Groundhouse River Fecal Coliform and Biota (Sediment) Total Maximum Daily Load Implementation Plan

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Submitted to:
Minnesota Pollution Control Agency

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1. Problem Statement

1.1. TMDL Background

Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the Act's goal of "fishable and swimmable" waters. Minnesota adopted its first statewide water quality standards in 1967. These standards have been updated by adding new standards and regulations periodically since then. The comprehensive Clean Water Act amendments of 1972 require states to adopt water quality standards that meet the minimum requirements of the federal Clean Water Act. Minnesota's water quality standards meet or exceed the federal requirements.

The purpose of a TMDL is to identify the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. Fecal coliform and sediment TMDLs have been approved by the US EPA for the Groundhouse River watershed. The final TMDL report is available for download at: ***http://www.pca.state.mn.us/water/tmdl/tmdl-approved.html***

1.2. TMDL Listing

The Groundhouse River is located in east-central Minnesota in the Snake River watershed (Cataloging Unit 07030004) (Figure 1). The majority of the Groundhouse River watershed is located in Kanabec and Mille Lacs counties with a small area in Isanti County. The watershed has a drainage area of approximately 139 square miles.

The Groundhouse River and South Fork of the Groundhouse River are classified as Class 2B; the West Fork of the Groundhouse River is Class 2C. Class 2B "surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface waters is also protected as a source of drinking water." Minnesota rules specify that the quality of Class 2C surface waters "shall be such as to permit the propagation and maintenance of a healthy community of indigenous fish and associated aquatic life, and their habitats. These waters shall be suitable for boating and other forms of aquatic recreation for which the waters may be usable."

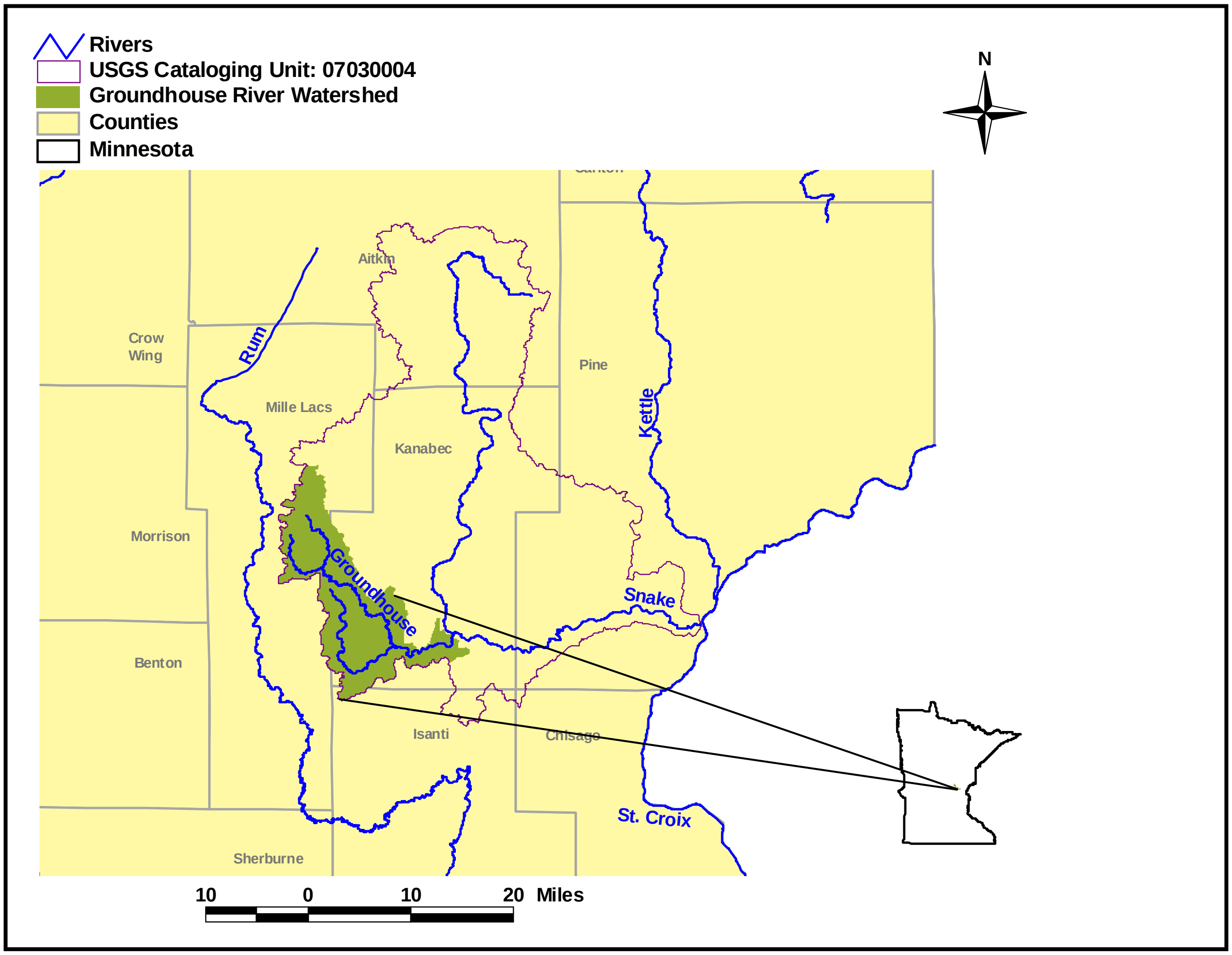


Figure 1. Location of the Groundhouse River Watershed

The Clean Water Act and U.S. Environmental Protection Agency (USEPA) regulations require that states develop TMDLs for waters identified as impaired on the Section 303(d) lists. The Groundhouse River and the South Fork Groundhouse River are listed on Minnesota's draft 2008 303(d) list as described in Table 1. Impaired waters listings based on the 2008 303(d) list are shown in Figure 2.

Table 1. 2008 Draft 303(d) Listing Information for the Groundhouse River Watershed

River ID	Name	Description	Designated Uses	Basis of Impairment	Year Listed
07030004-512	Groundhouse River	From South Fork Groundhouse River to Snake River	Aquatic Recreation	Fecal Coliform	2008
07030004-513	Groundhouse River	Headwaters to South Fork Groundhouse River	Aquatic Life Aquatic Recreation	Fish and Invertebrate IBIs Fecal Coliform	2002, 2004 2002
07030004-573	South Fork Groundhouse River	Headwaters to Groundhouse River	Aquatic Life Aquatic Recreation	Fish and Invertebrate IBIs Fecal Coliform	2004, 2008 2008

Source: MPCA (2008)

The listings for the impairment of recreational use are due to high levels of fecal coliform bacteria exceeding both the monthly five-sample geometric mean standard (200 orgs/100 mL) and the standard based on individual samples (10 percent equal to or greater than 2,000 orgs/100 mL). The listings for the impairment of aquatic life were based on the results of biological monitoring which showed that Indices of Biological Integrity (IBI) ranked below acceptable levels for both fish and invertebrate communities found in similar streams in the St. Croix River Basin. The leading cause of biological impairments in the Groundhouse River was determined to be excessive sediment levels. Therefore, to address the biological impairments, the TMDL focuses on sediment sources and load reductions.

IBI scores are the numeric criteria used to identify biotic impairment in Minnesota. Scores that fall below the criteria are listed as impaired. Table 2 shows the threshold values for both fish and invertebrate biotic impairments. Fish thresholds vary by watershed drainage area.

Table 2. Impairment Thresholds for Fish and Macroinvertebrate IBI Scores in the St. Croix River Basin

Drainage Area (mi^2)	Fish Threshold	Macroinvertebrate Threshold
0 to 20	46	50
20 to 54	68	50
55 to 200	69	50

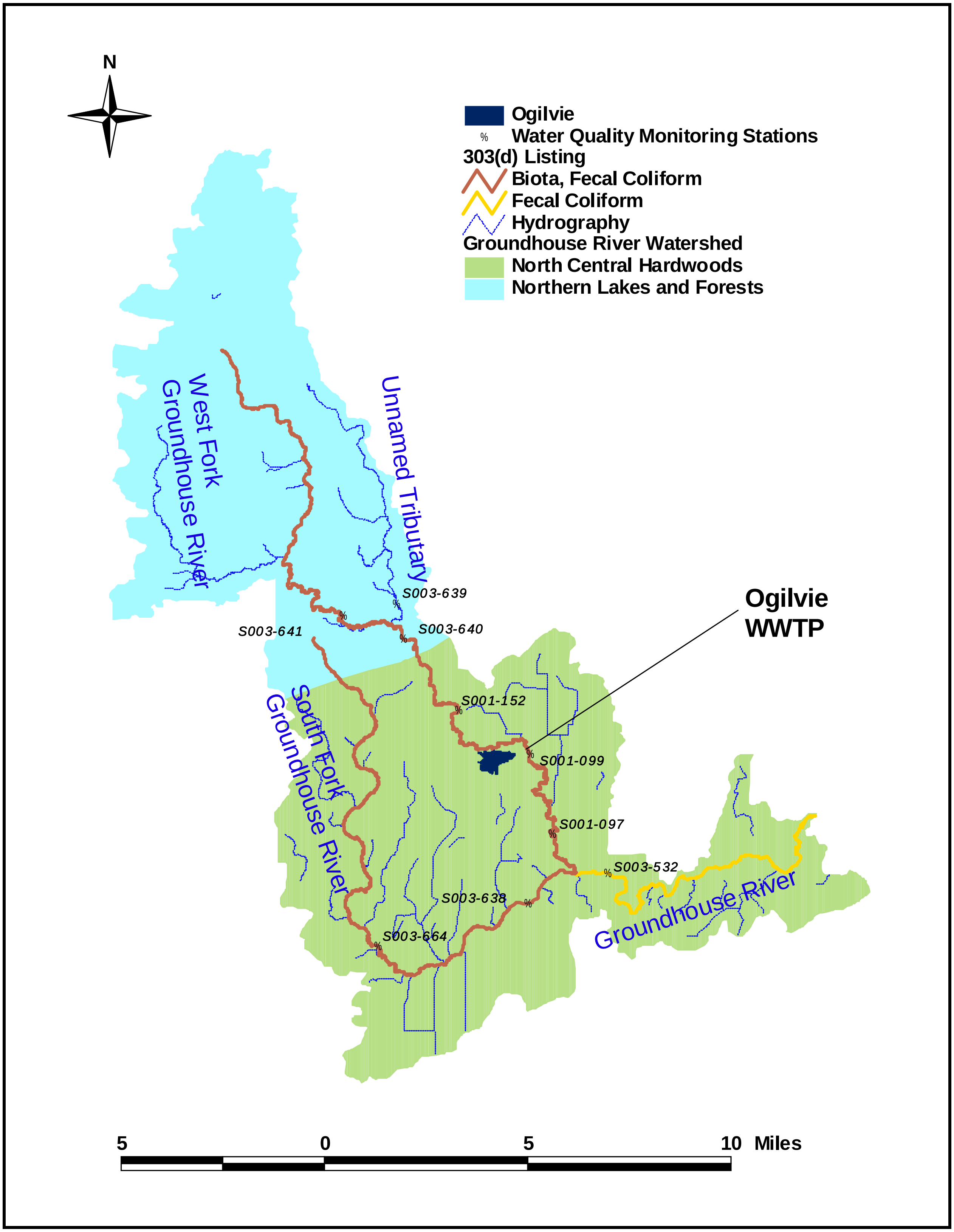


Figure 2. Location of 2008 Section 303(d) Impaired Segments, Monitoring Stations, and Level-Three Ecoregions in the Groundhouse River Watershed

1.3. Existing Conditions

1.3.1. Biological Data

Measures of biological health such as the Index of Biological Indicators (IBI) can be used as an indicator of the overall health of the fish and macroinvertebrate communities and are an excellent way to assess whether designated aquatic life uses are being supported. They also provide a quantitative method by which to interpret the narrative aquatic life criterion. Because fish and macroinvertebrates are able to respond differently to disturbance and stress, it is helpful to look at both communities in the assessment of the biological health of an aquatic system. Both fish and macroinvertebrate IBI data have been obtained for the Groundhouse River watershed and are presented below.

Metrics that make up the IBI should respond to anthropogenic disturbance; some metrics can be used as a general indicator of disturbance, while others can be an indicator of a specific stressor (Niemela and Feist, 2000; Chirhart, 2003). Because fish and macroinvertebrates are able to respond differently to disturbance and stress, it is helpful to look at both communities in the assessment of the biological health of an aquatic system. For instance, fish are mobile and may be better able to respond to impairment in isolated reaches of stream ecosystems than macroinvertebrate communities which depend on bed substrate and local water quality.

Fish and macroinvertebrate community composition data have been collected at 26 sites in the Groundhouse River watershed by the MPCA, Minnesota Department of Natural Resources (MNDNR), and the University of Minnesota. Figure 3 and Figure 4 show the locations of the sampling stations along the mainstem of the Groundhouse River and the South Fork. The biological data were collected between 1996 and 2006, typically between the months of June and September. Many of the sites were visited only once; however, several sites were visited two to three times.

The cause of biological impairment can be difficult to determine as many factors, including pollutants and habitat, can stress a biological community. An initial application of the Stressor Identification (SI) process to the Groundhouse River (USEPA, 2004) indicated that the most probable cause of impairment was “loss of suitable habitat from unstable or unsuitable substrates caused by excess fines less than 2 mm in diameter.” While fine sediment was indicated as the likely cause of the biological impairment, an intensive monitoring program to evaluate other potential stressors was performed in 2005. These data were reviewed during development of the TMDL and confirm that fine sediment is the most likely primary stressor in the watershed.

Fish IBI Scores and Impairments

Fish IBI scores have been calculated at the 21 sites in the watershed that were sampled in 2006 (Figure 3). Based on the fish IBI thresholds, four sites are impaired and the impairment is limited to two distinct geographic areas. The first area includes three sites at and near the town of Ogilvie on the main fork of the Groundhouse River. The second area includes only one site located near the headwaters of the South Fork Groundhouse River. Since these two areas differ dramatically in size (drainage area), surrounding land use, and channel morphology, data from the two areas were analyzed separately. The three sites at or near the town of Ogilvie are referred to as Impaired Area 1, and the site at the headwaters of the South Fork of the Groundhouse River is referred to as Impaired Area 2.

The most likely stressors identified in the Impaired Area 1 were fine sediments, particularly fine sands (0.06-2 mm) and combinations of silt/clay/muck. Anthropogenic sources of fine sediment exist in this area. Most notably, livestock operations located adjacent to and upstream of the impaired sampling locations allow cattle direct access to the stream, exacerbating stream bank instability and the potential for erosion due to flowpath alteration. Natural features of the landscape in Impaired Area 1 such as lower stream slope and highly erodible soil types may also contribute to fine sediment deposition and retention.

