CHUB CREEK WATERSHED ASSESSMENT

FINAL REPORT

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Prepared for:
North Cannon River Watershed Management Organization

Funded by:
Minnesota Board of Water and Soil Resources

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EXECUTIVE SUMMARY

The Chub Creek Watershed Assessment is an initiative of the North Cannon River Watershed Management Organization and the Dakota County Soil and Water Conservation District (SWCD). With funding from these two organizations and a grant from the Minnesota Board of Water and Soil Resources, the project started in the spring of 1999. The project objectives included to (1) quantitatively determine the overall health of the Chub Creek Watershed, (2) identify and prioritize resource management objectives, and (3) outline appropriate best management practices (BMPs) necessary to restore the resource. Water quality and quantity monitoring and landcover mapping by the SWCD continued through the fall of 2000. A citizen's group was established and periodic meetings were held to discuss the progress of the project and seek input on local concerns in the watershed.

In general, the health of the watershed could be described as "fair" to "good," meaning the aquatic and natural ecosystems are not functioning as well as they could be, but they are not so degraded that they are completely undesirable to wildlife, aquatic life, and citizens. There is evidence of a naturally reproducing population of northern pike, many sites possess macroinvertebrates (bugs) that indicate good water quality and habitat, and there are areas of large natural buffers and wetlands. However, there are also concerns throughout the watershed including very high levels of fecal coliform bacteria and elevated levels of ammonia, nutrients, and solids during runoff events that wash soil and other pollutants off the land. The watershed has also been subject to alteration in the way of wetland drainage and stream channelization which destroys habitat and increases water volume and erosion potential.

There are countless ways in which these concerns can be minimized. Local units of government, the North Cannon River Watershed Management Organization, and individual landowners, in cooperation with local, state, and federal agencies, can use best management practices and land protection and restoration actions to help enhance the natural resources within the Chub Creek watershed.

I. Project Objectives

The Chub Creek Watershed Assessment Project was designed to (1) quantitatively determine the overall health of the Chub Creek Watershed, (2) identify and prioritize resource management objectives, and (3) outline appropriate best management practices (BMPs) necessary to restore the resource. The project also helps to understand how local citizens feel about the quality of surface water in their area, and establish a baseline of information so trends in water quality and watershed health can be tracked as the watershed develops, landuse and best management practices change, and weather patterns change.

To meet these goals, the project partners set out to accomplish several tasks:

- in-stream water quality and quantity monitoring
- in-stream assessment
- macroinvertebrate sampling
- fish surveys
- landuse/landcover assessment using GIS mapping and modeling
- public participation and education
- implementation plan preparation

Ultimately, the project lays the foundation for the North Cannon River Watershed Management Organization's (NCRWMO) second generation 509 watershed management plan, which is scheduled for completion by January 2003.

II. Project Partners and Funding

Many agencies and organizations came together to support this project. Project partners included:

- Watershed Citizens
- North Cannon River Watershed Management Organization (NCRMWO)
- Cannon River Watershed Partnership (CRWP)
- Dakota County Office of Planning
- Dakota County Parks Department
- Dakota County Soil and Water Conservation District (SWCD)
- Dakota County Environmental Education Program (DCEEP)
- Rice County
- Rice County Soil and Water Conservation District
- Minnesota Board of Water and Soil Resources (BWSR)
- Minnesota Pollution Control Agency (PCA)
- Minnesota Department of Natural Resources (DNR)
- Natural Resources Conservation Service (NRCS)

The project was funded by a grant from the BWSR to the NCRWMO with cash and in-kind services coming from the NCRWMO, SWCD and others (Table 2-1).

Table 2-1. Chub Creek Watershed Assessment Project Funding

Organization	Contribution
Minnesota Board of Water and Soil Resources	$30,000 Challenge Grant
North Cannon River Watershed Management Organization	$20,000 Cash
Dakota County Soil and Water Conservation District	$10,000 Cash
Dakota County Soil and Water Conservation District	$27,000 In-kind
Cannon River Watershed Partnership	$1,000 Cash
Cannon River Watershed Partnership	$4,500 In-kind
Dakota County Parks	$6,000 In-kind
Dakota County Environmental Education Program	$6,000 In-kind
Natural Resource Conservation Service	$6,600 In-kind
Rice County Soil and Water Conservation District	$2,400 In-kind
TOTAL PROJECT BUDGET	**$113,500**

Additional agencies such as the Pollution Control Agency and the Department of Natural Resources also contributed many hours of staff time and travel expenses to the project.

A citizen advisory committee, termed the Chub Advisory Team (or ChAT), was established in March, 1999 with a "kick-off" meeting attended by over 40 citizens of the watershed. Subsequent meetings (9 total) were held with approximately 10 attendees on average. These meetings kept interested citizens informed on the project's progress and allowed them to discuss the issues that most concerned them.

Many citizens also participated in the project by volunteering to collect data and water samples from the creek, its tributaries, and Chub Lake. The information and assistance from these dedicated individuals was an important piece of the overall project!

A technical advisory committee was established early in the project and included representatives from each of the partners listed above. This committee met on two different occasions to lend technical advice and expertise to various project components. Technical assistance was also sought from many of the partners individually as questions arose.

III. Watershed Characteristics

General

The Chub Creek Watershed covers approximately 53,821 acres or 84 mi^2 in southwestern Dakota County, Minnesota with portions in far southeastern Scott County and northcentral Rice County (Figure 3-1). The watershed contains eight townships, the small city of Randolph, and the major road corridors of State Highway 3, County State Aid Highways 47 and 23, and Interstate Highway 35 (Figure 3-2). The average elevation of the watershed is 982.4 ft above sea level with a maximum elevation of 1,200 ft. in Section 35 of New Market Township and a minimum elevation of 860 ft. in Section 8 of Randolph Township. In general, the western portion of the watershed is higher in elevation and contains more topographic relief than the eastern portion of the watershed (Figure 3-3).

Although most of the watershed remains rural and agricultural in nature, development pressure from the Twin Cities metropolitan area is expected to become stronger in the coming years as the major road corridors develop.

Landuse

The dominant landuse in the Chub Creek Watershed is agriculture (Table 3-1, Figure 3-4). Row crops, alfalfa fields, sod farms, dairy farms, and horse farms make up the majority of the farming in the area. Less than 10% of the watershed is wetlands, and 9% of the land is used for farmsteads, residential areas, commerce, industry, and transportation.

Table 3-1. General landcover in the Chub Creek Watershed

Landcover	Acres	Percentage of Watershed
Cropland (row crops, sod farms, alfalfa fields, vegetable crops)	33,786	63%
Wetlands	5,111	9.5%
Farmsteads/Residential/Commercial/Industrial/Roads/RRs	4,864	9%
Forests/Woodlands	3,394	6%
Vegetated Agriculture (tree farms, hay fields, pasture)	3,385	6%
Open Lands (shrubland, grassland, sparse trees)	2,593	5%
Surface Water (creeks, lakes)	502	1%

Hydrologic Features

As noted in Table 3-1, surface water, such as creeks, lakes, and wetlands cover approximately 10.5% of the watershed. Water falling on the remaining 89.5% of the watershed drains into these waterbodies and makes its way to the Cannon River and eventually to the Mississippi River and the Gulf of Mexico (see sidebar) or into the groundwater. The mainstem of Chub Creek is 22.7 miles in length, while its tributaries Dutch Creek, Mud Creek, and the North Branch of Chub Creek are 9.3, 7.0, and 8.6 miles in length, respectively. Many other small tributaries and ditches – both perennial (constantly flowing) and intermittent (not always flowing) also run into Chub Creek for a total of 169 miles of stream channels in the watershed (Figure 3-5).

The hydrology of the Chub Creek watershed has changed substantially since Europeans began settling the area. An estimated 50% of the wetlands have been lost due to draining or filling, primarily for agricultural use. The watershed now has approximately 5,111 acres of wetland. Historically, many natural streams were straightened and many new ditches were created in an effort to move water away from wetlands. These changes impact the streams by forcing them to carry more water more quickly than nature intended carrying more pollutants causing streambank erosion and sedimentation.

Another man-made alteration occurred at the outlet of Chub Creek. The creek now empties into the Cannon River at Hwy. 56, just upstream of Lake Byllesby. Historically, however, the creek emptied directly into Lake Byllesby. The creek's channel was altered when Hwy. 56 was built in the 1950's (Figure 3-6). The wetlands and "backwaters" that were once associated with the outlet of Chub Creek into the lake were excellent spawning grounds for northern pike and other gamefish. The dike placed to redirect the creek's flow has been eroding away for decades as the creek tries to

EFFECTS OF THE MIDWEST IN THE GULF OF MEXICO

There is a hypoxia problem in the Gulf of Mexico and it begins in Minnesota. Hypoxia means an absence of oxygen reaching living tissues. In coastal waters, it is characterized by such low levels of dissolved oxygen that fish and other aquatic species cannot survive in the affected area.

Excessive nutrients traveling down the Mississippi River are the main cause of the hypoxic area - which sometimes is the size of New Jersey. Algae take advantage of the overabundance of nutrients by quickly multiplying. As the algae decays, huge amounts of oxygen are consumed leaving less and less for fish and other organisms. Research on the causes and effects of increased nutrients in the Gulf is ongoing. However, excess nutrients are known to come from a wide range of sources including runoff from developed land, atmospheric deposition, soil erosion, agricultural runoff, sewage, and industrial discharges. Research indicates that land use practices in the Midwest contribute largely to the uninhabitable area in the Gulf of Mexico.

Other historical, anecdotal evidence suggests that the creek once supported large populations of crappies, sunfish, northern pike, and bass. Fishing was so good that landowners would often charge parking fees and set up bait stands near the best fishing holes.

Soils

The soils of the Chub Creek Watershed can be characterized by dividing the region into two separate areas: the upper watershed and the lower watershed. The upper watershed consists of the watershed area that lies within New Market Township, Webster Township, Eureka Township, and the western half of Greenvale Township. The lower watershed consists of the watershed area that lies within the eastern half of Greenvale Township, Castle Rock Township, Waterford Township, Sciota Township, Randolph Township, and the City of Randolph.

The upper watershed is composed of an even distribution of well-drained and poorly-drained glacial till soils. The well-drained soils are found on the sloping and steep areas, while the poorly-drained soils can be found on the level and depressional areas. Textures of the soils in the upper watershed are primarily organic loams, sandy loams and clay loams (Figure 3-7). The permeability of these soils is moderately high and the runoff potential is low. Only 9.7% of the soils in the Chub Creek Watershed are classified as having a high runoff potential (Figure 3-8). The increased amount of coarse soil particles in the upper watershed enhances this area's permeability compared to the heavier clay soils found in the lower watershed. Hydric soils are typically found where permeability is low, drainage is poor, and/or groundwater is at or near the surface. Thirty four percent of the soils in the entire Chub Creek Watershed are classified as "hydric" (Figure 3-9). Hydric soils are prevalent in the upper watershed, but the region's distinct elevation changes cause the hydric soils to be confined to small scattered areas compared to the large level hydric soil areas found in the lower watershed. The soils of the upper watershed have a moderately high susceptibility to sheet and rill water erosion due to their texture, slope, and permeability. Only 9% of the Chub Creek Watershed is defined as "Highly Erodible Land" (HEL), but an overwhelming majority of the HEL soils within the watershed are concentrated in Webster and New Market Townships and along the banks of Chub Lake (Figure 3-10) because of the steep slopes found in those areas.

