Monitoring Plan for the St. Croix River: 2006

St. Croix Basin Water Resources Planning Team

Prepared in cooperation with the Wisconsin Department of Natural Resources and the U.S. Geological Survey

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Contents

Figures

Tables

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Introduction

The St. Croix River is a nationally important resource shared by Minnesota and Wisconsin. The St. Croix River Basin (20,000 km2) contains 15 major tributaries, with the St. Croix River marking a portion of the boundary between the two states. The St. Croix River Basin drains from forestlands and wetlands in the north, through agricultural lands in the central portion, and joins the Mississippi River near the urbanized Twin Cities Metropolitan Area (Figures 1 and 2). The lower 40 km of the river widens into what is known as Lake St. Croix. The St. Croix River is within an hour's drive of the Minneapolis/St. Paul metropolitan area, which has a rapidly expanding population. The population within the St. Croix Basin is expected to grow 39 percent by the year 2020. With proximity to a major metropolitan area, the watershed has experienced rapid development with housing, industry, and commercial properties being built in the watershed. The most intense development has occurred in the southern parts of the watershed, but that growth continues to progress northward. Recreational use on the river has doubled since 1973. The basin is a popular area for fishing, boating, hiking, and camping

The St. Croix River National Scenic Riverway was established in 1968 as one of the original eight components of the National Wild and Scenic Rivers Act (National Park Service, 1995a). The Riverway includes the Namekagon River from Namekagon Dam near Cable, WI to the confluence with the St. Croix River (158 km) and the St. Croix River from Gordon Dam near Gordon, WI to the confluence with the Mississippi River at Prescott, WI (248 km). Even though the shoreline adjacent

to the River has been designated as a National Scenic Riverway, there is no jurisdiction over what types of development can occur beyond that designated shoreline. The Riverway is effectively protected by the status of the National Wild and Scenic River Act; however the tributaries are not protected. To protect the Riverway, managing agencies understand the need to protect these tributaries.

Since 1994, state, federal, and local agencies have formed the St. Croix Basin Water Resources Planning Team (hereafter, the Basin Team) to investigate water issues and provide information to be used to understand the effects of growth and increased use of the river. In 1998, the Team developed a basin management plan that included nutrient monitoring and BATHTUB modeling of Lake St. Croix (O'Connell 1999). A number of recent studies (see Davis 2004) indicate that although the quality of the river is good, a continued rise in phosphorus inputs could enhance productivity and cause Lake St. Croix to become more eutrophic. Therefore, in 2004, the Basin Team recommended a 20-percent reduction in total phosphorus loading within the St. Croix Basin. This 20-percent phosphorus reduction goal will approximate the conditions of Lake St. Croix prior to 1950. The two state water quality regulatory agencies, the Minnesota Pollution Control Agency and the Wisconsin Department of Natural Resources, signed the agreement on April 6, 2006.

Background

In 2005, the St. Croix Basin Team, in cooperation with the Wisconsin Department of Natural Resources and the U. S. Geological Survey, began to develop a monitoring plan for the entire St. Croix River Basin. Presently, several state, local, and federal agencies conduct water quality and streamflow monitoring in the basin. The monitoring goals and objectives for these agencies vary with time, monitoring plans may not always coincide, and some monitoring duplication may occur. With a coordinated monitoring plan for the entire basin, any new or additional monitoring by agencies can be strategically placed to best benefit the phosphorus reduction goal set by the Basin Team. Representatives of the U.S. Geological Survey, National Park Service, Wisconsin

Department of Natural Resources, Minnesota Pollution Control Agency, Minnesota Department of Natural Resources, Metropolitan Council Environmental Services, and several counties all are supporting this effort, by maintaining existing monitoring stations and enhancing data collection efforts whenever feasible. Through the cooperative efforts of the Basin Team, this basin-wide monitoring plan will guide future expansions of the current monitoring network. The Basin Team focused monitoring emphasis on the lower half of the St. Croix River basin because 1) the most immediate development pressures are occurring in the southern and western parts of the basin, and 2) Lake St. Croix serves as a water quality integrator for the entire basin.

Nutrient and suspended sediment loading characteristics in the St. Croix River Basin were investigated from 1997 to 1999 and described in a report by Lenz et al. (2001). Response of the St. Croix River pools to phosphorus loading was investigated by Robertson and Lenz (2002). From these investigations, the major conclusions regarding tributary loading to the mainstem of the St. Croix River are as follows:

- Nutrient and sediment loading during storm events is a large portion of the annual loading from St. Croix River tributaries. The loads from these tributaries are insignificant during baseflow conditions.
- Storm intensity and runoff are the most important factors affecting annual tributary yields and loads.
- Storm events produce significant phosphorus loading from southern tributaries, where land use is predominantly agricultural and/or urban.
- Precipitation patterns and amounts control runoff volumes and thus affect the magnitude of nutrient and sediment loads. There can be a great disparity in climatological factors (hence runoff) throughout the St. Croix Basin.
- Most tributary loading of phosphorus and sediment to the St. Croix River mainstem comes from the large drainage area sub-basins, including the Snake, Kettle, Sunrise, and Apple Rivers and the St. Croix River at Danbury.
- Small storms in the southern portion of the St. Croix Basin produce small nutrient and sediment loads to the river mainstem.

- The Upper Tamarack River had the highest suspended sediment and nutrient concentrations and highest yields during storms.
- High loads and yields were observed in the Sunrise River because of high sustained discharges.
- In 1997, the snowmelt runoff contributed 50% of total annual phosphorus and sediment loads in the tributaries and as much as 70% of the total annual loads in the river mainstem.
- As much as 100 percent error exists in estimated loads from ungaged tributaries.
- Benthic invertebrate indices indicated excellent to good water quality in all tributaries except Valley Creek, Willow River and the Kettle River.
- Lake St. Croix is eutrophic because of high phosphorus loading.
- Increased phosphorus loads to Lake St. Croix will cause an increase in chlorophyll a concentrations, higher frequency of algal blooms, and a decrease in water clarity. Water quality response in Lake St. Croix is similar regardless of the flow regime.
- Since climate variability is one of the most important factors influencing tributary loading, monitoring over several years is very important to determine loading trends to the St. Croix Riverway.

Purpose

The purpose of this document is to describe a coordinated plan for water quality monitoring within the St. Croix Basin. The plan will be used as a guide for future monitoring and to measure progress toward the 20-percent phosphorus load reduction goal set by the St. Croix Basin Team. The plan was developed in the following steps: 1) identify key monitoring objectives for the basin and an ideal monitoring network that will achieve those objectives, 2) identify current (2005-2006) long-term monitoring sites, 3) identify gaps between the current and ideal monitoring networks, and 4) recommend priorities for additional monitoring.

Monitoring Objectives

Monitoring objectives for the St. Croix Basin were developed by expanding on the goals of the basin management plan (O'Connell 1999) The objectives are:

1. **Determine nutrient and sediment concentration trends and loads for the mainstem of the St. Croix River and Lake St. Croix.**
   - Lake St. Croix integrates the water quality of the basin, and the mainstem St. Croix River is the upstream source of Lake St. Croix.
   - Phosphorus tends to adsorb onto clay-sized particles, so this monitoring objective includes measures of sediments, turbidity, and clarity.
   - In addition, all nutrients (both phosphorus and nitrogen) will be important to track into the near future. Indeed, the Upper Mississippi River basin is the largest source of nitrogen loads contributed to the Gulf of Mexico hypoxia.
2. **Determine nutrient and sediment loads for the selected tributaries used to track progress on tributary nutrient management goals.**
   - Monitoring from the mouths of major tributaries to the mainstem St. Croix River will help to identify geographic sources of nutrients and sediments, thereby helping to target and prioritize future work.
3. **Determine trends in biological indicators in a) Lake St. Croix and Lake Mallalieu (pooled water locations), and b) at mainstem and tributary locations (flowing water locations).**
   - The end goal of the nutrient reduction agreement is not necessarily a particular number in phosphorus concentration, but good-to-excellent quality resource waters.
   - Biological variables integrate many physical and chemical water quality variables, and therefore are efficient indicators of overall water quality conditions.
   - The biological indicators for monitoring pooled versus flowing waters are slightly different, therefore should be evaluated separately.
4. **Provide information used in the development and modification of mainstem and tributary nutrient models, which are used to predict various nutrient management scenarios.**
   - Computer models help to predict which combination of land and water management practices will have the most benefit in reducing sediment and nutrient runoff.

Ideal Monitoring Network

An ideal monitoring network (figure 3) was delineated, including monitoring site locations, water quality variables, and sampling frequencies (Table 1). The selected monitoring sites in Table 1 will achieve more than one of the monitoring objectives listed above (monitoring objectives column, Table 1). The monitoring site locations required to achieve each objective are summarized below.

Monitoring Objectives #1

The first objective of the monitoring plan is to determine concentration trends and annual loads of sediments and nutrients within the mainstem of the St. Croix River and Lake St. Croix. To achieve this objective, a minimum of five monitoring sites on the St. Croix River are needed: Danbury, Norway Point, St. Croix Falls, Stillwater, and Prescott. These sites are listed in Table 1,

noted with a "1" in the monitoring objectives column. Continuous flow gaging is required to conduct loading analysis at each of these sites. The sediment variables (total suspended solids, volatile suspended solids, and laboratory analysis of turbidity) and nutrient variables (total phosphorus, dissolved phosphorus, total nitrogen, nitrate+nitrite-nitrogen, and ammonia-nitrogen) need to be sampled at frequencies sufficient to collect accurate loading data: monthly samples for baseflow loading and composite sampling of stormflow peaks for storm loading.

