Description of Existing Wetland Resources in the St. Croix River Headwaters Watershed

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Executive Summary

This project is part of a larger effort by the U.S. Army Corps of Engineers (USACE), Saint Paul District in partnership with the Wisconsin Department of Natural Resources (WIDNR) to study the Saint Croix Headwaters watershed. The purpose of this project was to map and describe the existing condition of wetland resources.

Wetlands were mapped and classified using on-screen digitizing methods in a GIS supported by field verification of photosignatures and classifications. Wetlands were concurrently mapped using the Wisconsin Wetland Inventory (WWI), U.S. Fish and Wildlife Service National Wetland Inventory (NWI) Cowardin system, and Landscape, Landform, Water Flow Path, and Waterbody (LLWW) classification systems. For the western portion of the watershed, wetlands were also mapped for 1948 and 1992. The data from these earlier years were then compared to the current 2009 data to provide insight into wetland change over time.

The use of LLWW descriptors allowed a wetland functional assessment to be performed. The functional assessment schema was developed through consensus of stakeholders, and local and regional experts familiar with the study area. The schema was used to generate queries which were then executed on the classified geospatial wetland data. Wetlands were classified as high, moderate, or not performing the wetland function being queried. The results were summarized and displayed on maps in order to provide a better understanding of the processes occurring in the watershed.

This study found that of the 215,509 acres in the watershed, 177, 719 acres (82.5%) are upland and 37,790 acres (17.5%) are wetland. Palustrine wetlands make up 72.8% of the wetlands and lacustrine wetlands make up 26.1%. Forest accounted for the most wetlands in terms of vegetation type.

For wetland functionality, carbon sequestration, surface water detention, and surface water maintenance were performed by the most wetlands. The least common function performed was shorebird habitat with less than 3.8% of the wetland. Maps were generated to show the areas within the watershed performing each function. A summary of the historical wetland functions was also produced with some functions showing gains and others losses when the 2009 data was compared to the historical data. The NWI classes were also summarized. Most of the change in wetland class occurred between three NWI classes: emergent, forested, and scrub-shrub.

The knowledge gained from working through the project leads to several conclusions. Most important is the need to adapt methodologies based on regional and local conditions, and this is only possible with cooperation from local experts. Also, the value of using every available data set supported by the imagery cannot be underestimated. Any data that can contribute to the decision-making process only enhances the detail required for a valid functional assessment. Multiple dates of field work are also vital to assure an accurate classification and hence a valid assessment. Finally the methodology developed for this project needs to be tested in a more urbanized environment for applicability.

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Introduction

Background

In October, 2007, the U.S. Army Corps of Engineers (USACE), St. Paul District entered into a partnership agreement with the Wisconsin Department of Natural Resources (WIDNR) to perform a watershed study of the Saint Croix Headwaters Watershed. Its purpose is to evaluate several key water resource issues within the watershed.

This study is a part of that comprehensive water resource management and planning effort for the Saint Croix River Headwaters Watershed. Other studies focus on habitat restoration or protection, water quality improvement, management of invasive species.

The purpose of this project is to map and describe existing conditions of wetland resources in the watershed to update and improve existing Wisconsin Wetland Inventory (WWI) data, concurrently classify wetlands in the Federal Geographic Data Committee (FGDC) standard classification system, primarily used by the National Wetlands Inventory (NWI) Program, and to classify wetland function by applying Wetland Landscape, Landform, Water Flow Path, and Waterbody (LLWW) Type Descriptors. NWI Plus is also known as LLWW.

Wetland data that is available for the Saint Croix Headwaters study area dates from the mid-1980s. As a result, study partners felt that it was important to undertake a project to update wetland mapping using current aerial imagery. It was also determined equally important to compare the WWI Classification and WIDNR mapping standards with the FGDC Classification and NWI mapping standards to determine an optimal method to apply LLWW descriptors.

The results of the research and analysis performed are important for similar future work that will be undertaken across Wisconsin to improve knowledge of existing wetland areas and functions.

Project Area

The Saint Croix River Headwaters watershed covers an area of 335 square miles within Douglas and Bayfield Counties in northwestern Wisconsin, (Figure 1). There are approximately 160 miles of rivers and streams including portions of the Saint Croix River, the Eau Claire River, and numerous tributaries. It is the headwaters of the St. Croix River, a river of high ecological quality that has been designated a National Wild and Scenic River. The watershed is defined as all areas draining to the St. Croix River upstream of the Gordon Dam. Downstream of the Gordon Dam, the Saint Croix is designated a Wild and Scenic river.

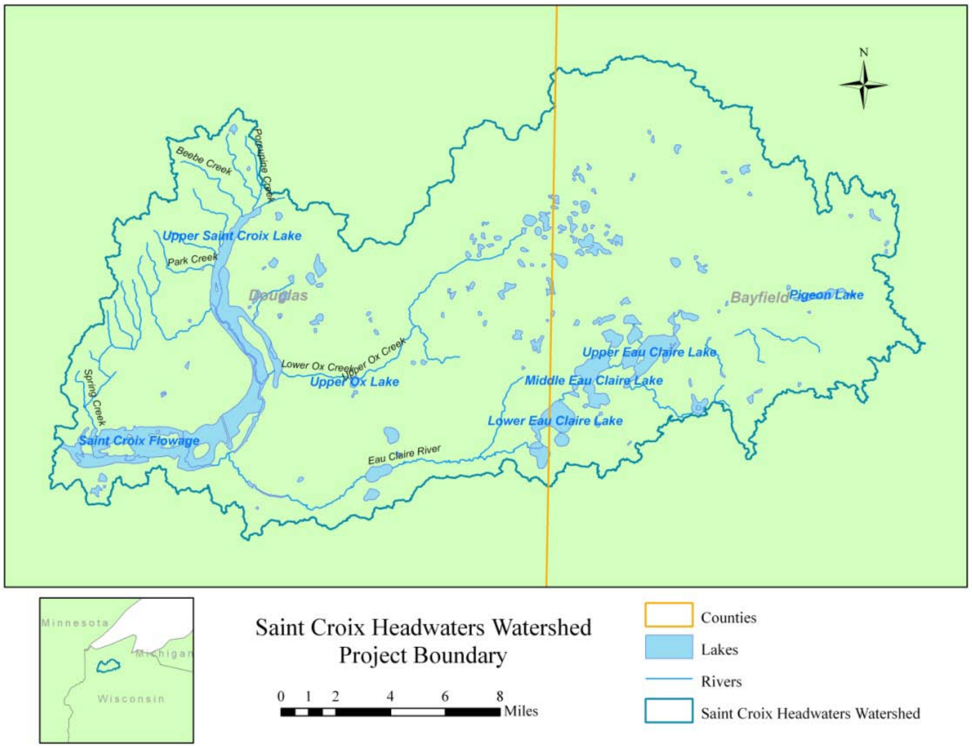


Figure 1. Saint Croix Headwaters Watershed. The watershed boundary delineates the limit of the project area.

Geography

The Upper Saint Croix Headwaters Watershed is located within two ecological landscapes in northwestern Wisconsin. The Northwest Sands Ecological Landscape covers approximately the western two-thirds of the watershed. It consists of flat plains or terraces along glacial melt water channels and pitted outwash plains containing kettle lakes. The North Central Forest Ecological Landscape occupies about one-third of the eastern portion of the watershed. This area is generally characterized by ground moraines, pitted outwash plains, and bedrock outcrops.

The watershed has extensive areas of internal drainage, particularly east of the Upper Saint Croix River. Streams obtain the majority of their flow from groundwater. Groundwater discharge sustains flows to many of the streams throughout the year. The Upper Saint Croix River has one impoundment, the Gordon (Saint Croix) Flowage, after which the Saint Croix National Scenic Riverway begins. The Eau Claire River has four impoundments, one creates the Eau Claire River Flowage near Gordon and three others are located at the lake outlets of the Eau Claire Chain of Lakes in the township of Barnes. Lakes occur in natural abundance, particularly within the glacial outwash plain of the north-eastern portion of the watershed.

The watershed is characterized by irregular, rolling topography with large areas of gentle slope. Surface elevations range from 1,000 to 1,530 feet above mean sea level. Extensive areas of internal drainage occur within the project area.

The Upper Saint Croix River watershed is within the humid continental climate zone and is characterized by variable weather patterns and large seasonal temperature changes. Most precipitation historically occurs from late spring through late summer. The average precipitation for this area is approximately 31 inches per year.

Vegetation, Soils, and Land Use

Dominant vegetation commonly consists of jack pine (*Pinus banksiana*) and prairie grasses in upland areas, with black spruce (*Picea mariana*), tamarack (*Larix laricina*), Northern white cedar (*Thuja occidentalis*), leatherleaf (*Chamaedaphne calyculata*), and mosses (*Sphagnum* spp.) in swamps and bogs. Fens and marshes are occupied by sedges (Cyperaceae) and Canada blue-joint (*Clamagrostis canadensis*). The soils in the watershed are distributed such that sand-textured soils cover the upland areas and loams and organics fill the depressions and bogs. Land uses in the watershed are predominantly forests/shrublands (66%) and grasslands (17%). Wetlands and surface water (12%) areas also are prevalent. Timberland occupies a large part of the watershed. Other agricultural and developed land (5%) is limited, with much of the development occurring around lakes and along streams.

Wetland Mapping and Classification

Geographic information systems (GIS) technology has allowed wetland mapping to advance from hard copy maps drawn directly on mylar to large searchable databases able to satisfy any number of queries. Wetlands are typically mapped using on-screen digitizing methods by photointerpreters (PI). Aerial imagery serves as a base map and when combined with collateral data such as soils, topographic, hydrologic, and land cover, the PI is able to make informed mapping decisions. The database structure has the advantage of being able to assign any number of attributes to characterize wetland features. How these attributes are assigned is dependent on the classification system being utilized. In the case of the Saint Croix Headwaters project there are three classification systems that are relevant, the National Wetlands Inventory (NWI), Wisconsin Wetland Inventory (WWI), and Landscape Position, Landform, Water flow path, and Waterbody (LLWW). LLWW is sometimes referred to as NWI Plus, but to minimize confusion for the purpose of this report it will be referenced as LLWW.

Notation

Since this project uses three different classification systems to characterize wetlands for the purposes of applying a functional assessment it would be very easy for the coding systems to create chaos in the mind of the reader. In an attempt to prevent confusion, some conventions on wetland code notation need to be established. NWI codes will be *italicized*, WWI codes will be <u>*italicized and underlined*</u>, and LLWW codes will be highlighted in **bold**. The pound sign(#) will be used as a place holder or “wild card” when necessary.

National Wetlands Inventory (NWI)

The National Wetlands Inventory is the system used by the U.S. Fish and Wildlife Service to classify wetlands and deepwater habitats within the United States. NWI relies on plant community types as indicators of surface hydrology. A wetland is defined as land supporting hydrophytic plant communities, or has hydric soils, or where the water table is at or near the surface for part of the year. If any of these conditions are met, then the area can be classified as wetland. Deepwater habitats consist of those permanently flooded areas that are below the deepwater boundary of wetlands. With the use of high resolution aerial photography the presence of hydrophytic vegetation becomes dominant in identifying wetlands, but collateral data is often used to aid in classification. Collateral data normally consists of soils, topographic, and land cover data. Soils provide information on the location of hydric soils while topographic data will often provide insight into surface hydrology. NWI applies an alpha numeric code to each mapped feature. The coding schema is shown below. Each underbar represents a component of the code. The codes are written without spaces between components, the spaces are inserted here for clarity.

<u>System</u> <u>Subsystem</u> <u>Class</u> <u>Subclass</u> <u>Water Regime</u> <u>Special Modifier</u>

Where:

System is a single uppercase alphabetic (letter) code that defines the classification in the broadest sense. There are only five systems defined by the NWI, marine *(M)*, estuarine *(E)*, lacustrine *(L)*, riverine *(R)*, and palustrine *(P)*. Of these only the latter three apply to the Saint Croix Headwaters because the first two refer to coastal and offshore saltwater environments. Subsystem consists of a single number that further specifies the wetlands type. For instance *L2* refers to the lacustrine system with a littoral subsystem. This is the habitat typically found around lake edges. It should be noted that the meaning of the subsystem code is dependent upon the system to which it is being applied. For example, *R2* does not mean riverine littoral, but rather riverine, lower perennial. There is no subsystem for the palustrine system. Palustrine wetlands as defined by Cowardin are nontidal wetlands dominated by trees, shrubs, persistent emergent vegetation, mosses, lichens including open water areas less than 2 meters in depth and smaller than 20 acres.

Class is a two letter uppercase code that refers to the dominant vegetation or substrate type. Examples of classes include emergent *(EM)*, forested *(FO)*, and unconsolidated bottom *(UB)*. The subclass, similar to the subsystem, refers to a more specific type and is again coded with a single number. For example, the code *FO1* refers to broad-leaved deciduous forest versus *FO4* which refers to needle-leaved evergreen forest. It is possible to have dual classes separated by a slash (/). The meaning of the subclass is dependent on the class to which it is being applied. Often the NWI data is not classified to the subclass level. In this case, there is no number after the class code, but another uppercase letter which is the water regime.

Water regime is sometimes referred to as the hydrologic modifier. It consists of a single uppercase letter. It encodes hydrologic information such as flooding frequency. For the nontidal water regimes present in the SCHW, the water regime only applies during the growing season, because flooding during the dormant season does not significantly affect the vegetation that is present. The water regime with the most acreage in the Saint Croix Headwaters is the saturated *(B)* water regime which is used to classify saturated soils. Other relevant water regimes for the Saint Croix Headwaters are the non-tidal flooded water regimes. These are, in order of ascending wetness, temporarily flooded *(A)*, seasonally flooded *(C)*, semi-permanently flooded *(F)*, intermittently exposed *(G)*, and permanently flooded *(H)*.

The final component of the NWI code is the special modifier. The special modifier is a lower case letter which characterizes very specific conditions present within the wetland. Among the conditions encoded by the special modifiers are whether the wetland is partially drained *(d)*, is the result of human activity such as excavation *(x)* or impoundment *(h)*, or if it is a wetland that is currently being drained for farming *(f)*. There are special modifiers for water chemistry, the acidic *(a)* water chemistry modifier for bogs is an example and for soil type where organic soils receive the *(g)* modifier and mineral soils receive the *(m)* modifier. A characteristic of NWI data is that not all special modifiers are regularly used and the lack of a special modifier does not necessarily mean that the condition that it represents does not exist in that wetland. This is especially true of the water chemistry and soil modifiers and is primarily due to interpretive limitations of the original source data. The excavated and impounded special modifiers are probably the most commonly applied because their presence is easily ascertained from aerial imagery. It is also possible to have more than one special modifier attached to a wetland. As imagery and collateral data resolution have improved, the use of the special modifiers has increased.

To help further explain NWI here are some examples of attributes present in the Saint Croix Headwaters:

> *PFO4Bg* – This is a palustrine *(P)* wetland, where needle-leaved evergreen trees *(FO4)* are the dominant vegetation. This wetland has saturated soil *(B)* which is organic in nature *(g)*. Note there is no subsystem for palustrine wetlands.
>
> *PEM1Cg* – This is a palustrine *(P)* wetland, where persistent emergent *(EM1)* vegetation such as bulrushes (*Scirpus* spp.) are the dominant vegetation type. This wetland is seasonally flooded *(C)* with organic soils *(g)*. Note again there is no subsystem for palustrine wetlands.
>
> *PSS1/EM1Cg* – This is a palustrine *(P)* wetland that is a mixture is broad leaf deciduous scrub shrub *(SS1)*, such alder (*Alnus* spp.), and persistent emergent vegetation *(EM1)*. This wetland is seasonally flooded *(C)* with organic soils *(g)*. Generally with a dual attribute neither class covers greater than 60% of the wetland, and the class of the dominant cover type is listed first.
>
> *L1UBH* – This is a lacustrine (lake) limnetic *(L1)* deep water habitat with an unconsolidated bottom *(UB)* or non-vegetated bottom that is permanently flooded *(H)*. There is no subclass or special modifier listed in this attribute.
>
> *L2EM2H* – This is a shallow water lake environment, lacustrine littoral *(L2)* wetland dominated by non-persistent emergent vegetation *(EM2)* that is permanently flooded *(H)*. This attribute is typically used in the Saint Croix Headwaters for wild rice (*Zizania aquatica*) beds.

By no means is this an exhaustive list of the NWI attributes present in the Saint Croix Headwaters. For a comprehensive explanation of the NWI classification system refer to Classification of Wetlands and Deepwater habitats of the United States (Cowardin, 1979).

Wisconsin Wetland Inventory (WWI)

The Wisconsin Wetland Inventory (WWI) classification system uses an approach very similar to NWI for classifying wetlands. Essentially anything mapped in WWI is also included according to NWI. As with NWI, areas supporting hydrophytic vegetation are included. Unlike NWI, WWI does not include any deepwater habitats. If hydrophytes are not present, an area must be classified by the Department of Agriculture's Natural Resource Conservation Service (NRCS) with poorly or very poorly drained soils in order to be included in the WWI. WWI maps to the tallest vegetation present and not necessarily the most dominant in terms of areal coverage. Also in contrast to NWI, WWI does not map deepwater habitats. Anything deeper than six feet is not included. WWI could be considered a lean version of NWI that is tailored specifically to the wetland communities found in Wisconsin. Wisconsin has their own set of codes, but the general idea of a hierarchy of alpha-numeric codes is the same. The coding schema for WWI is as follows:

<u>Class</u> <u>Subclass</u> <u>Hydrologic Modifier</u> <u>Special Modifier</u>

Where:

Class is a single letter uppercase code that refers to the tallest vegetation or substrate type. Examples of classes include emergent *(<u>E</u>)*, forested *(<u>T</u>)*, moss *(<u>M</u>)*, and open water *(<u>W</u>)*. The subclass, like NWI, refers to a more specific type and is coded with a single number. For example, the code *<u>T3</u>* refers to broad-leaved deciduous forest versus *<u>T5</u>* which refers to needle-leaved evergreen forest. Again similar to NWI, the meaning of the subclass is dependent on the class to which it is being applied. In WWI there are a total of eight possible classes. All classes except moss *(<u>M</u>)* and upland *(<u>U</u>)* have subclasses associated with them. Upland is only used as a class for signifying upland inclusions within a wetland complex. It is possible to have a wetland attributed with dual classes.

Hydrologic modifier in WWI is analogous to water regime in NWI. It consists of a single uppercase letter.   In WWI it encodes hydrologic information as well as some of the system information such as whether the wetland is a lake, river or palustrine system. There are only four hydrologic modifiers in WWI, standing water, lake *(<u>L</u>)*, flowing water, river *(<u>R</u>)*, standing water, palustrine *(<u>H</u>)*, and wet soil, palustrine *(<u>K</u>)*. With only four hydrologic modifiers in WWI versus eight possible water regimes in NWI, WWI is not as specific as NWI concerning hydrology, therefore wetlands delineated using this system may be more generalized.

The special modifier is the final component of the WWI code. The special modifier is a lower case letter encoding very specific conditions present within the wetland. The special modifier in WWI encodes similar conditions to NWI, as well as some situations unique to Wisconsin. Farmed *(<u>f</u>)* and excavated wetlands *(<u>x</u>)* are examples of the former, while cranberry bog *(<u>c</u>)* and Central Sands complex *(<u>j</u>)* are examples of the former. There are no modifiers in WWI that specifically address water chemistry or soil type. It is possible to have more than one special modifier attached to the same wetland.

To help further explain WWI here are some examples of attributes present in the Saint Croix Headwaters:

> *<u>S6K</u>* – This is a scrub-shrub *(<u>S</u>)* wetland dominated by deciduous evergreen *(<u>6</u>)* vegetation such as leatherleaf (*Chamaedaphne calyculata*). It has a saturated soil as indicated by the wet soil, palustrine *(<u>K</u>)* hydrologic modifier. This attribute might be associated with a bog.
>
> *<u>E2/S3K</u>* – This wetland consists of a mixture of narrow leaved persistent emergent vegetation *(<u>E2</u>)*, for example cattail (*Typha* spp.), and broad leaved deciduous shrubs *(<u>S3</u>)*, such as willow (*Salix* spp.). The first of the dual classes is the dominant class in terms of coverage area. The wet soil palustrine *(<u>K</u>)* hydrologic modifier indicates saturated soil.
>
> *<u>A3L</u>* – This is an aquatic bed of rooted floating plants *(<u>A3</u>)*. Water lilies (*Nymphaea odorata*) are an example of a plant species found in this class. The standing water, lake *(<u>L</u>)* hydrologic

modifier indicates this wetland is associated with a lake basin of at least 20 acres in size, but the wetland itself could actually be less than 20 acres.

T3K - This is a forested wetland *(T)* dominated by broad leaved deciduous *(3)* species. Again the wet soil, palustrine *(K)* hydrologic modifier indicates saturated soil conditions.

These are just a few examples of codes that occur in the SCHW. For more a detailed explanation of the WWI and lists of possible codes please refer to the Wisconsin Department of Natural Resources publications, A User's Guide to the Wisconsin Wetland Inventory and the Wisconsin Wetland Inventory Classification Guide (WI-DNR, 1991).

Landscape Position, Landform, Water Flow Path, and Water Body (LLWW)

Landscape Position, Landform, Water Flow Path and Water body (LLWW) descriptors were created to augment NWI attributes with hydrogeomorphic information. For this reason it is sometimes referred to as NWIPlus. LLWW is not based on vegetation as indicators, but instead classifies wetlands and water bodies based landscape position and hydrologic characteristics. For clarity it will be referenced here as LLWW. In a similar manner to NWI and WWI, LLWW uses alpha numeric codes to describe wetland characteristics. LLWW makes a distinction between wetlands and waterbodies. Wetlands are vegetated, while waterbodies are deepwater habitats. The coding schema can actually take two slightly different forms depending on whether the feature is being classified as a wetland or a waterbody. Vegetated wetlands, such as marshes and wet meadows, and non vegetated substrates that are periodically exposed, for example mud flats, are classified using the wetland landscape position and landform codes as shown below.

LandscapePosition Landform WaterFlowPath Modifier(s)

Where:

LandscapePosition is an uppercase two letter code that describes whether the wetland is associated with a lake, river, or surrounded by uplands. There are also classifications for marine and coastal areas that do not apply in the case of the Saint Croix Headwaters. Wetlands associated with lakes are defined as lentic (**LE**). Wetlands associated with flowing water are classified as lotic streams (**LS**) or lotic rivers (**LR**) depending upon their size. Wetlands that are surrounded by upland as part of an isolated basin are classified as terrene (**TE**). Landscape position can be more specifically classified using a hierarchal combination of lowercase letters and numbers similar to the subsystem or subclass in the NWI classification system. For example, the LLWW attribute for a wetland associated with a dammed river valley lake is **LE2**. If the lake is a reservoir it would be classified as **LE2a**, but if it were a hydropower lake it would be classified as **LE2b**. Similar to NWI, the modifying codes are dependent on the landscape position code to which they are being applied.

Landform is the second portion of the code. It is made up fundamentally of two uppercase letters that can be classified more specifically with the addition of a code consisting of two lower case letters. Landform refers to the geomorphic structure on or in which the wetland resides. There are both coastal and inland landforms defined. There are seven inland landforms included in LLWW, of these five are present in the SCHW. These are slope (**SL**), fringe (**FR**), floodplain (**FP**), basin (**BA**), and flat (**FL**). Further classification can occur by adding a lowercase two letter code. For example, a fringe wetland (**FR**), associated with a pond (**pd**) would be coded with **FRpd**. Lowercase codes only apply to specific landform types, and although there is not any repetition in codes between the landforms, the key (Tiner, 2003) should be consulted to insure a valid code is being used.

There are also water flow path and modifiers included in the code schema for wetlands. Since these are the same for both wetland and water bodies, the water body coding schema will be addressed first.

In LLWW any deepwater habitat greater than 2 meters deep is considered to be a water body and is classified using the waterbody type codes with no landform assigned. The water body coding schema is shown below:

<u>WaterBody</u> <u>WaterFlowPath</u> <u>Modifier(s)</u>

Where:

WaterBody consists of an uppercase two letter code. There are six water body types, two coastal and four inland. Of the four inland types three are present in SCHW including lake (**LK**), river (**RV**), and pond (**PD**). Additional codes consisting of a number followed by a lowercase letter can be added to further specify the water body's characteristics. Woodland ponds surrounded by uplands are a common water body type found in the watershed. These are classified as pond (**PD**), natural (**1**), woodland-dryland (**c**) or **PD1c**.

When a feature is classified as a water body there is no landform code applied, because the water body is considered to be its own landform. The next component of the code is WaterFlowPath which applies to both wetlands and water bodies as defined by LLWW. Water flow path refers to how and if the feature is part of the surface hydrology network. Common examples of the water flow path code include through-flow (**TH**), inflow (**IN**), and outflow (**OU**). Wetlands that are not connected to the surface hydrology network are classified as isolated (**IS**). Most of the water flow path codes are the same for both wetlands and water bodies, but there are some small differences so the reference materials need to be consulted to make sure the correct codes are being applied. It should be emphasized that this classification can only consider surface hydrology. Subsurface hydrologic connectivity is not considered because these characteristics cannot be assessed through image interpretation.

The final component of the LLWW code is the modifier. Modifier codes consist of two lower case letters. Modifiers are used to encode very specific conditions, and more than one modifier may be used. Common examples are **fv** for floating vegetation mats and the headwater modifier (**hw**). Again there are some differences in which modifiers can be applied to wetlands versus those applied to water bodies.

LLWW codes can vary in length from 5 characters up to 14 or more characters depending on how many modifiers are applied. Some examples of complete codes found in the Saint Croix Headwaters Watershed are shown below:

> **LE1BABIhw** – This is a basin (**BA**) wetland associated with a headwater (**hw**) natural lake (**LE1**). It has bidirectional flow (**BI**) which is the type of flow associated with fluctuating lake levels.

LS1FRpdTHbvhw – This wetland is a pond (**pd**) located on the fringe (**FR**) of a low-gradient stream (**LS1**). It is a headwater (**hw**) wetland with beaver (**bv**) activity that has throughflow (**TH**).

LR1FRTH – This wetland is located on the fringe (**FR**) of a low-gradient river (**LR1**). As might be expected for many of these types of wetlands, it has throughflow (**TH**).

TEBAIS – This code refers to a terrene (**TE**) wetland or a wetland surrounded by uplands. It is in a basin (**BA**) and due to its being disconnected from the surface hydrology network it is given the isolated (**IS**) water flow path.

LK1IN – This water body is a natural lake (**LK1**) with surface water flowing into it, but not out of it, thus inflow (**IN**) is the water flow path.

PD1cISfv – This code refers to a water body that is a natural woodland upland pond (**PD1c**) that is isolated (**IS**) from the rest of the surface hydrology network and is covered with floating vegetation (**fv**).

For a more comprehensive explanation of LLWW and listings of it codes refer to Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors (Tiner, 2003).

These various classification systems combined with the ability of GIS technology to query large spatial data sets provided by GIS technology allows the functionality of wetlands to be assessed on a large scale. In fact the intent of creating LLWW was to provide the additional information required to allow functional assessment when combined with existing NWI data.

Methods

The purpose of this project is to describe existing conditions of wetland resources in the St. Croix Headwaters Watershed, discuss potential changes from historical conditions, and to assess wetland function. The results of the research and analyses are important for similar future work in Wisconsin to improve knowledge of existing wetland areas and functions.

Project objectives include:

1. Development of an updated, photo interpreted digital wetland layer for the St. Croix headwaters watershed using the most recent digital aerial imagery and the best available topographic data plus other collateral layers such as SSURGO soils, USGS DRG, and WI DNR vegetation mapping. Wetlands are classified using both the FGDC National Standard for Wetland Mapping Cowardin system and the Wisconsin Wetland Inventory system. Photo interpretation is augmented by thorough ground-truthing in order to correlate photo signatures with existing field conditions and accurately describe wetland type, quality and function.

2. Characterization of the functional values of all updated wetlands using the descriptors defined in Wetland Landscape Position, Landform, Water Flow Path, and Waterbody (LLWW) classification system. This will be based on Ralph Tiner's "Barebones LLWW" which has been adapted from "Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors" (Tiner, 2003).

In addition to the objectives defined above, a third objective for the project includes the performance of a wetland change comparison within the watershed by comparing current wetland boundaries to those delineated from the historical aerial imagery. The historical delineation is based on aerial photography from the 1948 and 1992 time eras. The requirement for this assessment is the product of stakeholder discussions during the completion of objectives one and two, and includes the western portion of the watershed.

Over the course of the project, the scope expanded to include not only classification and functional assessment of the present state of the wetlands, but also historical mapping, and a literature review of economic valuation as it applies to wetlands. A diagram showing the general flow of the project is shown below in Figure 2.

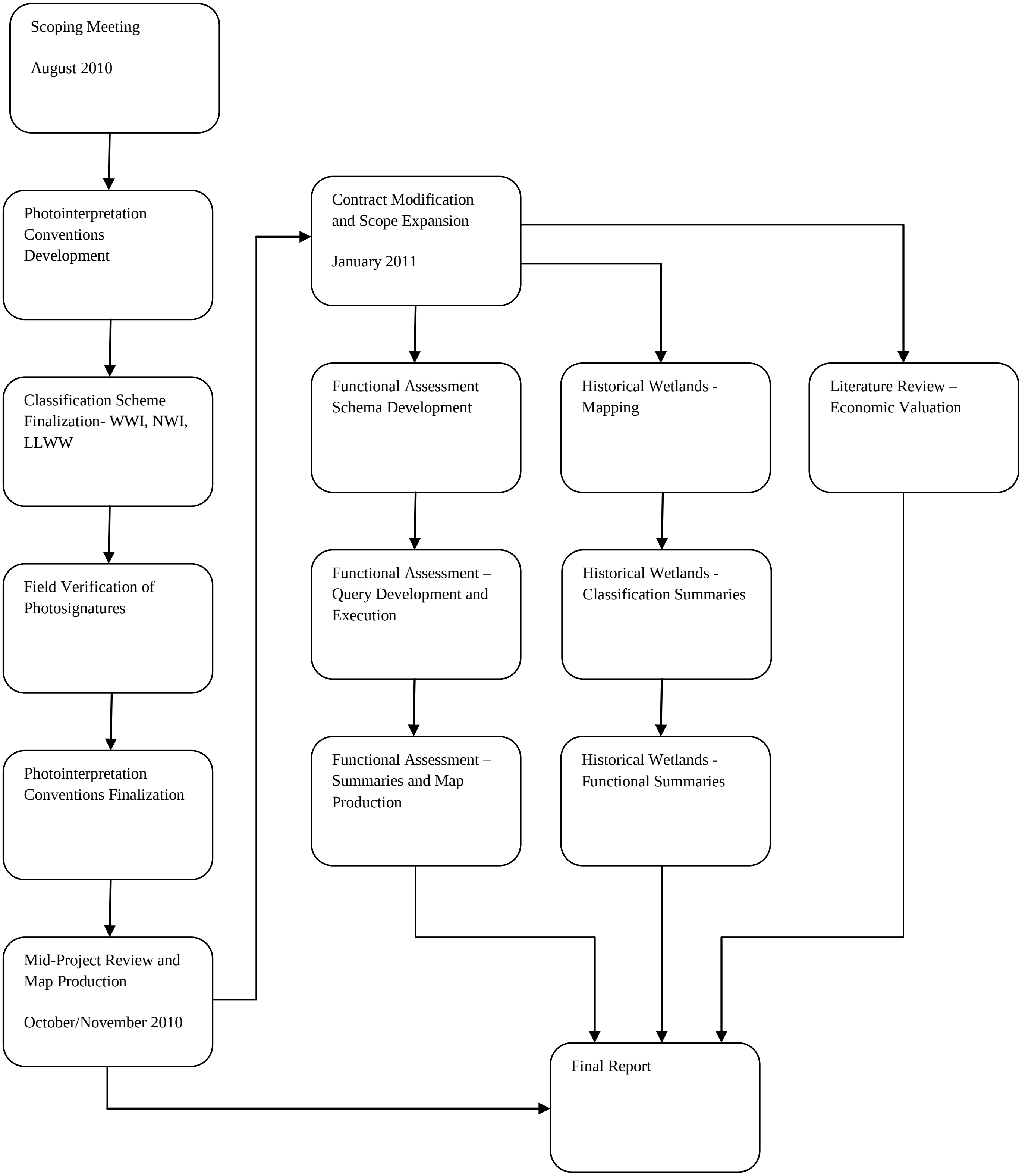


Figure 2. Saint Croix Headwaters Project Structure Diagram.

The project became very collaborative and dynamic in nature with input from multiple individuals and agencies at every stage. The primary stakeholders are the U.S. Army Corps of Engineers, Saint Paul District, and the Wisconsin Department of Natural Resources. Ralph Tiner of the U.S. Fish and Wildlife Service provided expertise on the LLWW classification system and functional assessment. Saint Mary's University of Minnesota, GeoSpatial Services coordinated the project and performed the work. The entire project team is listed below:

Elliott Stefanik – USACE, Biologist/Project Leader

Jason Berkner – USACE, Regulatory Branch

Ralph Tiner – USFWS, Regional Wetland Coordinator, Region 5

Pamela Toshner – WIDNR, Lake and River Management Coordinator

Tom Bernthal – WIDNR, Wetland Ecologist

Cherie Hagen – WIDNR, Wetland Team Leader

Steve LaValley – WIDNR, Water Regulation and Zoning Specialist

Alex Smith – WIDNR, Water Resource Specialist

John Anderson – SMUMN, Senior Image Interpreter

Andy Robertson – SMUMN, Project Manager

Wetland Classification Work Flow

GeoSpatial Services has developed a workflow for wetland updating and assessment projects that relies on a combination of fully digital wetland delineation and classification supported by field investigation to validate image signatures and assess wetland function. Building from this successful process, GSS utilized the following methodology for the St. Croix Headwaters project:

1. Assemble all available digital imagery and collateral GIS datasets for the project study area, located in Douglas and Bayfield counties in northwestern Wisconsin. These data include the most current digital orthophotography, individual scanned aerial photographs where available, Natural Resource Conservation Service (NRCS) SSURGO soils data, United States Geological Survey (USGS) digital topographic maps (DRG format), the best available digital elevation model (DEM), and surface hydrology (streams, lakes, rivers and watersheds) data.

2. Obtain the original WWI aerial photography and wetland delineations from the Wisconsin DNR. These images are used to assess original mapping conditions, provide reference stereographic coverage, and aid in signature confirmation for new imagery.

3. Obtain a wetland data checkout from the NWI Master Geodatabase covering the study area. This effectively locks the data from any other users and ensures that any updates submitted back to the USFWS will be in the correct format and projection.

4. Establish mapping conventions for on-screen delineation of wetland updates that are appropriate for the scale and accuracy of the new aerial imagery that is being used on the project. These specifications include: minimum mapping unit size, maximum on screen zoom scale for boundary delineation, maximum on-screen zoom scale for classification decisions, and determinations regarding the handling WWI classification updates (e.g. water regimes) that are no longer valid. GSS facilitated a meeting with the USACE, WIDNR and other project partners to define mapping conventions.

5. Perform on-screen delineations for a series of tests plots across the watershed. These plots were identified during meetings with USACE and Wisconsin DNR. Plots are approximately 5 square miles each, with a total of 10 plots evaluated. Plots may target known areas of sensitive or valuable wetland types. They may also target small wetlands, forested wetlands, or other wetland types often misidentified through aerial photo interpretation. On-screen delineations include a description of wetland features that is compatible with the National Wetland Inventory. GSS coordinated with USACE and WIDNR to determine the NWI Cowardin system is most appropriate and serves as the basis for the applying the WWI and LLWW classification systems.

6. Perform an on-site field review of study plots to validate actual wetland conditions identified from aerial photo signatures and other collateral data. Field review is performed in collaboration with USACE and Wisconsin DNR. USACE and WIDNR staff participated in all facets of the field site visits. Individuals from both USACE and WIDNR provided local expertise related to the SCHW.

7. Following field verification, USACE, WIDNR and GSS staff to review the verification results, and review the process, methodology and signatures utilized to identify wetlands from available georeferenced data.

8. Following approval of the methodology reviewed in step 7, update and classify wetlands across the project study area using the most current aerial imagery as the primary data source and consult collateral GIS data and field derived decision rules as necessary to assist in decision making.

9. Undertake LLWW classification on screen using collateral GIS data such as surface hydrology, DEM and DRG's to define wetland functional values. GSS collaborated with Ralph Tiner (USFWS) to assist with this classification process.

10. Wetland delineation and classification is reviewed for accuracy and line work quality.

11. Using the USFWS NWI Master Geodatabase Verification Tool and established NWI topology rules, the final wetland geodatabase integrity is validated.

12. Submit the final wetland update to the USACE and WIDNR for review and incorporate any changes that are identified.

13. Submit the final WWI update to the WIDNR for inclusion into the appropriate state database and to USFWS for crosswalk to NWI Cowardin classification and inclusion in the NWI Master Geodatabase.

14. Project management, oversight and staff supervision will be provided by the GSS Executive Director. Implementation and support for hardware, software and database technology will be provided by the GSS IT Coordinator.

From the beginning, this project has been a consultative, expert driven, collaborative effort that relied on the combined knowledge of many different members listed below. Saint Mary's University provided technical expertise in wetland delineation from aerial imagery as well as the knowledge of wetland biology and hydrogeomorphic characteristics required to apply wetland classification. University staff also facilitated and mediated project team meetings and provided procedural guidance for wetland functional assessment exercises. A series of meetings were conducted to guide the project from start to finish and these are summarized in this section.

