Sunrise River Watershed

Inventory of Historical and Aerial Extent of Aquatic Resources

U.S. Army Corps of Engineers ▪ St. Paul District

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1.0 Introduction

The Sunrise River Watershed is located in east central Minnesota approximately 35 miles north of the Twin Cities metropolitan area. The watershed area is 383 square miles in size and is located within parts of Washington, Anoka, Isanti, and Chisago Counties. The Sunrise River drains in a northeasterly direction to the St. Croix River at the border of Minnesota and Wisconsin. The Sunrise River and its watershed are shown in Figure 1.

Numerous streams and lakes within the Sunrise Watershed are classified as impaired by the Minnesota Pollution Control Agency (MPCA). Impairments are numerous and include: turbidity, nutrients, pH, fecal coliform, low dissolved oxygen, mercury, and ammonia. The St. Paul District of the Corps of Engineers has commissioned a pilot study of the watershed to "develop a framework for locating and prioritizing compensatory mitigation for impacts to waters of the United States". The Corps pilot study is part of a broader effort by Federal, State, and local agencies to develop a watershed management plan for the Sunrise River Watershed.

1.1 Study Objective

The objective of this study is to inventory aquatic resources within the Sunrise River watershed for the purpose of establishing a baseline for assessing changes. This study is a component of the Corps' watershed based mitigation pilot study for the watershed. The emphasis of the inventory is wetlands. Specific study objectives include:

- Developing a GIS inventory of existing and historic wetlands within the watershed.
- Assess changes in the type and extent of wetlands within specific minor basins.
- Assess the watershed land use to allow a future comparison to stream water quality and biodiversity from monitoring data. This comparison will allow an assessment of watershed vulnerability for the purpose of predicting impacts to water quality and aquatic resources based on land use and other watershed factors.

1.2 Study Terminology

It is important that the terminology used throughout this report be understood. Terms and interpretations specific to this study are described below.

Watershed refers to the entire area tributary to the Sunrise River at its confluence with the St. Croix River. This is also referred to as the Sunrise River Watershed.

Sub-Basin refers to the eleven areas within the watershed that have similar characteristics and reflects the area tributary to various stream segments. The sub-basins have a "HU 12" name on the USGS web page and are shown on Figure 1.

Minor Basins refer to the 85 small drainage areas shown on Figure 1. Minor basins have a 7 digit HUC code on the USGS web page.

Wetland Loss refers to the conversion of a wetland area to upland. For the purpose of this study, wetland losses do not include type changes or other wetland characteristic alterations provided the area remains a wetland.

Lake Loss refers to the reduction in size of water bodies deeper than 6.5 feet. For the purpose of this study, lake losses do not include changes in the lake depth or other lake characteristic alterations, provided the area retains lake characteristics.

Aquatic Resources refers to wetlands, lakes, and streams. These resources support multiple functions such as wildlife and fishery habitat, water quality treatment, flood control, groundwater recharge, recreation, and aesthetics. This includes both jurisdictional and non-jurisdictional wetlands.

Aquatic Degradation describes the loss of functions and values of aquatic resources. Aquatic degradation is associated with the system's vulnerability and could include diminished aquatic diversity, water quality, or habitat.

1.3 Watershed Characteristics

The topography of the watershed is relatively flat. The highest elevations are approximately 950 ft msl at the southern part of the watershed near Forest Lake. Approximately 20 miles to the northeast at the confluence with the St. Croix River the lowest elevations are approximately 800 ft msl. The landscape has significant lakes, wetlands, and depressions in the southern two-thirds of the watershed. The northern third of the watershed is dominated by agricultural land.