Impaired Area 2 in the headwaters of the South Fork Groundhouse River is most likely impaired by low dissolved oxygen levels caused by natural conditions. Flow measurements in Impaired Area 2 indicate that low flows may be causing the observed dissolved oxygen levels. Because of this, Impaired Area 2 may be functionally behaving more like a wetland than a stream ecosystem. Monitoring conducted in 2008 by the MPCA indicates that Impaired Area 2 is functioning more as a wetland system; thus causing low dissolved oxygen conditions in the area.

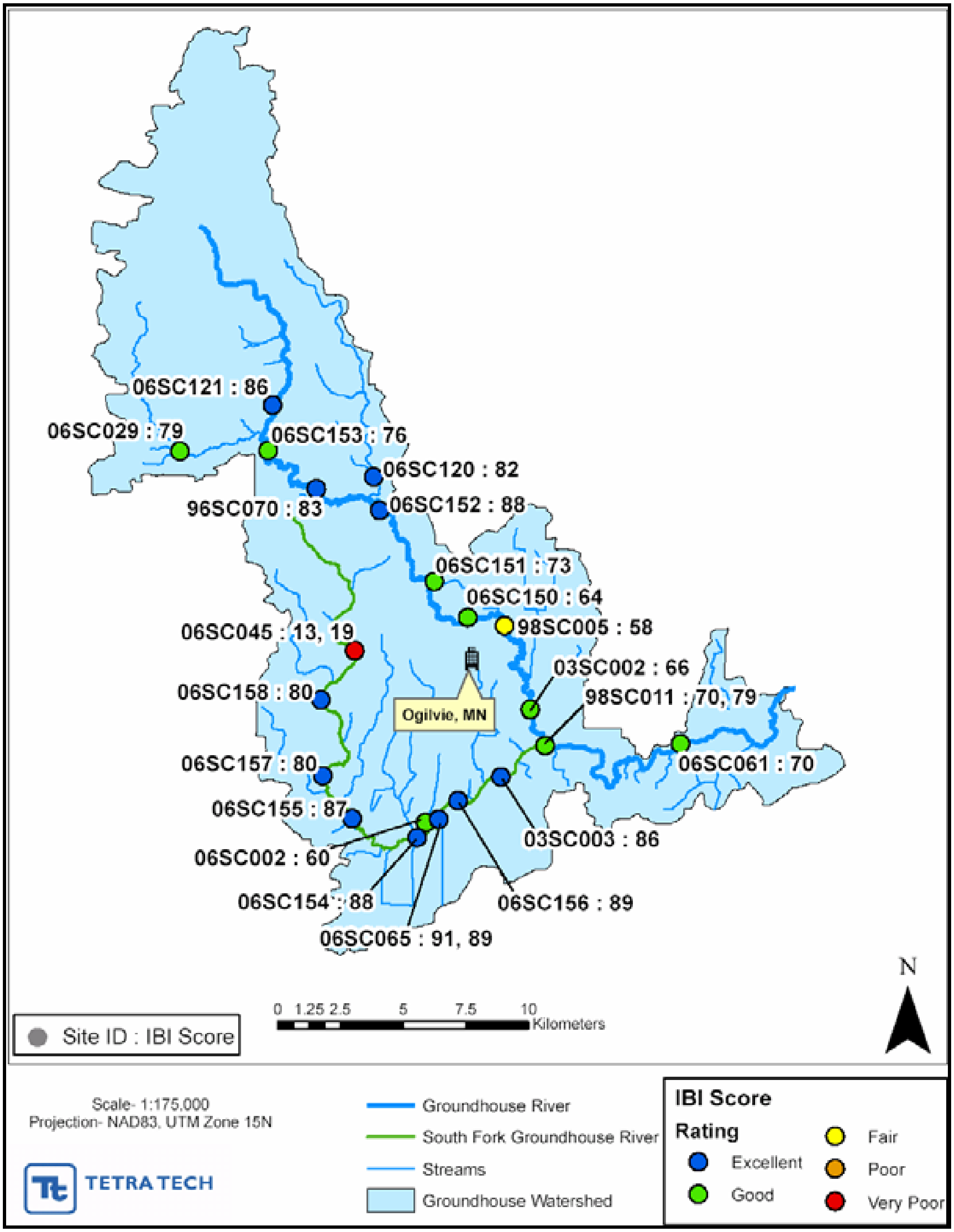


Figure 3. Fish IBI Scores Collected in the Groundhouse Watershed in 2006

Macroinvertebrate IBI Scores and Impairments

Macroinvertebrates were found to be impaired throughout the Groundhouse River watershed with only 40 percent of sites in the watershed scoring better than the impairment threshold for MIBI scores (50). Only four sites (16 percent of samples) had MIBI scores greater than 60. Figure 4 shows the MIBI scores calculated at the 24 sites in the watershed. Based on the widespread impairment of the benthic invertebrate communities, it appears that the invertebrate community is being impacted to a greater extent than the fish community.

The most consistent impairment among all South Fork Groundhouse River sites was an increase or presence of high levels of fine sediments. The presence of fine sediments also corresponded with a low-gradient channel. It is likely, then, that the low gradient corresponds to lower stream power to move bedded sediment out of the South Fork Groundhouse River. The mainstem Groundhouse River sites with severely impaired benthic invertebrate communities were separated into an upper river group and a lower river group. The upper river region sites were more frequently identified as having low gradient stream channels with some increased percent fines in habitable substrates. The lower group of sites on the mainstem Groundhouse River is located in a higher gradient reach and potential stressors at these sites included differing concentrations of total suspended solids (TSS), ammonium (NH4), and total phosphorus (TP). One of the sites in the lower group is located below the Ogilvie WWTP which contributes additional flow, nutrients, inorganics, and organic material to the river.

The lowermost site on the mainstem Groundhouse River had one of the highest biological condition scores despite trends at other sites showing biological impairment with high nutrient levels and percent fines. This may be because of a larger stream channel with a complex riparian structure and instream substrate structure that provides a variety of physical habitat. The cumulative impacts from pollutants on the biological community in large rivers do not appear to be as severe as individual effects from each pollutant on biological communities in smaller streams.

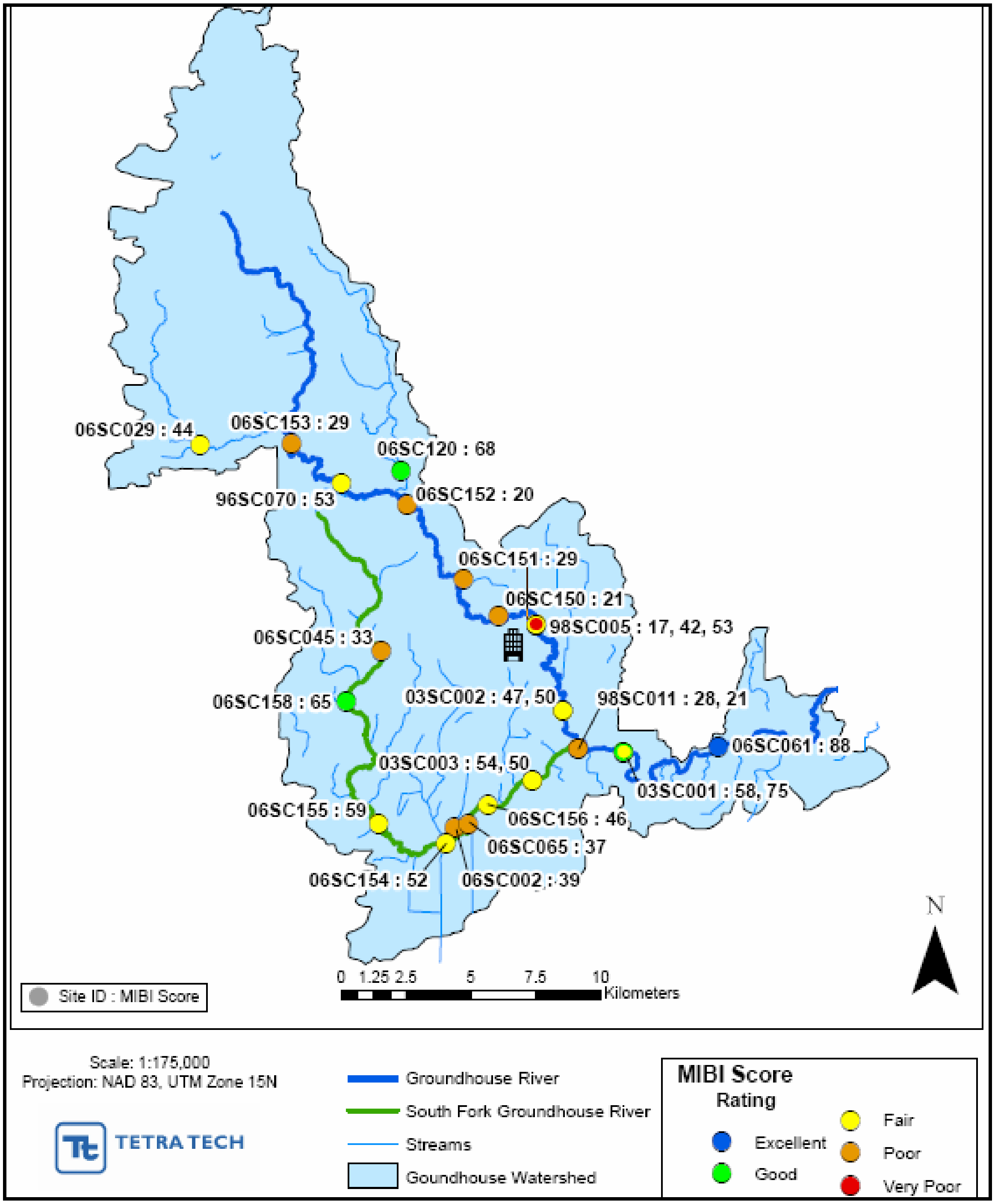


Figure 4. Macroinvertebrate IBI Scores Collected in the Groundhouse Watershed in 2006

1.3.2. Fecal Coliform Data

Fecal coliform bacteria are an indicator organism, meaning that not all the species of bacteria of this category are harmful, but they are usually associated with harmful organisms transmitted by fecal contamination. They are found in the intestines of warm-blooded animals (including humans). The presence of fecal coliform bacteria in water suggests recent contamination from fecal matter and the possible presence of harmful bacteria (e.g., some strains of *E. coli*) that are pathogenic to humans when ingested (USEPA, 2001). The Minnesota rules state that fecal coliform concentrations in Class 2C waters shall "not exceed 200 organisms per 100 milliliters as a geometric mean[1] of not less than five samples in any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 2,000 organisms per 100 milliliters. The standard applies only between April 1 and October 31." The TMDL report focuses on the geometric mean standard of 200 organisms per 100 milliliters.

Review of the fecal coliform data in the Groundhouse River watershed show a wide range of reported values which is consistent with the behavior of bacteria in natural systems. Median and geometric mean values are relatively similar at all stations with a few exceptions. The highest overall geometric mean values of fecal coliform have been observed on the South Fork Groundhouse River. The lowest overall values were obtained on an unnamed tributary near the confluence with the mainstem. To highlight the spatial variability of fecal coliform throughout the watershed, the geometric mean fecal coliform concentrations were plotted as shown in Figure 5.

[1] Geometric means are used to represent average fecal coliform concentrations. A geometric mean is appropriate for summarizing the central tendency of environmental data that are not normally distributed (Helsel and Hirsch, 1991). Unlike an arithmetic mean, a geometric mean tends to dampen the effect of very high or very low values. It is calculated by taking the n^{th} root of the product of n numbers (or by taking the antilog of the arithmetic mean of log-transformed numbers).

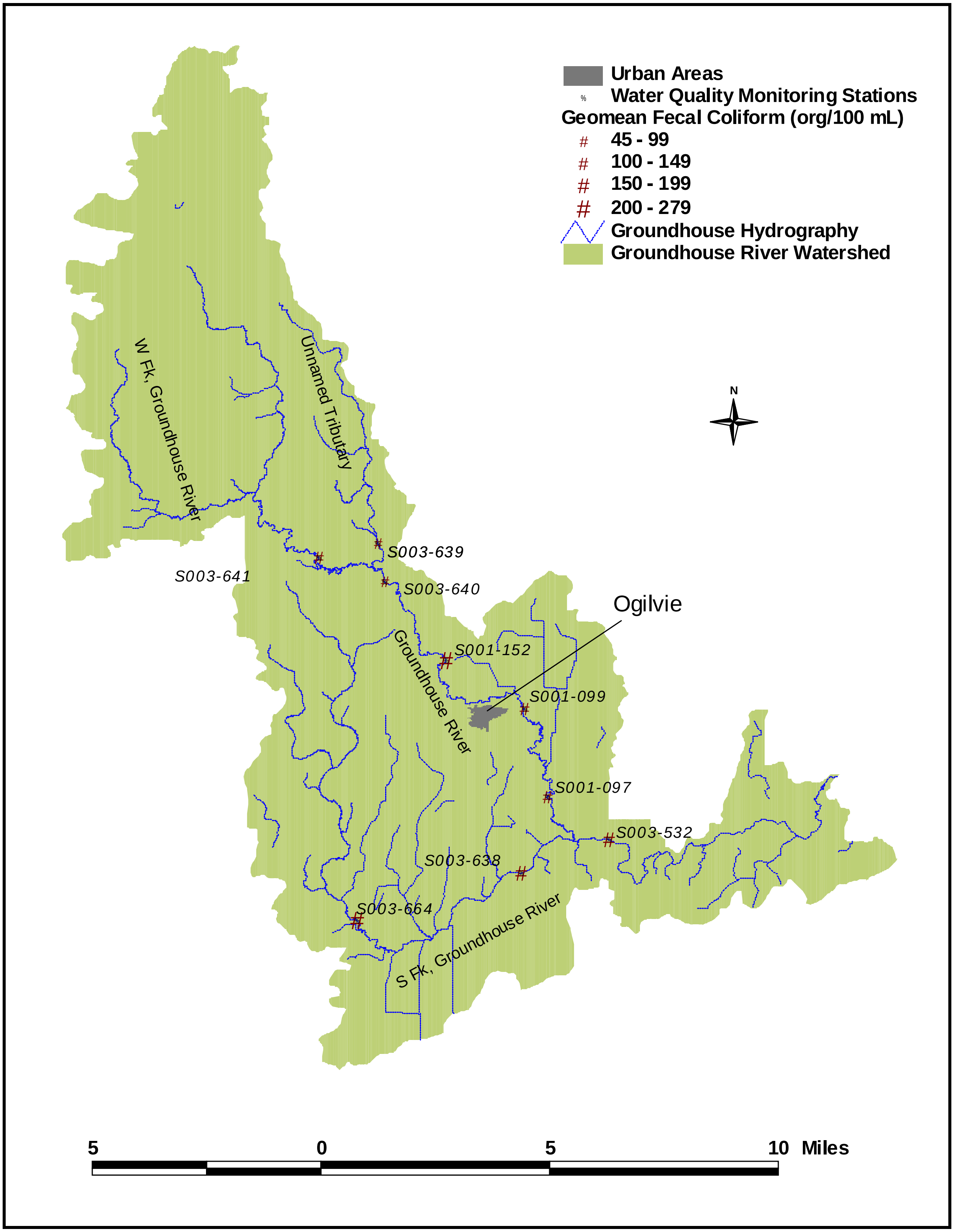


Figure 5. Spatial Distribution of Fecal Coliform Geomean in the Groundhouse River Watershed

A long-term evaluation of fecal coliform counts in the Groundhouse River watershed is only possible at station S001-152 as data have been collected in the late 1980s, the late 1990s, and 2005. Review of the median and geometric mean fecal coliform concentrations aggregated by the decade of sampling shown in Figure 6 indicate a potential long term increase in fecal coliform concentrations. These increases could be the result of some type of shift in land use or management.

