catch rates associated with each sample station can be found in Appendix C, Tables C2 through C9. Catch rates for each fish species at each sample station can be found in Appendix C, Table C10.

**Fish Species Index of Biotic Integrity (IBI)**

IBI scores ranged from 34 at station UK100 to 50 at Sand Hill River station SHR512 (Table 3). Biotic integrity was fair at all stations except SHR512 where the biotic integrity was good.

Individual metric scores varied between stations (Appendix D). The species richness and number of minnow species metrics scored the highest possible value (5) at all six stations. Headwater species were well represented at station SHR512, where the percent composition of headwater fish metric scored a 5. Station UK100 had a percent headwater fish score of 3 and the remaining stations scored a 1 for this metric. The metrics for percent lithophilic spawners, percent tolerant individuals and fish abundance was scored the lowest possible value (1) at all stations but SHR512 where each of these metrics received a score of 3. Two sensitive species were found at all stations except KC112 where only 1 species was sampled. After adjusting for drainage area, the metric for number of sensitive species was given a score of 3 at station KC112, SHR312 and SHR 412, and a score of 5 at stations KC111, SHR512 and UK100. A full description of IBI metrics and scores associated with each station can be found in Appendix D, Tables D1 and D2.

**Table 3.** Fish IBI scores (Niemela et al. 1998) calculated for stations in the Sand Hill River watershed sampled in the summer of 2005.

| Stream | Station Number | Gear | IBI Score | Biotic Integrity Classification |
|---|---|---|---|---|
| Kittleson Creek | KC111 | Backpack | 40 | Fair |
| Kittleson Creek | KC112 | Backpack | 39 | Fair |
| Sand Hill River | SHR312 | Tote Barge | 38 | Fair |
| Sand Hill River | SHR412 | Tote Barge | 36 | Fair |
| Sand Hill River | SHR512 | Backpack | 50 | Good |
| Unnamed Creek | UK100 | Backpack | 34 | Fair |

## Game Fish

No major game fish species were sampled during the summer of 2005. However, no sampling was done downstream of known fish passage barriers located in the lower portion of Reach 3 and in Reach 2.

## Stream Morphology and Classification

Stream morphology data was collected at 16 stations in the Sand Hill River watershed (Table 4).

***Bankfull Width and Depth***: The narrowest bankfull width estimate was 5.8 feet at station KC112 and the widest was 56.6 feet at SHR311 on Sand Hill River. Bankfull widths were correlated to drainage area (r=0.64). Bankfull cross-sectional areas ranged from 7.5 $ft^2$ at UK100 to 129.9 $ft^2$ at SHR410. Bankfull cross-sectional areas were correlated with drainage area (r= 0.84) and comparable to those of other streams in the Red River basin (Figure 21; MN DNR, unpublished data). Stream channel width-to-depth ratios ranged from 3.8 at KC112 to 47.6 at GS100. Mean bankfull depths ranged from 0.5 ft at UK100 3.5 ft at SHR111.

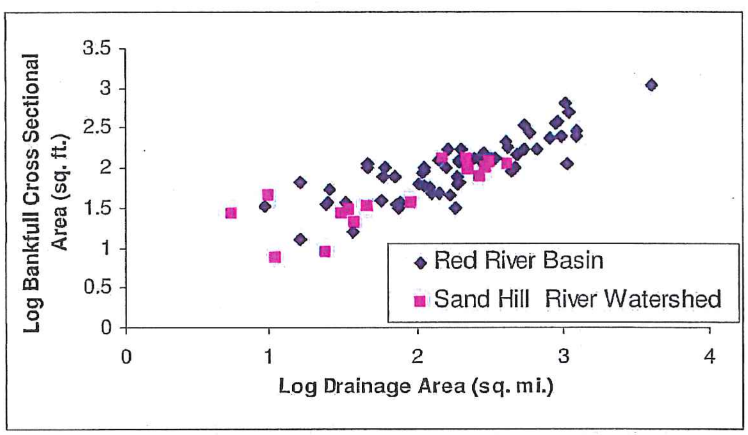



**Figure 21.** Relationship between drainage area and bankfull cross-sectional area for sample stations in the Sand Hill River watershed and other stations throughout the Red River basin.