Farming practices beginning in the late 1800s converted most of the landscape from what was predominately deciduous forest, mixed forest, shrublands, and herbaceous wetlands (Chisago County, 2006) to cropland and non-native grasses. These practices have included draining of wetlands, ditching, and stream modifications to increase usable agricultural land. Agriculture and its impact to native landscapes remained generally consistent thru the twentieth century. However, since 1960 development pressures have also increased in the watershed. For example, the population of Chisago County has quadrupled (273.6%) between 1960 and 2007 and was the sixth fastest growing county in the State between 2000 and 2007. (Minnesota Department of Employment and Economic Development, 2008).

2.0 Data Sources

The Corps of Engineers assembled and provided numerous GIS datasets and paper copies of data used in this study. The GIS data included ArcGIS files of:

- National Wetland Inventory (NWI) maps
- U. S. Geological Survey (USGS) Landcover mapping
- U. S. Department of Agriculture (USDA) County Soil Survey maps
- General Land Office (GLO) plat maps
- National Wetland Inventory mapping
- 2008 Farm Service Agency (FSA) aerial photography
- Subwatershed boundaries and names
- Chisago County Light Detection and Ranging (LIDAR) data
- Impervious surface mapping from the Remote Sensing and Geospatial Analysis Laboratory at the University of Minnesota

Paper copies of the Minnesota Department of Natural Resources Drained Wetland Survey of Chisago County were also provided by the Corps of Engineers.

Additional GIS data sets where collected by URS from other available sources which include:

- 2009 FSA aerial photography
- 2006 color infrared aerial photography
- 1991 black and white leaf-off aerial photography
- Minnesota Department of Natural Resources (DNR) lake, river, stream, and ditch datasets
- Minnesota Transportation Department (MnDOT) BaseMap features
- U. S. Geological Survey (USGS) National Elevation Data

3.0 Assessment of Current and Historic Extent of Aquatic Resources

3.1 Approach

The Sunrise River Watershed falls within portions of four counties, Anoka, Chisago, Isanti, and Washington. While conducting the existing and historic inventory, a primary objective was to maintain a consistent approach throughout the entire study area. Utilizing data that was available in one County but not another could yield inconsistent results. The inconsistent results could suggest inaccurate wetland gain and loss rates in areas with a given data set, as compared with areas without the same data.

The approach utilized GIS to assemble the electronic data and perform the analysis. The methods used to perform each analysis are described in the sections below.

3.2 Historic Inventory

The Historic Inventory is defined as conditions existing at the time of European settlement in the mid 19th century. Data for conducting the historic inventory is limited to Original Land Survey and County Soil Survey data.

For the purpose of this study, the soils data was used to determine historic wetlands based on the assumption that hydric soils take long periods of time to form. Therefore, hydric soils in former wetlands drained by humans would tend to retain the hydric characteristics that were observed during the soil survey. Areas developed or significantly disturbed at the time of the soil survey may not have been classified as a hydric soil and would therefore not be inventoried as a historic wetland. The soil survey has a relatively small fraction that is classified as disturbed soils so the net effect of this on the analysis is expected to be minor.

The Original Land Survey was utilized as supplemental data to validate the accuracy of the soils data.

<u>County Soil Survey Data</u>

Soil taxonomy was utilized to determine the plant community associated with a given soil series map unit. Because soil development is, in part, driven by the associated plant community, a determination was made regarding the historical wetland type.

Mollisols are soils with deep, dark A horizons, formed under a grassland plant community. The dark A horizon is the result of organic matter accumulated from the annual growth and decay of grass and forb roots.

Alfisols are often associated with forested areas. They are more weathered than entisols, and contain an E-horizon that is leached out and lighter in color.

Entisols are soils with no profile development other than the A horizon. Inhibition of soil development can be inhibited by a number of causes, but is likely the result of saturation that prevented soil genesis.

Histosols are organic soils that formed under wet conditions whose anoxic conditions inhibited decay of organic matter. Plant material was deposited annually, resulting in organic soils of varying decomposed states.

