Minnesota Board of Water & Soil Resources

A GIS BASED WETLAND ASSESSMENT METHODOLOGY
FOR URBAN WATERSHED PLANNING

6 January 1997
Prepared by
Douglas J Snyder

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Board of Water and Soil Resources
Metro Region

Internal Memorandum

March 4, 1997

To: Ron Harnack, Barb Cobb, Jim Birkholz, Greg Larson, John Jaschke, Doug Thomas, Jim Haertel, Barbara Ohman, Dan Eklund, Ron Shelito Jeff Nielson, Metro Staff, Tim Kelly, Coon Creek WD

From: Bruce Sandstrom

Re: GIS Based Wetland Assessment Method

Enclosed is a copy of Doug Snyder's report entitled "A GIS Based Wetland Assessment Methodology for Urban Watershed Planning." As you may recall, this effort was started by a grant from the University of Minnesota, Center For Urban and Regional Affairs. Since the project took longer than anticipated, EPA and BWSR funding was used to fund the project to completion.

I believe the report describes a viable approach to provide a consistent, reproducible method for assigning wetlands management classes for the purpose of developing comprehensive wetland management or watershed management plans. Because it is intended for use as a planning tool, care should be taken to emphasize this fact. Any LGU or consultant that might desire to use this approach to inventory wetlands should be encouraged to provide for an administrative process that will verify the assessment via site inspections and allow for reclassification as deemed appropriate. An LGU would be well advised to use TEP panel process in verifying the results of any similar planning level assessment based on GIS.

Since Doug Snyder is now on another assignment, he will only be available on a limited basis to assist in answering inquiries about this method. I would hope that the Wetland Program staff will become familiar with the concepts used in the report and provide BWSR's guidance and support for using the method. Drafts of this document went out for review to numerous people and agencies, however, the feedback was sparse at best. Doug used his professional judgement in most cases on whether to incorporate the input. However, in a few instances Doug varied from this approach and left out a concept or two because the input from the "experts" was totally contrary.

BWSR owes a great deal of appreciation for Doug's perseverance in bringing this project to completion. Most of the delay was related to the need to develop certain data layers and some severe limitations of earlier versions of EPPL7.

Enclosure

Encl.

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ACKNOWLEDGMENTS

This work was supported by the United States Environmental Protection Agency, the University of Minnesota through the Center for Urban and Regional Affairs, and the Minnesota Board of Water and Soil Resources.

I am grateful to all members of the Interagency Wetlands team and staff at the Board of Water and Soil Resources (BWSR) that took the time to read and comment on the many drafts of this project. I also wish to thank the staff of the Land Management Information Center for providing EPPL7 and EPIC software and support, and for producing many of the data sets necessary to attempt this work. And to Mr. Bryan Alpaugh, BWSR Data Management Specialist, for keeping my computer crunching numbers throughout the project.

A special thanks to Mr. Bruce Sandstrom, BWSR Metro Region Superviser for allowing me much personal intititive on this project while providing the guidance needed to complete it, and to Ms. Char Sokatch, Metro Region Support Staff, for her input and editing.

Author

At the time this work was completed Douglas Snyder was a Graduate Research Assistant at the Department of Landscape Architecture and the Center for Urban and Regional Affairs, a Student Intern at the Board of Water and Soil Resources, and a graduate student in the Department of Landscape Architecture at the University of Minnesota.

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INTRODUCTION

I. Introduction

The Twin Cities metropolitan area is a complex environmental and economic regional center. The region contains seven counties, 189 cities and towns, and 46 Watershed Management Organizations and Watershed Districts (WMO and WD). The geomorphology of the area is dominated by glacial till and outwash features. The resulting landform varies from flat outwash sand and gravel alluvial plains, to gently undulating ground moraines, to the pitted, hilly end and stagnant moraines. The tension zone traverses the northern edge of the region. The region has many diverse ecological communities, such as prairie, savanna, barrens, deciduous forest, and coniferous forest. This unique combination of geomorphology and plant communities provides a changing, diverse landscape through which flows three major rivers - the Minnesota River, the Mississippi River, and the St. Croix River. In addition, there are greater than 900 lakes, and more than 270,000 acres of wetlands[1] in the metropolitan region. In all, the surface water system comprises about 20 percent of the land cover in this region.[2]

The region ranks among the 25 largest urban areas in employment growth in the nation. The average annual growth rates (1970 to 1995) for population, households, and employment has been 1.1, 2.0, and 2.4% respectively. Forecasts call for an additional 650,000 people, 320,000 new households, and 380,000 new jobs in the metropolitan region by the year 2020.[3]

Much of the region's growth - residential, commercial and industrial - is occurring in second-ring suburban cities and in free-standing growth centers. The resulting urban development pattern is in turn placing a great deal of pressure on the region's surface water system. Ephemeral and seasonal wetlands and streambeds in particular are susceptible to development pressures. Correcting negative environmental impacts is less effective and more costly than preventing the problems which result from poor planning and project design. A balanced approach to economic growth and preserving high environmental quality is needed.

This paper describes a wetland assessment methodology (WAM) for urban watershed planning in the metropolitan region. The purpose of the assessment is to aid local government in their efforts to organize, prioritize, and manage wetland resources in a comprehensive manner. The assessment evaluates a limited number of regionally important wetland functions. The assessment is intended to be viewed as a living document. That is, as other, more detailed, data sets, assessment methods, or site work confirm or refute the method's outcome, changes should be made to the model to incorporate the new information. This information may be used to enhance the region's environmental and economic sustainability by identifying high functioning, high value wetland communities and developing strategies to preserve and manage them.

II. Review of: 1. Wetland Use, 2. Wetland Classification, and 3. Wetland Function Assessments

1. Wetland Use

Historically, wetlands in the United States were regarded by most European settlers as wastelands, whose best use could be attained through their destruction or alteration. Draining, dredging, and filling activities prepared wetlands for other more valuable agricultural, residential, commercial, and recreational uses. The environmental functions which wetlands provide were not well understood or valued. It was not until the removal of a vast amount of wetland area[4] did people begin to concern themselves with the impact caused by the losses, such as reduction to game fish and waterfowl populations. During the 1960's, the general public became more aware of the additional environmental benefits which wetlands provide, including such things as flood protection, water quality maintenance, groundwater recharge, and nutrient and sediment removal.(Tiner 1984)

With the increased public interest in wetlands some states and, finally, the federal government passed laws, such as Section 404 of the Federal Water Pollution Control Act (later amended as the Clean Water Act), protecting wetlands. Over time additional local, state, and federal laws have been added to further restrict avoidable disturbance to wetlands. In 1991, the Minnesota Legislature passed the Wetland Conservation Act (WCA), which aims for no-net-loss of wetlands.

2. Wetland Classification

In order to better understand and make sound environmental decisions regarding the nations wetland resources, the National Wetlands Inventory Project (NWI) was established in 1974. The goal of the NWI is to provide information on the characteristics and extent of the Nation's wetlands.(Tiner 1984) A corollary to this has been the establishment of a common, scientifically sound wetland definition and delineation procedure. Though there is still disagreement about the specificity of a few of the measures, generally wetlands are defined by three key ecological attributes: 1) hydrology - the duration and frequency of flooding or soil saturation, 2) vegetation - plant communities dominated by hydrophytes, and 3) hydric soils.

3. Wetland Function Assessments

There is a need for rapid, comprehensive approaches which evaluate a range of wetland functions and provide resource managers and planners with timely information to estimate the values of the wetland functions. Methods currently available do not meet the needs of many regional, watershed-based managers and planning agencies.(Tiner 1984)

Many of the assessment methods currently in use are reviewed in a recent World Wildlife Fund (1992) publication, and by Lonard et al. (1981) which identified twenty assessment methodologies and evaluated each for use with 404 regulated wetlands. Examples of these methods are: (a) the Wetland Evaluation Technique (WET) by Adamus et al. (1987), which is a revision of A Method for Wetland Function Assessment by Adamus and Stockwell (1983); (b) the Connecticut Method (Ammann, Franzen, and Johnson 1986) developed for use in New England and adapted by Ammann and Lindley-Stone (1991) for use in the State of New Hampshire; (c) the Oregon Freshwater Wetland Assessment Methodology (Roth, Olsen, Snow, and Sumner 1993) an adaptation of the Connecticut and New Hampshire methods for use as a planning tool in Oregon; and (d) The Minnesota Wetland Evaluation Methodology for the North Central United States (Wells 1988). Some of these methods require a great deal of expertise to administer and others are designed to be used with minimal training. The current consensus is that no one of these methodologies completely satisfies the analysis requirements for use in regulated/jurisdictional wetlands.

Wetland assessment models vary enormously in their scope, precision and application (Lonard 1984). In general, wetland assessments use direct measures of or indicators of wetland function to assign a value of the worth, quality, or importance of the wetland function. For this assessment, functions are defined as the physical, chemical, and biological processes that contribute to the self-maintenance of wetland ecosystems. Where direct measures of wetland function are not possible indicator associations may be used. The estimate of how well a wetland function performs is based on the assumption that wetlands having specific environmental indicators present are better at performing that function than those that do not. If the association between the indicator and the function is strong enough, then the presence of the indicator in a wetland is sufficient indication that the function is being performed to some degree (Hruby, Thomas, Cesanek, and Miller 1995). Brinson et al. (1993) describes the rationale for using wetland functions as the basis of analysis:

> "The need for functionally based classifications of wetlands is twofold. The first is to simplify our concept of wetlands, recognizing that while each one may be unique, each can be placed into categories in which similar wetlands share functional properties ... The result of this simplification should be improved communication among researchers and managers, and ... the public, by focusing on processes that are fundamental to the sustained existence of these ecosystems. The other need for functionally based classifications is to foster the development and the redevelopment of paradigms that clarify the relationship between ecosystem structure and function."

Forman and Godron et al. (1986) define ecosystem structure as the spatial relationships among the distinctive ecosystem elements present in the landscape. More specifically, it is the distribution of energy, materials, and species in relation to the sizes, shapes, numbers, kinds, and configurations of the ecosystem elements. It is the relationship between ecosystem structure and wetland function that provides the indicators which WAM uses to examine the wetland functions.

There is some confusion regarding the definition of the term "value" as it has been used in association with wetland function in wetland literature and wetland function assessment methodologies. Value may be define several ways. A value may be a belief, a fair return or equivalent in goods or services, or the relative usefulness, importance, or general worth of a thing. However defined, value always imposes an anthropogenic focus to the wetland functions by suggesting that the functions provide some benefit to humans (Hruby, Thomas, Cesanek, and Miller 1995). For this assessment, the term value refers to the assigned relative importance of a wetland function to an individual or group.

Value judgements also are made in choosing which wetland functions to assess. The choice of wetland functions and assessment methodology depend on the specific wetland processes and the program goals that are valued in the planning region. This assessment looks at those wetland functions which are often valued in developed and developing urban regions.

WAM separates wetland functions into two broad classes. The first, called Ecosystem Wetland Functions, refer the processes which occur in wetlands whether or not humans interact with the wetland. That they are included in this assessment reflects the fact that these processes are also valued by people. The second set of functions are those that occur only because people value the wetland function (And are in fact not true functions as the term is defined for this document). This set of functions are referred to as Human Ecosystem Function because of their anthropocentric focus.

The WAM uses physiographic (hydrology, soils, geomorphology), vegetation, and land use characteristics to characterize the existing relationships between ecosystem structure and wetlands to provide resource managers with an initial determination of wetland function. The value of each and any wetland function examined will be made by local decision makers, with respect to WCA rules, other applicable federal, state and local wetland law, and planned local comprehensive land use needs.

III. Basis of: 1. The Wetland Assessment Methodology, and 2. Evaluation of Function

1. The Wetland Assessment Methodology

This assessment is an interpretation of Mark M. Brinson's 1993 work A Hydrogeomorphic Classification for Wetlands, and P.R. Adamus's, et al. Wetland Evaluation Technique (WET). Other methodologies which influenced this method are a Method for the Comparative Evaluation of Nontidal Wetlands in New Hampshire by Alan P. Ammann and Amanda Lindley Stone and the Oregon Freshwater Wetland Assessment Methodology by E. Roth, R. Olsen, P. Snow, and R. Sumner. Unlike many of the earlier classifications and assessments that depend solely on internal characteristics of the wetland, these methods recognize that landscape factors, external to the delineated wetland, also affect the wetland functions.

2. Evaluation of Function

The goal of WAM is to provide a initial determination of a wetland's functional significance to the watershed in which it exists. Significance is divided into three broad classes - High, Medium, and Low. The approach of classifying wetlands into three broad functional significance classes is used because it is feasible with our current understanding of wetland functions, and with the resolution and accuracy of the digital data sets. The three classes provide managers, planners, and the public with the information necessary to meet the method's objectives without going beyond the realm of reasonable scientific validity.

The base evaluation is performed at the parameter level. Each parameter(s) used is an indicator of function. The process successively combines parameter significance to determine the likelihood a function is present. Some parameters are more important than others in determining the level at which a wetland performs a specific function and are given greater weight in the combination hierarchy.

The following section lists the wetland function to be evaluated along with a brief explanation of the parameter rationale. A more detailed discussion of rationale is presented in section 5 of this document.

Endnotes

1. Estimate made using 1994 NWI (National Wetlands Inventory).

2. Estimated using NWI and digital hydrographic data using EPPL7/EPIC. Data sets provided by Land Management Information Center.