Project Scoping – August 15, 2010

The first step was to define the scope of the project. This task was accomplished with USACE and WIDNR personnel in a meeting at the St. Paul District Headquarters, (Appendix A). A central outcome of the meeting was the establishment of the preferred locations of ten, five-square-mile sample plots to be completed as the first phase of the project.

This meeting also resulted in the development of generalized mapping parameters such as wetland types of particular interest (white cedar and wild rice) and classification of wetland functions. The schedule and planning for the initial field verification of photo-signatures was established. The group decided to conduct a mid-project review of sample plot draft maps in the field in consultation with the author of the LLWW System, Ralph Tiner.

Participants also determined that collateral data would be used to compensate for prolonged drought conditions. The St. Croix Headwaters Watershed area has experienced a prolonged drought, receiving below average precipitation for eight years prior to the date of image acquisition in 2009. As a result, open water ponds and shallow lake areas that are normally flooded were colonized by herbaceous and woody vegetation when imagery was acquired in 2009. To compensate for drought conditions, SMUMN photo-interpreters used the USGS digital topographic maps to determine the areas to be delineated in the updated database as open water in order to more accurately reflect the normal condition of these areas.

High priority areas were selected for more intensive ground-truthing and more detailed mapping than is typical for reconnaissance level wetland inventory projects. The Village of Solon Springs was thoroughly field checked. All wetlands visible in the field, regardless of size, were mapped as well as used as reference wetlands to identify, delineate, and classify, inaccessible wetlands within the limits of the village. As requested by stakeholders, intensified field verification was also conducted in the northwestern portion of the watershed (East Tom Green Road and the vicinity) in order to add previously unmapped wetlands. It was agreed that map product considerations, including discussion of wetland classification, minimum mapping unit (MMU), digitize scale, and classification scale would be finalized in subsequent discussions and during field verification activities.

Prior to the scoping meeting GeoSpatial Services (GSS) personnel assembled all available digital imagery and collateral geographic information system (GIS) datasets for the project study area. This data included the most current 2009 digital orthophotography acquired courtesy of Douglas and Bayfield Counties in enhanced compression wavelet (ECW) format. GSS also obtained hard-copy, black and white, aerial photographic stereo-pairs from the WIDNR. GSS downloaded SSURGO soils, topographic digital raster graphic (DRG) maps in TIFF format, National Hydrography Dataset (NHD), surface hydrology data (streams, lakes, rivers and watersheds), and existing WWI existing wetland data.

Development of Photointerpretation Conventions – August 18, 2010

Subsequent to the scoping meeting, a teleconference call discussion began to refine photointerpretation conventions. This discussion, during the meeting, included defining the scale at which photointerpretation would be conducted, and the use of collateral data to compensate for imagery taken during drought conditions. It was recognized that at this stage the conventions would be considered preliminary and the conventions would be finalized after completion of field work and review of interim draft maps generated from delineated sample plots.

A photointerpretation scale of 1:5,000 was determined to be optimal as it was close to the interpretative scale used by the WWI Program, and was achievable given the resolution of the primary project aerial imagery. WWI minimum mapping unit (MMU) and scale is due to the fact that the original source photography was "Section centered" and captured at a scale of 1:15,840. This scale provided for a practical photointerpretation scale of 1:5,280 when the original imagery was viewed and interpreted under three-power magnification of a stereoscope. The imagery available for the St. Croix Headwaters project is digital, twelve inch resolution. It was therefore practical to employ a mapping scale of 1:5,000 and an MMU of one-quarter acre for this project, as desired by the project team.

The initial project scope for the St. Croix Headwaters called for interpretation and classification of wetlands using the WWI system. However, it was recognized this system did not have sufficient differentiation of water regimes in order to support LLWW (NWI Plus) wetland functional analysis. As a result, there was considerable discussion centered on how to capture and classify wetlands and to provide both WWI and LLWW coding. Three potential solutions were proposed in order to incorporate detailed water regimes in the mapping exercise:

1. Each wetland polygon would be classified using both and NWI code and a WWI code in the attribute database and wetland delineation would be sufficient to map to the NWI water regime level. LLWW functional analysis codes would be added to the attribute database following delineation and classification. Project deliverables would include an NWI geodatabase and a WWI geodatabase. For the WWI geodatabase, internal boundaries in wetland polygons with the same adjacent WWI attributes would be dissolved.

2. Wetland polygons would be mapped and classified using only the WWI system, however, NWI detailed water regimes would be added to each polygon in order to facilitate LLWW functional analysis. In some cases internal divisions in WWI polygons would have to be added in order to accommodate water regime classification. The final geodatabase would include polygons with same adjacent attributes due to the addition of extra water regimes. Extra WWI regimes would include: Ka, Kb, and Kc while for NWI A, B and C, non standing water regimes and Hf, Hg, Hh

for F, G, and H, standing water regimes would be classified. LLWW functional analysis codes would be added to the attribute database following delineation and classification.

3. Wetland polygons would be mapped and classified using only the NWI system with the addition of WWI modifiers as required to capture features of the WWI classification that are not include in current NWI coding. LLWW functional analysis codes would be added to the attribute database following delineation and classification. This was the least preferential of the options as it precluded the delivery of a final product in WWI format.

Classification Scheme Finalization - September 8, 2010

After additional consultation via teleconference with agency personnel, it was decided that, the first option as listed above would be used, (Appendix B). It was agreed the Federal Geographic Data Committee (FGDC) NWI wetland classification system would be used to classify wetlands. The new NWI data would then be translated into the WWI system and LLWW System.

The NWI System was chosen for the initial classification of the wetland resource because the LLWW System was tailored to use NWI coding as base information from which wetland functions are developed. In addition, the NWI System has seven water regimes that are essential when assigning LLWW attributes. The WWI classification system has four water regime codes, making it impractical to assign existing WWI classifications.

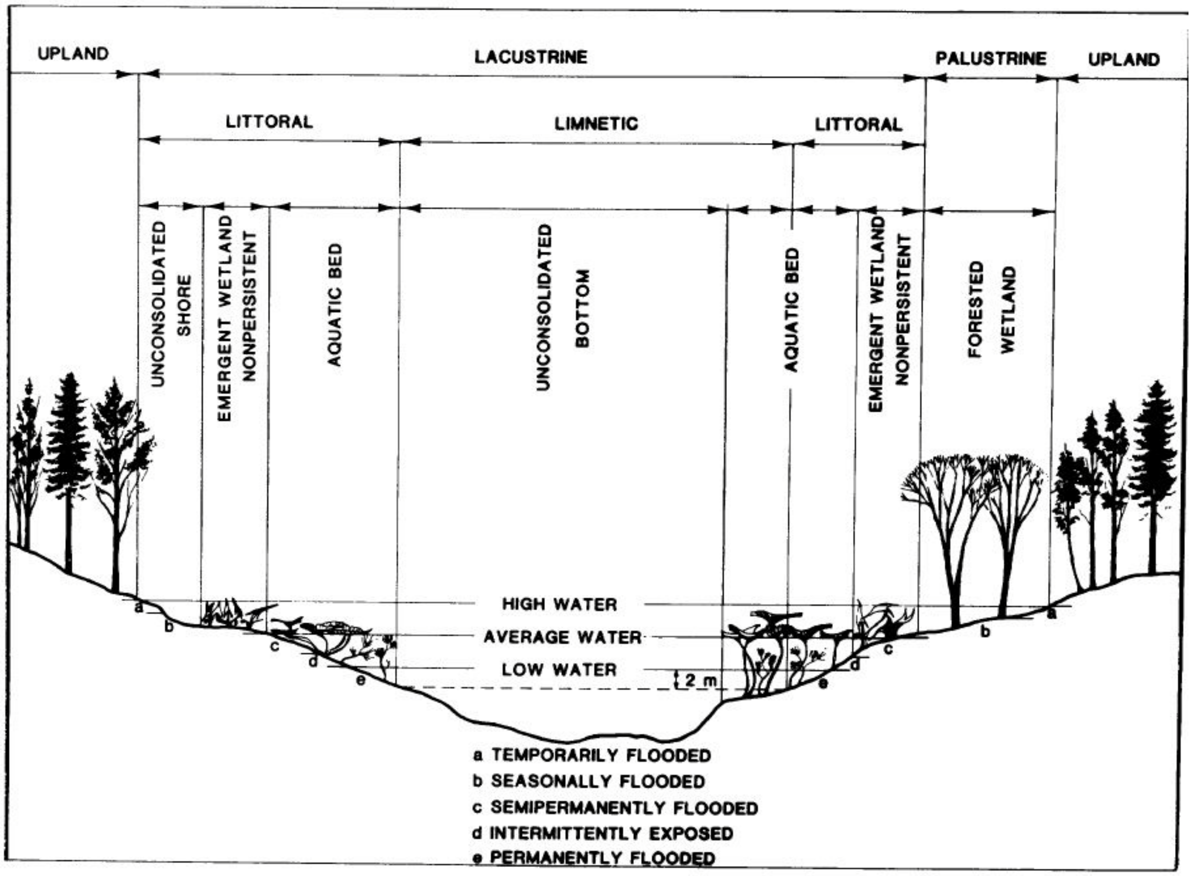


Figure 3. Cross Section of Wetland Habitat Types. Source: Cowardin, 1979.

The previous illustration (Figure 3), shows five different habitats. NWI classification guidelines provide more options for assigning water regime codes as compared to the WWI Classification System. Below is a cross reference table (Table 1) of NWI and WWI water regimes. The water regimes should be viewed as typical examples, not necessarily rules for applying specific water regimes to habitat types. It should be noted the lower case letters in Figure 3 do not refer to the actual water regime, but are merely a label within the graphic for illustrative purposes. The descriptions in Table 1 do however match the descriptions in Figure 3.

Table 1. NWI - WWI Water Regime Cross Reference

Habitat Type	NWI Water Regime		WWI Water Regime	
	Description	Code	Description	Code
Open Water	Permanently Flooded	*H*	Standing water, Lake	*L*
Deep Marsh	Semi-Permanently Flooded	*F*	Standing water, Palustrine	*H*
Shallow Marsh	Semi-Permanently Flooded	*F*	Standing water, Palustrine	*H*
Wet Meadow	Seasonally Flooded	*C*	Wet soil, Palustrine	*K*
Scrub/Shrub	Temporarily Flooded	*A*	Wet soil, Palustrine	*K*
Forested	Saturated	*B*	Wet soil, Palustrine	*K*

The U.S. Fish and Wildlife Service (USFWS) developed the LLWW System to use NWI data to predict wetland functions at the watershed level. LLWW Landscape attributes describe the relationship of wetland to water bodies (e.g. lentic, lotic, terrene). Landform attributes describe the physical shape of wetland (e.g. basin, flat, floodplain, fringe, island, slope). Water flow path attribute describe the type and direction if water movement within the wetland or water body (e.g. outflow, inflow, throughflow, isolated, bidirectional non-tidal). Water body attributes describe differing types of deep water habitats (e.g. lake, pond, river).

The LLWW System provides a convenient and consistent means of using NWI data to predict wetland functions for watersheds and other large geographic areas. LLWW classification metrics can be used to predict functions such as surface water detention, streamflow maintenance, nutrient transformation, sediment retention, carbon sequestration, shoreline stabilization, animal habitat, wildlife ecology, and conservation of biodiversity. Project stakeholders therefore decided to first classify wetlands using the NWI classification system in order to ultimately identify and inventory wetland functions for the watershed.

Field Verification of Photosignatures - September 13-17, 2010

As required, an on-site field review of the study area was conducted to validate actual wetland conditions identified from aerial photo signatures and other collateral data. Check sites were selected in-office by GSS personnel prior to the field trip. These sites were chosen based on the following criteria; commonly occurring signatures or habitats, unusual but important signatures, wetlands difficult to classify, signatures that were difficult to distinguish from upland, and locations to verify water regime classification. Another purpose of field verification was to reconcile specific signature issues related to the drought conditions present at the time of imagery acquisition.

Field review was performed in collaboration with USACE and WIDNR personnel. Agency personnel provided valuable input regarding current hydrological conditions versus normal circumstances as well as detailed information about soils and plant communities in the watershed area. GSS personnel communicated how the representative photosignatures would be used to inventory wetlands not visited in the field a Field Trip Summary Report, (Appendix C).

Higher densities of field check sites were visited within the boundaries of the test plots and the Village of Solon Springs. Figure 4 shows the locations of the check sites, and travel routes.

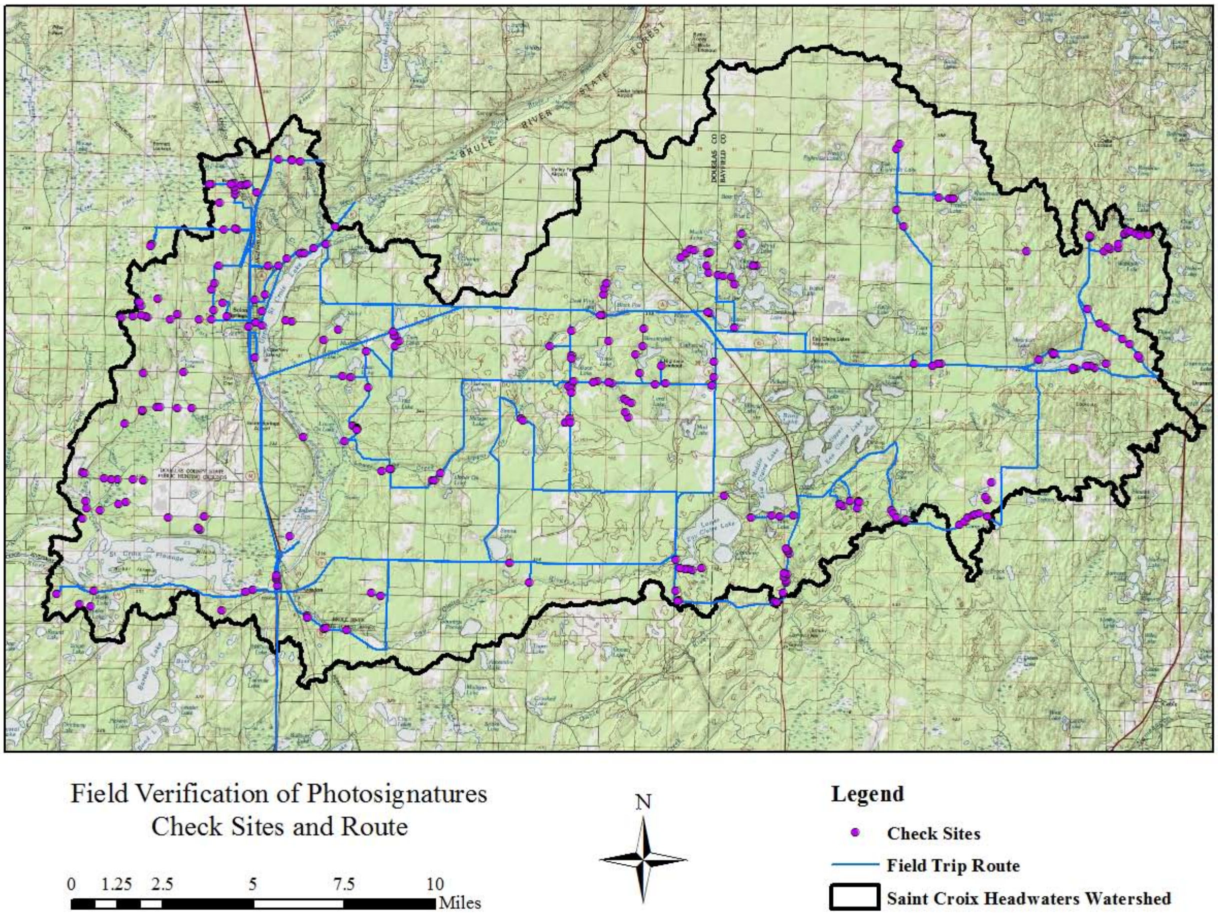


Figure 4. Field Work Check Sites and Travel Route.

An example of a site chosen specifically to establish the water regime is shown below in Figure 5. The field data notes are available in Appendix D. The field verification team agreed that the water regime under the FGDC/NWI System is" Seasonally Flooded/Saturated" ("C" Water Regime). The WWI System classification is "Wet soil, Palustrine" ("K" Water Regime). This site visit confirmed that this photosignature could reliably be classified as Seasonally Flooded Saturated and Wet Soil Palustrine throughout the project area.

A NWI Field Data Sheet was completed and ground level photos document photosignatures and field characteristics (Appendix E). The field team documented 84 check sites and an additional 200 locations were visited and noted on hard-copy field maps.

Figure 5. Field Check Site #115, located approximately ¾ of a mile south of the Gordon Dam. The road across the top is Hill Lane. The blue triangle marks the actual site location. The tan photosignature in the "butterfly" shaped feature indicates an NWI classification of *PEM1Cg* or a WWI classification of *E2K*.

Photointerpretation Conventions Development - September 20-24, 2010

Upon return from the field trip, the observation data was analyzed. The analysis results were then used by GSS personnel to develop a written "selective key' of photosignatures and corresponding wetland/upland communities. The key served as the basis for draft project photointerpretation conventions, (Appendix F and Appendix G). The draft photointerpretation conventions were then distributed to project stakeholders for final input and approval.

As agreed in the initial scoping meeting, open water areas as mapped by the United States Geological Survey (USGS) on their 7.5 minute quadrangle topographic maps would be classified as open water in the updated database, regardless of whether or not the imagery indicated open water. Where open water was present on the imagery and on USGS maps it was delineated and classified as either Standing water, Lake or Standing water, Palustrine. Those open water areas, as seen on the DRG or imagery, that were dominated by floating vegetation, as identified on summertime Google Earth imagery, were classified as "Aquatic bed, Rooted Floating, Standing water, Lake" or "Aquatic bed, Rooted Floating, Standing water, Palustrine". All wetland and deep water lake areas also were classified in the NWI classification system.

White cedar (*Thuja occidentalis*) and wild rice (*Zizania aquatica*) were identified by stakeholders as species of particular interest. A photosignature representative of white cedar dominated swamp was documented at a location approximately three-miles northeast of Solon Springs, less than one-half mile north of the intersection of Douglas County Roads A and P. White cedar appears similar to black spruce (*Picea mariana*) on true color imagery, therefore these signatures were difficult to identify for these areas that were not visited in the field.

Wild rice signatures were identified in the field along the St. Croix River at Cut-Away-Drive trail crossing and Lower Ox Lake public access landing. This signature was also identified along the course of the Saint Croix River and in the southern extremity of Lake Saint Croix. Google Earth, late summer imagery, WI DNR wild rice vegetation maps and USGS topographic maps were of assistance in refining boundaries of this wetland type.

NWI water regime codes describe, in general terms, the duration and timing of surface water inundation and soil saturation. Generally, organic soils retain moisture in the soil profile for longer periods than do mineral soils. The field verification team therefore decided to incorporate these modifiers into the classification scheme of the project. Special modifier codes for soil type were applied to the NWI database, only. Soil modifiers incorporated into the coding were the organic soil modifier (*g*) and the mineral soil modifier (*m*). The team conducting field verification recognized that these modifiers would help map users more fully understand duration and frequency of flooding and/or soil saturation.

Sample Plot Delineation and Classification - September 25, 2010 to October 22, 2010

With consensus on the photointerpretation conventions, GSS proceeded to delineate and classify ten sample plots. Work was performed using an on-screen digitizing approach in the ESRI ArcGIS 9.3 environment. Polygons were developed by using the “Cut Polygon Features” tool to divide the overall watershed polygon into wetland polygon features. Wetlands were initially classified to the NWI standard before they were classified in the WWI and LLWW Systems.

Where possible a query and classify approach was used to classify features to the WWI and LLWW standards. This approach first selects a group of polygons based on their NWI code and then the field calculator is used to populate the WWI and LLWW classifications of the selected data. This system only works where there is a specific one-to-one relationship between the NWI and the associated code in WWI or LLWW. This approach works especially well for the deepwater habitats classified in NWI. However, in most cases individual analysis of each wetland polygon was required.

To help ensure delineation and classification accuracy, hard copy black and white stereo pairs of the original WWI data were regularly referenced using a mirror stereoscope. Viewing in stereo made it possible to resolve questions about plant life-form, water regimes, or the presence of wetland drainage patterns that on-screen examination would not allow. Stereo-pairs were available in the western part of the study area only. Five different eras of Google Earth imagery were also consulted where needed. The five eras were 1992, 1998, 2005, 2008, and 2010. The two earliest years were black and white, and the latter three were true color. Google Earth “Street View” and fly-through features were also used where appropriate.

SSURGO soils data was symbolized to display where only poorly and very poorly drained soil were present. The two drainage classes were differentiated using distinct colors. Marsh and swamp symbols represented in the USGS topographic data corroborated the presence of wetland within the project area.

Field documentation and ground-level photos were relied upon to insure correct classification by comparing the signatures at check site locations with those signatures in areas that were not visited. The first-hand experience acquired through the field visits proved invaluable in establishing confidence in the photosignatures and assigning classification codes.

Mid-Project Review and Final Map Production – October 26-27, 2010

A mid-project review of NWI, WWI and LLWW classifications for the ten sample plots was conducted at the WIDNR Northern Region Headquarters in Spooner, Wisconsin. The meeting provided the project team with an opportunity to review the interim draft map with feedback from Ralph Tiner, USFWS, the author of the LLWW System (Appendix G).

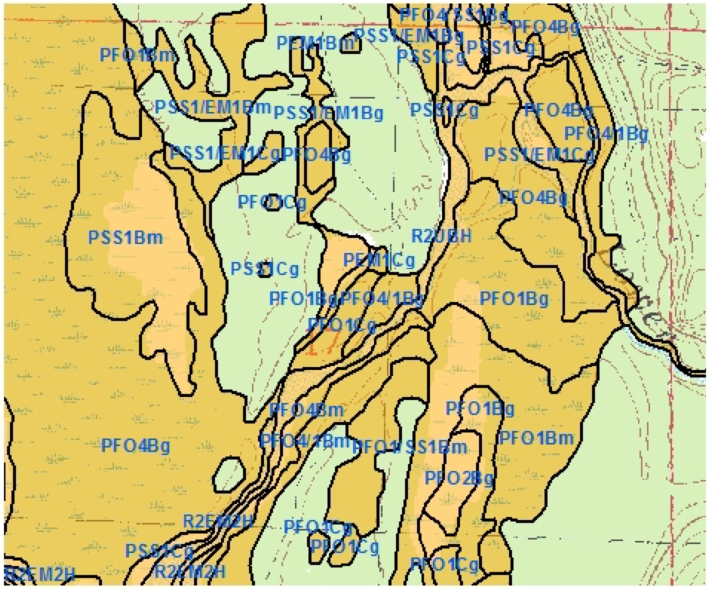
During the meeting, Tiner provided a detailed over view of the LLWW System, in a conference room setting. . He emphasized that the LLWW System is to be used at the landscape level only, but that it also may be further refined to correlate wetland functions (e.g. surface water detention) with LLWW classifications. The group then adjourned to the field for assessment of classified wetlands in order to address such items as: photo signature validation, hydrologic connectivity issues related to culverts and roadside ditches, differentiation of isolated and outflow wetlands, confirmation of soil characteristics, and assessment of water regimes under normal precipitation conditions.

Field review established that GSS was on track with expectations for spatial resolution and classification accuracy. As a result, mapping continued until completion on December 17th, 2010. Quality assurance measures were then implemented to identify and correct any errors of omission or commission. This included the deletion of river channel polygons and open water abutting non-wetland from the WWI database, to conform to WWI mapping standards. Upland areas classified as “ROAD” (WWI System) were merged with abutting non-wetland or classified as non-wetland in the NWI database.

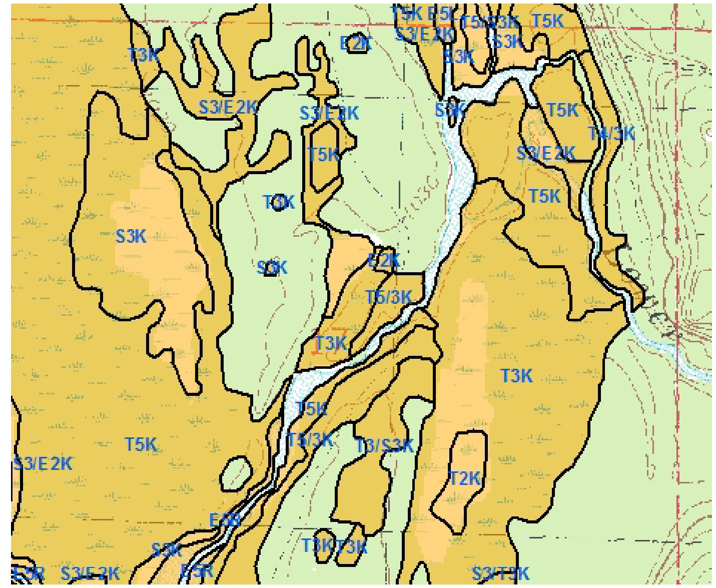
Further quality assurance included removal or, where appropriate, attribution of NULL geometry. Polygons smaller than the MMU were merged with adjacent polygons. The digitized geometry was scanned for neatness and correct signature to attribute correlation. The data was also examined for erroneous classification attributes such as typographic errors. Topology was used to check for gaps and overlaps in the data. After all errors were resolved, the geodatabase was compacted.

The final geodatabase was validated using the NWI Master Geodatabase Verification Tool and established NWI topology rules. The base data was dissolved by NWI, WWI, and LLWW to form three different feature layers (Figure 6).

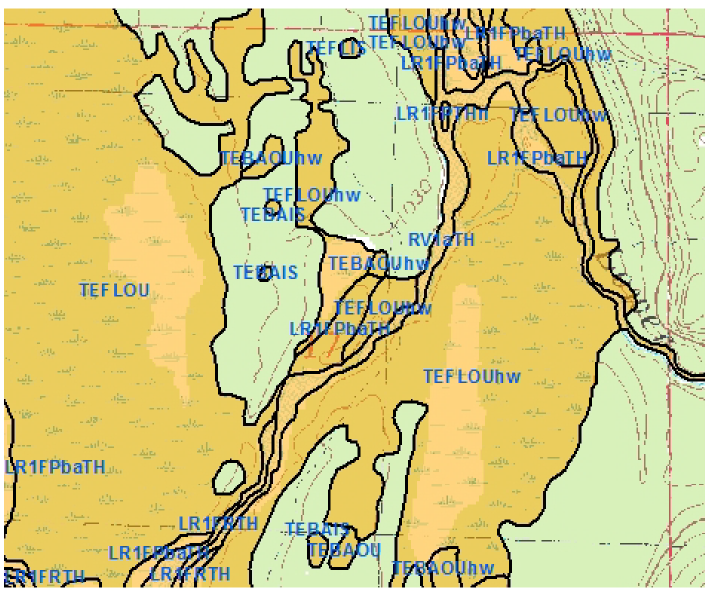
As illustrated in Figure 6 wetland landscapes classified in the NWI System will most often result in a greater number of polygons than the same areas classified in the WWI System. Multiple NWI codes will, when translated to the WWI System, result in classifying adjacent polygons with the same code. Adjacent polygons with identical attributes are then merged.



NWI



WWI



LLWW

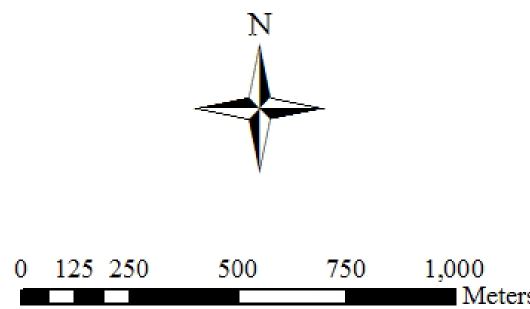


Figure 6. Example illustrating the differences between the three classification systems. Upper left is NWI, upper right is WWI, and lower left is LLWW. All three graphcs are of the same area. The orange shade with the black outline are the wetlands. Each wetland is labeled in dark blue with it's respective code. Background data is the USGS 7.5 minute topographic map.

LLWW databases also will be less complex than NWI databases because adjacent NWI classifications that are classified differently (PSS1C versus PEM1C, for example) are classified the same in the LLWW. After development of the three databases they were then submitted to the USACE and WIDNR for review on January 19, 2011.

Contract Modification and Project Scope Expansion - January 2011

GeoSpatial Services met with the steering committee on October 13, 2010. Due to an initial expression of interest from project stakeholders and further discussions in early 2011, the decision was made to expand the project's scope. Additions to the project included the following three areas:

1. Development of an assessment schema that correlates wetland types and LLWW classes to a variety of key wetland functions and values (goods and services). This item involved a variety of members of the Wisconsin DNR Bureau of Watershed Management and the U.S. Army Corps of Engineers (USACE) St. Paul District participating in meetings facilitated by GSS staff, Tom Dahl and Ralph Tiner of the U.S. Fish and Wildlife Service. The goal of these meetings was to define priority wetland goods and services for the study area and then correlate NWI/WWI wetland types and LLWW functional classes to those goods and services. A secondary product from this item is a series coded maps that display wetland location shaded by primary function(s) for the Saint Croix Headwaters study area.

2. Preparation of a literature review that assesses the current state of scientific knowledge regarding the economic valuation of priority wetland functions (e.g. flood attenuation, water quality etc.). This literature review focuses on techniques that are appropriate for assessing wetlands in non-urban environments in an effort to develop recommendations that are appropriate for a primarily rural/natural landscape such as the St. Croix Headwaters. The product from this review is a report, available in Appendix I, summarizing a variety of techniques that can be applied to the valuation of wetlands in the St. Croix Headwaters. The techniques presented are based on the spatial and functional wetland data generated through the mapping process.

3. Delineation and classification of historical wetland boundaries for the portion of the project study area in Douglas County. This pilot project focuses on the western portion of the study area bounded on the north, south and west by the watershed boundary and on the east by a line running from north to south parallel to the eastern shore of Lake St. Croix (see Figure 7). Wetland delineation is based on historical aerial photography from two time periods; 1948 and 1992. 1948 was chosen because it is the first year quality aerial photography was available and it provides a good baseline for analysis. 1992 was chosen because it is just prior to the implementation of significant wetland regulation in Wisconsin. All of the mapping utilizes the NWI/WWI classification scheme developed in the first phase of this project. The purpose of developing this data is to create an historic record of wetland boundaries that can serve as a base line for future investigations to identify changes related to both natural succession (i.e. change in wetland type), anthropogenic influence (i.e. conversion, gain or loss) and implementation of wetland regulations.

Functional Assessment Schema Development

One of the goals for this project was development of a protocol for correlating NWI and LLWW classification codes with the ecological functions a wetland performs. With this in mind, the first step was defining the primary functions performed by wetlands in the Saint Croix Headwaters watershed. After the functions were determined, NWI and LLWW codes could be used to identify the wetlands performing each function, and to what degree, whether high or moderate a wetland might perform the function. The level at which a wetland performs a function is often determined by some of the more specific modifiers such as those specifying soil type or water chemistry. Palustrine emergent, seasonally flooded wetlands (*PEMC*) as applied to carbon sequestration are a good example. In this case, wetlands with organic soils (*PEMCg*) function highly while those with mineral soils (*PEMCm*) function moderately. Almost all wetlands are performing multiple functions. As an example, lacustrine littoral aquatic beds (*L2AB*) perform, among other functions, both carbon sequestration and sediment retention. Tables 5 through 15 in the Results sections contain a comprehensive listing of the specific NWI and LLWW codes and conditions that determine wetland function.

Economic Valuation of Wetlands

Given the fiscal restraints imposed on local, regional, and state government, policy makers like to fully understand the economic impacts of their decisions. In the case of wetlands which often have indirect and intrinsic value, determining economic value can be a challenging exercise. A literature review on the current state of wetland economics was conducted as part of this project. The literature review is included in Appendix I. Most economic valuation methods are based on the functions a wetland performs.

Historical Wetlands Boundaries

The western portion of the study area was mapped to two additional time periods of photography, 1948 and 1992. Only the portion outlined in purple in Figure 6 was mapped due to limited image availability and budget constraints. For this mapping work, the 2009 data was used as a baseline. Boundaries were delineated for each time step based on the imagery from that era. All wetlands were classified to NWI, WWI, and LLWW standards. A basic summary of wetland change was performed comparing the three time periods of data. The data could be used to carry out more in depth studies of temporal change in the watershed. Time and resource constraints limited the amount of change analysis that could be performed for this project.

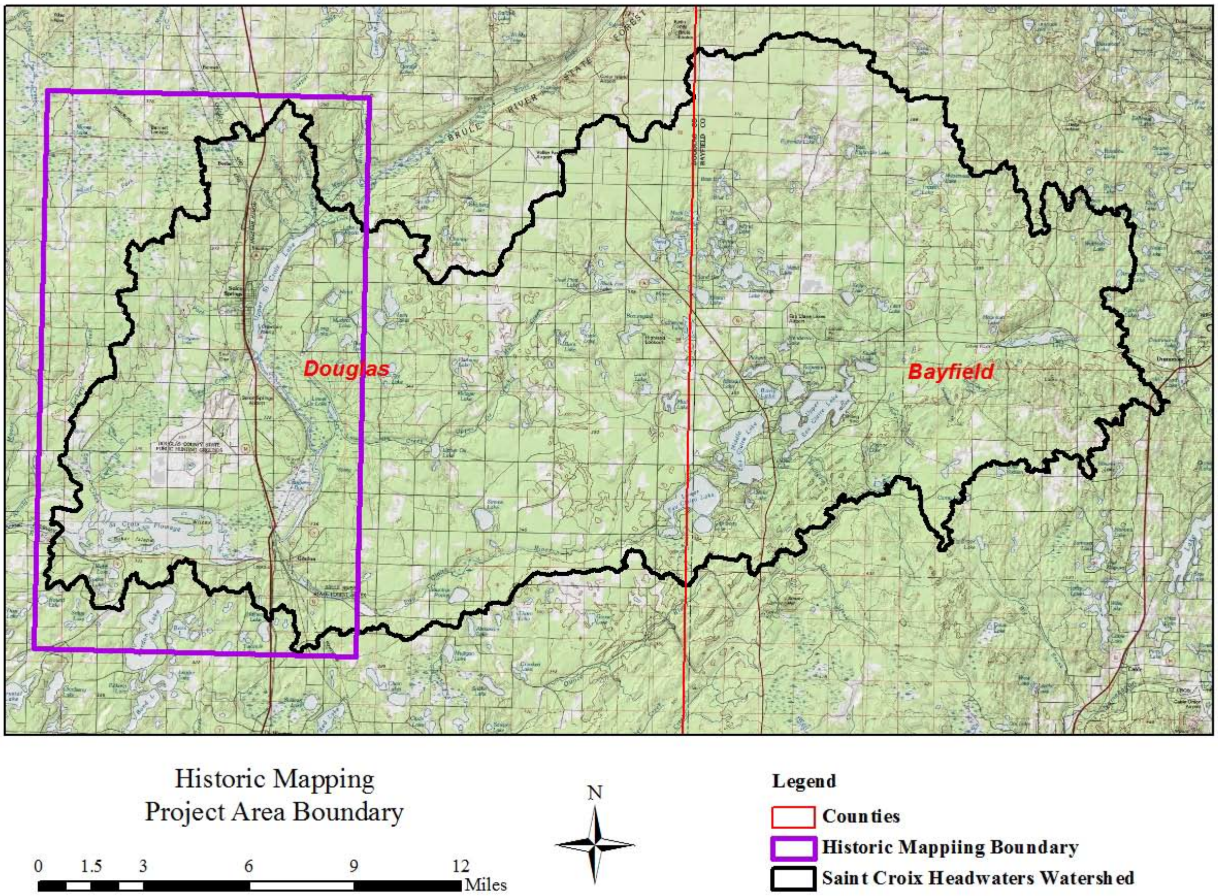


Figure 7. Historic Wetland Mapping Project Boundary. The wetlands within the area outlined in orange were mapped using imagery from three eras, 1948, 1992, and 2009.

Results

The main purpose of this project is to describe the existing state of wetland resources within the Saint Croix Headwaters Watershed. Mapping, and determination of wetland function through classification are at the core of this effort, but a deeper understanding of wetland type and extent can be attained through a view of the summaries included below. As part of this project the wetland data is summarized by selected parameters of each of the classification systems and wetland function. Acreages were determined from the geospatial data. Using percentages, these acreages were compared to acreage of the entire watershed and to the total wetland within the watershed. The end result is an overview of wetland types and functions present within the watershed. Using a similar approach wetland function summaries are performed on the 1948 and 1992 data. The 1948 and 1992 data were then compared to the 2009 data for the same area in the western portion of the watershed. This summary went a step further to calculate the changes in acreage of wetland performing specific functions.

The tables in the following sections contain the summary of the data for each classification system and for wetland function. The summaries list the acreages classified with the listed parameter. In cases where there are dual attributes the dominant attribute was used for the summary. In all cases with NWI, LLWW, and WWI all features can have only discrete classifications that are mutually exclusive of each other. For example, in LLWW if a feature is classified as terrene (**TE**) it cannot also be classified as lentic (**LE**). This is not the case with wetland functions because most wetland features perform multiple functions. There are also some subtle differences between the WWI and NWI classification systems affecting the summaries that will be explained in the following sections. Figure 8 shows the locations of both WWI and NWI wetlands in the watershed.