The USDA-NRCS Official Soil Series Descriptions provides information on vegetation associated with each soil series. In cases where only one plant community is described, the soil series was given a wetland type corresponding with that community. In cases where an additional plant community was described (i.e. grasses with some trees) and the first plant community corresponded with the soil order (i.e. grasses and a Mollisol) the primary wetland type corresponded with the former, and the secondary wetland type corresponded with any additional plant communities described. The Soil Series Descriptions are provided in the appendix.

Prior to European settlement, the landscape was impacted by indigenous populations of the region. These populations engaged in intentional burning of vegetation of grasslands and forests to improve travel, encourage the growth of berry producing plants, and to attract game to newly forming shoots. This resulted in plant communities that were adapted to fire, and that generally contained less woody plant and shrub growth. Following Columbian contact 500 years ago, 90% of the indigenous population was wiped out by disease, altering the fire regime, and allowing woody plants and trees to expand into areas previously dominated by grasses (Lentz). This may have allowed Mollisol soils to become forested.

Original Land Survey Data

Original Land Survey data provides information regarding vegetation and aquatic resources at the time of European settlement.

Under the General Land Office (GLO), the Original Land Survey was conducted in the 1850's in the Sunrise River Watershed. The survey was conducted along section lines as well as along the shore of water bodies that fell on section lines. The survey notes contain observed data and locations regarding lakes, rivers, swamps, waterfalls, and areas of prairie and forest, as were surveyed. The surveyors also created maps that depicted surveyed features from section lines and meander lines, as well as less accurate observations of physical land features that fell within sections. From the GLO data, the Marschner Map of Original Vegetation was created to describe plant communities at the time of the Original Land Survey. The Marschner Map plant communities are at a scale that is not useful for this study, and was utilized for confirmation of the hydric soils analysis only.

Observations along section lines are known to be reasonably accurate (Galatowitsch). Aquatic resources such as lakes and large wetlands that are depicted within sections on the GLO maps were drawn, but were not surveyed. These are particularly inaccurate when compared to air photos. Because the survey was limited largely to section lines, the data was deemed not practical for the scope of this historic inventory. The GLO data was utilized as a visual check of the inventory derived from the soil survey.

Difficulties in identifying lakes and waterways were encountered. The soil survey method led to a more narrow field of wetland type categories as compared with the existing inventory. For example, the soil survey data does not specifically describe shrub carr wetlands. While these were no doubt present prior to European settlement, this type of plant community is not associated with a specific soil type in the soil series descriptions. Also not described in the soil survey are deep marshes and open water communities. These wetland types are often associated with "water" map units in the soil survey data. This raises another problem, because it is difficult to discern which "water" map units are associated with deeper wetlands versus lakes. The use of the soil survey in identifying historical lakes is complicated by this fact, as well as that the soil survey was performed in more recent times. While the hydric soils represent historical wetlands with reasonable accuracy, "water" map units are generally areas of permanent standing water. It is likely that historical lakes that were drained following European settlement were mapped in the soil survey as hydric soils, but there is no way to systematically identify these areas as historical lakes.

Historical records from the Original Land Survey notes and GLO maps were not complete enough to provide an accurate representation of historical lakes and waterways. As was described previously, detailed data was only collect along section lines, and along lake shores that the surveyors had to meander around because they fell along section lines. While the GLO maps show lakes and waterways away from the section lines, these were estimated by the surveyors and were not accurate enough to determine historical lakes or waterways with any degree of accuracy. However, because historical lakes and waterways with a historical riparian zone would be expected to be dominated by hydric soils, these areas would be covered in the more general aquatic resource inventory, but the detail needed to type these areas as lakes is extremely limited.

3.3 Existing Inventory

The Existing Inventory is defined as aquatic resources existing during the summer of 2009 (when the 2009 aerial photographs were taken of the entire watershed). A large body of data is available for conducting the existing inventory, including aerial photographs, National Wetland Inventory (NWI), Public Waters Inventory (PWI), topographic data, as well as the use of ground reconnaissance.