**Table 4.** Stream morphology (Rosgen 1996) summary statistics for streams sampled in the Sand Hill River watershed.

| Stream | Station ID | Drainage Area ($mi^2$) | Bankfull Width (ft) | Mean Depth (ft) | Bankfull XS Area ($ft^2$) | Width/Depth Ratio | Flood Prone Width (ft) | Entrenchment Ratio | D50 Substrate Type | Water Surface Slope | Sinuosity | Rosgen Stream Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sand Hill River | SHR110 | 425.8 | 50.5 | 2.3 | 113.7 | 22.4 | 58.3 | 1.2 | Silt/clay | 0.00038 | 1.9 | F6 |
| Sand Hill River | SHR111 | 318.1 | 34.3 | 3.5 | 121.0 | 9.7 | 70.7 | 2.1 | Silt/clay | 0.0021 | 2.0 | E6 |
| Sand Hill River | SHR210 | 297.7 | 40.5 | 2.5 | 100.1 | 16.4 | 50.4 | 1.2 | Sand | 0.00075 | 1.1 | F5 |
| Sand Hill River | SHR211 | 275.9 | 26.5 | 2.9 | 75.8 | 9.3 | 68.7 | 2.6 | Silt/clay | 0.00120 | 1.0 | E6 |
| Sand Hill River | SHR311 | 232.1 | 56.6 | 1.7 | 94.7 | 33.8 | 63.5 | 1.1 | Sand | 0.0024 | 1.4 | F5 |
| Sand Hill River | SHR312 | 220.7 | 41.0 | 3.2 | 129.7 | 13.0 | 111.1 | 2.7 | Sand | 0.00059 | 1.4 | C5 |
| Sand Hill River | SHR410 | 151.9 | 53.1 | 2.4 | 129.9 | 21.7 | >600 | ~11.2 | Silt/clay | 0.00007 | 1.3 | C6c- |
| Sand Hill River | SHR412 | 93.9 | 34.8 | 1.1 | 37.0 | 32.7 | 560.0 | 16.1 | Silt/clay | 0.00081 | 1.3 | C6c- |
| Sand Hill River | SHR511 | 47.9 | 19.4 | 1.7 | 32.7 | 11.5 | ~600 | ~31.0 | Silt/clay | 0.00110 | 1.4 | E5 |
| Sand Hill River | SHR512 | 32.0 | 15.1 | 1.8 | 26.9 | 8.5 | 38.0 | 2.5 | Silt/clay | 0.00240 | 1.3 | E6 |
| Garden Slough | GS100 | 9.8 | 45.5 | 1.0 | 45.5 | 47.6 | 356.0 | 7.7 | Silt/clay | 0.00068 | 1.1 | C6c- |
| County Ditch 47 | CD47 | 5.6 | 18.6 | 1.4 | 26.2 | 13.2 | 25.1 | 1.3 | Silt/clay | 0.00166 | 1.0 | F6 |
| Kittleson Creek | KC110 | 38.7 | 10.6 | 2.0 | 20.9 | 5.4 | 16.9 | 1.6 | Sand | 0.00065 | 1.2 | G5 |
| Kittleson Creek | KC111 | 35.3 | 15.8 | 1.8 | 29.1 | 8.6 | 19.8 | 1.3 | Sand | 0.00091 | 1.4 | G5 |
| Kittleson Creek | KC112 | 24.4 | 5.8 | 1.5 | 8.9 | 3.8 | 63.5 | 10.9 | Sand | 0.00680 | 1.2 | E5 |
| UnnamedCreek | UK100 | 11.2 | 14.3 | 0.5 | 7.5 | 27.3 | 14.8 | 1.0 | Sand | 0.00420 | 1.5 | F5 |

***Entrenchment***: Flood prone widths ranged from 14.8 feet at UK100 to greater than 600 feet at SHR410 (Table 4). The stream was either entrenched or moderately entrenched (entrenchment ratios $\leq$2.2) at eight stations and slightly entrenched at eight stations (entrenchment ratios >2.2; Table 4). The lowest entrenchment ratio (1.0) was found at UK100 while the highest (approximately 31.0) was found at Sand Hill River station SHR511 (Figure 22).


**Figure 22.** Station UK100 (left), located on an unnamed tributary stream to Sand Hill River, and station SHR511 on upper Sand Hill River (right).

***Sinuosity***: Stream sinuosity ranged from 1.0 at stations SHR211 and CD47, to 2.0 at SHR111 (Table 4). Sinuosity was high (sinuosity >1.5) at both stations located in Sand Hill River Reach 1 (SHR110 and SHR111) and low (<1.2) at the four stations located in either channelized or ditched stream segments (SHR210, SHR211, GS100, and CD47). The streams through the remaining ten stations were moderately sinuous ($\geq$1.2 – 1.5).

***Stream classification***. Rosgen (1996) stream classification was determined at sixteen stations in the Sand Hill River watershed (Table 4). Four stations were classified as C type channels, including the upstream-most station in Reach 3 (SHR312) and both stations located in Reach 4 (SHR410 and SHR412). Five stations were classified as E channels, which included both stations in Sand Hill River Reach 5, while five stations were classified as F type channels. The two stations located farthest downstream on Kittleson Creek, KC110 and KC111, were the only two located in G type channels. General characteristics of channel types identified in the Sand Hill River watershed are shown in Table 5.