Monitoring Objectives #2

The second objective of the monitoring plan is to determine concentration trends and annual loads of sediments and nutrients contributed by tributaries to the St. Croix River. To achieve this objective, as many as 23 tributary monitoring sites may be needed. These sites are listed in Table 1, noted with a "2" in the monitoring objectives column. All of these sites are for individual tributaries, with the exception of one: the Danbury site was selected to represent the upper St. Croix tributaries (including the Totogatic and the Namekagon) since the land use/land cover is expected to remain relatively uniform for the near future, with no major agricultural or urban developments. The ideal sampling strategy for this objective is similar to that of Objective #1: continuous flow gaging, and sufficient sampling frequency of sediment and nutrient variables (see lists above) to collect baseflow and storm loading data.

Monitoring Objectives #3

The third objective of the monitoring plan is to determine trends of biological indicators a) within pools of Lake St. Croix and Lake Mallalieu and b) within the mainstem and tributaries to the St. Croix River. The biological indicators for monitoring pooled versus flowing waters are slightly different, so these two parts will be evaluated separately. To achieve Objective #3a, seven monitoring sites within the pools of Lake St. Croix and Lake Mallalieu, and at the upgradient and downgradient ends of Lake St. Croix, are required. These sites are listed in Table 1, noted with a

"3a" in the monitoring objectives column. These locations need to be sampled semi-monthly (twice per month, May-September) for water column variables and sampled once every three years for surface sediment variables. The water column variables are secchi depth, dissolved organic carbon, total chlorophyll-a, and phytoplankton biomass and composition, while the surface sediment variables are diatom biomass and composition.

To achieve Objective #3b, as many as 25 monitoring sites may be needed, including the 23 tributary locations (see Objective #2) and mainstem locations at Norway Point and St. Croix Falls. These sites are listed in Table 1, noted with a "3b" in the monitoring objectives column. These locations need to be sampled semi-monthly (twice per month, May-September) for water column variables and sampled annually (August) for surface sediment variables. The water column variables are transparency tube, dissolved organic carbon, total chlorophyll-*a*, and diurnal dissolved oxygen, while the surface sediment variables are periphyton biomass and composition.

Monitoring Objectives #4

The fourth objective of the monitoring plan is to provide useful data for the calibration of SWAT nutrient models of mainstem and tributary locations. Ideally, the monitoring of a targeted subwatershed will precede modeling efforts, providing 5 years or more of flow data and 2 years or more of water quality data. To achieve this objective, 1-4 monitoring sites per targeted subwatershed are needed at the following locations: the mouth, separate branches, and impoundment inflow/outflow. Currently, the Willow River is undergoing SWAT modeling, but no sites are listed in Table 1 with an objective "4" because the next targeted subwatershed has not yet been selected. The sampling strategy is similar to the requirements of loading analysis: continuous flow gaging, monthly baseflow samples and composite storm samples. The water quality variables are dependent on the model abilities, but usually include a conservative tracer (chloride), sediments (total suspended solids), and nutrients (total phosphorus, total nitrogen, and nitrate+nitrite-nitrogen).

Current 2006 Monitoring Sites

An inventory was conducted of the local, state, and federal agencies currently monitoring in the St. Croix River Basin, including: the locations of long-term monitoring sites, water quality variables, and sampling frequencies. Monitoring variables were grouped into six types: flow, field, sediment, nutrients, ions, and biological. This information was placed into an ACCESS database and displayed using ARCMAP.

The current monitoring sites for streamflow, nutrients, suspended sediment, and biological constituents in the St. Croix Riverway are shown in Figure 4. A summary of all current monitoring sites in the Riverway is listed in Table 2. The monitoring site locations for streamflow, nutrients, suspended sediment, and biological constituents are shown in Figures 5, 6, 7, and 8, respectively. Streamflow gaging locations are listed in Table 3. Monitoring locations, monitoring agencies, constituents sampled, and sampling frequency for nutrients, suspended sediment, and biological components are listed in Tables 4, 5, and 6, respectively. Streamflow in the basin is measured by the Metropolitan Council Environmental Services (MCES), U.S. Geological Survey (USGS), Washington County Conservation District (WCD), and Minnesota Pollution Control Agency (MPCA). Water quality (nutrient and suspended sediment) constituents are measured by the MCES, Wisconsin Department of Natural Resources (WDNR), MPCA, National Park Service (NPS), WCD, and the Anoka County Conservation District (ACCD). Biological constituents are measured by the MCES, MPCA, WDNR, NPS, and ACCD.

Streamflow Monitoring

Streamflow is currently being measured at the mouth of most major tributaries to the mainstem of the St. Croix River. These tributaries contribute the majority of the nutrient and sediment loads to the river mainstem, according to Lenz et al. (2001). The Snake, Kettle, Sunrise,

and Apple Rivers and the St. Croix River at Danbury contribute the majority of these loads to the St. Croix River, because of their large flow volumes. The Apple, Kinnickinnic, and Willow Rivers contribute an insignificant amount of loading during low flow and baseflow conditions. Streamflow in the Sunrise River is measured at the mouth, as well as in parts of the upper basin. Streamflows in the Upper and Lower Tamarack, Sand, and Crook Rivers in the northern part the St. Croix River Basin are not being measured. These basins also contributed significant loads during storm events but were not important load contributors during baseflow conditions. In the southern part of the basin, MCES measures tributary streamflow in Browns, Silver, and Valley Creeks.

Streamflow in the mainstem of the St Croix River is currently being measured at Danbury, WI, and St. Croix Falls, WI. Streamflow at the mouth of the St. Croix River is not directly measured, however it is indirectly estimated using routing techniques. The flow of the Mississippi River at Prescott, WI, is derived, in part, by the discharge of the St. Croix River. The contribution of flow by the St. Croix River at Prescott is derived from flow measured at the Apple River near Somerset and the flow of the St. Croix River at St. Croix Falls, WI. The sum of these discharges is further adjusted by adding a one-day lag for time of travel, and by multiplying the combined flow by 1.034 to adjust for ungaged drainage areas. Crest stage gage monitoring sites are located at 4 sites in the basin and are listed in Table 3.

Nutrient Monitoring

Nutrient monitoring locations are shown in Figure 6 and listed in Table 4. In the northern part of the St. Croix River Basin, above St. Croix Falls, WI, monitoring is conducted by the MPCA, WDNR, and NPS. Five monitoring sites are located on the mainstem of the St. Croix River, and four sites are located near the mouths of major tributaries, including the Namekagon River near Trego, Snake River, Kettle River, and Sunrise River. Total phosphorus, total nitrogen, nitrate-

nitrogen, and ammonia-nitrogen are analyzed at all of these sites on a monthly basis from March to November. The sites monitored by the MPCA are sampled two years in every five.

There are two additional nutrient monitoring sites (Sites 9 and 1, Figure 6) located upstream from the tributary mouths on the Snake and Sunrise Rivers. Nutrient monitoring is also conducted in the upper reaches of the Sunrise River Basin by the WCD, as shown on the inset map of Figure 6.

Nutrient monitoring below St. Croix Falls, WI is currently being conducted by the MPCA, NPS, MCES and WCD. Mainstem St. Croix River monitoring sites are located at Stillwater, Hudson, Bayport, Pool 2 and Pool 4 (Figure 6 and Table 4). With the exception of the monitoring sites at Stillwater and Prescott, the nutrient constituents analyzed and the sampling frequency are similar to sites in the northern part the St. Croix Basin. At Stillwater and Prescott, MCES is collecting bi-weekly nutrient samples year-round, with analysis of total phosphorus, orthophosphate, dissolved phosphorus, nitrate-nitrogen, ammonia-nitrogen and total Kjeldahl nitrogen. Both the MPCA and the MCES collect nutrient samples at Stillwater.

However, the Stillwater and Hudson sites are monitored two years in every five years by the MPCA, with monthly sampling during the March-November period. Below St. Croix Falls, the major tributaries being monitored monthly include Silver, Browns, and Valley Creeks and the Apple, Kinnickinnic, and Willow Rivers. Silver, Browns, and Valley Creeks are also being sampled during all storm events. Nutrient samples from these three creeks are being analyzed for total phosphorus, orthophosphate, dissolved phosphorus, nitrate-nitrogen, ammonia-nitrogen and total Kjeldahl nitrogen. Additional nutrient monitoring by WCD is shown on the inset map of Figure 4.

Suspended Sediment Monitoring

Locations of suspended sediment monitoring sites, shown in Figure 7 and listed in Table 5, are similar to those for nutrients. Analysis is comprised primarily of total suspended solids. Volatile suspended solids are measured biweekly by MCES at Stillwater and Prescott, monthly and during

storm events by MCES at Silver, Browns, and Valley Creeks, and monthly and during storm events by the WCD at sites located in the upper Sunrise River Basin

Biological Monitoring

Locations of biological monitoring sites are shown in Figure 8 and listed in Table 6. Chlorophyll-a is the predominant biological constituent analyzed at tributary and St. Croix River mainstem locations. With the exception of the monitoring sites at Stillwater and Prescott, sampling is conducted monthly from March to November at sites shown in Figure 8. At Stillwater and Prescott, MCES obtains chlorophyll-a samples year-round on a bi-weekly basis. MCES also obtains annual phytoplankton, zooplankton, periphyton, and macroinvertebrate samples at Stillwater and Prescott. The MPCA collects monthly chlorophyll-a samples (March-November) at six sites in the northern St. Croix Basin, but monitoring is conducted only 2 years in 5.

Gap Analysis and Monitoring Priorities for the St. Croix River Basin

Monitoring gaps were identified when the current monitoring was compared with the ideal monitoring network. The next step was the prioritization of monitoring sites and variables that are recommended to be added as more funding becomes available.