In the lower watershed, Castle Rock Township has large areas of well-drained to excessively-drained soils, but the majority of the lower watershed is characterized by somewhat poorly-drained to poorly-drained soils. The majority of the soils in the lower watershed were formed from glacial till and glacial outwash and have a clay loam texture. However, a substantial amount of sandy loam soils that were formed from bedrock parent material can be found on the eastern edge of the watershed (Figure 3-7). The permeability of the soils in the lower watershed is moderately high with low runoff potential (Figure 3-8). Waterford Township and the eastern half of Greenvale Township have large areas of poor drainage and low permeability classified as hydric soils (Figure 3-9). The remainder of the lower watershed has hydric soils only along the edges of Chub Creek and the North Branch of Chub Creek. Scattered areas of HEL soils can be found in the steepest areas of Castle Rock and Sciota Township, but overall the lower watershed has very little HEL soils (Figure 3-10) and the soils have a low susceptibility to sheet and rill water erosion because of the region's gradual and nearly level slopes (Figure 3-3).

Biological Features

Pre-settlement vegetation in the Chub Creek Watershed was dominated by prairie, oak openings and barrens, and wetlands (Figure 3-11). Today, biological features in the watershed include Chub Lake and its surrounding wetlands and woodlands (see sidebar). Other significant natural communities include oak forests and wet meadows (Figure 3-12). According to the DNR, there are also many endangered or threatened species or species of concern documented in the watershed. These include the birds loggerhead shrike (*Lanius ludovicianus*) and upland sandpiper (*Bartramia longicauda*), the Blandings turtle (*Emydoidea blandingi*), and the plants rattlesnake master (*Eryngium yuccifolium*), a member of the parsley family, long-bearded hawkweed (*Hieracium longipilum*), lilia-leaved twayblade (*Liparis lilifolia*), valerian (*Valeriana edulis*), American ginseng (*Panax quinquefolius*), big tick-trefoil (*Desmodium cuspidatum*), cowbane (*Oxypolis rigidior*), and small white lady's slipper (*Cypripedium candidum*) (Figure 3-12).

GRASSROOTS ACTION SAVES RARE PROPERTY ON CHUB LAKE

On July 15, 2000, over 100 people gathered to celebrate the success of a two-year effort in fund raising and partnership among local citizens, governments, and the Department of Natural Resources (DNR). The effort culminated in the purchase of 192 acres of hardwoods, wetlands, and grasslands at the southern end of Chub Lake in Eureka Township that were close to being developed into a golf course and townhomes. Now, the area will be open to the public as a DNR wildlife management area in perpetuity thanks to the dedication and generosity of many donors and grants. The area is home to several rare and threatened species as well as deer, turkey, herons, egrets, pheasants, and many other species of wildlife and plants.

IV. Project Methods

Monitoring Sites

In the spring of 1999, six sites were identified throughout the watershed (Figure 3-2, Table 4-1) for water quality and quantity monitoring and biological monitoring. Two of the sites also included tipping bucket rain gauges to measure rainfall amounts and intensity. All six sites were placed in accessible locations that would give an indication of water quality and quantity for a particular sub-watershed or portion of the mainstem.

Table 4-1 Location of Water Quality and Quantity Monitoring Sites

Site Name	Site Location	Reason for Location
CHB23	Chub Creek Mainstem at Hwy. 23	Upstream, gives an indication of water condition from Chub Lake area and Rice County area; included rain gauge
CHB3	Chub Creek Mainstem at Hwy. 3	Middle of the watershed, gives an indication of water condition between Hwy. 23 and Hwy. 3
CHB47	Chub Creek Mainstem at Hwy. 47	Just downstream of confluence with N. Branch, subtracting N. Br. influence gives an indication of water condition between Hwy. 3 and Hwy. 47
CHBRD	Chub Creek Mainstem on James Ferguson property in City of Randolph	Near the outlet of Chub Creek just upstream of confluence with Cannon R.
MUD3	Mud Creek at Hwy. 3	Near outlet of Mud Creek, gives an indication of water condition in Mud Creek watershed
NB47	North Branch Chub Creek at 290th St. just off Hwy. 47	At the outlet of the North Branch, gives an indication of water condition in N. Branch watershed; included rain gauge

Water Quality and Quantity Monitoring

At each of the six sites monitoring equipment was installed in April and May of 1999, removed in October for the winter, and re-installed at the same sites in March of 2000. Water quality and quantity monitoring occurred spring through fall of 1999 and 2000.

Monitoring equipment was installed to record the water's depth (or stage) every 15 minutes with a pressure-sensitive transducer placed near the stream bottom and attached to a staff gauge. The transducer's cable was laid on shore and attached to a datalogger, or small computer, which recorded the information (Figure 4-1).

The amount of water flowing (flow) at each site was measured in the stream using a hand-held pygmy flow meter and wading rod. This instrument has small cups that spin in the current and give a velocity reading. The velocity is measured at regular intervals across the width of the stream and used to calculate flow in cubic feet of water per second (cfs). Flow was measured at each site several times during the two monitoring years at various stream stages. Using statistical regression equations between simultaneous stage and flow measurements, the flow for each station was calculated for the entire time the monitoring equipment was in place.

Water quality at each site was measured in a variety of ways both during periods of low flow when precipitation snowmelt was not influencing the stream, and during rainfall and snowmelt "events" when runoff from the land was reaching the stream. Water samples were taken as one-time "grab" samples, chilled, and transported the same day to the state certified Metropolitan Council Environmental Services Laboratory in St. Paul for analyses. Samples were typically analyzed for total volatile and total suspended solids, total phosphorus, soluble phosphorus, total Kjeldahl nitrogen, ammonia nitrogen, alkalinity, pH, and conductivity.

Loadings, or the total amount of a substance moving through the stream at a given time, were calculated for each substance using the software program "FLUX".

Citizen volunteers also regularly monitored creeks in the watershed through the Minnesota Pollution Control Agency's Citizen Stream Monitoring Program. They collected data including rainfall, water transparency using a transparency tube, and other observational information.

Bacteria Monitoring

Fecal coliform bacteria are found in the digestive tracts of warm-blooded animals and aid in the breakdown of food. Thus, they are also found in the feces of humans and other animals. Fecal coliform can enter a river through direct discharge from mammals and birds, from agricultural and stormwater runoff, and from untreated human sewage of failing septic systems.

Fecal coliform are indicator organisms and are not themselves harmful. Water is tested for these bacteria because it is a safe, inexpensive way to determine if other, harmful bacteria may be present. If fecal coliform counts are high (over 200 colonies /100 ml of water sample), it is likely that pathogenic organisms are also present. Diseases and illnesses such as typhoid fever, dysentery, and others may result from contact with water having pathogenic organisms.

In 1999, water quality samples were taken from the six monitoring stations indicated that Chub Creek and its tributaries had elevated levels of fecal coliform, especially after rainfall events. In 2000, more intensive fecal coliform monitoring was performed in order to determine if the creek and/or tributaries should be listed on the Clean Water Act's 303(d) list of impaired waters. (If a waterbody is listed as being impaired, there is the possibility of receiving funding from the U.S. EPA and the Minnesota PCA to calculate a total maximum daily load and implement plans to alleviate the problem.) In 2000, five samples were taken each month, May through September, and a geometric mean for bacteria was calculated for each site. Three watershed citizens and a Dakota County Parks employee helped to collect weekly fecal coliform samples from the various sites and delivered them to nearby lab pick-up points. State-certified labs such as the Minnesota Valley Testing Lab and the Metropolitan Council Environmental Services Lab performed the fecal coliform analyses.

Biological Monitoring

Biological monitoring is often considered a better indicator of stream health because it assesses the health of the biological communities that depend on the quality of the water. Aquatic organisms integrate the effects of various stressors and thus reflect current conditions as well as changes over time and cumulative effects. Benthic macroinvertebrates (bugs that live on the bottom of the stream) are often collected, counted, and identified. Because certain types of bugs can tolerate different levels of water quality, this information is used to calculate an index of biotic integrity or a score that reflects stream health. Habitat characteristics such as the size of the rocks in the stream, water depth and flow, the amount of sunlight reaching the stream, and streambank erosion, are also measured and ranked.

In October 2000, benthic macroinvertebrates were collected from each of the six monitoring sites. Bugs were collected by kicking and disturbing the rocks and cobble in the streambed and catching the dislodged bugs in a net placed just downstream (Figure 4-2). At each site, three separate kick samples were collected, put in jars, and preserved in alcohol.

Samples were taken back to the office where the macroinvertebrates were identified to family, counted, and used to calculate various indices of biotic integrity including the family biotic index, the ephemeroptera, plecoptera, trichoptera index (EPT), and the total number of families. These indices are described below.

Family Biotic Index (FBI)

This index summarizes the various pollution tolerance values of all macroinvertebrate families in a sample. FBI ranges from 0 to 10, with lower values reflecting higher water quality. Each macroinvertebrate family has a unique pollution tolerance value associated with it. Pollution intolerant families such as stoneflies can only survive in excellent water quality. Pollution tolerant organisms such as leeches and aquatic worms can live in poor quality water. According to Hilsenhoff, who developed this metric, "Use of the FBI is advantageous for evaluating the general status of organic pollution in streams within a watershed for the purpose of deciding which streams or watersheds should be studied further."

Evaluation of water quality using Hilsenhoff's Family Level Biotic Index

Family Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.75	Excellent	Organic pollution unlikely
3.76-4.25	Very good	Possible slight organic pollution
4.26-500	Good	Some organic pollution probable
5.01-5.75	Fair	Fairly substantial pollution likely
5.76-6.50	Fairly poor	Substantial pollution likely
6.51-7.25	Poor	Very substantial pollution likely
7.26-10.0	Very poor	Severe organic pollution likely

EPT

This index uses the number of mayfly (**E**phemeroptera), stonefly (**P**lecoptera), and caddisfly (**T**richoptera) families in the sample. These families represent the pollution intolerant insects. A higher EPT score reflects better water quality than a lower one. The national EPT standard is between 10-12 different families.

Number of Families

This index uses the number of different benthic macroinvertebrate families found at the site. In general, more diversity is better. Therefore a larger number of families reflects a healthier community than a smaller number.

Habitat characteristics were also measured at each site during macroinvertebrate collections and used to calculate a "habitat score." This score reflects the suitability of a site to host invertebrates regardless of water quality. Ideal stream habitat includes things such as a rocky bottom with low sedimentation and good water flow. Twelve habitat characteristics are examined in the field and rated on a scoring worksheet. A higher habitat score reflects better quality habitat than a lower one.