**Table 5.** General characteristics of channel types found in the Sand Hill River watershed (Rosgen 1996).

| Channel Type | Entrenchment | Width to Depth | Sinuosity |
|---|---|---|---|
| C | Slightly entrenched | Moderate to high | High |
| E | Slightly entrenched | Very low | Very High |
| F | Entrenched | Moderate to high | Moderate |
| G | Entrenched | Low | Moderate |

## Stream Channel Stability

Stream channel stability was evaluated at 16 stations in the Sand Hill River watershed (Table 6). Channel stability was good at Sand Hill River station SHR311 and Garden Slough station GS100, and fair at stations SHR410, SHR 412, KC110 and CD47. The remaining ten stations had poor channel stability including 7 of the 10 stations located on Sand Hill River (Table 6).

Of the four C type channels, stability was good at GS100 and fair at stations SHR410 and SHR412, however channel stability was poor at station SHR312. The primary differences between SHR312 and the other stations was the presence of steep upper stream banks with frequent mass wasting and prevalent lower stream bank erosion.

Channel stability was poor at all five stations in E type channels. Prevalent lower bank erosion, extensive deposits of predominantly fine substrate particles, and a lack of stable stream bottom materials were factors at all stations. SHR111 also had eroding upper stream banks that lacked effective vegetative protection.

Channel stability was poor at three of the five stations located on F type channels (SHR110, SHR210 and UK100). These stations had near vertical stream banks with frequent areas of mass wasting on the upper stream banks and extensive lower bank erosion as primary contributing factors (Figure 23). In addition, the stream bottom at these stations was comprised of loose, unconsolidated materials with few, if any, stable materials present.

**Figure 23.** Unstable stream channels at stations SHR110 (left) and KC111 (right).

Channel stability was poor at one of the two stations located on G channels (KC111) and fair at the other (KC110). The stream bottom at both stations was comprised of loose, unconsolidated materials, however, there was noticeably more lower bank erosion and within-channel scour was noticeably worse at KC111 compared to KC110.

**Table 6.** Results of stream channel stability assessments (Pfankuch 1975, Rosgen 1996) conducted at Sand Hill River watershed sample stations in the summer of 2005.

| Stream | Station ID | Stream Channel Stability Score | Stream Type (Rosgen 1996) | Interpretation |
|---|---|---|---|---|
| Sand Hill River | SHR110 | 143 | F6 | Poor |
| Sand Hill River | SHR111 | 138 | E6 | Poor |
| Sand Hill River | SHR210 | 148 | F5 | Poor |
| Sand Hill River | SHR211 | 137 | E6 | Poor |
| Sand Hill River | SHR311 | 109 | F5 | Good |
| Sand Hill River | SHR312 | 130 | C5 | Poor |
| Sand Hill River | SHR410 | 96 | C6c- | Fair |
| Sand Hill River | SHR412 | 105 | C6c- | Fair |
| Sand Hill River | SHR511 | 116 | E5 | Poor |
| Sand Hill River | SHR512 | 105 | E6 | Poor |
| Garden Slough | GS100 | 75 | C6c- | Good |
| County Ditch 47 | CD47 | 96 | F6 | Fair |
| Kittleson Creek | KC110 | 124 | G5 | Fair |
| Kittleson Creek | KC111 | 134 | G5 | Poor |
| Kittleson Creek | KC112 | 112 | E5 | Poor |
| UnnamedCreek | UK100 | 140 | F5 | Poor |

## Instream Habitat

***Mesohabitat Types***. Instream habitat was evaluated at 16 stations (Table 7). The relative amounts of pool, riffle and run habitats present varied widely among sample stations, however, run habitat was by far the most common of the three mesohabitat types present in the watershed. Run habitat dominated all 16 stations including stations SHR210, SHR410, SHR412, GS100, CD47, and KC110, which were comprised entirely of run habitat. Station SHR110 was the only station with an appreciable mix of pool, riffle and run habitats.

***Thalweg Water Depth***. Average thalweg depths ranged from one foot at station UK100 to 3.7 feet at station SHR211. The maximum water depth exceeded two feet at all station ranging from 2.0 feet at station SHR412 to 8.7 feet at station SHR312. Water greater than four feet deep was found only at stations located Sand Hill River Reaches 1,2 and 3.

***Substrate particle composition***. Silt was dominant at eight stations including both stations in Sand Hill River reaches 1 (SHR110 and SHR111) and 4 (SHR410 and SHR412). The substrate at stations SHR410 and CD47 were comprised of 100% silt, while station SHR311 had the lowest proportion of silt (14%). Sand was the predominant substrate particle type present at four of the 16 habitat stations including: SHR210, SHR311, SHR312 and SHR511. Gravel was present at all stations except stations SHR410 and CD47 and was the dominant particle substrate size at all three stations located on Kittleson Creek (KC110, KC111 and KC112), as well as UK100. Cobble/rubble was present at seven stations; the highest percentage (8%) was found at station SHR311.