The locations of current monitoring gaps and the list of monitoring locations and constituents that are necessary to achieve the four monitoring plan objectives established by the St. Croix Nutrient Subcommittee are presented in Figure 3 and Table 1. Table 1 also indicates the priority ranking and degree to which the monitoring objectives are currently being achieved at each monitoring site. All monitoring sites and constituents are ranked by priority, from "high" to "moderate" to "lower". The assignment of priorities was based on prior knowledge of relative pollutant loading among the subwatersheds and expected development pressures. For each site and constituent, the level of monitoring achievement is also denoted, from "fully achieved by current monitoring" to "partly achieved by current monitoring" to "not achieved by current monitoring". In

this manner, monitoring gaps are highlighted and future monitoring efforts can be strategically directed based upon priority and current level of achievement.

Streamflow

There are currently no streamflow gaging stations located on the mainstem of the St. Croix River between St. Croix Falls, WI and the mouth at Prescott, WI. The highest priority for installation of a new streamflow gaging station would be at the mouth of the St. Croix River near Prescott. A gage at this location would measure pollutant loading from the entire St. Croix Basin, including phosphorus and sediment loads delivered to the Mississippi River. A new streamflow gaging station at Stillwater is also ranked as a high priority, as it would allow direct measurement of the goal of a 20% reduction in phosphorus loading to Lake St. Croix. Installation of a streamflow gaging station at Norway Point in the upper St. Croix Basin is also ranked as a high priority. A moderate priority is given for the installation of streamflow gaging stations located on tributaries in the northern part of the basin, including the Yellow, Upper and Lower Tamarack, and Clam Rivers. These tributaries were monitored from 1997 to 1999 by Lenz et al. (2001), and contributed moderate (18.2-37.5 kg/day) phosphorus loads to the St. Croix River

Nutrient and Suspended Sediment

The most important gap in water quality monitoring of nutrients and suspended sediment is the absence of storm event sampling. With the exception of Browns, Valley, and Silver Creeks, there are no sites where streamflow is being sampled during storm events. The most significant loading to the St. Croix River occurs during storm events and snowmelt runoff. Current water quality monitoring is generally focused on water quality trends, but not on loading to the St. Croix River. Regular monthly sampling may miss a significant (>50%) portion of the annual nutrient and suspended sediment loading to the St.Croix River. Since the sampling frequency for nutrients and suspended sediment at the sites listed in Table 6 does not include storm events and does not extend

for greater than one to two years, long term trend analyses of loads and loading rates are currently not possible. Only 2 sites (St. Croix River at Stillwater and Prescott) are currently monitored for nutrients and suspended sediment on a bi-weekly basis year round. The remainder of the nutrient sampling sites are monitored monthly during the ice- out period of March through November. The MPCA milestone monitoring frequency for most major tributaries is 2 years in every 5, with the St. Croix River Basin tributaries next scheduled for monitoring in 2007. With the exception of the MCES Watershed Outlet Monitoring Program (WOMP) sites on Browns, Valley, and Silver Creeks, all of the other highest priority sites listed in Table 1 only partially achieve the monitoring objectives for nutrients and suspended sediment. Dissolved phosphorus is currently measured at only 11 sites in the St. Croix Basin, and these sites are located in the southern portion of the basin. Volatile suspended solids (VSS) is currently measured at only 5 sites in the St. Croix Basin

Biological

Beginning in 2006, biological monitoring will be largely focused on Lake St. Croix and its immediate tributaries. In the northern part of the basin, sampling of tributaries will be limited to a 2 in 5 year rotation. Determination of long term chlorophyll-a trends and algal contributions from tributaries in the northern portion of the St. Croix Riverway will not be possible given the current sampling frequency

Monitoring Considerations and Recommendations for St. Croix River Basin

Storm event monitoring of tributaries is necessary to measure progress toward the 20 percent phosphorus reduction goal. Storm events (intense rainfall and subsequent runoff) are responsible for most of the nutrient and sediment loading from St. Croix River tributaries. Monthly water quality monitoring could miss the most significant loading events. Monthly samples can be collected by field personnel, but storm samples require dedicated automatic (electronic) monitoring equipment.

- To determine annual and/or seasonal nutrient and sediment loading from major tributaries, continuous stream flow measurement is needed at the mouths of these tributaries.
- Real-time water quality monitoring stations with continuous flow measurement and automated sampling during storm events would be helpful for better estimates of annual tributary loading.
- Monitoring of tributaries for water quality during snowmelt runoff may be more important than monitoring monthly during baseflow. Fifty percent of the total load to the St. Croix River in 1998 was from snowmelt runoff.
- Some of the northern tributaries (Snake, Kettle, and Namekagon Rivers) have the greatest drainage areas and therefore contribute a significant portion of the nutrient and sediment loading to the St. Croix River. However, some southern tributaries (Sunrise, Apple, Willow, and Kinnickinnic Rivers) contribute significant loading due to developmental pressures. Their proximity to Lake St. Croix makes them of special concern.
- Monitoring needs to be conducted for multiple years in order to detect trends in nutrient and suspended sediment concentrations and loads.

As project funding becomes available, it may be possible to expand the current monitoring network toward the ideal network, or that which is needed to achieve the monitoring goals of the St. Croix Basin Team. The monitoring stations and variables in Table 1 are categorized as highest, moderate, or lower priorities. The highest priorities are given more detailed ranking in the following list of recommended expansions of the current monitoring network:

1. Flow gaging on the mainstem St. Croix River (at Prescott, Stillwater, and Norway Point).
2. Nutrient and sediment storm loading monitoring on the mainstem St. Croix River (at Prescott, Stillwater, St. Croix Falls, Norway Point, and Danbury).
3. Nutrient and sediment storm loading monitoring on tributaries (Kinnickinnic, Willow, Apple, Sunrise, Snake, and Kettle Rivers).

NOTE: These top three priorities, while given relative rankings, are seen as nearly equally important for the minimum achievement of the monitoring goals of the Basin Team. The remaining priorities, while still ranked as high priority, are seen as slightly less important.

4. Surface sediment cores collected for biological indicators in Lake Mallalieu and Lake St. Croix pools (at Stillwater, Bayport pool, Troy Beach pool, Black Bass pool, Kinnickinnic pool, and Prescott).
5. Increased sampling frequency of water column biological samples collected in Lake Mallalieu and Lake St. Croix pools (at Stillwater, Bayport pool, Troy Beach pool, Black Bass pool, Kinnickinnic pool, and Prescott).
6. Increased sampling frequency of water column biological samples collected from river sites (at Kinnickinnic, Willow, Apple, Sunrise, and Snake Rivers, plus the St. Croix River at Norway Point).
7. Periphyton collected from artificial substrate placed at river sites (at Kinnickinnic, Willow, Apple, Sunrise, Snake, and Kettle Rivers, plus the St. Croix River at St. Croix Falls, Norway Point, and Danbury).

Inevitably, the result of prioritization is that, with respect to monitoring budgets and analysis, moderate and lower priority monitoring locations will receive less attention than highest priority locations. Therefore, it is important that the prioritization scheme remain dynamic: lower and moderate priority locations need some on-going monitoring to confirm that they continue to be minor contributors of nutrient and sediment loads. The ecological and hydrological health of those locations need to tracked on an intermittent basis at a minimum.

Monitoring Plan Revisions

A final goal of the St. Croix Basin Team, with respect to water quality monitoring, is to revise this monitoring plan on a regular basis. Specifically, the Monitoring and Assessment Subcommittee will seek to evaluate the monitoring data at the end of the field season each autumn, publish an annual report on the status of the river, and make any necessary revisions to the monitoring plan each spring, in time for the next field season. If this proves too ambitious, the assessment/revision cycle may be biannual.

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Figure 1. Minneapolis, St Paul.Metropolitan area and the St. Croix River Basin

Figure 2. Land Use of the St. Croix river Basin

Figure 3. Ideal Monitoring Network St. Croix River Basin

Figure 4. 2005-2006 monitoring site locations

Figure 5. Streamflow monitoring locations

Figure 6. Nutrient monitoring locations

Figure 7. Sediment monitoring locations

Figure 8. Biological indicator monitoring locations

Table 1. The ideal Network monitoring site locations, water quality constituents, and sampling frequency.