Fish were also collected at various points along the Chub Creek mainstem in May 2000 by the Minnesota Department of Natural Resources (DNR), and again in October 2000 at many points throughout the watershed by the DNR and the SWCD working together (Figure 4-3). The fish were seined, species and relative abundance were recorded for each site, and the fish were released back into the stream.

Landcover Mapping

Landcover describes the vegetation, water, natural surface, and cultural features on the earth's surface. The Minnesota Land Cover Classification System (MLCCS) was used to create a computerized geographic information system (GIS) of the landcover in the Chub Creek Watershed with a hierarchical design containing five levels of detail. Landcover was interpreted and drawn as polygons (various shapes) using 1997 aerial photographs. This information was then field-checked and digitized or drawn in a computer mapping program. Landcover data can be used to determine things like the total acreage of soybean fields, the average width of natural vegetation along a stream, or the acreage of wetlands in a certain sub-watershed, to name a few. The data can also be used in conjunction with water quality data to determine areas in need of protection and restoration.

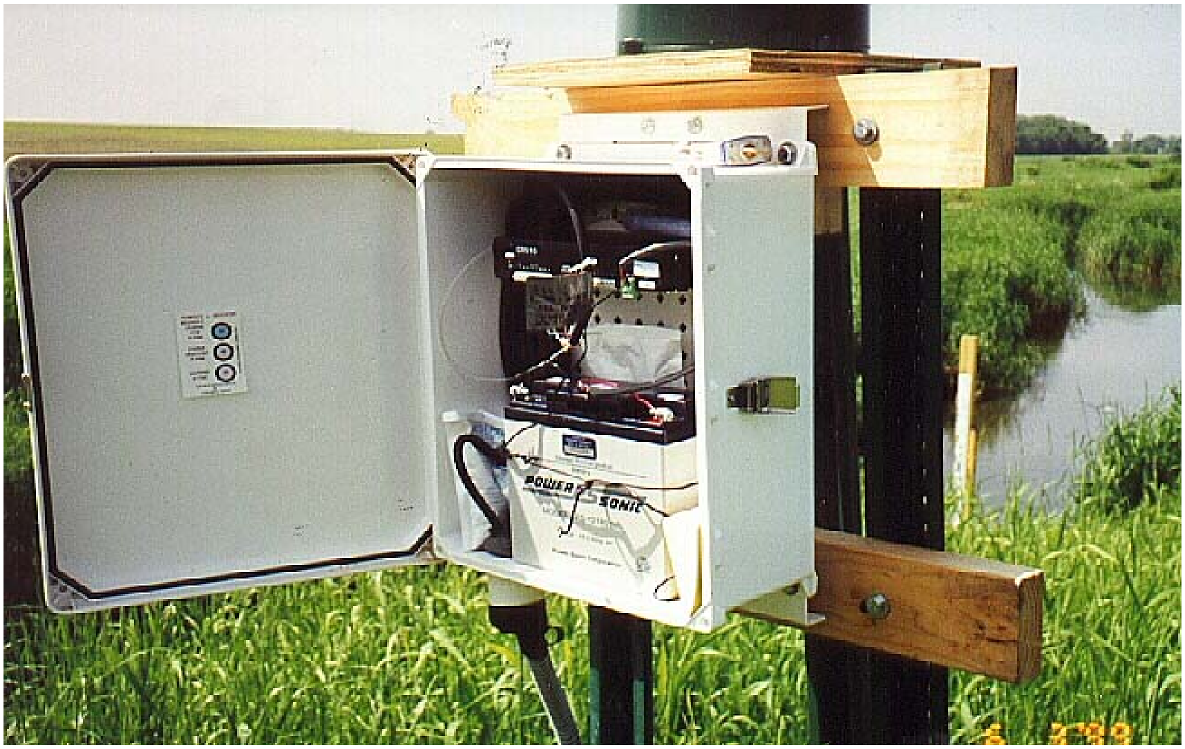


Figure 4-1. Equipment used at each water monitoring site; seen here on North Branch Chub Creek.

Figure 4-2. Macroinvertebrate monitoring on Chub Creek using kick net.

Figure 4-3. Fish seining in Chub Creek with DNR staff.

V. Project Results

Precipitation

The amount and frequency (and thus intensity) of rainfall was measured at CHB23 and NB47 during the sampling seasons with a tipping bucket rain gauge. These sites were 6 miles apart and frequently measured different rainfall amounts. Precipitation records from the State Climatology Office were also used to determine rainfall in the Chub Creek area. Unfortunately, state records for the area do not agree with our rain gauges for 1999 (Table 5-1) (although various state gauges agree with each other and the historical average). In 2000, our records are similar to state records as well as the historical average (Table 5-2). State precipitation records were used in graphs rather than the data we collected due to the inconsistencies recorded in 1999.

Table 5-1. Total Rainfall in Inches in Chub Creek Watershed for 1999

Month	CHB23 1999	NB47 1999	Average 1999	T112N R20W Section 8 (near CHB23)	National Weather Service in Farmington	Historical Average
June	2.94	1.85	2.39	3.25	4.86	4.1
July	4.86	4.57	4.71	4.58	6.61	3.5
August	3.59	2.20	2.89	4.53	4.24	3.6
Sept.	1.42	1.04	1.23	3.10	1.56	2.7
October	0.69	0.67	0.68	1.80	1.01	2.2
TOTAL	13.50	10.33	11.92	17.26	18.28	16.10

Table 5-2. Total Rainfall in Inches in Chub Creek Watershed for 2000

Month	CHB23 2000	NB47 2000	Average 2000	T112N R20W Section 8 (near CHB23)	National Weather Service in Farmington	Historical Average
April	0.94	1.15	1.04	0.90	1.08	2.4
May	4.46	3.03	3.74	3.44	3.81	3.4
June	5.12	5.89	5.50	5.27	4.77	4.1
July	2.88	4.05	3.46	3.50	5.55	3.5
August	3.13	2.94	3.03	3.20	4.27	3.6
Sept.	1.41	1.02	1.21	1.37	0.74	2.7
October	0.87	0.50	0.68	0.90	1.24	2.2
TOTAL	18.81	18.58	18.66	18.58	21.46	21.90

State records indicate that total rainfall during the sampling period in 1999 was approximately 6 inches below the historical average total rainfall for the same period in Minneapolis, MN. Although it cannot be tested statistically, this appears to be a major difference in total rain, indicating a non-normal precipitation year. However, total rainfall during the sampling period in 2000 was only 3.24 inches below the historical average total rainfall for the same period in Minneapolis, MN. This does not appear to be a major difference in total rain so 2000 was considered a normal precipitation year.

Periods of rainfall or storms are often called "events." Each event varied in rainfall amount and intensity. These factors, along with vegetative cover and soil moisture conditions, effect the potential for overland runoff of water to the stream. This, in turn, affects stream flow and water quality. Rainfall amounts and intensity can be used to understand the stream's response to various events and can aid in determining the best time to sample a stream for event affects.

Also see Appendix A for hydrographs of each site with local rainfall.

Water Quantity

Stream flow was measured at each monitoring site late May – October of 1999 and March – November 2000. In general, the flow of Chub Creek, the North Branch of Chub Creek, and Mud Creek is perennial (constant) (Figure 5-1a-b). There do not appear to be any significant "losing" reaches (or places where stream water seeps into the ground) in the mainstem of Chub Creek. However, at times our gages measured slightly more water flowing in Chub Creek at Hwy. 47 than downstream in Randolph. This may be due to a slight influx of creek water into the streambed and/or evaporation of water between the two sites. The difference may be due to the level of precision within the flow data. Flows are measured several times during the monitoring season at varying stages and calculated for the remainder of the stages using a rating curve equation. (There are no perennial water courses that enter the stream between the two points.)

The average flow of Chub Creek near the outlet (CHBRD) during the monitoring periods in 1999 and 2000 was 41cubic feet per second (cfs). This average includes storm events and periods of low flow. The maximum flow measured at the outlet of Chub Creek (CHBRD) was 243 cfs on June 5, 2000 while the lowest measured flow at CHBRD was 9 cfs during the fall of 2000 (Table 5-3).

Table 5-3. Summarized flow data for Chub Creek watershed during monitoring season in 1999 and 2000

1999 - 2000	Chub Cr. @ Hwy 23	Chub Cr. @ Hwy 3	Chub Cr. @ Hwy 47	Chub Cr. in Randolph	Mud Cr. @ Hwy 3	North Br. @ 290th
Average Flow (cfs)	13	21	41	41	3	9.5
Minimum Flow (cfs)	1	3	7	9	0.5	2
Maximum Flow (cfs)	136	146	243	243	55	47
Date of Maximum Flow	06-June-00	06-June-00	05-June-00	05-June-00	10-July-00	05-June-00

During base flow conditions, or dry weather flow, the stream is influenced by groundwater seepage and/or tile line drainage rather than precipitation. However, base flow levels can vary depending on the length of time between rainfall events. During the late summer of 2000 when rainfall was extremely minimal, Chub Creek had a base flow of approximately 12 cfs (or 5,386 gallons per minute or gpm). You can compare this with the base flow of 75 cfs (33,662 gpm) for the Vermillion River in Hastings, and 450 cfs (201,973 gpm) for the Cannon River in Welch during the same time period. Chub Creek contributes approximately 2.7% of the Cannon River flow.

The hydrograph of the sites on Chub Creek indicate that after a significant rainfall, stream flow peaks in approximately 3 days and falls back to "non-event" flows after approximately 5 days (Figure 5-1a-b). (Also see Appendix A for hydrographs of each site with local rainfall.) This stream is not considered to be "flashy" as it doesn't rise and fall extremely quickly as typical urban streams. However, tiled fields and drained wetlands have no doubt influenced the stream by allowing a larger volume of water to enter quickly after a rainfall. Additional tiling, draining, and development in the watershed would further increase the rate that water enters the stream and the volume of water it's forced to convey to the Cannon River.

Water Quality

Water quality was measured at the monitoring sites by analyzing grab samples for substances such as ammonia nitrogen, total nitrogen, total phosphorus, total and volatile suspended solids, turbidity, alkalinity, and pH. Dissolved oxygen was also measured during sampling. A description of each substance measured is contained in Appendix B.