***Cover For Larger Fishes***. Fish cover was evaluated at 14 sample stations and is reported as the percentage of a station's total surface area covered by each cover type. Fish cover was limited to less than 2% at 8 of the 14 stations, including stations SHR512 and KC110 where there was no fish cover. Cover was greatest in stations SHR410 (95%) and SHR412 (90%); however, fish cover at each station was comprised entirely of submerged vegetation at both stations. Submerged vegetation provided no cover for larger fishes at 12 of the 14 stations where fish cover was measured. No cover was provided by emergent vegetation at any station and only one station, SHR311, had cover that was provided by overhanging vegetation. With the exception of station SHR311, boulders provided little or no cover for larger fishes in any station

Woody material providing fish cover was present at sample stations located in Sand Hill River Reaches 1,2 and 3, as well as KC111, KC112 and UK100. Stations in Sand Hill River Reaches 4 and 5, Garden Slough and CD47 had no measurable amount of woody fish cover. Among stations that contained woody material, the highest proportion of woody material as cover was found in station KC112 (2.8%).

**Table 7.** Summary of instream habitat characteristics within Sand Hill River watershed sampling stations. Substrate composition values may not sum to 100% as a result of value rounding.

| | Kittleson Creek | | | Garden Slough | County Ditch 47 | Unnamed Creek |
|---|---|---|---|---|---|---|
| | **KC110** | **KC111** | **KC112** | **GS100** | **CD47** | **UK100** |
| | | | **Mesohabitat Type Distribution (% of station)** | | | |
| Pool | | 17 | 1 | | | 8 |
| Riffle | | | 5 | | | 8 |
| Run | 100 | 83 | 94 | 100 | 100 | 84 |
| | | | **Thalweg Water Depth (ft)** | | | |
| Minimum | 1.3 | 1.2 | 0.9 | 0.2 | 0.9 | 0.4 |
| Average | 1.9 | 2.4 | 2.0 | 2.0 | 1.6 | 1.0 |
| Median | 1.8 | 2.4 | 1.8 | 2.2 | 1.6 | 0.9 |
| Maximum | 2.8 | 3.7 | 3.9 | 2.6 | 2.5 | 2.1 |
| | | | **Substrate Particle Composition (% of station)** | | | |
| Silt | 23 | 20 | 15 | 88 | 100 | 24 |
| Sand | 22 | 35 | 42 | | | 34 |
| Gravel | 44 | 46 | 43 | 5 | | 38 |
| Cobble/rubble | | | | 2 | | 4 |
| Boulder | | | | 5 | | |
| | | | **Cover for Larger Fishes (% of station)** | | | |
| Undercut Bank | | 1.1 | 6.6 | | | 2 |
| Boulders | | | | | | <0.1 |
| Overhang Veg. | | 0.2 | | | | |
| Submerged Veg. | | | | | | |
| Emergent Veg. | | | | | | |
| Woody Material | | 0.5 | 2.8 | | | 0.2 |
| Total Cover | none | 1.8 | 9.4 | N/A | N/A | 2.2 |

Table 7. (continued).

| | Sand Hill River | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Reach 1 | | Reach 2 | | Reach 3 | | Reach 4 | | Reach 5 | |
| | SHR110 | SHR111 | SHR210 | SHR211 | SHR311 | SHR312 | SHR410 | SHR412 | SHR511 | SHR512 |
| **Mesohabitat Type Distribution (% of station)** | | | | | | | | | | |
| Pool | 9 | 9 | | 4 | | 30 | | | | 9 |
| Riffle | 29 | | | 4 | 6 | | | | | |
| Run | 62 | 91 | 100 | 92 | 94 | 70 | 100 | 100 | | 91 |
| **Thalweg Water Depth (ft)** | | | | | | | | | | |
| Minimum | 0.5 | 0.6 | 0.9 | 2.9 | 1.1 | 1.2 | 1.5 | 0.7 | 1.4 | 1.3 |
| Average | 1.9 | 2.5 | 1.4 | 3.7 | 2.5 | 3.5 | 2.3 | 1.3 | 2.2 | 1.9 |
| Median | 2.1 | 2.6 | 1.6 | 3.6 | 2.5 | 3.1 | 2.2 | 1.0 | 2.2 | 1.9 |
| Maximum | 4.8 | 4.3 | 3.1 | 5.6 | 4.3 | 8.7 | 3.1 | 2.0 | 3.3 | 2.7 |
| **Substrate Particle Composition (% of station)** | | | | | | | | | | |
| Silt | 72 | 59 | 22 | 72 | 14 | 31 | 100 | 96 | 19 | 71 |
| Sand | 6 | 1 | 68 | 19 | 44 | 66 | | | 42 | 6 |
| Gravel | 21 | 25 | 9 | 8 | 13 | 4 | | 3 | 36 | 23 |
| Cobble/rubble | 1 | 3 | | | 8 | | | 1 | 3 | |
| Boulder | | 12 | | | 21 | | | | | |
| **Cover for Larger Fishes (% of station)** | | | | | | | | | | |
| Undercut Bank | | | | | | <0.1 | | | <0.1 | |
| Boulders | <0.1 | <0.1 | <0.1 | | 8.2 | | | | | |
| Overhang Veg. | | | | | 0.1 | | | | | |
| Submerged Veg. | | | | | | | 95 | 90 | | |
| Emergent Veg. | | | | | | | | | | |
| Woody Material | 0.5 | 0.1 | <0.1 | 0.2 | 0.9 | 1.7 | | | | |
| Other | <0.1 | | | | | | | | | |
| Total Cover | 0.5 | 0.1 | <0.1 | 0.2 | 9.2 | 1.7 | 95 | 90 | <0.1 | none |