3. Regional Blueprint. Metropolitan Council. 1994

4. About 60 percent of Minnesota's original wetland acreage has been lost to draining and filling activities.

WAM FUNCTION EVALUATION

Hydrologic Control

A.a. Surface Water Runoff Storage

Landscape Indicators

1. **Watershed Position**
   - **H** Intermittent or first order stream
   - **M** Second or third order stream
   - **L** Greater than third order stream

2. **Wetland Size Relative to Watershed**
   - **H** Wetland is ≥2% of watershed
   - **M** Wetland is ≥0.5% & <2% of watershed
   - **L** Wetland is <0.5% of watershed

3. **Average Gradient of Contributing Landscape**
   - **H** ≥6% Average gradient
   - **M** ≥2% & <6% Average gradient
   - **L** <2% Average gradient

Wetland Indicators

4. **Vegetative Type**
   - **H** Circ 39 Types 3, 4, 5, 6, 7
   - **M** Circ 39 Types 2, 8
   - **L** Circ 39 Types 1

5. **Soil Infiltration**
   - **H** Hydrologic group A, B
   - **M** Hydrologic group C, A/D or B/D
   - **L** Hydrologic group D

6. **Actual Wetland Size**
   - **H** ≥ 5 acres
   - **M** ≥1 and <5 acres
   - **L** <1 acre

BRIEF EXPLANATION OF INDICATOR

A.a. Surface Water Runoff Storage

Surface water runoff storage results in the attenuation of peak high and low stream flows by the storage and slow release of water.

Landscape Indicators

1. Wetlands along headwater streams receive proportionately more overland runoff than downstream wetlands. Being positioned high in the watershed results in their water storage capacity having a greater impact on the overall watershed hydrology.

2. One of the primary determinants of a wetland's capacity to hold runoff is its relative size. All other things being equal, the larger the wetland's relative size is to the watershed, the greater its potential to store water.

3. This parameter, gradient, assumes that flow rate and erosive force of a sheet, rill, and stream flows are increased as the gradient increases. That is, wetlands located in areas of rolling topography offer a greater opportunity to provide storm water control than wetlands in areas where land is relatively flat.

Wetland Indicators

4. Some types of wetlands due to their physical and vegetative characteristics are better able to detain and retain additional surface water input.

5. Soil Hydrologic groups are used to indicate a soil's ability to receive and store water before additional water will runoff.

6. As stated earlier, one of the primary determinants of a wetland's capacity to hold runoff is simply its size. All other things being equal, the larger the wetland's actual size, the more water it can store.

A.a. Surface Water Runoff Storage

Evaluation of Landscape Indicators (1-3)

- **H** If 1 is H, or if 1 is M and both 2 and 3 are H
- **M** All other combinations
- **L** Any combination of 1, 2, and 3 resulting in LLL or LLM

Evaluation of Wetland Indicators (4-6)

- **H** Any combination of 4, 5, and 6 resulting in HHH or HHM
- **M** All other combinations
- **L** Any combination of 4, 5, and 6 resulting in LLL or LLM

Evaluation of Surface Water Runoff Storage

- **H** HH
- **M** All other combinations
- **L** LL or rated LM

BRIEF EXPLANATION OF INDICATOR

A.a. Surface Water Runoff Storage

Evaluation of Landscape Indicators
Landscape position of the wetland is the indicator which is given the greatest weight in this analysis. Any wetland with a high value landscape position (1) is of High value, regardless of the value of the other landscape indicators. If both the relative size (2) and gradient (3) are High and the watershed position is M, then the wetland also receives a High valuation. If the indicators (1-3) combine LLM or LLL, the wetland will be a Low. All other combinations of value for the indicators (1-3) yields a Moderate value for landscape indicators.

Evaluation of Wetland Indicators:
No indicator in this group is given greater importance in determining function potential. Any combination of indicator (4-6) values equaling HHM or HHH receives a High value. Combinations of LLM or LLL receive a Low value and all other combinations receive a Moderate value for wetland indicators.

Evaluation of Surface Water Runoff Storage
When combining the above values both landscape and wetland indicators are given equal weight. Combinations of HM or HH receive a High value for surface water runoff storage. Combinations of LM or LL receive a Low value and combinations of MM or LH receive a Moderate value for surface water runoff storage.

A.b. Flood Water Storage

Landscape Indicators

1. **Watershed Position**
   - **H** Fourth order stream or higher
   - **M** 2nd or 3rd order stream
   - **L** 1st order, intermittent or no stream

2. **Wetland Size Relative to Watershed**
   - **H** Wetland is ≥2% of watershed
   - **M** Wetland is ≥0.5% & <2% of watershed
   - **L** Wetland is <0.5% of watershed

3. **Land Cover Adjacent to Wetland**
   - **H** >50% developed & annual agriculture
   - **M** >25% & <50% developed & annual agriculture
   - **L** <25% developed & annual agriculture

Wetland Indicators

4. **Vegetative Types**
   - **H** Circ 39 types 6, 7
   - **M** Circ 39 types 3, 4, 5
   - **L** Circ 39 types 1, 2, 8

5. **Flooding and Ponding Potential**
   - **H** Occasional to frequent flooding and ponding
   - **M** Seasonal flooding and ponding
   - **L** Infrequent flooding and ponding

6. **Actual Wetland Size**
   - **H** ≥ 5 acres
   - **M** ≥1 and <5 acres
   - **L** <1 acre

BRIEF EXPLANATION OF INDICATOR

A.b. Flood Water Storage

Evaluates the potential wetland significance in providing temporary storage of flood waters to alleviate down stream flooding.

Landscape Indicators

1. Wetlands receiving floodwater tend to be lower in the watershed. Wetlands along higher order streams, downstream in the watershed, are the most significant in receiving and storing flood waters.

2. The greater the relative size, the greater the opportunity to store water.

3. This is based on the assumption that flow rate and erosive force of a stream are increased when land is developed and cleared. That is, wetlands located in areas of intensive land use offer a greater opportunity to provide flood and storm water control than wetlands in areas where land is relatively undisturbed.

Wetland Indicators

4. Wetlands with persistent woody vegetation are better at slowing the flow of flood waters. Some types also remove greater amounts of water through higher evapotranspiration rates.

5. Soil genesis which show a history of flooding are more likely to continue flooding and ponding than those without a history of flooding.

6. One of the primary determinants of a wetland's capacity to hold flood water is simply its size. All other things being equal, the larger the wetland's actual size, the more water it can store.

A.b. Flood Water Storage

Evaluation of Landscape Indicators (1-3)

- **H** If 1 is H, or if 1 is M and both 2 and 3 are H
- **M** All other combinations
- **L** Any combination of 1, 2, and 3 resulting in LLL or LLM

Evaluation of Wetland Indicators (4-6)

- **H** Any combination of 4, 5, and 6 resulting in HHH or HHM
- **M** All other combinations
- **L** Any combination of 4, 5, and 6 resulting in LLL or LLM

Evaluation of Flood Water Storage

- **H** HH or any combination of HM
- **M** All other combinations
- **L** LL or rated LM

<u>BRIEF EXPLANATION OF INDICATOR</u>

A.b. Flood Water Storage

Evaluation of Landscape Indicators
Landscape position of the wetland is the indicator which is given the greatest weight in this analysis. Any wetland with a high value landscape position (1) is of High value, regardless of the value of the other landscape indicators. If both the relative size (2) and land cover (3) indicators are High and the watershed position is M, then the wetland also receives a High valuation. If the indicators (1-3) combine LLM or LLL, the wetland will be a Low. All other combinations of value for the indicators (1-3) yields a Moderate value for landscape indicators.

Evaluation of Wetland Indicators:
No indicator in this group is given greater importance in determining function potential. Any combination of indicator (4-6) values equaling HHM or HHH receives a High value. Combinations of LLM or LLL receive a Low value and all other combinations receive a Moderate value for wetland indicators.

Evaluation of Surface Water Runoff Storage
When combining the above values both landscape and wetland indicators are given equal weight. Combinations of HM or HH receive a High value for surface water runoff storage. Combinations of LM or LL receive a Low value and combinations of MM or LH receive a Moderate value for surface water runoff storage.

A.c. Shoreline Stabilization

Landscape Indicators

1. **Proximity to Water Body**
   - **H** Connected to second order or higher stream; or lake ≥10 acres in size
   - **M** Connected to first order stream or lake ≥2.5 and <10 acres in size
   - **L** All other wetlands

2. **Land Cover Adjacent to Wetland**
   - **H** >50% Developed & annual agriculture
   - **M** >25% & <50% Developed & agriculture
   - **L** <25% Developed & annual agriculture

3. **Wetland Proximity to Upland Erodible Soils**
   - **H** ≥25% highly erodible soils
   - **M** ≥10% highly erodible or ≥25% moderately erodible soils
   - **L** All others

Wetland Indicators

4. **Length of Edge Exposed to Open Water or Stream**
   - **H** >200 Meters(M) of wetland edge
   - **M** >60M & <200M of wetland edge
   - **L** <60M of wetland edge

5. **Vegetative Types**
   - **H** Circ 39 types 6, 7
   - **M** Circ 39 types 2, 3, 4, 5
   - **L** Circ 39 types 1, 8

BRIEF EXPLANATION OF INDICATOR

A.c. Shoreline *Stabilization*

Wetlands can provide significant reductions in sediment runoff by holding the soil and shoreline in place in the face of erosive forces (e.g. wave action or stream flow).

A.c. Shoreline Stabilization

Landscape Indicators

1. The larger the stream or the greater the fetch, the more likely it is that erosive force will be present.

2. Assumes that developed and cleared land increases runoff and therefore flow rate and erosive force is greater than where native or forested conditions exist. Therefore, wetlands in these areas offer greater opportunity to mitigate upland erosive effects to shorelines.

3. Assumes that where the gradient of the wetland/upland edge is relatively high and the soils are highly erodible, the opportunity for the wetland to provide shoreline anchoring is relatively greater. (Gradient is one factor in the Soils Erosion Index used for the assessment)

Wetland Indicators

4. The longer or more edge the wetland occupies the greater the chance to provide stabilization relative to other wetlands.

5. Wetland types with deeply rooted, persistent vegetation provide better stabilization than other vegetative types.

A.c. Shoreline Stabilization

Evaluation of Landscape Indicators (1-3)

H All indicators (1-3) are H;
or 2 indicators are H and 1 is M.
M All other combinations
L All indicators are L; or 2 are L and 1 is M.

Evaluation of Wetland Indicators (4-5)

H HH or HM
M All other combinations
L LL or rated LM

Evaluation of Flood Water Storage

Combines landscape and wetland indicators.

H Any combination of HH or HM
M All other combinations
L LL or rated LM

A.c. Shoreline Stabilization

Evaluation of Landscape Indicators
No one indicator is given greater weight in the evaluation. If two indicators are High, and the other indicator is M, then the value of the landscape indicators is High. The reverse of this valuation scheme is true for Low value landscape indicators. Combinations of landscape indicators yielding LLL, or LLM result in a Low value for the landscape indicators. All other combinations of value for the indicators (1-3) yield a Moderate value for landscape indicators.

Evaluation of Wetland Indicators
Both the width of the vegetation and the type of the vegetation are very important in determining a wetlands ability to stabilize banks. If either indicator (4-5) is High then wetland indicators receive a High value. Only if both indicators are low does the wetland receive a Low value. All other combinations of value for the indicators (4-5) yield a Moderate value for landscape indicators.

Evaluation of Shoreline Stabilization
When combining the above values both landscape and wetland indicators are given equal weight. Combinations of HM or HH receive a High value for shoreline stabilization. Combinations of LM or LL receive a Low value and combinations of MM or LH receive a Moderate value for shoreline stabilization.

A. Hydrologic Control

If the existing wetland acreage in the hydrologic unit is less than 15% of total area, all remaining wetlands must be rated HIGH for hydrologic control functions. Otherwise the following evaluation applies. It combines the results from surface water runoff storage, flood water storage, and shoreline stabilization to determine the hydrologic control for the wetland.

Evaluation of Hydrologic Control

- **H** One or more of the hydrologic control functions is High
- **M** All other combinations
- **L** Two or three functions are Low and no function is High

BRIEF EXPLANATION OF INDICATOR

A. Hydrologic Control

If any one of the hydrologic control functions is evaluated as High, the wetland is given a High value for hydrologic control. Sustaining the existing hydrologic control system through the urbanizing process may be possible if High value wetlands are identified on a watershed basis prior to development. These wetlands may then be avoided or enhanced to provide the greatest amount of hydrologic control for the watershed.

B. Water Quality

Landscape Indicators

1. **Proximity to Pollutant Sources**
   - **H** ≥50% Urban, roads & annual agriculture
   - **M** ≥15% and <50%Urban, roads & annual agriculture
   - **L** <15% Urban, roads & annual agriculture

2. **Wetland Proximity to Upland Erodible Soils**
   - **H** ≥25% highly erodible soils
   - **M** ≥10% highly erodible
   - **L** All others

3. **Watershed Position**
   - **H** Intermittent or no stream or 1st order stream
   - **M** 2nd or 3rd order stream
   - **L** ≥ 4th order stream

Wetland Conditions

4. **Sensitivity of Wetland Type**
   - **H** Circ 39 Types 3, 4, 5
   - **M** Circ 39 Types 6, 7, 8
   - **L** Circ 39 Types 1, 2

5. **Soil Infiltration**
   - **H** Hydrologic group A, B, or A/D
   - **M** Hydrologic group C, or B/D
   - **L** Hydrologic group D

BRIEF EXPLANATION OF INDICATOR

B. Water Quality

Removal of sediment and related pollutants from overland runoff and precipitation is essentially the only water quality function which may be evaluated.