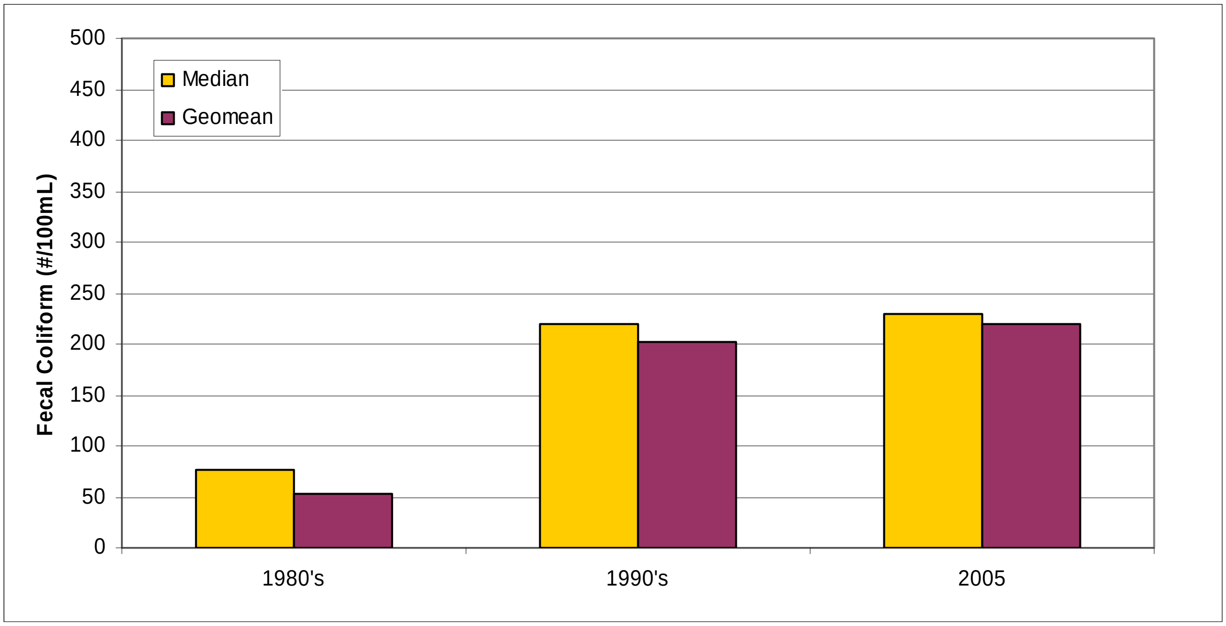
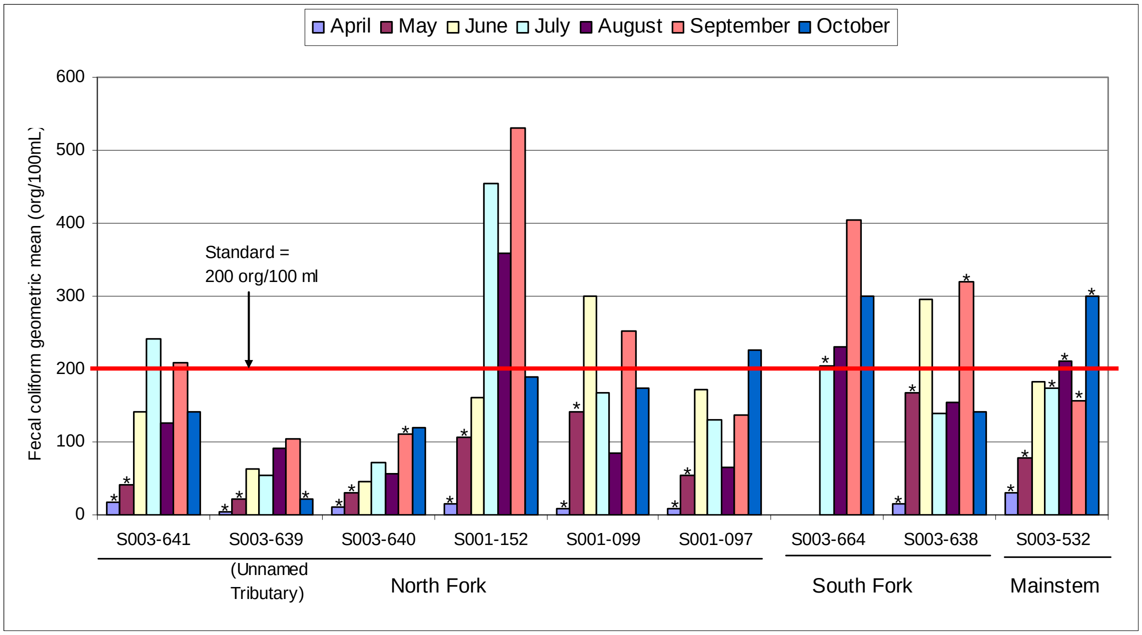


Figure 6. Median and Geometric Mean Annual Fecal Coliform Concentrations at S001-152

The 2005 data throughout the watershed were also evaluated with a monthly geometric mean component to evaluate potential seasonal trends (Figure 7). It should be noted that the April and May values are based on sample sizes less than 5, which is less than required for evaluation of the water quality standard. The monthly geometric mean values are highly variable by month, potentially due to the occurrence of rain events during any given month.



*Fewer than 5 samples obtained during this month.

Figure 7. Geometric Mean Fecal Coliform Concentrations by Month

Generally, storm events are the primary cause of nonpoint source loading to streams. To evaluate the importance of stormwater runoff on instream concentrations, the 2005 data set was evaluated based on antecedent rainfall. Monitoring events which occurred within 24 hours of at least a 0.5-inch rainfall event or 48 hours of at least a 1-inch rainfall event were considered to be wet (w) sampling. The remaining sampling was considered to have been done under dry (d) conditions. A box and whisker plot was developed to illustrate the differences between the wet and dry monitoring (Figure 8). A systematic increase in fecal concentrations is seen under wet conditions at all locations.

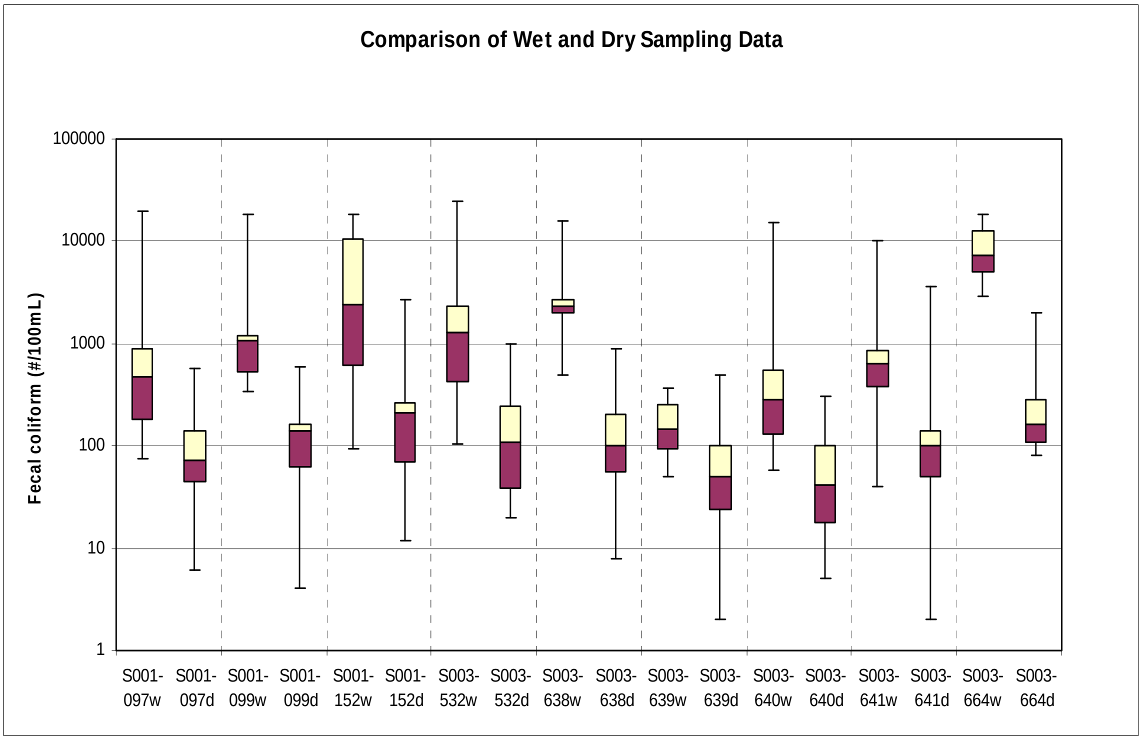


Figure 8. Comparison of Wet and Dry Weather Fecal Coliform Sampling[2]

2. TMDL Summary

This section of the implementation plan summarizes the findings of the draft sediment and fecal coliform TMDLs for the South Fork and mainstem Groundhouse Rivers. EPA has approved this document which is now posted on the MPCA's website in its finalized form.

2.1. Source Assessment

As part of the TMDL analysis, a Source Assessment was completed that identifies the potential point and nonpoint pollutant sources that may contribute to the biota/sediment and fecal coliform impairments in the Groundhouse River watershed. The potential sources contributing fecal coliform and sediment loads to the listed reaches are briefly discussed below. Additional detail can be found in the TMDL report.

2.1.1. Sediment Sources

The average annual total sediment load estimated to originate in the South Fork watershed is 6,661.1 US tons/per year. Figure 9 shows the estimated percent contribution of each source in the watershed. Only sources contributing more than 0.2 percent display in the pie chart. The 7,000 acres of row crop production contribute over 47 percent of the load, and streambank erosion contributes over 39 percent of the load. Lands classified as pasture make up most of the remaining load (over 9 percent).

[2] The box and whisker plot shows the range from the 5th to the 95th percentile of the observations at each station during wet and dry conditions. The first quartile (25th percentile), median, and third quartile (75th percentile) define the size of each box.

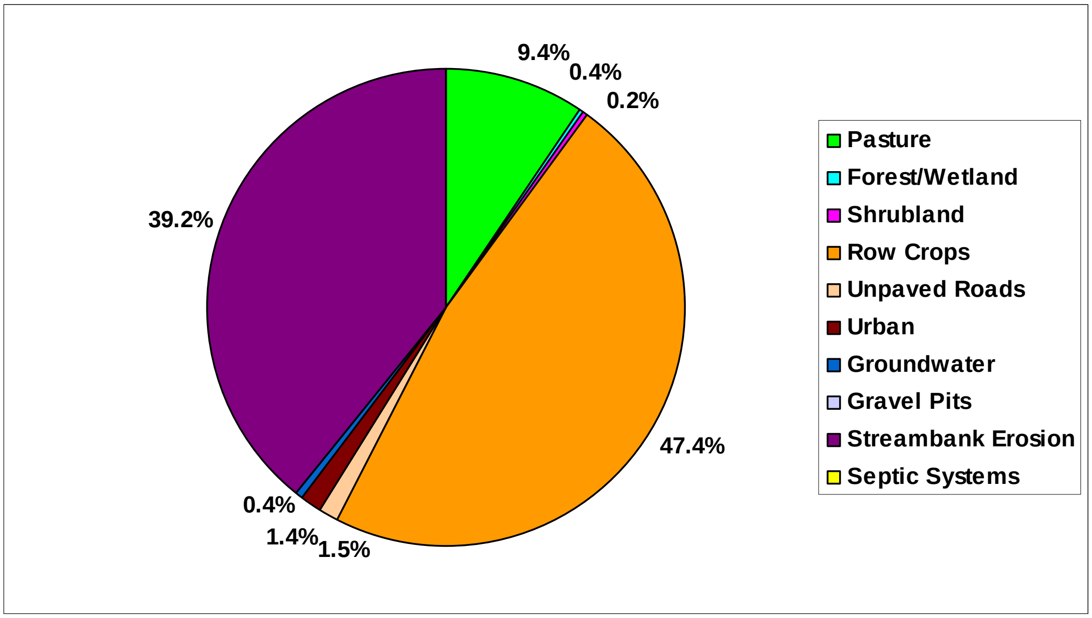


Figure 9. Percent Contribution of Sediment Sources in the South Fork Groundhouse Watershed

The annual sediment load in the mainstem Groundhouse watershed is 6,074.4 US tons/yr. Figure 10 shows the percent contribution from the sources in the watershed that contribute more than 0.2 percent of the total load. Again, the majority of the sediment load originates from either streambank erosion (over 53 percent) or row crop production (approximately 30 percent) with nearly 10 percent from pasture lands.

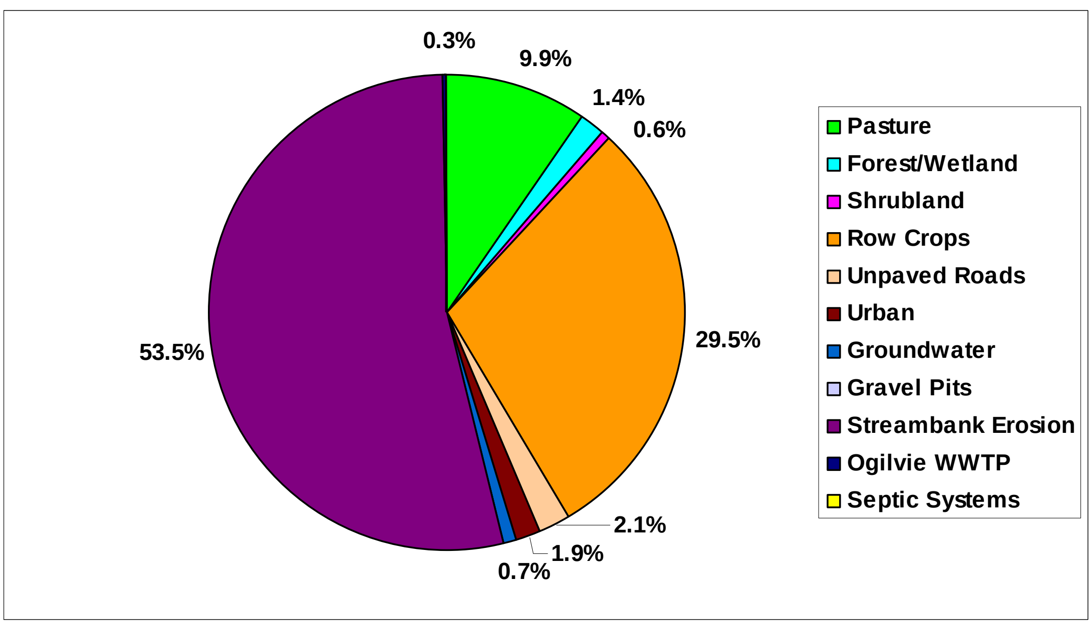


Figure 10. Percent Contribution of Sediment Sources in the Mainstem Groundhouse Watershed

2.1.2. Fecal Coliform Sources

Fecal coliform loads from each major source were estimated using watershed data, literature values of fecal coliform loading rates, and a delivery factor approach developed by MPCA (2006). The estimated daily fecal coliform load delivered to the South Fork Groundhouse River is 6,832,411 million organisms per day, and the load delivered to the mainstem is estimated to be 2,826,497 million organisms per day. It is acknowledged that there is a great deal of uncertainty in the loading estimates for all sources of fecal coliform.