# DISCUSSION

A limited amount of lakes and streams exist in the Sand Hill River watershed. However, the waters that do exist provide important habitat for all life stages of fish species found in the watershed. Significant stream resources include Sand Hill River and Kittleson Creek, which constitute the majority of perennial stream found in the watershed. Numerous small lakes exist in the north-central and western portions of the watershed including Sand Hill Lake, which is the largest lake in the watershed and the only one with a public access.

**Fish Community**

A relatively simple fish species assemblage currently exists across the Sand Hill River watershed. Nineteen of the thirty-six species known to have been sampled from waters in the Sand Hill River watershed between 1962 and 2004 (Appendix B, Table B1) were sampled during this investigation (Table 2). Many of the fish species known to occur but not sampled in this study, such as channel catfish, freshwater drum, goldeye and sauger were previously found in Sand Hill River Reaches 1, 2 and 3 downstream of the fish passage barriers (Huberty 1996, Huberty 2004). These areas were not sampled for this report.

A healthy stream fish community is comprised of a relatively high number of different fish species, a variety of year classes and life stages, and an abundance of fish. Based on these criteria, the health fish populations in the Sand Hill River watershed upstream from the fish passage barriers were generally fair, as indicated by IBI scores. However, fish communities at each station consistently showed a low proportion of simple lithophilic spawners that require clean substrates, a high proportion of tolerant individuals, low fish densities and an absence of piscivores.

Lithophilic spawners broadcast eggs into the water column when spawning and the eggs sink to the stream bottom where they settle into the interstitial spaces between substrate particles and develop. Lithophilic spawners that require cleans substrates are sensitive to environmental disturbance, particularly siltation (Ohio EPA 1987). Berkman and Rabeni (1987) found a significant inverse relationship between the number of lithophilic spawner species and the proportion of silt in riffles. The low proportions of lithophilic spawners found within fish sample stations indicates that spawning habitats for these species have been substantially degraded, compared to least disturbed reference conditions within the Red River basin (Niemela et al. 1998). This is likely a result of increased sediment inputs from both overland runoff and stream bank erosion.

Niemela et al. (1998) listed fifteen species known to increase in abundance as environmental disturbances, including water quality and habitat degradation, increase. Tolerant fishes dominated the catches at all six fish sample stations, which resulted in the lowest possible value for this IBI metric at each station. This indicates an elevated level of environmental disturbance compared to reference conditions within the Red River basin. Major contributors to disturbances include a general lack of habitat complexity (e.g., little or no cover, relatively homogeneous mesohabitat availability) and unstable stream channels, likely resulting from altered hydrologic regimes and excess sedimentation caused by land use practices, ditching and stream channelization.

Pioneer fish species are those that first colonize headwater stream sections after dewatering and tend to dominate unstable environments affected by human stresses. Therefore, a fish community characterized by a high proportion of pioneer fishes indicates an unstable or stressed environment. Greater than 40% of all the fishes sampled upstream of the fish passage barrier in Reach 3 were of pioneer species. Station SHR412 was comprised of the lowest proportion (31%) of pioneer species and station UK100 had the highest (59%). The pioneer metric score for pioneer species (5) given to stations SHR412 and SHR512 indicates that the number of pioneer fishes was not unusual, compared to other reference streams in the Red River basin. However, a score of 3 at UK100, KC111 and KC112, suggests that fish communities in these headwater stream segments are being stressed and it is likely that watershed land use practices are responsible.

A number of factors are negatively affecting stream fish communities. Perennial stream resources are limited within the watershed and stream channel alterations are common. Instream habitat is homogeneous, especially in segments with altered channels, and fish cover is limited. Sediment from surface runoff and stream bank erosion has degraded habitat quality in most, if not all, stream segments.

**Game Fish**

Angling opportunities in streams within the Sand Hill River watershed are currently limited to Reach 1 and the portion of Reach 2 located downstream of the fish passage barriers. No game fish species were captured in Reaches 3, 4 or 5 during the summer of 2005. In 1994, Huberty (1996) sampled Reaches 1,2 and 3 and found channel catfish only in Reach 1, one northern pike above and one below the fish passage barriers, and one largemouth bass above the barriers. Similarly, Hubery (2004) surveyed Reached 1,2 and 3 in the summers of 2002 and 2003 and the only game fish species he sampled were channel catfish and sauger, and these were found only downstream of the fish passage barriers.