The approach utilized soil survey data and NWI data to identify areas that may contain aquatic features. Areas that possibly contained aquatic features were searched for visually by inspecting air photos from a number of years, including 2009, 2008, 2006 infrared, and 1991 black and white (leaf off) photos. Areas that did not contain hydric soils or NWI wetlands were also visually inspected. The PWI generally identified shallow marshes, deep marshes, shallow open water communities that were also identified in the NWI, as well as lakes. NWI, PWI, Soil Survey, topographic data, and earlier air photos were used to identify possible aquatic resources, but the final identification and delineation of a given aquatic body was based on its appearance in the 2009 air photo.

Any area identified as an aquatic resource was digitized manually in GIS and assigned a code (based on the visual indicators described below) identifying the aquatic resource type. The type (as defined in Section 3.6 below) was determined by visually inspecting the air photo to determine vegetative cover and hydrology of the wetland. Topographic data, where available, was used to refine the placement of the wetland line once a wetland was identified

3.4 Visual Indicators of Wetlands

The process of identifying wetlands using air photos required utilizing visual indicators of wetlands. The visual indicator depends on the wetland type, and is described in the wetland type section below. Wetlands with standing water are easy to identify, whereas wetlands that do not typically have standing water, such as wet meadows and forested wetland are more difficult to identify and often require the use of supplemental data such as the NWI to make a positive identification.

Wetlands often stand out as a patch surrounded by a residential or developed matrix. Small residential lots surrounding an open grassy area, and irregularly shaped non-farmed areas surrounded by plowed fields are two such examples. Additional visual indicators of wetlands include:

- Clearings in forested areas. These are typically areas that are too wet to support an upland forest, and are dominated by reed canary grass which prevents establishment of woody plants.
- ATV trails through grassy areas. This type of area is typically dominated by reed canary grass, and is usually too wet to be cut for hay on a regular basis or brought into row crop production.
- Failed tree plantings. Trees planted in rows that pass through a wetland may exhibit stunted or missing trees. This is a result of tree species that are not suited for wetlands, and inadequate control of competition in the more competitive wetland plant community.
- Non-farmed areas that are "plowed around." These are typically too wet to plow in the spring. Farmers plow around them to avoid getting stuck in mud. These can contain small areas of upland but are dominated by wetland conditions. Also, non-farmed areas on the perimeter of plowed fields may be wetland. Crops such as corn and soybeans tend not to grow in wet conditions, and suggest areas of non-wetland.

3.5 Ground Truthing

Ground truthing visits were conducted to further refine the accuracy of the wetland visual indicators observed in the aerial photographs. The past experience of the investigator provided additional ground truthing information. The investigator has performed approximately 50 wetland determinations and delineations in the Sunrise Watershed and surrounding areas. These studies involved the use of aerial photographs, soil survey, and NWI data for both a pre-site-visit analysis as well as post site visit mapping of delineated wetlands. Utilizing air photo both before the site visit as an off-site determination, as well as following the site visit provided a confirmation and refinement of the visual indicators used for this study.

Additionally, site visits to a forested wetland site and a fallow sod farm site were conducted to confirm and refine the wetland visual indicators utilized in the analysis. Multiple plant communities at each location were evaluated, and photographs and notes from the site visit are provided in the Appendix.

3.6 Identification of Wetland Types

Identification of wetland types was performed based partially on the Circular 39 system developed by the U.S. Fish and Wildlife Service (USFWS). Wetlands were classified based on depth of hydrology and plant community. Additionally, lakes, ditches, excavated ponds, and riverine areas were identified.

<u>Seasonally Flooded Wetlands</u>

These include farmed wetlands and wetlands that may not exhibit wetland characteristics every year, but do in more than 50% of years. Farmed wetlands typically are indicated as areas of crop stress or disturbance in a farm field. They are confirmed by the presence of a dark spot in the 1991 leaf-off black and white air photo. They are inconsistently depicted in the NWI, and are often mapped as upland soils due to their small size.