Figure 11 shows the estimated percent contribution of the fecal coliform sources in the South Fork watershed. Almost 96 percent of the delivered load likely originates from animal operations; onsite wastewater treatment systems make up most of the remaining load at just under 4 percent. The load from wildlife and pets is not significant.

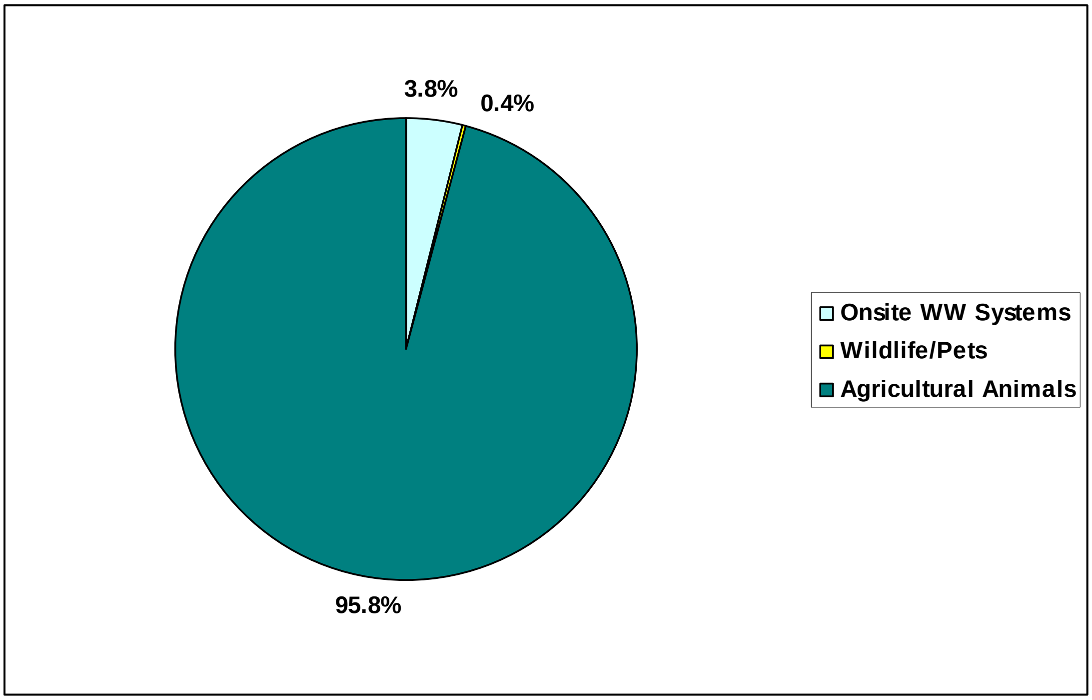


Figure 11. Percent Contribution of Fecal Coliform Sources in the South Fork Groundhouse Watershed

Figure 12 shows the percent contribution from the sources in the mainstem watershed that contribute more than 0.2 percent of the total load. Again, the majority of the delivered fecal coliform load comes from animal operations (over 84 percent) with most of the remaining load from onsite wastewater treatment systems (over 14 percent). Wildlife and pets contribute approximately 1 percent of the delivered load. The load from the Ogilvie WWTP is only 0.06 percent of the total load and does not display on the pie chart.

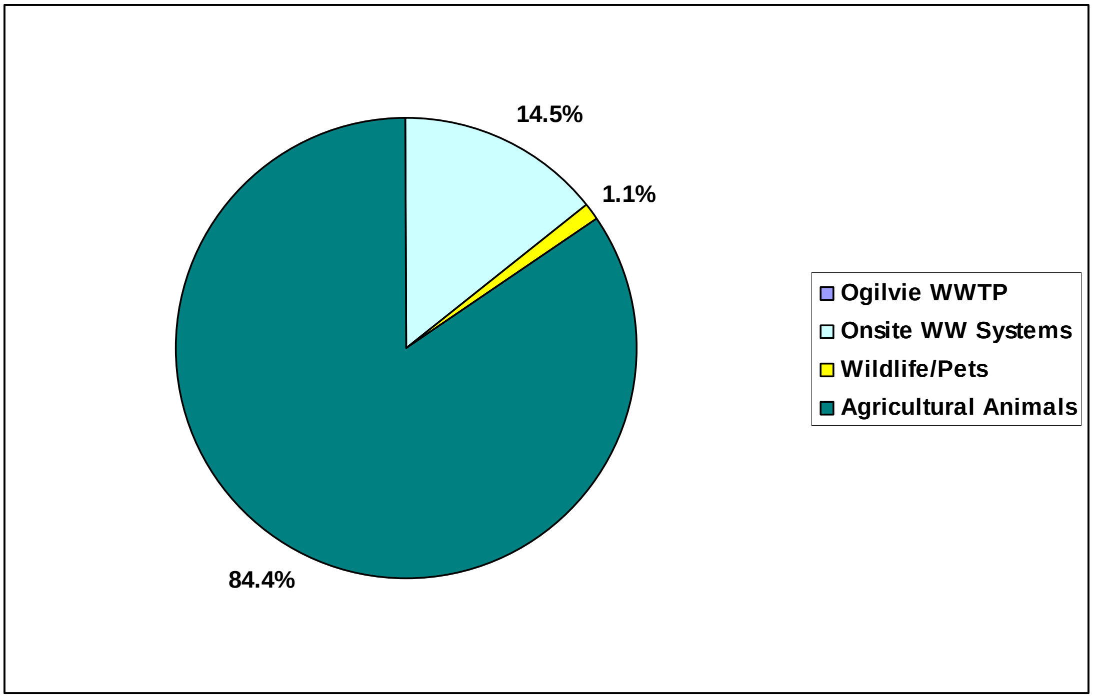


Figure 12. Percent Contribution of Fecal Coliform Sources in the Mainstem Groundhouse Watershed

2.2. Water Quality Goals

2.2.1 Sediment

Similar to most states, Minnesota does not currently have numeric water quality standards for TSS or fine sediments which could be directly used to quantify the allowable load of sediment in the Groundhouse River watershed. The sediment TMDL is based upon reducing loads from all of the significant anthropogenic sources in the watershed such that future loads will better approximate "natural" conditions. Achieving a "natural" sediment load in the watershed is then expected to promote improvements in aquatic communities measured with evaluation tools for biological conditions described in the State Narrative Standard. The following approach was used to estimate the natural (i.e., allowable) sediment load in the watershed:

- Sediment loads from gravel pits and animal operations were set to zero.
- Erosion from row crops was assumed to decrease by 50 percent through the increased use of BMPs such as conservation tillage, cover crops, grassed waterways, and filter strips.
- Streambank erosion was assumed to decrease to rates reported for areas with no cattle access and vegetated riparian zones based on Zaimes et al. (2005 and 2006).

To attain "natural" conditions, total sediment loads need to be reduced by 30.8 percent in the Groundhouse River and 39.4 percent in the South Fork Groundhouse River.

2.2.2 Fecal Coliform

Though needed fecal coliform load reductions were not used as the allocation method in this TMDL, the TMDL focuses on the monthly geometric mean component of the fecal coliform standard of 200 organisms/100 mL. It is believed that achieving the necessary reductions to meet the geometric mean component of the standard will reduce the exceedances of the acute standard, therefore complying with both parts of the water quality criteria. Of nine total sampling stations in the Groundhouse River watershed, all but two stations displayed fecal coliform geometric mean values above the water quality standard. Increasing fecal coliform concentrations were also noted in a temporal trends analysis and this potential long term increase which could be a result of some type of shift in land use or management.

3. Implementation Partners and Planning

A variety of possible measures are suggested for implementation throughout the Groundhouse River watershed to achieve the recommended fecal coliform and sediment reductions, attain water quality standards, and improve biological health. Multiple partners will be involved in this implementation process, and a coordinated effort will be needed to successfully carry out the implementation plan.

3.1. Implementation Partners

The Snake River Watershed Management Board (SRWMB) will coordinate the effort to achieve the recommended fecal coliform and sediment load reductions, attain water quality standards, and improve the biological health throughout the Groundhouse River Watershed. The SRWMB is assisted by the Citizens Advisory Committee and technical representatives from the four Soil and Water Conservation Districts (SWCD) within the Snake River Watershed.

The Implementation partners for this project include the SWCD's of Kanabec and Mille Lacs Counties, Kanabec County Environmental Services, Minnesota Board of Water and Soil Resources, Minnesota Department of Natural Resources, IMPACK 6 – Engineering Technical Services Area, Natural Resources Conservation Services (NRCS), and Resource Conservation and Development (RC&D Council). Other Partners include local stakeholders, such as, land owners, lake associations, and sportsman's clubs; who have provided input at local meetings. Work plans were developed with the Minnesota Pollution Control Agency (MPCA), through the Kanabec SWCD and Project Consultant for the TMDL study.

3.2. Funding Opportunities

This section briefly describes the potential funding programs available for the Groundhouse River watershed.

Environmental Quality Incentives Program (EQIP)

Several cost share programs are available to farmers and landowners who voluntarily implement resource conservation practices in the Groundhouse watershed. The most comprehensive is the NRCS Environmental Quality Incentives Program (EQIP) which offers cost sharing and incentives to farmers statewide who utilize approved conservation practices to reduce pollutant loading from agricultural lands. In order to participate in the EQIP cost share program, all BMPs must be constructed according to the specifications listed for each conservation practice.

Conservation Reserve Program (CRP)

The Farm Service Agency of the USDA supports the Conservation Reserve Program (CRP) which rents land converted from crop production to grass or forestland for the purposes of reducing erosion and protecting sensitive waters. This program is available to farmers who establish vegetated filter strips or grassed waterways.

The Conservation Reserve Program also sponsors the Farmable Wetlands Pilot Program. The goal of this program is to restore 500,000 acres of wetland and buffer areas to a more natural hydrologic and vegetative condition. The CRP also sponsors the Conservation Reserve Enhancement Program, which provides incentives to land owners who retire environmentally sensitive agricultural lands.

Wetlands Reserve Program

The USDA NRCS sponsors the federal Wetlands Reserve Program which encourages voluntary participation of farmers and land owners to enhance, restore, and protect wetland environments. The program provides support through technical assistance and cost share programs.

Wildlife Habitat Incentives Program

The USDA NRCS also sponsors the Wildlife Habitat Incentives Program (WHIP). This program offers technical assistance and cost sharing to farmers and land owners who want to improve fish and wildlife habitat. Eligible lands include grassland, woodland, pastureland, wetlands, streams, and riparian areas. Only land not eligible for other federal or state conservation programs, such as the Wetlands Reserve Program or the Conservation Reserve Program, may be considered for WHIP assistance.

AgBMP Loan Program

The AgBMP Loan Program offered through the Minnesota Department of Agriculture provides low-interest loans to assist farmers or land owners who implement conservation practices aimed at reducing water pollution caused by agricultural activities or failing onsite wastewater treatment systems. Examples of covered practices include feedlot improvements, manure storage basins, manure handling equipment, conservation tillage equipment, repair of onsite wastewater treatment systems, grassed waterways, streambank protection, sedimentation basins, wind breaks, and other erosion control practices.

Sustainable Agriculture Grant Program (SARE)

The Sustainable Agricultural Grant Program funds research, education, and outreach efforts for sustainable agricultural practices. Private landowners, organizations, educational, and governmental institutions are all eligible for participation in this program.

Local Soil and Water Conservation Districts (SWCDs)

The local Soil and Water Conservation Districts (SWCDs) issue State cost-share funds administered by the Minnesota Board of Water and Soil Resources.

Snake River Watershed Management Board

The Snake River Watershed Management Board offers cost share incentives through a continuation of the Minnesota Clean Water Partnership Grant Program.

Clean Water Act Section 319 Programs

Financial assistance is provided to address non-point source water pollution, including the study of water bodies with pollution problems, development of action plans, and implementation of the action plans.

Clean Water Partnership (CWP) Grants and Loans

Financial assistance is provided through the CWP program to protect and restore areas either listed as unimpaired or water bodies not currently assessed. Also, available are SRF loan funds for septic systems. These funds are administered by the Minnesota Pollution Control Agency.

Clean Water Fund (Amendment)

Amendment funds are available through the Minnesota Board of Water and Soil Resources to implement approved Total Maximum Daily Load Implementation Plans.

4. Implementation Actions

Controlling pollutant loading to the impaired reaches of the Groundhouse watershed will require implementation of various BMPs. This section describes BMPs that may be used to reduce loading of sediment, TSS, or fecal coliform from livestock operations, crop production, and onsite wastewater treatment systems. In addition, options for stream restoration and habitat improvement projects are anticipated to reduce pollutant loadings as well as result in improved biological community health.

Although the TMDLs focus on reducing loads of fecal coliform and sediment, reported reductions in nutrient, pesticide, and organic loading are discussed as well. Many of the BMPs also address these additional pollutants which may be causing secondary impacts to biota in the watershed. For example, pesticide runoff from cropland may result in toxic conditions for aquatic organisms.

Livestock Operations:

- Proper manure handling, collection, and disposal
- Manure storage facilities
- Feedlot runoff control
- Composting
- Alternative watering systems
- Cattle exclusion from streams
- Reinforced cattle access points
- Grazing land management
- Manure / nutrient management plans
- Education

Onsite Wastewater Treatment Systems:

- Upgrading, inspections and proper maintenance
- Education

Crop Production:

- Conservation tillage
- Cover crops
- Vegetative filter strips
- Grassed waterways
- Controlled drainage
- Sedimentation basins
- Field windbreaks
- Education

Restoration and Habitat Improvements:

- Streambank erosion BMPs
- Habitat improvements
- Wetland restoration
- Riparian veg. buffer establishment
- Forest stewardship and management planning
- Education

Although this TMDL has been recently completed, the project partners have already begun working with landowners in the Groundhouse River Watershed on some of these BMPs; including streambank restoration and stabilization, feedlot runoff control, agricultural waste storage, livestock exclusion, conservation tillage, nutrient management planning and forest stewardship planning. Funding for these projects has been provided through a Clean Water Partnership grant through the Snake River Watershed Management Organization, which works with projects throughout the entire Snake River Watershed. The Watershed Organization is also administering a Septic System Loan Program through the CWP grant for Kanabec County. Other current funding sources for BMP implementation include the Federal EQIP program, Kanabec County Water Management Plan, DNR Forestry, Kanabec SWCD, and landowners.