Landscape Indicators

1. Proximity to the sources of possible non-point is an opportunity parameter. It is based on the notion that some types of land uses adjacent to (within 200 meters) the wetland are more likely to contribute pollutants to the wetland.

2. The Soil Erodibility Index reflects the soil's water erosion potential. (Wind erosion factors are not part of the equation developed here). The index equation includes K (k-fact), R (rainfall factor), and LS (slope length and percent) from the Universal Soil Loss Equation. The erodibility index LS factor is used in place of gradient. It provides essentially the same information by estimating velocity of water.

3. Wetlands higher in the watershed provide greater opportunity to intercept waterborne contaminants than wetlands lower in the watershed.

Wetland Indicators

4. Wetland sensitivity to storm water input is based on the State of Minnesota Storm Water Advisory Group's *Guidance for Evaluating Urban Storm Water and Snowmelt Runoff Impacts to Wetlands*. Those wetland types able to more easily accept storm water (additional inundation, sediment, etc.) are rated high.

5. Wetlands soils that allow for infiltration have greater potential to provide water quality benefits than those soils which do not allow infiltration.

B. Water Quality

Evaluation of Landscape Indicators (1-3)

- **H** HHH, or any combination of HHM or HMM
- **M** All other combinations
- **L** LLL, or any combination of LL and no H

Evaluation of Wetland Indicators (4-5)

- **H** HH, or (4) is H and (5) is M
- **M** All other combinations
- **L** If (4) is L and (5) is H, or LM

Evaluation of Water Quality

- **H** HH or HM
- **M** All other combinations
- **L** LL, or (Wetland) is L and (Landscape) is M

B. Water Quality

Evaluation of Landscape Indicators

If the landscape conditions suggest that the adjacent land use will contribute significant sediment/pollutants (moderately high to high) to the surface water system the wetland's functional rating is high. If any one of the parameters (1, 2, 3) is high, the lowest rating the wetland may receive is moderate. Only if two or more are low and the other is not high is the wetland functional rating low.

Evaluation of Wetland Indicators

Rates the wetland conditions for its ability to accept storm water input. If wetland sensitivity (4) is low, the rating is low. A low rating here means the wetland type is very sensitive to storm water input. That is, small amounts of inputs can have large effects on the wetland.

Rating System for Water Quality

If the rating of the wetland conditions is low, then the water quality rating is low. Again, this is to try and avoid those wetlands sensitive to storm water input. Wetlands rating high for either landscape or wetland conditions, and not rated low for the other, receive a high water quality rating.

C. Habitat

Landscape Indicators

1. **Wetland Juxtaposition**
   - **H** Other wetlands within 200M
   - **M** Other wetlands within 800m
   - **L** Isolated from other wetlands >800m

2. **Surrounding Habitat**
   - **H** >50% of land cover within 800m composed of natural vegetation
   - **M** All other land cover combinations
   - **L** >50% of land within 800m developed

3. **Connectivity other Habitat**
   - **H** Connected to contiguous natural vegetation, lake, stream, or ditch
   - **M** Within 200M of natural vegetation, lake, stream, or ditch
   - **L** Isolated from other natural vegetation, lakes, streams, or ditches

4. **Wetland Island Function**
   - **H** Isolated wetland ≥5 acres in size
   - **M** Isolated wetland ≥1 and <5 acres in size
   - **L** Wetland <1 acre in size

C. Habitat

Since the objective is to generalize about habitat quality, the more habitat requirements the wetland fills for the greatest number of species, the higher is its habitat rating.

Landscape Indicators

This is an examination of the quality of habitat provided by the upland area surrounding the wetland. Compatible adjacent habitats provide animals access to additional food and cover, safer dispersal into other wetlands and uplands, and refuge from temporarily adverse conditions in the wetland.

1. A distance of 800 meters is within the movement range of most wildlife species and within the distance even quite small species might move if seeking refuge. The more compatible habitat within this distance, the more suitable the overall habitat.

2. This parameter reflects the significance of connecting upland and wetland complexes in providing habitat.

3. This is an evaluation of the wetland's capacity for providing movement or dispersal pathways, i.e. its connectivity. A wildlife corridor is a potential movement pathway through areas of unsuitable habitat such as agricultural or developed land. The corridor may include areas of natural upland vegetation as well as wetlands.

4. Non-continuous islands of habitat can also provide movement pathways for wildlife in urban areas, provided that these islands are of sufficient size and within reasonable travel distance of one another. Wetlands are considered isolated if they are greater than 800M away from the nearest surface water element - streams, lakes, wetlands.

C. Habitat

Wetland Indicators

5. **Size of Habitat Complex acres**
   H ≥80 acres
   M ≥20 & <80 acres
   L <20 acres

6. **Vegetative Diversity of Wetland** (based on Circ 39)
   H ≥ 4 types
   M 2 or 3 types
   L 1 type

7. **Water Regimes of Wetland**
   H Permanent open water present, intermittently exposed, or permanently flooded
   M Semipermanently, intermittently or seasonally flooded
   L Saturated or temporarily flooded

C. Habitat

Wetland Indicators
This series of indicators examines the characteristics of the wetland to provide habitat without considering the relation of the wetland to surrounding habitat conditions.

5. For interior-dwelling species (as opposed to edge species), the larger the area of unbroken habitat the better. Interior habitat complexes are those contiguous unbroken areas of wetlands which remain after allowing for areal reduction by edge effects. The current break points are arbitrary in the sense that they are not based on any single species needs.

6. Areas with greater wetland vegetative heterogeneity generally provide suitable habitat for more species and often better habitat for individual species due to greater food sources, nesting sites, and cover. Wetland vegetative heterogeneity is measured by the number of Circ 39 types present in the wetland complex.

7. Availability of surface water is important to many species and limiting to some. Even if species live elsewhere and visit the wetland to drink, the presence of water results in the area being more heavily used and having high habitat significance.

C. Habitat

Evaluation of Landscape Indicators (1, 2, 3, 4)

First evaluate 1-3

- **H** Any combination of HHM or HHH
- **M** Other combinations
- **L** Both rated LLM or LLL

Second adjust L and M values with 4

- **H** M and (4) H
- **M** L and (4) H
- else the value stays the same

Evaluation of Wetland Indicators (5, 6, 7)

- **H** Any combination of HHM or HHH
- **M** Other combinations
- **L** Both rated LLM or LLL

Rating System for Landscape and Wetland Habitat

- **H** HH or HM
- **M** Other combinations
- **L** LL or LM

C. Habitat

Evaluation of Landscape Indicators

No one of the first three parameters (1, 2, 3) is considered to be more influential than the others. Therefore, any combination of HHH or HHM results in a rating of H for landscape habitat. Any combination LLM or LLL results in a rating of L for landscape habitat. Any other combination results in a rating of M for landscape habitat. Providing island habitat opportunities is very important in urban areas. For those areas rated L or M, the landscape habitat rating is adjusted by using indicator 4. If the combination of 1-3 yields a M rating and 4 is H then the final landscape habitat rating would be H. For those areas with a L rating for combinations of indicators 1-3 and (4)H yields M.

Evaluation of Wetland Indicators

No one of the first three indicators (5, 6, 7) is considered to more influential than the others. Therefore any combination of HHH or HHM results in a rating of H for landscape habitat. Any combination LLM or LLL results in a rating of L for landscape habitat. Any other combination results in a rating of M for landscape habitat.

Evaluation of Habitat

A wetland with high habitat quality, or a wetland within a high quality landscape habitat are rated high so long as the other rating is not so low (L) as to counteract it. So combinations of HH or HM receives an overall rating of H, HL and MM receives a rating of M, and ML and LL receives an overall rating of L.

D. Landscape and Wetland Characterization

Landscape Indicators

1. **Percent of land in intensive agricultural use**
   H ≥50%
   M ≥20 and <50%
   L <20%

2. **Percent of land in urban/developed uses**
   H ≥10%
   M ≥2.5 and <10%
   L <2.5%

Wetland Indicators

3. **Percent of subwatershed composed of wetlands**
   H ≤15%
   M >15 and ≤50%
   L >50%

4. **Percent of watershed composed of wetlands**
   H ≤15%
   M >15 and ≤50%
   L >50%

5. **Percent of wetlands in the watershed composed of this Circ 39 type**
   H <10%
   M ≥10 and <25%
   L >25%

D. Landscape and Wetland Characterization
This evaluates the wetland's in relation to the land use and wetlands as elements of the landscape. It tries to determine the relative risk to watershed integrity posed by the wetland's loss.

Landscape Indicators
The more intensive is land use in the watershed, the greater is the significance of the functions of remaining wetlands.

1. Agricultural land may be a significant source of sediment and nonpoint pollution. The more intensive agricultural land uses in the landscape, the more significant are the wetlands in removing pollutants before they enter surface waters.

2. Urban land development increases surface runoff, increases pollutant loadings, decreases vegetative diversity, and destroys wildlife habitat. As development increases, all the functions of remaining wetlands become more significant. Since this is the most intensive land use with the most adverse impacts, only a small proportion of the landscape needs to be developed to impact wetlands.

Wetland Indicators
The rarer the type or amount of wetlands present the greater the value of those wetlands.

3. & 4. The higher the proportion of a watershed's land area that is occupied by wetlands, the less vital to the watershed's hydrologic integrity is one particular wetland. Where wetlands often comprise more of the land area the values would be different for other landscapes with fewer wetlands.

5. Rarity of wetland type. In terms of its contribution to landscape diversity, the rarer the wetland type, the greater is its significance.

D. Landscape and Wetland Characterization

Evaluation of Landscape Indicators

H HH or HM
M Other combinations
L LL or LM

Evaluation of Wetland Indicators

H If 3 or 4 or 5 = H then H
M Other combinations
L LLL or LLM

Evaluation of Landscape and Wetland Characterization

H Both parameters rated H; or Hand M
M Other combinations
L Both parameters rated L; or L and M

BRIEF EXPLANATION OF INDICATOR

Evaluation of Intensive Land Use
If both types of intensive land uses occupy a significant portion of the watershed, then the land use parameter is rated H. If either parameter is H and the other is M the rating is H. If the two land uses are of low intensity and none is high, the landscape rating is L.

Evaluation of Wetland Extent and Rarity
If either the proportion of wetlands in the watershed is low or the wetland is a rare type, the rating is H. If wetlands are widespread in the landscape and this wetland type is common, the rating is L.

Evaluation of Landscape and Wetland Character
If the extent of wetlands in the watershed is small or the wetland is of a rare type or land use is intensive, the functions of remaining wetlands are highly significant. If, on the other hand, wetlands are common, the wetland is a common type, or most of the landscape is in natural vegetation, the loss of the wetland would probably not have a significant detrimental impact on the ability of the remaining wetland to function.

E. Noteworthy Natural and Cultural Features

1. Endangered Species/Significant Natural Areas

H Verified existing feature
M Possible feature
L No features exist

BRIEF EXPLANATION OF INDICATOR

E. Noteworthy Natural and Cultural Features

If threatened or endangered species on either federal or state lists are verified as present in or near the wetland, or if the area is locally identified as a significant natural area then, the rating is high.

These are over-riding considerations that result an overall wetland rating of H. Other features which may be included are burial mounds, archeological sites, etc.

F. Restoration/Enhancement

Landscape Indicators

1. Site is located in sensitive ground water area

- **H** Yes
- **L** No

2. Site is in a designated historical, scenic, or other priority area

- **H** Yes
- **L** No

3. Site contains or is in close proximity to verified, federal or state defined, threatened or endangered species

- **H** Yes
- **L** No

4. Existing Land Use Condition

- **H** Predominantly undisturbed or recreational land use
- **M** Mixed agricultural/residential use
- **L** Predominantly in agricultural use and in row crops or hay/row rotation, or high density urban uses

5. Soils erodibility adjacent to site

- **H** ≥50% highly erodible soils
- **M** ≥15%and <50% highly erodible soils
- **L** <15% highly erodible soils

F. Restoration/Enhancement

This assessment assumes that restoration and enhancement of wetlands should be used to develop and sustain the existing surface water/wetland matrix. Preferred sites are those which will reestablish lost linkages/corridors, buffer existing high quality wildlife areas, reduce soil erosion, or otherwise enhance the value of the surface water matrix by providing habitat, water quality, and water quantity benefits.

Landscape Indicators
Site indicators are existing physical, natural, or cultural features or conditions located in or near the surface water matrix. Site indicators include such things as ground water recharge areas, archeological sites, threatened and endangered plant and animal species, designated natural areas, or any locally defined high priority area.

1. Wetlands often reside in areas of ground water recharge and discharge. Establishing or maintaining wetlands in these areas helps sustain water quality and water quantity in the watershed.

2. Generally designated areas should provide sites with compatible adjacent land uses. Restorations can be used both to protect designated feature and be protected by the designated feature.

3. Wetlands provide habitat for some rare and endangered species.

4. Preferred restoration sites will be in areas with adjacent land uses which is compatible with the restoration. Generally these are low disturbance landscapes. Examples of low disturbance are pastures, regional parks, cemeteries, or nature centers.

5. Restorations provide an opportunity to remove highly erodible soils from other more disruptive land uses.

F. Restoration/Enhancement

Landscape Indicators

6. Soils Flooding Potential
- **H** Frequent flooding
- **M** Occasional/Seasonal flooding and ponding
- **L** Infrequent flooding or ponding

7. Site is in close proximity to lake, river, stream, ditch, or wetland
- **H** ≤60 Meters
- **M** >60 M and ≤ 200 M
- **L** >200 M

8. Site is in close proximity to wetland(s) receiving High valuation
- **H** 3 or more High ecosystem functions
- **M** 1 or 2 High ecosystem functions
- **L** No Highs

Brief Explanation of Indicator

F. Restoration/Enhancement

Landscape Indicators

6. Soils with a history of inundation are likely to provide the necessary hydrologic conditions for the restoration to sustain itself over time.