<u>Wet Meadow / Sedge Meadow</u>

Wetlands in this category have saturation up to the surface, but typically do not have standing water. They are dominated by grasses, usually reed canary grass, but can also be dominated by other native grasses, sedges, and wildflowers. The visual indicator was typically a darker green than the surrounding area and lacking a predominance of woody vegetation. These areas are typically too wet to farm or mow in normal years. During dry years some mowing is observed as the grass can be used for forage material. These wetlands often transition into a forested upland area.

Shallow Marsh

This type of wetland has some standing water during the growing season. Emergent vegetation such as cattail usually dominated in dense monocultures, but other native species such as bulrush, arrowhead, and water plantain can also be present. The visual indicator use is typically of a green with brown appearance given by the previous year's growth that has not yet decayed at the time of the aerial photo. Often a small area of water with a reduced concentration of emergent vegetation can be observed in the center of the wetland.

Deep Marsh

These wetlands typically have more than six inches, but less than three feet of standing water, allowing the growth of emergent and floating vegetation. Generally, deep marshes have standing water that can be observed in the air photos. These wetlands were identified based on the appearance of vegetative cover such as water lily, cattail, bulrush, and arrowhead with standing water clearly visible.

Open Water Community

These wetlands have standing water more than three feet, but less than six-and-a-half feet in depth. They are vegetated with submergent and floating vegetation but lack emergent vegetation. They tend to be smaller than lakes, lack recreational uses such as boating and also do not have docks or boat launches. These wetlands were identified based on the appearance of open water with sparse floating vegetation.

Shrub Wetlands

These wetlands typically have soils that are saturated to the surface and have a predominance of shrub cover such as alder and dogwood.

Forested Wetlands

Forested wetlands include hardwood swamps, forested floodplains, and tamarack swamps. Forested wetlands can be difficult to identify as wetland because of the generally short duration of hydrology. Many trees associated with wetlands such as green ash, cottonwood, box elder, and American elm are early successional species and can also be found growing in upland areas. Identifying forested wetlands through the use of air photos was also difficult. However, the approach included the use of the aerial photos from 2009, the color infrared from 2006, and the leaf-off black and white from 1991. In addition, the NWI and Soil Survey data was used along with topographic data. The 1991 aerial photo was useful for determining if a given forest was wetland, but the ultimate wetland line was based on the more recent air photos.

Lake

A lake is a water body deeper than two meters, and is usually larger than 10 acres. Lakes are usually observed as being utilized for recreational uses such as boating. Private docks, boat launches, and channels are often observed. Areas along lakeshores where residential development and docks are not present are frequently wetlands adjacent to lakes.

Excavated Ponds and Storm Water Ponds

Excavated ponds are often found on residential property with larger lots. They are usually excavated from wetlands that are saturated to the surface. Excavation is often done by the landowner as part of an effort to "improve" the wetland, attract wildlife, or as a borrow site for soil.

Storm water basins are often found in residential and commercial area, but generally are not found in existing wetland areas. In the case of both excavated and storm water ponds, these features were identified when observed, regardless of whether they were excavated in upland or wetland areas.

Riverine Areas

These include large streams and rivers, as well as adjacent riparian wetland communities. These are linear features with hydrology that is driven largely by the stream or river.

Smaller creeks could not be easily identified in the study due to the “leaf-on” conditions of the air photos that resulted in these features being obscured.

3.7 Cumulative Impact Analysis

Cumulative impacts to the aquatic resources of the Sunrise River Watershed were determined based on the difference between the historic and existing inventories. The overall impact to the Watershed was a 26.3% decrease in aquatic resources. Minor basin impacts ranged from slight increases in nine of the sub-basins, to losses as high as 84.2% decrease in aquatic resources.