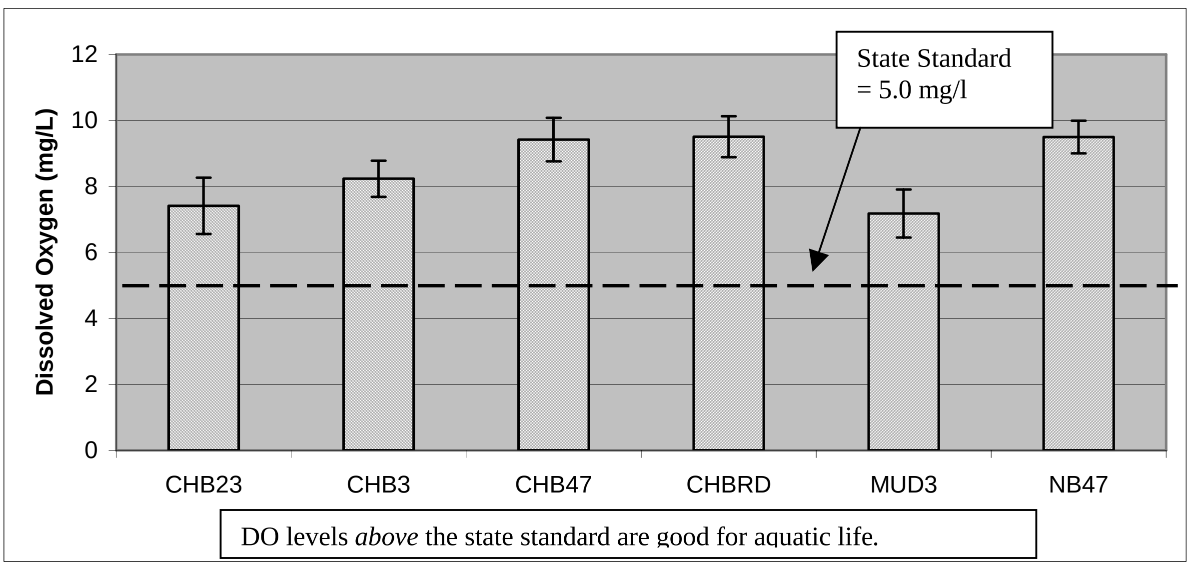
In general, the water quality of Chub Creek, Mud Creek, and North Branch Chub Creek could be rated as "fair to good" during periods of base flow (no runoff events). However, water quality decreases significantly during snowmelt and storm events.

Dissolved Oxygen

In general, dissolved oxygen levels in the watershed are above the state standard of 5.0 mg/l. Aquatic life depends on dissolved oxygen (DO) in the water to survive. Many processes can affect the amount of oxygen in the water. Decaying organic debris decreases DO while agitation of the water due to wind or riffles (areas where the water falls over rocks) can increase DO. Additionally, cold water can hold more oxygen than warm water. DO was measured during this assessment 23 times with a hand held meter when water quality samples were collected. Because DO fluctuates daily with water temperatures, a constant record of DO is desirable to truly understand oxygen levels in the water. Those measurements were not feasible for this project. The data collected, however, does give some indication of DO levels in the streams.

The average DO level measured at the various monitoring sites ranged from 7.2 mg/l in Mud Creek to 9.5 mg/l in North Branch Chub Creek and in Chub Creek near the outlet (Figure 5-2). The DO dipped below 5.0 mg/l at Chub Creek at Hwy 23 and Mud Creek at Hwy 3 a few times during sampling when water temperatures were high and the water was flowing slowly.

Figure 5-2. Average dissolved oxygen levels and 95% confidence intervals at Chub Creek Watershed monitoring sites measured during water sample collections 1999 – 2000.



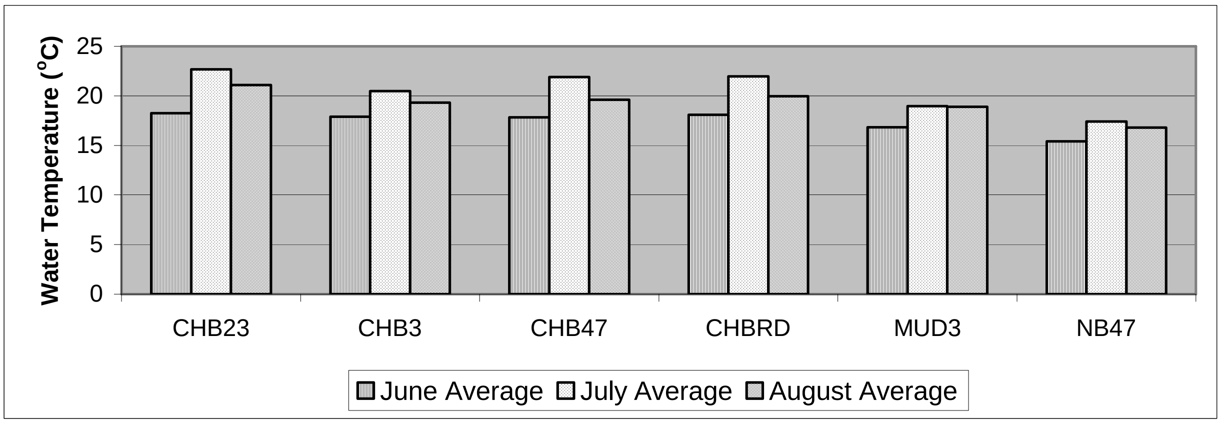
Water Temperature

Water temperature in small streams varies dramatically in a 24-hour period and generally follow fluctuating air temperatures. Water temperature can affect chemical processes and aquatic life. Different fish species require different temperatures for survival. For instance, brown trout thrive in water temperatures less than 18 ^{o}C. Temperatures between 19 and 25 ^{o}C are stressful for brown trout; and temperatures greater than 25 ^{o}C are lethal. Chub Creek and its tributaries are considered warm water fisheries with temperatures generally higher than those needed for a cold water, trout fishery.

Water temperatures were measured, along with dissolved oxygen, with a hand held meter when water quality samples were collected. Because temperature fluctuates regularly, a constant record of temperature is desirable to truly understand the highs and lows of water temperature. Those measurements were not feasible for this project. The data collected, however, does give some indication of water temperatures during the day.

In general, water temperatures measured occasionally during the summer averaged between 16 and 22 ^{o}C throughout the watershed. The highest temperatures were measured in July. The North Branch of Chub Creek had consistently lower temperatures than Chub Creek and Mud Creek (Figure 5-3).

Figure 5-3. Average water temperatures at Chub Creek Watershed monitoring sites measured during water sample collections 1999 – 2000.



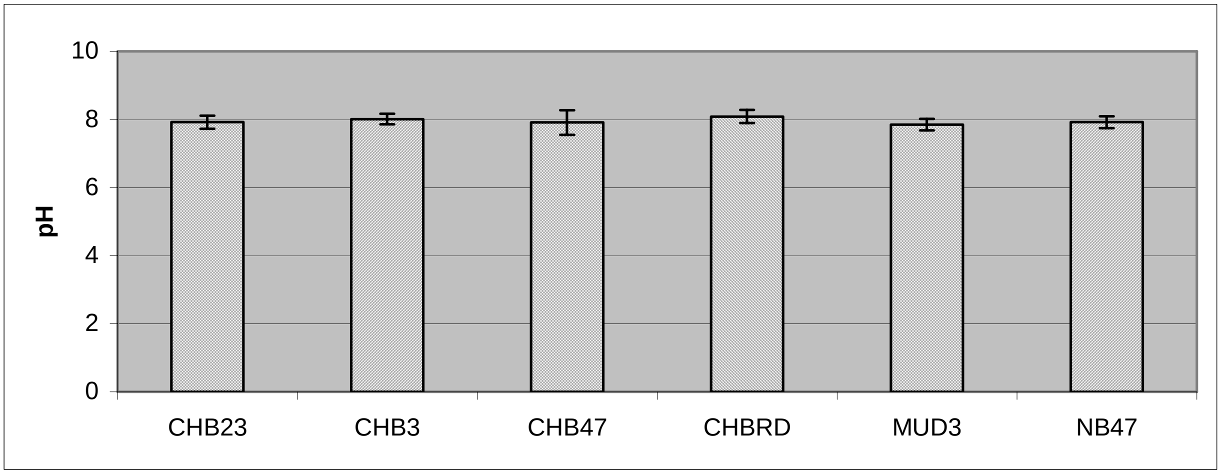
pH and Alkalinity

PH and Alkalinity were analyzed by the laboratory from water samples grabbed during periods of low flow and during runoff events throughout the monitoring seasons of 1999 and 2000.

Water's pH is an index of its acid level. It is inversely related to the amount of hydrogen ion in the water. A pH of 7 is neutral with a lower pH being more acidic and a higher pH being more basic. Although moderately low pH does not usually harm fish, some pollutants found in water become more soluble under low pH and thus more available to accumulate in fish tissue. The state standard for pH is between 6.5 and 9.0.

All Chub Creek watershed monitoring sites had an average pH of approximately 8.0 with little variation among the sites or throughout the monitoring season (Figure 5-4).

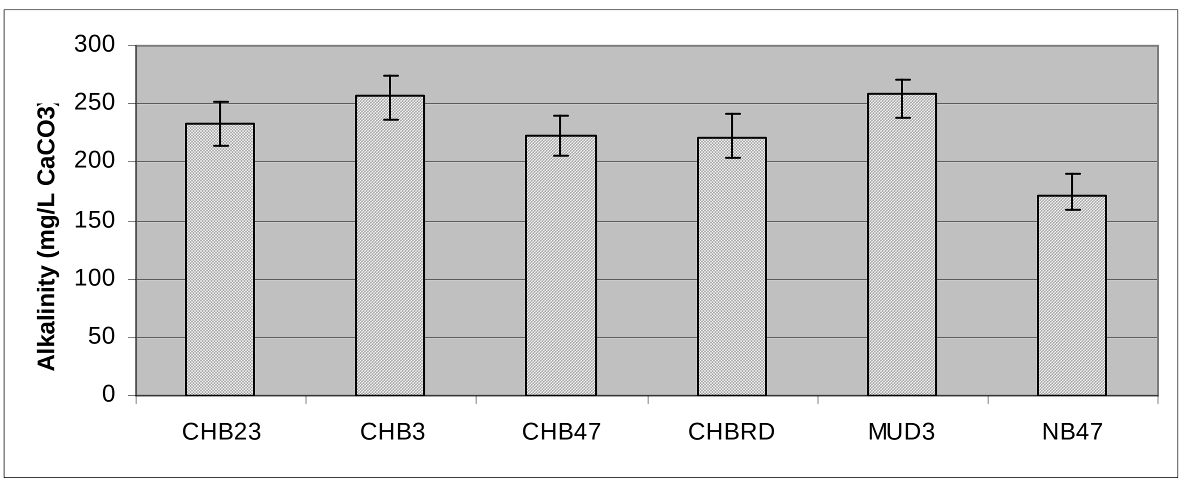
Figure 5-4. Average pH in Chub Creek Watershed 1999 – 2000.



Alkalinity is a measure of the water's buffering capacity against acid or the ability of the water to maintain a pH at or above 7.0. If the alkalinity is above 100 mg/l of calcium carbonate ($CaCO_3$) then it's an effective buffer (depending on the amount of carbon dioxide in the water). Water below 80 mg/l $CaCO_3$ is not effectively buffering the stream from acidity.

The average alkalinity of Chub Creek and Mud Creek ranged from 220 – 260 mg/l $CaCO_3$ during the sampling season while the North Branch of Chub Creek had a significantly lower average alkalinity of 172 mg/l $CaCO_3$ (Figure 5-5). These levels are in the range of hard water (150 – 300 mg/l $CaCO_3$).

Figure 5-5. Average alkalinity in Chub Creek watershed 1999 – 2000.