7. Identifying sites near the existing surface water system will allow the restorations to be used to reestablish lost linkages and to protect existing features.

8. This targets those areas adjacent to existing high value wetlands. Restoration and enhancement of adjacent areas can help sustain the functions which already exist in these wetlands.

F. Restoration/Enhancement

Evaluation of Landscape Indicators (1-8)

H 4 or more indicators are High
M 1-3 of the indicators are High;
or indicators 4-8 are all Moderate
L No indicator is High

F. Restoration/Enhancement

Evaluation of Restoration/Enhancement Site Indicators
Where a majority of the indicators exist and are High value, there is High value for restoration or enhancement. If any one of the indicators is High or indicators 4 through 8 are all Moderate value, the site is Moderate value for restoration or enhancement. All other combinations of indicators result in restoration/enhancement receiving a Low value.

G. Aesthetic Potential

Landscape Indicators

1. **Adjacent Urban Land use**
   - **H** <10% in urban land use
   - **M** ≥10 and <50% in urban land use
   - **L** ≥50% in urban land use

2. **Distance from Highway 1 & County 2 Roads**
   - **H** No roads within 800 meters
   - **M** Roads between 200M & 800m
   - **L** Roads within 200M

Wetland Indicators

3. **Number of wetland Circ 39 types**
   - **H** 3 or more types
   - **M** 2 types
   - **L** 1 type

4. **Dominant wetland type**
   - **H** = Type 3, 4, 5
   - **M** = Type 2, 6, 7, 8
   - **L** = Type 1

5. **Vegetative structure diversity**
   - **H** Herbaceous layer, shrub layer, and canopy are present
   - **M** 2 layers present
   - **L** 1 layer only

6. **Presence of upland inclusions**
   - **H** 1 or more present
   - **L** No inclusions

G. Aesthetic Potential

While there is a great deal of variety in what people find aesthetic pleasing to look at, there are some things which most people agree add to the beauty of natural scenes.

Landscape Indicators

1. For most individuals, the most appealing views of wetlands are from other adjacent areas of natural beauty, such as open upland forest.

2. While impression of noise levels vary from person to person, most people will agree that excessive traffic noise detracts from aesthetic appreciation. This is particularly true for those wishing to listen for song birds and other wildlife sounds.

Wetland Indicators

3. The assumption is that the greater the scenic diversity the higher its visual quality.

4. Marshes, with open water, are assumed to be the most widely recognizable wetland type. Familiarity with a landscape type generally increases preference for the landscape type. Open water features greatly enhance the viewer preference for wetland scenes.

5. A variety of wetland types, which offers all possible horizontal and vertical vegetative structure of the wetland cluster ensures greater seasonal contrasts and variety of vegetative colors and textures. This will be estimated using NWI class/subclass designations

6. These island landform elements provide points of visual interest which contrast with wetland elements. They are often havens for wildlife. Wetland views which include wildlife are more highly valued than those which have no wildlife.

G. Aesthetic Potential

Evaluation of Landscape Indicators

H Both H or (1)H & (2)M
M All others
L Either L & neither H

Evaluation of Wetland Indicators

H = If any two of the measures are H
M = All others
L = 3 of 4 L and no H

Evaluation of Aesthetic

H Combinations of HH or HM
M All others
L Combinations of LL or LM

BRIEF EXPLANATION OF INDICATOR

G. Aesthetic Potential

Evaluation of Landscape Indicators
Land use is given more weight in rating because it is a constant, while noise from roads varies by time of day, day, and season.

Evaluation of Wetland Indicators
If any two of the indicators are High, the wetland is likely to provide some visual interest. Only those wetlands which are Low on 3 or more of the indicators and High on none are rated Low.

Evaluation of Aesthetic Potential
If either landscape or wetland indicators are High and the other is not Low, then the wetland is rated High for aesthetic potential. A wetland only receives a combined low rating if both are low. As aesthetic values vary widely, it is hoped only a very few wetlands will rate low and that those which rate moderate and high are, or will with slight modification, be viewed positively by most of people.

ECOLOGICAL ASSUMPTIONS OF WAM FUNCTION EVALUATION

Hydrologic Control

A.a. Surface Water Runoff and A.b. Floodwater Storage

Hydrologic control refers to the physical processes of the storage (temporary or permanent) or conveyance of flood water and surface water runoff in the watershed containing the wetland, or groundwater within the substrate of the basin containing the wetland. A combination of landscape and wetland characteristics can indicate how much water may be detained or retained in the wetland. Table 1 lists the indicators used to assess a wetland's potential for surface water runoff storage and flood water storage, and the strength of the association between the indicator and the wetland function.

Table 1. Indicators of Function: Hydrologic Control	
Indicator of Function	Importance to Function
Landscape characteristics	
Landscape position	High
Relative Size (wetland to watershed ratio)	High
Gradient of the watershed	Moderate
Wetland Characteristics	
Type of vegetation	Moderate
Soils	Moderate
Actual Size of wetland	Moderate

(adapted from Adamus et al. 1987)

Landscape position refers to the relative location of the wetland in the watershed. The position of wetlands in the landscape influences water flow and water storage in the watershed. Wetlands located in headwaters generally desynchronize peak flows in tributaries and in the main channel, while wetlands lower in the watershed hold back storm water and attenuate flood peaks. Novitzki (1979) indicates that a 50% reduction in flood peaks can result from the first 5 percent of the wetland area in the watershed. Adamus and Stockwell (1983) found significant storage of floodwater is possible only in palustrine, lacustrine, and upper riverine wetlands.

If all other parameters are equal, the greater the relative size of the wetland basin to the watershed the greater is the potential for the wetland to intercept sediment, toxins, and nutrients (Adamus and Stockwell 1983). Loss of wetlands, which are small relative to the watershed, impacts the storm water and floodwater the watershed hydrology less than loss of a relatively large wetland area.

Wetland basins in steeply sloping watersheds, where runoff will be rapid and therefore more likely to be erosive, will have greater opportunity to remove sediment (Adamus and Stockwell 1983).

The vegetative characteristics of wetlands affect the ability of the wetland to store and detain water. Frictional resistance varies depending on wetland width, density and type of vegetation, and rigidity of vegetation. Vegetation slows flood waters by creating frictional drag in proportion to stem density (Adamus and Stockwell1983). Adamus et. al. found that wetlands, to effectively store water, should be at least 70% upright woody vegetation (Adamus and Stockwell 1983). Based on the above factors Adamus et al ranked wetland vegetative types from least to most effective: aquatic bed (rooted vascular), emergent nonpersistent, emergent persistent, scrub-shrub, deciduous forest, coniferous forest. Because of their persistence and rigidity, trees and shrubs are particularly important to water storage. Wetlands with a conifer canopy have the greatest potential for water storage. In addition to the physical storage capacity of the wetland, conifers remove greater amounts of water from the system than do other vegetative types due to their high rate of transpiration.

Wetland basins with underlying permeable soils will have greater drainage rates and have higher potential to reduce storm water and floodwater through groundwater recharge processes (Adamus and Stockwell1983). Those wetland basins with impermeable soils will be less likely to attenuate additional water. This assumes all other wetland parameters affecting storage are equal for the wetland basins.

Actual wetland basin size influences the amount of water that can be stored. Given that all other conditions are equal, the larger the basin the greater the amount of water it is possible to store. Degradation of the wetland is less likely to occur in larger wetland basins with the same amount of storm water input. Adamus (1983) suggests minimum critical storage size for a constricted, depressional, or palustrine wetland should be at least 5 acres.

Wetlands adjacent to an upper-riverine water course with a high percentage of woody or permanent emergent vegetation, that are large relative to the watershed, will be most likely to detain and retain surface water runoff. Wetlands which are lower in the watershed, adjacent to a watercourse, with a high percentage of woody vegetation, that are relatively large will be most likely to detain and retain floodwater runoff.

A. Hydrologic Control

A.c. Shoreline Stabilization

Shoreline and streambank stabilization refers to the ability of a wetland to protect the shoreline of a lake, stream, or river from the erosive force of water. Table 2 lists the indicators used to assess a wetland's opportunity and ability for shoreline and stream bank stabilization, and the strength of the association between the indicator and the wetland function.

Table 2. Indicators of Function: Shoreline Stabilization

Indicator of Function	Importance to Function
Landscape characteristics	
Connection to surface water	High
Land use in basin	Moderate
Gradient of wetland/upland edge	High
Soil erodibility of wetland/upland edge	Moderate
Wetland Characteristics	
Width of vegetation	High
Type of vegetation	High

(adapted from Adamus et al. 1987)

It may seem too obvious to state but in order for a wetland to provide shoreline or stream bank stabilization the wetland must be adjacent to a lake or stream. The opportunity to provide this function occurs only when the wetland is connected to a surface waterbody or watercourse. Where erosive forces are higher the need to maintain shoreline stabilizing cover is greater. Proximity to second or higher order streams, or lakes greater than 10 acres in size, where erosive force due to flow and wind/wave action is likely to be higher, offer greater opportunity for bank stabilization.

Land use in the watershed affects a wetland's ability to stabilize stream bank or shoreline through increased runoff quantity and runoff velocity. Urbanization contributes to peak flow by increasing the impervious surface in the watershed as water is channeled and removed from urbanized areas. This action increases the erosive force of water in the watershed. According to Adamus et al., if greater than 10 percent of the watershed is impervious surface, the wetlands will have good potential to provide bank stabilization.

The gradient of land in close proximity to the water body affects runoff into the basin. Steeply sloped adjacent upland areas are more likely to be unstable. Soil characteristics will also affect the stability of shorelines and streambanks. The soil erodibility index takes both these factors into account. The assessment uses the soil erodibility index to indicate the stability of the wetland basin/upland edge.

The key to a wetland's ability to stabilize a shoreline or streambank is the width and type of vegetative cover. Vegetation dissipates erosive forces and keeps the soils of the streambank in place. Plant species which best perform this are those plants that have deep roots, high regenerative capacity, long life span, and rigid form (Adamus and Stockwell 1983). Tree and shrub species with low growth forms, with branching morphology, with deeply penetrating root systems, and with high regenerative capacity (suckers) are most effective for bank stabilization. Shoreline vegetation needs to be at least 20 feet in width to effectively stabilize a streambank or shoreline (Adamus and Stockwell 1983).

This assessment uses raster data sets with cell size of 20 meters square (or approximately 67 feet per side). If the cell has been classed as a wetland, the minimum width is assumed to exist or the cell would have been classified as some other land cover. For this reason, the assessment looks only at length of edge common to both wetland and surface water with good vegetation rather than both length and width.

B. Water Quality

Sediments often have chemically and physically attached toxins and nutrients such as heavy metals, pesticides, phosphorous, and nitrogen. Table 3 lists the indicators of wetland function used to evaluate both opportunity and ability of the wetland to assimilate and accept waters laden with sediment and related toxins and nutrients.

Table 3. Indicators of Function: Water Quality	
Indicator of Function	Importance to Function
Landscape characteristics	
Land use in basin	Moderate
Landscape position	High
Gradient of watershed	High
Soil erodibility in basin	High
Wetland Characteristics	
Type of wetland	Moderate
Soils of wetland	Moderate

(adapted from Adamus et al. 1987)

The opportunity to remove sediment and transform nutrients is related to the wetland's position in the basin, the land use in the basin which contributes to the wetland and the erodibility of the soils in the contributing area. Land use activities which are likely to contribute to sediment, toxin, and nutrient load are croplands, urban runoff, construction, extractive mining, residential chemical use on lawns and gardens, and road sanding (MPCA 1994). This is not an exhaustive list, but it does provide sufficient evidence for which land cover types are linked to sediment, toxin, and nutrient sources. Urban residential, commercial and industrial, annual croplands and roads are highly likely to contribute one or all of the nonpoint pollutants. Wetlands in close proximity to the sources have a greater opportunity to attenuate the negative impacts of the pollutants. Those wetlands in areas of continuous vegetative cover or forest cover will have less opportunity to remove sediment and remove or transform toxins and nutrients from surface water runoff.

Wetlands located in the upper parts of the watershed have greater opportunity to affect water quality because it is these wetlands which tend to hold the water the greatest amount of time. This allows the processes which remove sediment, nutrients, and toxins the time needed to perform the function.

Soils which are highly susceptible to water erosion are more apt to contribute sediment through surface water runoff. A soil erodibility index was developed using a portion of the Universal Soil Loss Equation (U.S.L.E.). Three factors used are R - the rainfall factor- which accounts for the interrelationship between the erosive forces of falling rain and runoff, K - the soil's susceptibility to water erosion - determined by its resistance to detachment by rainfall or flowing water as well as its ability to take up water, and LS - length slope factor - which is a function of the ratio of soil loss at any length and slope relative to the standard (Foth 1984).The erodibility index makes two assumptions: 1) acceptable soil loss is very close to zero (any soil loss is too much), and 2) at some point during construction activities a bare soil condition will exist. Soils are often scraped up & down exposing lower horizons to the erosive action of water during construction. The result of these assumptions ensures that the soil erodibility index is conservative and that the highest value of K will be used for each soil unit.