As might be expected, agriculture and development appeared to account for the losses. Drainage associated with agricultural production has resulted in significant wetland losses. The most dramatic is located in the far northeast portion of the watershed, near the confluence of the Sunrise River and St. Croix River. Several of the largest historical wetland complexes have been lost through the ditching and draining activities associated with the sod farming of the area. Only small forested wetland patches remain. Many areas in the northeast are completely devoid of existing wetlands. Large patches of lost wetlands are observed in the Lower North Branch Sunrise River, Sunrise River, and Mud Lake – Sunrise River sub-basins. These three sub-basins, all located in the northeast portion of the watershed, experienced the most severe losses in historical aquatic resources. While developed areas were also associated with areas experiencing significant wetland losses, it is difficult to discern how much wetland loss occurred from pre-existing agricultural activities versus the development itself.

Aquatic resource losses in the Chisago Chain of Lakes sub basin were observed to be in the 26% to 50% range. The combination of agriculture and development in this area has resulted in wetland losses that are smaller in size, but more numerous than in the northeast portion of the watershed. This led to a fragmentation of the landscape, resulting in smaller remnant patches of wetlands, as well as losses to entire small wetlands. Because the Chicago Chain of Lakes is in close proximity to these wetland losses and this is an area experiencing development in recent decades, it raises concerns regarding water quality for the lakes in the sub basin. A similar pattern of many small wetland losses were observed in the Upper North Branch Sunrise River and the Middle North Branch Sunrise River sub basins in the northwest portion of the watershed. These areas are also heavily dominated by agriculture. This area lacks the lakes other areas of the watershed, but water quality impacts to the North Branch of the Sunrise River is a concern.

Excavated ponds are a phenomenon observed throughout the watershed. They are usually less than a half acre in size, and are found in residential back yards and on larger residential lots. They are frequently created in existing wetland areas, but some are also created in upland areas. Because of their small size, they are of negligible wildlife habitat value. Because many are mowed around as landscape amenities, they lack significant buffer vegetation. As a result many of the excavated ponds appear to result in overall degradation to the wetlands they were constructed in.

Areas experiencing lighter losses or gains were associated with the Carlos Avery Wildlife Management Area (CAWMA). The CAWMA is about two-thirds wetland, with a series of 20 pools where water is actively managed for waterfowl. Pool management may account for the increase observed in some minor basins through increased hydrology. This area had a high concentration of wetlands in the historical inventory, and many of them have are still in existence.

4.0 Watershed Vulnerability Analysis

Land uses within a watershed can cause degradation of aquatic resources. Increases in impervious surface and cropland land cover types and decreases in wetland acreage within a watershed have been demonstrated to cause such impacts. The various land use factors that could impact aquatic resources were inventoried for the possible future correlation to water monitoring and watershed modeling results. The effort to develop this correlation, to establish aquatic degradation thresholds similar to the CWP vulnerability analysis, and to analyze the relationship between the land use factors and a measureable impairment in the watershed is not included in the scope of this study.

Land cover data for the watershed was obtained from the USGS (2003) and the University of Minnesota (2007). The University of Minnesota data set appeared to provide greater detail and accuracy in distinguishing between cropland and turf areas and between developed and turf areas. Therefore, this data set was used to review non-impervious land covers. The USGS data set provided more detail regarding the impervious fraction and was used to estimate the imperviousness for each watershed.

This overall land cover for the watershed is listed in Table 2. Figure 8 shows the land cover areas for each sub-basin. Pie charts showing the percentage of land cover for open water, wetlands, turf, forest, development, and cropland are included. The land cover areas were determined within GIS.

4.1 Impervious Land Cover Analysis

A recent study by the Center for Watershed Protection (CWP) (Zielinski, J, 2002) correlated watershed imperviousness with stream quality. This study identified levels of degradation when the impervious fraction reached 10 percent and 25 percent and established three minor basin categories. Watersheds with less than 10 percent imperviousness have a “sensitive” watershed classification and are characterized by high quality streams, stable channels, and excellent habitat. Watersheds with imperviousness greater than 10 percent show signs of deterioration whereby sensitive stream elements are lost from the system. Watersheds with greater than 25 percent imperviousness have an “impacted” minor basin classification and are characterized by poor water quality, stream instable, and have poor biodiversity.