The number and size distribution of channel catfish present in Reach 1 of Sand Hill River provides good channel catfish angling opportunities. The average catfish length captured in August of 1994 using trap nets was 12.9 inches (Huberty 1996) and the average length in 2003 using trap nets was 20.8 inches (Huberty 2004). Channel catfish exceeding 26 inches total length were caught during each of the two surveys. Pool and riffle habitats are available in Reach 1 and fish cover provided by woody material is common. These features, as well as connectivity to Red River, are beneficial not only to channel catfish populations but many other fish species as well.

Results of stream sampling conducted in the Sand Hill River watershed suggest that walleye and sauger inhabit Sand Hill River but their current distributions are limited to Reach 1 and the numbers of fish are low. Few records exist of either species being captured in the watershed. Koel (1997) reported that both walleye and sauger were sampled in Sand Hill River near its confluence with Red River between 1962 and 1977 and Huberty (2004) captured three sauger downstream from the fish passage barriers in Reach 2. Historically, northern pike have been found in all portions of Sand Hill River (Koel 1997), however, recent sampling efforts suggest that they are currently found primarily downstream of the fish passage barriers (Huberty 1996 and Huberty 2004).

Efforts are currently underway to modify the barriers in Reaches 2 and 3 to allow for fish passage. Elimination of these barriers would allow many different species, including channel catfish, walleye, sauger and northern pike, to access Sand Hill River upstream of the passage barriers. This would increase angling opportunities much farther upstream than currently exists. Fish populations should be monitored in order to track upstream expansion resulting from fish passage barrier removal efforts.

**Fish Species of Special Interest**

*Common Carp.* Common carp (carp) have been well established in the Red River basin since the 1930's (Aadland et al. 2005). However, carp numbers appear to be consistently low in Sand Hill River and their distribution limited to below the fish passage barriers in Reach 2. No carp were sampled upstream of the barriers in 1994 (Huberty 1996), 2003 (Huberty 2004) or in this survey. Only one carp was sampled below the fish passage barriers in 2003 (Huberty 2004) and no carp were sampled below the barriers in 1994 (Huberty 1996). Plans to restore fish passage through Reach 2 could expand carp distribution into the upstream portions of the watershed. Carp distribution expansion could impact other species by increasing suspended sediment during feeding, uprooting aquatic vegetation and predation on fish eggs and larvae. If these impacts occur, they would most likely take place in Sand Hill River Reach 4, which flows through a large wetland and in tributary streams that flow through wetlands, such as Garden Slough.

**Stream Morphology And Stream Stability**

All 16 stream morphology stations in the Sand Hill River watershed are very sensitive to disturbance (i.e., changes in hydrology and sediment supply); 13 of these have high erosion potential (Table 8). The combination of stream vulnerability to disturbance and watershed-wide existence of factors negatively impacting stream channels was reflected in the poor channel stability found at the majority of the stations.

**Table 8.** Management interpretations of various stream types (*from:* Rosgen 1996)

| Stream Type | Sample Stations | Sensitivity to Disturbance | Recovery Potential | Sediment Supply | Stream bank Erosion Potential | Vegetation Controlling Influence* |
|---|---|---|---|---|---|---|
| C5 | SHR312 | Very high | Good | High | Very high | Very high |
| C6 | SHR410, SHR412, GS100 | Very high | Good | High | High | Very high |
| E5 | SHR511, KC112 | Very high | Good | Moderate | High | Very high |
| E6 | SHR111, SHR211, SHR512 | Very high | Good | Low | Moderate | Very high |
| F5 | SHR210, SHR311, UK100 | Very high | Poor | Very high | Very high | Moderate |
| F6 | SHR110, CD47 | Very high | Fair | High | Very high | Moderate |
| G5 | KC110, KC111 | Extreme | Very poor | Very high | Very high | High |

* Vegetation that influences width-to-depth ratio stability

Stream channel manipulation and land use practices have altered and destabilized many waterways in the Sand Hill River watershed. According to MN DNR's hydrography data (MN DNR GIS dataset 2005), approximately 46% of the waterways in the Sand Hill River watershed are either ditches or channelized stream segments, the majority of which lie in the fertile agricultural lands of the Glacial Lake Agassiz bed. The least amount of ditching has occurred in the streams lying within the hummocky portions of the Eastern Broadleaf Forest Province ecoregion, where few waterways are ditches, likely because of the hummocky topography associated with glacial moraine. Many of the smaller stream tributaries in the watershed with intermittent or ephemeral flows have been directly modified and are being farmed. Approximately one-third of the waterways in the eastern half of the watershed are ditches, most of which are small, intermittent ditches draining relatively small areas. The cumulative effects of channelization and ditching have increased sediment loads and altered the hydrology of downstream segments, which is destabilizing the channels.