Given the same opportunity to attenuate and mitigate the impacts of nonpoint sources of pollution, some types of wetlands will be better able to accept the impact. That is, some wetland types are more sensitive to storm water impacts. The MPCA's *Guidance for Evaluating Urban Storm Water and Snowmelt Runoff Impacts to Wetlands* summarizes wetland susceptibility to degradation by storm water input this way: 1) highly susceptible types - sedge meadows, bogs, coniferous bogs, open bogs, calcareous fens, wet and wet-mesic prairies, coniferous swamps, lowland hardwood swamps, and seasonally flooded basins, 2) moderately susceptible types - shrub-carrs, alder thickets, fresh (wet) meadows, shallow marshes, and deep marshes, 3) slightly susceptible types - floodplain forest, fresh wet meadows, and shallow marshes, and 4) least forest, fresh wet meadows, and shallow marshes, and 4) least susceptible types - those wetlands which exist at highly impacted sites such as previously cultivated hydric soils, or in old dredge/fill disposal sites and old gravel pits.

Class overlap may occur as a result of vegetative conditions in the wetland. For example, it is possible that a wet meadow may be slightly susceptible if it is dominated by reed canary grass or purple loosestrife or cattail, but it may be moderately susceptible if the plant community is dominated by forbes (asters-composite) and grasses (gramineae). This assessment assumes a high quality vegetative community until a site visit proves otherwise. This ensures each wetland will be placed in its most appropriate management class, based on the assessment's assumptions, until further information proves otherwise. So, in the above example, all wet meadows would be classified moderately susceptible to storm water input.

C. Habitat

Assessing a habitat value is difficult because of the diversity of wildlife species and the variety of food and habitat needs of those species which may use wetlands during their life cycle. Much of the research is focused on game species of birds and mammals. However the objective of this assessment is to generalize about habitat quality. The more habitat requirements the wetland provides for the greatest number of species, the higher it's habitat value.

Table 4. Indicators of Function: Habitat	
Indicator of Function	Importance to Function
Landscape Indicators	
Land use	Moderate
Landscape position	High
Wetland Indicators	
Vegetative diversity	High
Presence of permanent open water	High
Actual size of habitat	Moderate

(adapted from Adamus et al. 1987)

Determining the size or width of habitat for wildlife is extremely difficult since some species live primarily in wetland areas while others require wetlands during reproductive stages, and other need wetlands for survival but live primarily in adjacent upland communities. Landscape indicators look at land use and habitat position, that is , where the wetland is relative to other wetland habitat and upland habitat in the watershed. Human disturbance in the surrounding landscape can affect the habitat value of the wetland. Golet (1976) suggests that if over 90% of the land within 300 feet of a wetland is in natural vegetation, then the wetland is relatively free of human disturbance. If less than 50% of the surrounding landscape is naturally vegetated, then the wetland is significantly impacted by human activity. Requirements for buffer widths tend to be substantially higher for wildlife than for protection of water quality. A thick border along urban wetlands is especially important for wildlife.

Plant species provide food and shelter for wildlife. The horizontal and vertical diversity of vegetation has been positively correlated with the diversity of wildlife species (Golet 1976). The presence of well developed herbaceous, shrub, and tree layers is important for wildlife diversity. This assessment uses NWI subclass designations to estimate the vegetative horizontal and vertical structure in and near the wetland. In general, wetlands with well interspersed patches of vegetation or diffuse open stands of vegetation provide the best habitat.

Because this assessment generalizes habitat, determining a minimum size for habitat is virtually impossible. The Wetland Evaluation Technic (WET, Adamus et al 1987) use a minimum threshold of thirty acres for wildlife. However this number appears to be based on limited research. In Golet's ranking system of wetlands for wildlife, the lowest category are those wetlands less than ten acres, and the highest are those wetlands over five hundred acres. It seems reasonable, that in an urban area, the minimum size will fall somewhere in this range of ten to thirty acres and the maximum only needs to be large enough to accommodate internal species (birds) that do not require a great deal of area. The twenty and eighty acres break points used in this assessment are discretionary.

Wetlands support wildlife habitat by providing water in varying amounts and at varying times. Some species are dependent on ephemeral wetlands and some on permanently flooded wetlands. The greater the variety of water regimes that the wetlands in a watershed can provide, the greater the habitat opportunities will be for wildlife. This assessment uses NWI water regimes to determine the amount and timing of the presence of water in a wetland.

Landscape and Wetland Characterization

Landscape and wetland characterization evaluates the relative risk to the watershed posed by the loss of wetlands in the watershed. The idea is to be aware of wetlands as an integral element of the landscape ecology and not as independent sites. It is a characterization of the land cover in the watershed and the amount and type of wetlands present in the watershed.

The percentage of wetlands and lakes in a watershed affects the amount of water which may be stored or detained. Losses of wetlands in watersheds having an initially low percentage of wetland area tends to have a greater impact on stream flow than losses of wetlands from watersheds initially having large percentages of wetlands. In basins with few remaining wetlands, or with an initially low percentage of wetlands, the existing wetlands have a relatively higher value. Protection and preservation of the hydrologic functions wetlands provide is critical in these watersheds. The minimum wetland to watershed ratio of the watershed is set at 1:7 (or 15% of land cover). Impacts to wetlands in watersheds with less than 15% of the land cover in wetland and lakes are to be avoided because of the high probability that it will greatly affect quantity and quality functions provided by wetlands.

Noteworthy Natural and Cultural Features

Noteworthy natural and cultural features are things, places, plants, and animals which are associated to some degree with the water resources of the watershed. These features may protect endangered, threatened and rare plant and animals, or provide unique user experiences, or be a place of solitude and scenic beauty. The feature may be locally defined or be designated by county, state, or federal agencies. They might be springs or waterfalls or dams or an historic mill ruins.

The intent of this human ecosystem function is to provide a means of protection for water and land related resources which might otherwise be missed. It is highly dependent on local knowledge and input. This assessment looks only at state and federally designated threatened and endangered plant and animal species. However any water and related land resource element may defined as an important and noteworthy natural or cultural feature. Some of these features may be of such importance that the presence of them in the wetland means avoidance is mandatory. Much of this needs to be determined locally with abundant public participation.

Restoration and Enhancement

This assessment assumes restoration and enhancement should be given priority in areas with existing high functioning wetlands that need restoration or enhancement to ensure the sustainability of the existing wetland system. In developed and developing urban areas wetlands are often used as part of the storm water system. Often to the detriment of the wetland. By locating restoration and enhancement areas near to high functioning wetlands it is hoped that the existing functions may be sustained over a longer period of time with fewer future inputs.

In urban areas, wetland restoration should be considered as an integral part of the development of larger open space systems within the watershed and the urban region. Wetland restoration may be used to reestablish corridors, or provide secondary or tertiary storm water treatment to protect other high value wetlands, scientific and natural areas, and the watershed's significant natural and cultural features.

The goal of the assessment is to identify restoration and enhancement areas which will establish a surface water system that is able to sustain itself over time with minimal inputs and management. And to integrate wetlands into the larger open space system of the urban region.

Wetland Aesthetics

In Minnesota law and rules concerning water (WCA, MS 103A.201 Subd. 2 4b, MS 7050.0150), there is either explicit or implicit reference to the "natural beauty" of wetlands, and the need to identify and preserve areas of high aesthetic value. This assessment of wetlands needs to include an aesthetic function component. While keeping in mind that preference for landscapes vary widely and may be highly subjective, the approach tries to identify areas with the characteristics that are commonly present in preferred landscape scenes.

Kaplan and Kaplan (1989) summarized the research on the perception and categorization of landscapes. There are numerous ways to classify different kinds of environments. Each may be appropriate and correct in its context and use. However, if the contexts differ, they may clash with other assessments of the same landscape. Decisions about the alteration of the natural environment are generally based on expert categorization. Both the Bureau of Land Management (1980) and the Forest Service (1974) use classification systems in which land form and land use create the "character types" and "variety classes" to categorize the landscape. These categorizations, which experts generate, are often not meaningful (and may even be disturbing) to those who do not share that expertise (Kaplan and Kaplan 1989).

Landscape preference research analyzes the rating of scenes by extracting common patterns from the participant responses to the scenes (Vining and Stevens 1986). Two major categories emerge: content-based and spatial configuration (Kaplan and Kaplan 1989). Content-based categories reflect a concern for the balance between the natural environment and human influence/impact. Spatial configuration reflects the observer's intuitive (perhaps unconscious) interpretation of their ability to function in the pictured "space". Two components appear to be particularly important in this interpretation: degree of openness and spatial definition. The spatial configuration that generates the greatest degree of favorable responses are those which are open, yet defined; such as, open forest (R. Kaplan 1984), parkland (R. Kaplan 1985), or park like savanna (Woodcock 1982).

Wetlands are sometimes viewed as common or unspectacular nature scenes. Ulrich (1986) found that preference for unspectacular nature scenes may be comparatively high if:

1. the number of vegetative elements (complexity) in the scene is moderate to high,

2. the complexity is structured either with a focal point, or some other organizing pattern or element,

3. the scene has a moderate to high clearly defined depth,

4. the scene contains deflecting or curvilinear sight lines giving the impression of new landscape beyond the immediate visual boundary, and

5. the scene has a ground surface which is relatively uniform in texture and gives the impression that movement through the landscape is possible.

The addition of open water bodies greatly enhances the preference of respondents to landscape scenes (Ellsworth 1982).

These studies show that while expert classification systems may highly rate wetlands as a landscape structural element because of the wildlife habitat or the water quality functions they provide, non-experts may give the same landscape element a low preference rating because of its content or because it is not well defined spatially. It also points out the need to inform and educate people about the value of wetland functions. Familiarity with a landscape type generally increases preference for the landscape type (Kaplan and Kaplan 1989). Wetlands with little visual human influence, that are part of or near parklike and natural settings, with open water will be rated higher than isolated, small wetlands in urban settings by this assessment.

WETLAND RESOURCE MANAGEMENT

Resource Management Guidance

A. Limitations of the Method

Every assessment methodology has limitations to its application. Understanding the limits of the method will allow for its best possible use. The following are the limitations of this method:

- The method is a planning assessment tool.
- The method is not designed for impact analysis.
- The method is not designed for use in legal proceedings that require detailed, site specific information about an individual wetland.
- The method uses a raster-based geographic information system. The assessment is only as good as the data provided. It is extremely important to know the source, age, encoding techniques, raster cell size, and other characteristics of the data sets and to understand how each limits the conclusions one may draw from the assessment procedure.
- The method is designed for use in the seven county metropolitan area.

B. Recommended uses of the Method

The method is an inventory and planning tool. It is intended to be used to assess wetland functions relative to the natural and human ecosystems within the hydrologic unit in which it is located. **It is not for evaluating site-specific impacts to wetlands or for delineation of wetland boundaries**. While the information collected during the assessment may be useful to a wetland professional's detailed assessment of an individual wetland, it is not, in and of itself, a suitable method of evaluating an individual wetland. Specific function analysis can only be determined through on-site inspection and measurement.

The method is not intended as a justification for the destruction of wetlands or for allowing adverse impacts to a wetland because the evaluation of the wetland is low on one or more of the assessment's functional indices. Wetland professionals and many lay persons agree that each wetland provides some ecological value and that impacts to wetlands should, if possible, be avoided, or where impact is unavoidable, mitigated.

This method is designed for the following purposes:

- To collect basic information about wetlands in watersheds in the seven county metropolitan region.
- To create an accessible natural resources database containing information about the wetland functions and the value of wetland functions, as well as other wetland data.
- To support planning and decision making within LGUs.
- To support regulatory policies and decisions of LGUs.
- To educate those parties, public and private, within the watershed community, who are committed to the protection, management, or development of land resources.

C. Interpretations of Function Analysis

The method can assist a local government unit (LGU) in making informed decisions about its wetland resources. The method is designed to assess wetland functions with respect to the adjacent existing land use conditions and the wetland's position in the landscape ecosystem.

Each wetland unit must be evaluated for the same functions if it is to be used to classify and prioritize a watershed's wetland resources. The method characterizes some of the functions a wetland may provide to the ecosystem. The value assigned to the wetland is based on the assessment outcomes, the water quality and water quantity needs of the watershed, and other goals of the watershed as determined by the watershed management organization, citizen groups, and other interested parties. Planning the "best use" of wetland resources can result from this process.

In the absence of locally defined wetland and watershed goals, the management classes which follow will provide the baseline for wetland resource management.

Class I
Five or more of the functions are evaluated as high.

Class II
Three or four of the functions are evaluated as high.

Class III
One or two is evaluated as high.

Class IV
No function is evaluated as high.

D. Prioritizing Wetland Resources
Wetland resource management guidelines allow for some local variation in existing conditions and priorities, while providing defensible, reasonable baseline value determinations. It should be remembered that all wetlands provide some benefit(s) to the ecosystem even though the wetland is evaluated low by this assessment. The priority scheme imposed here preserves those wetlands which are evaluated as critical to the maintenance of the wetland resource and watershed hydrologic processes, and investigates those wetlands which are evaluated as having a marginal influence on the maintenance of wetland function and the watershed.

Prioritizing watershed wetland resources may be accomplished using the above classes. Those wetlands which fall in Class I or Class II are to be protected and enhanced to maintain the functions which already exist. This can be done by designating them as wetland preservation areas and requiring full sequencing if impact to the wetland is absolutely unavoidable. The wetlands in Class III and Class IV allow for sequencing flexibility. A priority site investigation schedule should be employed to verify this assessment's outcomes for those wetlands in Class III and Class IV. As outcomes are corroborated, the site investigation schedule may be adjusted.