One of the objectives of this study was to inventory impervious land uses and identifying the watershed classification as defined by the CWP study. The USGS land cover data sets provided the best detail for imperviousness and was therefore used to develop this inventory. The pixilation of the USGS data set is categorized by the percent imperviousness of the area covered by the pixel. The surface area for each of these impervious categories was totaled for each minor basin. The overall impervious fraction of the minor basin was estimated using the impervious fraction ranges. Overall the impervious fraction varied from 0 percent to 10 percent as shown in Table 3. Figure 9 illustrates the percent of impervious surface for each minor basin.

Only 7 of the 85 minor basins had an impervious fraction greater than 5 percent and no minor basin had an impervious fraction greater than 10 percent. All of the minor basins would be classified as “sensitive” according to the CWP watershed classification and would not be expected to show signs of aquatic degradation. Since numerous streams and lakes in the Sunrise River watershed are defined as impaired by the MPCA, this suggests that imperviousness does not correlate well with aquatic degradation in this watershed.

4.2 Watershed Vulnerability Analysis – Other Factors

The CWP vulnerability assessment focused on imperviousness as the primary factor that influences degradation. Much of the data used for the CWP study was from the Pacific Northwest and Mid-Atlantic ecoregions where the predominant land use change was the conversion of the native landscape to development (residential, institutional, industrial, and commercial). By contrast, the most significant historic land use changes in the Sunrise River watershed have been the conversion of the native landscape to agriculture and the draining of wetlands. As discussed below, these factors were inventoried for the Sunrise River to provide data for a possible future correlation to aquatic degradation.

Another land cover factor that could influence the degree of aquatic degradation is the amount of open water and wetland. Open water and wetland areas remove nutrients and sediment, attenuate runoff rates, and affect the flow to downstream areas. An inventory of the wetland and open water land uses was developed to provide data for a possible future correlation to aquatic degradation.

4.3 Cultivated Cropland

Farming practices will typically increase the rate and volume of runoff and often increase the sediment and nutrient load to lakes and streams compared to undisturbed or pre-settlement land uses. The replacement of forests and prairies with row crops in this watershed was often accompanied by wetland draining and tile drainage systems that further change the hydrology of the basin. The amount of cropland was inventoried to provide data for a possible future correlation factor to aquatic degradation. .

Table 4 shows the area of cropland and percentage for each minor basin along with the cumulative percentage for each sub-basin. The areas were determined in GIS using the U. S. Geological Survey (USGS) Landcover mapping. The GIS description for the cropland dataset is “cultivated crops”. The small amount of bare land was included in this inventory because it typically has similar hydrologic characteristics and erosion potential to cultivated crops.

Figure 10 shows the results graphically for each minor basin. Most of the minor basins near the Chisago Chain of Lakes and the Carlos Avery Nature Preserve have less than 20 percent cropland with some minor basins having less than 5 percent. By contrast, many of the minor basins in the north part of the watershed have greater than 30 percent cropland with some minor basins having between 40 and 60 percent cropland.

Figure 11 shows the cumulative percentage of cropland for each sub-basin. The cumulative values reflect the entire contributing watershed at the sub-basin discharge point and could be used to assess the relationship between areal extent of cropland and aquatic impacts. The overall percentage of cropland within the watershed is 25 percent.

4.4 Drained Wetland Inventory

The drainage of wetlands is expected to be a factor in the degradation of aquatic resources. Draining wetlands can change the hydrology by increasing the peak discharge to lakes and streams, reducing the groundwater infiltration, and affecting the natural nutrient and sediment balance. The amount of wetland loss was inventoried as a possible correlation factor to aquatic degradation.

Table 5 shows the historic wetland areas, existing wetland areas, and the percentage of the historic wetland that has been lost. The historic and existing wetlands were determined as discussed in Section 3.