It should be noted that some of the photos included in this section were taken from actually BMPs installed within the Groundhouse River Watershed. The other photos are examples of BMPs or equipment courtesy of the USDA NRCS or other SWCD's. The definition list below is to provide a better understanding of the terms used in this section.

Definitions:

- ***Implementation Partners*** – These are the local agencies or groups who will provide assistance, guidance, or financial support to projects related to the defined action.
- ***Estimated Cost*** – The estimated amount of money needed to install all of the necessary described BMPs within the watershed.
- ***Timeframe*** – This is the estimated timeframe in which all of the BMPs in each action could be implemented. This will need to be reassessed on occasion and adjustments made to reflect what is happening locally.

- ***Estimated Load Reductions*** – This is the estimated amount of reductions achieved by installing or implementing all of the BMPs in that action item.
- ***Interim Milestones*** – These are short term achievements which the group hopes to achieve once funding is available.
- ***Targeted Owners*** – These are landowners, feedlot owners, etc. who have some direct or indirect impact on the water quality and habitat of the Groundhouse River.

4.1. Livestock Operations

The implementation partners and local agencies will encourage the use of BMPs at animal operations to reduce pollutant transport to streams and to protect streambanks from cattle access. BMPs will be discussed at educational forums along with the grants and funds available to voluntary participants. When appropriate, television news, internet, radio, and newspaper advertisements and articles will be used to highlight the benefits of incorporating these BMPs into facility operations to improve water quality, protect animal and human health, and improve environmental conditions in the watershed.

The following sections discuss the BMPs available for use at livestock operations. This information will form the basis of the educational material used to encourage voluntary implementation of these BMPs. The benefits discussed include reported reductions in fecal coliform loading as well as additional benefits to streambank stability and aquatic habitat.

Implementation Partners	Kanabec and Mille Lacs Counties Kanabec and Mille Lacs SWCDs Snake River Watershed Management Board IMPACK 6 – Joint Powers Area Farm Services Agency Feedlot Owners Board of Soil and Water Resources Minnesota Pollution Control Agency Natural Resources Conservation Service Resource, Conservation, and Development MN Department of Natural Resources
Estimated Cost:	$181,980
Timeframe:	Spring 2010 – Summer 2030
Estimated Load Reduction: Phos. reduction = 78 lbs/yr COD reduction = 5,694 lbs/yr Nitrogen reduction = 294 lbs/yr BOD reduction = 1,266 lbs/yr	29 – 99%
Interim Milestones	Targeted feedlot owners within the watershed contacted by spring 2011

4.1.1. Proper Manure Handling, Collection, and Disposal

Depending on whether or not an animal operation is pasture-based or confined, manure is typically deposited in feedlots, around watering facilities, and within confined spaces such as housing units and milking parlors. Except for feedlots serving a low density of animals, each location will require the collection and transport of manure to a storage structure, holding pond, storage pit, or lagoon prior to final disposal. The following practices should be used to prevent contamination of surface waters (USEPA, 2003):

- Manure collected from open lots and watering areas is often collected by a tractor equipped with a scraper. This manure is in solid form and is typically stored on a concrete pad surrounded by three walls that allow for stacking of contents. Depending on the climate, a roof may be required to protect the manure from frequent rainfall.
- Clean water from rooftops or up-grade areas should be diverted around waste stockpiles and heavy use areas with berms, grassed channels, or other means of conveyance.
- Runoff from the feedlot areas and wash water used to clean confinement buildings is considered contaminated and is typically treated in a lagoon or filter strip.
- Stored manure may be land applied when the ground is not frozen and precipitation forecasts are low. A nutrient management plan should be developed to ensure that manure is applied at agronomic rates.
- Waste storage lagoons, pits, and above ground tanks are good options for large facilities.
- Methane gas recovered from anaerobic treatment processes can be used to generate electricity.

A photo of an earthen manure storage pit taken by the Kanabec County Soil and Water Conservation District shown in Figure 13.

(Photo courtesy of KCSWCD)

Figure 13. Earthen Manure Storage Pit in the process of being pumped for land application near the South Fork of the Groundhouse River

Benefits

Though little change in total phosphorus or organic content has been reported, reductions in fecal coliform as a result of proper manure storage have been documented in two studies:

- 97 percent reduction in fecal coliform concentrations in runoff when manure is stored for at least 30 days prior to land application (Meals and Braun, 2006)
- 90 percent reduction in fecal coliform loading with the use of waste storage structures, ponds, and lagoons (USEPA, 2003)
- Reducing fecal coliform loading to adjacent streams will reduce animal and human health risks

4.1.2. Composting

Composting is the biological decomposition and stabilization of organic material. The process produces heat that, in turn, produces a final product that is stable, free of pathogens and viable plant seeds, and can be beneficially applied to the land. Like manure storage areas, composting facilities should be located on dry, flat, elevated land at least 100 feet from streams. The landowner should coordinate with local NRCS staff to determine the appropriate design for a composting facility based on the amount of manure generated. Extension agents can also help landowners achieve the ideal nutrient ratios, oxygen levels, and moisture conditions for composting on their site.

Composting can be accomplished by simply constructing a heap of the material, forming composting windrows, or by constructing one or more bins to hold the material. Heaps should be 3 feet wide and 5 feet high with the length depending on the amount of manure being composted. Compost does not have to be turned, but turning will facilitate the composting process (University of Missouri, 1993; PSU, 2005). Machinery required for composting includes a tractor, manure spreader, and front-end loader (Davis and Swinker, 2004). Figure 14 shows a poultry litter composting facility.

(Example Photo courtesy of USDA NRCS.)

Figure 14. Poultry Litter Composting Facility

Benefits

Composting stabilizes the organic content of manure and reduces the volume that needs to be disposed of. In addition, the following reductions in loading are reported:

- 99 percent reduction of fecal coliform concentrations as a result of the heat produced during the composting process (Larney et al., 2003)
- 56 percent reduction in runoff volumes and 68 percent reduction in sediment as a result of improved soil infiltration following application of composted manure (HRWCI, 2005)
- Reducing fecal coliform loading to adjacent streams will reduce animal and human health risks

4.1.3. Alternative Watering Systems

A primary management tool for pasture-based systems is supplying cattle with watering systems away from streams and riparian areas. Livestock producers who currently rely on streams to provide water for their animals must develop alternative watering systems, or controlled access systems, before they can exclude cattle from streams and riparian areas. One method of providing an alternative water source is the development of off-stream watering using wells with tank or trough systems. These systems are often highly successful, as cattle often prefer spring or well water to surface water sources. Figure 15 shows a centralized watering tank allowing access from rotated grazing plots and a barn area.

Landowners should work with an agricultural extension agent to properly design and locate watering facilities. One option is to collect rainwater from building roofs (with gutters feeding into cisterns) and use this water for the animal watering system to reduce runoff and conserve water use (Tetra Tech, 2006). Whether or not animals are allowed access to streams, the landowner should provide an alternative shady location and water source so that animals are encouraged to stay away from riparian areas.

(Example Photo courtesy of USDA NRCS.)

Figure 15. Centralized Watering Tank

Benefits

The USEPA (2003) reports the following pollutant load reductions achieved by supplying cattle with alternative watering locations and excluding cattle from the stream channel by structural or vegetative barriers:

- 29 to 46 percent reductions in fecal coliform loading
- 15 to 49 percent reductions in total phosphorus loading
- Reducing fecal coliform loading to adjacent streams will reduce animal and human health risks
- Minimizes streambank erosion associated with livestock trampling

Some researchers have studied the impacts of providing alternative watering sites without structural exclusions and found that cattle spend 90 percent less time in the stream when alternative drinking water is furnished (USEPA, 2003). Prohibiting access to the stream channels will also prevent streambank trampling, decrease bank erosion, protect bank vegetation, and reduce the loading of organic material to the streams. These benefits will help to improve stream habitat conditions and would help support healthy fish and macroinvertebrate communities.

4.1.4. Cattle Exclusion from Streams and Restricted Access Points

Cattle manure is a substantial source of nutrient and fecal coliform loading to streams, particularly where direct access is not restricted and/or where cattle feeding structures are located adjacent to riparian areas. Direct deposition of feces into streams may be a primary mechanism of pollutant loading during baseflow periods. During storm events, overbank and overland flow may entrain manure accumulated in riparian areas resulting in pulsed loads of nutrients, total organic carbon (TOC), biological oxygen demand (BOD), and fecal coliform bacteria into streams. In addition, cattle with unrestrained stream access typically cause severe streambank erosion. The impacts of cattle on stream ecosystems are shown in (Example Photo courtesy of USDA NRCS.)

Figure 16 and (Example Photo courtesy of USDA NRCS.)

Figure 17.

(Example Photo courtesy of USDA NRCS.)

Figure 16. Typical Stream Bank Erosion in Pastures with Cattle Access to Stream

(Example Photo courtesy of USDA NRCS.)

Figure 17. Cattle-Induced Streambank Mass Wasting and Deposition of Manure into Stream

An example of proper exclusion and the positive impacts on the stream channel are shown in Figure 18.

(Example Photo courtesy of USDA NRCS.)

Figure 18. Stream Protected from Cattle by Fencing

Allowing limited or no animal access to streams will provide the greatest water quality protection. On properties where cattle need to cross streams to have access to pasture, stream crossings should be built so that cattle can travel across streams without degrading streambanks and contaminating streams with manure. Figure 19 shows an example of a reinforced cattle access point to minimize time spent in the stream and mass wasting of streambanks.

(Example Photo courtesy of USDA NRCS.)

Figure 19. Restricted Cattle Access Point

Benefits

Fencing cattle from streams and riparian areas using vegetation or fencing materials will reduce streambank trampling and direct deposition of fecal material in the streams. As a result, eroded sediment and pollutant loads will decrease. The USEPA (2003) reports the following reductions in phosphorus and fecal coliform loading as a result of cattle exclusion practices:

- 29 to 46 percent reductions in fecal coliform loading
- 15 to 49 percent reductions in total phosphorus loading
- Improved stream habitat and support healthy biological communities
- Minimizes streambank erosion and riparian vegetation loss
- Reducing fecal coliform loading to adjacent streams will reduce animal and human health risks

4.1.5. Grazing Land Management

While erosion rates from pasture areas are generally lower than those from row-crop areas, a poorly managed pasture can approach or exceed a well-managed row-crop area in terms of erosion rates. Grazing land protection is intended to maximize ground cover on pasture, reduce soil compaction resulting from overuse, reduce runoff concentrations of nutrients and fecal coliform, and protect streambanks and riparian areas from erosion and fecal deposition. Figure 20 shows an example of a pasture managed for land protection. Cows graze the left lot while the right lot is allowed a resting period to revegetate.

(Example Photo courtesy of USDA NRCS.)

Figure 20. Example of a Well Managed Grazing System

Benefits

Maintaining sufficient ground cover on pasture lands requires a proper density of grazing animals and/or a rotational feeding pattern among grazing plots. Increased ground cover will also reduce transport of sediment. Dissolved oxygen concentrations in streams will likely improve as the concentrations of organic material in runoff are reduced proportionally with the change in number of cattle per acre. The following reductions in loading are reported in the literature (USEPA, 2003; Government of Alberta, 2007):

- 40 percent reduction in fecal coliform loading as a result of grazing land protection measures
- 90 percent reduction in fecal coliform loading with rotational grazing
- 49 to 60 percent reduction in total phosphorus loading
- Improved stream habitat and support healthy biological communities
- Reducing fecal coliform loading to adjacent streams will reduce animal and human health risks

4.2. Crop Production

Crop production in the Groundhouse watershed is estimated to contribute approximately 4,950 tons of sediment a year to the South Fork and mainstem segments. As fine sediment has been linked to impairments of the macroinvertebrate and fish communities through out the watershed, reducing loads from crop production is crucial to restoring biotic integrity. The implementation partners and local agencies will educate local farmers on the appropriate BMPs for reducing erosion and sediment transport from agricultural fields. Information concerning secondary impacts to aquatic health will also be highlighted. For example, reductions in pesticide loading will reduce acute and chronic toxicity to aquatic organisms and reductions in runoff volumes and velocities will reduce erosive forces causing streambank erosion.

This information will be passed along to local farmers through local meetings as well as print, radio, and internet media.

Implementation Partners	Kanabec and Mille Lacs Counties Kanabec and Mille Lacs SWCDs Snake River Watershed Management Board IMPACK 6 – Joint Powers Area Farm Services Agency Cropland Owners Board of Soil and Water Resources Minnesota Pollution Control Agency Natural Resources Conservation Service Resource, Conservation, and Development MN Department of Natural Resources
Estimated Cost:	$62,180
Timeframe:	Spring 2010 – Summer 2030
Estimated Load Reduction: Phos. reduction = 50 lbs/year Soil loss reduction = 50 tons/year	47 – 90% loading reduction
Interim Milestones	Targeted landowners within the watershed contacted by spring 2011

4.2.1. Conservation Tillage

Conservation tillage practices and residue management are commonly used to control erosion and surface transport of pollutants from fields used for crop production. The residuals from harvested crops not only provide erosion control, but also provide a nutrient source to growing plants, and continued use of conservation tillage results in a more productive soil with higher organic and nutrient content. Increasing the organic content of soil has the added benefit of reducing the amount of carbon in the atmosphere by storing it in the soil. Researchers estimate that croplands and pasturelands could be managed to trap 5 to 17 percent of the greenhouse gases produced in the United States (Lewandrowski et al., 2004).

Several practices are commonly used to maintain the suggested 30 percent residual surface cover: no-till, strip till, ridge till, and mulch till. (Example Photo courtesy of USDA NRCS.) Figure 21 shows a comparison of ground cover under conventional and conservation tillage practices.

(Example Photo courtesy of USDA NRCS.)

Figure 21. Comparison of Conventional (left) and Conservation (right) Tillage Practices

Though no-till systems are more effective in reducing sediment loading from crop fields, they tend to concentrate phosphorus in the upper two inches of the soil profile due to surface application of fertilizer and decomposition of plant material (IAH, 2002; UME, 1996). This pool of phosphorus readily mixes with precipitation and can lead to increased concentrations of dissolved phosphorus in surface runoff. Chisel plowing may be required once every several years to reduce stratification of phosphorus in the soil profile.