APPENDICES

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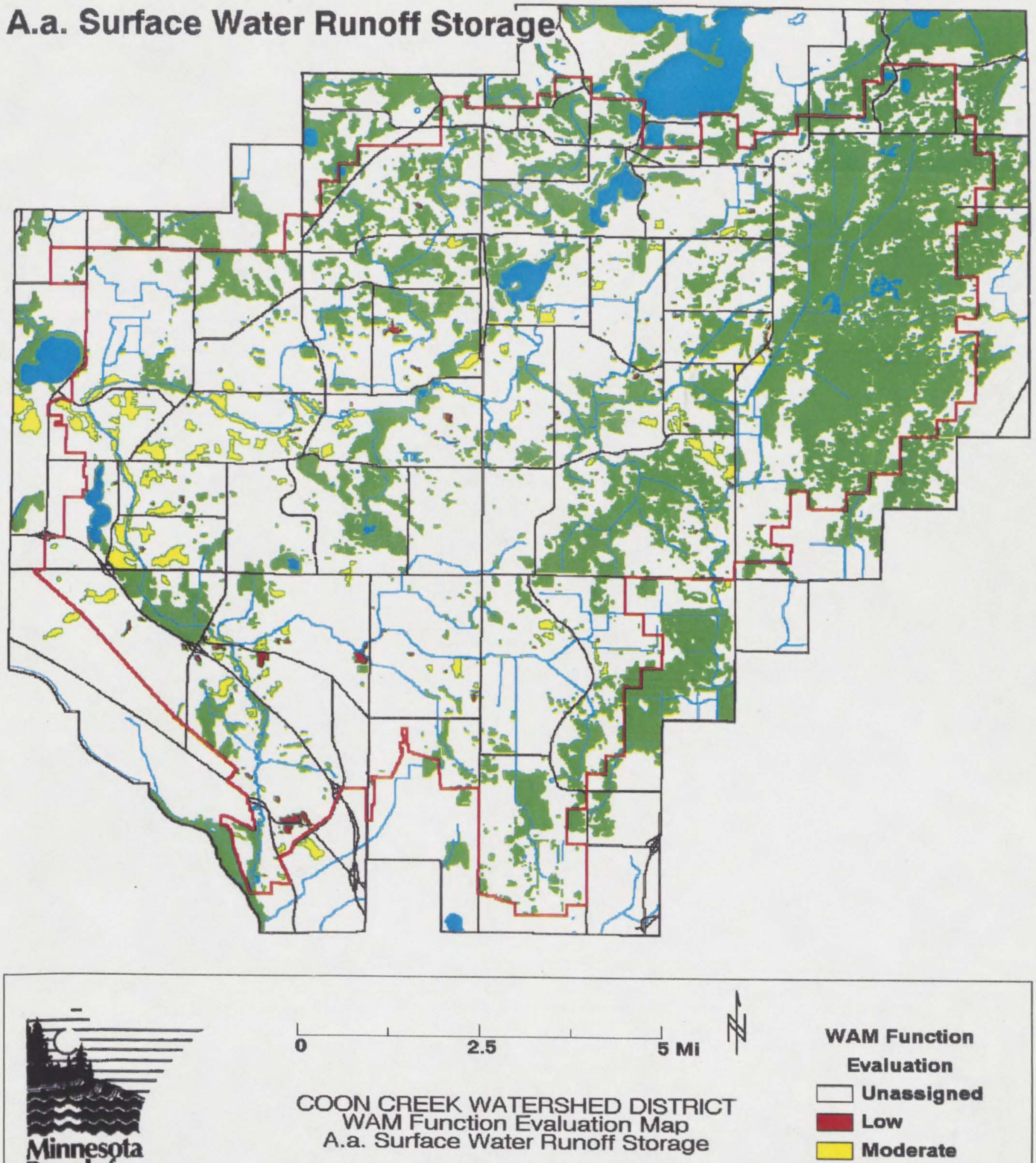
A.a. Surface Water Runoff Storage



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COON CREEK WATERSHED DISTRICT
WAM Function Evaluation Map
A.a. Surface Water Runoff Storage

Board of Water and Soil Resources
One West Water Street
Saint Paul, MN 55107
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WAM Function Evaluation

- Unassigned
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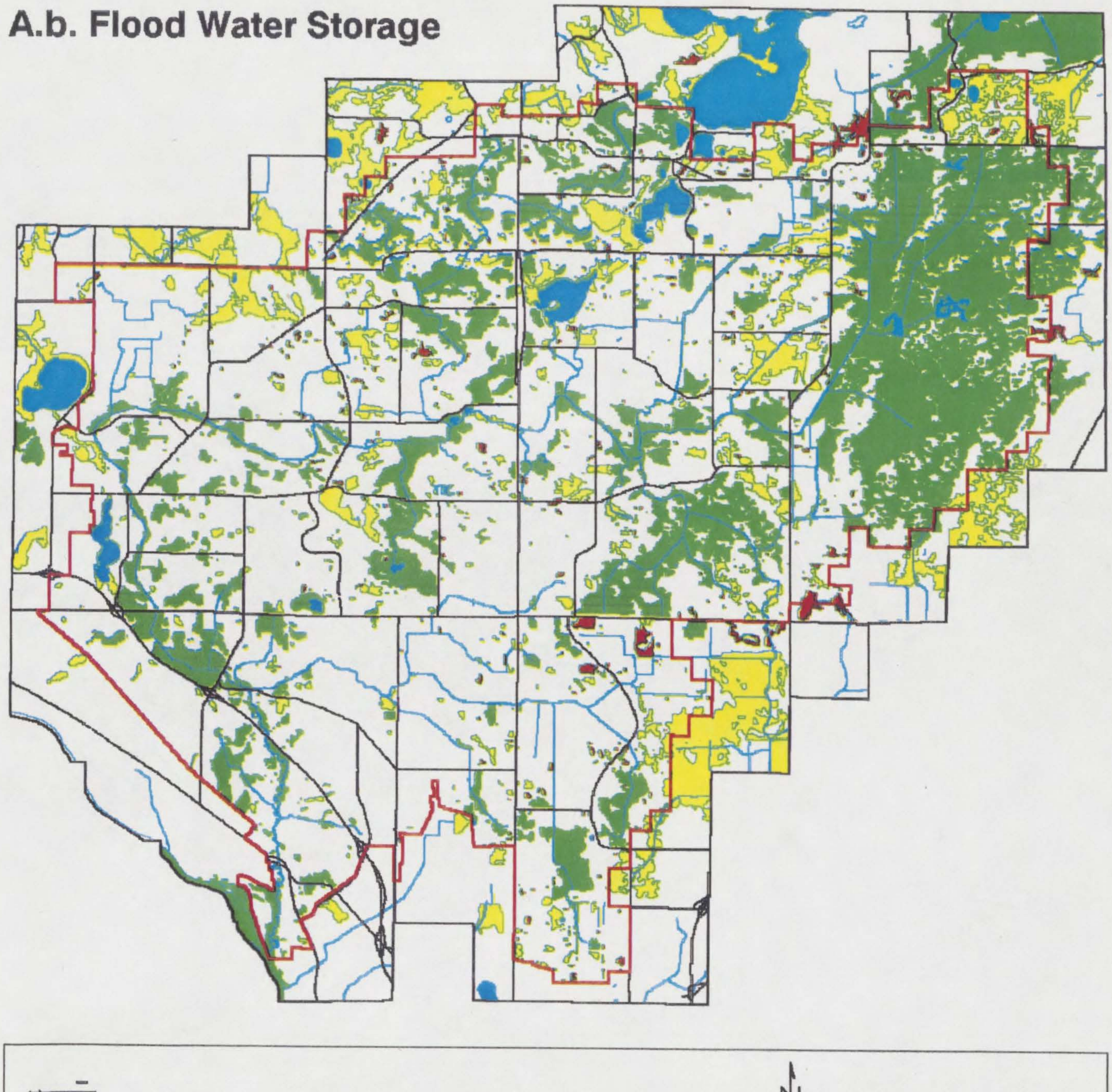
- Moderate
- High
- Water

Minnesota Board of Water & Soil Resources

A.b. Flood Water Storage



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Minnesota Board of Water & Soil Resources

COON CREEK WATERSHED DISTRICT
WAM Function Evaluation Map
A.b. Flood Water Storage

Board of Water and Soil Resources
One West Water Street
Saint Paul, MN 55107
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WAM Function Evaluation

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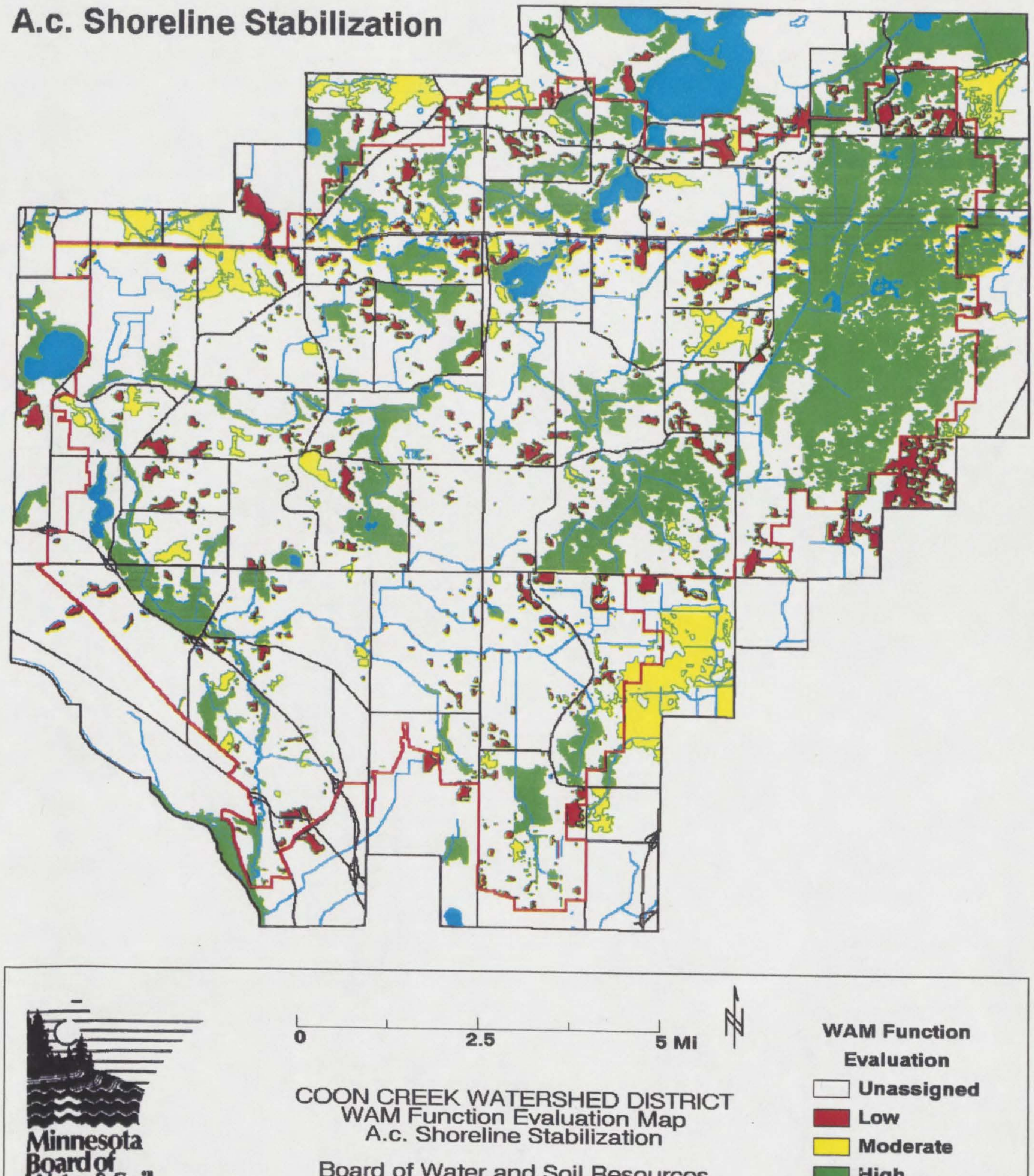
- High
- Water

A.c. Shoreline Stabilization



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COON CREEK WATERSHED DISTRICT
WAM Function Evaluation Map
A.c. Shoreline Stabilization