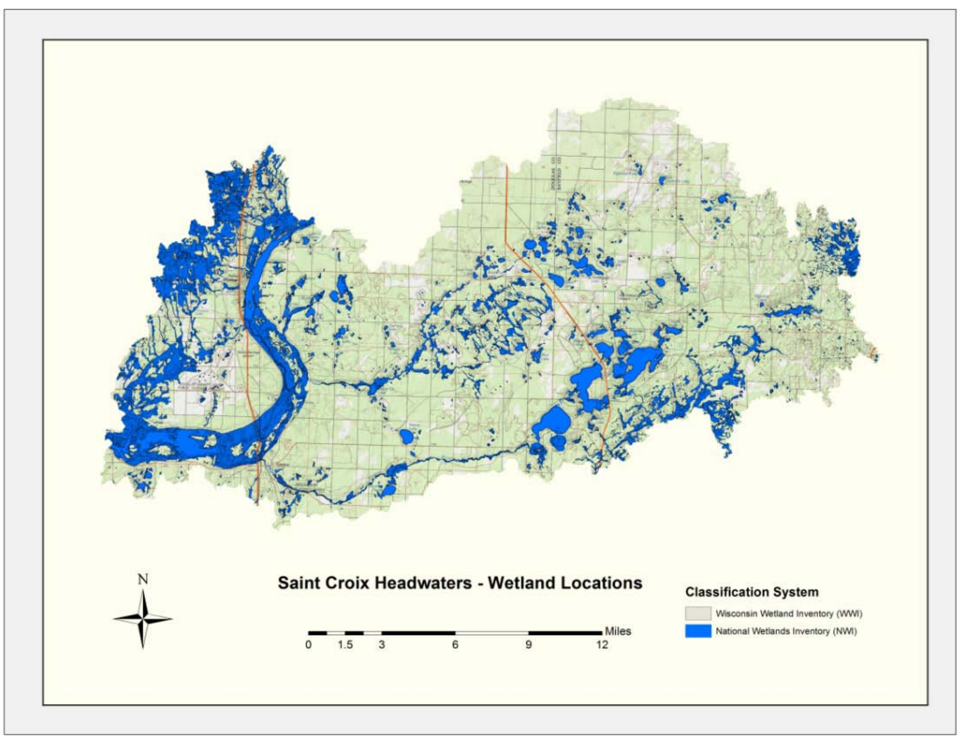


Figure 8. Saint Croix Headwaters – WWI and NWI Wetland Locations.

Wisconsin Wetland Inventory

Wisconsin Wetland Inventory contains the least number of classifications and therefore has the smallest summary table. The summary of the WWI data is presented in Table 2. Unlike NWI, WWI does not include deep water habitats as part of it classification system. Therefore, if Table 2 is compared to the other summary tables, which are all based on the NWI classification system, there are approximately 7,000 fewer acres of wetland in the WWI table. These acres are accounted for in the Non-Wetland category. Deep water lake (DW) is listed as a WWI class although it technically is not included in the WWI. The reader should note that the acreage for DW is included as non-wetland. Therefore percentage of total wetlands is not calculated for the Deep Water (DW) class.

Not surprisingly, most of the wetland in the watershed is classified as forested or scrub-shrub, at 54.4 % and 18% respectively. These two classes account for almost 75% of the wetlands in the watershed. Emergent wetlands make up most of the remaining area at 14.4% of total wetland. These numbers are a little misleading. If deep water were included as wetland, forested drops to 44% of wetland, scrub-shrub to 14% and emergent to 11.8%. Deep water lake areas with depths greater than six feet account for 3.1% of the entire area of the watershed, uplands included. If deep water is included as wetland it would account for 17.7% of the wetland area in the watershed.

In terms of hydrologic modifier, the wet soil, palustrine (K) classification accounts for the majority of the wetland area at 83.6%. This is not surprising since this is typically the hydrologic modifier associated with forested, scrub-shrub, and emergent wetlands.

Table 2. WWI Summary Table.

Wisconsin Wetland Inventory (WWI) - 2009 Wetlands Acreage Summary Saint Croix Headwaters Watershed				
	Summary Parameter Saint Croix Headwaters Watershed	Acreage	% of Watershed Acreage	% of Total Wetland Acreage in Watershed
General				
	Total Area of Watershed	215,508.3	--	--
	Non-Wetland	184,699.1	85.7%	--
	Wetland	30,808.9	14.3%	--
WWI Class				
A	Aquatic Bed	688.0	0.3%	2.2%
E	Emergent / wet meadow	4,434.4	2.1%	14.4%
S	Scrub / shrub	5,540.4	2.6%	18.0%
T	Forested	16,760.4	7.8%	54.4%
F	Flats / unvegetated wet soil	60.3	0.0%	0.2%
W	Open water	3,325.3	1.5%	10.8%
DW	Deep water	6,650.0	3.1%	--
WWI Hydrologic Modifier				
K	Wet soil, palustrine	25,760.1	12.0%	83.6%
H	Standing water, palustrine	1,788.1	0.8%	5.8%
L	Standing water, lake	3,142.6	1.5%	10.2%
R	Flowing water, river	118.1	0.1%	0.4%

National Wetlands Inventory

Table 3 is the summary table for the NWI classification. In the NWI classification system, deep water habitats are included in the classification. These deep water habitats account for approximately 7,000 acres that were not included as wetland by WWI. Wetlands and deep water habitats comprise 17.5 % of the land area of the watershed. Palustrine systems account for almost three-fourths (72.8%) of the wetland area, lacustrine systems make up approximately a fourth (26.1%), and riverine systems make up the balance at only 1.1% of the wetlands. NWI classes follow the same proportions as their WWI counterparts. The total wetland area consists of 72.6% vegetated wetlands and 27.4% non-vegetated wetlands. Of the non-vegetated, the vast majority is unconsolidated bottom (27.2%). This indicates that there is very little wetland area within the watershed that is neither vegetated nor covered by surface water. It should be noted that in the table the NWI System and NWI Class sections should not be expected to sum to 100%. This is due to the fact that some entries in the table are not mutually exclusive of each other. For example, in the NWI System section of the table, the Lacustrine, Combined entry is made up of both the L1 and L2 systems which are also listed. Similarly, the NWI Class section of the table includes entries for non-vegetated and vegetated. The non-vegetated entry is the combined area of the unconsolidated bottom and unconsolidated shore classes, while the vegetated combined entry is the combined area of all of the vegetated classes (AB, EM, FO, SS).

In terms of water regime, the most abundant is the saturated *(B)* water regime with 47.1% of the wetlands classified as such. This is consistent with the majority of wetlands being classified as forested, scrub-shrub, or emergent. The second most abundant is the permanently flooded *(H)* water regime at 26.6%. This is reasonable given the percentage of wetland classified as lacustrine. There are only 14 acres of artificially flooded *(K)* water regime, which is applied to a few retention ponds along the highway.

Of special note for this project are bogs, which are classified with organic soils and either acidic or circumneutral water chemistry *(###ag, ###tg)*. Wetlands classified as bogs account for 10.8% of the total wetland area with the watershed, and 1.9% of the entire area of the watershed.

Species of particular interest are Northern white cedar *(Thija occidentalis)* and wild rice *(Ziziana aquatic)*.   Wild rice *(Ziziana aquatic)* is designated by the non-persistent emergent classification *(#EM2#)* and only covers 165.8 acres within the watershed constituting 0.4% of the wetland area. Similarly, Northern white cedar *(Thija occidentalis),* which is designated *PFO3Btg,* only covers 326 acres or 0.9% of the wetland area in the watershed.

Table 3. NWI Summary Table (page 1 of 2).

National Wetland Inventory (NWI) - 2009 Wetlands Acreage Summary Saint Croix Headwaters Watershed				
	Summary Parameter Saint Croix Headwaters Watershed	Acreage	% of Watershed Acreage	% of Total Wetland Acreage in Watershed
General				
	Total Area of Watershed	215,508.3	--	--
	Upland	177,718.5	82.5%	--
	Wetland	37,789.8	17.5%	--
NWI System				
P	Palustrine	27,496.4	12.8%	72.8%
L	Lacustrine, Combined	9,875.3	4.6%	26.1%
L1	Lacustrine, Limnetic	6,638.5	3.1%	17.6%
L2	Lacustrine, Littoral	3,236.8	1.5%	8.6%
R2	Riverine, Lower Perrenial	417.0	0.2%	1.1%
NWI Class				
AB	Aquatic Bed	706.2	0.3%	1.9%
EM	Emergent	4,425.9	2.1%	11.7%
SS	Scrub / Shrub	5,552.0	2.6%	14.7%
FO	Forested	16,769.7	7.8%	44.4%
UB	Unconsolidated Bottom	10,286.7	4.8%	27.2%
US	Unconsolidated Shore	60.3	0.0%	0.2%
	vegetated (AB,EM,SS,FO comb.)	27,442.7	12.7%	72.6%
	non-vegetated (UB, US)	10,347.0	4.8%	27.4%
NWI Water Regime				
B	Saturated	17,810.7	8.3%	47.1%
A	Temporarily Flooded	280.4	0.1%	0.7%
C	Seasonally Flooded	7,667.4	3.6%	20.3%
F	Semi-permanently Flooded	883.7	0.4%	2.3%
G	Intermittently Exposed	1,095.4	0.5%	2.9%
H	Permanently Flooded	10,038.2	4.7%	26.6%
K	Artificially Flooded	14.0	0.0%	0.0%

Table 3. NWI Summary Table (page 2 of 2).

National Wetland Inventory (NWI) - 2009 Wetlands Acreage Summary (cont.) Saint Croix Headwaters Watershed				
Summary Parameter Saint Croix Headwaters Watershed		Acreage	% of Watershed Acreage	% of Total Wetland Acreage in Watershed
NWI Modifiers				
x + h	Excavated, Impounded	7,015.0	3.3%	18.6%
f	Farmed	234.5	0.1%	0.6%
b	Beaver	1,193.3	0.6%	3.2%
g	Organic Soils	17,346.4	8.0%	45.9%
m	Mineral Soils	6,267.4	2.9%	16.6%
ag + tg	Bogs	4,070.8	1.9%	10.8%
NWI Species Specific				
EM2	Wild Rice (*Zizania aquatic*)	165.8	0.1%	0.4%
PFO3Btg	Nor. W. Cedar (*Thija occidentalis*)	326.6	0.2%	0.9%

Landscape Position, Landform, Water Flow Path, Water Body Type (LLWW)

The summary for the LLWW data is presented in Table 4. Terrene is the most common landscape position at 52.0% of the wetland are in the watershed. Not surprisingly given the number of lakes in the watershed, lentic landscape position is the second most abundant at 17.0% of the wetland area in the watershed. Lake is the most common water body type. In terms of LLWW landform, flat (**FL**) was the most common classification at 39.1% with basin (**BA**) the second most abundant at 18.5%. This is reasonable given the area's history of glaciations. Outflow (**OU**) was the most common water flow path with 45.8% of the wetland area classified as such. The headwater modifier (**hw**) was applied to 40.9% of the wetland area. The abundance of outflow and headwater classifications is reasonable considering this watershed is the origin of much of the water for the Saint Croix River. It is important to note linear features were not mapped as part of this project, therefore there are no features to classify as streams. Again, the table sections should not be expected to sum to 100%. Vegetated wetlands are classified with Landscape position while open water wetlands are classified with Waterbody Type and they are mutually exclusive of each other. Also, waterbodies do not receive a landform classification.

Table 4. LLWW Summary Table (page 1 of 2).

Landscape Position, Landform, Water Flow Path, Water Body Type(LLWW) - 2009 Wetlands Acreage Summary Saint Croix Headwaters Watershed				
Summary Parameter Saint Croix Headwaters Watershed		Acreage	% of Watershed Acreage	% of Total Wetland Acreage in Watershed
General				
	Total Area of Watershed	215,508.3	--	--
	Upland	177,718.5	82.5%	--
	Wetland	37,789.8	17.5%	--
LLWW Landscape Position				
LE	Lentic	6,406.0	3.0%	17.0%
LR	Lotic River	1,081.1	0.5%	2.9%
LS	Lotic Stream	2,943.2	1.4%	7.8%
TE	Terrene	19,637.3	9.1%	52.0%
LLWW Water Body Type				
LK	Lake	6,638.7	3.1%	17.6%
PD	Pond	783.5	0.4%	2.1%
RV	River	299.9	0.1%	0.8%
ST	Stream (*linears not mapped)	0.0	0.0%	0.0%
LLWW Landform				
BA	Basin	6,973.6	3.2%	18.5%
FL	Flat	14,775.6	6.9%	39.1%
FP	Floodplain	945.2	0.4%	2.5%
FR	Fringe	4,396.6	2.0%	11.6%
SL	Sloped	3,320.5	1.5%	8.8%
LLWW Water Flow Path				
BI	Bidirectional - nontidal	5,716.3	2.7%	15.1%
IN	Inflow	3,047.8	1.4%	8.1%
IS	Isolated	3,086.8	1.4%	8.2%
OU	Outflow	17,293.2	8.0%	45.8%
TH	Throughflow	8,410.0	3.9%	22.3%

Table 4. LLWW Summary Table (page 2 of 2).

Landscape Position, Landform, Water Flow Path, Water Body Type(LLWW) - 2009 Wetlands Acreage Summary (cont.) Saint Croix Headwaters Watershed				
Summary Parameter Saint Croix Headwaters Watershed		Acreage	% of Watershed Acreage	% of Total Wetland Acreage in Watershed
LLWW Modifiers				
cr	Cranberry Bog	231.2	0.1%	0.6%
hw	Headwater	15,464.2	7.2%	40.9%
pd	Pond	1,271.2	0.6%	3.4%

NWI, LLWW, and Expert Input - Functional Classification Development

There are natural chemical and physical processes that occur in the wetland environment which contribute to the overall function of the ecosystems. Wetland functions are the specific goods and services provided by wetlands in the ecosystem based on the conditions and processes that are present. Since wetlands can perform more than one function and some are better able to provide one function than others wetlands can be classified as highly or moderately performing a given function.

As indicated above, the Cowardin System is applied in NWI mapping projects to provide general baseline information about surface hydrology, plant communities, water chemistry, soils, and human impacts and wildlife influences on wetland hydrology and hydrophytic plant communities. Selection of Cowardin System coding attributes specific to the Saint Croix Headwaters Watershed area during the mapping process allowed for correlations with LLWW hydrogeomorphic metrics to be made during the initial phase of the project. The final analysis of these combined coding systems results in a classification of wetland functions. Since the Cowardin System and the LLWW System are complimentary, classification of functions could result from queries of NWI codes alone, LLWW codes alone, a combination of NWI and LLWW codes, and/or spatial constraints such as adjacency or physical size. The designations of which metrics (e.g., NWI, LLWW, spatial) best represent a given function are, as is the case of the Saint Croix Headwaters Watershed project, typically developed by a team of experts familiar with wetland science and local conditions.

Below are two examples which describe how NWI and LLWW coding are integrated to arrive at wetland functionality. The next section contains the entire list of functions for the SCHW with the criteria describing the classifications that provide each function.

Surface Water Detention (SWD)

The types of wetlands that are highly functional for surface water detention are those that are adjacent to rivers, lakes, streams, ponds or otherwise have through-flow surface hydrology or are lakes or river (streams were not mapped). Those that are determined to be moderately functional are those that are through-flow flats adjacent to rivers, lakes or streams and isolated basin wetlands.

Because water bodies and wetlands are first classified in the Cowardin System it is apparent which wetlands are adjacent to Lacustrine and Riverine water bodies, and therefore they are classified as Lentic or Lotic wetlands. Also NWI Water Regime categories added value by allowing analysts to determine LLWW Landforms of Flat, Basin and Fringe. Wetlands with a Saturated Water Regimes are classified as Flats, Seasonally Flooded Water Regime are LLWW “Basin” wetlands with a Semipermanently Flooded Water Regime are LLWW “Fringe” wetlands and are classified as highly functional for SWD as these landforms are adjacent to Lentic or Lotic Waterbodies. Flats are equivalent to the Saturated Water Regime, when located in low gradient areas. Flats and Ponds with through-flow hydrology adjacent to LLWW Stream Waterbodies are classified as highly functional. LLWW Waterbodies classified as “natural lake”, dammed river valley lake”, “other dammed lake” and “River” are classified as highly functional for SWD. Flats adjacent to “dammed river valley lake” and “other dammed lake” are also ranked high.

Wetlands that rated as “Moderately Functional” for SWD are wetland Flats (Temporarily Flooded or Saturated Water Regimes) adjacent to Lacustrine/Lentic Waterbodies that are classified as “natural lake”. Other Moderately Functional wetlands are those with “Isolated”, “Outflow” or “Inflow” surface hydrology as classified in the LLWW System.

Surface Water Maintenance (SWM)

Analysis by the project team determined that wetlands located in the upper reaches of the watershed, wetlands adjacent to water bodies and wetlands with highly absorbent soil are highly functional for maintaining adequate surface water in rivers, lakes and streams. Wetlands classified as headwater, because they are located adjacent to First and Second Order Streams are classified as highly functional. Many streams visible on aerial photography, but not represented on USGS digital raster graphs (topographic maps) or in the National Hydrography Dataset (NHD) database were identified during the photointerpretation process. These features are classified and therefore contributed to accurately including all headwaters wetlands that are highly functional for SWM.

Experts also determined that water bodies that are classified as Lacustrine/Lentic and Riverine/Lotic, or are adjacent to these water bodies that have; Saturated Water Regimes/ Wetlands on Flats and Slopes, have “organic” soil (Cowardin) are highly functional for SWM.

Moderately functional wetlands consist of those classified in the Palustrine System (Cowardin), that are Temporarily Flooded (Flats) or Seasonally Flooded (Basin) and located in a “Floodplain” (LLWW), and have a “Throughflow” LLWW Water Flow Path. They are Lotic Waterbody and Throughflow water flow (LLWW) because they are adjacent to feature classified as Riverine (Cowardin).

Palustrine, Emergent (Cowardin) wetlands that have a Semipermanently Flooded Water Regime ad are adjacent to Palustrine/Pond and Lacustrine/Lentic Waterbodies are classified as Fringe (LLWW) wetlands also are moderately functional. Palustrine wetlands are always classified as Terrene in the LLWW System. Palustrine/Terrene wetlands that are Temporarily Flooded/Flats or Saturated (Flats or Slopes) with “Outflow” (LLWW) and have “mineral soil” (Cowardin) were determined to be moderately functional due to the reduced ability of mineral soil to hold water.

Wetland Function

As stated previously, wetlands perform a number of ecological functions that help improve and maintain environmental quality. Where natural wetlands are degraded or filled, some of these functions can be performed through human intervention and technology. However, healthy natural systems typically provide the functions more effectively in terms of both cost and performance. For further information on the economic valuation of wetlands refer to Appendix I. The wetland functions identified as most pertinent for the Saint Croix Headwaters:

1. Surface Water Detention (SWD) – storage of runoff from rain events and spring melt waters which attenuates peak flood levels downstream.
2. Surface Water Maintenance (SWM) – this is often referenced as stream flow maintenance. During drought conditions and periods of low discharge, wetlands provide a source of water to keep streams from drying up.
3. Nutrient Transformation (NT) – wetlands through natural chemical processes break down nutrients from both natural sources as well as fertilizers and other pollutants essentially treating the runoff.
4. Sediment Retention (SR) – wetlands act as filters to physically trap sediment particles before they are carried further downstream.
5. Carbon Sequestration (CAR) – wetlands serve as carbon sinks that help trap atmospheric carbon.
6. Shoreline Stabilization (SS) – wetland plants help hold the soil to prevent erosion.
7. Fish Habitat (FIS) – wetlands serve as habitat for a variety fish. Within this function is a special category containing those factors such as stream shading that keep water temperatures low enough for cold water species such as trout.
8. Waterfowl Habitat (WFH) – wetlands serve as habitat for waterfowl, and other water birds such as coots and loons.
9. Shorebird Habitat (SBH) – wetlands serve as habitat for shorebirds, such as herons, egrets, and sandpipers.
10. Amphibian Habitat (APH) – wetlands serve as habitat for amphibians such as frogs, toads and salamanders.

11. General Wildlife Habitat (GWH) – wetlands serve as habitat for a variety of other animals from songbirds to turtles to larger mammals such as deer and raccoons.

The following sections contain a verbal description of the codes that apply to each function as well as a table containing lists of the applicable codes. Horizontal bars divide the tables. The wide blue bars divide the codes between high, moderate, and exception codes. The narrow gray/brown bars subdivide the codes further. The area between the gray bars contains a group of codes that when combined satisfy the criteria for that particular function. In the tables, the "#" is used as a wild card and asterisks are used to reference a notation. Conditional statements are sometimes required if multiple criteria factor into determining the function of a wetland. Conditional statements can take two forms, logical and spatial. Logical statements include AND, OR, and NOT statements, while spatial statements refer to the geospatial relationship between features. Adjacency is the most common spatial condition in determining wetland function. To try and minimize confusion, conditional statements are italicized in the tables.

Surface Water Detention (SWD)

Wetlands trap and store surface water. This can take the form of precipitation or in colder climates spring snow melt. The wetlands then release the water slowly over time through surface or underground hydrologic networks.. From the human perspective, this process equates to lower peak flood levels. Generally, depressional wetlands that capture and store precipitation and runoff perform the function of surface water detention. They provide ground water recharge points and include wetlands found along stream and river floodplains, in lake basins, fringes, and islands. Table 5 contains the combinations of wetland classification codes that determine SWD.

There are a number of LLWW classifications that indicate a wetland performs this function at a high level. Lentic basins (**LEBA#**) and lentic fringe (**LEFR#**) wetlands are two major examples. Flat wetlands associated with dammed lakes (**LE2FL#**, **LE3FL#**) also function highly in this capacity. Lentic islands (**LEIL#**) are the final Lentic classification performing this function at a high level. Lotic classifications providing highly functioning SWD include basins (**LSBA#**, **LRBA#**), fringe wetlands (**LSFR#**, **LRFR#**), and lotic river island wetlands (**LRIL#**). Non-vegetated lotic fringe wetlands such as gravel bars do not perform this function. Terrene basins, terrene ponded basins, and terrene fringe wetlands perform this function to a high degree provided there is throughflow present (**TEBATH#, TEBApdTH**, **TEFRpdTH**). In terms of LLWW water body type all types (**PD#, LK#, ST#, RV#**) contribute highly to this function as well. Finally, any wetland with organic soils, as indicated by the lower case g NWI *(###g)* modifier that is adjacent to a LLWW lake (**LK#**), river (**RV#**), or stream (**ST#**) is highly functioning for surface water detention.

All wetlands not specifically listed as highly functioning or as an exception perform the function of surface water detention to a moderate level.

Wetlands considered to never perform this function are terrene sloped wetlands, (**TESL#**) and sewage treatment ponds (**PD2f**). Also, non-vegetated banks and bars along rivers *(R2US#)* do not provide any SWD. The final and relatively uncommon exceptions are flat wetlands on a drainage divide **(#FL#dd**).

Figure 9 is a map of the watershed showing the locations of the wetlands performing the surface water detention function.

Table 5. Surface Water Detention Wetland Codes and Conditions.

Surface Water Detention (SWD)												
LEVEL	**WETLAND CODES**											
	LLWW						**NWI**					**NOTES**
	Land-scape Posi-tion	CON	Water body	Land form	Water-flow Path	Sp. Mod.	CON	System	Class	Water Regime	Sp. Mod.	
High	LE			BA								
				FR								
				IL								
	LE2			FL								
	LE3			FL								
	LR			BA								
				FR								
				IL								
	LR			FP		ba						
	LS			BA								
				FR								
	TE			BA	TH							
				BApd	TH							
				FRpd	TH							
			PD		#							
			LK		#							
			ST		#							
			RV		#							
							*adj**	#	#	#	g	* any wetland with organic soils adjacent to LK, RV, or ST waterbody
Moderate	#	*NOT**		#	#	#	*NOT**	#	#	#	#	*all wetlands that are not specifically listed above as highly functioning or below as exceptions perform SWD to a moderate level
Exceptions	TE			SL								sloped wetlands
			PD2f									
								R2	US			non-vegetated banks and bars
	#		#	FL	#	dd						all drainage divide wetlands are excluded

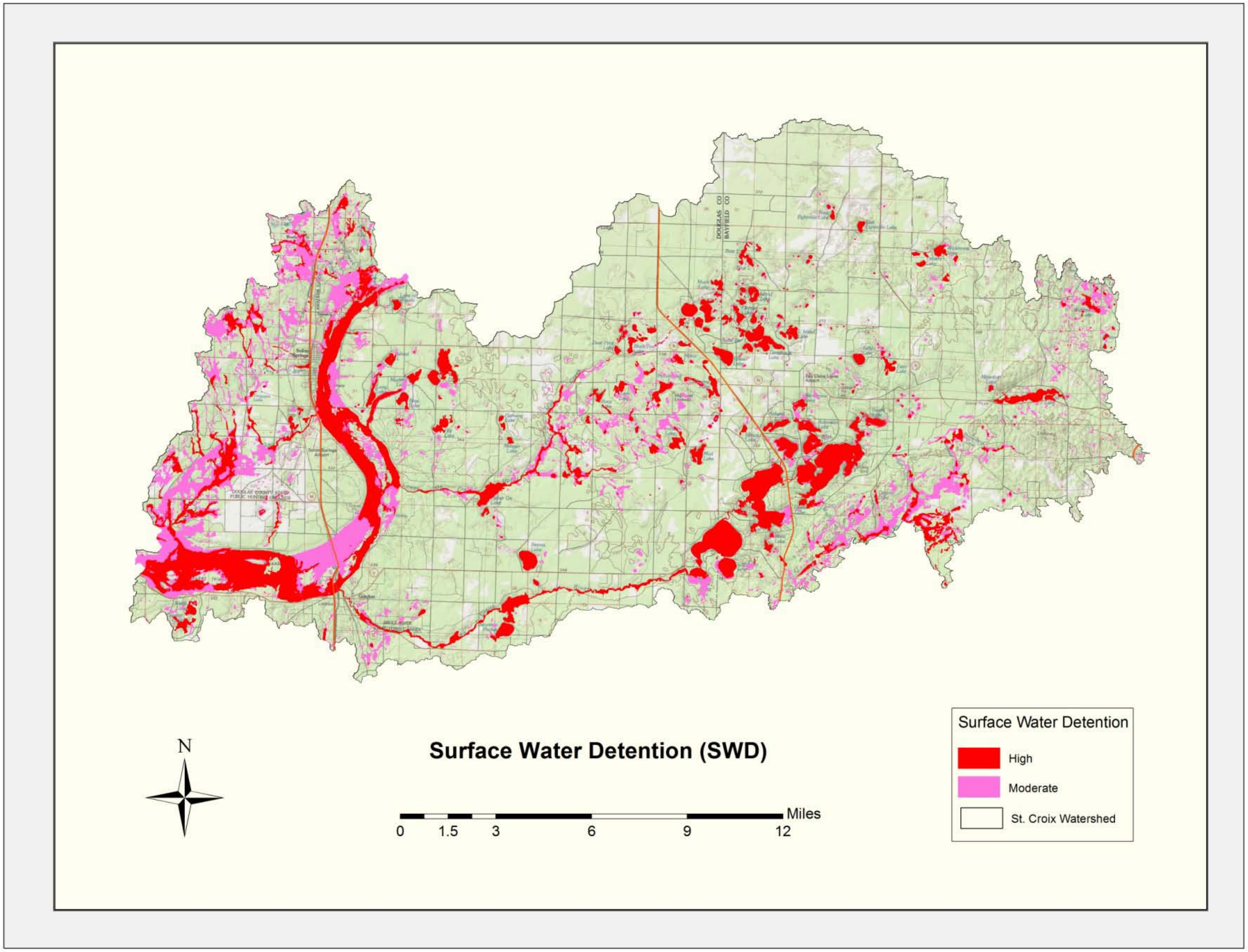


Figure 9. Surface Water Detention Map.

Surface Water Maintenance (SWM)

Surface water maintenance is the ability of a watershed to keep water traveling through the drainage system. Wetlands that help maintain stream flow are those that contribute water to the interconnected conduits within a watershed. Wetlands providing highest surface water maintenance are headwaters. Most other wetland types that provide surface water maintenance are throughflow and outflow types, although in some cases isolated and inflow wetlands also provide this function to a moderate degree. Table 6 contains the classifications and conditions that determine surface water maintenance functioning.

All headwater wetlands **(###hw**) provide surface water maintenance to a high degree. Lentic wetlands with throughflow or outflow (**LE#TH, LE#OU**) provide SWM to a high degree. Similarly terrene wetlands with throughflow and outflow provide this function to a high degree if they are associated with a pond (**TE#THpd, TE#OUpd**). Water body types functioning highly for SWM are ponds and lakes, provided again that they have throughflow or outflow (**PDTH#, PDOU#, LKTH#, LKOU#**). All wetlands and wetland complexes adjacent to rivers (**RV#**) and streams (**ST#**) function highly as well. All wetlands with organic soils *(###g)* adjacent to third order streams or higher (further downstream) are highly functioning as well.

There are two types of lentic wetlands that moderately function for SWM. Lentic wetlands with bidirectional flow (**LE#BI#**) provide SWM to a moderate degree. Also, lentic wetlands with throughflow (**LE#TH#**) that are adjacent to lakes (**LK#**) also provide this function. Low gradient river floodplain (**LR1FP#**) wetlands and lotic stream basins (**LS#BA#**) perform surface water maintenance to a moderate level as well. Several types of terrene wetlands provide SWM to a moderate degree. The broadest terrene category is terrene wetlands with throughflow (**TE#TH#**). Isolated and inflow terrene wetlands associated with ponds (**TE#ISpd, TE#INpd**) also function moderately. Terrene wetland flats with outflow (**TEFLOU#**) consisting of saturated soils *(##B#)* that are adjacent to third order streams or higher are moderately functioning. In terms of water bodies, ponds and lakes that are with inflow or isolated water flow paths (**PDIS#, PDIN#, LK#IS#, LK#IN#**) are considered moderately functioning. Figure 10 illustrates the areas in the watershed providing surface water maintenance.

Table 6. Surface Water Maintenance Wetland Codes and Conditions.

Surface Water Maintenance (SWM)												
LEVEL	**WETLAND CODES**											
	LLWW						**NWI**					**NOTES**
	Land-scape Posi-tion	CON	Water body	Land form	Water-flow Path	Sp. Mod.	CON	System	Class	Water Regime	Sp. Mod.	
High	#			#	#	hw						all headwater wetlands
			PD		TH							
			LK		OU							
	LE				TH							
					OU							
	#	*adj.*	RV									all wetlands and wetland complexes adjacent to lakes, rivers, and streams
			ST									
	LS		#	#	#		*adj.**	#	#	*not* B	g	*all wetlands adjacent to third order streams (LS)or higher (downstream in the watershed) with organic soils (g)
	TE				TH	pd						
					OU	pd						
Moderate	LE	*adj.**	LK	#	TH							*lentic wetlands adjacent to lakes
	LR1			FP	#							
	LS			BA	#							
	TE			#	TH							natural and partially drained terrene wetlands
	TE				IS	pd						
					IN	pd						
	TE	*adj.**		FL	OU		*AND*	P	#	B	#	*all saturated wetlands adjacent to third order streams (LS)or higher (downstream in the watershed)
			PD		IS							
			LK		IN							
	LE				BI							

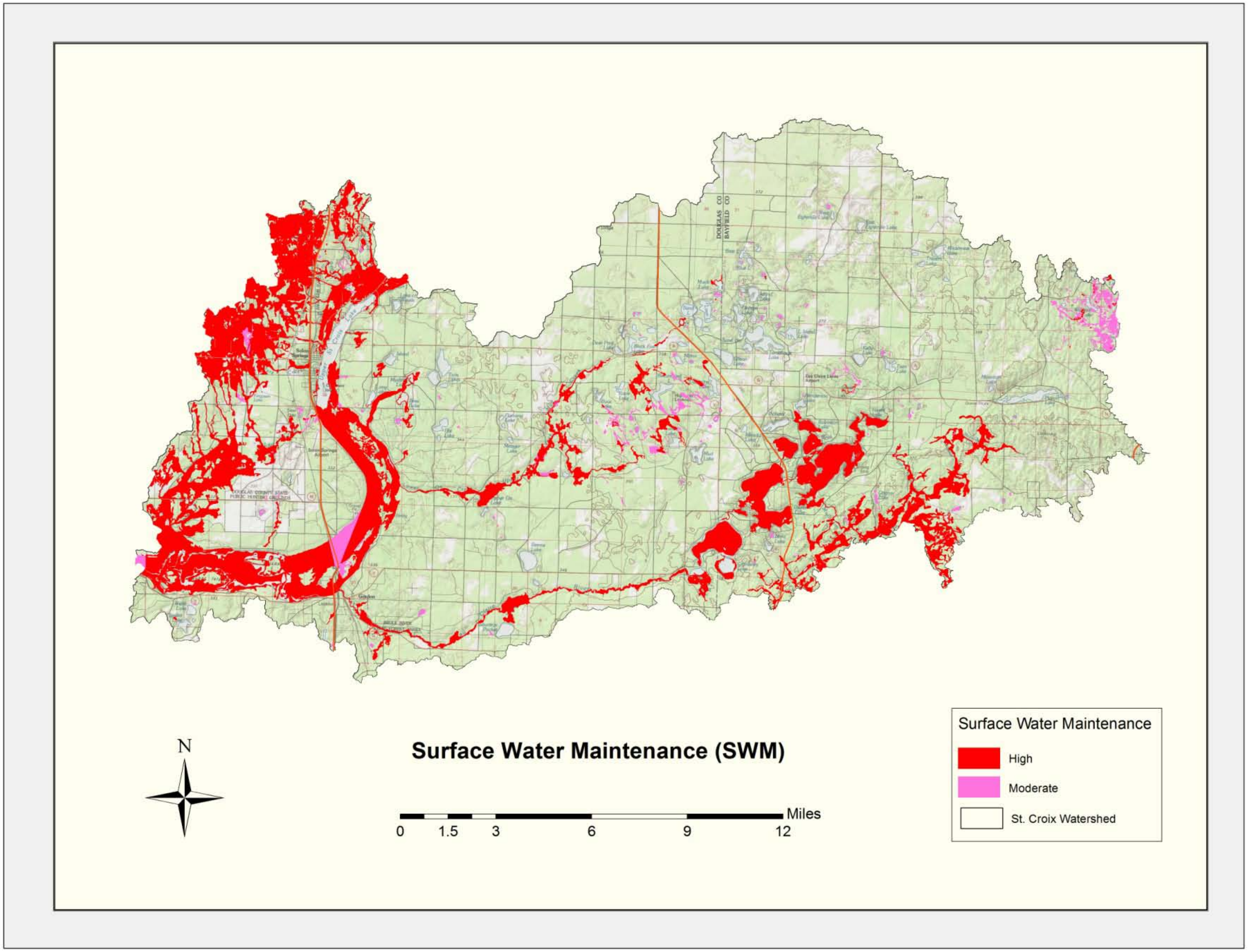


Figure 10. Surface Water Maintenance Map.

Nutrient Transformation (NT)

Nutrient transformation refers to the natural chemical processes that remove or recycle compounds in the environment. In the case of wetlands, nitrates and phosphorous from agricultural runoff are the primary nutrients of concern. Wetlands performing this function are sinks for excess nutrients. The nutrients are prevented from moving further through the watershed through either storage or by wetland vegetation using the nutrients for their own life cycle.

For nutrient transformation, landscape position is less important than the other factors such as vegetation and soil type. For this reason the NWI classification becomes the primary system that defines the functioning of a wetland for nutrient transformation. Vegetated lacustrine littoral and palustrine wetlands that are seasonally flooded, semi-permanently flooded, intermittently exposed, or permanently flooded *(L2{AB, EM, SS, FO}{C,F,G,H}, P{AB, EM, SS, FO}{C,F,G,H}),* function highly for nutrient transformation. Any mixes of vegetated and non-vegetated NWI classes also function highly if the they are semi-permanently flooded or wetter *(L2{[AB, EM, SS, FO]/[US,UB]}{F,G,H}, P{[AB, EM, SS, FO]/[US,UB]}{F,G,H}).* Vegetated palustrine wetlands with organic saturated soil *(P{EM, SS, FO}Bg)* provided they are not on a coastal or glaciolacustrine plain are also considered to be highly functional.

For moderate nutrient transformation activity vegetation is important, but moderately functioning wetlands tend to be drier than their highly functioning counterparts. Vegetated palustrine wetlands that are temporarily flooded as defined by NWI, *(P{EM, SS, FO}A),* function moderately for nutrient transformation. Any mixes containing vegetated NWI classes also function highly if the they are temporarily flooded,*(P{EM, SS, FO}/{US,UB}A).* Vegetated palustrine wetlands with saturated soil *(P{EM, SS, FO}B)* that are on coastal or glaciolacustrine plains are also considered to be moderately functioning. Finally, any vegetated, palustrine wetland with saturated soil is considered to be moderately functioning if it has the mineral soil modifier *(P#Bm).*

Wetland types that do not provide a nutrient transformation function include bogs, *(P{SS2, SS3, SS4, FO2, FO3, FO4}#).* Similarly, any wetland with acidic water chemistry *(P{EM, SS, FO}Bag)* is excluded. Open water wetlands *(#UB#)* and unconsolidated shore *(#US#)* also do not perform this function.

Table 7. Nutrient Transformation Wetland Codes and Conditions.