Nutrients and Solids - Concentrations

Note: The following section will discuss the data from each monitoring site individually and then will take a look at the watershed as a whole. Please see Appendix B for a description and review of each measured parameter and ecoregions. The notation "mg/l" indicates milligrams per liter which is equivalent to parts per million (ppm).

Chub Creek at Hwy. 23 (CHB23)

The average ammonia concentration measured at CHB23 was 0.085 mg/l; more than twice the state standard of 0.04 mg/l. Ten of the twenty-one samples taken in 1999 and 2000 were above the state standard, with the majority of those taken during runoff events. The highest ammonia level at this site was 0.56 mg/l measured during the snowmelt event in February 2000 (Figure 5-6a-b in Appendix C).

Total nitrogen levels at CHB23 ranged from 0.56 mg/l during a period of low flow in August 1999 to 1.90 mg/l during the snowmelt event in February 2000 (Figure 5-7a-b in Appendix C). The average total nitrogen concentration was 1.19 mg/l.

Total phosphorus concentrations at CHB23 ranged from 0.03 mg/l during a period of low flow in October 1999 to 0.32 mg/l measured both during a storm event in July 1999 and during a period of low flow in August 2000. Eight of the twenty samples collected had a total phosphorus concentration above the mean for the ecoregion of 0.24 mg/l. Of these samples, seven were taken during runoff events (Figure 5-8a in Appendix C). There was a significant difference in total phosphorus between samples taken during periods of low flow and samples taken during runoff events (Figure 5-8b in Appendix C). The average total phosphorus level measured at CHB23 was 0.205 mg/l.

Total suspended solids concentrations at CHB23 ranged from 2 mg/l during low flow in October 1999 to 58 mg/l during a storm event in May 2000. The average measurement was 7.6 mg/l, well below the mean for the ecoregion of 27 mg/l. However, during runoff events, total suspended solids rose significantly (Figure 5-9a-b in Appendix C).

The average volatile suspended solids at CHB23 were 5.3 mg/l during 1999 and 2000. There was not a significant difference between low flow and runoff event measurements (Figure 5-10a-b in Appendix C).

Turbidity measurements at CHB23 ranged from 2.2 NTU during low flow in July 2000 to 15.0 NTU during a storm event in May 2000 with an average of 6.5 NTU across 1999 and 2000 sampling. The measurements never reached above the state standard of 25 NTU, although turbidity levels were significantly higher during runoff events than during periods of low flow (Figure 5-11a-b in Appendix C).

Chub Creek at Hwy. 3 (CHB3)

The average ammonia concentration measured at CHB3 during 1999 and 2000 was 0.085 mg/l; more than twice the state standard of 0.04 mg/l. Ten of the twenty-one samples taken were above the state standard, with the majority of those taken during runoff events. The highest ammonia level at this site was 0.75 mg/l measured during the snowmelt event in February 2000 (Figure 5-12a-b in Appendix C).

Total nitrogen measurements at CHB3 ranged from 0.28 mg/l during low flow in October 2000 to 3.20 mg/l during the snowmelt event in February 2000. The average total nitrogen concentration measured here between 1999 and 2000 was 1.06 mg/l. There was a significantly more nitrogen in at this site during runoff events than periods of low flow (Figure 5-13a-b in Appendix C).

Total phosphorus at CHB3 ranged from 0.04 mg/l measured during low flow in both October 1999 and 2000 to 0.61 mg/l during a storm event in June 1999. Only 6 of the 20 samples were above the ecoregion mean of 0.24 mg/l. However, there was a significant difference between periods of low flow and runoff events (Figure 5-14a-b in Appendix C).

Total suspended solids measured at CHB3 ranged from 2 mg/l during low flow in October 1999 to 130 mg/l during a storm event in May 2000. The average measurement during the 1999 and 2000 sampling was 26.3 mg/l; just below the ecoregion mean of 27 mg/l (Figure 5-15a-b in Appendix C). There was a significant difference between periods of low flow and runoff events.

The average volatile suspended solids concentration was measured at 5.9 mg/l during 1999 and 2000 with a significant difference between periods of low flow and runoff events (Figure 5-16a-b in Appendix C).

Turbidity measurements at CHB3 ranged from 2.3 NTU during low flow in October 2000 to 27 NTU during a runoff event in May 2000 with an average of 7.4 NTU. Most of the samples collected were well below the state standard of 25 NTU (Figure 5-17a-b in Appendix C).

Chub Creek at Hwy. 47 (CHB47)

Average ammonia concentrations measured at CHB47 were 0.064 mg/l; well above the state standard of 0.04 mg/l. The highest ammonia concentration was measured at 0.50 mg/l during the snowmelt event of February 2000. However, overall, there was no significant difference between periods of low flow and runoff events (Figure 5-18a-b in Appendix C).

Total nitrogen concentrations ranged from 0.28 mg/l during low flow in April 2000 to 2.50 mg/l during the snowmelt event of February 2000. The average total nitrogen concentration measured during sampling in 1999 and 2000 was 0.83 mg/l with a slight difference between periods of low flow and runoff events (Figure 5-19a-b in Appendix C).

Total phosphorus concentrations ranged from 0.01 mg/l measured during low flow in both October 1999 and 2000 to 0.47 mg/l during a storm event in June 1999. The average concentration was 0.178 mg/l which is below the ecoregion mean of 0.24 mg/l for total phosphorus. There was, however, a significant increase in total phosphorus during storm events as compared to periods of low flow (Figure 5-20a-b in Appendix C).

Total suspended solids concentrations ranged from 2 mg/l measured during low flow in October 1999 to 137 mg/l measured during a storm event in May 2000. The average concentration at CHB47 was 37 mg/l; well above the ecoregion mean of 27 mg/l. Additionally, there was a significant increase in total suspended solids during runoff events (Figure 5-21a-b in Appendix C).

The average volatile suspended solids concentration measured during 1999 and 2000 was 7.8 mg/l with a significant increase during runoff events (Figure 5-22a-b in Appendix C).

Turbidity measurements at CHB47 ranged from 2 NTU during low flow in 1999 and 2000 to 24 NTU during a storm event in May 2000. The average turbidity was 8.5 NTU. Although there was a significant increase in turbidity during runoff events, there were no turbidity measurements above the state standard of 25 NTU (Figure 5-23a-b in Appendix C).

Chub Creek in Randolph (CHBRD)

The average ammonia concentration at CHBRD during 1999 and 2000 sampling was 0.068 mg/l; well above the state standard of 0.04 mg/l. The highest concentration was 0.74 mg/l measured during the snowmelt event in February 2000. Although there is a large variation in ammonia concentrations during runoff events, the difference between low flow periods and runoff events is apparent (Figure 5-24a-b in Appendix C).

Total nitrogen concentrations ranged from 0.22 mg/l during low flow in October 2000 to 3.30 mg/l measured during the snowmelt event in February 2000. The average concentration measured at CHBRD was 0.94 mg/l with a slight difference between periods of low flow and runoff events (Figure 5-25a-b in Appendix C).

Total phosphorus concentrations ranged from 0.01 mg/l during low flow in October 1999 to 0.59 mg/l measured during the snowmelt event of February 2000. The average concentration was 0.184 mg/l; well below the ecoregion mean of 0.24 mg/l. However, there was a significant increase in total phosphorus concentrations during runoff events (Figure 5-26a-b in Appendix C).

Total suspended solids concentrations at CHBRD ranged from 2 mg/l measured during periods of low flow in 1999 and 2000 to 145 mg/l during a storm event in June 1999. The average total suspended solids concentration was 39.4 mg/l; well above the ecoregion mean of 27 mg/l, with a significant increase during runoff events (Figure 5-27a-b in Appendix C).

The average volatile suspended solids concentration at CHBRD was 8.1 mg/l with a significant increase during runoff events (Figure 5-28a-b in Appendix C).

Turbidity at CHBRD ranged from 1.7 NTU measured during low flow in 1999 to 32 NTU measured during a storm event in June 1999. The average turbidity level measured at this site was 9.3 NTU with only two samples reaching above the state standard of 25 NTU. However, there was a significant increase in turbidity during runoff events (Figure 5-29a-b in Appendix C).

Mud Creek at Hwy 3 (MUD3)

The average ammonia concentration at MUD3 was 0.111 mg/l, almost 3 times higher than the state standard of 0.04 mg/l. Over 50% of the samples collected were over the state standard with the highest level of 0.39 mg/l measured during a storm event in November of 2000. There was a significant increase in ammonia concentrations during runoff events (Figure 5-30a-b in Appendix C).

Total nitrogen concentrations at MUD3 ranged from 0.28 mg/l during low flow in October 2000 to 3.40 mg/l during a storm event in May 2000. The average total nitrogen concentration was 0.96 mg/l with no significant difference between periods of low flow and runoff events (Figure 5-31a-b in Appendix C).

Total phosphorus concentrations at MUD3 ranged from 0.03 mg/l during periods of low flow to 0.66 mg/l measured during a storm event in May 2000. The average concentration was 0.225 mg/l, just under the ecoregion mean of 0.24 mg/l. There was a significant difference in total phosphorus concentrations between periods of low flow and runoff events (Figure 5-32a-b in Appendix C).

Total suspended solids concentrations ranged from 2 mg/l during low flow in October 1999 to 193 mg/l measured during a storm event in May 2000. Overall, MUD3 had an average of 23.3 mg/l total suspended solids; just under the ecoregion mean of 27 mg/l. There is a discernable, although not statistically significant difference in concentrations between periods of low flow and runoff events (Figure 5-33a-b in Appendix C).

The average volatile suspended solids concentration at MUD3 was 5.5 mg/l. Although there is not a significant difference in volatile suspended solids concentrations between periods of low flow and runoff events, the highest concentration of 37 mg/l was measured during a storm event in May 2000 (Figure 5-34a-b in Appendix C).

Turbidity at MUD3 ranged from 1.8 NTU during a storm event in September 1999 to 37 NTU measured during a storm event in May 2000. The average turbidity measurement was 6.6 NTU. Only one sample reached a turbidity level above the state standard of 25 NTU. There is a discernable, although not statistically significant difference in turbidity between periods of low flow and runoff events (Figure 5-35a-b in Appendix C).

North Branch Chub Creek at 290th St. (NB47)

The average ammonia concentration at NB47 was .067 mg/l; well above the state standard of 0.04 mg/l. The highest concentration of 0.49 mg/l was measured during the snowmelt event in February 2000. There is a discernable, although not statistically significant difference in ammonia concentrations between periods of low flow and runoff events (Figure 5-36a-b in Appendix C).

Total nitrogen concentrations ranged from 0.2mg/l measured during low flows to 3.3 mg/l during the snowmelt event in February 2000. The average concentration was 0.76 mg/l with a significant increase in total nitrogen concentrations during runoff events (Figure 5-37a-b in Appendix C).

Total phosphorus concentrations at NB47 during the sampling in 1999 and 2000 ranged from 0.03 mg/l measured during low flow to 0.52 mg/l during the snowmelt event in February 2000. The average total phosphorus concentration was 0.157 mg/l, well below the ecoregion mean of 0.24 mg/l. However, there was a significant increase in phosphorus concentrations during runoff events (Figure 5-38a-b in Appendix C).