Board of Water and Soil Resources
One West Water Street
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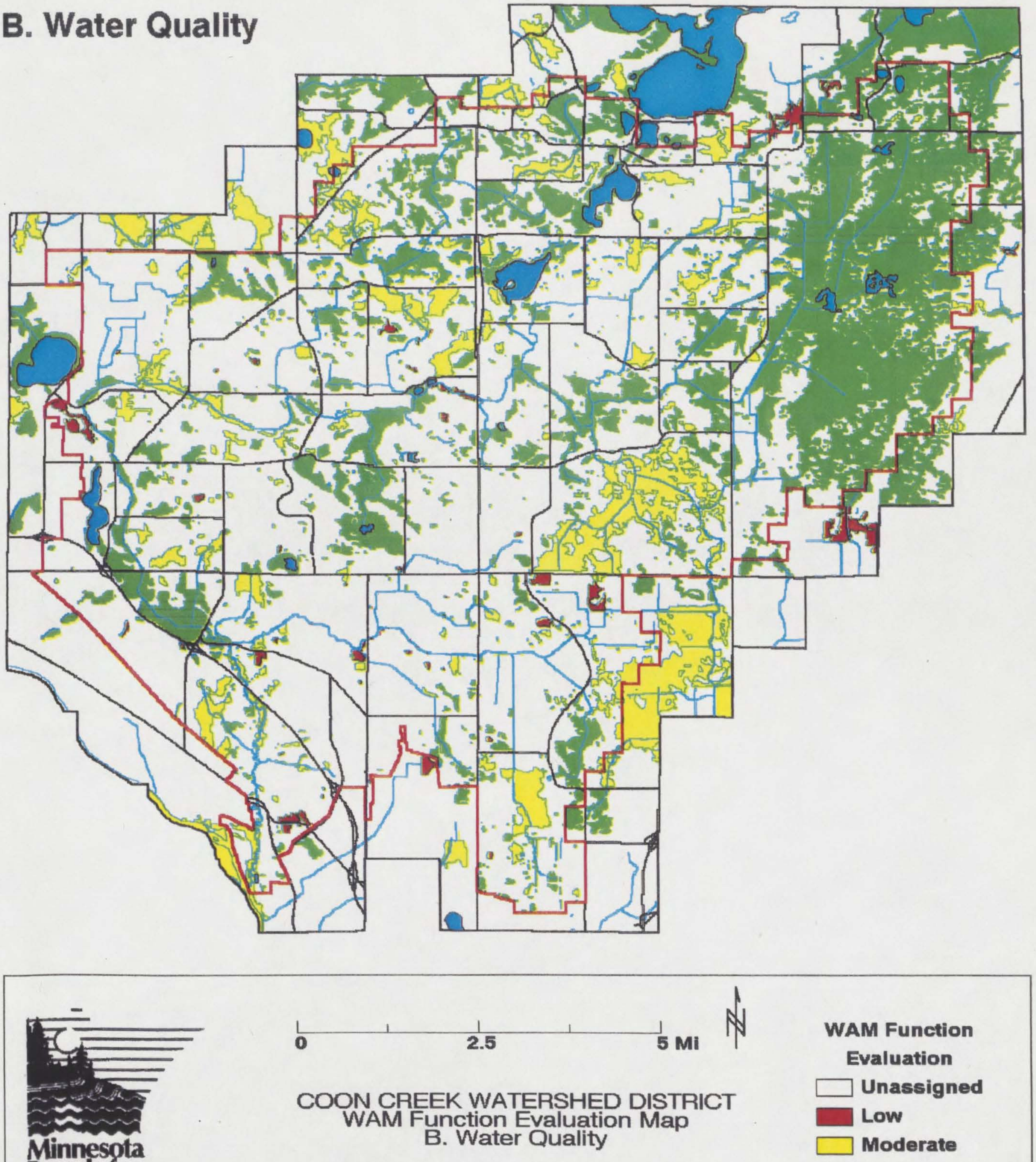
B. Water Quality



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B. Water Quality

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One West Water Street
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WAM Function Evaluation

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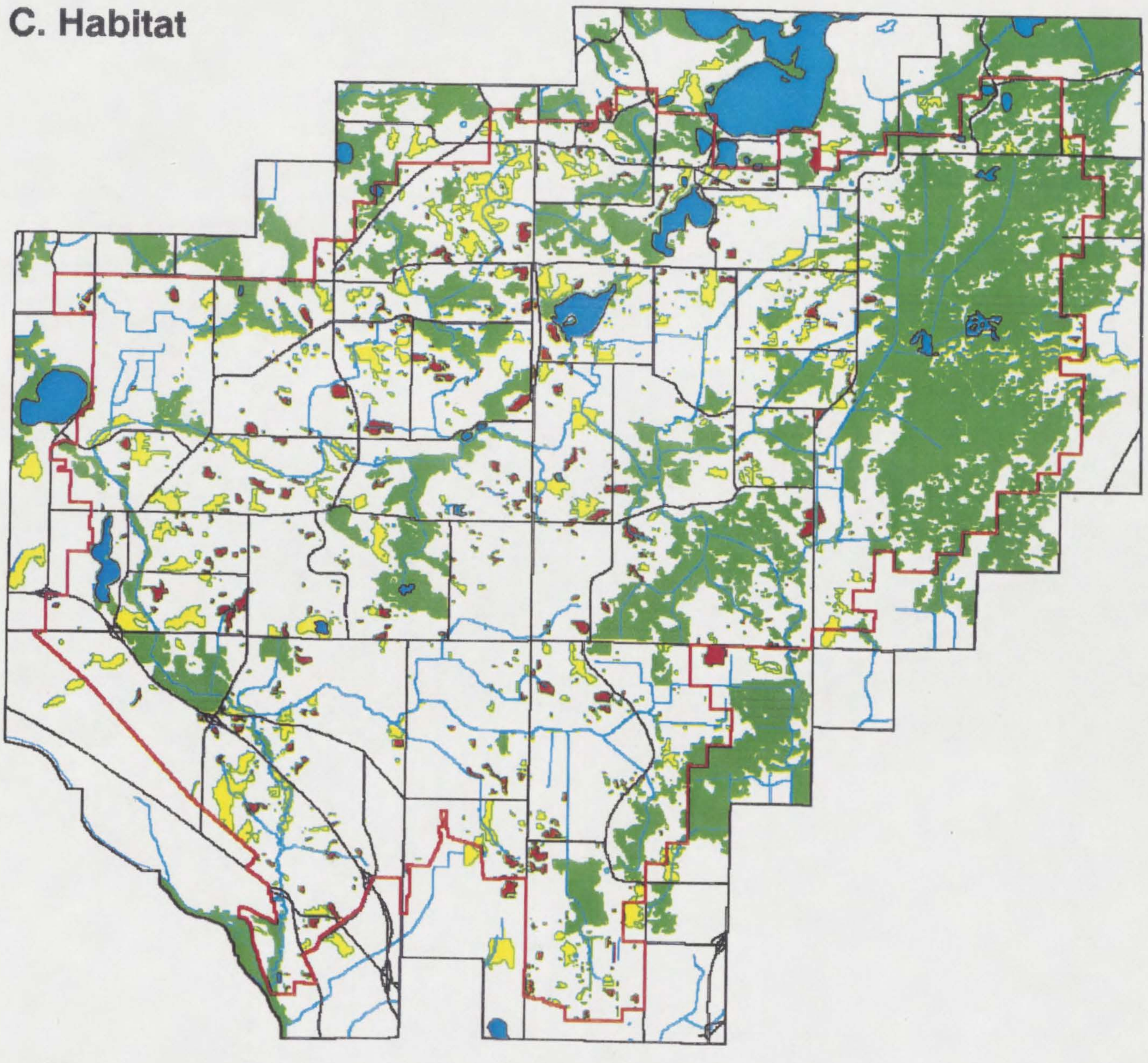
- Water

Minnesota Board of Water & Soil Resources

C. Habitat



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COON CREEK WATERSHED DISTRICT
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C. Habitat

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Minnesota Board of Water & Soil Resources

WAM Function Evaluation

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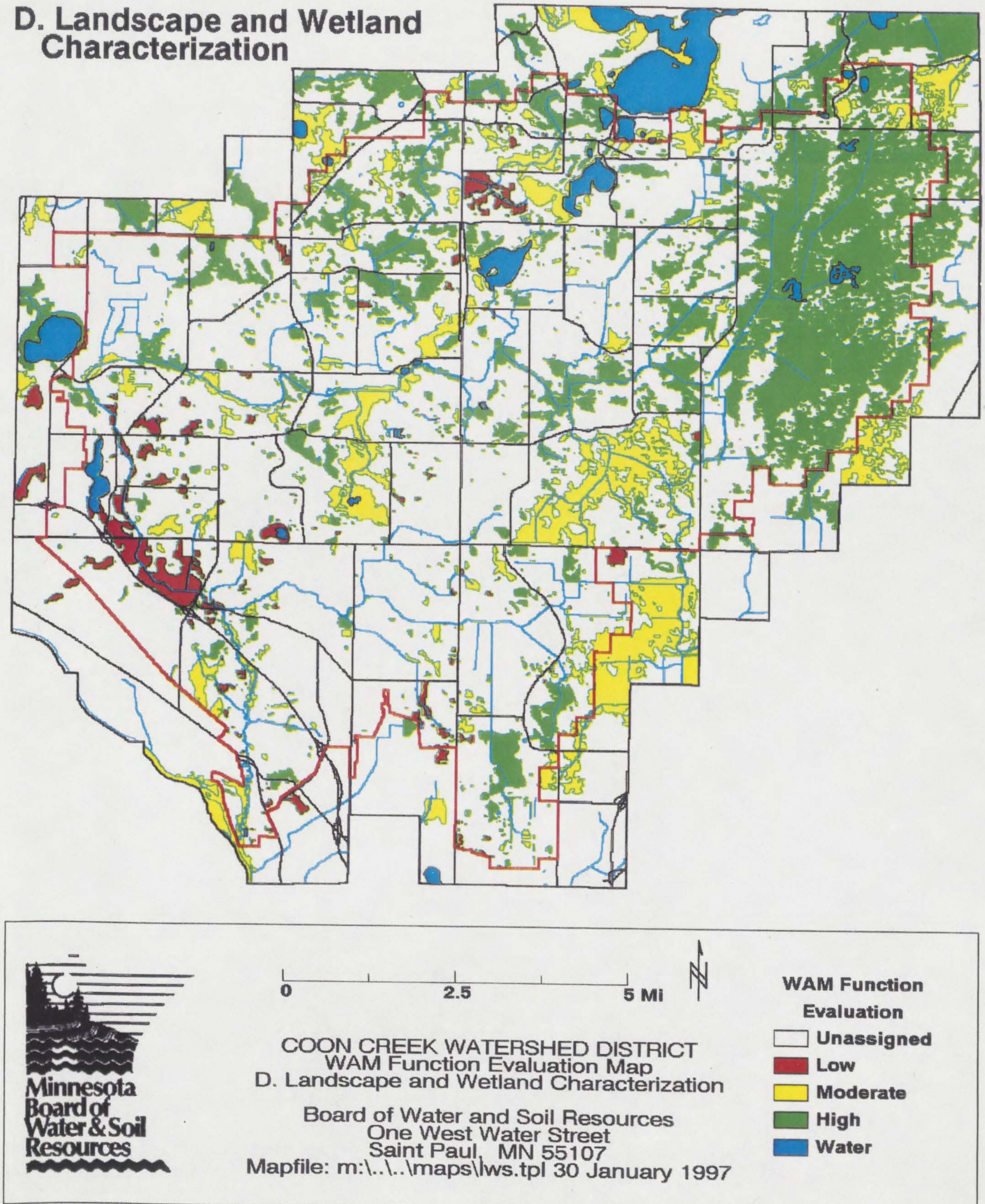
- Moderate
- High
- Water

D. Landscape and Wetland Characterization



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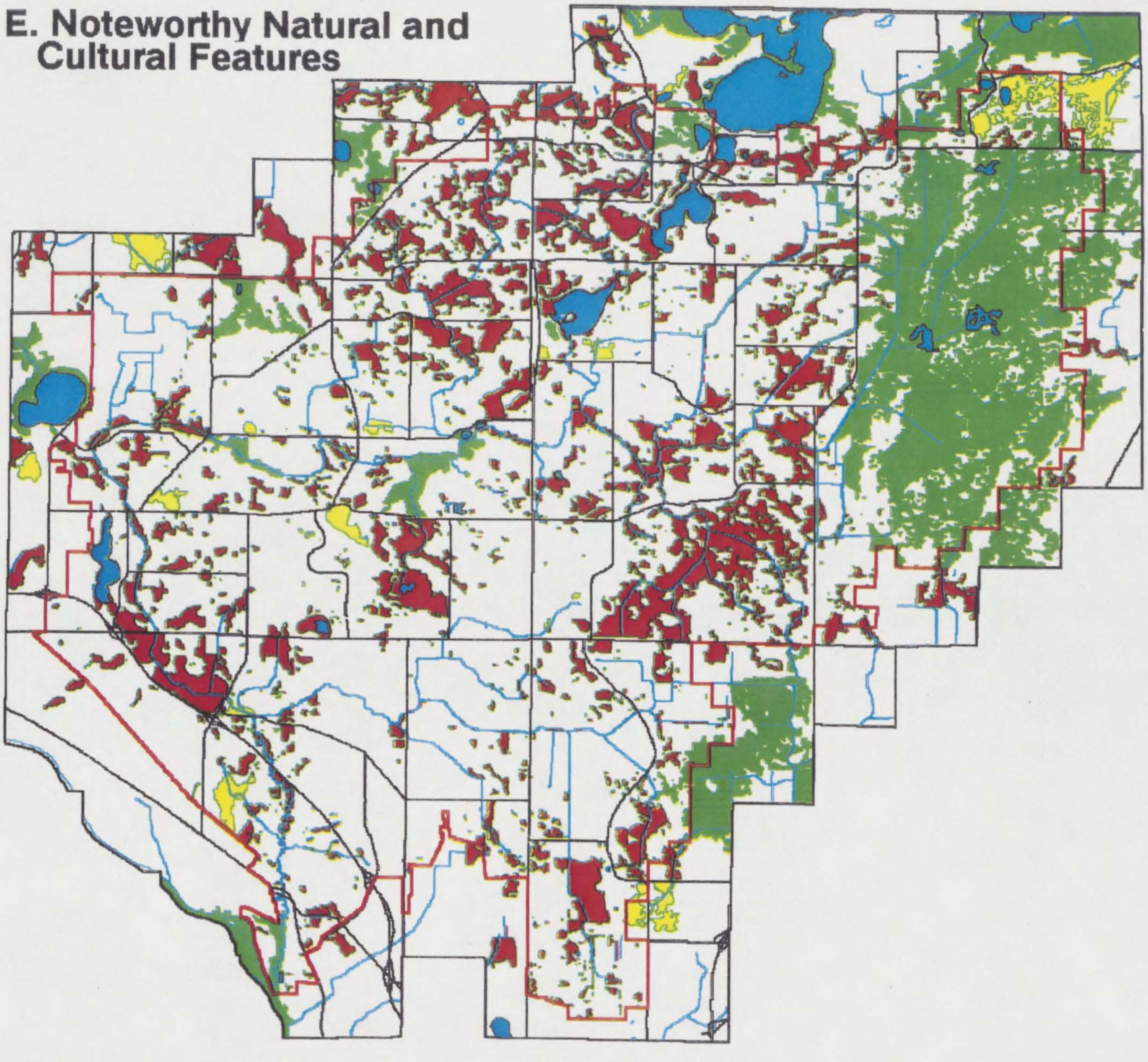