Benefits

The following reductions and impacts have been reported for conservation tillage (Czapar et al., 2006; USEPA, 2003):

- 68 to 76 percent reduction in total phosphorus
- 50 percent reduction in sediment for practices leaving 20 to 30 percent residual cover
- 90 percent reduction in sediment for practices leaving 70 percent residual cover
- 90 percent reduction in pesticide loading for ridge till practices
- 67 percent reduction in pesticide loading for no-till practices
- 69 percent reduction in runoff losses for no-till practices
- Sediment, nutrient, pesticide, and runoff reductions will likely improve stream habitat and water quality and support healthy biological communities

4.2.2. Cover Crops

Grasses and legumes may be used as winter cover crops to reduce soil erosion and improve soil quality (IAH, 2002). These crops also contribute nitrogen to the following crop, reducing fertilizer requirements. Grasses tend to have low seed costs and establish relatively quickly, but can impede cash crop development by drying out the soil surface or releasing chemicals during decomposition that may inhibit the growth of a following cash crop. Legumes take longer to establish, but are capable of fixing nitrogen from the atmosphere, thus reducing nitrogen fertilization required for the next cash crop. Legumes, however, are more susceptible to harsh winter environments and may not have adequate survival to offer sufficient erosion protection. Planting the cash crop in wet soil that is covered by heavy surface residue from the cover crop may impede emergence by prolonging wet, cool soil conditions. Cover crops should be killed off two or three weeks prior to planting the cash crop either by application of herbicide or mowing and incorporation, depending on the tillage practices used. Use of cover crops is illustrated in Figure 22.

(Example Photo Courtesy of NRCS)

Figure 22. Use of Cover Crops

Benefits

The effectiveness of cover crops in reducing pollutant loading has been reported by several agencies. In addition to these benefits, the reduction in runoff losses will reduce erosion of streambanks and allow for the establishment of vegetation and canopy cover. The reported reductions are listed below:

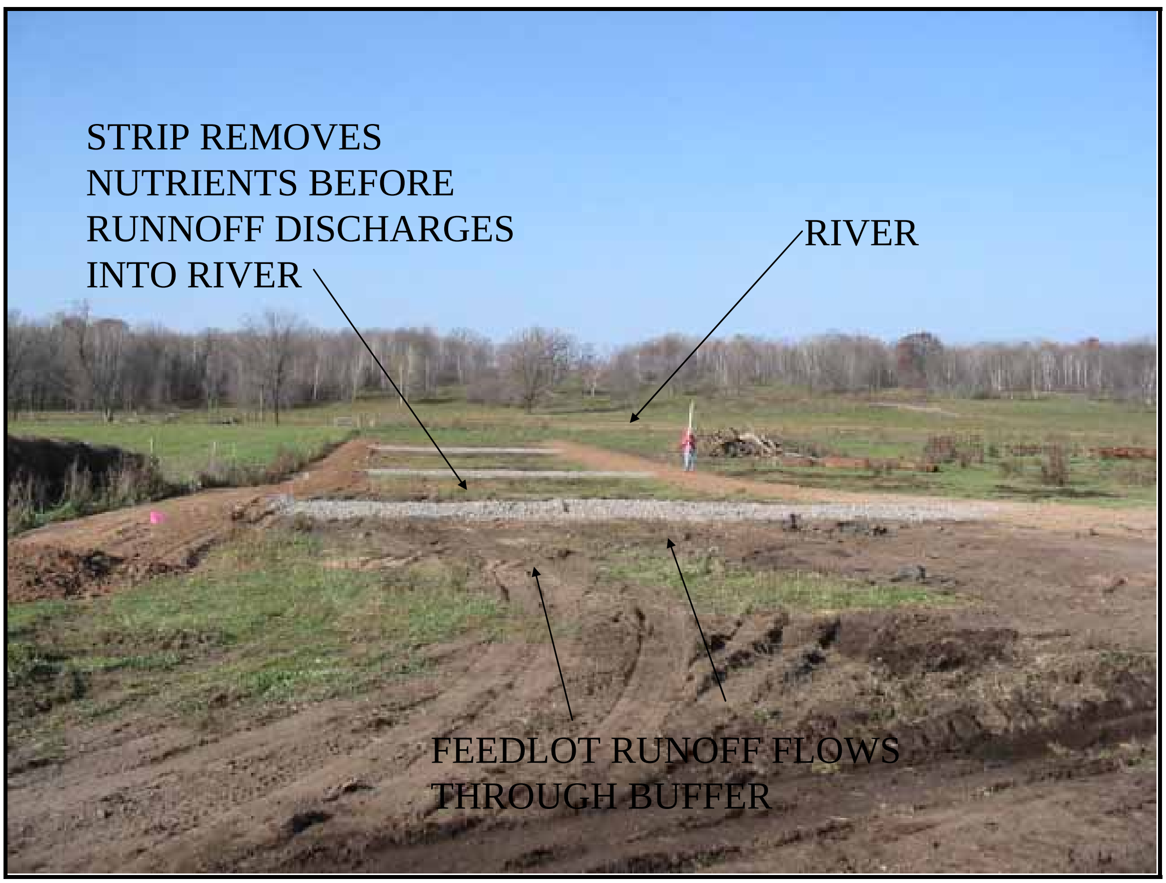
- 50 percent reduction in soil and runoff losses with cover crops alone. When combined with no-till systems, may reduce soil loss by more than 90 percent (IAH, 2002)
- 70 to 85 percent reduction in phosphorus loading on naturally drained fields (HRWCI, 2005)
- Reduction in fertilizer and pesticide requirements (OSUE, 1999)

- Useful in conservation tillage systems following low-residue crops such as soybeans (USDA, 1999)
- Sediment, nutrient, pesticide, and runoff reductions will likely improve stream habitat and water quality and support healthy biological communities

4.2.3. Filter Strips

Filter strips are used in agricultural and urban areas to intercept and treat runoff before it leaves the site. If topography allows, filter strips may also be used to treat effluent from tile drain outlets. For small dairy operations, filter strips may be used to treat milk house washings and runoff from the open lot (NRCS, 2003).

Filter strips will require maintenance, including grading and seeding, to ensure distributed flow across the filter and protection from erosion. Periodic removal of vegetation will encourage plant growth and uptake and remove nutrients stored in the plant material. Filter strips are most effective on sites with mild slopes of generally less than 5 percent, and to prevent concentrated flow, the upstream edge of a filter strip should follow one elevation contour (NCDENR, 2005). A filter strip at a feedlot adjacent to the Groundhouse River in Kanabec County is shown in Figure 23.



(Photo Courtesy of KCSWCD)

Figure 23. Grass Filter Strip Protecting Stream from Adjacent Feedlot near the main stem of the Groundhouse River

Filter strips also serve to reduce the quantity and velocity of runoff, which should reduce erosive forces on stream channels. Filter strip sizing is dependent on site specific features such as climate and topography, but at a minimum, the area of a filter strip should be no less than 2 percent of the drainage area for agricultural land (OSUE, 1994). The minimum filter strip width suggested by NRCS (2002) is 30 ft. The strips are assumed to function properly with annual maintenance for 30 years before requiring replacement of soil and vegetation.

Benefits

Filter strips have been found to effectively remove pollutants from agricultural runoff. The following reductions are reported in the literature (USEPA, 2003; Kalita, 2000; Woerner et al., 2006):

- 65 percent reduction in sediment
- 55 to 87 percent reduction in fecal coliform
- 11 to 100 percent reductions for atrazine
- 65 percent reductions for total phosphorus
- Slows runoff velocities and may reduce runoff volumes via infiltration
- Sediment, nutrient, pesticide, and runoff reductions will likely improve stream habitat and water quality and support healthy biological communities

4.2.4. Grassed Waterways

Grassed waterways are stormwater conveyances lined with grass that prevent erosion of the transport channel. They are often used to divert clean up-grade runoff around contaminated feedlots and manure storage areas (NRCS, 2003). In addition, the grassed channel reduces runoff velocities, allows for some infiltration, and filters out some particulate pollutants. A grassed waterway providing surface drainage for a corn field is shown in Figure 24.

(Example Photo Courtesy of NRCS)

Figure 24. Grassed Waterway

Benefits

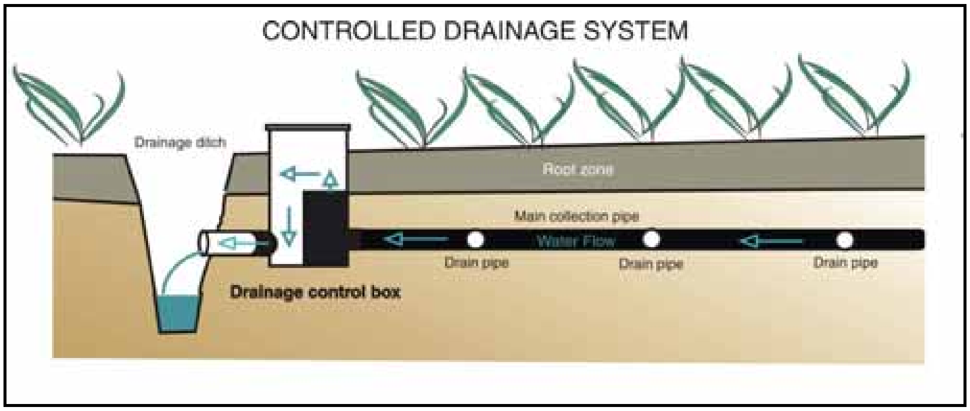
The effectiveness of grass swales for treating agricultural runoff has not been quantified. The Center for Watershed Protection reports the following reductions in urban settings (Winer, 2000):

- 5 percent reduction in fecal coliform
- 68 percent reduction of total suspended solids
- 30 percent reduction in total phosphorus
- Vegetation reduces erosion within conveyance
- May reduce runoff volumes via infiltration

In addition, grassed waterways that allow for water infiltration may reduce atrazine loads by 25 to 35 percent (Kansas State University, 2007). The resulting sediment, nutrient, pesticide, and runoff reductions will likely improve stream habitat and water quality and support healthy biological communities

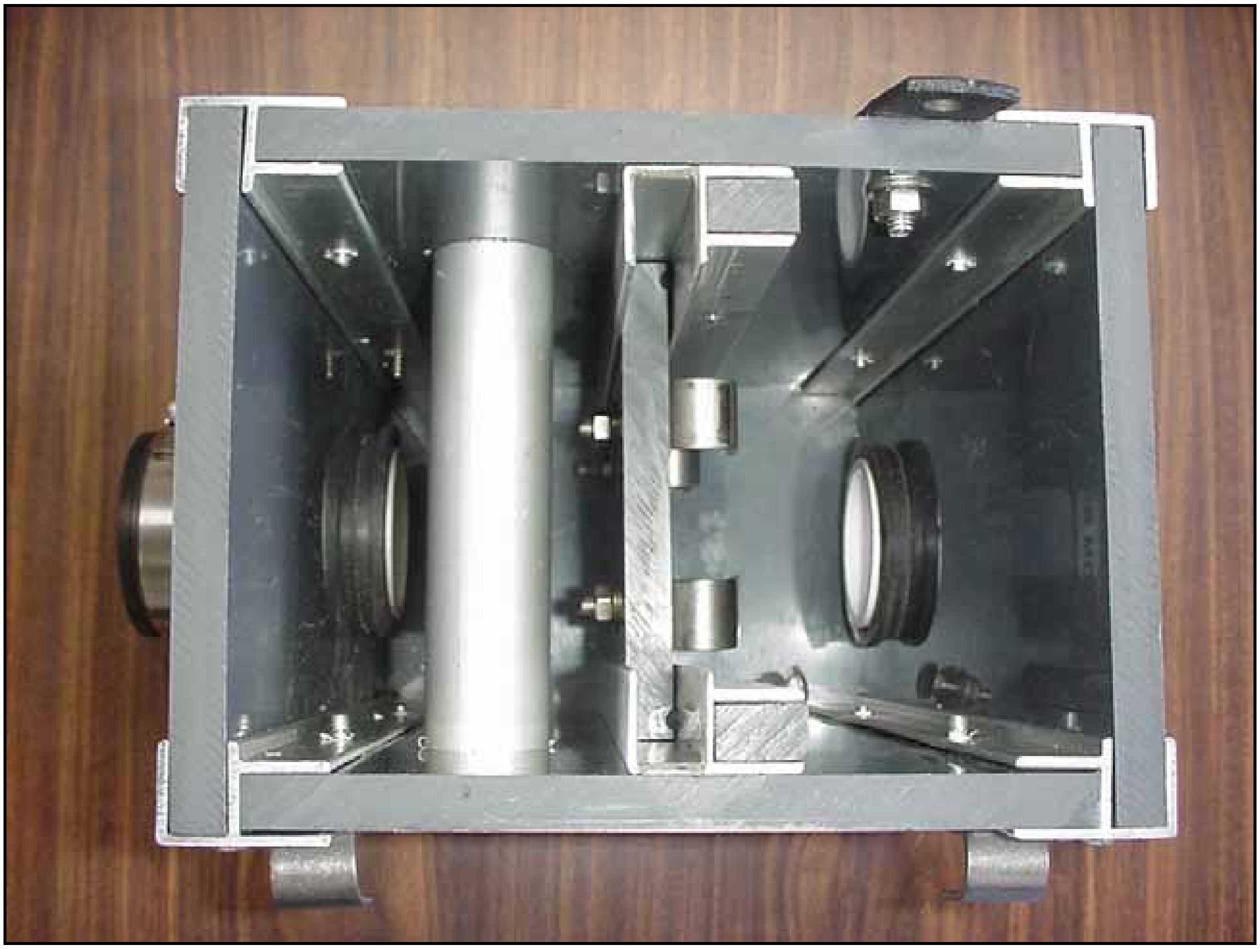
4.2.5. Controlled Drainage

A conventional tile drain system collects infiltrated water below the root zone and transports the water quickly to a down-gradient surface outlet. Placement of a water-level control structure at the outlet (Figure 25 and Figure 26) allows for storage of the collected water to a predefined elevation. The stored water becomes a source of moisture for plants during dry conditions and undergoes biological, chemical, and physical processes that result in lower nutrient concentrations in the final effluent. Installation of outlet control structures can also be used to plug old farm ditches and restore wetland areas (Section 4.4.3).



(Illustration Courtesy of the Agricultural Research Service Information Division)

Figure 25. Controlled Drainage Structure for a Tile Drain System



(Example Photo Courtesy of CCSWCD)

Figure 26. Interior View of a Drainage Control Structure with Adjustable Baffle Height

Benefits

Use of control structures on conventional tile drain systems in the coastal plains has resulted in the reduction of total phosphorus loading by 35 percent (Gilliam et al., 1997). Researchers at the University of Illinois also report reductions in phosphorus loading with tile drainage control structures. Concentrations of phosphate were reduced by 82 percent, although total phosphorus reductions were not quantified in this study (Cooke, 2005). Going from a surface draining system to a tile drain system with outlet control reduces phosphorus loading by 65 percent (Gilliam et al., 1997).