Reduction or removal of riparian areas is also common in the Sand Hill River watershed. Little or no buffer exists between many waterways and agricultural land. Healthy riparian areas can reduce the impacts of agricultural activities on stream stability by reducing sediment inputs, reducing bank erosion and slowing storm water runoff. Stream segments without functional riparian "buffers" are more susceptible to erosion and sediment yields are generally higher compared to those with functional buffers.

**Instream Habitat**

The Sand Hill River watershed has the potential to provide important spawning and rearing habitat for both migratory and resident fish populations. Several streams in the watershed could provide such habitats, especially where streams pass through the beach ridge area of Glacial Lake Agassiz. An appreciable amount of cobbles and/or gravels were present at stations SHR111, SHR311, SHR511, all three stations in Kittleson Creek, and in UK100, which could potentially provide spawning habitat for species that require clean gravel or rocky substrates such as walleye or sauger. Although these streams have the potential to provide high quality habitat for species that require coarser substrates, stream channel instability and high sediment loads are reducing both habitat quantity and quality. Habitats for species that require larger rock substrates for spawning, such as lake sturgeon, are most likely to be found in the downstream portion of Reach 3, however, it is unlikely that there are substantial amounts of these habitats available.

Lowland areas susceptible to flooding and seasonal watering provide northern pike spawning and rearing habitat. Sand Hill River Reach 4 flows through a wide valley with a substantial amount of wetland, which has the potential to provide high quality northern pike spawning habitat. Garden Slough is also a larger wetland and could provide northern pike spawning habitat as well.

Little is known about natural reproduction of channel catfish in Sand Hill River watershed streams and no evidence of channel catfish reproduction was found during this survey. Efforts to describe natural reproduction trends for walleye, northern pike, and channel catfish and to identify factors limiting natural reproduction of these important game species should be considered. The fish passage barriers in Reached 2 and 3 prevent many fish species from accessing some of the best spawning habitat available in the watershed. Activities designed to alleviate these barriers should be among the highest fisheries restoration priorities in the watershed.

Habitat complexity is an important factor influencing fish community composition. Generally, stream segments containing a wide variety of depths, velocities, substrate particle sizes and cover types have a higher probability of supporting a healthy fish community than stream segments lacking variety in these features. Stream fish habitat throughout the watershed can be described as very simple. Cover for larger fishes was scarce with the exception of stations SHR410 and

SHR411 where submerged vegetation was prominent. Woody material, known to be an important instream feature for fishes and macroinvertebrates, was lacking at all stations. Riffle and pool habitats were of limited availability and silt, sand, and clay particles overwhelmingly dominated the stream bottom at most locations. Stream restoration efforts designed to achieve a more natural hydrograph, stabilize stream channels, reduce surface runoff and increase the amount of woody fish cover would increase the complexity and quality of instream habitat, which would result in healthier fish communities across the watershed.

**Hydrology**

The annual hydrograph of a stable, natural stream exhibits a peak spring discharge and relatively stable base flows. These characteristics, along with a floodplain sufficient to attenuate high discharges during storm events, provide a variety of conditions and habitats throughout the year, which promotes healthy fish communities. Hydrology throughout the Sand Hill River watershed has been altered by changes in land use and drainage patterns. Extensive ditching and channelization, and intensive agricultural activities have altered the natural hydrograph of most streams in the watershed. The typical result of these activities is to make stream flows more "flashy." That is, accelerated runoff causes peak discharges from storm events to arrive faster and have a higher discharge than would occur naturally occur. Also, the amount of water available to maintain base flows during the drier times of the year is reduced because the water leaving the system as runoff is no longer available to percolate into the soil and recharge the groundwater resources. Altering a hydrologic regime in this way reduces instream habitat quality by destabilizing stream channels, reduces base flows and changes the availability of different habitat types, which adversely affects aquatic communities. The bankfull discharge is the stage at which a stream begins to access its floodplain and it is at these flow levels where the major channel forming processes occur. Bankfull flows are important for maintaining channel stability and for providing habitat diversity (Harvey et al. 1997). Restoring the flow regimes of many of the streams in the watershed to more natural conditions would, eventually, stabilize stream channels and provide instream conditions conducive to healthy stream communities.

The current method for determining the protected low flow value is to use the Q90, defined as the stream discharge that statistically is exceeded 90% of the time during the period of record analyzed. The Q90 is an extremely low flow and offers inadequate instream flow protection (MN DNR Waters 2005, Olson et al. 1988, Harvey et al. 1997). The protected flow value of nine cubic feet per second in Sand Hill River offers very little protection for the aquatic community and provides little habitat diversity. The Instream Flow Incremental Methodology (IFIM; Bovee 1982) is a widely used method for addressing instream flow issues that combines hydraulic simulation procedures with the habitat requirements of the aquatic community. The results provide quantitative relationships between stream flow and habitat, and these relationships are used to determine appropriate stream flows for protecting aquatic resources A good example of this is the work done in the Red Lake River watershed by Harvey et al. (1997). IFIM methodologies should be used to determine future designated minimum flow values.