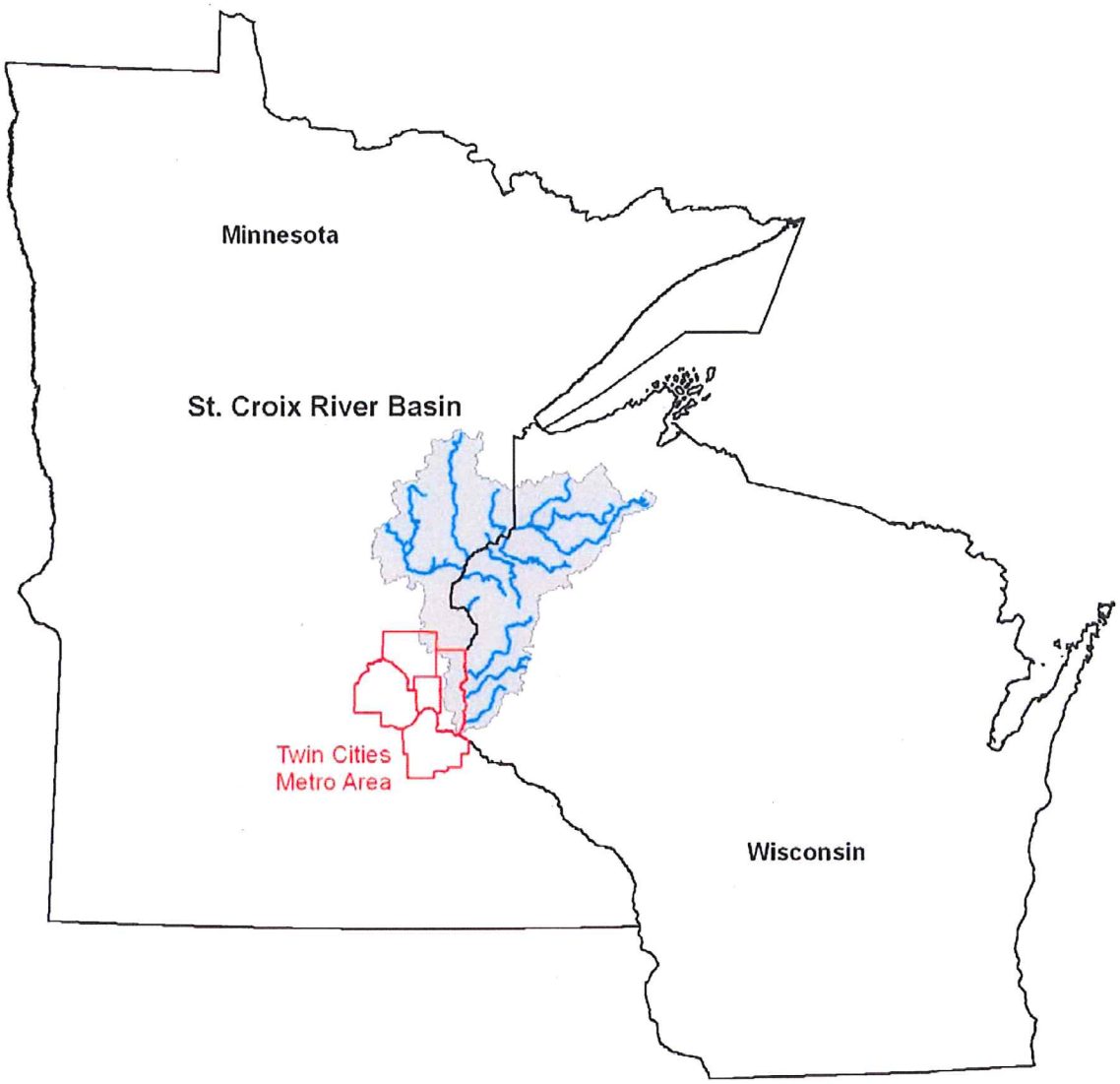

Figure 1. Minneapolis, St. Paul Metropolitan area and the St. Croix River Basin

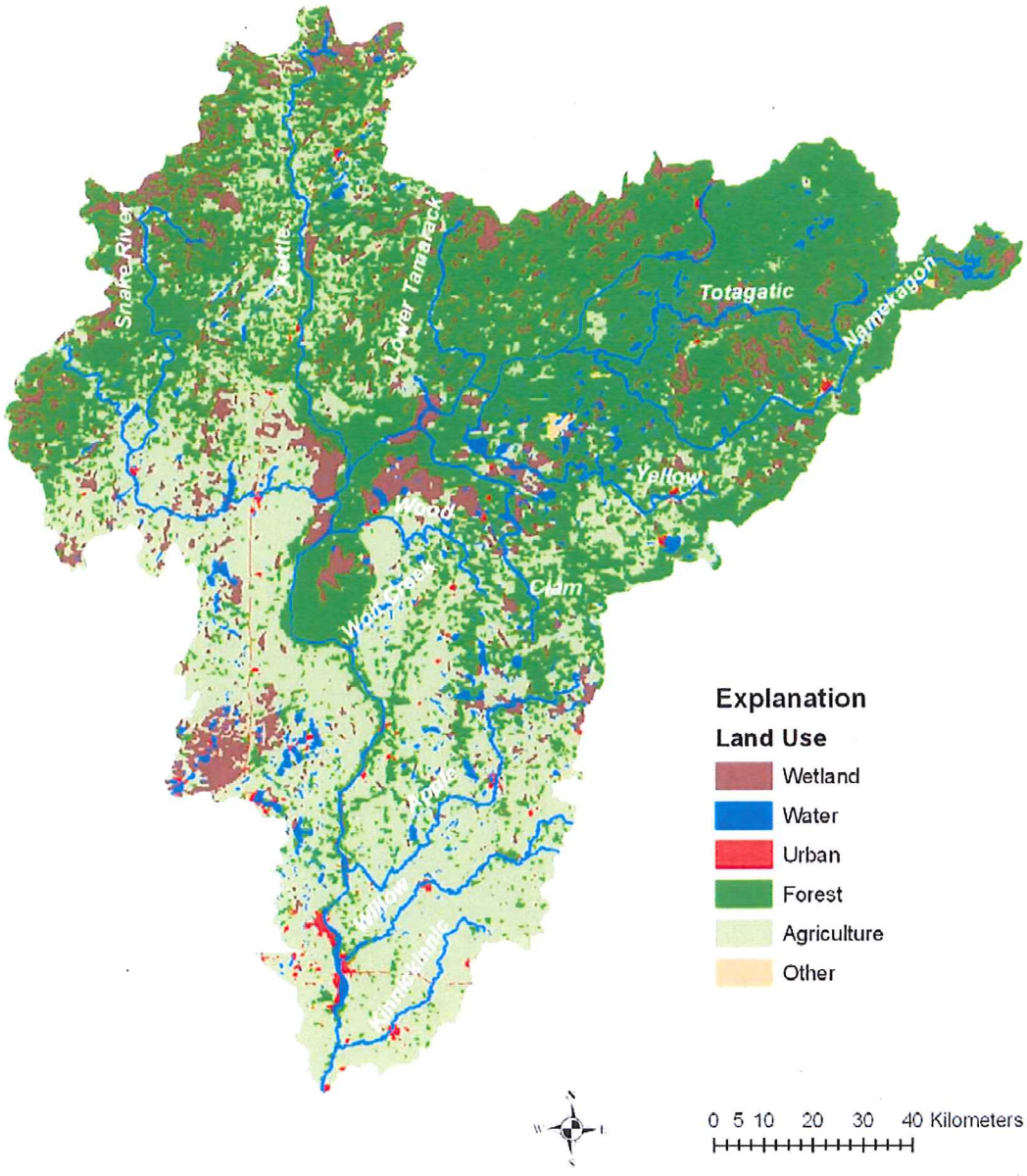

Figure 2. Land Use of the St. Croix River Basin, Wisconsin and Minnesota

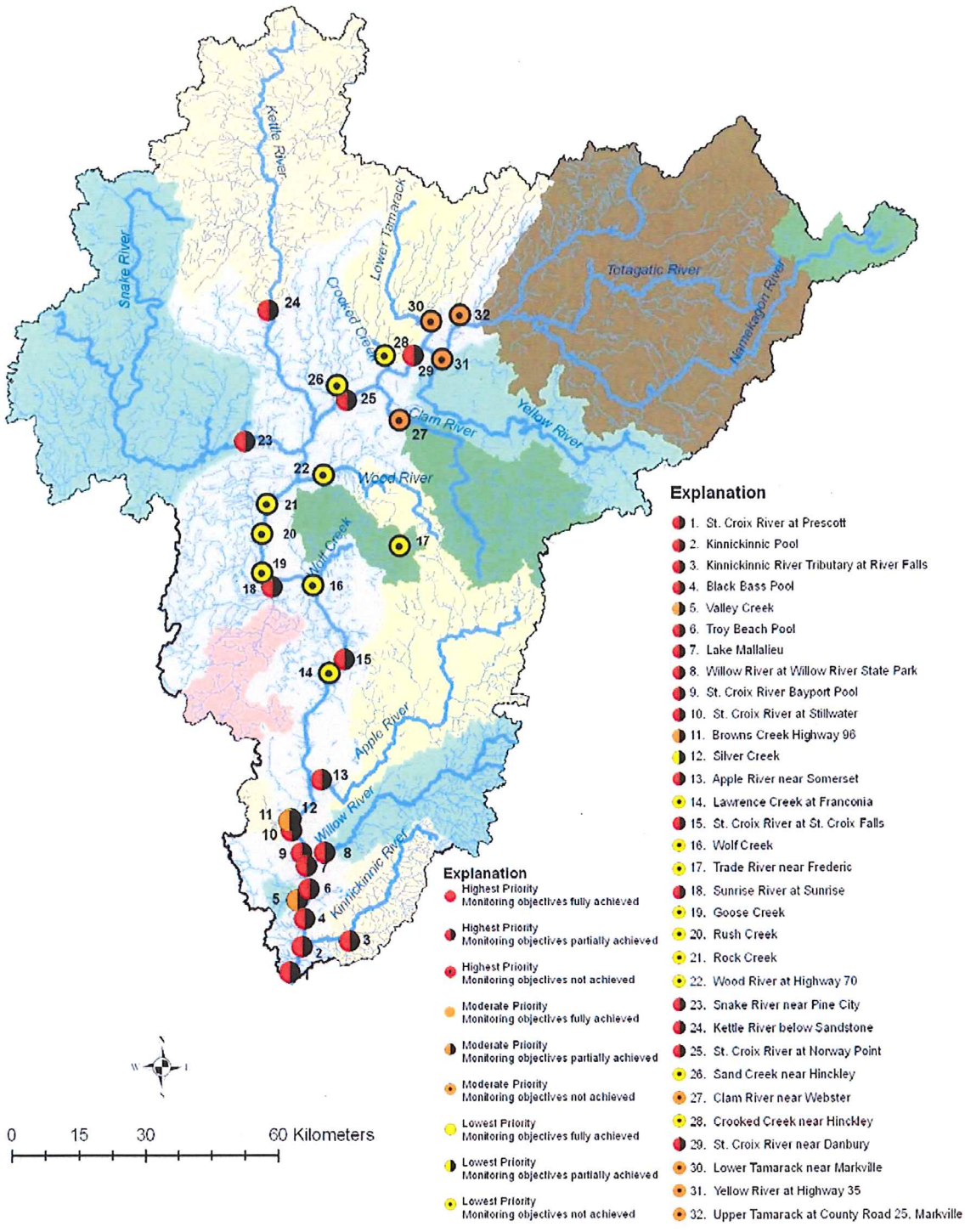

Figure 3. Ideal Monitoring Network St. Croix River Basin, Wisconsin and Minnesota