Total suspended solids concentrations ranged from 2 mg/l during low flow in October 1999 to 234 mg/l during a storm event in May 2000. The average concentration was 35.2 mg/l; above the ecoregion mean of 27 mg/l. There was a significant increase in total suspended solids during runoff events (Figure 5-39a-b in Appendix C).

The average volatile suspended solids concentration was 6.8 mg/l with the highest measurement of 37 mg/l taken during a storm event in May 2000. There was a significant increase in volatile suspended solids during runoff events (Figure 5-40a-b in Appendix C).

Turbidity at NB47 ranged from 1.8 NTU measured during low flow in April 2000 to 38 NTU during a storm event in May 2000. The average turbidity level was 7.6 NTU. Only one measurement was above the state standard of 25 NTU, however, there was a significant increase in turbidity during runoff events (Figure 5-41a-b in Appendix C).

Entire Chub Creek Watershed

Average ammonia concentrations in the watershed ranged from 0.64 mg/l at CHB47 to 0.111 mg/l at MUD3 with no significant difference among the 6 sites (Figure 5-42). Average ammonia concentrations at the monitoring sites were 60% to 177% higher than the state standard of 0.04 mg/l. Thirty-seven percent of all the samples taken were above the state standard. Of the samples above the standard, 79% were taken during runoff events, and the highest ammonia concentration at 5 of the 6 sites was measured during the snowmelt event of February 2000. Although there was no statistically significant difference between samples taken during low flows and samples taken during runoff events (due to the high variability in the runoff event samples), there is still a discernable increase in ammonia concentrations during runoff events.

Average total nitrogen concentrations in the watershed ranged from 0.76 mg/l at NB47 to 1.19 mg/l at CHB23 (Figure 5-43). Although most of the sites were not significantly different from each other, NB47 and CHB23 were significantly different. The highest total nitrogen concentration measured was taken during the snowmelt event of February 2000 at 5 of the 6 sites.

Average total phosphorus concentrations in the watershed ranged from 0.157 mg/l at NB47 to 0.225 mg/l at MUD3, and the average concentration at each site was below the ecoregion mean of 0.24 mg/l (Figure 5-44). There was no significant difference in the averages among the sites. However, there was a significant increase in total phosphorus concentrations during runoff events at each site. Thirty percent of the samples collected were above the ecoregion mean. Of the samples above the ecoregion mean, 92% were taken during runoff events. Moreover, at each site, the highest total phosphorus concentration was measured during a snowmelt or storm event.

Average total suspended solids in the watershed ranged from 7.6 mg/l at CHB23 to 39.4 mg/l at CHBRD. Although the sites were not significantly different from each other, there is an apparent trend in the data which indicates an increase in total suspended solids as you move downstream in Chub Creek (Figure 5-45). The average at three sites: CHB47, CHBRD, and NB47 was above the ecoregion mean of 27 mg/l, and 31% of all samples taken were above the ecoregion mean. At most sites, there was a significant increase in total suspended solids concentrations during runoff events. At 5 of the 6 sites, the highest total suspended solids concentrations were measured during a storm event in May of 2000.

Average volatile suspended solids in the watershed ranged from 5.3 mg/l at CHB23 to 8.1 mg/l at CHBRD. Again, there was a noticeable increase in volatile suspended solids concentrations as you move downstream but no statistically significant difference among the sites (Figure 5-46). At most sites there was a significant increase in concentrations during runoff events.

Average turbidity levels in the watershed ranged from 6.5 NTU at CHB23 to 9.3 NTU at CHBRD. Although the sites are not statistically different, there is a noticeable increase in average turbidity as you move downstream (Figure 5-47). Although turbidity increased significantly at 5 of the 6 sites during runoff events, only 4% of all the samples taken were above the state standard of 25 NTU.

Nutrient and Solids – Loadings

Although the concentrations of pollutants are important to analyze and report, *pollutant loads* take into consideration the amount of water at each site and give an indication of just how much of each pollutant is exported from the watershed each year.

Thousands of pounds of pollutants leave the watershed each year (Table 5-4). Many of the nutrients will be used by plants and algae in Lake Byllesby to contribute to its hypereutrophic condition (or excessive nutrient enrichment). Most of the solids will settle to the bottom of Lake Byllesby, slowly filling it in. Those pollutants that pass through Lake Byllesby may spur algal growths or help to fill in Lake Pepin on the Mississippi River, or they may travel all the way to the Gulf of Mexico to contribute to the serious hypoxic zone there (see page 10). Most of the pollution in this watershed can be prevented with the use of agricultural and residential best management practices.

Pollutant loads were also calculated by subwatershed using each sampling site as the exit of a subwatershed (Figure 5-48). By taking the number of acres in each subwatershed to determine the relative amount of pollutant coming off each acre, it is easy to prioritize different areas of the watershed for various best management practices (Tables 5-5 and 5-6).

Table 5-4. Estimated amount of pollutants leaving Chub Creek watershed each year.

Pollutant	**Tons/Year**
Ammonia	2.2
Total Nitrogen	51.6
Total Phosphorus	10.7
Soluble Phosphorus	5.7
Total Suspended Solids	2,720.6
Volatile Suspended Solids	515.8

Table 5-5. Estimated amount of each pollutant leaving subwatersheds (ranked highest to lowest for each pollutant).

Subwatershed Name (Fig. 5-48)	**Pounds/Year**	**Pounds/Year/Acre**
AMMONIA		
Middle Chub A	1,198	0.168
North Branch	1,469	0.138
Mud Creek	808	0.136
Upper Chub	1,745	0.090
Middle Chub B	-522*	-0.077*
Lower Chub	-207*	-0.091*
TOTAL NITROGEN		
Lower Chub	10,274	4.53
Middle Chub A	21,340	3.00
North Branch	19,243	1.81
Middle Chub B	12,179	1.79
Upper Chub	31,983	1.65
Mud Creek	8,174	1.37
TOTAL PHOSPHORUS		
Middle Chub A	5,785	0.813
Middle Chub B	4,582	0.675
North Branch	3,515	0.330
Mud Creek	1,793	0.302
Upper Chub	5,765	0.297
Lower Chub	4	0.002
TOTAL SUSPENDED SOLIDS		
Middle Chub B	2,436,460	358.8
Lower Chub	521,682	230.1
Middle Chub A	727,174	102.1
North Branch	944,786	88.6
Mud Creek	229,890	38.7
Upper Chub	581,150	30.0
VOLATILE SUSPENDED SOLIDS		
Middle Chub B	487,478	71.8
Lower Chub	62,879	27.7
Middle Chub A	124,933	17.5
North Branch	165,724	15.5
Mud Creek	45,800	7.7
Upper Chub	144,704	7.5

* Due to estimations of flows and subsequent calculations, the ammonia loads at these sites were lower than the ammonia loads upstream, resulting in a negative number for the subwatershed. Although there is certainly some ammonia entering the stream in these subwatersheds, it is probably minimal.

Table 5-6. Subwatershed ranking based on pollutant loads. 1 = highest loads and highest priority; 6 = lowest loads and lowest priority.

Subwatershed	**Ammonia**	**Total Nitrogen**	**Total Phosphorus**	**Total Suspended Solids**	**Volatile Suspended Solids**	**Average Nutrients Score**	**Average Solids Score**
Upper Chub	4	5	5	6	6	4.7	6
Middle Chub A	1	2	1	3	3	1.3	3
Middle Chub B	5	4	2	1	1	3.7	1
Lower Chub	6	1	6	2	2	4.3	2
Mud Creek	3	6	4	5	5	4.3	5
North Branch	2	3	3	4	4	2.7	4

Bacteria

The Minnesota state standard for fecal coliform bacteria is 200 organisms per 100 ml of water as a geometric mean of not less than five samples in any calendar month from March 1 to October 31 (Minnesota Rules, Chapter 7050). Bacteria levels higher than the state standard are considered dangerous for human contact. Fecal coliform bacteria levels are high throughout the Chub Creek watershed. Monthly geometric means (averages) exceeded the state standard in every month monitored and at all sampling sites in 2000 (Figure 5-49). The site in Randolph (CHBRD) had the highest bacteria levels in May and July with >1200 and >2100 organisms per 100 ml, respectively. Mud Creek (MUD3) had the highest level in June with >2000 organisms per 100 ml. The North Branch of Chub Creek (NB47) had the highest level in August with >2200 organisms per 100 ml. And, Chub Creek at Hwy 23 (CHB23) had the highest level in September with >900 organisms per 100 ml (Figure 5-49).

If all the data from 2000 is averaged (using a geometric mean), each site has fecal levels over 400 organisms per 100 ml (Figure 5-50). Additionally, the highest measured fecal levels (at any one time) are 20 to 400 times the state standard (Figure 5-50). These high levels were measured during snowmelt or rainfall events for all sites except CHB23 which had its highest measured fecal level during a period of low flow when the water was almost stagnant.

Bacteria levels were lower when the creek was sampled during periods without rain (or non-event periods), although they were still a concern at some sites during some months. The site in Randolph (CHBRD) had consistently high levels of bacteria throughout the season even during non-event periods (Figure 5-51). During May and June, most sites had bacteria levels under the standard during non-event periods. During July and August bacteria levels rose substantially at most sites. High bacteria levels during non-event periods indicate that the source is constant such as failing septic systems, livestock in the water, or wildlife.

Bacteria levels during rainfall events rose significantly from levels at non-event periods (Figures 5-52, 5-53). This indicates that even more bacteria are washing into the stream with rainwater. Sources may include unimproved feedlots, riparian pastures, and land applied manure.

It is difficult to calculate bacteria levels for subwatersheds due to the nature of the bacteria itself. Fecal coliform can die or multiply quickly, thus making it impossible to assume that the bacteria measured at one site is the accumulation of bacteria from that contributing subwatershed and all of the upstream bacteria measurements. Rather, bacteria levels can simply indicate a pollution source somewhere upstream.

It is not unusual for streams in central and southeastern Minnesota to consistently exceed the fecal coliform bacteria standard. However, the standards are set based on risks to human health and should be considered a serious detriment to the water quality in the Chub Creek watershed. The bacteria data will be submitted to the national water quality database (STORET) administered by the U.S. Environmental Protection Agency. Chub Creek and possibly Mud Creek and the North Branch of Chub Creek will probably be listed on the national list of impaired waters due to the bacteria contamination when the list is revised in 2002.

<u>Citizen Monitoring</u>

In addition to the data collected by the Dakota County Soil and Water Conservation District, several watershed citizens volunteered to monitor Chub Creek and Mud Creek during 1999 and 2000 as part of the Minnesota Pollution Control Agency's (PCA) Citizen Stream Monitoring Program. Table 5-7 shows the 1999 water transparency data and some of the data from 2000. Higher transparencies reflect fewer dissolved and particulate solids in the water and thus better water clarity.

Table 5-7. Results of citizen volunteer stream monitoring. (First 3 entries are from 1999; last 2 entries are from 2000.)