Storage of tile drain water for later use via subsurface irrigation has shown decreases in dissolved phosphorus loading of approximately 50 percent (Tan et al., 2003). However, accumulated salts in reuse water may eventually exceed plant tolerance and result in reduced crop yields. Mixing stored drain water with fresh water or alternating irrigation with natural precipitation events will reduce the negative impacts of reuse. Salinity thresholds for each crop should be considered and compared to irrigation water concentrations.

4.2.6. Sedimentation Basins

Sedimentation basins are used to settle out sediment and any attached pollutants before runoff leaves the field. They can also be used to protect wetlands from high levels of pollutant loading that may disturb the flow and water quality functions of the system. Basins need to be dredged periodically when the sediment storage capacity is full. A sedimentation basin constructed in Kanabec County is shown in Figure .

(Photo Courtesy of KCSWCD)

Figure 27. Sedimentation Basin at the edge of cropland collecting runoff near the South Fork of the Groundhouse River.

Benefits

Sediment control structures offer the following pollutant reduction benefits (Winer, 2000):

- Fecal coliform reductions of 70 to 78 percent
- Sediment reductions of 47 to 80 percent
- Total phosphorus reductions of 19 to 51 percent
- Reductions in fecal coliform would help to minimize animal and human health risks

- The resulting sediment and nutrient reductions will likely improve stream habitat and water quality and support healthy biological communities. Storage of runoff water following storm events will reduce erosive forces that lead to streambank erosion.

4.3. Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems contribute approximately seven percent of the fecal coliform load to the waterbodies in the Groundhouse River watershed. In addition, these systems add nutrients and organic material to streams, which may contribute to the secondary impacts to biota.

Education of rural homeowners is the primary BMP for reducing pollutant loading from onsite wastewater treatment systems. To communicate with as many people as possible, the implementation partners will include discussions of proper operation and maintenance of these systems during the educational meetings targeted to animal operators and crop producers in the watershed. In addition, periodic announcements will be made via news, television, and radio to remind all local homeowners of their responsibilities to maintain their onsite wastewater treatment systems.

Implementation Partners	Kanabec and Mille Lacs Counties Kanabec and Mille Lacs SWCDs Snake River Watershed Management Board Residential Home Owners Minnesota Pollution Control Agency
Estimated Cost:	$258,740
Timeframe:	Spring 2010 – Summer 2030
Estimated Load Reduction: Phos. reduction = 380 mg/L TSS reduction = 1,100 mg/L BOD 5 reduction = 3,600 mg/L Fecal coli. reduction = 10,000,000,000 MPN/100 mL	100% reduction for onsite treatment systems brought into compliance
Interim Milestones	Targeted landowners within the watershed contacted by spring 2011

4.3.1. Inspections and Proper Maintenance

The most effective BMP for managing loads from septic systems is regular maintenance. Unfortunately, many people do not think about their wastewater systems until a major malfunction occurs (e.g., sewage backs up into the house or onto the lawn). When not maintained properly, septic systems can cause the release of pathogens and excess nutrients into surface water. Good housekeeping measures relating to septic systems are listed below (CWP, 2004; University of Minnesota, 2006):

- Inspect system annually and pump the septic tank every three to five years.
- Refrain from trampling the ground or using heavy equipment above a septic system (to prevent collapse of pipes).

- Prevent septic system overflow by conserving water, not diverting storm drains or basement pumps into septic systems, and not disposing of trash through drains or toilets.

The USEPA recommends that septic tanks be pumped every 3 to 5 years depending on the tank size and number of residents in the household (2002b). Annual inspections, in addition to regular maintenance, ensure that systems are functioning properly. An inspection program would help identify those systems that are currently connected to tile drain systems. All tanks discharging to tile drainage systems should be disconnected immediately.

Some communities choose to formally regulate septic systems by creating a database of all the systems in the area. This database usually contains information on the size, age, and type of system. All inspections and maintenance records are maintained in the database through cooperation with licensed maintenance and repair companies. These databases allow the communities to detect problem areas and ensure proper maintenance. At this time, approximately 36 percent of systems in the watershed are permitted and registered in the Kanabec County database. It is not known what percent of systems are registered in Mille Lacs County.

Benefits

The reductions in pollutant loading resulting from improved operation and maintenance of all systems in the watershed depend on the wastewater characteristics and the level of failure present in the watershed. Reducing the level of failure to 0 percent may result in the following load reductions (Siegrist et al., 2000):

- TSS loads may be reduced by 90 percent
- Fecal coliform loads may be reduced by 99.99 percent
- Total phosphorus loads may be reduced by up to 100 percent
- BOD_5 loads may be reduced by 90 percent
- Reductions in fecal coliform would help minimize animal and human health risks
- The resulting TSS and nutrient reductions will likely improve stream habitat and water quality and support healthy biological communities

4.4. Restoration and Habitat Improvements

Implementing BMPs at animal operations and crop production areas will likely reduce sediment loading to the South Fork and mainstem Groundhouse Rivers and protect streambanks from additional trampling. Due to the erosive nature of soils in this watershed and the low gradient measured in several of the reaches, these BMPs may not be sufficient to improve fish and macroinvertebrate scores in the watershed. It may be necessary to incorporate direct restoration measures for wetlands, riparian zones, and stream channels. During the targeted informational sessions for farmers in the watershed, the implementation partners will present the benefits of restoration BMPs as well as the opportunities for grants and funds available to voluntary participants.

Implementation Partners	Kanabec and Mille Lacs Counties Kanabec and Mille Lacs SWCDs Snake River Watershed Management Board MN. Department of Natural Resources Riparian Home Owners Board of Soil and Water Resources Minnesota Pollution Control Agency Natural Resources Conservation Service Resource Conservation and Development
Estimated Cost:	$118,980
Timeframe:	Spring 2010 – Summer 2030
Estimated Load Reduction: Phos. reduction = 13 lbs/year Soil loss reductions = 13 tons/year	Variable reductions in sediment loading
Interim Milestones	Targeted landowners within the watershed contacted by spring 2011

4.4.1. Streambank Erosion BMPs

Reducing erosion of streambanks in the watershed will decrease sediment and nutrient loading to the listed segments and improve temperature and dissolved oxygen conditions by allowing vegetation to establish. These reductions will improve stream habitat and water quality and allow for the development of healthy biological communities. The agricultural BMPs that reduce the quantity and volume of runoff, or prevent cattle access, will all provide some level of streambank erosion protection.

In addition, the streambanks in the watershed should be inspected for signs of erosion (as displayed in Figure). Banks showing moderate to high erosion rates (indicated by poorly vegetated reaches, exposed tree roots, steep banks, etc.) can be stabilized by engineering controls, vegetative stabilization, and restoration of riparian areas. In areas where channels were historically straightened to maximize agricultural development, it may be necessary to restore channel sinuosity. Incised channels may require reconnection with the flood plan or development of a two-stage channel that allows for development of a low flow channel within a larger cross section.

The effectiveness and costs of stream restorations are site specific and highly variable. Watershed planners and water resource engineers should be utilized to determine the reaches where restoration will result in the most benefit for the watershed as a whole.

Figure 28. Streambank Erosion along the South Fork Groundhouse River

In comparison to the unstable and eroding streambanks seen in Figure , the stream reach seen in Figure displays stable streambanks, healthy riparian vegetation (grasses, trees, and shrubs), and no visible signs of streambank erosion.

Figure 29. Healthy Stream Segment along the Mainstem Groundhouse River

4.4.2. Habitat Improvements

Habitat restoration activities may be required in certain locations on the mainstem and South Fork Groundhouse Rivers to increase biota scores to acceptable levels. A stream habitat restoration plan has already been developed for the most impaired reach around Ogilvie (Magner, 2006). Following implementation of source control BMPs, it may be necessary to restore habitat where conditions have not been mitigated by pollutant reduction alone.

The restoration plan developed by MPCA (Magner, 2006) for the reaches near Ogilvie may be briefly summarized by the following concepts:

- Use fallen logs to create cross vanes and root wads that provide habitat and food sources for macroinvertebrates
- Slightly modify the channel to restore hydraulic capacity

A copy of the restoration plan may be obtained from MPCA.

The effectiveness and costs of stream habitat restorations are site specific and highly variable. Watershed planners and water resource engineers should be utilized to determine the reaches where habitat restoration will result in the most benefit for the watershed as a whole.

4.4.3. Wetland Restoration

Wetland restoration is appropriate for areas that were historically functioning as a wetland environment, but were altered to accommodate other land uses, such as agriculture. Because wetlands are typically located between upland areas and receiving streams or rivers, they serve as natural filters for pollutants such as sediment and nutrients. They also provide habitat for wildlife and reduce peak flows in stream channels by storing flood waters. Natural or restored wetland areas should not be used to treat point or nonpoint pollution (USEPA, 2003); constructed wetlands may be created for this purpose. Figure 30 shows a restored wetland supporting wildlife in Iowa.

Wetland restoration must include the rehabilitation of the soils, hydrology, and vegetation to a natural condition. Practices to consider include constructing embankments or dikes, plugging drainage ditches, removing tile drain lines, or installing outlet control devices on existing tile systems.

The state of Minnesota is currently mapping areas for potential wetland restoration, and when that data is available (fall of 2008) it will be useful to target specific areas in which wetland restoration would be best suited.

(Example Photo Courtesy of NRCS)

Figure 30. Restored Wetland Providing Wildlife Habitat

4.4.4. Riparian Zone Improvements

Riparian corridors, including both the stream channel and adjacent land areas, are important components of watershed ecology. The streamside forest slowly releases nutrients as twigs and leaves decompose. These nutrients are valuable to the fungi, bacteria, and invertebrates that form the basis of a stream's food chain. Tree canopies of riparian forests also cool the water in streams which can affect the composition of the fish species in the stream, the rate of biological reactions, and the amount of dissolved oxygen the water can hold. Channelization or widening of streams moves the canopy farther apart, decreasing the amount of shaded water surface, increasing water temperatures, and decreasing dissolved oxygen concentrations.

Preserving natural vegetation along stream corridors can effectively reduce water quality degradation associated with human disturbances. The root structure of the vegetation in a buffer enhances infiltration of runoff and subsequent trapping of nonpoint source pollutants. However, the buffers are only effective in this manner when the runoff enters the buffer as a slow moving, shallow “sheet”; concentrated flow in a ditch or gully will quickly pass through the buffer offering minimal opportunity for retention and uptake of pollutants.

Even more important than the filtering capacity of the buffers is the protection they provide to streambanks. The rooting systems of the vegetation serve as reinforcements in streambank soils, which help to hold streambank material in place and minimize erosion. Riparian buffers also prevent cattle access to streams, reducing streambank trampling and defecation in the stream. Due to the increase in stormwater runoff volume and peak rates of runoff associated with agriculture and development, stream channels are subject to greater erosive forces during stormflow events. Thus, preserving natural vegetation along stream channels minimizes the potential for water quality and habitat degradation due to streambank erosion and enhances the pollutant removal of sheet flow runoff from developed areas that pass through the buffer. A riparian buffer protecting the stream corridor from adjacent agricultural areas is shown in Figure .

(Photo Courtesy of NRCS)

Figure 31. Riparian Buffer Between Stream Channel and Agricultural Areas

Benefits

Riparian buffers should consist of native species and may include grasses, grass-like plants, forbs, shrubs, and trees. Minimum buffer widths of 25 feet or more are required for water quality benefits. Higher removal rates are provided with greater buffer widths. Riparian corridors typically treat a maximum of 300 ft of adjacent land before runoff forms small channels that short circuit treatment. Buffer widths based on slope measurements and recommended plant species should conform to NRCS Field Office Technical Guidelines. The following reductions are reported in the literature:

- 70 to 90 percent reduction of sediment (NCSU, 2002)
- 34 to 74 percent reduction of fecal coliform for 30 ft wide buffers (Wenger, 1999)
- 87 percent reduction of fecal coliform for 200 ft wide buffers (Wenger, 1999)
- 25 to 30 percent reduction of total phosphorus for 30 ft wide buffers (NCSU, 2002)

- 70 to 80 percent reduction of total phosphorus for 60 to 90 ft wide buffers (NCSU, 2002)
- 62 percent reduction in BOD_5 for 200 ft wide buffers (Wenger, 1999)
- 80 to 90 percent reduction of atrazine (USEPA, 2003)
- Increased canopy cover provides shading which may reduce water temperatures and improve dissolved oxygen concentrations (NCSU, 2002). Wenger (1999) suggests buffer width of at least 30 ft to maintain stream temperatures
- Reductions in fecal coliform would help to minimize animal and human health risks
- The resulting sediment, nutrient, and pesticide reductions will likely improve stream habitat and water quality and support healthy biological communities
- Increased channel stability will reduce streambank erosion

4.5 Information and Education

Using targeted approaches, education, and outreach to landowners and elected officials will be implemented to inform them of the need to reach the recommended fecal coliform and sediment reductions in order to achieve water quality standards and to improve biological health.

- Visit county and township board meetings to explain watershed impairments; and how BMPs can be implemented to address the problem.
- Visit local organizations (sportsman's clubs, cattleman's groups, etc.) to explain the watershed impairments, and how BMPs can be implemented to address the problem.

Conduct media outreach to emphasize priority areas and the project in general. Emphasize local publication including newsletters from various agencies, co-op mailing to members, etc.

4.5.1. Landowner Information Packets and Support

A more targeted approach will be used for landowners located in areas of the watershed determined to be of specific importance to target with one type of BMP implementation or another. Individualized information packets will be developed for landowners within the Groundhouse River Watershed. The packets will contain current aerial photographs of property with eligible lands and financial options highlighted. Landowners will be contacted individually and provided with information regarding the BMPs and available funding.

- Identify priority areas (sub-watersheds) for targeted BMP recommendations
- Create landowner packets highlighting lands potentially eligible for conservation programs, with a payments schedule, and further information. Packets will be created as priority areas are identified.
- Eligible conservation practices include, but are not limited to, prescribed grazing plans, manure management plans, grassed filter strips, forested riparian buffers, livestock use exclusion, manure storage facilities, runoff control structures, tillage and nutrient management plans, shoreline stabilization, and septic upgrades.

- Identify sites within the Groundhouse River Watershed with resource impacts and prioritize pollution potential based on distance to waters, slope, and size of impact (animal units and area).
- Landowners may be individually contacted and provided with information on the effects and potential solutions to overgrazed pastures with best management practices encouraged. When appropriate, landowners will be directed to technical service agencies, such as the Mille Lacs SWCD, Kanabec SWCD, and NRCS.
- Septic system care and maintenance information, as well as information on septic replacement and funding will be provided to landowners within areas of the watershed identified as being highly susceptible to failing septic systems.