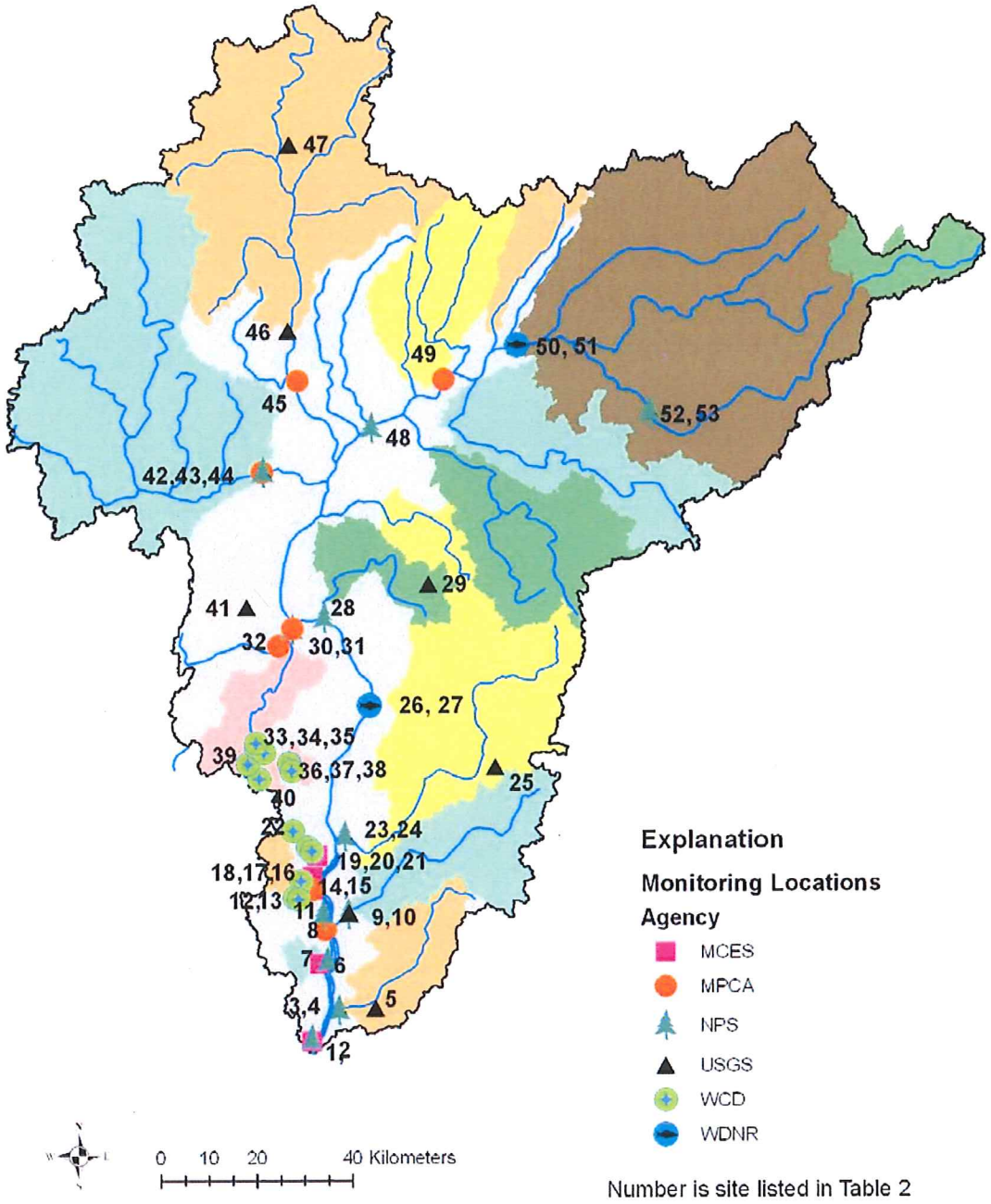

Figure 4. 2005-2006 monitoring site locations, St. Croix River Basin, Wisconsin and Minnesota

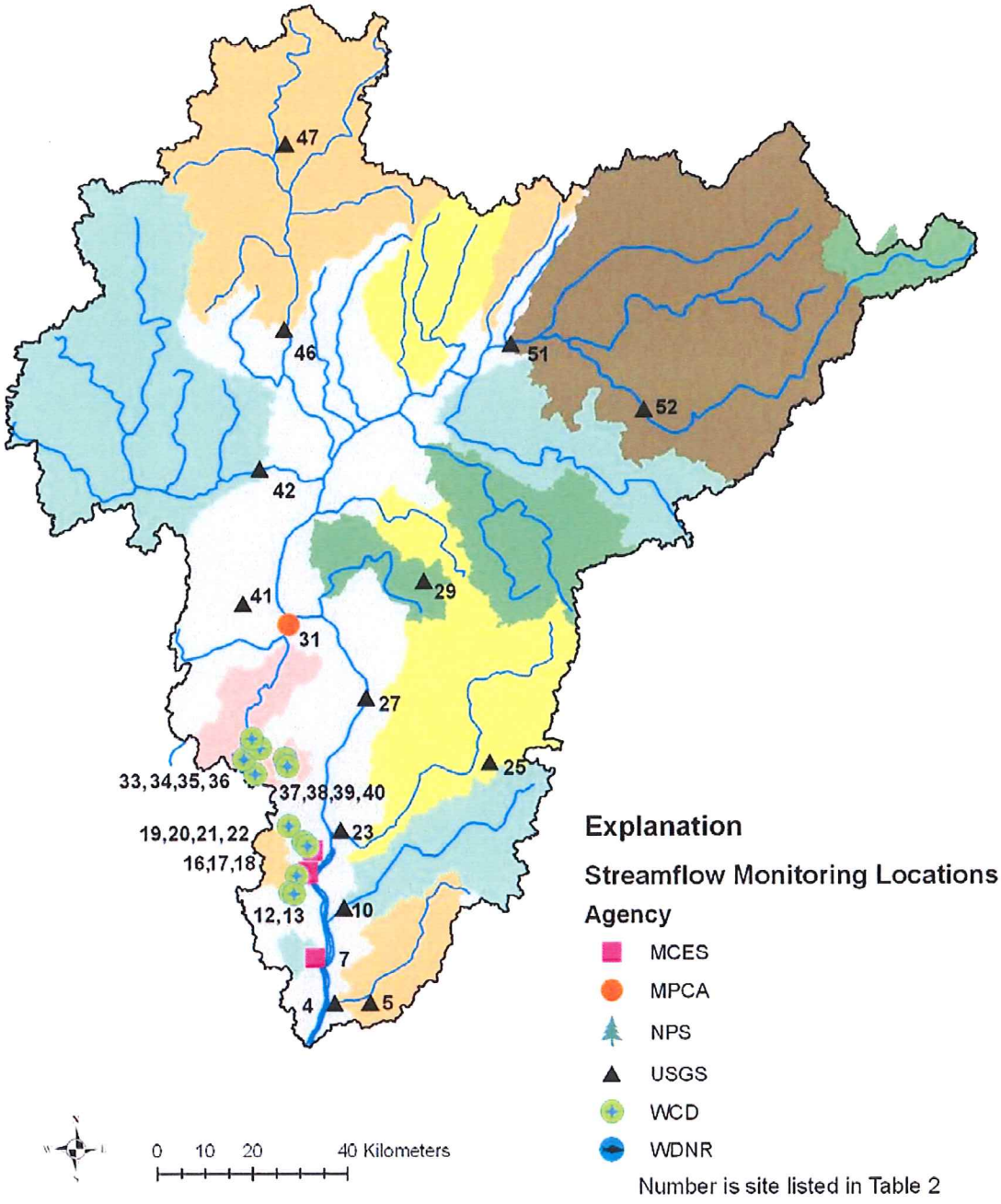

Figure 5. Streamflow monitoring locations, St. Croix River Basin, Wisconsin and Minnesota