Figure 5 shows the results graphically for each minor basin. The north part of the watershed had the greatest wetland losses with many minor basins having over 40 percent wetland loss.

4.5 Inventory of Lakes and Wetlands

Lakes and wetland that are within the watershed can affect downstream water resources. The amount of open water and wetland was inventoried as a possible correlation factor to aquatic impairment.

Table 6 shows the percentage of open water and wetland for each minor basin and the cumulative percentage for each sub-basin. The areas were determined in GIS using the U. S. Geological Survey (USGS) Landcover mapping.

Figure 12 shows the results graphically for each minor basin and Figure 13 shows the cumulative results by sub-basin. Many of the minor basins near the Chisago Chain of Lakes and the Carlos Avery Nature Preserve have over 40 percent of their area as open water and wetland. By contrast, many of the minor basins in the north part of the watershed have less than 10 percent open water and wetland.

5.0 Summary

Existing wetlands were determined based using air photos, soil survey data, and NWI data to identify areas that may contain aquatic features. Areas that did not contain hydric soils or NWI wetlands were also visually inspected. Any area identified as an aquatic resource was digitized manually in GIS and assigned a code (based on the visual indicators described below) identifying the aquatic resource type.

Historic wetlands were inventoried based on County Soil Survey data. The Original Land Survey was utilized as supplemental data to validate the accuracy of the soils data. Information in the soil series descriptions was used to determine likely wetland types.

Cumulative impacts to the aquatic resources of the Sunrise River Watershed were determined based on the difference between the historic and existing inventories. The overall impact to the Watershed was a 26.3% decrease in aquatic resources. Minor basin impacts ranged from slight increases in nine of the sub-basins, to losses as high as 84.2% decrease in aquatic resources.
As might be expected, agriculture (including drainage) and development appeared to account for the losses. The most dramatic is located in the far northeast portion of the watershed, near the confluence of the Sunrise River and St. Croix River. While developed areas were also associated with areas experiencing significant wetland losses, it is difficult to discern how much wetland loss occurred from pre-existing agricultural activities versus the development itself. Aquatic resource losses in the Chisago Chain of Lakes sub basin were observed to be in the 26% to 50% range.

An inventory of the watershed imperviousness was completed for the purpose of estimating aquatic degradation as described in the Center for Watershed Protection's (CWP) "Watershed Vulnerability Analysis" report. This CWP study identified levels of degradation when the impervious fraction reached 10 percent and 25 percent. Using USGS Landcover data we determined that none of the minor basins had an impervious fraction greater than 10 percent. Since numerous streams and lakes in the Sunrise River watershed are defined as impaired by the MPCA, this suggests that imperviousness does not correlate well with aquatic degradation in this watershed.

Other factors were inventoried for the possible future correlation to water monitoring and watershed modeling results. These factors include cropland, drained wetlands, and open water and wetlands. These factors show more cropland, more drained wetlands, and less open water and wetland in the northern part of the watershed. Thus, it is assumed that aquatic degradation in lakes and streams in the northern part of the watershed will be greater than those in the southern part of the watershed.

5.1 Assumptions

Identification of Historic Wetlands

An area mapped as hydric soil in the county soil survey was a wetland prior to European settlement. It is assumed that hydric soils take a long time to develop such that hydric soils are a representation of the extent of wetlands.

Soil Inclusions

A number of the soil series within the Sunrise Watershed are defined as non-hydric soils that may contain hydric inclusions – small areas of hydric soils in lower positions in the landform that are too small to be individual mapping units. Conversely, hydric soil map units may contain non-hydric soils in lower positions in the landform.

Inconsistent Overlap of Historic and Existing Wetlands

A number of existing wetlands were observed to not perfectly overlay historic wetlands. This yielded small "slivers" of historic wetland that were not identified as existing wetland, and existing wetland that were not identified as historic wetland. The error was assumed to be based on the precision of the soil mapping units.

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