Nutrient Transformation (NT)

LEVEL	WETLAND CODES: LLWW Land-scape Posi-tion	LLWW CON	LLWW Water body	LLWW Land form	LLWW Water-flow Path	LLWW Sp. Mod.	NWI CON	NWI System	NWI Class	NWI Water Regime	NWI Sp. Mod.	NOTES
High								L2	AB	C	#	
								P	EM	F		
									SS	G		
									FO	H		
								L2	AB	F	#	mixes of two vegetated or a vegetated and non vegetated class semipermanetly flooded or wetter are included
								P	EM	G		
									SS	H		
									FO			
									US			
									UB			
								P*	EM	B	g	* wetlands on coastal or glaciolacustrine plains are excluded
									SS			
									FO			
							NOT	P	EM	B	m	mineral soils are excluded from high
									SS			
									FO			
Moderate								P	EM	A		
									SS			
									FO			
								P	EM	A		mixes of two vegetated or a vegetated and non vegetated class temporarily flooded are included
									SS			
									FO			
									US			
								P*	EM	B		*wetlands on coastal or glaciolacustrine plains are included
									SS			
									FO			
								P	EM	B	m	
									SS			
									FO			
Exceptions								#	UB			non-vegetated wetlands are excluded
									US			
								P	SS2	#	#	bogs are excluded
									SS3			
									SS4			
									FO2			
									FO3			
									FO4			
								P	EM	B	ag	organic soils with acidic water chemistry are excluded
									SS			
									FO			

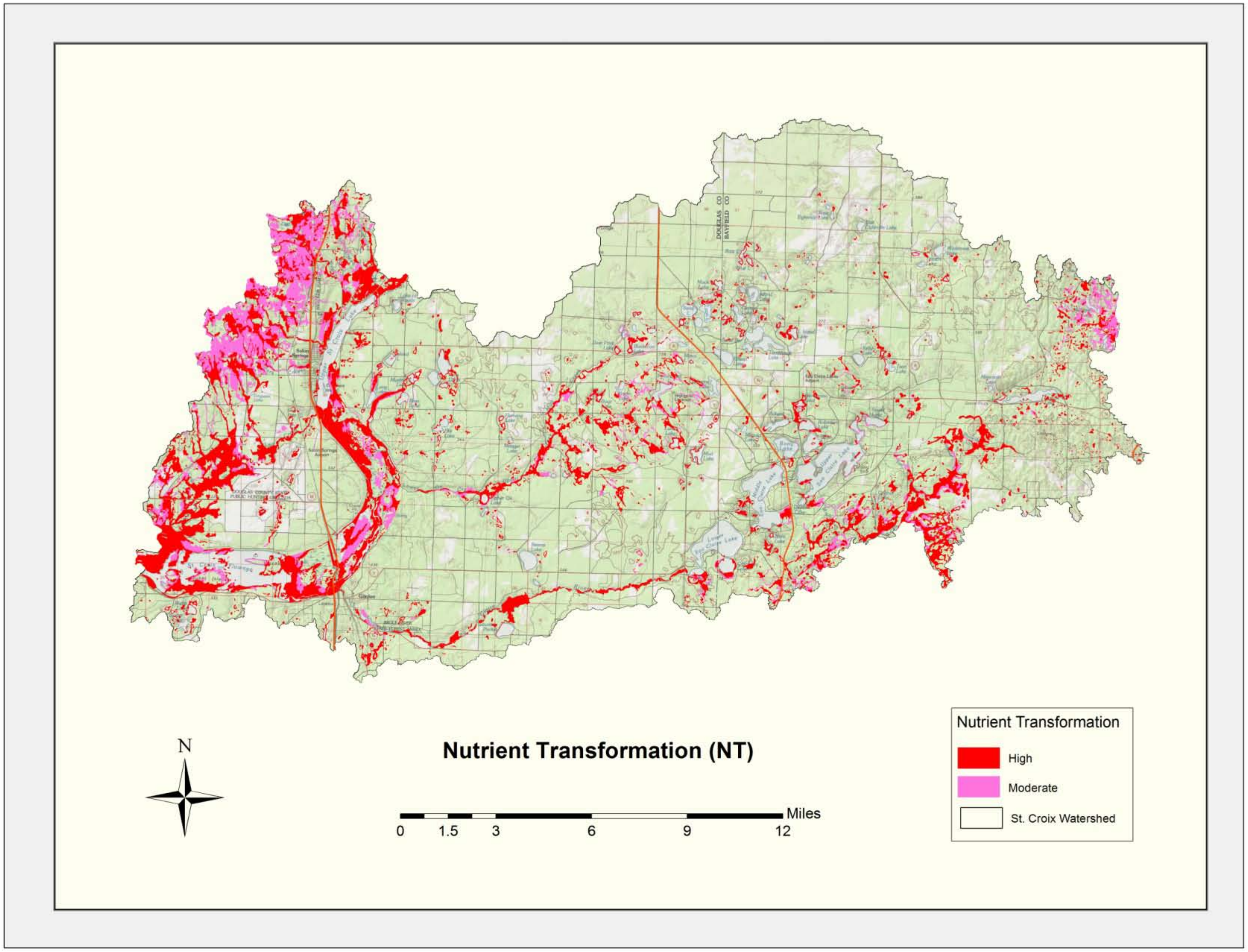


Figure 11. Nutrient Transformation Map.

Sediment/Particle Retention (SR)

Wetlands that physically trap particles that affect water quality have sediment retention properties. In contrast to nutrient transformation which involves chemical processes, SR is a physical process where the suspended particles are filtered by the soil and plant roots. The removal of suspended particles helps to improve water clarity and help maintain cooler temperatures on cold water streams. Due to the physical nature of sediment retention LLWW is the primary system used to make SR determinations with the NWI vegetation classes and water regime also factoring into the process.

In general wetlands functioning highly for SR tend to be vegetated. However, lentic basins (**LEBA#)** and lotic river fringes (**LRFR#**) perform sediment retention to a high degree regardless of the presence of vegetation. Lentic fringe, and island wetlands (**LEFR#, LEIL#**) that are vegetated *({L, P}{AB, EM, SS, FO})* or vegetated mixes *({L, P}{[AB, EM, SS, FO]/[UB/US]})* perform well in removing particulates. Vegetated lotic stream basins and fringe wetlands (**LSBA#, LSFR#**) are included as well as vegetated lotic river basin, floodplain, fringe, and island wetlands (**LRBA#, LRFP#, LRIL#**). Several terrene wetlands types function highly for sediment retention. All ponded terrene throughflow wetlands are included (**TE#pdTH**). Terrene basins with throughflow (**TEBATH**) and terrene interfluve basins with both regular and intermittent throughflow (**TEIFbaTH, TEIFbaTI**) also perform SR to a high degree. In terms of waterbody type, all ponds with throughflow (**PD#TH**) provide this function to a high level. Any wetland classified as severely human induced **(####hi**) in LLWW and impounded *(###h)* in NWI functions highly for sediment retention as well.

Wetlands that moderately perform the sediment retention function include some non-vegetated types. Lentic fringe (**LEFR#**), lotic stream flats (**LSFL#**), lotic stream fringe (**LSFR#**), lotic river fringes (**LRFR#**) and lotic river islands (**LRIL#**) with non-vegetated NWI classes *(#{UB, US}#)* all fit this category. However, lentic flat wetlands (**LEFL#**) classified with vegetated NWI classes *(#{AB,EM,SS,FO}#)* also moderately perform the SR function. Ponded terrene wetlands (**TE#pd#**) not classified with a throughflow waterflow path are considered to moderately perform sediment retention as well. Non-saturated *(P#B#)* terrene basins (**TEBA#**) with waterflow path other than throughflow (**##TH#**) or intermittent through flow **(##TI#**) function moderately. Terrene flat wetlands (**TEFL#**) with the temporarily flooded *(P#A#)* water regime also fall into the moderately performing category. Natural ponds classified as bogs (**PD1a**), woodland-wetland (**PD1b**), or sinkhole-woodland (**PD1h**) are the only water body types that moderately function in sediment retention. All lacustrine unconsolidated shore and unconsolidated bottom *(L2US#, L2UB#)* wetlands that are not already classified as highly functioning are considered to be moderately functioning. In terms of LLWW water body any pond without through flow (**PD#**) that is not listed as an exception is moderately functioning as well.

There are several universal exceptions of wetland types that do not function as sediment retention areas. are never considered to perform the sediment retention function. First, the saturated NWI water regime *(##B#)* is removed from any consideration. Sediment retention only applies to the flooded water regimes. Secondly, floating mat wetlands as designated by the LLWW **(##fm**) code are not considered to provide the sediment/particle retention function. Finally several types of ponds never perform the sediment retention function. Woodland-dry land (**PDc**) and prairie – dryland (**PDe**) are the two types relevant to the Saint Croix headwaters that never perform the sediment retention function.

Table 8. Sediment Retention Wetland Codes and Conditions (page 1 of 2).

Sediment Retention (SR)												
LEVEL	WETLAND CODES											
	LLWW						NWI					NOTES
	Land-scape Posi-tion	CON	Water body	Land form	Water-flow Path	Sp. Mod.	CON	System	Class	Water Regime	Sp. Mod.	
High	LE			BA	#	#						
	LE			IL		*NOT* fm	*AND*	L1	AB	C		floating mat wetlands are excluded
								L2	EM	F		
								P	SS	G		
									FO	H		
	LE			FR		*NOT* fm	*AND*	L1	AB	C		1. mixes of two vegetated or a vegetated and non vegetated class are included 2. floating mat wetlands are excluded
				IL				L2	EM	F		
								P	SS	G		
									FO	H		
									US			
									UB			
	LS			BA			*AND*	L1	AB	A		
				FR				L2	EM	C		
								P	SS	F		
									FO	G		
										H		
	LR			FR	#							
	LR			BA			*AND*	L1	AB	A		
				FP				L2	EM	C		
				IL				P	SS	F		
									FO	G		
										H		
	TE			#pd	TH							
	TE			BA	TH							
	TE			IFba	TH							
					TI							
			PD	#	TH							
	#		#	#	#	hi	*AND*	#	#	*not* A	h	
Moderate	LE			FR	#		*AND*	L1	US	A		non-vegetated fringe wetlands
								L2	UB			
								P				
	LE			FL			*AND*	L1	AB	A		
								L2	EM			
								P	SS			
									FO			
	LS			FL			*NOT*	P	#	B		
	LS			FR			*AND*	L1	US	A		non-vegetated fringe wetlands
								L2	UB	C		
								P		F		
										G		
										H		

TABLE IS CONTINUED ON NEXT PAGE

Table 8. Sediment Retention Wetland Codes and Conditions (page 2 of 2).

Sediment Retention (SR) (cont.)												
LEVEL	WETLAND CODES											
	LLWW						NWI					NOTES
	Land-scape Posi-tion	CON	Water body	Land form	Water-flow Path	Sp. Mod.	CON	System	Class	Water Regime	Sp. Mod.	
Moderate	LR			IL			*AND*	L1	US	A		
(cont.)				FR				L2	UB	C		
								P		F		
										G		
										H		
	TE			BA	*NOT* TH		*NOT*	P	#	B		
					NOT TA							
	TE			#pd	*NOT* TH		*NOT*	P	#	B		
	TE			FL	#		*AND*	P	#	A		
			PD1a									bog
			PD1b									woodland wetland
			PD1h									woodland sinkhole
								L2	US	#	#	
									UB			
			PD		*NOT* TH							
Exceptions	#		#	#	#	fm						all floating mat wetlands are excluded
								#	#	B	#	all saturated water regime wetlands are excluded
			PD#			c						
						e						
						f						
						g						
						f						

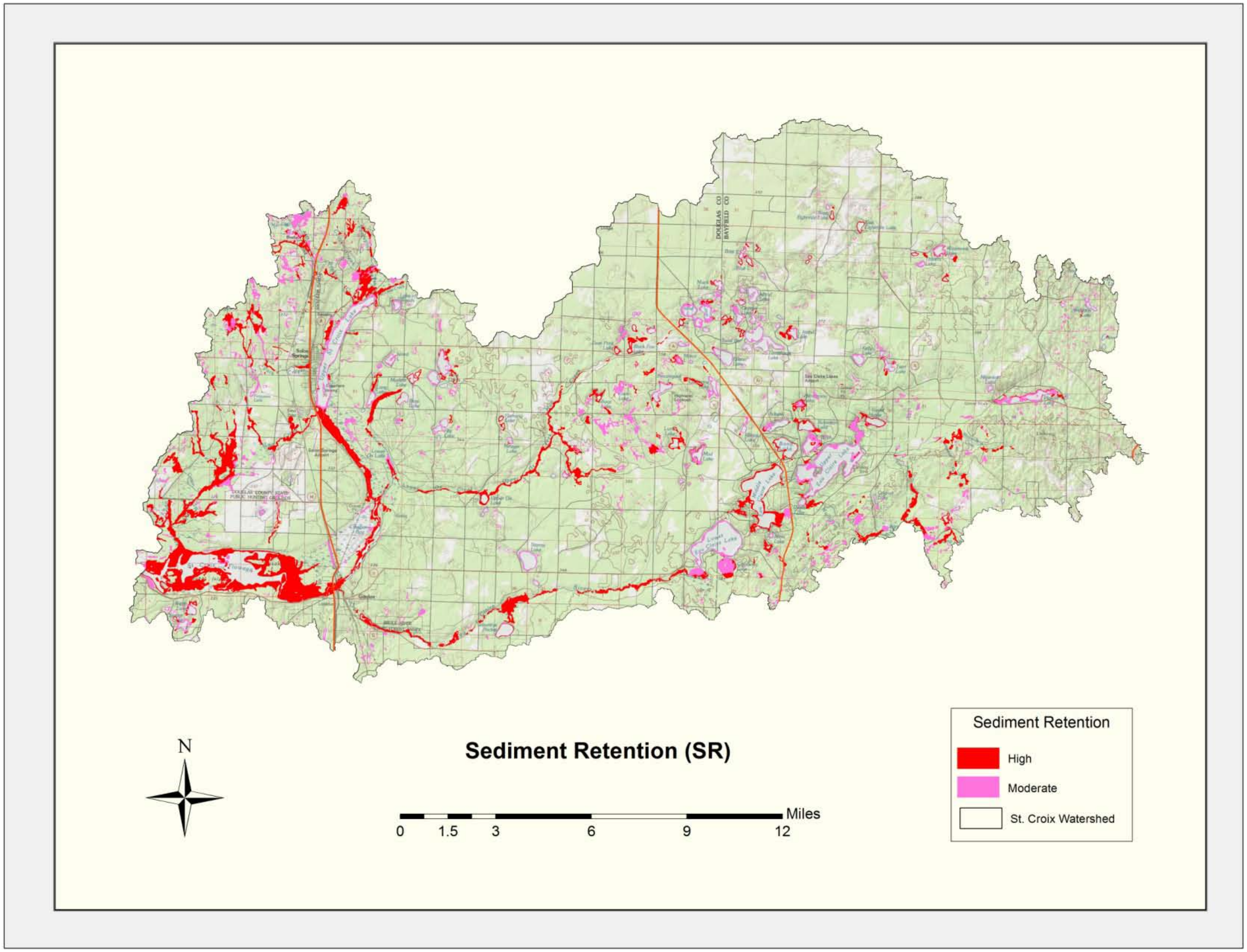


Figure 12. Sediment Retention Map.

Carbon Sequestration (CAR)

Carbon sequestration occurs when wetlands act as carbon sinks through chemical and biological processes such as photosynthesis. Typically wetlands performing carbon sequestration are vegetated to some degree. Therefore, NWI classifications become the major source of information in making determinations regarding carbon sequestration. Soil and water regime information are also important in determining whether a wetland functions at a high or moderate level for this function. Table 5 contains the list of the classificatioin and conditions that apply to the carbon sequestration function.

Lacustrine and palustrine aquatic beds *({L2,P}AB{F, G, H}})* perform this function to a high level. Bog and northern white cedar wetlands are also major contributors to carbon sequestration. NWI classifications identifying bogs include palustrine and littoral limnetic wetlands dominated by broad leaf evergreen shrubs with a saturated water regime, acidic water chemistry modifier, and organic soil modifier *({L2/P}SS3Bag)*. Similarly, scrub-shrub and forested bogs dominated by needle leaf evergreens with the saturated water regime and organic soils modifier *({L2/P}{SS,FO}4Bg)* are included as highly functioning as well. Saturated Northern white cedar wetlands with circumneutral water chemistry and organic soils *(PFO3Btg)* also perform CAR at a high level. Wild rice wetlands fall into the highly functioning category. In NWI, wild rice is given the non-persistent *(#EM2#)* designation. There are several wetland types containing wild rice that function highly for CAR. Lower perennial riverine with an intermittently exposed or permanently flooded water regime *(R2EM2{G, H}* are included, as well as littoral lacustrine and palustrine wetlands that are semi-permanently flooded or wetter *({L2,P}EM2{,F,G,H})*.

Moderately functioning wetlands for CAR include all wetlands and water bodies not already specified as highly functioning. There are no wetlands that do not perform carbon sequestration to some degree.

Table 9. Carbon Sequestration Wetland Codes and Conditions.

Carbon Sequestration (CAR)												
LEVEL	**WETLAND CODES**											
	LLWW						**NWI**					**NOTES**
	Land-scape Posi-tion	CON	Water body	Land form	Water-flow Path	Sp. Mod.	CON	System	Class	Water Regime	Sp. Mod.	
High								L2	AB	F		
								P		G		
										H		
								L2	SS3	B	ag	bog - broad leaf evergreen shrubs, organic soils, acidic water chemistry
								P				
								L2	SS4	B	ag	bog - needle leaf evergreen, organic soils
								P	FO4		ag	
								P	FO3	B	tg	Northern white cedar wetland, circumneutral water chemistry, organic soils
								R2	EM2	G		wild rice wetland along rivers
										H		
								L2	EM2	F		littoral lacustrine and palustrine wild rice wetlands
								P		G		
										H		
Moderate	#		#	#	#	#	•	#	#	#	#	• all other wetlands not specifically listed as high function moderately

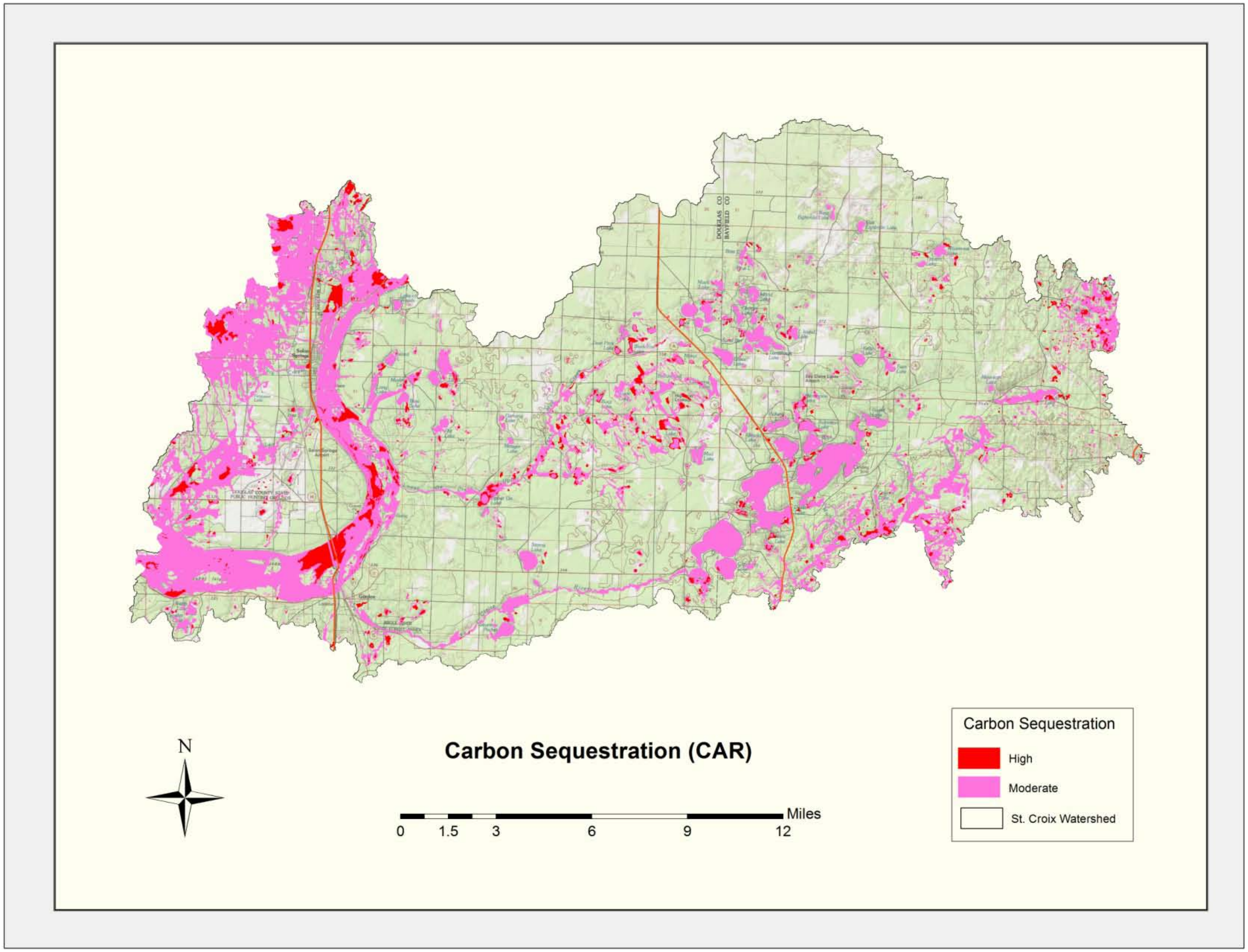


Figure 13. Carbon Sequestration Map.

Shoreline Stabilization (SS)

Natural shoreline stabilization structures and vegetation prevent erosion or remediate erosion that has already occurred by binding soils. Vegetation and mixed vegetation along lake, river, stream, and pond shorelines prevent soil from being washed or blown away. Table 6 contains the criteria for the shoreline stabilization function. Figure 14 shows the wetlands in the SCHW that perform shoreline stabilization.

Vegetation is the main factor that contributes to wetlands functioning highly for shoreline stabilization. Non-island lentic, lotic river and lotic stream wetlands ({**LE,LR,LS}{BA,FL,FP,FR,IF,SL}##**), with vegetated NWI classes *({L2,R2,P}{AB,EM,SS,FO}#)* all function highly with respect to shoreline stabilization. Similarly wetlands with the same LLWW attributes and vegetation dominant mixes are also included as highly functioning *({L2,R2,P}{AB,EM,SS,FO}/{UB/US}#).* The only LLWW water body type that provides SS are ponds (**PD##**) adjacent to streams. Island (**#IL#**) and floating mat (**##fm**) wetlands never perform the shoreline stabilization function.

Wetlands performing shoreline stabilization at a moderate level are vegetated with terrene LLWW attributes. Terrene ponded wetlands (**TE#pd**) attributed as vegetated and dominant vegetated mixes NWI wetlands *({L2,R2,P}{AB,EM,SS,FO}#), ({L2,R2,P}{[AB,EM,SS,FO]}/[UB,US]}#)* perform this function to a moderate degree. Terrene, outflow, headwater wetlands (**TE#OUhw**) and consisting of vegetated and vegetated mixes like the terrene ponded wetland previously described also provide this function if they are hydrologically connected to a stream. Connectivity in the case of the Saint Croix Headwaters was determined by intersecting wetlands data with a stream data set extracted from the National Hydrography Dataset as provided by the Wisconsin DNR. Lower perennial river wetlands *(R2EM1#)* which are not wild rice beds are also included as moderately functioning for shoreline stabilization.

Wetlands that are never considered to be performing the wetland function include all island wetlands (**#IL##**), isolated wetlands (**##IS#**), inflow wetlands (**##IN#**), floating mat wetlands (**##fm**), and unconsolidated shore wetlands *(#US#)*.

Table 10. Shoreline Stabilization Wetland Codes and Conditions.

Shoreline Stabilization (SS)

LEVEL	WETLAND CODES											
	LLWW						NWI					NOTES
	Land-scape Posi-tion	CON	Water body	Land form	Water-flow Path	Sp. Mod.	CON	System	Class	Water Regime	Sp. Mod.	
High	LE			BA	#		*AND*	L2	AB	#		IL are not included, global exception
	LR			FL				R2	EM			
	LS			FP				P	SS			
				FR					FO			
				IF								
				SL								
	LE			BA	#		*AND*	L2	AB	#		IL are not included, global exception includes mixes of vegetated and non-vegetated mixes
	LR			FL				R2	EM			
	LS			FP				P	SS			
				FR					FO			
				IF					UB			
				SL					US			
		*adj.**	PD		#	#						*all ponds adjacent to streams (LS) are included
Moderate	TE			#	#	pd	*AND*	L2	AB	#		
								P	EM			
									SS			
									FO			
	TE			#	#	pd	*AND*	L2	AB	#		
								P	EM			
									SS			
									FO			
									UB			
	TE	*hc**		#	OU	hw	*AND*	L2	AB	#		*include only if hydrologically connected to a stream, stream data source is the NHD stream extract porvided by WI DNR
								P	EM			
									SS			
									FO			
	TE	*hc**		#	OU	hw	*AND*	L2	AB	#		1. vegetated dominant mixes are included 2.*include only if hydrologically connected to a stream, stream data source is the NHD stream extract porvided by WI DNR
								P	EM			
									SS			
									FO			
									UB			
								R2	EM1	#		riverine vegetated that are not EM2
Exceptions				IL	#	#						island wetlands are excluded
	#			#	#	fm						all floating mat wetlands are excluded
								#	US	#		all unconsolidated US wetlands are excluded
	#			#	IS	#						all isolated and and inflow wetlands are excluded
					IN							

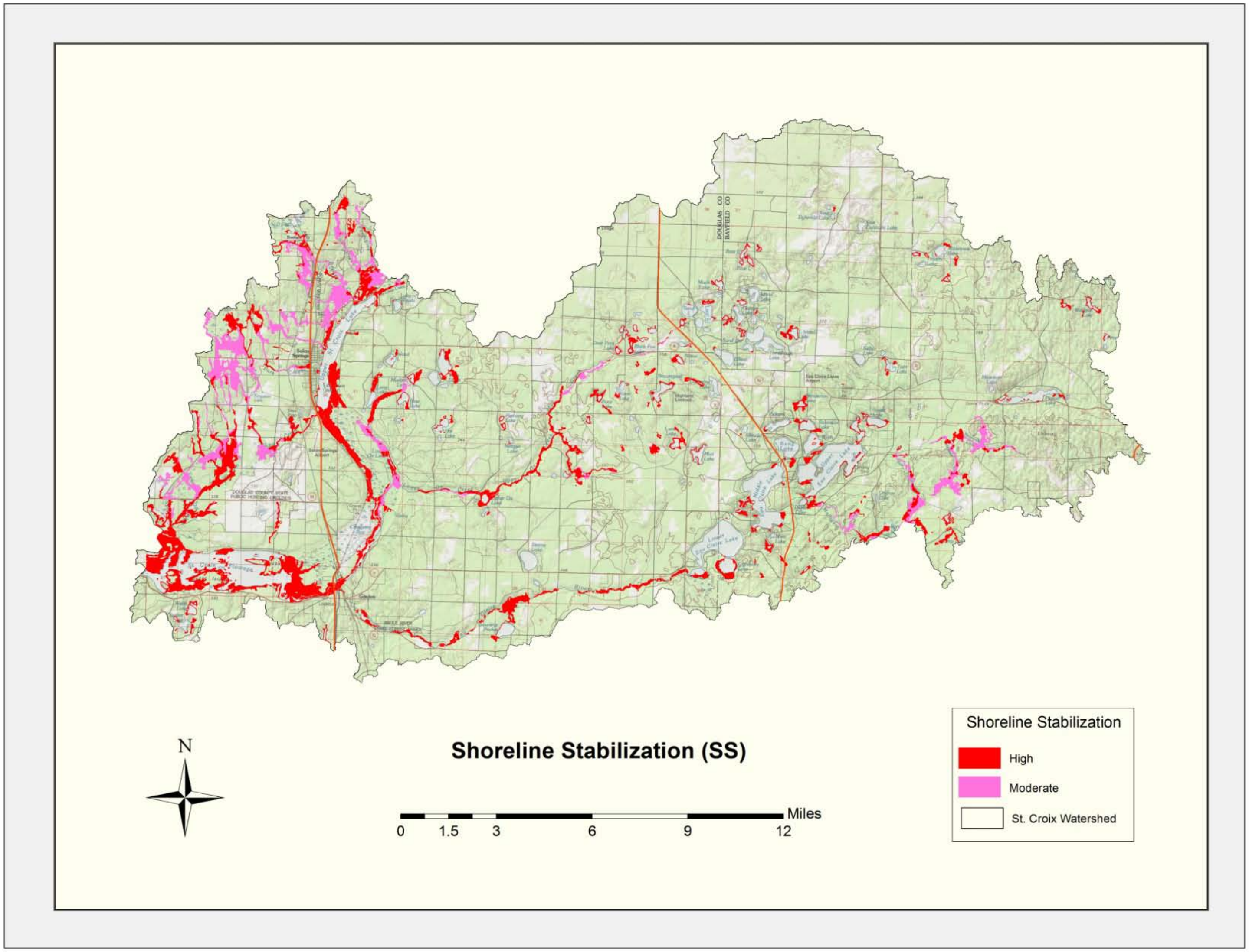


Figure 14. Shoreline Stabilization Map.

Fish Habitat (FIS)

Wetlands performing the function of fish habitat provide areas vital for various parts of their life cycle. Many organisms on which fish feed need wetlands to survive. Wetlands also provide spawning and nursery areas. Wetland plants provide cover essential to small and young fish avoiding predators. The shade provided by wetland trees and shrubs helps to maintain cooler water temperatures for cold water species. Determining wetland functioning for fish habitat requires using a combination of the LLWW and NWI codes. The codes and conditions providing this function are listed in Table 11. The map in Figure 15 shows the features performing this function.

Wetlands functioning highly for fish habitat tend to have wetter water regimes and are mostly associated with large or moving bodies of water. Headwater wetlands also function highly as fish habitat. Specifically, lentic, lotic stream, and lotic river wetlands (**LE#, LS#, LR#**) that are semi-permanently flooded, intermittently exposed, or permanently flooded *(##F#, ##G#, ##H#)* are highly functioning for fish habitat. Terrene outflow headwater (**TE#OUhw**) wetlands and any wetlands hydrologically connected to them with semi-permanently flooded or wetter water regimes *(##F#, ##G#, ##H#)* are included in highly functioning as well. Water bodies providing this function include all lakes (**LK##**) and rivers (**RV##**).

Wetlands performing the function of fish habitat to a moderate degree are typically LLWW lotic types. Seasonally flooded *(##C#)* basins classified as low gradient lotic streams (**LS1BA#**) are moderately functioning for fish habitat. Similarly, seasonally flooded *(##C#)* lotic river floodplain basins (**LR#FPba**), oxbows for example, are also moderately functioning as fish habitat. In terms of waterbody, all throughflow ponds (**PD#TH**) are classified as moderately functioning.

Due to the very specific habitat conditions required for trout and other cold water species to thrive, a third level of performance specifically for trout is added to this function. The wetland types included typically contribute to maintaining cooler water temperature through stream shading. Forested palustrine wetlands *(PFO#)* associated with natural high, middle, and low gradient stream wetlands (**LS1#, LS2#, LS3#**) that are not ponded (**###pd**) perform this function. Similarly, scrub-shrub palustrine wetlands *(PSS#)* associated with the same lotic stream types, partly drained or not, also perform this function.

Wetlands that are not considered for the fish habitat function are shrub bog types. Specifically, wetlands classified as saturated palustrine broad leaf evergreen scrub-shrub bogs *(PSS3Ba)* are never considered. Commercial bogs *(PSSf)*, mainly cranberry bogs, are also removed from consideration.

Table 11. Fish Habitat Wetland Codes and Conditions.

Fish Habitat (FIS)

LEVEL	WETLAND CODES											
	LLWW						NWI					NOTES
	Land-scape Posi-tion	CON	Water body	Land form	Water-flow Path	Sp. Mod.	CON	System	Class	Water Regime	Sp. Mod.	
High	LE			#	#		*AND*	#	#	F		
	LS									G		
	LR									H		
	TE			#	OU	hw	*AND*	#	#	F		
										G		
										H		
			LK		#							
			RV		#							
Moderate	LS1			BA	TH		*AND*	#	#	C		
	LR			FP	TH	ba	*AND*	#	#	C		seasonally flooded oxbows
			PD	#	TH							
Trout	LS1			#	#	*not* pd	*AND*	P	FO	#		
	LS2					*not* pd						
	LS3					*not* pd						
	LS1			#	#	#	*AND*	P	SS	#		
	LS2											
	LS3											
Exceptions								P	SS3	B	a	saturated broad leaf evergreen scrub-shrub bogs and commercial bogs such as cranberry bogs are always excluded from fish habitat
								P	SS	#	f	saturated broad leaf evergreen scrub-shrub bogs and commercial bogs such as cranberry bogs are always excluded from fish habitat

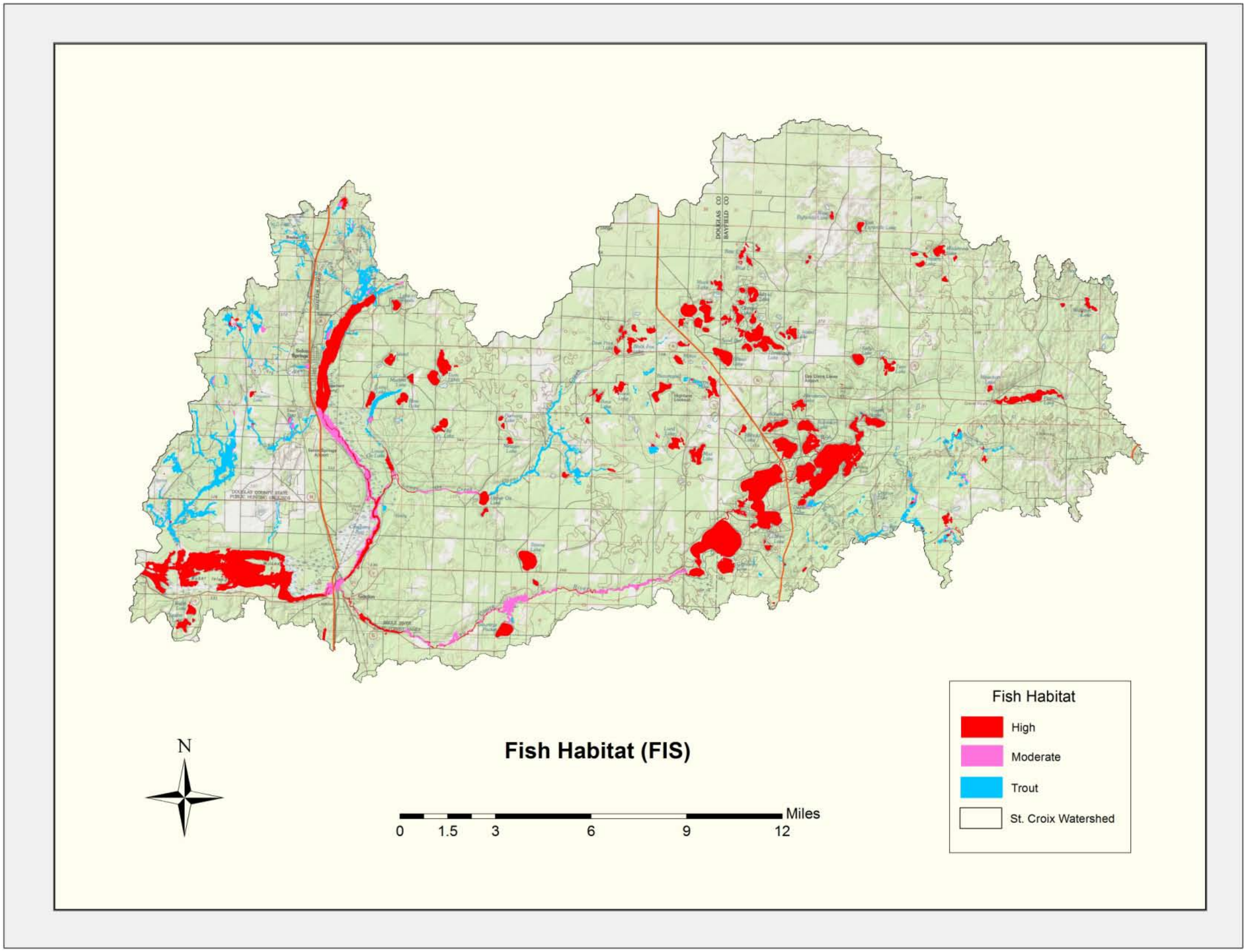


Figure 15. Fish Habitat Map.

Waterfowl and Waterbird Habitat (WFH)

Ducks, geese and swans are most commonly thought of as waterfowl, but a number of other types of birds, such as loons, coots and grebes also rely on similar habitats for survival. Their highly functioning habitat is typically associated in some way with open water. Depending on the species, habitats can range from large open littoral areas, to forested ponds and streams. Much of the functioning of wetlands for WFH is dependent on a combination of specific LLWW and NWI classifications. Table 12 contains the codes and conditions for (WFH), and Figure 16 shows the features that are classified as WFH.