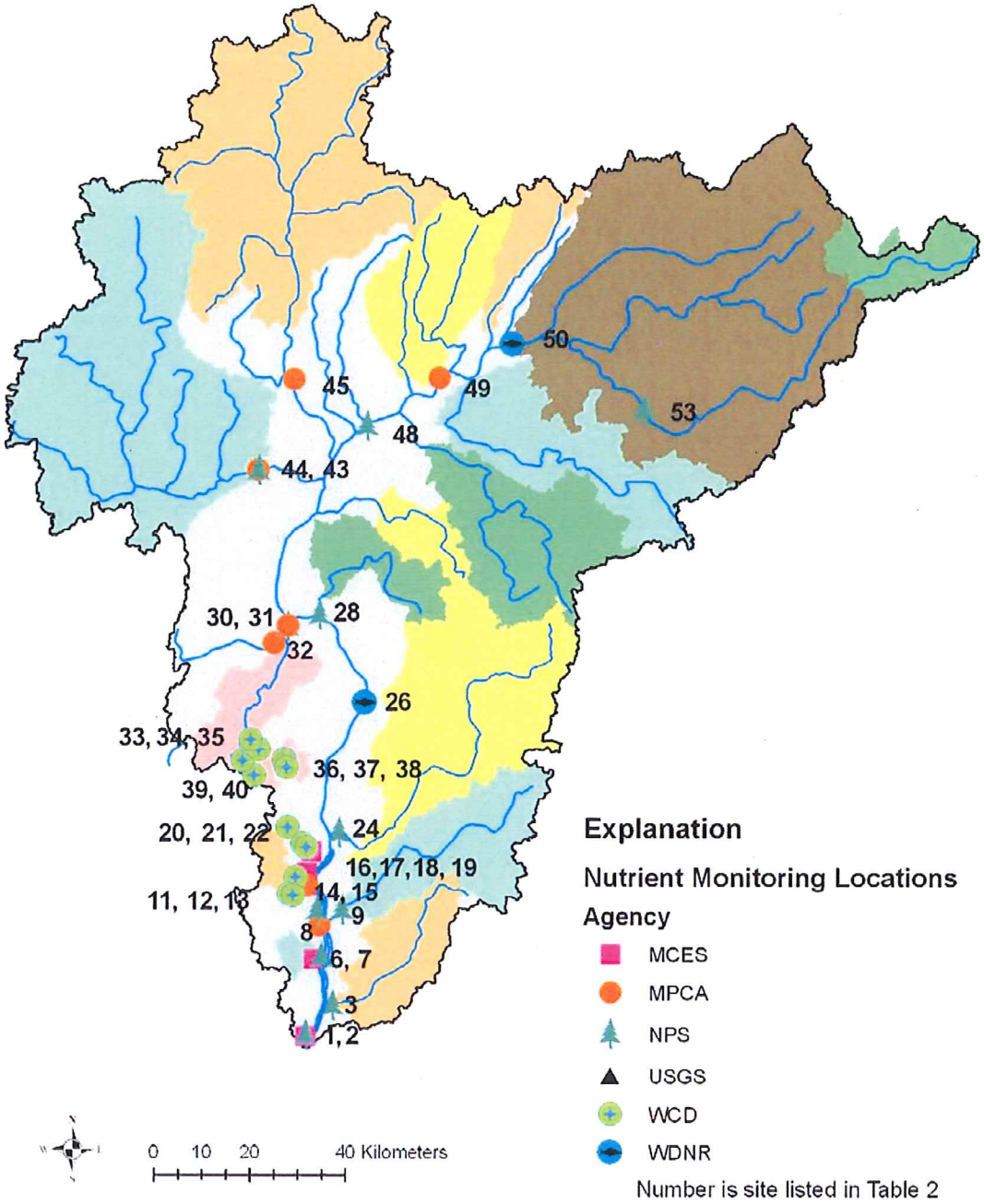

Figure 6. Nutrient monitoring locations, St. Croix River Basin, Wisconsin and Minnesota

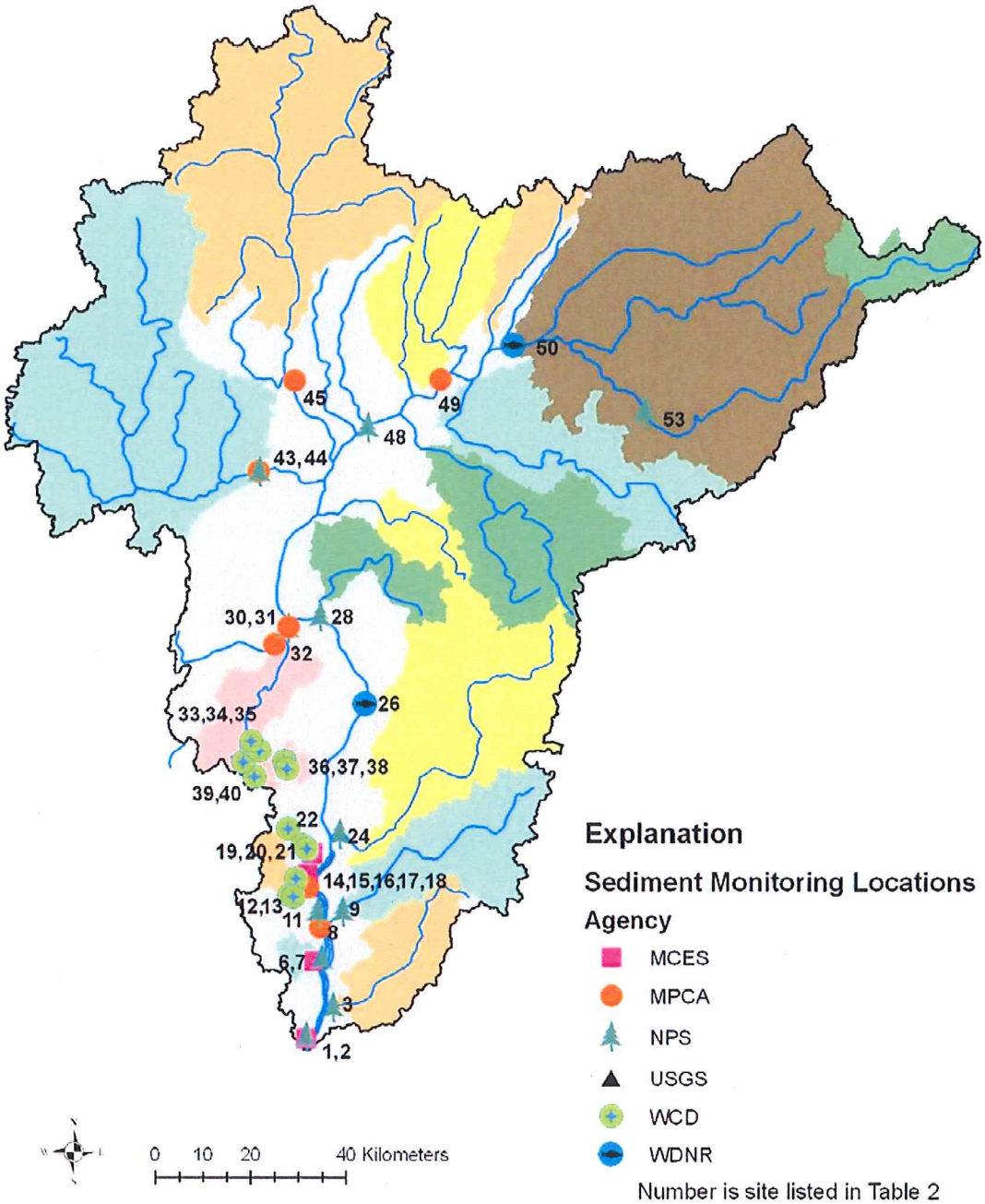

Figure 7. Sediment monitoring locations, St. Croix River Basin, Wisconsin and Minnesota

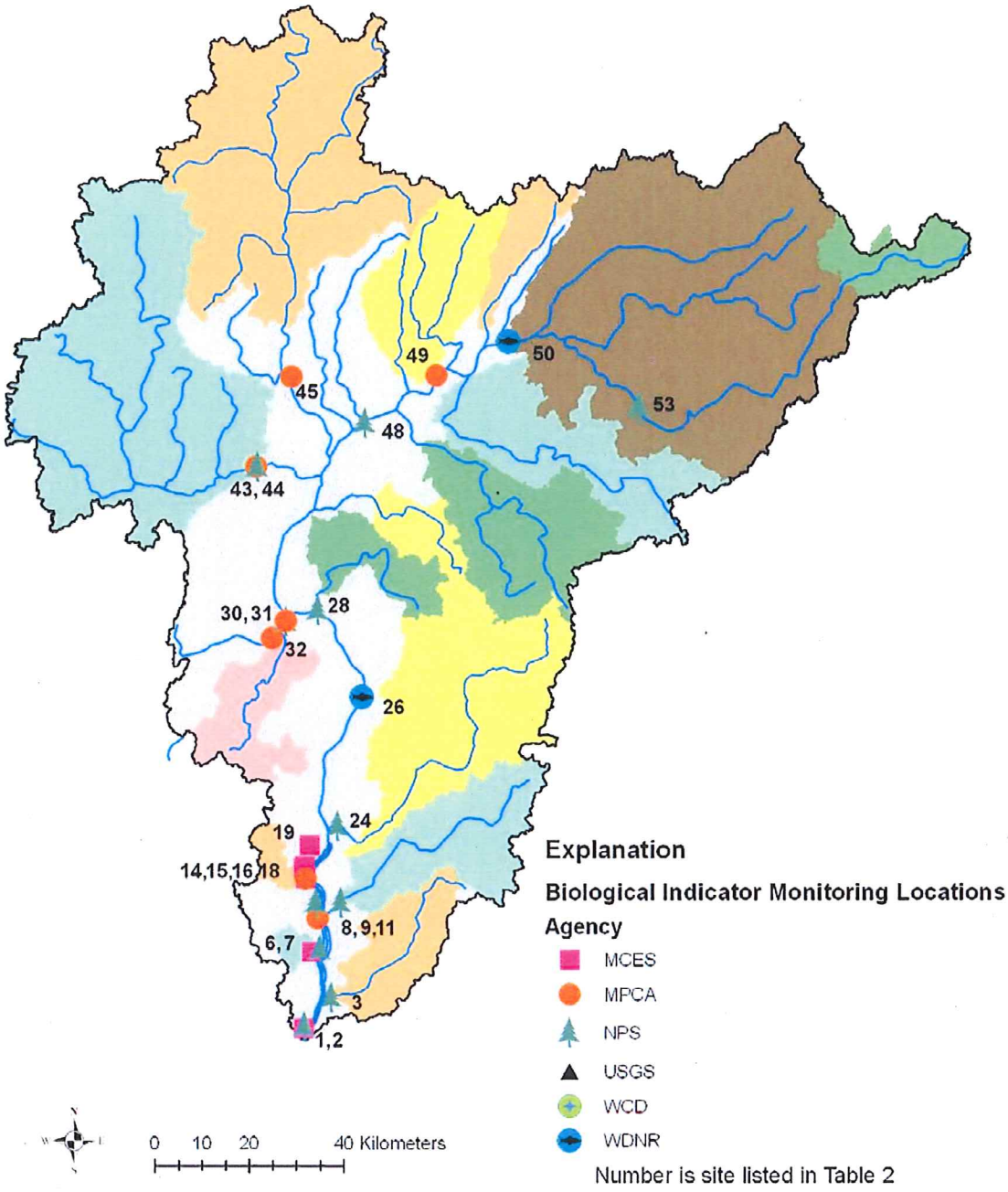

Figure 8. Biological Indicator monitoring locations, St. Croix River Basin, Wisconsin and Minnesota