5. Water Quality Monitoring

Managing impairments in the Groundhouse watershed will likely involve multiple BMPs. The goal of the monitoring plan is to assess the effectiveness of the implemented BMPs. Continuing to monitor the water quality and biota scores in the listed segments will determine whether or not the crop and animal operation BMPs are having the desired impacts; or if stream habitat restoration measures are required to bring the watershed into compliance. At a minimum, fish and macroinvertebrate sampling should be conducted by the MPCA or the MN DNR every six to ten years during the summer season at each established location until compliance is observed for at least two consecutive summers, and fecal coliform (now e. coli) monitoring should occur at least five times per month from April through October at each water quality station. The Snake River Watershed Management Board, a four-county joint powers board, began monitoring in 2008 and will continue until the fall of 2010; this includes the Groundhouse and South Fork Groundhouse Rivers.

Tracking the implementation of BMPs while continuing to monitor water quality and biological conditions in the watershed will assist the stakeholders and public agencies in determining the effectiveness of the implementation plan. If concentrations remain above the water quality standards or biota scores continue to indicate impairments, further encouragement of the use of BMPs throughout the watershed through education and incentives will be a priority.

Implementation Partners	Kanabec and Mille Lacs SWCDs Snake River Watershed Management Board Residential Home Owners Minnesota Pollution Control Agency MN Department of Natural Resources Minnesota Department of Health (or another Certified Laboratory)
Estimated Cost:	$60,000
Timeframe:	Spring 2010 – Summer 2030

6. Adaptive Management Process

The Groundhouse River Watershed Biota (Sediment) and Fecal Coliform TMDLs have been developed based on the best data and simulation models available for the task. Though care was taken to produce the most accurate TMDLs possible, monitoring data and model simulations inherently involve some degrees of uncertainty, which are explicitly or implicitly accounted for by the Margin of Safety (MOS). In addition to the MOS, an adaptive management process is useful to address the uncertainty with the TMDL development as well as the uncertainty associated with implementation.

BMPs often result in a range of load reductions and water quality improvements depending on the design, construction, and maintenance of the BMP as well as the characteristics of the flow or land surface to be treated. Thus, it is difficult to predict the exact number or location of BMPs that will result in compliance. The adaptive management approach for the Groundhouse River watershed will be an iterative process that involves monitoring of water quality and biota scores and tracking of BMP implementation to determine 1) which BMPs are resulting in attainment of the TMDLs, 2) whether or not additional voluntary participation in BMPs will be required to achieve these goals, and 3) if direct restoration measures are required to bring macroinvertebrate and fish scores into compliance.

As TMDLs are implemented and water quality and biotic scores are being monitored, adaptations to the implementation plan may be necessary to address unforeseen circumstances or conditions. The adaptive management approach is not linear, but rather circular, and should allow stakeholders to integrate results back into this Implementation Plan. Stakeholders should create decision points at which information is reviewed and decisions are made on whether to make changes in the Plan or stay the course.

7. Evaluation Plan

This implementation plan will be evaluated over several measures. First, the level of voluntary participation of animal operation owners and crop producers will be monitored and recorded. A database will be developed to track the following items:

- The owner, type, size, installation date, and GPS coordinates of each selected BMP.
- The method by which the participant learned of the BMP. This information will identify the most effective forms of communication for future educational efforts.
- Why a particular BMP was chosen by the owner: this information will help the implementation partners address the reasons why certain BMPs were consistently not chosen (costs, complexity, space requirements, etc.)
- The amount of time and all costs associated with the design and construction of the BMP.
- The amount of land or number of animals treated by the BMP as well as an estimation of the load reductions for sediment and/or fecal coliform.

Second, the implementation of BMPs will be assessed spatially using the information on location recorded in the database. Geographically displaying the location of each BMP will identify areas where additional implementation would be appropriate. A comparison to the location of water quality or biota monitoring stations will focus implementation efforts to areas that will most likely improve conditions at these sites.

Third, water quality and biota scores will be monitored to track the improvements related to BMP implementation and to determine whether or not the Groundhouse River watershed is compliant with MPCA water quality and biota standards. As discussed in previous sections, this third measure of success will be part of an iterative process of monitoring and implementation until the watershed is in compliance. Specifically, individual fecal coliform concentrations may not exceed 2,000 organisms per 100 mL and the geometric mean of five samples collected with in a calendar month may not exceed 200 organisms per 100 mL. IBI scores for macroinvertebrates should be greater than 50, and scores for fish should be greater than 48 for drainages up to 20 square miles, greater than 68 for drainages up to 54 square miles, and greater than 69 for drainages up to 200 square miles.

8. Summary

Implementation of the Biota (sediment) and fecal coliform TMDLs will require several action items to bring the watershed into compliance with water quality and biota standards set by MPCA. Table 3 summarizes these activities along with the cost and time frames expected for completion.

Table 3. Implementation Actions for the Groundhouse River Watershed TMDLs

Action	Costs	Time Frame	Goals	Reductions
Committee activities	ML - $5,000	2010-2030	Encourage voluntary participation of BMPs through education of both the benefits and cost share programs available.	NA
Implementation of animal operation BMPs	$181,980	2010-2030	Reduce fecal coliform, nutrient, and organic loading to streams. Eliminate streambank trampling.	Reduce fecal coliform load from animal operations by 29 to 99 percent. Eliminate streambank trampling.
Implementation of crop production BMPs	$62,180	2010-2030	Reduce sediment loads and runoff volumes from crop production areas to improve aquatic habitat in downstream reaches.	Reduce sediment loads from crop lands by 47 to 90 percent.
Implementation of onsite wastewater treatment system BMPs	$258,740	2010-2030	Reduce fecal coliform and nutrient loading from malfunctioning onsite wastewater systems.	Reduce fecal coliform loads from malfunctioning onsite wastewater treatment systems by 99.99 percent.
Restoration activities for wetlands, riparian zones,	$118,980	2010-2030	Select strategic locations for wetland, riparian, streambank, and habitat restoration to bring	Variable reductions in loading.

and stream channels and habitat			macroinvertebrate and fish scores into compliance.	
Water quality monitoring	$60,000 (3 years)	2010-2030	Track water quality and biota scores relative to the implementation of BMPs. Determine compliance or non compliance with MPCA standards.	NA
Implementation tracking		2010-2030	Ensure that BMPs are being implemented throughout the watershed with focus on areas that will benefit sites identified as impaired. Determine if implementation plan needs to be altered to achieve compliance.	NA

Furthermore, the Groundhouse River Fecal Coliform and Biota (Sediment) TMDL also offers considerations with regards to prioritization of BMP Implementation (Section 6.2). These areas include:

- Failing Onsite Wastewater Treatment Systems
- Animal Operations
- Crop Production

Through the TMDL development and on the ground work these three areas have been suggested as areas of high importance and areas to focus in on. More detailed information on these as far as locations and methods can be found in the Groundhouse River TMDL. The TMDL can be found at: ***http://www.pca.state.mn.us/water/tmdl/project-groundhouseriver-bacteriabiota.html***

9. References

Anonymous (2002) Fish Community Sampling Protocols for Stream Monitoring Sites. Standard Operating Procedure, Minnesota Pollution Control Agency. 7 pg. URL: http://www.pca.state.mn.us/water/biomonitoring/sf-sop-fish.pdf

Chirhart, J. (2003). Development of a Macroinvertebrate Index of Biological Integrity (MIBI) for Rivers and Streams of the St. Croix River Basin in Minnesota. Minnesota Pollution Control Agency. 45p.

Cooke, Richard. 2005. Economic Aspects of Drainage and Water Management, University of Illinois, 2005 Corn & Soybean Classic.

CWP. 2004. The Stormwater Manager's Resource Center: Fact Sheets on Residential Pollution Prevention Practices. Center for Watershed Protection, Ellicott City, MD.

Czapar, G.F., J.M. Laflen, G.F. McIsaac, D.P. McKenna. 2006. Effects of Erosion Control Practices on Nutrient Loss, University of Illinois.

Davis, J. G., and A. M. Swinker. 2004. Horse Manure Management. Colorado State Cooperative Extension.

Gilliam, J.W., D.L. Osmond, and R.O. Evans. 1997. Selected Agricultural Best Management Practices to Control Nitrogen in the Neuse River Basin. North Carolina Agricultural Research Service Technical Bulletin 311, North Carolina State University, Raleigh, NC.

Government of Alberta. 2007. Beneficial Management Practice Evaluation in the Battersea Drain and Lower Little Bow River Watersheds.

HRWCI. 2005. Agricultural Phosphorus Management and Water Quality in the Midwest. Heartland Regional Water Coordination Initiative. Iowa State University, Kansas State University, the University of Missouri, the University of Nebraska–Lincoln and the USDA Cooperative State Research, Education and Extension Service.

IAH. 2002. Illinois Agronomy Handbook, 23rd Edition. University of Illinois Extension, College of Agricultural, Consumer, and Environmental Sciences.

Kalita, P. 2000. Vegetative Filter Strips to Reduce Pathogens and Nutrients in Runoff from Livestock Feedlots. Department of Crop Sciences College of Agriculture, Consumer and Environmental Sciences, University of Illinois Extension.

Kansas State University. 2007. Atrazine Best Management Practices for the Little Arkansas River Watershed. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF-2768.

Larney, F. J., L.J. Yanke, J.J. Miller, and T.A. McAllister. 2003. Fate of Coliform Bacteria in Composted Beef Cattle Feedlot Manure. Journal of Environmental Quality. 32:1508 1515 (2003).

Lewandrowski, J., M. Peters, C. Jones, R. House, M. Sperow, M. Eve, and K. Paustian. 2004. Economics of Sequestering Carbon in the U.S. Agricultural Sector, Technical Bulletin No. (TB1909) 69 pp, United States Department of Agriculture, Economic Research Service.

Magner, J.A. 2006. An Analysis of TMDL Elements for Impaired Biota in the Groundhouse River near Ogilvie, Minnesota, HUC: 07030004-513. Minnesota Pollution Control Agency, Final Version July 2006.

Meals, D.W. and D.C. Braun. 2006. Demonstration of Methods to Reduce E. coli Runoff from Dairy Manure Application Sites. J Environ Qual 35:1088-1100. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

Moore, M. T. 1999. Fate of Chlorpyrifos, Atrazine, and Metolachlor from Nonpoint Sources in Wetland Mesocosms. A Dissertation presented for the Doctor of Philosophy Degree, University of Mississippi, Oxford, MS.

MPCA. 2006. Fecal Coliform Total Maximum Daily Load (TMDL) - North Branch of the Sunrise River. Minnesota Pollution Control Agency, Chisago County, June 2006, wq-iw6-01d.

MPCA. 2008. 2008 Final Draft Minnesota Pollution Control Agency (MPCA) Clean Water Act (CWA) Section 303(d) Total Maximum Daily Load (TMDL) List of Impaired Waters.

NCDENR. 2005. Updated Draft Manual of Stormwater Best Management Practices. North Carolina Department of Environment and Natural Resources, Division of Water Quality.

NCSU. 2002. Riparian Buffers and Controlled Drainage to Reduce Agricultural Nonpoint Source Pollution. Departments of Soil Science and Biological and Agricultural Engineering, North Carolina Agricultural Research Service, North Carolina State University, Raleigh, North Carolina. Technical Bulletin 318, September 2002.

Niemela, S. and M. Feist. (2000). Index of Biotic Integrity (IBI) Guidance for Coolwater Rivers and Streams of the St. Croix River Basin in Minnesota. Minnesota Pollution Control Agency. 52p.

NRCS. 2002. Natural Resources Conservation Service Conservation Practice Standard Constructed Wetland (Feet) Code 656. United States Department of Agriculture, Natural Resources Conservation Service.

NRCS. 2003. Costs Associated With Development and Implementation of Comprehensive Nutrient Management Plans Part I—Nutrient Management, Land Treatment, Manure and Wastewater Handling and Storage, and Recordkeeping. United States Department of Agriculture, Natural Resources Conservation Service.

OSUE. 1994. Vegetative Filter Strips: Application, Installation and Maintenance. Ohio State University Extension Food, Agricultural and Biological Engineering. Fact Sheet AEX-467-94.

OSUE. 1999. Cover Crop Fundamentals. Ohio State University Extension Food, Agricultural and Biological Engineering. Fact Sheet AGF-142-99.

PSU. 2005. Composting for Small Scale Livestock Operations. Pennsylvania Nutrient Management Program. Pennsylvania State University.

Siegrist, R.L., E.J. Tyler, and P.D. Jenssen. 2000. Design and Performance of Onsite Wastewater Soil Adsorption Systems. Proceedings of the Decentralized Wastewater Management Research Needs Conference, Washington University, St. Louis, MO, May 19-20, 2000.

Tan, C.S., C.F. Drury, T.Q. Zhang, W.D. Reynolds, J.D. Gaynor. 2003. Wetland-Reservoir System Improves Water Quality and Crop Production, Paper number 032327, 2003 ASAE Annual Meeting.

Tetra Tech. 2006. Lake Maumelle Watershed Management Plan. Prepared for Board of Commissioners Central Arkansas Water, October 2006, draft.

UME. 1996. Tillage Best Management Practices for Corn-Soybean Rotations in the Minnesota River Basin, University of Minnesota Extension, FO-06676.

University of Minnesota. 2006. Septic System Owner's Guide. University of Minnesota Extension.

University of Missouri. 1993. How to Build a Compost Bin. University of Missouri Extension.

USDA. 1999. CORE4 Conservation Practices Training Guide The Common Sense Approach to Natural Resource Conservation. United States Department of Agriculture, Natural Resources Conservation Service.

USEPA. 2001. *Protocol for Developing Pathogen TMDLs*. First Edition. Jan. 2001, EPA 841-R-00-0002.

USEPA. 2002a. Development Document for the Final Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations. EPA-821-R-03-001. December 2002.

USEPA. 2002b. *Onsite Wastewater Treatment Systems Manual.* EPA/625/R-00/008. February 2002.

USEPA. 2003. National Management Measures to Control Nonpoint Source Pollution from Agriculture. EPA 841-B-03-004, July 2003.

USEPA. 2004. Screening Level Causal Analysis and Assessment of an Impaired Reach of the Groundhouse River, Minnesota. U.S. Environmental Protection Agency and Minnesota Pollution Control Agency, October 14, 2004.

Wenger, 1999. A Review of the Scientific Literature on Riparian Buffer Width, Extent, and Vegetation. For the Office of Public Service & Outreach Institute of Ecology, University of Georgia, Revised Version March 5, 1999.

Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.

Woerner, B. and J. Lorimer. 2006. Alternative Treatments to Minimize Water Pollution from Open Animal Feedlots. Department of Ag and Bio Systems Engineering, Iowa State University.

Zaimes, G.N., R.C. Shultz, T.J. Isenhart, S.K Mickelson, J.L. Kovar, J.R. Russell, and W.P. Powers. 2005. Streambank erosion under different riparian land-use practices in northeast Iowa. *AFTA 2005 Conference Proceedings.*

Zaimes, G.N., R.C. Shultz, and T.J. Isenhart. 2006. Riparian land uses and precipitation influences on streambank erosion in central Iowa. *Journal of the American Water Resources Association (JAWRA)*. 42(1):83-97.