As might be expected, due to the variety of waterfowl and waterbird species there are a variety of classifications that function at a high level. Vegetated wetlands and wetlands with mixes of vegetation and non-vegetated classes that are semi-permanently flooded or wetter are considered highly functioning for waterfowl habitat *({L2,R2,P}{AB,EM,SS,FO}{F,G,H}), ({L2,R2,P}{AB,EM,SS,FO}/{UB/US}{F,G,H})*. Basin and fringe wetlands associated with streams (**LSFR#, LSBA#**) are considered highly functioning waterfowl habitat provided they are seasonally or semi-permanently flooded *(###C)(###F)*. Similarly, lotic river floodplain basin and fringe wetlands (**LRFPba#, LRFR#**) function highly, again provided they are semi-permanently, or seasonally flooded *(###C)(###F).* Of special note are oxbows that have through flow (**LRFPbaoxTH**) which are considered highly functioning regardless of water regime. All natural (**PD1#**) and beaver ponds (**PD4**) are also considered highly functioning.

Moderately functioning wetlands for waterfowl habitat as the term implies do not perform the function as well as the highly functioning wetlands. In many cases this is the result of drier conditions or a different position within the landscape. All littoral open water wetlands *(L2UB#)* are moderately functioning, as well as littoral unconsolidated shore *(L2US{A,C})* Isolated terrene basins (**TEBAIS#**) that are classified as palustrine emergent wetlands which are semi-permanently flooded or wetter *(PEM{F ,G, H})* function at the moderate level. All temporarily flooded wetlands (###A) are moderately functional as waterfowl habitat. All impounded and excavated ponds (**PD2#, PD3#**) are included as moderately functioning. Other water bodies that are included are lakes (**LK#**) and rivers (**RV#**).

Wetlands classified with the saturated water regime *(###B)* are not considered to perform the function of waterfowl/waterbird habitat.

Table 12. Waterfowl and Waterbird Wetland Codes and Conditions.

Waterfowl and Waterbird Habitat (WFH)

LEVEL	WETLAND CODES											
	LLWW						NWI					NOTES
	Land-scape Posi-tion	CON	Water body	Land form	Water-flow Path	Sp. Mod.	CON	System	Class	Water Regime	Sp. Mod.	
High								L2	AB	F		*exception emergent dominant wetlands in isolated terrene basins are moderatly functioning (TEBAIS)
								R2	EM*	G		
								P	SS	H		
									FO			
								L2	AB	F		vegetated mixes
								R2	EM	G		
								P	SS	H		
									FO			
									UB			
									US			
	LR			FP	TH	ba ox						oxbows
	LS			FR	#		*AND*	#	#	C		forested or scrub-shrub, shrub bogs and commercial bogs are excluded
				BA	#					F		
	LR			FR	#		*AND*	#	#	C		
				FP	#	ba				F		
			PD1	#	#							
			PD4	#	#							
Moderate								L2	UB	#		mixes are excluded from moderate
	TE			BA	IS		*AND*	P	EM	F		
										G		
										H		
								#	#	A	#	all A WR
			PD2	#	#							
			PD3	#	#							
			LK#									
			RV#									
								L2	US	A		littoral unconsolidated shore
										C		
Exceptions								#	#	B	#	all saturated B WRs are excluded

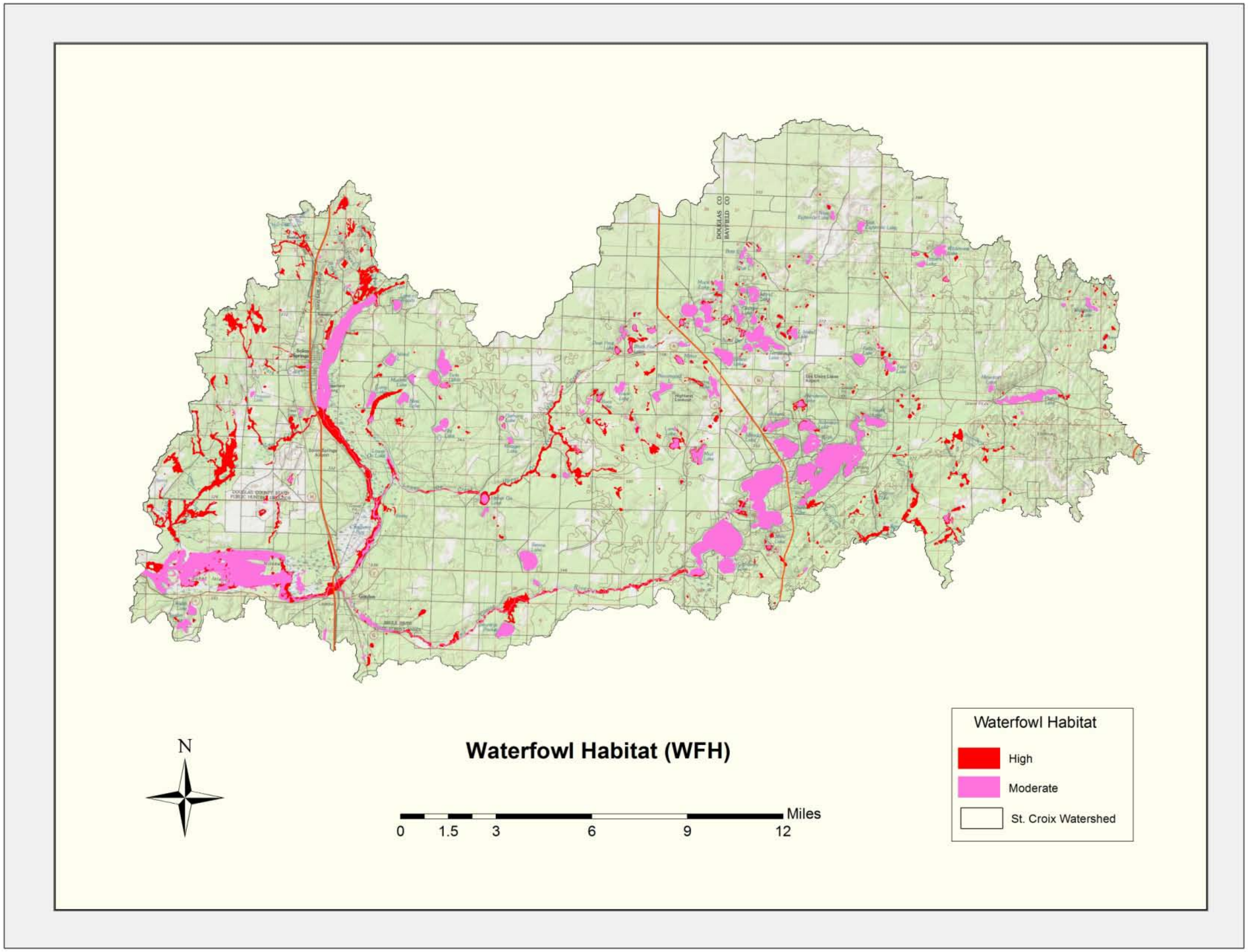


Figure 16. Waterfowl Habitat Map.

Shorebird Habitat (SBH)

Birds including: herons, cranes, egrets, and sandpipers are shorebirds, and are commonly referred to as wading birds. They require shallow open water areas of lakes or ponds, sometimes mixed with emergent vegetation for feeding on invertebrates, fish, and amphibians. Nesting occurs on sandy beaches and bars and mudflats. Classifying wetlands functioning as shorebird habitat is relatively straight forward as compared to some of the other functions because it depends entirely on the NWI Cowardin classification system. Table 13 contains the codes and conditions providing the determination for SBH. Figure 17 shows features performing SBH.

Highly functioning wetlands for shorebird habitat are seasonally or temporarily flooded unconsolidated shore areas *({P, L2,}US{A, C})* and mixes of unconsolidated shore and emergent vegetation *({P,L2}{[US,EM]/[US,EM]}{A, C})*.

Wetlands moderately functioning for shorebird habitat are palustrine and littoral lacustrine wetlands with unconsolidated bottom or aquatic beds *({P,L2}{UB,AB}{F, G})*. Unconsolidated bottom and aquatic bed mixes and either type mixed with emergent *({P, L2}{[UB,AB,EM]/[UB,AB,EM]}{F,G})* are also included as moderately functioning.

Table 13. Shorebird Habitat Wetland Codes and Conditions.

Shorebird Habitat (SBH)

LEVEL	WETLAND CODES											
	LLWW						NWI					NOTES
	Land-scape Posi-tion	CON	Water body	Land form	Water-flow Path	Sp. Mod.	CON	System	Class	Water Regime	Sp. Mod.	
High								L2	US	A		*US and mixes of EM and US are included, dominance irrelevant, EM only excluded
								P	EM*	C		
Moderate								L2	UB	F		*UB, AB and mixes containing UB, AB, and EM, dominance irrelevant, EM only wetlands are excluded
								P	AB	G		
									EM*			

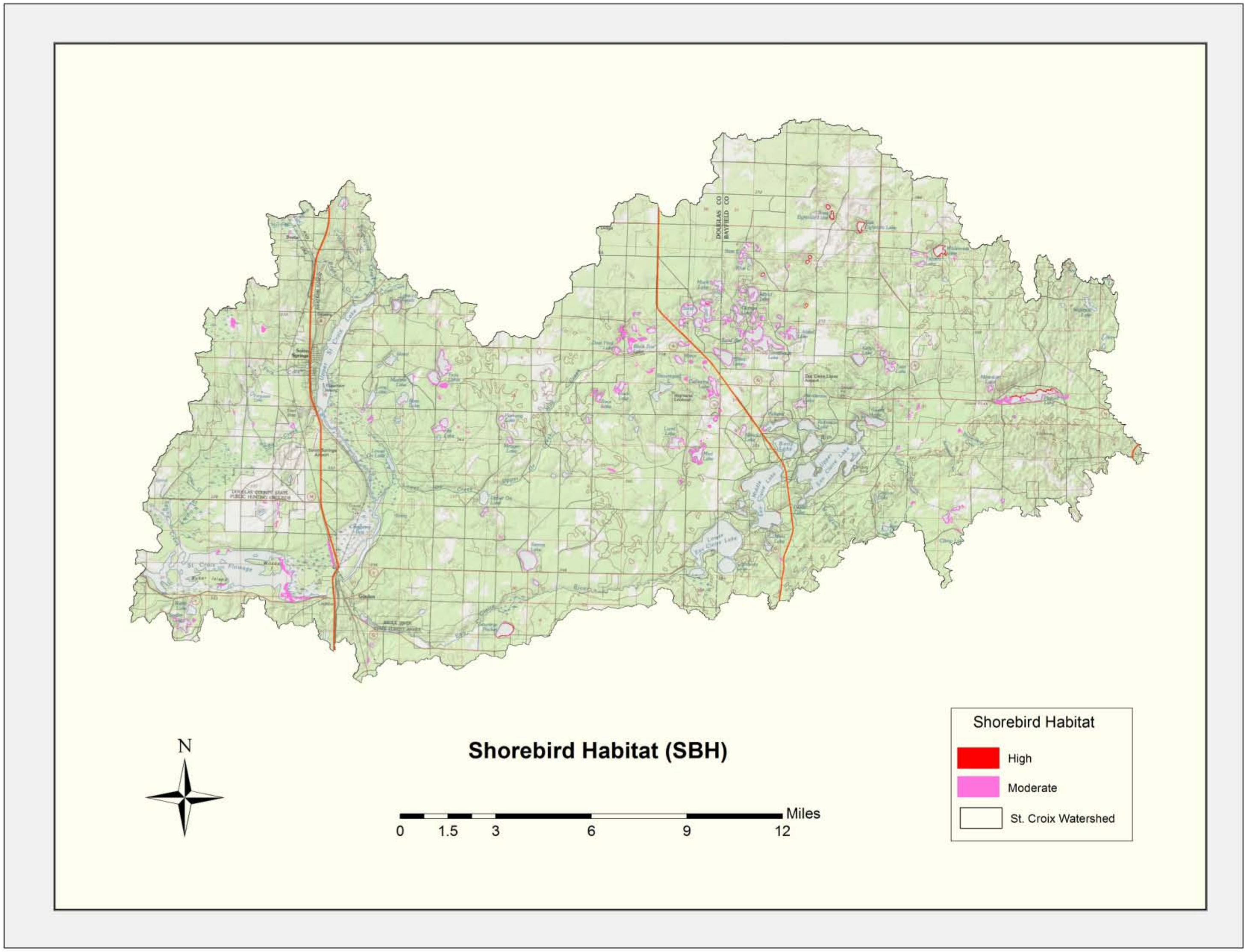


Figure 17. Shorebird Habitat Map.

Amphibian Habitat (APH)

Amphibians such as frogs, toads, and salamanders are commonly found in floating vegetation and wild rice. Some amphibian species require a variety of habitats for their life cycle, while others tend to stay in much wetter areas throughout their lives. Typically seasonally flooded to permanently flooded wetlands provide amphibian habitat. Shallower water habitats tend to be best for amphibians. As might be expected most wetlands classifications providing amphibian habitat are palustrine or lacustrine littoral. Table 14 contains the codes for APH.

Palustrine and lacustrine littoral aquatic beds *(PAB#, L2AB#)* function highly as amphibian habitat. Seasonally flooded or wetter emergent palustrine and lacustrine littoral wetlands also provide excellent amphibian habitat *({P, L2}EM{C, F, G, H})*. If organic soils are present the palustrine classifications providing the amphibian habitat become much broader including all classes with seasonally flooded or wetter water regimes *(P{AB, EM, SS, FO, US, UB}{C, F, G, H}g)*. Fens are a special habitat type of this group *(PEM1Bg)*. Wild rice beds *({L2, R2, P}EM2#)* are also considered highly functional for amphibian habitat. From a water body perspective woodland ponds (**PD1{b, c}**) provide high quality amphibian habitat.

All permanently flooded and intermittently exposed palustrine and lacustrine littoral wetlands *({P, L2}#,#)* are considered moderately functioning regardless of water regime. Water body types providing moderately functioning amphibian habitat include all natural ponds not already classified as highly functioning, impoundments, and excavated ponds (**PD1{not b OR c}**, **PD2#**, **PD3#**).

Table 14. Amphibian Habitat Wetland Codes and Conditions.

Amphibian Habitat (APH)

LEVEL	WETLAND CODES											NOTES
	LLWW						NWI					
	Land-scape Posi-tion	CON	Water body	Land form	Water-flow Path	Sp. Mod.	CON	System	Class	Water Regime	Sp. Mod.	
High								L2	AB	#		
								P				
								L2	EM	C		
								P		F		
										G		
										H		
								P	AB	C	g	organic soils
									EM	F		
									SS	G		
									FO	H		
									US			
									UB			
								P	EM1	B	g	fens
								L2	EM2	#		wild rice beds
								R2				
								P				
			PD1	#	#	b						woodland pond - wetland
						c						woodland pond - dryland
Moderate								L2	UB	#		all L2UB# and PUB welands are included regardless of water regime
								P	US			
			PD1	#	#	*not* b						natural ponds not included as highly functioning
						not c						
			PD2	#	#							excavated ponds and impoundments
			PD3	#	#							

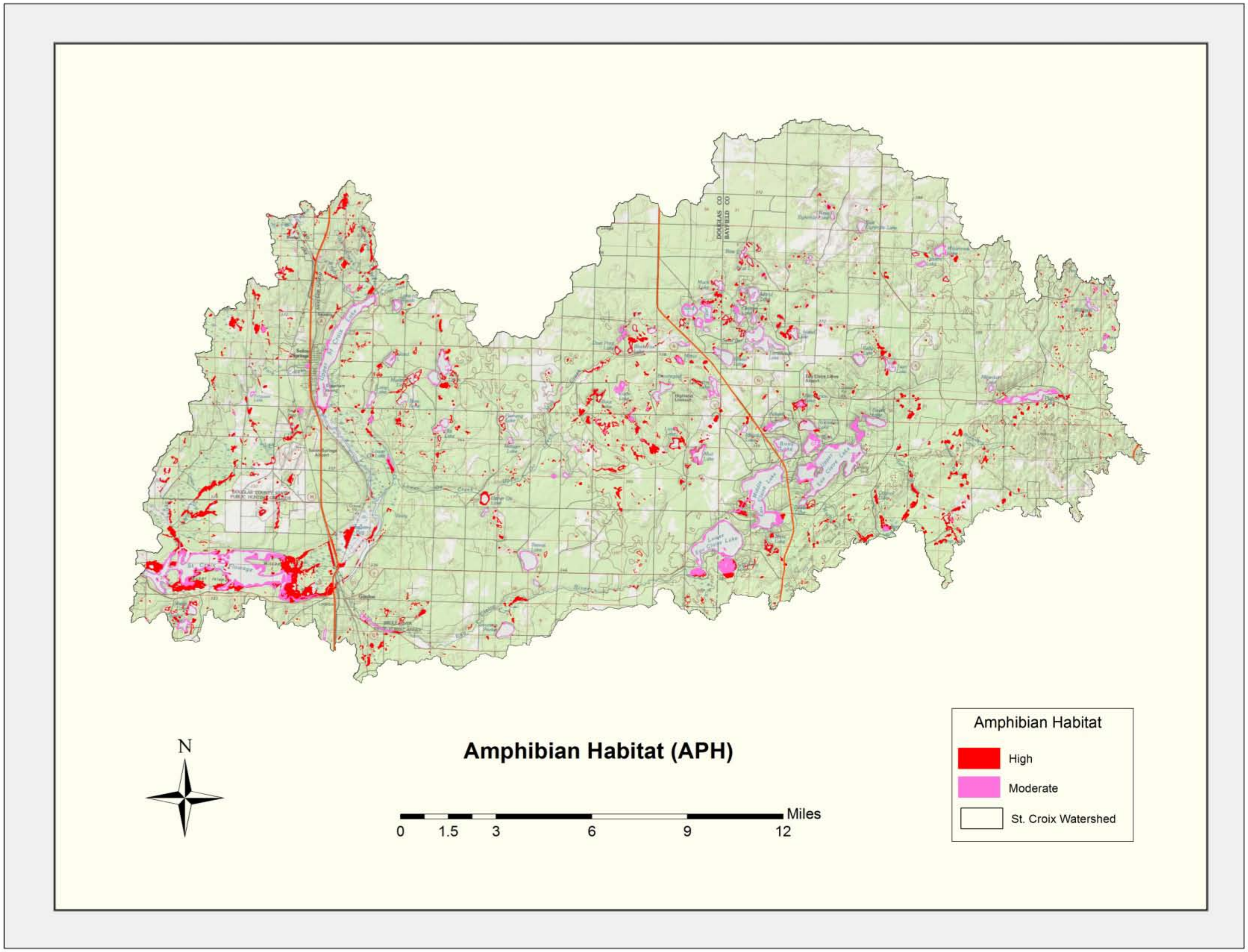


Figure 17. Amphibian Habitat Map.

General Wildlife Habitat (GWH)

General wildlife in this case includes mammals, reptiles, and songbirds. All vegetated wetlands perform this function to some degree, and only vegetated wetlands perform this function. The size and whether there are multiple vegetation types in a complex determine the level at which a wetland complex is functioning for GHW. It needs to be emphasized that this function is dependent on wetland complexes that may be made up of many different interconnected wetlands types. In other words it is the size of the entire wetland complex that determines its level of function and not the size of the individual wetlands making up the complex. Table 15 contains the codes and conditions that define this function. Figure 18 is the map showing the features performing GWH.

All vegetated wetland complexes *({L#,P}{AB, EM, SS, FO}#)* greater than or equal to 20 acres in size are highly functioning for GHW. Wetland complexes of greater than or equal to 10 acres are highly functioning provided they are made up of multiple vegetative types. For example, a monotypic patch of wild rice *(#EM2#)* that is 14 acres in size would not be highly functioning, but if the complex is 14 acres in size and made up of a mixture of wild rice and water lilies *(#AB#)* it is highly functioning.

All other vegetated wetlands not already classified as highly functioning are moderately functioning. For monotypic wetlands this includes all wetlands less than 20 acres in size. For wetland complexes with multiple vegetation types this includes all wetlands less than 10 acres in size.

Table 15. General Wildlife Habitat Wetland Codes and Conditions.

General Wildlife Habitat (GWH)												
LEVEL	WETLAND CODES											
	LLWW							NWI				NOTES
	Land-scape Posi-tion	CON	Water body	Land form	Water-flow Path	Sp. Mod.	CON	System	Class	Water Regime	Sp. Mod.	
High							*AND**	L#	AB	#		*all monotypical plant communites greater than or equal to 20 acres in size
								R#	EM			
								P	SS			
									FO			
							*AND**	L#	AB**	#		*all complexes with multiple vegetation class or subclass types greater than or equal to 10 acres in size **must have multiple classifications within the complex
								R#	EM			
								P	SS			
									FO			
Moderate							*AND**	L#	AB	#		*all monotypical plant communites less than 20 acres in size
								R#	EM			
								P	SS			
									FO			
							*AND**	L#	AB**	#		*all complexes with multiple vegetation class or subclass types less than 10 acres in size **must have multiple classifications within the complex
								R#	EM			
								P	SS			
									FO			

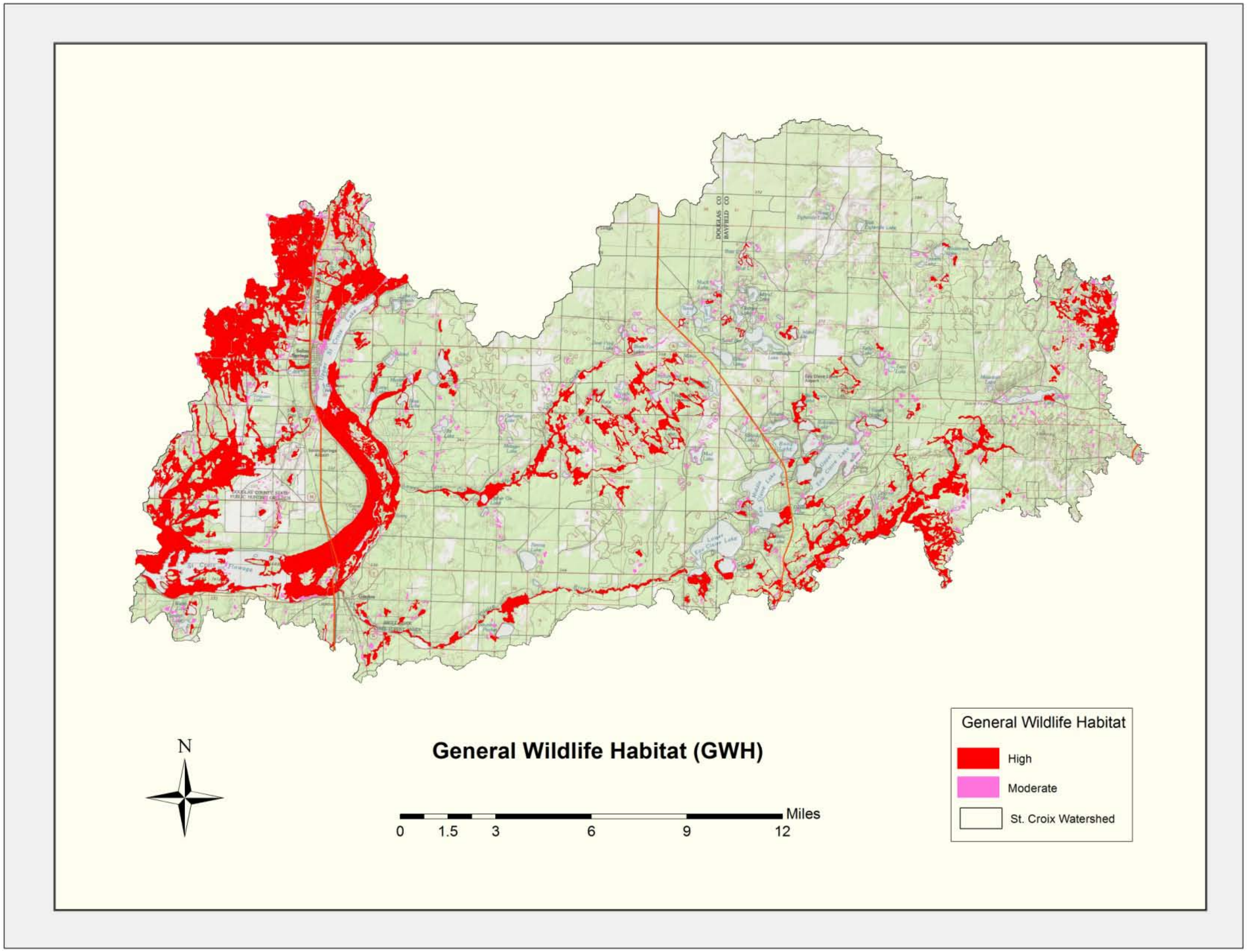


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Figure 18. General Wildlife Habitat Map.

Wetland Function – An Overview of the SCHW

Wetland functions were summarized in a similar fashion to the wetland classifications. Table 16 contains the summary of the wetland functions. The acreages of each wetland function were calculated for both highly and moderately functioning conditions. In order to better understand the contributions of wetlands in the watershed the total acreage and percentage was also calculated for each function. While wetland classifications are discrete and a single feature cannot be assigned multiple classifications within the same system, a single feature can perform multiple wetland functions. High and moderate designations within each function category are, however, mutually exclusive, making it possible to add the high and moderate acreages to get a total acreage for each function. The Fish Habitat function has an exception to this rule with the added category of Trout in addition to High and Moderate. Trout was added to address the unique conditions required for trout and the cold water species on which they depend to thrive, mainly through stream shading. There could be some overlap between wetlands classified as functioning for trout and the high and moderate designations in fish habitat, therefore Trout is not included in the totaled percentages.

The three most common functions performed by wetlands in the Saint Croix headwaters are carbon sequestration, surface water detention, and surface water maintenance. Carbon sequestration occurs to some degree in 100% of the wetlands in the watershed. Surface water detention is performed by 86.3% of the wetland area, and 84.8% of the wetland area contributes to surface water maintenance. It is not surprising SWD and SWM are significant in the SCHW because it is, after all, a headwater watershed. The least common function performed in SCHW is shorebird habitat with 3.8% of the area performing this function, and only 0.2% classified as highly functioning.

Table 16. Wetland Function Summary Table (page 1 of 2).

Wetland Functional Summary - 2009 Saint Croix Headwaters Watershed			
Wetland Function	Acreage	% of Watershed Acreage	% of Total Wetland Acreage in Watershed
General			
Total Area of Watershed	215,508.3	--	--
Upland	177,718.5	82.5%	--
Wetland	37,789.8	17.5%	--
Surface Water Detention (SWD)			
High	18,284.3	8.5%	48.4%
Moderate	14,315.7	6.6%	37.9%
Function Total	32,600.0	15.1%	86.3%
Surface Water Maintenance (SWM)			
High	26,765.2	12.4%	70.8%
Moderate	4,918.2	2.3%	13.0%
Function Total	31,683.4	14.7%	83.8%
Nutrient Transformation (NT)			
High	16,745.4	7.8%	44.3%
Moderate	7,201.1	3.3%	19.1%
Function Total	23,946.5	11.1%	63.4%
Sediment Retention (SR)			
High	14,222.4	6.6%	37.6%
Moderate	4,659.5	2.2%	12.3%
Function Total	18,881.9	8.8%	50.0%
Carbon Sequestration (CAR)			
High	4,839.3	2.2%	12.8%
Moderate	32,950.5	15.3%	87.2%
Function Total	37,789.8	17.5%	100.0%
Shoreline Stabilization (SS)			
High	7,852.4	3.6%	20.8%
Moderate	3,552.2	1.6%	9.4%
Function Total	11,404.6	5.3%	30.2%

Table 16. Wetland Function Summary Table (page 2 of 2).

Wetland Functional Summary - 2009 (cont.) Saint Croix Headwaters Watershed			
Wetland Function	Acreage	% of Watershed Acreage	% of Total Wetland Acreage in Watershed
Fish Habitat (FIS)			
High	10,829.4	5.0%	28.7%
Moderate	3,322.8	1.5%	8.8%
Function Total (High + Moderate)	14,152.2	6.6%	37.4%
Trout (stream shading)	2,730.8	1.3%	7.2%
Waterfowl/Waterbird Habitat (WFH)			
High	5,815.3	2.7%	15.4%
Moderate	10,250.1	4.8%	27.1%
Function Total	16,065.3	7.5%	42.5%
Shorebird Habitat (SBH)			
High	60.3	0.0%	0.2%
Moderate	1,380.2	0.6%	3.7%
Function Total	1,440.5	0.7%	3.8%
Amphibian Habitat (APH)			
High	5,067.2	2.4%	13.4%
Moderate	3,017.8	1.4%	8.0%
Function Total	8,085.1	3.8%	21.4%
General Wildlife Habitat (GWH)			
High	24,829.7	11.5%	65.7%
Moderate	2,681.9	1.2%	7.1%
Function Total	27,511.6	12.8%	72.8%

Historic Wetland Mapping - Functional Change

A modification of the original project was to delineate and classify wetlands for two additional photo periods within the western portion of the watershed. Historical wetlands were mapped based on 1948 and 1992 era imagery. These were then compared with the current, 2009 data for the study area. Table 17 contains the results of this comparison. Overall numbers for wetland and upland are included as well. Using the queries for the 2009 functional assessment, acreages were obtained for each of the wetland functions occurring in the western study area for each historic time step. The acreage change was calculated by subtracting the 2009 acreage from the acreage for each respective year and function. The percentage change was then calculated by dividing the change in acreage by the acreage from the year to which the 2009 data was being compared.

The ratio of wetland to upland within the study area is a very consistent 37% wetland to 63% upland for all three time eras examined. It is difficult to determine any definite trends from just three time "snapshots", but a few statements can be made about the data. The overall numbers indicate that the amount of wetland present in the watershed has remained relatively unchanged over the time period examined. This does not mean that there haven't been changes in wetland type or function, but it does mean losses in one area have been offset by gains in other areas. The total acreage for surface water detention has increased over time, but it appears the gains are in the moderately functioning category while the highly functioning acreage is decreasing. Surface water maintenance showed a similar pattern, but in this case the gains in moderate acreage were not enough to offset the losses in the high category causing a decrease in total acreage. Nutrient transformation acreage decreased between 1948 and 1992 and then bounced back to some degree between 1992 and 2009. Sediment retention showed the opposite pattern with a large increase in acreage between 1948 and 1992 and then a slight decrease between 1992 and 2009. Carbon sequestration is a unique case because all wetlands perform this function. Therefore, a gain in one category means there is a loss in another. However, the data indicates a higher proportion of highly functioning wetland over time for this function. Shoreline stabilization remained basically flat across the three time frames. Fish habitat again showed losses in high being offset by gains in moderate for slight gains in overall acreage performing function. The special case of Trout showed an increase from 1948 to 1992 and a decrease from 1992 to 2009. This could be due to timber harvest cycles because forested wetlands and the shade they provide are a major factor for this function. Waterfowl/waterbird habitat also decreased from 1948 to 1992, and then increased by almost 1,000 acres from 1992 to 2009, a 39.7% increase. Shorebird habitat was by far the smallest function in terms of acreage. The acreages are so small in fact to make the percentages misleading. Amphibian habitat exhibited large jumps in acreage between the years. Similar to trout habitat, this could be due to timber harvest cycles and large areas going from forested to emergent wetland. General wildlife habitat remained relatively flat from 1948 to 2009. It is not surprising given the universal nature of the factors contributing to general wildlife habitat, that it would follow the same trend as the overall proportion of wetlands within the study area.

Table 17. Wetland Functional Change Summary Table (page 1 of 3).

Wetland Functional Summary - 1948, 1992, 2009
Western Portion of Saint Croix Headwaters Watershed

	1948		1992		2009		Change 1948 to 2009		Change 1992 to 2009	
Wetland Function	Acreage	% of Study Area	Acreage	% of Study Area	Acreage	% of Study Area	Change in Acreage	% Change in Acreage	Change in Acreage	% Change in Acreage
General										
Total Area of Study Area	58,759.5	--	58,759.5	--	58,759.5	--	--	--	--	--
Upland	37,223.8	63.3%	37,268.5	63.4%	37,179.9	63.3%	-43.9	-0.1%	-88.6	-0.2%
Wetland	21,535.7	36.7%	21,491.0	36.6%	21,579.6	36.7%	43.9	0.2%	88.6	0.4%
Surface Water Detention (SWD)										
High	11,742.5	20.0%	11,373.0	19.4%	8,960.5	15.2%	-2,782.0	-23.7%	-2,412.5	-21.2%
Moderate	3,971.3	6.8%	4,392.8	7.5%	8,652.9	14.7%	4,681.6	117.9%	4,260.1	97.0%
Total	15,713.8	26.7%	15,765.8	26.8%	17,613.4	30.0%	1,899.6	12.1%	1,847.6	11.7%
Surface Water Maintenance (SWM)										
High	19,976.9	34.0%	19,975.5	34.0%	17,883.3	30.4%	-2,093.6	-10.5%	-2,092.2	-10.5%
Moderate	984.2	1.7%	897.8	1.5%	728.0	1.2%	-256.2	-26.0%	-169.8	-18.9%
Total	20,961.1	35.7%	20,873.3	35.5%	18,611.3	31.7%	-2,349.8	-11.2%	-2,262.0	-10.8%
Nutrient Transformation (NT)										
High	11,320.6	19.3%	10,139.2	17.3%	10,185.3	17.3%	-1,135.3	-10.0%	46.1	0.5%
Moderate	4,952.1	8.4%	4,933.0	8.4%	5,130.3	8.7%	178.2	3.6%	197.2	4.0%
Total	16,780.1	28.6%	15,072.2	25.7%	16,073.7	27.4%	-706.4	-4.2%	1,001.5	6.6%
Sediment Retention (SR)										
High	5,627.7	9.6%	5,326.3	9.1%	5,184.3	8.8%	-443.4	-7.9%	-142.0	-2.7%
Moderate	375.9	0.6%	1,707.1	2.9%	1,665.6	2.8%	1,289.8	343.1%	-41.4	-2.4%
Total	6,003.6	10.2%	7,033.4	12.0%	6,850.0	11.7%	846.4	14.1%	-183.4	-2.6%

Table 17. Wetland Functional Change Summary Table (page 2 of 3).

Wetland Functional Summary - 1948, 1992, 2009 (cont.)
Western Portion of Saint Croix Headwaters Watershed

	1948		1992		2009		Change 1948 to 2009		Change 1992 to 2009	
Wetland Function	Acreage	% of Study Area	Acreage	% of Study Area	Acreage	% of Study Area	Change in Acreage	% Change in Acreage	Change in Acreage	% Change in Acreage
Carbon Sequestration (CAR)										
High	2,360.4	4.0%	2,593.9	4.4%	2,831.7	4.8%	471.3	20.0%	237.8	9.2%
Moderate	19,175.3	32.6%	18,897.1	32.2%	18,747.9	31.9%	-427.4	-2.2%	-149.1	-0.8%
Total	21,535.7	36.7%	21,491.0	36.6%	21,579.6	36.7%	43.9	0.2%	88.6	0.4%
Shoreline Stabilization (SS)										
High	4,992.8	8.5%	4,981.8	8.5%	5,128.7	8.7%	136.0	2.7%	147.0	3.0%
Moderate	3,007.0	5.1%	2,766.4	4.7%	2,807.8	4.8%	-199.2	-6.6%	41.3	1.5%
Total	7,999.8	13.6%	7,748.2	13.2%	7,936.5	13.5%	-63.3	-0.8%	188.3	2.4%
Fish Habitat (FIS)										
High	4,150.9	7.1%	4,117.2	7.0%	4,054.8	6.9%	-96.1	-2.3%	-62.4	-1.5%
Moderate	1,305.5	2.2%	2,001.9	3.4%	2,357.8	4.0%	1,052.3	80.6%	355.9	17.8%
Total	5,475.8	9.3%	6,119.1	10.4%	6,423.1	10.9%	947.2	17.3%	304.0	5.0%
Trout	1,320.0	2.2%	2,090.4	3.6%	1,935.7	3.3%	615.7	46.6%	-154.7	-7.4%
Waterfowl/Waterbird Habitat (WFH)										
High	2,945.1	5.0%	2,441.1	4.2%	3,377.5	5.7%	432.3	14.7%	936.4	38.4%
Moderate	3,625.0	6.2%	3,860.2	6.6%	3,855.5	6.6%	230.5	6.4%	-4.7	-0.1%
Total	6,636.4	11.3%	6,336.8	10.8%	7,315.1	12.4%	678.7	10.2%	978.3	15.4%
Shorebird Habitat (SBH)										
High	0.3	0.0%	0.4	0.0%	0.1	0.0%	-0.3	-84.8%	-0.4	-87.8%
Moderate	308.4	0.5%	414.1	0.7%	270.5	0.5%	-37.9	-12.3%	-143.6	-34.7%
Total	308.8	0.5%	414.5	0.7%	270.6	0.5%	-38.2	-12.4%	-144.0	-34.7%

Table 17. Wetland Functional Change Summary Table (page 3 of 3).