Table 1. The ideal monitioring network, site locations, water quality constituents, and sampling frequency

StnID	MapSymb	Water body	Site Loc.	Obj#	Flow[a]	TP[b]	DP[b]	TN[b]	NOx[b]	NHx[b]	TSS[b]	VSS[b]	turb[b]	diatom[c]	phyto[d]	secchi[d]	T-tube[d]	DOC[d]	Tchla[d]	periphy[e]	diurDO[d]
29		U St. Croix Tribs	Danbury	1,2,3b	USGS	MPCA,WDNR		WDNR	MPCA,WDNR	MPCA,WDNR	MPCA,WDNR		MPCA,WDNR						MPCA,WDNR		
31		Yellow R.		2,3b																	
32		U Tamarack R.		2,3b																	
30		L Tamarack R.		2,3b																	
28		Crooked Cr.		2,3b																	
27		Clam R.		2,3b																	
26		Sand Cr.		2,3b																	
25		St. Croix R.	Norway Point	1		NPS	NPS	NPS	NPS	NPS	NPS		NPS				NPS	NPS	NPS		
24		Kettle R.	Sandstone	2,3b	USGS	MPCA			MPCA	MPCA	MPCA		MPCA						MPCA		
23		Snake R.	Pine City	2,3b	USGS	NPS,MPCA	NPS	NPS	NPS,MPCA	NPS,MPCA	NPS,MPCA		NPS,MPCA				NPS	NPS	NPS,MPCA		
22		Wood R.		2,3b																	
21		Rock Cr.		2,3b																	
20		Rush Cr.		2,3b																	
19		Goose Cr.	Harris	2,3b																	
18		Sunrise R.	Sunrise	2,3b	MPCA	NPS,MPCA	NPS	NPS	NPS,MPCA	NPS,MPCA	NPS,MPCA		NPS,MPCA				NPS	NPS	NPS,MPCA		
17		Trade R.	Fredric	2,3b																	
16		Wolf Cr.		2,3b																	
15		St. Croix R.	St. Croix Falls	1	USGS	WDNR		WDNR	WDNR	WDNR	WDNR		WDNR						WDNR		
14		Lawrence Cr.	Franconia	2,3b																	
13		Apple R.	Somerset	2,3b	USGS	NPS	NPS	NPS	NPS	NPS	NPS		NPS				NPS	NPS	NPS		
12		Silver Cr.		2,3b	MCES	MCES	MCES	MCES	MCES	MCES	MCES	MCES	MCES								
11		Browns Cr.	Hwy 96	2,3b	MCES	MCES	MCES	MCES	MCES	MCES	MCES	MCES	MCES								
8		Willow R.	Willow R. S.P.	2,3b	USGS	NPS	NPS	NPS	NPS	NPS	NPS		NPS				NPS	NPS	NPS		
5		Valley Cr.		2,3b	MCES	MCES	MCES	MCES	MCES	MCES	MCES	MCES	MCES								
3		Kinnickinnic R.	River Falls	2,3b	USGS	NPS	NPS	NPS	NPS	NPS	NPS		NPS				NPS	NPS	NPS		
7		L. Mallalieu	Willow R. S.P.	3a																	
10		Lake St. Croix	Stillwater	1,3a		MCES,MPCA	MCES	MCES	MCES,MPCA	MCES,MPCA	MCES,MPCA	MCES	MCES,MPCA					MCES	MCES		
9		Lake St. Croix	Bayport Pool	3a												MCESV	NPS	NPS	NPS		
6		Lake St. Croix	Troy Beach Pool	3a												MCESV		NPS	NPS		
4		Lake St. Croix	Black Bass Pool	3a												MCESV	NPS				
2		Lake St. Croix	Kinni. Pool	3a												MCESV	NPS	NPS	NPS		
1		Lake St. Croix	Prescott	1,3a		MCES	MCES	MCES	MCES	MCES	MCES	MCES	MCES					MCES	MCES		

KEY:

- fully achieved by current monitoring
- partly achieved by current monitoring
- not achieved by current monitoring
- lower priority
- moderate priority
- highest priority

NOTES:

[a] flow measured continuously

[b] nutrients and sediments monitored for loads, both baseflow (monthly) and stormflow (composite) sampling frequencie

[c] diatoms in surface sediments, sampled once every 3 years

[d] biological indicators sampled from water column semi-monthly (twice per month), May to Septembe

[e] biological indicators sampled from artificial substrate, collected annuall

Table 2. Summary of 2006 monitoring in the St. Croix Riverway. Site numbers are shown on figure 1. [WDNR, Wisconsin Department of Natural Resources; MCES, Metropolitan Council Environmental Services; WCD Washington County Conservation District; ACD Anoka County Conservation District; MPCA, Minnesota Pollution Control Agency; NPS, National Park Service; USGS, U.S. Geological Survey]

Site Number	Station Location	Sampling Agency	Latitude	Longitude	Applicable Monitoring Plan Objectives	Period of Record	Sampling rotation(year/ total sampling period)	Monitoring Categories
1	St. Croix River at Stillwater	MCES	45.055958	-92.80274133	1, 3	1976-present	1/1	Field, Sediment, Nutrients, Ions, Biology
2	St. Croix River at Prescott	MCES	44.769958	-92.80821847	1, 3	1976-present	1/1	Field, Sediment, Nutrients, Ions, Biology
3	Little Carnelian Lake outlet	MCES*	45.118936	-92.79173911	2a	1995-present	1/1	Flow, Field, Sediment, Nutrients, Ions, Biology
4	Silver Creek	MCES*	45.079376	-92.8039181	2a	1998-present	1/1	Flow, Field, Sediment, Nutrients, Ions, Biology
5	Browns Creek at Hwy 96	MCES*	45.075528	-92.80819568	2a	1998-present	1/1	Flow, Field, Sediment, Nutrients, Ions, Biology
6	Valley Creek	MCES*	44.915871	-92.78595449	2a	1999-present	1/1	Flow, Field, Sediment, Nutrients, Ions, Biology
7	St. Croix River near Danbury	MPCA	46.0125	-92.444	1, 3	1957-present	2/5	Field, Sediment, Nutrients, Biology
8	Kettle River at mile 11	MPCA	46.0109	-92.8398	2a, 3	1967-093078, 100180-present	2/5	Field, Sediment, Nutrients, Biology
9	Snake River at mile 10	MPCA	45.8397	-92.9363	2a, 3	1971-present	2/5	Field, Sediment, Nutrients, Biology
11	Sunrise River at MN-95	MPCA	45.5133	-92.8932	2a, 3	1974-76, 100190-present	2/5	Field, Sediment, Nutrients, Biology
12	St. Croix River at Stillwater	MPCA	45.0567	-92.8022	1, 3	1953-65, 100180-093083, 100190-present	2/5	Field, Sediment, Nutrients, Biology

Table 2 continued. Summary of 2006 monitoring in the St. Croix Riverway. Site numbers are shown on figure 1. [WDNR, Wisconsin Department of Natural Resources; MCES, Metropolitan Council Environmental Services; WCD Washington County Conservation District; ACD Anoka County Conservation District; MPCA, Minnesota Pollution Control Agency; NPS, National Park Service; USGS, U.S. Geological Survey]

Site Number	Station Location	Sampling Agency	Latitude	Longitude	Applicable Monitoring Plan Objectives	Period of Record	Sampling rotation(year /total sampling period)	Monitoring Categories
13	St. Croix River at Hudson	MPCA	44.9803	-92.7706	1, 3	1967-present	2/5	Field, Sediment, Nutrients, Biology
14	Namekagon River near Trego, WI	USGS	45.948001	-91.888235	1	Flow: 1927-70, 1987-present, WQ: 1966-2003	1/1	Flow
15	St. Croix River near Danbury, WI	USGS	46.074943	-92.24741521	1	Flow: 1914-1981, 1984-present, WQ: 1964-2003	1/1	Flow
16	Glaisby Bridge near Kettle River, MN	USGS	46.455224	-92.85964813	2	1959-1970	1/1	Flow
17	Kettle River below Sandstone, MN	USGS	46.105505	-92.8640899	2	1967-present	1/1	Flow
18	Snake River near Pine City, MN	USGS	45.841622	-92.93354115	2a	Flow: 1913-1917, 1951-1981, 1992-present, WQ: 1962-1997	1/1	Flow
19	Goose Creek at Harris, MN	USGS	45.58635	-92.97771547	2	1986-present	1/1	Flow
20	Trade River near Fredric, WI	USGS	45.628009	-92.4888112	2	1958-present	1/1	Flow
21	St. Croix River at St. Croix Falls, WI	USGS	45.406906	-92.64715129	1	Flow:1902-present, WQ: 1966-present	1/1	Flow
22	Bull BRiver at C.T.H. F near Amery, WI	USGS	45.284129	-92.31685716	2	1995-present	1/1	Flow
23	Apple River near Somerset, WI	USGS	45.157467	-92.71659447	2	Flow: 1914-1970, 1986-present, WQ: 1966-1999	1/1	Flow
24	Kinnickinnic River Trib at River Falls, WI	USGS	44.832467	-92.63991958	2	1959-present	1/1	Flow

Table 2 continued. Summary of 2006 monitoring in the St. Croix Riverway. Site numbers are shown on figure 1. [WDNR, Wisconsin Department of Natural Resources; MCES, Metropolitan Council Environmental Services; WCD Washington County Conservation District; ACD Anoka County Conservation District; MPCA, Minnesota Pollution Control Agency; NPS, National Park Service; USGS, U.S. Geological Survey]