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WAM Function Evaluation

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- Moderate
- High
- Water

COON CREEK WATERSHED DISTRICT
WAM Function Evaluation Map
E. Noteworthy Natural Features

Board of Water and Soil Resources
One West Water Street
Saint Paul, MN 55107
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Minnesota Board of Water & Soil Resources

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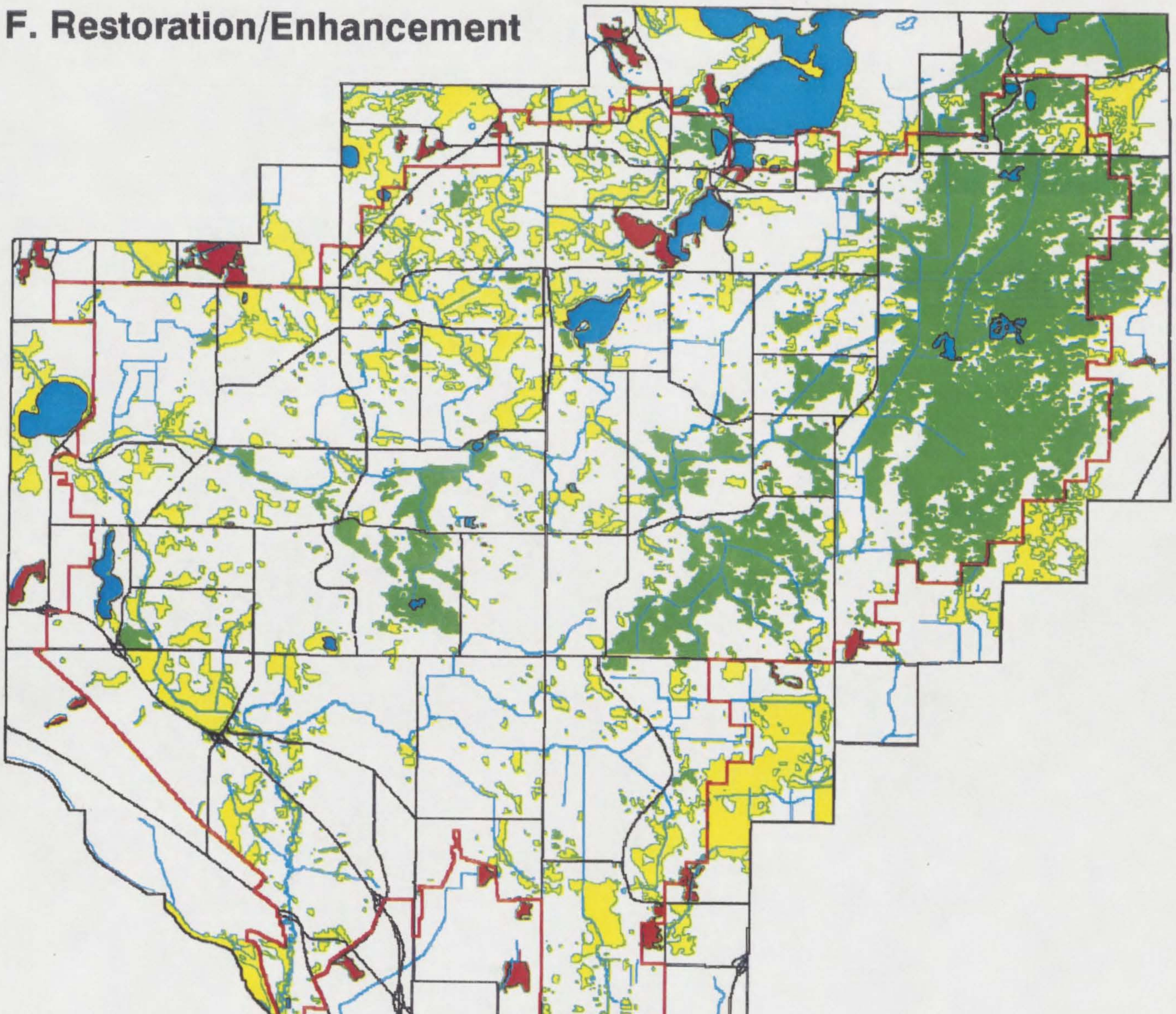

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COON CREEK WATERSHED DISTRICT
WAM Function Evaluation Map
F. Restoration/Enhancement

Board of Water and Soil Resources
One West Water Street
Saint Paul, MN 55107
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WAM Function Evaluation

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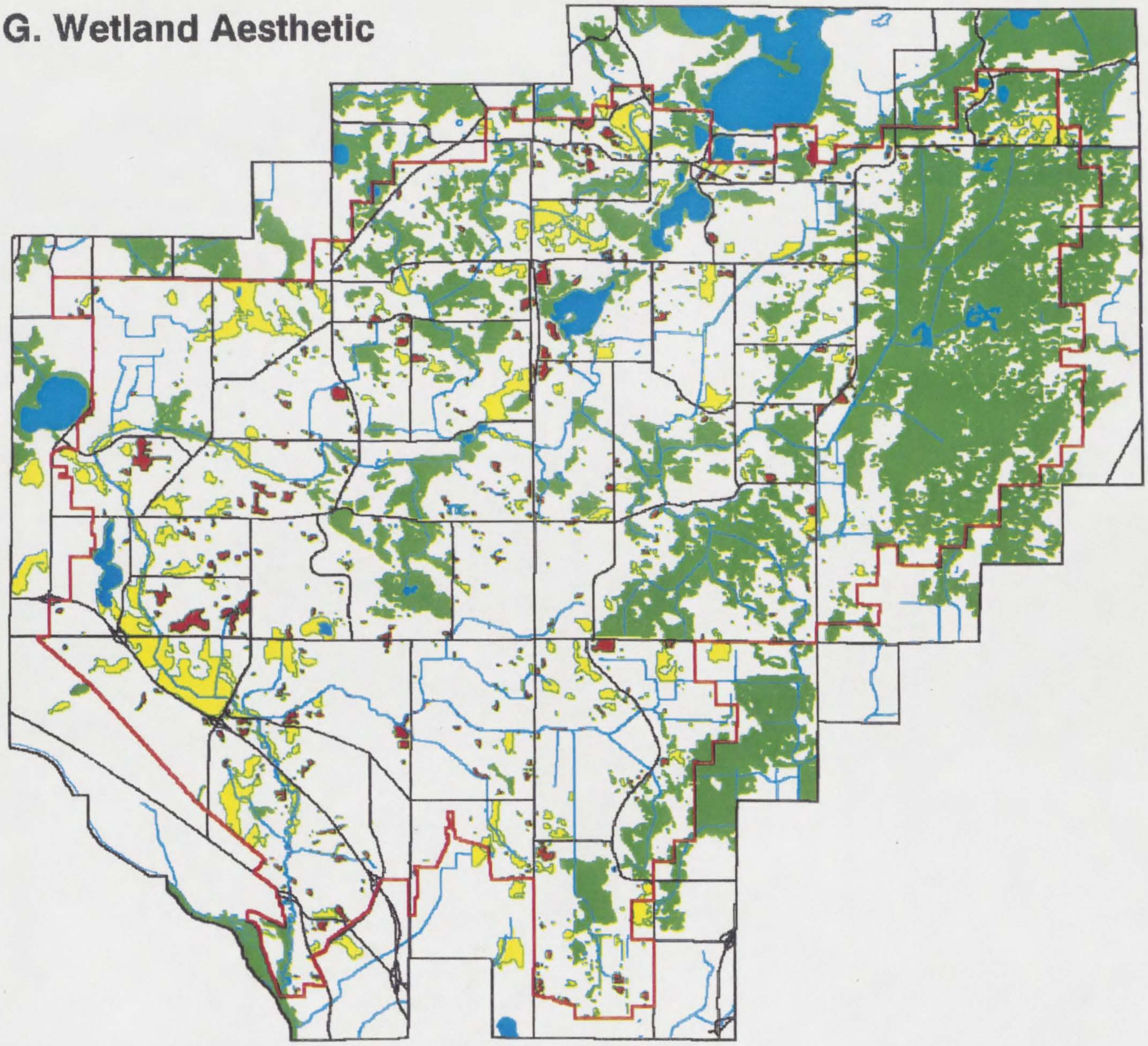
- Low
- Moderate
- High
- Water

G. Wetland Aesthetic



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COON CREEK WATERSHED DISTRICT
WAM Function Evaluation Map
G. Wetland Aesthetic

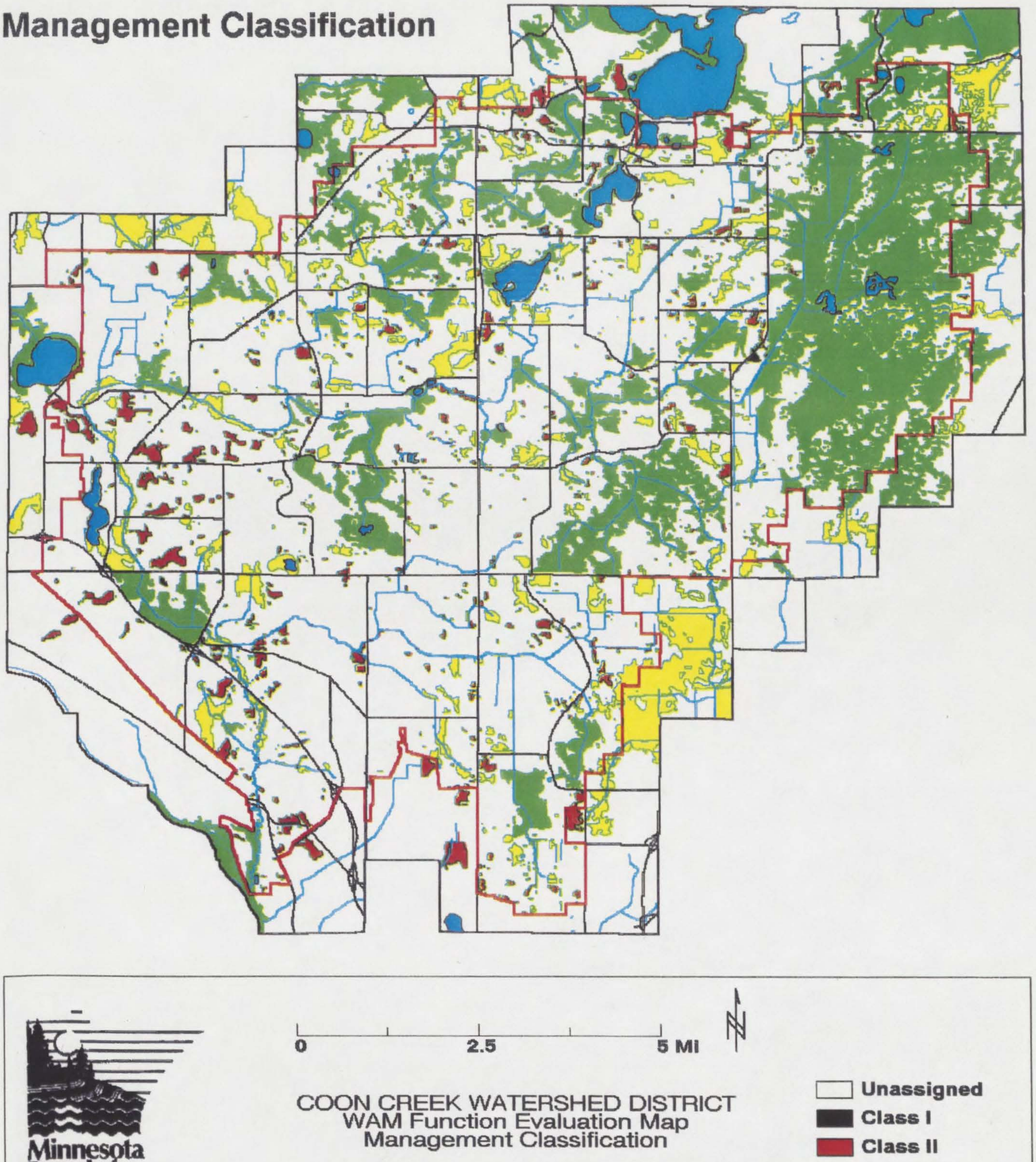
Board of Water and Soil Resources
One West Water Street
Saint Paul, MN 55107
Mapfile: m:\..\..\maps\ap.tpl 30 January 1997

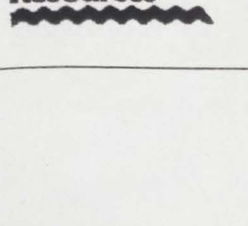
WAM Function Evaluation

- Unassigned
- Low
- Moderate
- High
- Water

Minnesota Board of Water & Soil Resources

Management Classification





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COON CREEK WATERSHED DISTRICT
WAM Function Evaluation Map
Management Classification

Board of Water and Soil Resources
One West Water Street
Saint Paul, MN 55107
Mapfile: m:\..\..\maps\class.tpl 30 January 1997

- Unassigned
- Class I
- Class II
- Class III
- Class IV