Wetland Functional Summary - 1948, 1992, 2009 (cont.)
Western Portion of Saint Croix Headwaters Watershed

	1948		1992		2009		Change 1948 to 2009		Change 1992 to 2009	
Wetland Function	Acreage	% of Study Area	Acreage	% of Study Area	Acreage	% of Study Area	Change in Acreage	% Change in Acreage	Change in Acreage	% Change in Acreage
Amphibian Habitat (APH)										
High	3,056.4	5.2%	2,197.3	3.7%	2,514.2	4.3%	-542.2	-17.7%	316.9	14.4%
Moderate	946.9	1.6%	1,200.2	2.0%	1,148.0	2.0%	201.0	21.2%	-52.3	-4.4%
Total	4,782.0	8.1%	3,397.5	5.8%	4,121.8	7.0%	-660.2	-13.8%	724.2	21.3%
General Wildlife Habitat (GWH)										
High	17,313.1	29.5%	16,817.3	28.6%	16,969.6	28.9%	-343.5	-2.0%	152.3	0.9%
Moderate	783.6	1.3%	923.0	1.6%	876.9	1.5%	93.3	11.9%	-46.1	-5.0%
Total	18,096.7	30.8%	17,740.2	30.2%	17,918.7	30.5%	-178.0	-1.0%	178.5	1.0%

Historic Wetland Mapping – Classification Change

An additional component of the project is an analysis of change in wetland classifications between the 1948 data and the 2009 data in the western study area. It should be emphasized that this analysis refers strictly to the class component of the NWI code, or in the case of dual attributes the dominant NWI class. This analysis was executed using database queries to compare the two data sets, and look for changes. Table 18 displays the results of the analysis. This table contains the number of features that wholly or partially changed for each class from 1948 to 2009 and the acreage of those features, not the actual "shared" acreage between coincident 1948 and 2009 features. For this reason comparisons between Table 18 and previous tables are not valid because previous tables are based on actual acreage. The major NWI classes present in the data are listed with 1948 down the left side and 2009 across the top. The only NWI class not included in the analysis was unconsolidated shore, because there was very little present in the data. For example, to find the number of features that changed from emergent in 1948 to unconsolidated bottom in 2009, find the emergent row on the far left side of the table and move to the unconsolidated bottom column under 2009 NWI Classification Change. In this example, there were 95 features with a total of 95.17 acres that were classified as emergent in 1948 classified as unconsolidated bottom in 2009. The total on the far right hand side of the table is total acreage that changed from the respective 1948 NWI class to a different class in 2009.

The most change in terms of acreage from 1948 to 2009 occurred between the emergent, forested, and scrub-shrub classes. A possible cause for this is the timber harvest cycle. Because timber harvest is a significant industry in the Saint Croix Headwaters, tracts of land could be in various stages of regeneration, with the emergent tracts having been the most recently logged, and forested tracts reaching the stage where they might be logged in the near future, and scrub-shrub tracts in the interim stages.

Some of the changes between the time periods are probably due to small shifts in the wetland boundaries and not due to large scale changes in the landscape. An example of this is type of change is from aquatic bed in 1948 to upland in 2009. This change only consisted of three features with an area of only 0.16 acres. It should be noted the data was delineated by the same individual using a consistent procedure, however the base imagery was not consistent between the two time periods in terms of type and resolution. Given the differences in the source imagery, it is likely the smaller changes (50 acres or less) are largely due to these small shifts in wetlands boundaries form year to year and do not necessarily represent wholesale changes. The NWI data model also presents a limitation to the query process in that the entire code is contained in one field. This makes querying on the different elements of the code much more difficult than if the elements were parsed into separate fields. For this reason there is data in Table 18 comparing identical classes in both time eras. The purple boxes in the table signify those features that did not change class, but changed in some other aspect of the NWI code, such as water regime, subclass, or special modifier. These acreages are not included in the total acreage change in the far right column of the table. In many cases, changes in vegetation dominance caused a dual attribute to be added or removed. The subclass changing is another possibility. An example of a subclass change is a forest that was formerly dominated by broad-leaf deciduous trees (*PFO1*) such as silver maple (*Acer saccharinum*) is now dominated by needle-leaf evergreens (*PFO4*) such as black spruce (*Picea mariana*). Changes in water regime are also present between 1948 and 2009. One example of this is beaver activity causing a palustrine emergent saturated wetland (*PEMB*) to change to palustrine emergent seasonally flooded (*PEMCb*).

Table 18. NWI Class Change for Western Portion of Saint Croix Headwaters Watershed 1948-2009.

Wetland Change for Western Portion of Saint Croix Headwaters Watershed 1948-2009														
	2009 NWI Classification Change												2009 Total Change	
1948 NWI Classification	Aquatic Bed		Emergent		Forested		Scrub-Shrub		Unconsolidated Bottom		Upland		Total	
	Count	Acreage	Count	Acreage	Count	Acreage	Count	Acreage	Count	Acreage	Count	Acreage	Count	Acreage
Aquatic Bed	10	41.57	47	175.67	1	0.01	8	9.45	18	163.64	3	0.16	77	348.93
Emergent	11	14.52	316	558.55	581	1,071.86	271	711.03	95	95.17	71	42.86	1,029	1,935.44
Forested	2	3.44	339	595.80	550	3,251.91	327	911.94	80	57.72	119	95.07	867	1,663.97
Scrub-Shrub	3	3.10	158	318.97	274	1,149.84	184	909.21	44	39.80	38	23.44	517	1,535.14
Unconsolidated Bottom	1	1.11	128	208.20	20	4.16	49	23.60	22	20.81	16	4.34	214	241.40
Upland	0	0.00	24	10.77	29	38.44	12	10.57	31	33.79	0	0.00	96	93.57

Historic Wetland Mapping – Filled Wetlands

A final component of this project is a preliminary investigation of filled wetlands. This investigation concentrates on the developed areas of Solon Springs and Gordon. The 1992 wetlands data was compared to the 2009 data and areas that had been filled were attributed in the 1992 data with the 2009 land use or human activity for which the filled wetland is currently being utilized. The results are presented in Table 19. The main uses for which wetlands are being filled in the Saint Croix Headwaters are roads followed by residential. In fact roughly 90% of the filled wetlands were converted to these two land uses.

Table 19. Filled Wetlands 1992-2009.

Filled Wetlands 1992-2009			
Human Activity	Count	Acreage	% of Filled Wetlands
Mining	6	5.04	8.60%
Residential	43	15.95	27.24%
Road	47	36.55	62.41%
Utility	1	0.34	0.57%
Other	3	0.69	1.18%
Total	100	58.56	100.00%

Conclusions and Recommendations

The purpose of this project was to describe the existing wetland conditions in the Saint Croix Headwaters Watershed. This was accomplished by first mapping and classifying the wetlands to the NWI's Cowardin and LLWW classification systems. The classified wetland data combined with expert input was then used to develop a functional assessment scheme and perform a functional analysis. Functional analysis provides a better understanding of the roles played by the Saint Croix Headwaters wetlands in the ecosystem as a whole. Historical mapping provided a better understanding of how conditions are changing over time. The knowledge gained through completion of the project provides the basis for the following recommendations:

1. LLWW provides a useful tool for storing hydrogeomorphic metrics of wetland function. However, codes are quite detailed, not necessarily intuitive and need to be regionally adapted.
2. Expert local and regional input is required for determining applicable/appropriate wetland functions for specific study areas and for defining the wetland types that perform those functions.
3. Wetland change assessment is only possible when using delineation and classification methods that are consistent across all time steps. It is very difficult to adapt previously classified wetlands to a change summary because of different methods.

4. NWI, LLWW and spatial metrics are required for adequate assignment of wetlands to functional categories because each plays a role. In particular, Cowardin water regimes are critically important to determining wetland function.

5. During delineation and classification interpreters should employ as complete a range of Cowardin and LLWW modifiers as project imagery will support in order to provide detail for the functional assessment. The process could also include incorporation of classified upland buffers and, where interpretable, vegetative species (e.g. leatherleaf (*Chamaedaphne calyculata*), willow (*Salix* spp.), alder (*Aldus incana*), black spruce (*Picea mariana*) etc.). Species could be coded using the standard identifiers defined in the NRCS PLANTS database.

6. Multiple dates of field work are required to adequately validate image signatures, delineation, classification and functional assignment.

7. Detailed soils, surficial geology and bedrock geology would help to define sub-surface and internal drainage which has implications for functional assignment.

8. The image interpretation exercise should capture linear wetlands as well as polygons in order to adequately depict hydrologic connectivity and fully utilize the LLWW classification system.

9. Methods and function assignments from this project should be tested in a more urbanized watershed for applicability.

10. Basic (generalized) parameters should be defined to assist with economic valuation of wetlands. These could include: a gallon per acre storage number for different types of wetlands; water infiltration rates for generalized substrates; vegetation transpiration rates for emergent, scrub shrub and forested wetlands etc.

References

Wisconsin Wetland Inventory Classification Guide. 1992. Wisconsin Department of Natural Resources.

A User's Guide to the Wisconsin Wetland Inventory. 1991. Wisconsin Department of Natural Resources.

Cowardin, Lewis M., et.al. (1979). Classification of Wetlands and Deepwater Habitats of the United States. U.S Fish and Wildlife Service. FWS/OBS-79/31

Tiner, R.W. 2003. Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Northeast Region, Hadley, MA. 44 pp.

Appendices

Appendix A – Scoping Meeting

St. Croix Headwaters Watershed Meeting Summary
Monday August 15th, 2010

List of Participants

John Anderson – SMUMN, Photointerpreter
Jason Berkner – USACE, Project Manager Douglas, Ashland, Bayfield Counties
Kathy Bartleson (for Pamela Toshner) – WIDNR
Tom Bernthal – WIDNR, Wetland Ecologist
Steve Eggers – USACE, Senior Ecologist
Cherie Hagen – WIDNR, Wetland Team Leader
Steve LaValley – WIDNR, Watershed Manager – Douglas County
Andy Robertson – SMUMN, Project Manager
Elliot Stefanik - USACE, Biologist-Regional Technical Specialist

This project kickoff meeting was hosted by the USACE, St. Paul District. The primary purpose of the meeting was to discuss and finalize the scope of the St. Croix Headwaters watershed delineation project. Secondarily, the meeting provided the opportunity for: introductions of the project team, refinement of the project methodology, pre-selection of project test plots, and development of a tentative project schedule.

Project Methodology

<u>Pre-Field Trip Preparation</u>

1. Checkout wetland spatial data from master geodatabase, assemble desired digital imagery, hard-copy aerial photographic prints (stereo-pairs) with index, and beneficial collateral data (including SSURGO soils, digital topographic maps, and local precipitation data for three months prior to date of base photo acquisition and field verification trip
2. Rectify data if needed, and build ArcMap Project
3. Select check sites based on wetland photosignatures that are common to the project area as well as those that are uncommon (e.g. disturbed sites). High priority areas/signatures to be field checked are:
    a. ground water source wetlands (seeps) near Lake St. Croix and the Village of Solon Springs;
    b. possible errors of commission in the existing WWI database such as wetlands dominated by aspen or balsam poplar;
    c. other forested wetlands especially those dominated by northern white cedar;
    d. wetlands on non-sandy soils;
    e. disturbed, logged wetlands; and,
    f. wetlands on privately held land
4. Select study plots based on concentrations of high priority areas and selected photosignatures
5. Print hard-copy maps annotated with photo interpreters question/need for investigation and point coordinates. Upload waypoints and imagery into GPS unit. Assemble field gear/materials; Routine Wetland Determination Data Form, LLWW field documentation forms, Munsell Soil Color Chart Book, plant guides, tree spade, hand-lens, topographic maps, soil surveys, pencils, pens, GPS, digital camera.

6. Contact potential field-trip participants, reserve motel and vehicle (preferably four-wheel drive passenger truck or van)

Field-Trip Activities

1. Visit pre-selected check sites and document presence wetland, deep water habitat, or upland using USACE Routine Wetland Determination procedure, describe photo signature classify area in WWI and LLWW classification systems
2. As field-work progresses and similar signatures are encountered, sort and reprioritize pres-selected check sites and study plots
3. In consultation with other field team members, develop “working” document of photointerpretation signatures conventions. Photosignature conventions are designed to correlate photosignature “keys’ (colors, tones, size, shapes, patterns, textures, associations, and shadows) with associated land features.

Post-Trip Tasks

1. Upon return, write photointerpretation conventions to formally document signatures and the characteristics of the wetland and upland features that they were found to represent.
2. Submit photointerpretation conventions to WIDNR and USACE for authorization.
3. Delineate and classify study plots
4. Submit completed study plots to WIDNR/USACE as part of feedback loop.

Data Development and Submission

1. Delineate and classify wetland, deep water habitat, and upland for the entire project area using WWI and LLWW Systems. As base-line imagery was flown during severe drought, polygons in the existing WWI data base that are attributed as Deep Water Lake and Open Water will be incorporated in the updated database as previously mapped. These areas may have included aquatic bed vegetation, and persistent and non-persistent emergent vegetation. Point polygons will be applied to designate wetlands smaller than that can be represented by as polygon (e.g. Solon Springs). Current imagery will be used as a backdrop and collateral data will be referred to as necessary. Ralph Tiner will be consulted as project needs dictate to accurately apply the LLWW attributes.
2. Internal quality assurance procedures including validation of the final wetland geodatabase integrity using the USGS Master Geodatabase Verification Tool and established NWI topology rules.
3. The final wetland update will be submitted to the USACE and WIDNR for final review and incorporate any changes based on agreed upon photointerpretation conventions.
4. Develop metadata
5. Submit final WWI update to the DNR for inclusion into appropriate state database and to USFWS for crosswalk to NWI Cowardin classification and inclusion in the NWI Master Geodatabase.

Project Partners Commitments

1. To provide knowledge and information about wetland resources of the St. Croix River Headwaters project area.
2. To assist in the selection of appropriate test plot locations based on local knowledge of the watershed.
3. To participate in initial field photosignatures verification field trip.
4. To review and authorize agreed upon photointerpretation conventions
5. To provide feedback as needed to photointerpreter during course of the photointerpretation task.

Tentative Timelines/Schedules

1. August 17 to 20 – Request all imagery and collateral data not already obtained
2. August 23 to September 2 – Select photosignatures, and design sample plots
3. September 6 to 12 – Finalize field verification participants and logistics
4. September 13 to 17 – Conduct field verification of photosignatures
5. September 20 to 24 – Continue field verification, if needed and/or write and submit photointerpretation conventions
6. September 27 to November 12 – Conduct photointerpretation analysis and print draft maps
7. November 15 – Review draft maps in field
8. November 16 to November 30 – Incorporate any draft map changes, finalize and submit data

Appendix B – Conference Call

St. Croix Headwaters Watershed Conference Call Meeting Summary
9:30 AM to 10:30 AM Central Standard Time
Wednesday, September 08, 2010

List of Participants:

John Anderson – SMUMN, Photointerpreter
Tom Bernthal – WIDNR, Wetland Ecologist
Cherie Hagen – WIDNR, Wetland Team Leader
Andy Robertson – SMUMN, Project Manager
David Rokus – SMUMN, GIS Analyst
Chris Smith – WIDNR GIS/Biologist
Elliot Stefanik **-** USACE, Biologist-Regional Technical Specialist
Ralph Tiner– USFWS, Regional Wetland Coordinator, Region 5

This project coordination meeting was hosted by GeoSpatial Services, via a conference telephone call. The primary purpose of the meeting was to discuss technical aspects of wetland and water classification with respect to the application of the LLWW Functional Assessment within the St. Croix Headwaters Watershed project area. Secondarily, the meeting provided the opportunity for the introduction of Ralph Tiner to the project team, refinement of the project methodology and development of a tentative coordination schedule.

Project Overview:

Cherie Hagen provided an overview of the project for call participants:
In October, 2007, the USACE, St. Paul District entered into a partnership agreement with the WIDNR to perform a watershed study of the St. Croix Headwaters Watershed. This study is cost shared evenly between USACE and WDNR and its purpose is to evaluate key water resource issues within the watershed. These include evaluation of surface water quality and loading of key water quality constituents; identification of critical lake and riparian habitat for protection; identification and description of invasive species concerns; comprehensive fish passage; public outreach and other issues. It also includes assessing existing wetlands, including identification of wetland areas, identifying rare or unique wetland habitats, describing wetland functions, and identifying potential cumulative wetland change or loss. As a future step, the project may be modified to include analysis of historical imagery in order to assess wetland change (gains, losses, conversions) over time in the Headwaters area.

Discussion of WWI, NWI, and NWI Plus Systems:

The discussion centered on the applicability of the NWI and WWI Systems to provide baseline data needed to develop NWI Plus functional assessment classifications for each wetland. Ralph Tiner inquired about the WWI Classification System and how it compares to the NWI System. He stated that classifying Water Regimes using NWI standards is a key to implementing the LLWW System. He asked for the WWI Users Guide to better understand the coding system and possibly work through the basics parameters of a crosswalk between WWI and NWI.

The current project scope for the St. Croix Headwaters calls for interpretation and classification of wetlands using the WWI system. Unfortunately, this system does not have sufficient differentiation of water regimes in order to support LLWW wetland functional analysis. As a result, there was considerable discussion centered on how to capture and classify wetlands for this project so as to provide both WWI classification and NWI Plus functional analysis. In the end, three potential solutions were proposed to include water regime in the mapping exercise:

1. Each wetland polygon would be classified using both and NWI code and a WWI code in the attribute database and wetland delineation would be sufficient to map to the NWI water regime level. LLWW functional analysis codes would be added to the attribute database following delineation and classification. Project deliverables would include an NWI geodatabase and a WWI geodatabase. For the WWI geodatabase, internal boundaries in wetland polygons with the same adjacent WWI attributes would be dissolved.

2. Wetland polygons would be mapped and classified using only the WWI system, however, NWI detailed water regimes would be added to each polygon in order to facilitate LLWW functional analysis. In some cases internal divisions in WWI polygons would have to be added in order to accommodate water regime classification. The final geodatabase would include polygons with same adjacent attributes due to the addition of extra water regimes. Extra WWI regimes would include: Ka, Kb, and Kc for NWI A, B and C non standing water regimes and Hf, Hg, Hh for F, G, and H for standing water regimes. NWI Plus functional analysis codes would be added to the attribute database following delineation and classification.

3. Wetland polygons would be mapped and classified using only the NWI system with the addition of WWI modifiers as required to capture features of the WWI classification that are not include in current NWI coding. LLWW functional analysis codes would be added to the attribute database following delineation and classification. This is the least preferential of the options as it would preclude the delivery of a final product in WWI format.

Andy Robertson pointed out that maps will visually appear much more complex, as there will be more polygon subdivisions than the existing WWI maps due to the application of NWI Water regimes. If solution two is chosen then there will be same adjacent polygon errors in the final geodatabase and Lois Simon will need to be consulted about the implications of this to current WI wetland mapping protocols. There are seven NWI Water Regimes compared to the four WWI Water Regimes. This led to a discussion of the trade-offs between classification systems and database complexity.

Action: SMUMN will assess the relative merits of each option balanced against the project budget/timeline and make a recommendation to Elliott and Cherie regarding which approach will be utilized. It is essential that the classification system(s) to be used be agreed upon no later than the end of the field trip so that the photointerpretation process is not delayed.

Photo interpretation scale was then discussed particularly as a determinant of database complexity and the primary limiting factor of delineation time. Ralph Tiner stated that NWI applies a zoom scale of no larger than 1:7,000 for updating maps. Andy Robertson stated that the WWI minimum mapping unit and zoom scale is due to the fact that original photography is “Section centered” and is captured at a scale of 1:15840. This scale provides for a practical photointerpretation scale of 1:5280 when the original imagery is viewed and interpreted under three-power magnification. Given that the imagery available for the St. Croix Headwaters project is digital twelve inch resolution, it is practical to employee a maximum zoom scale of 1:5000 and a minimum mapping unit of one-quarter acre for this project.

The discussion then centered on the benefits and challenges cross-walking the NWI and WWI systems or alternatively, how they could be merged into a hybridized system. Tom Bernthal provided insight on the benefits of incorporating the Wisconsin’s existing hydrography dataset along with updated wetland maps as a basis for creating the NWI Plus layer.

Action: Tom Bernthal and Chris Smith to provide GSS with a download link for the WI NHD data as well as any other collateral layers that would be beneficial for the NWI Plus functional analysis process.

Ralph Tiner then proposed that Tom and Chris get in touch with Virginia Tech in order to discuss their efforts in automating portions of the NWI Plus functional analysis using a variety of GIS base layers and a decision model.

Action: Ralph to provide contact information for Virginia Tech.

Andy Robertson informed the members of the teleconference, that even though a classification scheme has not yet been finalized, next week's field work would proceed as planned September 13^{th} to 17^{th}. The field notes will include both NWI and WWI classifications for all check sites. Elliot Stefanik was unable to participate in our discussion, however. He indicated his interest in participating in field work during the week of September 28^{th}.

Next Steps:

Following the fieldwork that will take place between September 13^{th} and 24^{th}, SMUMN will undertake the delineation and classification of wetlands for the ten sample plots identified in previous project meetings. Wetlands in the sample plots will be coded according to the agreed upon classification system and will also include LLWW functional analysis code. There would then be a group face to face meeting to review the results of the sample plots and discuss the completion of the mapping for the remainder of the project study area. A tentative date of October 25, 26 or 27^{th} was selected for this meeting given Ralph's availability. A specific location for the meeting will be determined.

Action: Ralph plans to get in touch with Elliot to discuss financial arrangements for travel.

Appendix C – Field Trip Report

Field Trip Summary Report for Verification of Aerial Imagery
Wisconsin Wetland and National Wetland Inventory
St. Croix Headwaters Watershed
September 13th to 17th, 2010

Purpose

This field trip was conducted for the purpose of verification of wetland features and non-wetland features so that a "selective key' of photosignatures could be created. This baseline information will serve as a guide for identifying and classifying features, as seen on imagery, in the WWI and NWI, and LLWW Classification Systems.

Field Verification Team

John Anderson – SMUMN, Photointerpreter
Jason Berkner – USCOE, Manager Douglas, Ashland, Bayfield Counties
Leslie Day – USCOE, Field Technician
Eric Hanson – USCOE, Field Technician
Steve LaValley-WIDNR, Watershed Manager – Douglas County
David Rokus – SMUMN, GIS Analyst

Method

The field-verification process involved three stages; check-site selection, in-field verification, and post-trip documentation.

Check Site Selection

Leaf-off, 2009 imagery was reviewed for check site selection. Points representing sites to be visited were created heads-up using ArcGIS 9.3. Check sites were selected in areas that could not clearly be identified as upland or wetland or classified accurately on the imagery with the aid of the WWI database, or collateral imagery or maps.

Points were located where collateral data indicated that a wetland may exist but was not mapped due to an error of omission. Such indications as a USGS DRG depression or potential hydric soil from the SSURGO database provided check site locations. Conversely, check sites were selected from areas where imagery photosignatures do not support previous mapping and may have been added by errors of commission (e.g. tree shadow). Other types of pre-trip selection include correlation of water regime or class or subclass with representative photosignatures.

Additionally, sites were selected that exhibited signatures caused by drawn down water levels due to prolonged drought. Site selection also focused on identifying signatures of plant communities of interest such as Eastern white cedar (*Thuja occidentalis*). Wild rice (*Zizania aquatic*) will also now be captured in the new database.

500 check sites were pre-selected based on the above criteria. Approximately 200 of these check sites were determined to be road accessible. Hard-copy images showing accessible check sites were printed as map layouts for the use under field conditions. In addition, hard-copy topographic DRGs overlaid with

poorly and very poorly drained soils polygons and WWI polygons were printed and stapled to each image for use as collateral data. Field data sheets, field maps with imagery, plant field guides, magnification loupe, tree-spade, and Munsell Soil Color Chart were accessible during the trip. Team members were contacted to coordinate logistics.

Field Verification

The field trip consisted of a rapid inventory by car of as many wetland features as possible in the project area. A great majority of the project area is in private ownership and therefore large areas are not accessible. Most of the accessible or visible wetlands are located along public roads or in parklands that are easily accessible by foot.

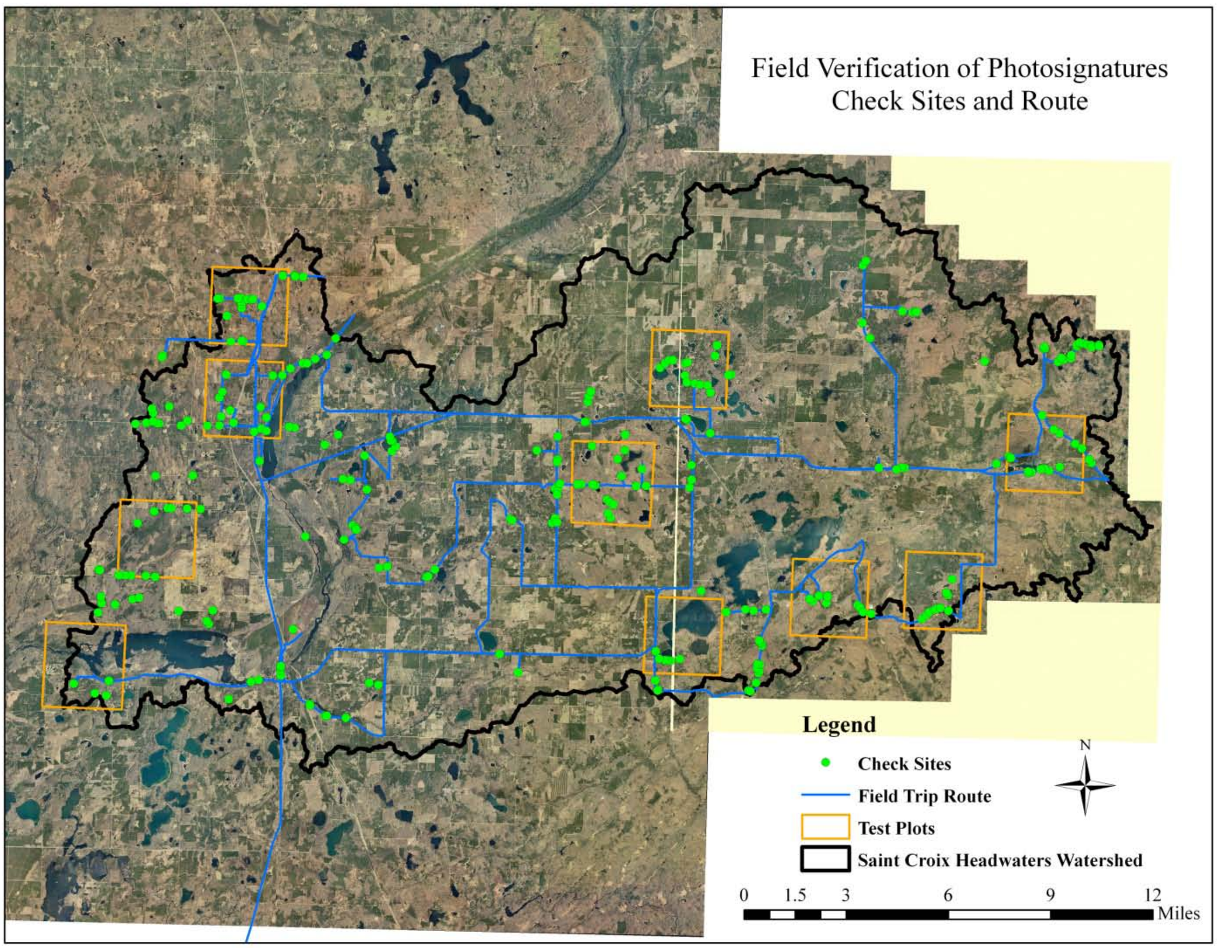

Figure C1. Field Work Check Sites and Travel Route.

Approximately 150 sites were checked during the field trip (Figure 4). Many were documented using the NWI Field Data Sheet format. At these sites, surface hydrology indicators were observed, soil profiles were characterized, and species of hydrophytes were documented to determine the presence or absence of wetland, classify wetland, and describe associated photosignatures.

Features were classified in the WWI and NWI Classification System. At each site, a GPS point and a series of ground-level photos were taken. Other sites were documented with an in-field classification written on the hard-copy map with corresponding GPS coordinates and a ground-level photo.

In addition, the City of Solon Springs was thoroughly field checked to map all wetlands within its borders. Flat forested wetland areas that were under-mapped north and west of Lake St. Croix were also thoroughly checked.

Appendix D – Mid-Project Review

St. Croix Headwaters Watershed Meeting Summary
Tuesday, October 26th and Wednesday, October 27, 2010

List of Participants:

John Anderson – SMUMN, Photointerpreter
Tom Bernthal – WIDNR, Wetland Ecologist
Cherie Hagen – WIDNR, Wetland Team Leader
Steve LaValley – WIDNR, Watershed Manager – Douglas County
Andy Robertson – SMUMN, Project Manager
Elliot Stefanik - USACE, Biologist-Regional Technical Specialist
Ralph Tiner– USFWS, Regional Wetlands Coordinator
Pamela Toshner – WIDNR, Water Resources Management Specialist

This project coordination meeting was hosted by WIDNR at the Northern Region Headquarters in Spooner. The primary purpose of the meeting was to review photointerpreted wetland delineations and classifications in ten, five square mile, sample plots. Technical aspects of wetland and water classification with respect to the application of the Wisconsin Wetland Inventory (WWI), National Wetland Inventory (NWI) and the USFWS, "NWI Plus" (LLWW) Functional Assessment were reviewed. Secondarily, the meeting provided the opportunity for Ralph Tiner to provide detailed information about the NWI Plus Classification System and to provide feedback about LLWW classification apply this system in the St. Croix Headwaters project area.

Discussion of WWI, NWI, and NWI Plus Systems:

The first day consisted of presentations by Andy Robertson of an overview project goals and objectives and general technical approaches to data development. John Anderson then described field verification procedures and results from the September 2010 field trip. He went on to discuss wetland photointerpretation methods and technical challenges specific to identifying and classifying wetlands in this project area using available imagery.

The salient points of Mr. Anderson's presentation are as follows:

1. Field verification
    a. Sample plots that were selected because they were the most complex in the project area and therefore would provide many opportunities to field check typical and atypical photosignatures
    b. Approximately 100 sites were GPS located with corresponding site specific information
    c. An additional 200 sites were classified informally in writing on hard-copy imagery.
    d. Wetland/non-wetland characteristics (hydrology, soils, vegetation) and photosignatures (color, tone, texture, association, shape, size) were correlated and documented.
    e. Steven LaValley and Jason Birkner provided input based on their expertise in the area.
    f. Leaf-on conditions were a hindrance to efficiency in the field.

   g. Late season timing of the trip made it more difficult to determine Water Regime. Spring-normal conditions are preferable as the understory of forested areas is more visible, herbaceous plant communities have emerged, and water conditions are usually optimal.

2. Photointerpretation
   a. Image analysis was performed using true-color digital imagery in a heads-up environment in ArcMap 9.3
   b. Stereoscopic collateral imagery was reviewed where coverage is available
   c. Other useful collateral data includes Wisconsin Wetland Inventory data, SSURGO Soils Data (classified as poorly and very poorly drained soils), USGS topographic information (DRG's-marsh symbols, depression symbols, and flat areas), NHD streams data base, Google Earth historical imagery and "street view" application also was used as collateral.
   d. Wetland was classified in the NWI (Cowardin et.al.) classification system then equivalent WWI classifications were added to the geodatabase along the LLWW "Barebones" classifications.
   e. Examples of NWI Water Regimes were presented along with a description of the benefits of applying NWI Soil Modifiers in providing more precise information about the frequency and duration of inundation and saturation of wetlands in this area.
   f. Using the current drawdown condition of Pigeon Lake as an example, Mr. Anderson discussed how he applied the NWI and WWI classification Systems to address this situation. The littoral (less than six feet deep) lake zones that were drawn-down at the date of photography will be classified as "Intermittently Exposed", The NWI "G" Water Regime when they are shown as open water on the DRG. Open Water (DRG) littoral zones that are open water on the imagery will be classified as "Permanently Flooded" the NWI "H" Water Regime. Both of these areas are classified at W0L in the WWI System. The Limnetic (greater than six feet deep) lake zones will also be described as Permanently Flooded in the NWI system and DWL in the WWI system.
   g. Limitations of true-color, two-dimensional imagery were discussed, in that true-color imagery has a poor soil moisture discrimination capability and differentiation of forested subclass areas is more difficult (e.g. cedar, Thuja occidentalis from black spruce, Picea mariana). Where stereo is not available it is more difficult to determine plant community life-form. Crown diameter size of shrubs versus trees is one of the helpful clues.

3. NWI Plus (LLWW)
   a. Ralph Tiner followed with a detailed presentation about the Landscape Position, Landform, Water flow-path, and Water body Classification System
   b. Ralph pointed out the benefits of this system that when NWI Water Regimes have been delineated and classified for an area, LLWW data can be developed to become a powerful analytical tool, allowing users to predict wetland functions for large geographic areas, better characterize wetlands (Palustrine wetlands associated with lakes, rivers, streams, and ponds) and generate information of interest to policymakers and others (e.g. how many and how much of the wetland resource is isolated or connected to waters of the United States).
   c. Ralph emphasized that this method is a "first approximation" of wetland functions and that more detailed information using the HGM Method or a Rapid Assessment Method (RAM) would be needed to determine the functions of a specific wetland or wetland complex.
   d. Mr. Tiner stated LLWW data is dependent on source data limitations (i.e. imagery, wetland or other surface water databases) which may include errors or omission or commission.
   e. He described how the LLWW data could be synthesized to make values determinations for the ability of the resource to sequester carbon, stabilize shoreline, provide habitat for fish and shellfish, moderate flooding, and recharge groundwater.

Group Discussions-Day One

After Presentations by Mr. Robertson, Mr. Anderson, and Mr. Tiner, the group entered into a discussion focused on specific wetland areas. Feedback was provided by Ralph about LLWW classifications of the draft data produced for each plot. Tom Bernthal, in particular, had many questions about NWI plus coding.

Field trip – Day Two

Delineated plots in the western part of the project were field checked by the group. These areas are in Solon Springs, a plot in the northwestern portion of the study area, and a plot at the St. Croix Flowage dam site. Ralph Tiner lead discussions about the LLWW classifications found in the field. In Solon Springs, for example, he pointed out that hydrological connections such as road-side ditches and culverts must be taken into account establish that connectivity exist and to differentiate isolated wetland from outflow wetland. John Anderson pointed out differences in photosignatures and their correlation to wetland types. Numerous discussions about applications of the LLWW System and methods throughout Wisconsin were engaged by group members.

Action: Wild Rice data layer will be provided to GeoSpatial Services (GSS) to incorporate this information into the project database. A statewide wetland mapping document will be provided.

Action: A statewide wetland mapping document will be provided to GSS.

Next Step:
GSS will incorporate information gathered from group feedback and field trip to complete the remainder of the project by the end of December, 2010

Appendix E – Example Field Data Sheets

<u>Field Data Sheet - 115</u>

Field Form ID: 115

Site Code: 31

State: Wisconsin County: Douglas

USGS Quad: Minong Flowage (B-8)

TWP/R: 20/6 Lat/Long (dd.dd): 46.24 N; 91.93 W

Datum: NAD 83

Reported by: John Anderson-SMUMN Date: September 14, 2010
(Name and affiliation) (dd/mm/yyyy)

Other Participants: Jason Birkner-USACE
Steven LaValley-WIDNR,
David Rokus-SMUMN

Accessed Via: Road
(Boat /road /helicopter /air boat/etc.)

Wetland type: isolated depression

Cowardin Classification: PEM1Cg (E2K-WWI)
(Lake, fen, pothole, etc.)

Video: Photograph(s): quantity: 2
(Direction and view angle)

Direction and view angle: #0492, North, horizontal
#0493, vertical (pit and plug)

Source Imagery

Type of Imagery Used: Photograph: **<u>X</u>** DOQQ:

Sat. Image: Other:

Date of Imagery: June, 2009

Imagery source: Douglas County Type: True-Color Scale: 1:500

Discussion of Imagery:
Signature has a smooth photographic texture, light tone, whitish color, irregular shape and is represented by a wetland Point Symbol by the WWI and Marsh Symbols by the USGS

Wildlife

Wildlife Observations:

Tide Stage: High: Low: Slack:

Water Depth at the time of field visit: Surface water absent, standing water in soil pit at 14”
(Feet or inches)

Indicators

Standing water Water Marks

Buttressed Trunks Water Stained Leaves

Water Carried Debris Saturated Soils **X**

Floating Mat Shallow Roots

Bare Areas Oxidized Rhizospheres

Other Indicators of Hydrology

Surrounding Land Use: Forest Land
(Farmland, residential, mining, etc.)