Volunteer Name	Monitoring Site	Minimum Transparency	Maximum Transparency	Average Transparency	Number of Data Points
Barry Becker	Mud Creek	20 cm	60 cm	48.9 cm	8
Roger Dack	Mud Creek at Hwy 3	28 cm	60 cm	46.8 cm	20
Paul Irrthum	Chub Creek	40 cm	60 cm	52 cm	13
Ann Lundstrom	Chub Creek	15 cm	58 cm	33.9 cm	24
Duane Ness	Chub Cr. at Arkansas Ave.	15.9 cm	60 cm	32.0 cm	10

Biological Monitoring

Fish surveys performed by the DNR and the SWCD found that the watershed supports a typical assemblage of warm water species with some game fish such as northern pike and many species of minnows and dace. Although an index of biotic integrity was not calculated, most of the fish species are tolerant or somewhat tolerant of polluted or degraded waters. However, a fish usually indicative of good water quality, the rosyface shiner, was found in Chub Creek in May 2000 (Tables 5-8 to 5-10). The common carp, an exotic species, was also found in numerous places in Chub Creek. The carp can actually have a negative affect on water quality by rooting around on the streambed and stirring up sediments.

Table 5-8. Fish species seined in Chub Creek in 2000

Fish Species	Month	Tolerance to Degraded Water
Black Bullhead	Oct	intermediate
Bluntnose Minnow	May	tolerant
Brassy Minnow	May & Oct	intermediate
Central Mudminnow	May & Oct	tolerant
Common Carp	May & Oct	tolerant (exotic)
Common Shiner	May	intermediate
Creek Chub	May	tolerant
Fathead Minnow	May & Oct	tolerant
Green Sunfish	May & Oct	tolerant
Hybrid Bluegill	Oct	intermediate
Johnny Darter	May & Oct	intermediate
Largemouth Bass	Oct	intermediate
Northern Pike (24”) (20”)	May & Oct	intermediate
Pumpkinseed Cross	Oct	intermediate
Redhorse sp.	May	?
Rosyface Shiner	May	intolerant
Sand Shiner	May & Oct	intermediate
Spotfin Shiner	May	intermediate
Tadpole Madtom	May	intermediate
White Sucker	May	tolerant

Table 5-9. Fish species seined in Mud Creek in 2000

Fish Species	Month	Tolerance to Degraded Water
Black Bullhead	October	intermediate
Blacknose Dace	October	tolerant
Bluntnose Minnow	October	tolerant
Brassy Minnow	October	intermediate
Central Mudminnow	October	tolerant
Central Stoneroller	October	intermediate
Common Carp	October	tolerant (exotic)
Common Shiner	October	intermediate
Creek Chub	October	tolerant
Fathead Minnow	October	tolerant
Green Sunfish	October	tolerant
River Shiner	October	intermediate
Sand Shiner	October	intermediate
White Sucker	October	tolerant

Table 5-10. Fish species seined in North Branch Chub Creek in 2000

Fish Species	Month	Tolerance to Degraded Water
Blacknose Dace	October	tolerant
Bluntnose Minnow	October	tolerant
Brassy Minnow	October	intermediate
Brook Stickleback	October	intermediate
Central Stoneroller	October	intermediate
Common Shiner	October	intermediate
Creek Chub	October	tolerant
Fathead Minnow	October	tolerant
Johnny Darter	October	intermediate
River Shiner	October	intermediate
Sand Shiner	October	intermediate
Southern Redbelly Dace	October	intermediate

Macroinvertebrates (bugs that live on the bottom of the stream) collected in Chub Creek and its tributaries varied among sites. Overall, the streams were rated with fair to excellent water quality according to the Hilenshoff Family Level Biotic Index (FBI) (Table 5-11). All sites ranked above the national standard of 10 – 12 for the Ephemeroptera-Plecoptera-Trichoptera (EPT) biotic index.

Chub Creek in Randolph (CHBRD) scored the highest and was ranked with excellent water quality by the FBI. This site also had the highest habitat rating. However, the EPT score and # of families score was only the third highest of all the sites. Regardless, it is obvious this site has excellent macroinvertebrate habitat as it is in a riffle with a nice cobble substrate, fast water, and plenty of canopy cover (Figure 5-54).

North Branch of Chub Creek at 290th (NB47) also scored high on the FBI and was ranked with excellent water quality. This site received the second highest and highest EPT and # of families scores, respectively, and scored fairly high on the habitat rating. The stream at this site always has good, cold flow and the substrate consists of sand and medium-sized cobble.

Chub Creek at Hwy 23 (CHB23) scored the third highest on the FBI and was ranked with good water quality. It also received the highest EPT and # of families ranking and the third highest habitat score. This site is characterized by a small section of good cobble and riffle with some overhead canopy and good flow most of the year.

Chub Creek at Hwy 3 (CHB3) was ranked with good water quality and scored in the middle range for all indices and the habitat score among the six sites. Sampling was done just downstream of the Hwy 3 bridge in a small riffle with mostly gravel substrate, eroding banks and no overhead canopy.

Chub Creek at Hwy 47 (CHB47) scored the lowest on the FBI and was ranked with only fair water quality. The EPT and # of families scores were also low. Interestingly, however, CHB47 ranked second highest on the habitat score. This indicates that although the habitat is suitable for desired macroinvertebrates, the water quality may be inhibiting their survival. CHB47 is also distinguished by a beaver dam that was built downstream of the site late in August 2000, just two months before we collected the macroinvertebrate samples. Water depth increased while flow decreased which may have displaced desirable species.

However, in general, habitat for desirable macroinvertebrates (mayflies, caddisflies, and stoneflies) is lacking throughout the watershed. There is very little gradient from the top of the watershed to the bottom which makes the streams meander slowly. Riffle areas with rocky substrates are rare, many times only found near bridges and most likely due to the addition of rock riprap during road construction. As silt and sediment settle to the bottom of the stream it buries macroinvertebrate habitat. Macroinvertebrate sampling was done in the few existing areas in the watershed with suitable habitat.

Table 5-11. Macroinvertebrate indices of biotic integrity and habitat scores for Chub Creek watershed

Site	FBI[a]	EPT	# Families	Water Quality Rating[b]	Habitat Score
CHB23	4.3	11	19	Good	106
CHB3	4.4	8	18	Good	88
CHB47	5.5	6	15	Fair	115
CHBRD	3.1	9	15	Excellent	124
MUD3	4.4	5	11	Good	86
NB47	3.5	10	19	Excellent	93

[a] The lower the number, the better the rating
[b] According to the Hilsenhoff Family Level Biotic Index

Figure 5-54. Chub Creek riffle in Randolph (CHBRD)

Landuse and Landcover

Landuse describes the way the land is being used. Landcover describes the vegetation, water, natural surface, and cultural features on the earth's surface. Both landuse and landcover were mapped from 1997 aerial photographs and computerized in a geographic information system.

General landcover in the watershed was summarized in Section I. Table 5-12 and Figure 3-4 show the distribution of various landuses in the watershed. Landuse can also be summarized for each subwatershed (Table 5-13). Please see Figure 5-48 for a map of the Chub Creek subwatersheds.

Table 5-12. Landcover in the Chub Creek Watershed

Landcover	Acres	Percentage of Watershed
Cropland (row crops, sod farms, alfalfa fields, vegetable crops)	33,786	63%
Wetlands	5,111	9.5%
Farmsteads/Residential/Commercial/Industrial/Roads/RRs	4,864	9%
Forests/Woodlands	3,394	6%
Vegetated Agriculture (tree farms, hay fields, pasture)	3,385	6%
Open Lands (shrubland, grassland, sparse trees)	2,593	5%
Surface Water (creeks, lakes)	502	1%

Table 5-13. Acres of various landcover types in the Chub Creek subwatersheds and the percentage of total land each type covers within each subwatershed.

Landcover	Upper Chub	Middle Chub A	Middle Chub B	Lower Chub	Mud Creek	North Branch
Cropland (row crops, sod farms, alfalfa fields, vegetable crops)	7,754 40%	5,220 73%	5,191 76%	1,771 78%	4,512 76%	8,408 79%
Wetlands	3,366 17%	442 6%	337 5%	29 1%	562 9%	374 3.5%
Farmsteads/Residential/Commercial/Industrial/Roads/RRs	2,170 11%	448 6%	554 8%	175 8%	346 6%	824 8%
Forests/Woodlands	2,083 11%	395 6%	183 3%	92 4%	192 3%	332 3%
Vegetated Agriculture (tree farms, hay fields, pasture)	1,995 10%	451 6%	280 4%	100 4%	255 4%	253 2%
Open Lands (shrubland, grassland, sparse trees)	1,602 8%	145 2%	245 4%	78 3.5%	54 1%	470 4%

Along the major streams and tributaries in the Chub Creek watershed, approximately 31% of the streambanks are buffered with at least 300 feet of vegetation or wetlands. The Upper Chub subwatershed (see Figure 5-48) has the highest percentage of stream miles with a vegetative buffer 300 feet wide or greater (Table 5-14). By comparison, the North Branch subwatershed has the least amount of 300-foot buffer.

Table 5-14. Percentage of stream miles with at least 300 feet of vegetative buffer including native and non-native grasses, woodlands and forests, and wetlands; percentages include both sides of the stream, individually.

Subwatershed	**Percentage of Stream Miles with ≥ 300 foot buffer**
Upper Chub	54%
Middle Chub A	32%
Middle Chub B	25%
Lower Chub	27%
Mud Creek	17%
North Branch	6%

Landuses and landcover types adjacent to the streams can give an indication of potential sources of pollution. Cropland such as row crops, vegetable crops, alfalfa fields and sod farms, accounts for 44% of the land within 300 feet of the major streams and tributaries across the watershed. However, open land, wetlands, and woodlands account for 48% of the land within 300 feet of the stream (Table 5-15, Figure 5-55). Within 30 feet of the stream, cropland and vegetated agriculture account for 19% of the land while open land, wetlands, and woodlands account for 71% of the land (Table 5-15, Figure 5-55).

Table 5-15. Landcover within 300 feet and 30 feet of Chub Creek and major tributaries

Landcover	**Percentage of land within 300 ft.**	**Percentage of land within 30 ft.**
Cropland (row crops, sod farms, alfalfa fields, vegetable crops)	38%	14%
Farmsteads/Residential/Commercial/Industrial Roads/RRs	4.4%	2%
Forests/Woodlands	12%	19%
Vegetated Agriculture (tree farms, hay fields, pasture)	6%	5%
Open Lands (shrubland, grassland, sparse trees)	36%	52%
Open Water (ponds, etc.)	4%	8%

Landuse and landcover data can also be used to determine where potential restoration sites are located. For instance, hydric soils are those that either do support or can support wetlands and low areas where water can pond. By calculating the difference between hydric soils and current wetlands the potential wetland restoration areas can be mapped and summarized. Across the entire watershed, over 11,700 acres have the potential to be sites of wetland restoration (Figure 5-56).