**Dams and Fish Passage Barriers**

Dams interrupt stream connectivity and often times act as fish passage barriers. There are at least seven dams in the Sand Hill River watershed, six of which are fish passage barriers including the four "drop structures" located in Reach 2, the "sloped culvert" located in Reach 3, and the Sand Hill Lake outlet structure. In addition, the "Texas crossing" located in Sand Hill River Reach 2 is also a fish passage barrier for a total of seven fish passage barriers on Sand Hill River. Work by Huberty (2004) demonstrated definitively that the structures in Sand Hill River Reaches 2 and 3 are barriers to fish passage. Huberty (2004) sampled a total of 23 species using trap nets and electrofishing in 2002 and 2003. Eleven (11) of the 23 species, most of which were larger riverine species including: common carp, channel catfish, freshwater drum, golden redhorse, goldeye, quillback, rock bass, sauger, shorthead redhorse, stonecat and trout perch were only found downstream of the structures. Huberty also found 5 species upstream of the structures that were not found downstream including: brown bullhead, western blacknose dace, blackside darter, central mudminnow, and johnny darter. A cooperative effort headed by the Sand Hill River Watershed District to modify these structures to allow for fish passage is currently underway. Current plans are to place rock weirs downstream of the structures, which would transform the passage barriers into riffles with a 5% slope and, thus, eliminating the passage barrier and restoring river connectivity.

Goals of this survey were to evaluate the general health and condition of streams and stream fish populations, and to identify opportunities to restoration and/or enhancement. The potential exists to greatly enhance the fisheries resources in the watershed. A number of factors relating to land use and stream channel alteration (e.g., row crop agriculture, channelization, ditching) have been responsible for decreased fish community health, lower quality instream habitat and stream instability problems. There is likely a multitude of opportunities to improve the condition of the stream resources in the Sand Hill River watershed. Restoring the hydrograph to of a more natural shape is likely the most effective approach to improving stream stability, instream habitat and the health of the biological community. Bankfull discharges are the primary channel forming flows and are critical to the maintenance of restored channels. Restoration of natural bankfull discharges into the original channels would not only benefit fisheries and wildlife, but would help to stabilize the overall hydrology of the entire system as well.

## RECOMMENDATIONS

The streams in the Sand Hill River watershed have the capacity to provide a variety of high quality habitats for fish and other animals. Hydrologic conditions and unstable channels limit many stream reaches from achieving their potential. The recommended activities listed below will help improve the quality of waterways and the condition of aquatic communities in the Sand Hill River watershed. Activities should be implemented progressing from upstream to downstream whenever possible.

**Habitat Protection and Enhancement**

- Remove or modify dams and culverts that are acting as fish passage barriers including, but not limited to: the Texas crossing, four drop structures and sloped culverts located in Sand Hill River Reaches 2 and 3 downstream from Fertile.
- Re-establish natural functioning stream channels wherever possible using natural channel design principles.
- Consider opportunities and options to augment base flows and attenuate peak flows in streams throughout the watershed to attain more natural hydrographs.
- Stop or mitigate future activities that will continue to disrupt hydrology (e.g., drainage, tiling, etc).
- Implement agricultural Best Management Practices (BMPs) to reduce erosion and sedimentation, and to facilitate natural channel evolution.
- Establish and/or protect riparian corridors along all waterways, including ditches, using native vegetation whenever possible.
- Define areas critical for sustaining base stream flows.
- Use seasonal aquatic community based IFIM methodologies, such as those used by Harvey et al. (1997) on Clearwater and Red Lake rivers, to develop protected stream flows within the Sand Hill River watershed.
- Increase habitat complexity in stream segments throughout Sand Hill River.
- Work with appropriate entities to alleviate water quality problems that may be affecting aquatic communities.
- Encourage the accumulation of woody material in streams to enhance habitat.
- Use the American Fisheries Society guidelines (AFS 1983) when identifying stream obstructions and prescribing a corrective course of action.

**Data and Monitoring**

- Monitor the effects of dam removal projects on fish communities and individual species populations.
- Identify and protect important stream spawning locations and enhance the quality of habitat in these locations when possible.
- Track land use changes in the watershed, particularly continuous sign-up CRP and CREP lands.
- Monitor the potential expansion of common carp populations throughout the watershed.
- Survey culverts in the basin (dimensions and slope).
- Conducted spring trap net surveys in the watershed to assess northern pike and walleye spawning runs.
- Conduct pre- and post-monitoring of approved NRE and FDR projects.

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