Hydrogeomorphic Classification: Depressional, Herbaceous Marsh

Plant Community

Dominance Type: sedge

Abundance - Cover Dense (high) 70 - 100% **X**

Common (medium) 30 - 69%

Occasional < 30%

Common Plant Spp.: *Carex lacustris* (Obligate)

Less Common Plant Spp.:

Rare or Unique Plant Spp.:

Soils/Substrate

Substrate type: Silt Sand Clay Loam Peat **X**

Rubble Rock Other

Soil Map Unit Name: N/A - inclusion

Taxonomy:

Drainage Class: very poor Hydric List (National)

Other

Soil Survey Publication Date: 2006

Munsell: hue value chroma

10 YR 2/1 0” to 16” (inches)

Hydric Soil Indicators

Histosol **X** Concretions Histic Epipedon

High Organic Content **X** Sulfidic Odor Organic Streaking

Aquic Moisture Regime1 Reducing Conditions Gleyed

Other Remarks Hemic

Disturbance

Fill Waste Dredging Fire

Channels/ditches Farming Industrial Residential

Commercial Timber Harvesting Roads Drainage

Impoundment Other

Land Ownership

Federal State **X** County Private

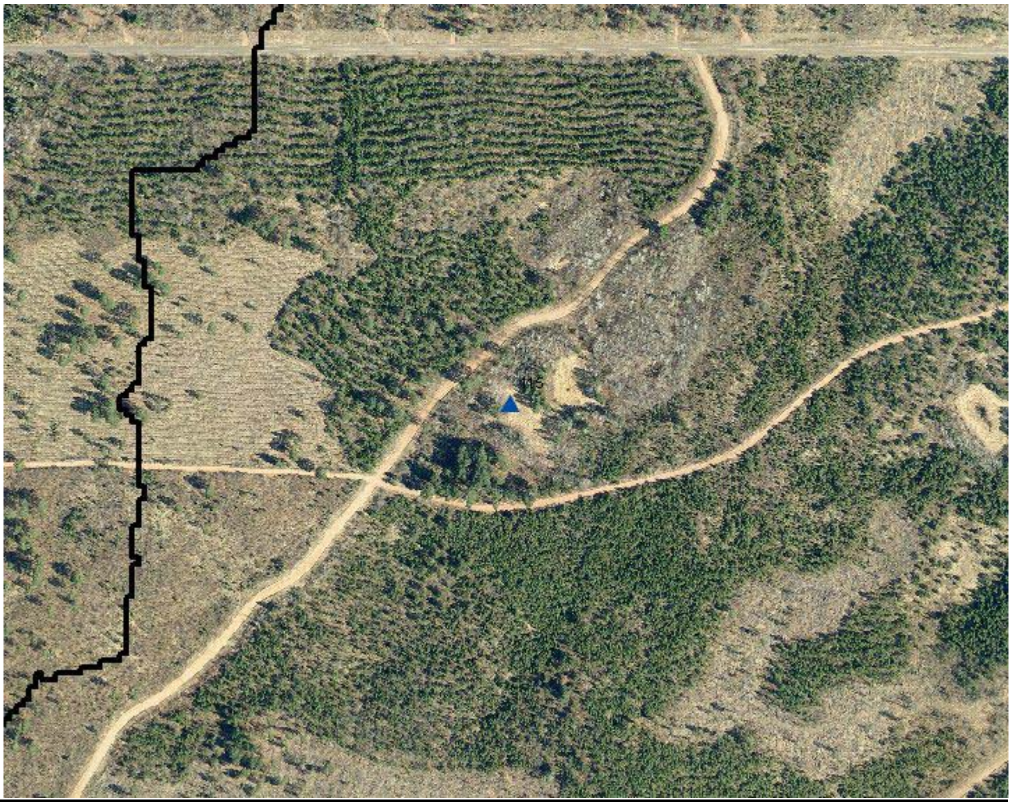

Figure E1. Field Verification, Site #115, Imagery view.

Figure E2. Field Verification, Site #115. Looking North.

Figure E3. Field Verification, Site #115, Soil plug.

Field Data Sheet - 28

Field Form ID: 28

Site Code: 31

State: Wisconsin County: Douglas

USGS Quad: Solon Springs (C-7)

TWP/R: 44/12 Lat/Long (dd.dd): 46.32 N; 91.86 W

Datum: NAD 83

Reported by: John Anderson-SMUMN Date: September 13, 2010
(Name and affiliation) (dd/mm/yyyy)

Other Participants: Jason Birkner-USACE
Leslie Day-USACE
Steven LaValley-WIDNR
David Rokus-SMUMN

Accessed Via: Road
(Boat /road /helicopter /air boat/etc.)

Wetland type: flat

Cowardin Classification: PFO1Bm (T3K-WWI)
(Lake, fen, pothole, etc.)

Video: Photograph(s): quantity: 3

Direction and view angle: #0471, North, horizontal
#0472, South, horizontal
#0473, vertical (pit and plug)

Source Imagery

Type of Imagery Used: Photograph: **X** DOQQ:

Sat. Image: Other:

Date of Imagery: June, 2009

Imagery source: Douglas County Type: True-Color Scale: 1:500

Discussion of Imagery: Gray tone and smooth texture; an area dominated by aspen similar to nearby upland aspen areas; utilize WWI, stereopairs, collateral soils, DRG to differentiate

Wildlife

Wildlife Observations:

Tide Stage: High: Low: Slack:

Water Depth at the time of field visit: Surface water absent, standing water in pit absent
(Feet or inches)

Indicators

Standing water Water Marks

Buttressed Trunks Water Stained Leaves

Water Carried Debris Saturated Soils

Floating Mat Shallow Roots **X**

Bare Areas Oxidized Rhizospheres

Other Indicators of Hydrology: Wetland Drainage Pattern

Surrounding Land Use: Forest Land
(Farmland, residential, mining, etc.)

Hydrogeomorphic Classification: Mineral Soil Flat

Plant Community

Dominance Type: poplar

Abundance - Cover Dense (high) 70 - 100% **X**

Common (medium) 30 - 69%

Occasional < 30%

Common Plant Spp.: *Populus tremuloides* (FAC), *Calamagrostis canadensis* (OBL)

Less Common Plant Spp.: *Onoclea sensibilis* (FACW)

Rare or Unique Plant Spp.:

Soils/Substrate

Substrate type: Silt Sand **X** Clay Loam Peat

Rubble Rock Other

Soil Map Unit Name: N/A - inclusion

Taxonomy:

Drainage Class: very poor Hydric List (National)

Other

Soil Survey Publication Date: 2006
Munsell: hue value chroma

10YR2/2	0" to 1.5"	loamy sand
10YR5/3	1.5" to 7"	sand
10YR5/3	7" to 14"	organic streaking (30%)
7.5YR3/3	14" to 16"	sand

Hydric Soil Indicators

Histosol Concretions Histic Epipedon

High Organic Content Sulfidic Odor Organic Streaking **X**

Aquic Moisture Regime Reducing Conditions Gleyed

Other Remarks

Disturbance

Fill Waste Dredging Fire

Channels/ditches Farming Industrial Residential

Commercial Timber Harvesting Roads Drainage

Impoundment Other

Land Ownership

Federal State County **X** Private

Figure E4. Field Verification, Site #28, Imagery view.

Figure E5. Field Verification, Site #28, Looking North.

Figure E6. Field Verification, Site #28, Looking South.

Figure E7. Field Verification, Site #28, Soil Plug.

Field Data Sheet - 37

Field Form ID: 37

Site Code: 31

State: Wisconsin County: Douglas

USGS Quad: Solon Springs (C-7)

TWP/R: 45/12 Lat/Long (dd.dd): 46.36 N; 91.81 W

Datum: NAD 83

Reported by: John Anderson-SMUMN Date: September 13, 2010
(Name and affiliation) (dd/mm/yyyy)

Other Participants: Jason Birkner-USACE
Leslie Day-USACE
Steven LaValley-WIDNR
David Rokus-SMUMN

Accessed Via: Road
(Boat /road /helicopter /air boat/etc.)

Wetland type: flat

Cowardin Classification: PFO1Cg (T3K-WWI)
(Lake, fen, pothole, etc.)

Video: Photograph(s): quantity: 1

Direction and view angle: #0458, South, horizontal

Source Imagery

Type of Imagery Used: Photograph: **X** DOQQ:

Sat. Image: Other:

Date of Imagery: June, 2009

Imagery source: Douglas County Type: True-Color Scale: 1:500

Discussion of Imagery: Gray tone and rough texture; black ash signature per Steve LaValley

Wildlife

Wildlife Observations:

Tide Stage: High: Low: Slack:

Water Depth at the time of field visit: Surface water absent, standing water in pit absent
(Feet or inches)

Indicators

Standing water Water Marks

Buttressed Trunks Water Stained Leaves

Water Carried Debris Saturated Soils

Floating Mat Shallow Roots **X**

Bare Areas Oxidized Rhizospheres

Other Indicators of Hydrology: Wetland Drainage Pattern

Surrounding Land Use: Residential
(Farmland, residential, mining, etc.)

Hydrogeomorphic Classification: Organic Soil Flat

Plant Community

Dominance Type: black ash

Abundance - Cover Dense (high) 70 - 100% **X**

Common (medium) 30 - 69%

Occasional < 30%

Common Plant Spp.: *Fraxinus pennsylvanica* (FACW)

Less Common Plant Spp.: *Thuja occidentalis* (FACW)

Rare or Unique Plant Spp.:

Soils/Substrate

Substrate type: Silt Sand Clay Loam Peat

Rubble Rock Other Muck

Soil Map Unit Name: Bowstring muck

Taxonomy: Fluvaquentic Haplosaprist

Drainage Class: Very Poor Hydric List (National)

Date: 2006
Munsell: hue value chroma
Not sampled – private land

Hydric Soil Indicators

Histosol Concretions Histic Epipedon

High Organic Content Sulfidic Odor Organic Streaking

Aquic Moisture Regime Reducing Conditions Gleyed

Other Remarks

Disturbance

Fill Waste Dredging Fire

Channels/ditches Farming Industrial Residential

Commercial Timber Harvesting Roads Drainage

Impoundment Other

Land Ownership

Federal State County Private **X**

Figure E8. Field Verification, Site #37, Imagery view.

Figure E9. Field Verification, Site #37, Looking South.

Field Data Sheet - 38

Field Form ID: 38

Site Code: 31

State: Wisconsin County: Douglas

USGS Quad: Solon Springs (C-7)

TWP/R: 45/12 Lat/Long (dd.dd): 46.38 N; 91.81 W

Datum: NAD 83

Reported by: John Anderson-SMUMN Date: September 13, 2010
(Name and affiliation) (dd/mm/yyyy)

Other Participants: Jason Birkner-USACE
Leslie Day-USACE
Steven LaValley-WIDNR
David Rokus-SMUMN

Accessed Via: Road
(Boat /road /helicopter /air boat/etc.)

Wetland type: flat

Cowardin Classification: PFO1/4Cg (T3/5K-WWI)
(Lake, fen, pothole, etc.)

Video: Photograph(s): quantity: 1

Direction and view angle: #0459, North, horizontal
#0460, South, horizontal

Source Imagery

Type of Imagery Used: Photograph: X DOQQ:

Sat. Image: Other:

Date of Imagery: June, 2009

Imagery source: Douglas County Type: True-Color Scale: 1:500

Discussion of Imagery: True color imagery makes distinguishing deciduous from coniferous more difficult; black spruce have tight crowns and black ash trees have wider crowns and have a light tone; WWI mapped as non-wetland, NRCS-very poorly drained soils

Wildlife

Wildlife Observations:

Tide Stage: High: Low: Slack:

Water Depth at the time of field visit: Surface water absent, standing water in pit absent
(Feet or inches)

Indicators

Standing water Water Marks

Buttressed Trunks Water Stained Leaves

Water Carried Debris Saturated Soils **X**

Floating Mat Shallow Roots **X**

Bare Areas Oxidized Rhizospheres

Other Indicators of Hydrology:

Surrounding Land Use: Residential
(Farmland, residential, mining, etc.)

Hydrogeomorphic Classification: Organic Soil Flat

Plant Community

Dominance Type: black ash and black spruce

Abundance – Cover Dense (high) 70 – 100% **X**

Common (medium) 30 – 69%

Occasional < 30%

Common Plant Spp.: *Fraxinus pennsylvanica* (FACW), *Picea mariana* (FACW)

Less Common Plant Spp.: *Acer rubrum* (FAC), *Alnus Rugosa* (OBL) *Onoclea sensibilis* (FACW)

Rare or Unique Plant Spp.:

Soils/Substrate

Substrate type: Silt Sand Clay Loam Peat

Rubble Rock Other Muck

Soil Map Unit Name: Wozny muck

Taxonomy: Typic Epiaqualfs

Drainage Class: Very Poor Hydric List (National) **X**

Other

Soil Survey Publication Date: 2006
Munsell: hue value chroma
Not sampled – private land

Hydric Soil Indicators

Histosol Concretions Histic Epipedon

High Organic Content Sulfidic Odor Organic Streaking

Aquic Moisture Regime Reducing Conditions Gleyed

Other Remarks

Disturbance

Fill Waste Dredging Fire

Channels/ditches Farming Industrial Residential

Commercial Timber Harvesting Roads Drainage

Impoundment Other

Land Ownership

Federal State County Private **X**

Figure E10. Field Verification, Site #38, Imagery view.

Figure E11. Field Verification, Site #38, Looking North.

Figure E12. Field Verification, Site #38, Looking South.

Field Data Sheet - 41

Field Form ID: 41

Site Code: 31

State: Wisconsin County: Douglas

USGS Quad: Bennett (B-7)

TWP/R: 45/12 Lat/Long (dd.dd): 46.38 N; 91.92 W

Datum: NAD 83

Reported by: John Anderson-SMUMN Date: September 13, 2010
(Name and affiliation) (dd/mm/yyyy)

Other Participants: Jason Birkner-USACE
Leslie Day-USACE
Steven LaValley-WIDNR
David Rokus-SMUMN

Accessed Via: Road
(Boat /road /helicopter /air boat/etc.)

Wetland type:

Cowardin Classification: Upland
(Lake, fen, pothole, etc.)

Video: Photograph(s): quantity: 1

Direction and view angle: #0461, West, horizontal

Source Imagery

Type of Imagery Used: Photograph: **X** DOQQ:

Sat. Image: Other:

Date of Imagery: June, 2009

Imagery source: Douglas County Type: True-Color Scale: 1:500

Discussion of Imagery: Signature similar to nearby forested wetland areas; marsh symbols and mapped as muck soils; higher elevation and non-hydric soil observed in road cut

Wildlife

Wildlife Observations:

Tide Stage: High: Low: Slack:

Water Depth at the time of field visit: Surface water absent, standing water in pit absent
(Feet or inches)

Indicators

Standing water Water Marks

Buttressed Trunks Water Stained Leaves

Water Carried Debris Saturated Soils

Floating Mat Shallow Roots

Bare Areas Oxidized Rhizospheres

Other Indicators of Hydrology:

Surrounding Land Use: Forest
(Farmland, residential, mining, etc.)

Hydrogeomorphic Classification: Organic Soil Flat

Plant Community

Dominance Type: black ash and black spruce

Abundance – Cover Dense (high) 70 – 100% **X**

Common (medium) 30 – 69%

Occasional < 30%

Common Plant Spp.: *Populus tremuloides* (FAC), *Abies balsamea* (FACW)

Less Common Plant Spp.:

Rare or Unique Plant Spp.:

Soils/Substrate

Substrate type: Silt Sand Clay Loam Peat

Rubble Rock Other

Soil Map Unit Name:

Taxonomy:

Drainage Class: Hydric List (National)

Other: Non-hydric inclusion in muck soil association

Soil Survey Publication Date: 2006
Munsell: hue value chroma
Not sampled – private land

Hydric Soil Indicators

Histosol Concretions Histic Epipedon

High Organic Content Sulfidic Odor Organic Streaking

Aquic Moisture Regime Reducing Conditions Gleyed

Other Remarks

Disturbance

Fill Waste Dredging Fire

Channels/ditches Farming Industrial Residential

Commercial Timber Harvesting Roads Drainage

Impoundment Other

Land Ownership

Federal State County Private **X**

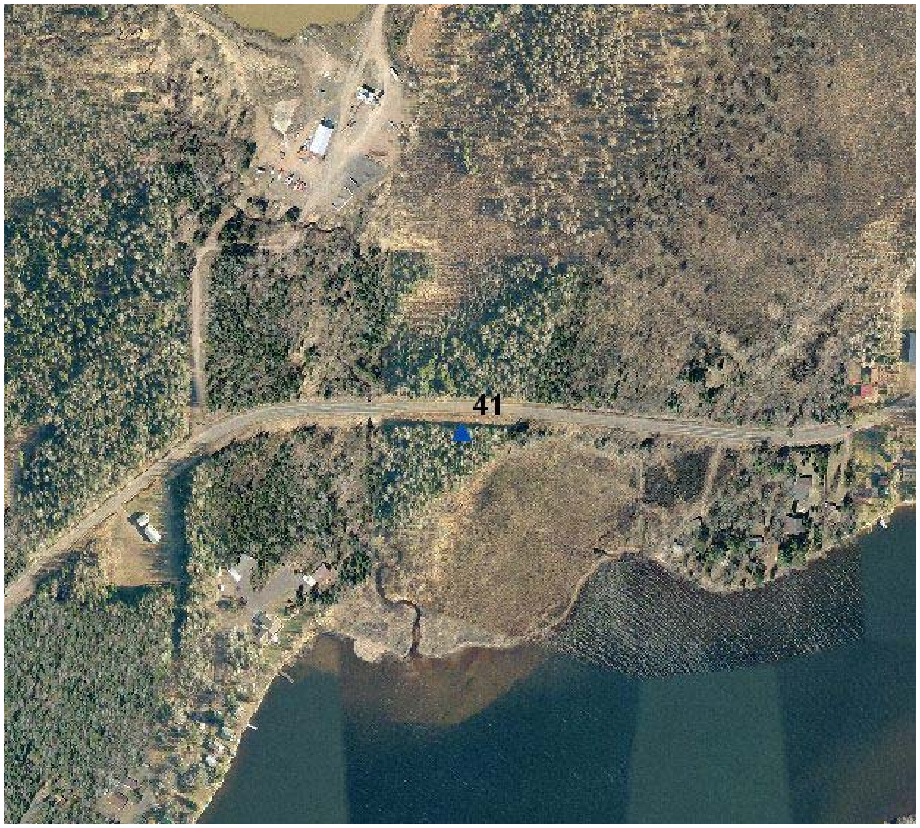

Figure E13. Field Verification, Site #41, Imagery view.

Figure E14. Field Verification, Site #41, Looking West.

Field Data Sheet - 44

Field Form ID: 44

Site Code: 31

State: Wisconsin County: Douglas

USGS Quad: Bennett (B-7)

TWP/R: 45/11 Lat/Long (dd.dd): 46.38 N; 91.78 W

Datum: NAD 83

Reported by: John Anderson-SMUMN Date: September 13, 2010
(Name and affiliation) (dd/mm/yyyy)

Other Participants: Jason Birkner-USACE
Leslie Day-USACE
Steven LaValley-WIDNR
David Rokus-SMUMN

Accessed Via: Road
(Boat /road /helicopter /air boat/etc.)

Wetland type: PSS1Cg (S3K-WWI)

Cowardin Classification: Upland
(Lake, fen, pothole, etc.)

Video: Photograph(s): quantity: 2

Direction and view angle: #0462, West, horizontal
#0463, East, horizontal

Source Imagery

Type of Imagery Used: Photograph: **X** DOQQ:

Sat. Image: Other:

Date of Imagery: June, 2009

Imagery source: Douglas County Type: True-Color Scale: 1:500

Discussion of Imagery: Light and dark bands inherent to digital imagery prominent in this area; vegetation somewhat smooth texture in wetland drainage pattern and associated with lake

Wildlife

Wildlife Observations: leopard frog

Tide Stage: High: Low: Slack:

Water Depth at the time of field visit: Surface water absent, standing water in pit absent: 1 foot (Feet or inches)

Indicators

Standing water **X** Water Marks

Buttressed Trunks Water Stained Leaves

Water Carried Debris Saturated Soils

Floating Mat Shallow Roots

Bare Areas Oxidized Rhizospheres

Other Indicators of Hydrology:

Surrounding Land Use: Forest
(Farmland, residential, mining, etc.)

Hydrogeomorphic Classification: Shrub Swamp

Plant Community

Dominance Type: Shrub Swamp

Abundance – Cover Dense (high) 70 – 100% **X**

Common (medium) 30 – 69%

Occasional < 30%

Common Plant Spp.: *Spirea alba* (OBL), *Carex lacustris* (OBL), *Salix* sp.

Less Common Plant Spp.: *Aster simplex* (FACW), *Myrica gale* (OBL), *Salix exigua* (OBL)

Rare or Unique Plant Spp.:

Soils/Substrate

Substrate type: Silt Sand Clay Loam Peat

Rubble Rock Other Muck

Soil Map Unit Name: Saprists, aquents, and aquepts

Taxonomy:

Drainage Class: Very Poor Hydric List (National) **X**

Other:

Soil Survey Publication Date: 2006
Munsell: hue value chroma
Not sampled – private land

Hydric Soil Indicators

Histosol Concretions Histic Epipedon

High Organic Content Sulfidic Odor Organic Streaking

Aquic Moisture Regime Reducing Conditions Gleyed

Other Remarks

Disturbance

Fill Waste Dredging Fire

Channels/ditches Farming Industrial Residential

Commercial Timber Harvesting Roads Drainage

Impoundment Other

Land Ownership

Federal State County Private **X**

Figure E15. Field Verification, Site #44, Imagery View.

Figure E16. Field Verification, Site #44, Looking West.

Figure E17. Field Verification, Site #44, Looking East.

Appendix F – Check Site List

List of Check Sites Report Forms and Photographs

Check Site - NWI/WWI Classifications = Field Documentation

Symbol Key:
* = Aerial image available in field
(0615) = Ground level photo number and direction
= Wetland Parameters/Photosignature Documented
& = LLWW Documented
P&P = pit and plug

1 – PSS3/FO2Bg; S6/T2K
2 - PFO1Bg; T3K (0503-W)*
3 – PEM1/SS1Cg; E2/S3K
4 – PSS1Cg; S3K
5 – PAB3Hx; A3Hx
7 – PSS3Bag; S6K
9 – PFO1/4Bm; T3/5K
10 – U
11 – U
12 – U
13 – PFO4Bag; T5K
14 - PEM1/AB3Fg; E2/A3H*
15 – PEM1/SS1CBg; E2/S3K
17 – U
19 - PSS1/EM1Bg; S3/E2K (0486-N)*
23 - PSS1Cg; S3K (0480-W)*
24 - PFO1Cg; T3K (0478-W)*
25 – PFO1Cg; T3K
26 – PFO1Bg; T3K
27 – PUB/EM1Fbg; W0/E1H
28 - PFO1Bm; T3K (0471-N, 0472-S, 04733-P&P)
29 – PFO1/SS1Cg; T3/S3K
34 – PEM1/SS1Cbg; E2/S3K
35 – PEM1Fg; E2H
36 – PAB3H; A3H
37 - PFO1Cg; T3K (0458-S)*#
38 - PFO1/4Bg; T3/5K (0459-N, 0460-S)*#
39 – PFO1/4Bg; T3/5K
40 – PEM1Cg; E2K
41 – U (0461-S)*
44 - PFO1/SS1Cg; T3/S3K (0462-W, 0463-E)*
45 – PAB3G; A3H
46 – PEM1Cg; E2K
47 – PFO1/SS1Bg; T3/S3K
48 – PSS3/EM1Bg; S6/E2K
49 - U (0645-W)*
50 – U

51 – PEM1Btg; E2K
52 – PEM1/SS1Cg; E2/S3K
53 – PFO1Cg; T3K
54 – U
55 – PFO1/SS1Bg; T3/S3K
56-L2EM2H; E5L (0655-W)*
58-PSS1/EM1Cg; S3/E2K*
59 – R2UBH
60 – PSS3Bag; S6K (0520-S)*
61 – PSS3/FO4Bag; S6/T5K (05335-S)*
62 - L2UBGh; W0L (0504-N)*#
63 – PSS3/EM1Bg; S6/E2K
64 – PUBGx; W0Lx
65 – U
66 – PEM1Fhg; E2H
67- PFO1/SS1Cg; T3/S3K (0548-N)*
68 – PEM1Cg; E2K
69 – PEM1/SS3Bg; E2/S3K
70 – L2UBG; W0L
71- PEM1/SS1C; E2/S3K (0633-W)*
72 - PSS1Cg; S3K (0700-W 0701-E)*#&
73 – PEM1Cg; E2K
74 – PSS1Cg; S3K
75 – PSS1Cg; S3K
76 - U (0666-S)*
77- PUBH; W0H (0667-N)*
78- PEM1Fg; E2H (0674-S)*
79 - PSS1/FO1Cg; S3/T3K (0712-N)*
80 -PFO1C; T3K (0713-W)*
81 - PFO1/4Bg; T3/5K (0718-W)
82 - PFO1B=T3K (0719-E)*
83 - PSS1/EM1Cg=S3K/E2K (0720-NE)*
84 - U (0722-S)*
85 – U (0727-N)*
86 - PSS1Cg; S3K*
87 – PSS1Cg; S3K*
88 - PEM1Cg; E2K (0675-SW)*
89 - L2UBG=W0L (0679-NE),*
90 - PEM1Cg; E2K (0678-N)*
91 - PEM1Cg; E2K (0552-E)*
92 - PSS1Cg; S3K (0732-SW)*
93 – PSS1Cg; S3K*
94 –PFO1Cg; T3K*
95 – PFO1/SS1Bm; T3/S3K*
96 – U (0731-SW)*
97 – U*
98 - PFO1Cg; T3K (0823-NW)*
99 - PFO1Cg; T3K (0824-NW)*
100 – PEM1Fg; E2H (0831-SW)*
101 - U (0596-SW)*
102 - U (0595-SW)*

103 - PAB3H; A2H (0592-SW)*
104 - PFO4/1Bg; T5/3K (0566-S)*
105 - PFO1/4C; T3/5K (0580-SE)*
106 - PFO4Bag=T5K (0581-NW)*
107 – U (0562-E)*
108 - PSS1Cg; S3K (0561-W)
109 - PSS1Cg; 3K (0563-W)*
110 - PEM1Cg; E2K (0597-S)*
111 - PEM1Cg; E2K (0556-E, 0557-P&P)*#
112 - PEM1Fg; E2H (0555-N)*
113 - PEM1/SS1C=E2/S3K (0692-W)*
114 - PEM1Fh; E2H (0502-N)*#
115 - PEM1Cg; E2K (0492-N, 0493-P&P)*#&
116 - PFO1Bm; T3K (0481-SE, 0482-P&P)*#
117 – PEM1/SS1Cg; E2/S3K (0620-S)*
118 - PSS1Cg; S3K (0618-N)*
119 –U (0453-P&P, 0454-E) #
120 – PEM1Cg; E2K (0456-W, 0457-P&P)*&
121 - PFO1/4Bg; T3/5K #&
122 - PFO1Cg=T3K (0693-S) #
123 - PFO3Btg; T55KK (0615-N) #&
124 - R2EM2H; E5R, (0489-N, 0490-S) #&

Note: Field documentation for this project includes approximately 200 field notes written on hard-copy images and maps.

Appendix G – Conventions Documents

Photointerpretation/Mapping Conventions
St Croix Headwaters Watershed

Photography and Collateral Data

1. Photointerpretation will be performed at a scale of 1:5,000

2. Photointerpretation will be performed using true-color, March 2009, digital imagery as the primary source.

3. Photointerpreter also will use the following as collateral data; original WWI 1991 database, 1991 black and white stereo-pairs, 2007 spring-time leaf-off, color infrared imagery (Douglas County), Historic Google Earth Imagery, SSURGO soils database (poorly and very poorly drained soils), topographic DRG's, and field-documents describing photosignatures and related wetland characteristics (surface hydrology, plant communities, and soil properties).

4. Wetlands with organic soil will be classified using the NWI "g" Special Modifier. Wetlands with mineral soil will be classified using the NWI "m" Special Modifier. The use of the "g" Soil Modifier is intended to indicate areas that, when following the "C" Water Regime code, are flood for extended periods then will be saturated throughout the growing season. Those areas that labeled with the "m" Soil Modifier, when following the "C" Water Regime code, are flooded for extended periods with water being absent from the soil profile for the remainder of the growing season. However, areas where wetland hydrology is affected by impoundment, excavation, or beaver activity the soil modifier will not be applied as the NWI database filter does not accept more than one Special Modifier. The three previous modifiers help describe more accurately frequency and duration of flooding, ponding, and saturation than do Soil Modifiers.

5. WIDNR lakes database will be used as the default layer for open water.

6. WIDNR streams layer will be used as the default layer for rivers and streams where they are too narrow to delineate as polygons at a scale of 1:5000.

7. Split classes will be assigned where each class occupies no less than 30% of polygons

8. L2UBG/W0L areas will be delineated near locations of six foot contour in areas mapped as open water by USGS or WIDNR and where open water is present on 2009 imagery. Drawn-down lake bed areas that are mapped as open water and do not have 6' depth contour lines, but have with emergent, or other non-water signatures, due to draught conditions, will be classified as L2UBGand W0L.

9. The USACE will provide collateral data for the location and extent of wild rice.

10. Wet residential lawns in Solon Springs will not be delineated as a wetland.

11. USGS depressions, without positive collateral data, in sandy plain east of Lake St. Croix almost always are not wetland unless a white emergent signature or dark signature representing water is present.

12. Errors of commission (i.e. upland mapped as wetland) will be deleted from the WWI database.

13. Errors of omission (i.e. missed wetlands) will be added to the WWI and NWI databases.

14. The "$", will be added to labels where fill has occurred and error of commission is found in the WWI database.

15. Open water areas in lakes that, smaller than 20 acres, that are not impounded, that have open water on imagery, and are mapped as open water by the USGS will be assumed to be deeper than six feet and will be mapped as L1UBH and DWL. (Wisconsin definition of "Lake"?)

16. PSS3B, PSS4B, PFO2B, PFO3B, PFO4B will be assumed to have acidic pH. PEM1B when associated with any of previous classifications also will be assumed to have acidic pH. Emergent and broad-leaved deciduous dominated wetlands on mineral soil are assumed to have a circum-neutral pH.

17. Areas that are open water on USGS DRG's, but are emergent on aerial photos will be mapped as W0H and PUBG.

NWI/WWI/LLWW Classification Considerations

1. Wetlands will be classified in the WWI, NWI, and LLWW Systems.

2. WWI Special Modifiers and NWI Modifiers coding will only be applied within each classification system.

3. Deep Water Habitat will be classified as L1UBH, R2UBH, and R3UBH. These areas are "Non-wetland in the WWI System and will be deleted from the database.

4. Forested swamps dominated by cedar (*Thuja occidentalis*) will be classified using the "broad-leaved evergreen" subclass. The "Wisconsin Wetland Inventory Guide" (WIDNR,PUBL-WZ023, 1992) lumps this species with black spruce and balsam fir, that are classified by NWI as needle-leaved evergreen (e.g. T5K). However, it also has been classified as broad-leaved evergreen using the code "T6" (Johnston, 2002, p. 390). Guidance will be required for classification of cedar swamps in the WWI System. The "broad-leaved evergreen" (e.g. PFO3B) NWI subclass will be applied to cedar swamps.

5. WWI "Human Influence" Special Modifiers and their NWI equivalents, found in project area, include the following; Cranberry Bog "C" = Farmed "f", Excavated "x" open water ponds and mining ponds that support vegetation = Excavated "x" all excavated wetland and open water.

6. The following WWI Human Influence Special modifiers, found within the project area, do not have equivalent codes in the NWI System; Grazed “g”, Mats “m”, Vegetation recently removed “v”.

7. The WWI includes a Muskrat activity “z” modifier, the NWI does not have an equivalent modifier.

8. The following NWI Special Modifiers, found within the project area, do not have equivalent codes in the WWI System; Beaver “b”, and Impounded “h”. Where there is either of these impounding influences, the Soil Modifer will not be added as the NWI MasterGeodatabase will accept only one Special Modifier in each classification code.

9. Mixed classes in the WWI Systems will be separated by a slash (WWI-T3/S3K-PFO1/SS4B) in order to separate taller from shorter life-forms trees and shrubs.

10. NWI coding will be separated by a slash after the subclass code NWI - PFO1/SS1B to separate taller from shorter life-forms, such as trees from shrubs.

11. The WWI and NWI coding will be applied to separate subclass (such as T3/5K; PFO1/4B).

12. The WWI has four Water Regime classifications. The NWI has seven Water Regime classifications. The NWI final product will appear more detailed than the WWI finalized database as many WWI polygons will have same attributes and will be merged in the final product.

13. Polygons designated as “ROAD” in the WWI database will be deleted from the final NWI database and classified as “Upland”

14. Sewage lagoons and other man-made disposal pits will be excluded from the WWI database. These areas will be included in the NWI database

15. Open water in gravel pits or other mines will be excluded from the WWI unless vegetation is visible on imagery. These areas will be delineated and added to the NWI database.

16. Average minimum mapping unit is one-quarter acre for delineated polygons.

17. Non-wetland lakes surrounded by wetland are classified as “DEEP WATER LAKE”- DWL (Johnston, 2002, p.388).

18. Non-wetland open water in channels is classified as “RIVER” (Johnston, 2002, p.388).

19. Use “Table 1” crosswalk (Johnston, 2002, p. 390), which is more detailed, or the less detailed “Wisconsin Classification Guide”?

20. The Federal Geographic Data Committee (FGDC) standard for LLWW coding will be applied.

21. Coding is subject to revision pending guidance from WIDNR and US Fish and USFWS

Sources

http://dnr.wi.gov/wetlands/documents/WWI_Classification.pdf

http://glei.nrri.umn.edu/default/documents/Pubs/Johnston_2002.pdf

http://www.fws.gov/wetlands/_documents/gNSDI/FGDCWetlandsMappingStandard.pdf

Appendix H - NWI and WWI Codes and Signature Descriptions

	NWI		WWI	
Forested	PFO1B	Palustrine, Forested, Broad-leaved deciduous, Saturated	T3K	Forested, Broad-leaved deciduous, Wet soil, Palustrine
	Dark grey signature, dense tree crowns, commonly found not associated with collateral marsh symbols or very poorly drained soils.			
	PFO2B	Palustrine, Forested, Needle-leaved deciduous, Saturated	T2K	Forested, Needle-leaved deciduous, Wet soil, Palustrine
	Dark green forested signatures mapped as T2K by WWI; Located in wetland drainage patterns frequently with swamp symbols and very poorly drained soils.			
	PFO3B	Palustrine, Forested, Broad-leaved evergreen, Saturated	TK*	Forested,Wet soil, Palustrine
	Tightly grouped tree (*Thuja occidentalis*) crowns that are dark green as seen on true-color imagery; field reference site is along trail board-walk north side of Lake St. Croix.			
	PFO4B	Palustrine, Forested, Needle-leaved evergreen, Saturated	T5K	Forested, Needle-leaved evergreen, Wet soil, Palustrine
	Usually black spruce mixed with black ash. However, jack pine and white pine were found in wetland areas. Dark rough texture signatures in wetland drainage patterns with swamp symbols and/or very poorly drained soils.			
	PFO1C	Palustrine, Forested, Broad-leaved deciduous, Seasonally Flooded	T3K	Forested, Broad-leaved deciduous, Wet soil, Palustrine
	Usually dominated by black ash. Light grey, rough texture. April photography – black ash leafs-out later than other deciduous trees, therefore a good indicator of seasonally flooded forested wetland.			
Scrub/Shrub	PSS3B	Palustrine, Scrub/Shrub, Broad-leaved evergreen, Saturated	S6K	Shrub, Broad-leaved evergreen, Wet soil, Palustrine
	Dark brown, rough to mottled texture usually in center of isolated wetlands; Whitish emergent signatures often encompass these areas.			
	PSS1B	Palustrine, Scrub/Shrub, Broad-leaved deciduous, Saturated	S3K	Shrub, Broad-leaved deciduous, Wet soil, Palustrine
	Darker tone, rough texture, located in broad flat areas; plant community shorter than trees when viewed in stereo.			
	PSS1C	Palustrine, Scrub/Shrub, Broad-leaved deciduous, Seasonally Flooded	S3K	Shrub, Broad-leaved deciduous, Wet soil, Palustrine
	Darker tone, rough texture in depression or wetland drainage pattern. Light grey signature observed in areas where shrubs are mixed with emergent. Plant community shorter than trees when viewed in stereo.			
Emergent	PEM1B	Palustrine, Emergent, Persistent, Saturated	E2K	Emergent, Narrow-leaved persistent, Wet soil, Palustrine
	Whitish, somewhat smooth texture in flat-open areas. Frequently associated with very poorly drained soils.			
	PEM1C	Palustrine, Emergent, Persistent, Seasonally Flooded	E2K	Emergent, Narrow-leaved persistent, Wet soil, Palustrine
	Whitish, somewhat smooth texture in depressions and in wetland drainage patterns. Frequently associated with marsh symbols and very poorly drained soils.			
	PEM1F	Palustrine, Emergent, Persistent, Semi-permanently Flooded	E2H	Emergent, Narrow-leaved persistent, Standing water, Palustrine
	Cattail that was found to be rougher texture, somewhat darker tone emergent in center of depressions.			
Ponds	PUBH	Palustrine, Unconsolidated Bottom, Permanently Flooded	W0H	Water, Subclass unknown, Standing water, Palustrine
	Dark color, flat photographic texture, open water signature. Open water on DRG. PUBHb – beaver dams forms a straight-lined down-stream edge of polygon.			
	PAB3H	Palustrine, Aquatic Bed, Rooted Vascular, Permanently Flooded	A3H	Water, Rooted floating, Standing water, Palustrine
	Smooth mottled signature found within open water in some ponds. Not present in all ponds as is April imagery and aquatic bed has not matured.			
Lakes	L2UBG	Lacustrine, Littoral, Intermittently Exposed	W0L	Water, Sublass unknown, Stadning water, Lake
	L2UBG/W0H areas will be delineated near locations of six foot contour in areas mapped as open water by USGS or DNR.			
	L1UBH	Lacustrine, Limnetic, Permanently Flood	DWL	Deep Water Lake
	Open water deeper than 6' on DRG			
	L2EM2H	Lacustrine, Littoral, Non-persistent, Permanently Flooded	E5L	Emergent, non-persistent, Standing water, Lake
	Zizania aquatica - Light brown smooth signature in lakes. Collateral data to be made available.			
Streams and Rivers	R2EM2H	Riverine, Lower perennial, Emergent, Non-persistent, Permanently Flooded	E2R	Emergent, Narrow-leaved, Non-persistent, Flowing water, River
	Zizania aquatic - Marsh symbols on DRG along St. Croix River south of Lake St. Croix.			
	R2UBH	Riverine, Lower perennial, Unconsolidated Bottom, Permanently Flooded	Non-wetland	N/A
	Contour intervals 1.5 miles or more apart (polygon size).			
Upland	Upland	N/A	Upland	N/A
	Typically even light tone, brown color in under story in large forested areas; also large areas of light grey signature representing aspen			

Appendix I – Literature Review, Economic Valuation of Wetlands

Introduction

The purpose of this literature review is to summarize the current state of knowledge for economically valuing wetlands. Economic valuation of wetlands has roots going back to the 1920's, but most of the literature is from the late 1980's to the early 2000's. There has not been much published on economic valuation of wetlands in the last seven or eight years, and what has been published is quasi-economic in nature and tends to focus on particular species and not the ecosystem as a whole. Wetlands are complex systems that perform many different functions within the landscape. Examples of wetland functions include surface water retention, nutrient transformation, and wildlife habitat. Many functions can be derived from wetland classification schemes such as LLWW. An ecological function performed by a wetland can be thought of as a good or service in economics terms. Traditional economics attempts to identify the goods and services provided by a wetland and place a monetary value on each. In economics, values are typically determined by a market. The market price for a good or service is its value. This approach works for some aspects of wetlands, but not others. In the case of direct use, commercial timber harvest for example, the market value of the harvested timber can be used to easily determine value. For indirect services like surface water retention it becomes much more difficult to determine a value, because the service or good being valued is not traded in a market. There are also intrinsic values that need to be considered. Something with intrinsic value has value just because it exists, and there would be a loss to present and future generations by it being destroyed. Valuation of wetlands is difficult because of the combination of direct, indirect and intrinsic values. Direct values are relatively easy to quantify, but indirect and intrinsic values are much more subjective.