VI. Conclusions and Plan for the Future

The first objective of the Chub Creek Watershed Assessment was to determine the overall health of the watershed. There are many different ways one could judge the health of the watershed. For *water quality*, the watershed is in “fair” to “good” health during periods of low flow (without the influence of runoff events such as storms and snowmelt). During periods of runoff, the watershed is in “poor” health. There are two important caveats to these statements. First, it is necessary to understand that the water quality data collected through this project represents a “snap-shot” in time. The potential for pollutants reaching the stream varies greatly with subtle changes in land use and weather patterns. The data contained herein is useful for getting an idea of the pollution problems in the watershed, but water quality could change significantly in a matter of just a few years. One of the best ways to use this data is as a baseline for determining trends in water quality over time. Second, the water quality analyses did not include all of the potential pollutants in the stream. Pesticides, metals, organic pollutants and other harmful toxins were not part of the analyses due to the high laboratory costs and the limited scope of the project.

Across the nation, the greatest source of pollution in surface water is non-point source pollution or pollution that cannot be traced back to a single point (such as a discharge point from an industry). Instead, it is the accumulation of pollutants running off the land and developed areas from multiple minor sources which add up to serious problems in receiving waters. Best management practices (BMPs) are developed and used to curb and eliminate non-point source pollution. It is the responsibility of each individual land and lot owner to incorporate these practices in and around their homes, yards, businesses and farms.

In addition to BMPs, it is important to recognize areas in the landscape that can and should be preserved or restored. Land preservation and restoration efforts are important elements in managing a watershed and should be done on a watershed scale. In many cases, land preservation and restoration has the greatest positive impact on our water resources.

In order to prioritize areas of the watershed in need of protection and pollution abatement, several factors were considered. The upper section of the watershed (Upper Chub on Figure 5-48) was found to contribute the least amount of pollution per acre and also have the lowest percentage of cropland, the highest percentage of wetlands, the highest percentage of woodlands, and the highest percentage of stream miles with substantial buffers (Table 6-1). Clearly, this area of the watershed is favorable for preservation and protection. Development pressures may significantly threaten the natural resources of the area, especially in light of the fact that the I-35 corridor bisects the area.

The five other subwatersheds do not show as a clear distinction from each other, although generalizations can be made. For instance, Mud Creek was found to contribute the second lowest amount of pollution for both nutrients and solids and therefore should be a lower priority for BMP implementation (Table 6-1). The middle and lower sections of the watershed are in need of the most attention for both nutrients and solids. Additionally, the North Branch of Chub Creek was found to contribute the second highest amount of nutrients and has the lowest percentage of stream miles with good buffers (Table 6-1). These results indicate the need for the installation of best management practices in these areas.

Table 6-1. Summarized conditions in each subwatershed (map of subwatersheds see Figure 5-48)

Subwatershed	Nutrient Pollution Contribution	Solids Pollution Contribution	Percent of land in crops	Percent of land with wetlands	Percent of land with forests	Percent of stream miles w/ ≥ 300 ft. buffer
Upper Chub	4.7	6	40	17	11	54
Middle Chub A	1.3	3	73	6	6	32
Middle Chub B	3.7	1	76	5	3	25
Lower Chub	4.3	2	78	1	4	27
Mud Creek	4.3	5	76	9	3	17
North Branch	2.7	4	79	3.5	3	6

The following paragraphs describe specific problems the Chub Creek watershed is facing and lists ways in which these problems can be solved. The funding of solutions will come from a variety of sources including individuals, businesses, farmers, developers, local units of government, county, state and federal government programs, and the watershed management organization.

Management Strategies

<u>Bacteria</u>

The most serious threat to the water quality in the Chub Creek watershed is bacteria. Fecal coliform levels are extremely high throughout the watershed even during times of low flow; and the pollution is even worse during periods of rain and snowmelt. Although most fecal bacteria do not harm wildlife, they are potentially very harmful to humans. Additionally, suspended fecal matter contributes to the amount of suspended solids in the water and often carries nutrients such as phosphorus and nitrogen. It is possible that simply remedying the bacteria problem throughout the watershed, would greatly improve other water quality in several ways.

There are many possible sources of bacteria including runoff from feedlots and fields with land-spread manure, livestock in the stream, failing or non-compliant individual sewage treatment systems, and even wildlife.

Human sewage has the highest potential to carry hazardous pathogens. Nationally, the Environmental Protection Agency estimates that 10 – 30% of all individual sewage treatment systems (ISTS) are failing and that at least 50% of the ISTS across the nation are over 30 years old. Although it is impossible to know the failure rate of the ISTS in the Chub Creek watershed, anecdotal evidence indicates that there are some ISTS that are still without holding tanks. These systems discharge untreated sewage to tile drainage systems and ultimately to surface waters creating an imminent public health threat. The State of Minnesota now requires that all ISTS be pumped out once every three years. Those systems that are found to be an imminent public health threat are required (through enforcement by the local governmental unit) to be upgraded. Homeowners with septic systems must also undergo a compliance inspection before selling the property or adding an extra bedroom.

Just as there are many bacteria sources, there are also many solutions to the bacteria problem:

- ✓ Fence livestock off of streambanks and out of wetlands and all drainage ways
- ✓ Install a manure storage and handling system
- ✓ Improve feedlots for more efficient manure handling
- ✓ Buffer all watercourses from feedlot runoff (at least 33 feet of vegetation)
- ✓ Buffer all watercourses from fields with land-applied manure (at least 33 feet of vegetation)
- ✓ Incorporate manure into soil rather than broadcasting
- ✓ Maintain and upgrade ISTS regularly and try to prolong the working life of the system by avoiding planting trees and shrubs near the drainage field and pipes, avoiding driving or parking on the drainage field, composting vegetable and food scraps instead of using a garbage disposal, conserving water use, limiting the use of household chemicals, and using toilet paper made for septic systems
- ✓ Provide a checks and balance system within the local unit of government for ISTS pumping, maintenance, and upgrade enforcement
- ✓ Build a common wastewater treatment facility for small, unsewered communities such as the City of Randolph

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Nutrients

Water quality in the Chub Creek Watershed during periods of runoff should be classified as "poor" due to a significant increase in pollutants such as nutrients, solids and bacteria. Average ammonia concentrations rose well above the state standard of 0.04 mg/l at each site during runoff events, especially during snowmelt. Ammonia is toxic to aquatic life and is a serious detriment to water quality. The primary source of ammonia in this watershed is most likely runoff from fields applied with ammonia nitrogen. Best management practices which could help control this pollution include:

- ✓ Test soils regularly to determine appropriate agronomic fertilization rates
- ✓ Incorporate a nutrient management program to take full advantage of land-applied manure
- ✓ Rotate crops which fix nitrogen with those that need nitrogen (corn and soybeans)
- ✓ Prevent runoff from fields with vegetated buffers, contour plowing, no-till practices, grassed waterways, sediment basins, etc.
- ✓ Incorporate ammonia into the soil rather than over-spraying

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Solids

Another significant pollutant in the Chub Creek watershed is suspended solids, most of which is probably sediment (soil particles). Sediment in the water can harm aquatic life and degrade the stream in numerous ways (see Appendix B "Suspended solids"). Although turbidity (one measure of the suspended matter in water) rarely rose above the state standard of 25 NTU, average total suspended solids during runoff events was well above the normal mean for the western cornbelt plains ecoregion. Sources of sediment pollution include streambank erosion and runoff from agricultural fields and unvegetated land. In areas with significant development, a major source of sediment is erosion from construction sites. Soil erosion control practices include:

- ✓ Contour plowing
- ✓ No-till planting
- ✓ Grassed waterways
- ✓ Sediment basins
- ✓ Residue management
- ✓ Streambank stabilization
- ✓ Urban erosion control

Buffers

If erosion is not controlled at the source, the most effective way to prevent it from becoming a pollution problem is through the use of vegetated buffers along streams, ditches and intermittent watercourses. There is much evidence which indicates that buffering watercourses and streams with at least 17 feet of dense vegetation can decrease sediment pollution. However, there are many beneficial reasons (besides pollution prevention) for creating a buffer of at least 100 feet including:

- ✓ Greater pollution prevention
- ✓ Streambank stabilization
- ✓ Wildlife habitat
- ✓ Greenway or natural corridor creation
- ✓ Recreational opportunities
- ✓ Quality of life
- ✓ Educational opportunities

Preservation and Restoration

Land protection, preservation, and restoration are important ways to help maintain existing natural areas and enhance the condition of degraded areas. As seen in Figure 5-56, there are thousands of acres of potential wetland restoration sites. Additionally, the landcover data from the upper portions of the watershed indicate that there are good buffers along streams and many existing wetlands that could use permanent protection. Restoration in areas once degraded is important to improve fish and wildlife habitat, prevent pollution, and a higher quality of life for generations to come. There are many ways in which land preservation and restoration can be achieved:

- ✓ Permanent conservation easements
- ✓ Land acquisition
- ✓ Purchase of development rights
- ✓ Adoption of local zoning ordinances
- ✓ Native prairie restoration
- ✓ Wetland restoration
- ✓ Moving streambeds to re-meander channelized reaches
- ✓ Restoring the outlet of Chub Creek to its original channel

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Development

As development pressures become stronger, it is important to keep the protection of natural resources at the forefront of development planning. Greenway corridors should be planned, mapped, and protected with local ordinances to preserve wetlands and riparian areas. Within a developing site, the hydrology of the area can and should remain the same after construction as it is before construction. Keep in mind that it is far less costly to use best management practices as development happens rather than retrofitting the areas with changes in the future. There are many ways to protect natural resources in the face of development: (also see the Minnesota Urban Small Sites BMP Manual, Metropolitan Council, July 2001)

- ✓ Adoption of local zoning ordinances
- ✓ Greenway planning and protection
- ✓ Conservation site designs
- ✓ Stormwater infiltration basins and rain gardens
- ✓ Impervious surface reduction
- ✓ Construction site erosion control

Education

One of the best ways to protect and enhance water and natural resources is through the education of the local citizens and the cultivation of their pride and ownership in their natural surroundings. Informed citizens are more likely to protect the resources in their community and take an active role in decisions affecting those resources. There are countless ways children and adults can be educated about the water resources in the Chub Creek watershed including:

- ✓ Citizen volunteer water monitoring programs
- ✓ Watershed signage including stream names at road crossings and "entering the watershed" signs
- ✓ Informational presentations to local officials
- ✓ School, scout, or church group projects
- ✓ Clean-up days
- ✓ Newsletter and newspaper articles
- ✓ Websites

Monitoring

Water quality and quantity monitoring should continue regularly throughout the watershed such that changes can be tracked and trends, whether good or bad, can be detected. As agricultural practices change, development increases, and weather patterns shift, there is bound to be a change in the water quality and the water quantity in the Chub Creek watershed. Monitoring should be performed for a complete field season (spring – fall) every few years and should include flow and the analysis of conventional pollutants such as solids, nutrients, and bacteria. Other potential toxins, such as pesticides, should also be monitored in the coming years to fully understand the health of the watershed.

Watershed management and the protection of water quality is an on-going effort that involves everyone living and working in the watershed. It is important to remember that if we each do our part to protect our natural resources, the future will be a better place for the generations that follow.