Wetland Functions

Wetlands perform a wide variety of functions within the ecosystem. The wetland functions identified as most pertinent for the Saint Croix Headwaters:

1. Surface water detention (SWD) – storage of runoff from rain events and spring melt waters which attenuates peak flood levels.
2. Surface water maintenance (SWM) – this is often referenced as stream flow maintenance. During drought conditions and periods of low discharge, wetlands provide a source of water to keep streams from drying up.
3. Nutrient transformation (NT) – wetlands through natural processes break fertilizers and other pollutants down essentially treating the runoff.
4. Sediment and particulate retention (SR) – wetlands act as filters and trap sediment particles before they are carried away downstream.
5. Carbon sequestration (CAR) – wetlands serve as carbon sinks that help trap atmospheric carbon.
6. Shoreline stabilization (SS) – wetland plants hold the soil to prevent erosion.
7. Fish habitat (FIS) – wetlands serve as habitat for a variety of fish, and the organisms that fish need for food.

8. Waterfowl/Waterbird habitat (WFH) – duck, geese, and other water birds require wetlands for feeding, raising young and for resting areas during migration.
9. Shorebird habitat (SBH) – wading birds such as herons, egrets, and sandpipers require the shallow water areas for survival
10. Amphibian habitat (APH) – frogs, salamanders, and toads require wetlands for at least part of their life cycle, including ephemeral wetlands that hold water for a very short period of time.
11. General wildlife habitat (GWH) – wetlands are often an integral part of larger natural areas that provide habitat for a wide variety of other organisms.

Wetland function can be determined through various classification systems such as NWI (National Wetlands Inventory) and LLWW (Landscape Position, Landform, Water Flow Path, Waterbody Type). NWI is based primarily on vegetative indicators of surface hydrology. LLWW is an enhancement to NWI based on hydrogeomorphology and landuse within the watershed. There are also other similar classifications such as Wisconsin Wetland Inventory that could be used as well. From an economic standpoint, wetland function can be thought of as the goods and services provided by a wetland beyond actual production of a commodity. In most cases, wetland functions provide public benefits with little direct benefit to the owner of the wetland.

Purpose of Wetland Economic Valuation

In the current era of tightening government budgets, most policy decisions require some type of cost benefit analysis. Decision makers often prefer an economic basis for justification of their decisions. Plus, dollars are a metric understood by stakeholders from a variety of backgrounds. It should be noted however that a bad economic analysis is probably worse than no economic analysis. Also economics can be just as easily used to justify destroying a wetland as preserving a wetland. When using economic analysis, private benefits are often overvalued while public benefits are undervalued. The society wide benefits derived from wetlands are much harder to quantify when compared to the private benefits derived from marketable goods produced by wetlands. The public also tends to treat the lack of a justifiable dollar value as a zero value when making comparisons. In general when using economic tools to value wetlands the analyst must make sure all aspects are taken into account, and if not addressed quantitatively then at least qualitatively.

Basics of wetland economics

Wetlands are extremely complex ecosystems that interact with surrounding wetlands and non-wetland ecosystems in a myriad of ways. Thus by their very nature they are difficult to completely understand. Wetlands are also multi functional, often improving performance of one wetland function will lead to increasing performance of other functions of the wetland. Assigning economic values to wetlands is attempting to quantify the benefits provided by wetlands. Wetland values can be organized into subgroups a few different ways. On the purely economic end of the spectrum are those goods and service that are bought and sold in markets and therefore their value is easy to determine. On the other end of the spectrum are those intrinsic values that are entirely subjective and therefore very difficult to value in dollars.

Direct Benefits

Direct benefits fall toward the purely economic end of the spectrum. Direct benefits are those benefits typically realized at the local private ownership level. In most cases their value is easy to determine because the land owner realizes the benefit by selling a commodity on a market. Commercial fishing and timber harvest are two examples of a direct benefit from wetlands. Some other examples could include hunting, recreational fishing, and tourism where local businesses are realizing an economic benefit by providing services to individuals engaged in those activities. Direct benefits tend to be localized and realized most often by private individuals or groups. They also tend to be more finite and consumptive in nature, but can be sustainable if managed conscientiously.

Indirect Benefits

Indirect benefits fall somewhere in the middle of the economic to intrinsic spectrum. Indirect benefits can be realized thousands of miles away from the wetlands contributing to the benefit. Most indirect benefits are tied directly to the ecological functions of wetlands. One paper used the example of the Midwest flood of 1993. If the percentage of watershed that is wetland was increased from its current 5% of the watershed to 7% of the watershed there would be enough flood storage (surface water retention) to deal with extreme flooding events. To put these into perspective it is estimated that 9-11% of the watershed was wetland prior to European settlement. (Mitch & Gosselink, 2000) Indirect benefits of wetlands are typically realized by society as a whole. Indirect benefits are also typically not traded in a market and therefore their value is more difficult to determine. Because wetland functions are non-consumptive in nature, the indirect benefits derived from them can be realized into perpetuity provided the function is not destroyed or degraded. In many cases individuals realizing a direct benefit from a wetland can degrade the functioning of the wetland and reduce the indirect benefits a wetland provides.

Intrinsic Benefits

On the opposite end of the spectrum from direct values are intrinsic values. Something with intrinsic value has value for its own sake. In other words it is valued for its aesthetics or just because it is a unique place to visit. If it is considered a loss if it is destroyed or degraded and no longer exists for future generations, it is said to have bequest value. A wetland may be intrinsically valuable if it is a rare or unique ecosystem, or it is habitat for rare or endangered species. Calcareous fens in Minnesota and Wisconsin are examples of rare ecosystems that might be valued intrinsically because they have a disproportionate number of rare, endangered or threatened species. (Eggers & Reed, 1997) Intrinsic value is also dependent on location and abundance of surrounding wetland. Urban wetlands often have a high intrinsic value placed on them because of the relative scarcity of green space in the urban setting. A wetland type that is abundant in one area and has little intrinsic value might have a higher value in another area if it is unique or scarce. Intrinsic value is very subjective. Many in the environmental community take the stand that wetlands are worth saving just because they exist. Traditional economists are more likely to take the opposite approach of valuing wetlands only for their marketable production.

Valuation

The first step in any valuation of wetlands is determining what goods and services are provided by the wetland. In order for the valuation to have meaning, all goods and services provided by a wetland must be examined. Teasing out all of the services provided by a wetland can be a daunting if not impossible task, especially since many wetland functions provide indirect values that are not realized locally but may have benefits hundreds or even thousands of miles away. The examiner must strike a balance between the factors being evaluated and the cost in terms of both time and money to try and tease out each individual wetland function or factor. Opportunity costs need to be considered as well when evaluating alternatives. An opportunity cost is a benefit lost by choosing one alternative over another.   Any valuation must be very explicit in what factors it is valuing and what it is ignoring. The future value of any wetland good or service also needs to be taken into account since wetlands provide these services into perpetuity. Economists use a present value calculation to bring future values into present day dollars. This formula is shown below:

$$PV = \frac{C}{i}$$

Where

PV = the value of all future benefits in perpetuity in present day dollars

C = the current value in dollars

i = the discount rate.

Part of this calculation is the discount rate (i). The discount rate accounts for inflation, or in other words the fact that present day dollars will be worth less in the future due to rising prices. The discount rate can have a large impact on the present value of the wetland and must be chosen wisely.

Direct Values

The direct values provided by a wetland are typically those things that are easily quantified because they have a market. Since they are relatively easy to identify, it is important for total valuation that all direct values are examined. Examples include commercial fish harvest, fur harvest, and forest products. These values can be easily determined by harvest numbers and their respective market prices. Other direct values include activities such as bird watching, recreational fishing and hunting. This latter group can be quantified because in most cases the impact on the local economy can be estimated with confidence. Any future values of direct values of marketable commodities need to have the caveat that they are an estimate based on the current market value, and the present value calculation does not take into account any future market fluctuations.   It may be possible to use some sort of regression analysis to determine how the future market prices may behave based on past performance, but that is beyond the scope of this paper. For those direct values based on services such as tourism and recreational fishing, this market fluctuation issue is not as pronounced, as the cost of these services tend to be less subjected to large market fluctuations.

Indirect values

Indirect values associated with wetlands are typically associated with the ecological functions of the wetland. The services provided by wetland functions are non-consumptive in nature and as long as the wetland is not destroyed or degraded, the service is provided in perpetuity. Much of the benefit derived from the ecological functions wetlands are realized on a regional or national basis, with little local benefit. Surface water retention and nutrient transformation are both good examples. An assessment framework is often used to determine what functions a wetland is performing. Minnesota has the Minnesota Routine Assessment Method (MNRAM) which uses the pre-European settlement condition as a baseline. (Minnesota Board of Water and Soil resources, 2010) Classification systems such as LLWW and the National Wetland Inventory (Cowardin, 1979) are often an integral part of the assessment process. The complexity of wetland ecosystems can provide a challenge to assessment given the multiple interactions that are often involved. After a wetland's functions are determined, the economic value of the services provided by these functions can be examined. However, it is difficult to estimate the indirect values of wetlands because they are associated with services that are not typically traded in a market. Also wetlands tend to have indirect values to society as a whole rather than private owners or entities.

Economists have several methods for determining value when no market exists. Among these are willingness-to-pay/contingent valuation (WTP/CV), travel cost method, hedonic methods, and replacement cost.

Willingness-To-Pay/Contingent Valuation

Willingness-To-Pay (WTP) is sometimes referred to as contingent valuation (CV). WTP is a revealed preference method that uses surveys to determine how much the public values a good or service. WTP can take the form of questionnaires or in some cases focus groups. WTP is a favorite in the environmental economics field, because of its relative ease of execution. WTP simply asks a respondent how much they would be willing to pay for a good or service. WTP is attempting to create a proxy market for the good or service in question.

Hedonic Regression

Hedonic regression, another revealed preference method, tries to break the value of an item down into its contributory factors. In the case of wetlands, a home's value is analyzed in relation to its proximity to wetlands. Through statistical methods, the portion of a home's value that can be attributed to the proximity of the wetland is estimated. Hedonic regression as applied to wetlands work best in an urban setting, probably because of the larger sample sizes possible in more populated areas. The result could actually be negative if the nearness of a wetland is considered to be detrimental to the value of property.

Travel Cost

Travel cost analysis, as the name implies, uses the cost of traveling to a destination to estimate the value of the destination. Travel cost analysis, like the previous two methods is a revealed preference method. In the case of wetlands travel cost analysis works best for wetlands that require some effort to visit. Travel cost analysis is especially applicable for valuing recreational benefits such as sport fishing and bird-watching in rural wetlands. (Boyar & Polasky, 2004)

Replacement Cost

Replacement cost uses the value of the next best alternative as an estimate of the value of the wetland. For example, if a wetland was performing the function of nutrient transformation, the cost of a treatment plant to perform the same function could be used as an estimate of the value of the wetland. Using replacement cost to value wetland functions works when there are viable alternatives that allow valid, "apples-to-apples" comparisons on a similar scale. Replacement cost can be difficult to use with wetlands because of the regional nature of many wetland functions. Surface water detention would be difficult to value using replacement cost, because the alternative to surface water storage is building levees and other engineering works. In the case of a large river system such as the Mississippi – Missouri determining the cost of all the flood control structures in the watershed although possible would probably lead to an astronomically high number. Also, depending on the size of the flood event and location within the watershed not all areas of the watershed would be affected. In essence, the larger the scale, the more difficult it becomes to maintain a valid comparison. Difficulty in teasing out the individual functions can also make replacement cost analysis complicated to implement.

Intrinsic Value

Something has intrinsic value if it is valued for its own sake. Educational value and aesthetics are both intrinsic in nature. Sentimental value a family attaches to an heirloom is an example of intrinsic value. If a wetland is important to the culture of a group of people, that group will often place a high value on its existence, the Everglades' role in the Seminole culture for example. Another type of intrinsic value is bequest value. A wetland is said to have bequest value if its destruction or degradation is a loss to future generations. Monetary value has very little impact on intrinsic value; however intrinsic value should not be dismissed as unimportant. Often the public's perception of possible, but currently unknown, future values are part of intrinsic value. An example of this would be protecting rainforest because of the possibility of new pharmaceuticals that are being developed from compounds found only in rain forest plants. As one might imagine, intrinsic value is highly subjective, but in reality revealed preference methods of valuation, such as WTP, Hedonic Regression, and Travel Cost can be used to estimate intrinsic value in the same manner as indirect values.

Putting Valuation into Practice

Economic valuation of ecosystems as complex as wetlands presents some challenges. In the case of short term gain versus long term benefits there is the social trap of always being able to find a short term use for land that generates a greater economic gain than a long term wetland function. For example, in the Midwestern United States drainage for corn or soybean production will almost always be favored over wetland conservation if traditional cost-benefit analysis is carried out. (Mitsch & Gossleink, 2000). Similarly, direct consumptive uses tend to provide finite benefits, while wetland functions produce benefits into perpetuity as long as the wetland is not degraded. Direct values tend to locally benefit individual landowners, while the indirect and intrinsic values tend to benefit society as a whole. When attempting a total valuation of wetlands it may be necessary to use a variety of valuation methods in order ensure the method being used is appropriate to the function being evaluated.

Discussion

Most of the research published on economic valuation of wetlands dates from a relatively short time period in the late 1990's and early 2000's. Most of the studies linked ecological functions with economic benefits. However a few pieces of literature strayed from this general form. One article in particular was obviously trying to advance an agenda rather than trying to add to the knowledge base about wetland valuation. A couple of papers asked questions about the cost-effectiveness of regulations to protecting endangered species, and although it dealt with economic issues it didn't examine wetland functions on an ecosystem or larger scale. Another article (King, 1998) was written from more of a legal perspective than economic and offered some insight in how economic values might be exploited during the decision making process. From the literature, it becomes evident that the challenge of wetland valuation is integrating ecological and economic factors in a way that accurately reflects the value of both marketable and non-marketable goods and services.

This discussion will center on the papers that followed the ecosystem functionality approach to valuation. Although this approach has its shortcomings, it appears to be the most comprehensive and best at integrating marketable with non-marketable functions. Some of the legal aspects are also discussed.

From the literature, the general process to wetland valuation is determining wetland functions, determining the methodology for valuing each function, valuation of each function, and summing the values of all the functions to determine the total valuation.

Wetland Functional Assessment

Wetland function can best be determined through an on-site assessment protocol, although some of the information can be found through remotely sensed sources such as LLWW or NWI classification. In some cases, state mitigation programs have already developed assessment protocols for evaluating mitigation activities. Wisconsin (WI Dept. of Natural Resources & U.S. Army Corps of Engineers, 2002) and Minnesota (MN Board of Water and Soil Resources, 2010) both have assessment guidelines in place that examine wetland functionality. Anytime a valid assessment protocol is available it is probably best to use it in order to help integrate the ecology of the wetland with the economics of decision making.

Valuation

The methodology for each wetland function is determined by whether the good or service provided by the function is a marketable, direct value or non-marketable indirect value.

Marketable – Direct Values

These are the most straight-forward values to calculate because a market sets the price for the good or service. Commercial fur harvest is an example. Valuation is simply calculating the value based on the current market price. Even though this is the most straight forward valuation method, market prices and harvest numbers fluctuate over time and any value determined directly needs to considered an estimate. This is especially true if the value is calculated to perpetuity using the present value formula. The estimate might be improved by applying a regression to past market fluctuations to try and get an idea of future market behavior.

Non-Marketable – Indirect and Intrinsic Values

Although previously discussed separately, indirect and intrinsic values are combined here for discussion purposes because they are both determined using revealed preference methods and are therefore subject to the same limitations. In the environmental field, the most popular revealed preference method for valuing non-marketable wetlands goods and services appears to be willingness-to-pay (WTP)/contingent valuation (CV). WTP generally uses a survey questionnaire to determine the value respondents place on a function. There are a few limitations to the revealed preference approach. Wording of survey questions and lack of incentive to answer in good faith often introduce biases into WTP surveys. (Boyar & Polasky, 2004) Also it is often difficult to separate the indirect from intrinsic value. One study in eastern England that examined respondent's reasons for answering a questionnaire concerning a wetland there found 40% answered questions based on ethical and moral considerations (lexicographic) rather than economic. (Spash, 2000) In a similar fashion respondent's misperceptions and biases can affect their answers. For example, one respondent in a Michigan WTP survey placed no value on using wetlands for nutrient transformation, because environmental regulations and water treatment plants are supposed to perform that function. (Hoehn, et al, 2003) Demographics also play a significant role in survey results. A study in Minnesota compared the results of two WTP surveys from Margaret Lake and the Sauk River Chain of Lakes. These areas were chosen because they had different demographics, but similar size watersheds and issues with nutrient runoff. In the Margaret Lake area the majority of the homes were summer residences and a majority of the owners had college level education. In the Sauk Lake area the majority of homes were year-round residences and the average level of education was high school. The Margaret Lake survey valued restoration improvements at $267/acre, while Sauk Lake valued improvements at $17/acre. (Weele & Hodgson, 2008) In general, values arrived at through WTP estimates as just that, estimates. When citing a WTP valuation, the issues associated with WTP valuation need to be kept in mind.

Final Valuation

The final step is to sum the values obtained for each of the wetland functions to obtain the total value. This step was not actually explained in any of the literature. All of the literature implied that there were no interdependencies between wetland functions that would affect their value. It was also assumed the wetlands being valued were functioning at an adequate capacity. The possibility of non-linear relationships between wetland functions was not addressed by the WTP surveys. A rigorous assessment of wetland function and quality probably identifies some of these issues, but the revealed preference methods described in the literature would probably have a difficult time teasing out factors associated with non-linear effects just because they rely on input from the general public and not wetland professionals. One author did make the effort to highlight the fact that total economic value (TEV) as defined in economic terms and total wetland value are two different things (Turner, et al., 2000). This highlights the need to be very definitive in explaining the meaning of terms. The term value for example has very a different meaning to an economist versus an ethicist. This is probably a contributing factor to some of the issues associated with WTP surveys, or any other method that relies on input from the general public.

Legal Ramifications

There is little evidence that assigning a "best available" dollar value helps to protect wetlands. (King, 1998) From a legal standpoint wetland values can be difficult to defend in court or the hearing room. It needs to be emphasized that the wetland valuation process as outlined previously is using private market techniques to value societal benefits. Assigning a dollar value to a wetland opens the door to non-wetland uses for the land based solely on economic benefit. Municipalities struggling with shrinking budgets and trying to grow their property tax base are particularly susceptible to basing permitting decisions solely on a single dollar value. One author advocates avoiding attaching a dollar amount to a wetland all together if at all possible, because he feels they are either an underestimation or indefensible on court given the current state of wetland science, and at the very least we should be willing to pay at least as much to conserve natural wetlands as we are spending trying, with limited success, to restore degraded wetlands. (King, 1998)

Wetland Valuation in the Saint Croix Headwaters

The Saint Croix Headwaters watershed is largely undeveloped when compared to other areas of Wisconsin, especially in terms of agriculture and residential development. Timber and recreational resources could be valued directly using market methods. However, given the relative scarcity of directly marketable goods and services for the Saint Croix watershed the contingent valuation methods are probably the most applicable. With well defined wetland functions CV/WTP methods are easy to implement. As a relatively natural and unspoiled area intrinsic factors for SCHW could be a major contributor to its overall value. Contingent valuation could be used as well in an effort to determine the intrinsic value of the SCHW. As an added advantage, CV/WTP methods allow stakeholders to have a more active role in decisions affecting them. Regardless of how the wetlands in SCHW are valued, the limitations and implications of wetland economic valuation need to be understood in order to gain the most benefit.

Conclusion

Wetland valuation has merit in that it helps to highlight the functions wetlands perform in the ecosystem, and if applied in a conscientious manner can also be a valid tool for decision makers. The issue is that in today's budget conscious world quantitative dollar amounts whether based on sound practice or not will almost always outweigh more qualitative factors such as water quality and flood attenuation, especially in the eyes of the general public. Wetland values can be divided into direct, indirect, and intrinsic categories. Direct values are determined by the direct market price and are therefore the easiest to understand and obtain. Indirect values are much harder to determine and typically require revealed preference techniques to obtain. Willingness-to-Pay (WTP) appears to be the favorite in the environmental field. WTP uses surveys of stakeholders to determine a value based on the general public's preference, and is therefore vulnerable to the misperceptions and biases of the public. From a legal standpoint, economically valuing wetlands is a double-edge sword. The same number used to justify protecting a wetland can often be used to justify development and ultimate destruction of the wetland.

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Appendix J – NWI Codes Present in SCHW

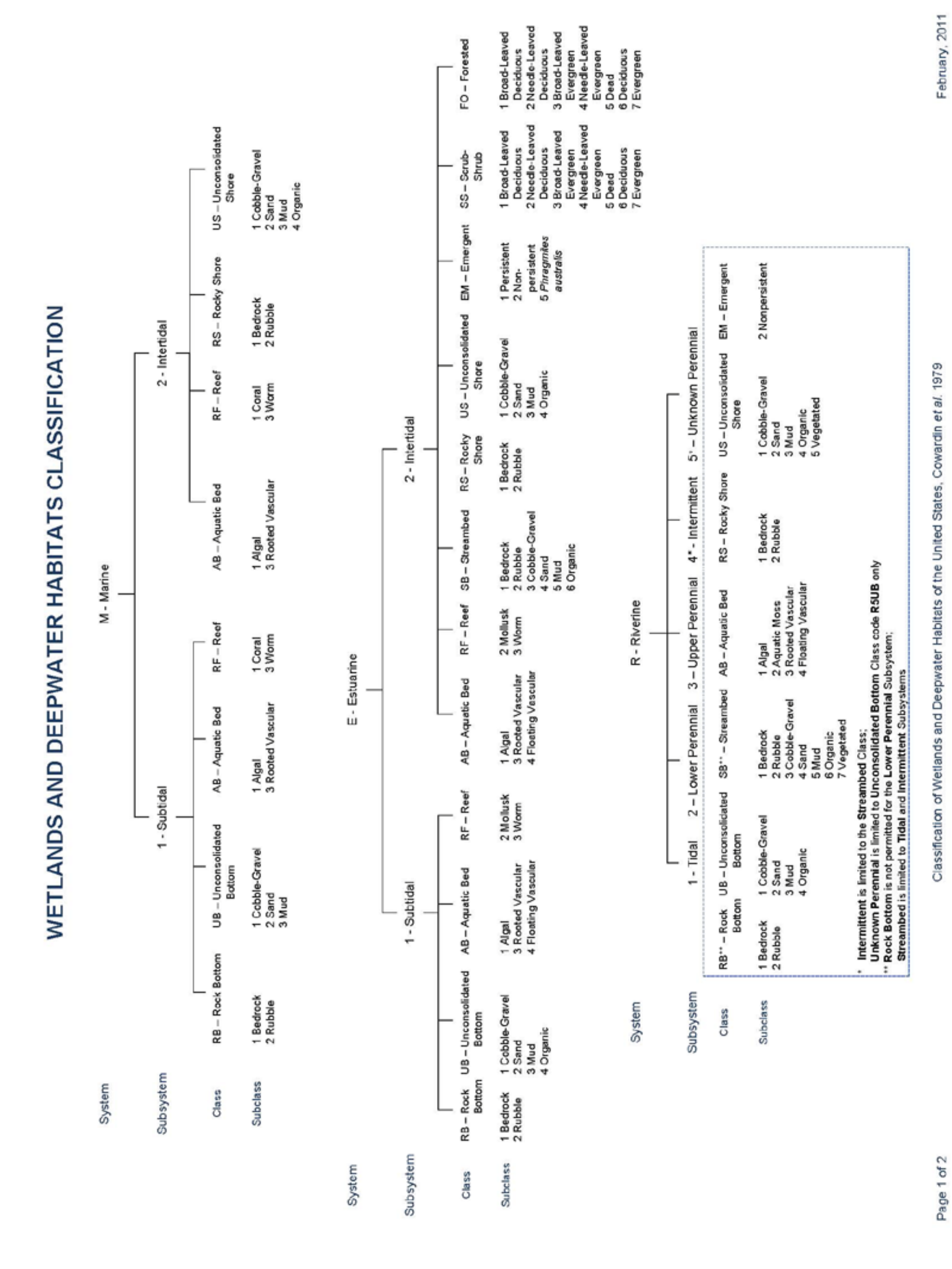
Table J1. Wetland Acreages by NWI Code (page 1 of 2).

National Wetland Inventory (NWI) - 2009 Wetlands Acreage by NWI Code Saint Croix Headwaters Watershed			
Summary Parameter	Acreage	% of Watershed Acreage	% of Total Wetland Acreage in Watershed
Watershed			
Total Area of Watershed	215,508.3	--	--
Upland	177,718.5	82.46%	--
Wetland	37,789.8	17.54%	--
NWI Codes			
L1UBH	6,638.5	3.08%	17.57%
L2AB3F	13.3	0.01%	0.04%
L2AB3G	194.6	0.09%	0.51%
L2AB3H	178.0	0.08%	0.47%
L2EM2H	45.9	0.02%	0.12%
L2UBF	4.0	0.00%	0.01%
L2UBG	588.4	0.27%	1.56%
L2UBH	2,159.1	1.00%	5.71%
L2USC	53.5	0.02%	0.14%
PAB3F	0.4	0.00%	0.00%
PAB3G	148.1	0.07%	0.39%
PAB3H	165.4	0.08%	0.44%
PEM1B	598.9	0.28%	1.58%
PEM1G	0.6	0.00%	0.00%
PEM1H	4.6	0.00%	0.01%
PEM1A	0.2	0.00%	0.00%
PEM1C	2,801.5	1.30%	7.41%
PEM1F	855.3	0.40%	2.26%
PEM2H	0.8	0.00%	0.00%

Table J1. Wetland Acreages by NWI Code (page 2 of 2).

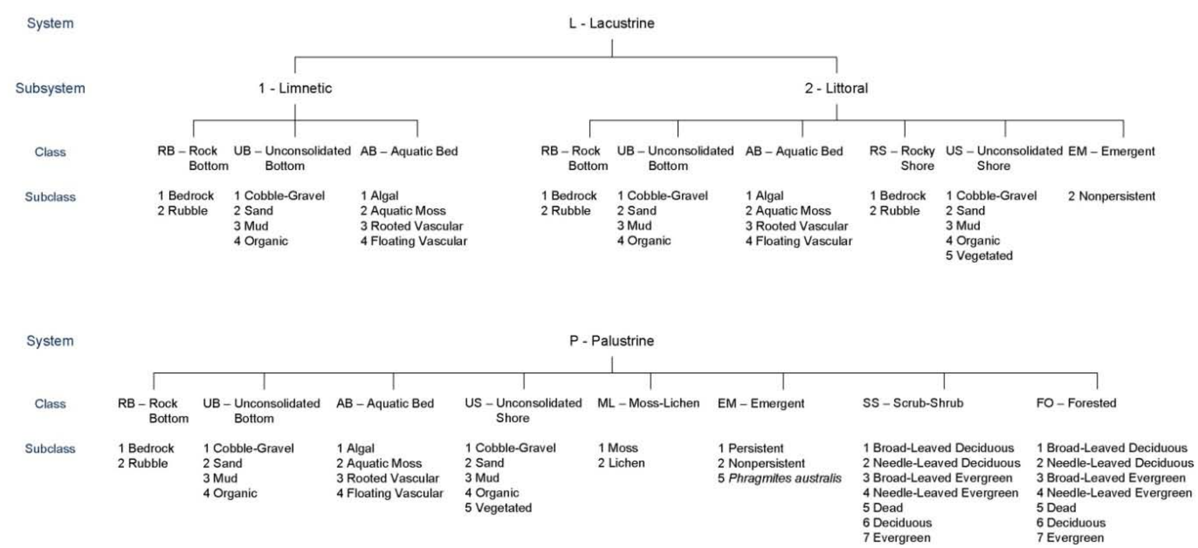
National Wetland Inventory (NWI) - 2009 Wetlands Acreage by NWI Code (cont.) Saint Croix Headwaters Watershed			
Summary Parameter	Acreage	% of Watershed Acreage	% of Total Wetland Acreage in Watershed
Watershed			
Total Area of Watershed	215,508.3	--	--
Upland	177,718.5	82.46%	--
Wetland	37,789.8	17.54%	--
NWI Codes			
PFO1A	275.4	0.13%	0.73%
PFO1B	6,873.9	3.19%	18.19%
PFO1C	2,050.7	0.95%	5.43%
PFO2B	249.1	0.12%	0.66%
PFO3B	492.6	0.23%	1.30%
PFO4A	1.4	0.00%	0.00%
PFO4C	11.0	0.01%	0.03%
PFO4B	6,791.9	3.15%	17.97%
PFO5F	12.6	0.01%	0.03%
PSS1F	3.7	0.00%	0.01%
PSS1A	12.7	0.01%	0.03%
PSS1B	1,237.4	0.57%	3.27%
PSS1C	2,877.5	1.34%	7.61%
PSS2B	21.6	0.01%	0.06%
PSS3C	9.1	0.00%	0.02%
PSS3B	1,177.9	0.55%	3.12%
PSS4B	212.0	0.10%	0.56%
PUBF	6.9	0.00%	0.02%
PUBG	163.7	0.08%	0.43%
PUBH	418.2	0.19%	1.11%
PUBK	14.3	0.01%	0.04%
PUSC	6.9	0.00%	0.02%
R2EM2H	118.1	0.05%	0.31%
R2UBH	299.9	0.14%	0.79%

Appendix K – NWI Classification Schema



Appendix K – NWI Classification Schema (cont.)

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION



MODIFIERS

In order to more adequately describe the wetland and deepwater habitats, one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

Water Regime			Special Modifiers	Water Chemistry			Soil
Nontidal	**Saltwater Tidal**	**Freshwater Tidal**		**Coastal Halinity**	**Inland Salinity**	**pH Modifiers for all Fresh Water**	
A Temporarily Flooded	L Subtidal	S Temporarily Flooded-Tidal	b Beaver	1 Hyperhaline	7 Hypersaline	a Acid	g Organic
B Saturated	M Irregularly Exposed	R Seasonally Flooded-Tidal	d Partly Drained/Ditched	2 Euhaline	8 Eusaline	t Circumneutral	n Mineral
C Seasonally Flooded	N Regularly Flooded	T Semipermanently Flooded-Tidal	f Farmed	3 Mixohaline (Brackish)	9 Mixosaline	i Alkaline	
E Seasonally Flooded/ Saturated	P Irregularly Flooded	V Permanently Flooded-Tidal	h Diked/Impounded	4 Polyhaline	0 Fresh		
			r Artificial	5 Mesohaline			
F Semipermanently Flooded			s Spoil	6 Oligohaline			
G Intermittently Exposed			x Excavated	0 Fresh			
H Permanently Flooded							
J Intermittently Flooded							
K Artificially Flooded							

Page 2 of 2

Appendix L – Landscape Position, Landform, Waterflow Path, and Waterbody Type (LLWW) Definitions

LLWW Functional Assessment Definitions (Page 1 of 3)

LLWW Attribute	Code	Definition
Landscape Position		
Lentic	LE	Wetlands associated with a lake basin or the relatively flat plain adjacent. (Lacustrine)
Lotic River	LR	Wetland that is within the banks or periodically flooded by a river. (Riverine)
Lotic Stream	LS	Wetland that is within the banks or periodically flooded by a stream. (Riverine)
Terrene	TE	Wetland or wetland complex that is surrounded by upland. It is not found within a floodplain or lake basin. It is not affected by lake, river, or stream flow processes. (Palustrine)
Landform		
Basin	BA	Wetlands that occur in a distinct depression.
Flat	FL	Wetlands that occur on relatively level ground surface.
Floodplain	FP	Wetlands that occur within an active flood zone of a river or stream.
Fringe	FR	Wetlands that occur in the shallow water zone of a permanent water body.
Interfluve	IF	Region of wetlands between two rivers, in the same drainage system.
Island	IS	A wetland or complex of wetlands that are completely surrounded by water.
Slope	SL	Wetlands occurring on a gradient of five-percent or greater.
Waterflow Path		
Bidirectional	BI	Wetlands adjacent to lakes that are subject to the rise and fall of its water level. There is no influence from rivers or streams to the lake or surrounding wetlands.
Inflow	IN	Wetlands found in sinks receiving water from streams, rivers, or other surface source. These wetlands lack surface water outflow.
Outflow	OU	Water flows out from the wetland or complex naturally, but there is no source of water inflow.
Outflow Artificial	OA	Water flows out from this wetland or complex via drainage ditches or underground tiles.
Outflow Intermittent	OI	Outflow occurs from this wetland or complex at intervals, not continuously, and lacks inflow source.
Throughflow	TH	Water flows naturally into and out of these wetlands. They are often adjacent to rivers and streams.
Throughflow Artificial	TA	Water flows into and out of these wetlands and complexes via drainage ditches.
Throughflow Intermittent	TI	Water flows into and out of at intervals, not continuously and is associated with intermittent streams.

Appendix L – Landscape Position, Landform, Waterflow Path, and Waterbody Type (LLWW) Definitions (cont.)

LLWW Functional Assessment Definitions (Page 2 of 3)

LLWW Attribute	Code	Definition
Waterbody Type		
Lake	LK	A body of water within a large lacustrine basin, much smaller than lakes. (Lacustrine)
Pond	PD	Open water, sand, or mud depressions much smaller than lakes. Ponds may be broken down into subclasses of natural, damned, excavated, beaver, or other. They can be further broken down by modifier to agriculture, commercial, industrial, aesthetic, or recreational. (Palustrine)
River	RV	A flowing watercourse that empties into a larger water body such as a lake, sea, ocean or other river. It must be a polygon feature on a U.S. Geological survey or National Wetland Inventory map. (Riverine)
Stream	ST	A flowing watercourse that empties into a larger water body such as a river, lake, or other stream. They are narrower, shorter, and carry less volume of water than rivers. Streams and rivers are broken into low, middle, and high gradients, intermittent or dammed. (Riverine)
Special Modifiers		
Barren	br	Wetlands lacking vegetation such as beaches, sand bars, and mud flats.
Beaver	bv	Wetlands that include area upstream flooded by beaver dams.
Channelized	ch	Stream or river that is dug wider or deeper to alter the general flow of a watercourse..
Cranberry bog	cr	Excavated shrub wetland constructed for cranberry production.
Drainage divide	dd	Wetlands found on watershed boundary that typically have outflow.
Diverted	dv	Wetlands where the course or direction of surface flow is altered.
Fragmented	fg	Wetlands broken from compexes due to railroads, roads, or utilities.
Floating Mat	fm	Carpet of vegetated material supported on water's surface - sphagnum moss.
Floating vegetation	fv	Duckweed, water hyacinth, or water lilies.
Leveed	lv	Wetlands altered by an artificially constructed dike or embankment.
Headwater	hw	Water source for wetlands and complexes downstream and includes wetlands along first and second order streams and intermittent streams upslope.
Lake island	li	Wetland connected to upland island that is completely surrounded by open water of lake.
Partly drained	pd	Wetland with majority of water removed - farmed wetland.
Pond island	pi	Wetland connected to upland island that is completely surrounded by open water of pond.

Appendix L – Landscape Position, Landform, Waterflow Path, and Waterbody Type (LLWW) Definitions (cont.)

LLWW Functional Assessment Definitions (Page 3 of 3)

LLWW Attribute	Code	Definition
Special Modifiers (cont.)		
River island	ri	Wetland connected to upland island that is completely surrounded by open water of river.
Human influenced	hi	Significantly degraded by human activities and often changes the function or level of function.
Spring-fed	sf	Wetlands where ground water reaches the surface to produce a seep or fen.
Subsurface flow	ss	Wetlands affected by the movement of water beneath the earth's surface.
Submerged vegetation	sv	Watercress, hydrillia, and water milfoil.
Surface water	sd	Wetlands that receive their water from runoff and flooding.

Appendix M – Landscape Position, Landform, Waterflow Path, and Waterbody Type (LLWW) – Example Diagram