Site Number	Station Location	Sampling Agency	Latitude	Longitude	Applicable Monitoring Plan Objectives	Period of Record	Sampling rotation(year/ total sampling period)	Monitoring Categories
25	Kinnickinnic River near River Falls, WI	USGS	44.830801	-92.7332563	2	Flow: 1998-1999, 2002-present, WQ: 1968-1999	1/1	Flow
26	St. Croix River at Hwy 35&Pansy Landing (near Danbury, WI)	WDNR	46.0764	-92.2461	1, 3	2003-present		Field, Sediment, Nutrients, Biology
27	St. Croix River at Interstate S.P. (near St. Croix Falls, WI)	WDNR	45.4006	-92.6503	1, 3	2003-present		Field, Sediment, Nutrients, Biology
28	Namekagon River near Trego	NPS	45.9489	-91.8881	1, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
29	St. Croix River at Norway Pt.	NPS	45.9239	-92.6389	1, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
30	St. Croix River near Trade River	NPS	45.5681	-92.7682	1, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
31	St. Croix River at Bayport	NPS	45.0108	-92.7745	1, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
32	St. Croix River at Pool 2	NPS	44.9208	-92.7632	1, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
33	St. Croix River at Pool 4	NPS	44.7755	-92.8061	1, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
34	Snake River at mouth	NPS	45.8416	-92.9335	2a, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
35	Sunrise River at mouth	NPS	45.5468	-92.8562	2a, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
36	Apple River at mouth	NPS	45.1574	-92.7165	2a, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology

Table 2 continued. Summary of 2006 monitoring in the St. Croix Riverway. Site numbers are shown on figure 1. [WDNR, Wisconsin Department of Natural Resources; MCES, Metropolitan Council Environmental Services; WCD Washington County Conservation District; ACD Anoka County Conservation District; MPCA, Minnesota Pollution Control Agency; NPS, National Park Service; USGS, U.S. Geological Survey]

Site Number	Station Location	Sampling Agency	Latitude	Longitude	Applicable Monitoring Plan Objectives	Period of Record	Sampling rotation(year/ total sampling period)	Monitoring Categories
25	Kinnickinnic River near River Falls, WI	USGS	44.830801	-92.7332563	2	Flow: 1998-1999, 2002-present, WQ: 1968-1999	1/1	Flow
26	St. Croix River at Hwy 35&Pansy Landing (near Danbury, WI)	WDNR	46.0764	-92.2461	1, 3	2003-present		Field, Sediment, Nutrients, Biology
27	St. Croix River at Interstate S.P. (near St. Croix Falls, WI)	WDNR	45.4006	-92.6503	1, 3	2003-present		Field, Sediment, Nutrients, Biology
28	Namekagon River near Trego	NPS	45.9489	-91.8881	1, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
29	St. Croix River at Norway Pt.	NPS	45.9239	-92.6389	1, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
30	St. Croix River near Trade River	NPS	45.5681	-92.7682	1, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
31	St. Croix River at Bayport	NPS	45.0108	-92.7745	1, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
32	St. Croix River at Pool 2	NPS	44.9208	-92.7632	1, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
33	St. Croix River at Pool 4	NPS	44.7755	-92.8061	1, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
34	Snake River at mouth	NPS	45.8416	-92.9335	2a, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
35	Sunrise River at mouth	NPS	45.5468	-92.8562	2a, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
36	Apple River at mouth	NPS	45.1574	-92.7165	2a, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology

Table 2 continued. Summary of 2006 monitoring in the St. Croix Riverway. Site numbers are shown on figure 1. [WDNR, Wisconsin Department of Natural Resources; MCES, Metropolitan Council Environmental Services; WCD Washington County Conservation District; ACD Anoka County Conservation District; MPCA, Minnesota Pollution Control Agency; NPS, National Park Service; USGS, U.S. Geological Survey]

Site Number	Station Location	Sampling Agency	Latitude	Longitude	Applicable Monitoring Plan Objectives	Period of Record	Sampling rotation(year/ total sampling period)	Monitoring Categories
37	Willow River at mouth	NPS	45.0116	-92.7085	2a, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
38	Kinnickinnic River at mouth	NPS	44.8308	-92.7332	2a, 3	Starting in 2006…	½	Field, Sediment, Nutrients, Ions, Biology
39	Carnelian Creek at May Avenue	WCD	45.1652	-92.8559	2b	2000, 2002-present	1/1	Flow, Sediment, Nutrients, Ions
40	Carnelian Creek at Ozark Trail	WCD	45.1352	-92.816	2b	2000-present	1/1	Flow, Sediment, Nutrients, Ions
41	Big Carnelian Lake outlet	WCD	45.1275	-92.8063	2b	2001-present	1/1	Flow, Sediment, Nutrients
42	Browns Creek at McKusick Rd	WCD	45.0715	-92.8344	2b	2000-present	1/1	Flow, Field, Sediment, Nutrients, Ions
43	Tributary to Sunrise River at Bone Lake N. inlet	WCD	45.2936	-92.8648	2b	2003, 2005-present	1/1	Flow, Sediment, Nutrients
44	Tributary to Sunrise River at Bone Lake outlet	WCD	45.2925	-92.8667	2b	2003-present	1/1	Flow, Sediment, Nutrients
45	Sunrise River at Forest Lake inlet	WCD	45.2629	-92.9457	2b	2005-present	1/1	Flow, Sediment, Nutrients
46	Sunrise River at Forest Lake outlet	WCD	45.2913	-92.9766	2b	2003-present	1/1	Flow, Sediment, Nutrients
47	Sunrise River at Big Comfort Lake inlet	WCD	45.3226	-92.9544	2b	2004-present	1/1	Flow, Sediment, Nutrients
48	Tributary to Sunrise River at Little Comfort Lake inlet	WCD	45.3128	-92.9327	2b	2004-present	1/1	Flow, Sediment, Nutrients

Table 2 continued. Summary of 2006 monitoring in the St. Croix Riverway. Site numbers are shown on figure 1. [WDNR, Wisconsin Department of Natural Resources; MCES, Metropolitan Council Environmental Services; WCD Washington County Conservation District; ACD Anoka County Conservation District; MPCA, Minnesota Pollution Control Agency; NPS, National Park Service; USGS, U.S. Geological Survey]

49	Sunrise River at Big Comfort Lake outlet	WCD	45.331	-92.9541	2b	2003-present	1/1	Flow, Sediment, Nutrients
50	Tributary to Sunrise River at Bone Lake S. inlet	WCD	45.2788	-92.8594	2b	2005-present	1/1	Flow, Sediment, Nutrients
51	Tributary to Long Lake at 62nd St	WCD	45.0394	-92.8529	2b	2005-present	1/2	Flow, Sediment, Nutrients
52	Tributary to Long Lake at Market Drive	WCD	45.0373	-92.8418	2b	2005-present	1/3	Flow, Sediment, Nutrients
53	Snake River at ??	PSWCD	0	0				
54	Snake River at ??	SRWMB	0	0				
55	Groundhouse River	KSWCD	0	0				
56	Sunrise River?	CSWCD	0	0				
57	Sunrise River at Hwy 77	ACD	0	0		2001, 2003	1/3-6	Field, Sediment, Nutrients, Biology
58	Data Creek, Typo Lake inlet	ACD	0	0		2001, 2003	1/3-6	Field, Sediment, Nutrients, Biology
59	Typo Creek, Martin Lake N. inlet	ACD	0	0		2001, 2003	1/3-6	Field, Sediment, Nutrients, Biology
60	Martin Lake S. inlet	ACD	0	0		2001, 2003	1/3-6	Field, Sediment, Nutrients, Biology
61	Boot Lake inlet	ACD	0	0		2001, 2003	1/3-6	Field, Sediment, Nutrients, Biology
62	Willow River at Willow R State Park	USGS	45.01163	-92.7085				Flow
63	Sunrise River at Sunrise, MN	MPCA	45.5468	-92.8562	2a,3	1967- present	2/5	Flow, Field, Sediment, Nutrients, Biology

Monitoring Plan Objectives

1. To determine ambient water quality concentration trends and nutrient and sediment loads for the mainstem of the St. Croix River and Lake St. Croix.
2. Determine nutrient loads for selected tributaries, used to track progress on tributary nutrient management goals (20 percent Phosphorous reduction.
3. Monitor algal indicators in Lake St. Croix (algal composition, bloom frequency, intensity and Chlorophyll A concentrations) and in strategically-selected mainstem and tributary locations (algal composition and Chlorophyll A concentrations) to measure progress toward the nutrient reduction goal.
4. Provide information used in the development of and modification of mainstem and tributary nutrient models which are used to predict of various nutrient management scenarios

Table 3. Streamflow gaging station locations. Site numbers are shown on figure 5. [USGS, U.S Geological Survey; MCES, Metropolitan Council Environmental Services; WCD Washington Conservation District; MPCA, Minnesota Pollution Control Agency.]

Site Number	Station Location	Collecting Agency	Record Description
19	Little Carnelian Lake outlet	MCES*	Continuous March through November
18	Silver Creek	MCES*	Continuous March through November
16	Browns Creek at Hwy 96	MCES*	Continuous March through November
7	Valley Creek	MCES*	Continuous March through November
52	Namekagon River near Trego, WI	USGS	Continuous- Annual
51	St. Croix River near Danbury, WI	USGS	Continuous- Annual
47	Glaisby Bridge near Kettle River, MN	USGS	Crest Stage Gage
46	Kettle River below Sandstone, MN	USGS	Continuous Annual
42	Snake River near Pine City, MN	USGS	Continuous Annual
41	Goose Creek at Harris, MN	USGS	Crest Stage Gage
29	Trade River near Fredric, WI	USGS	Crest Stage Gage
27	St. Croix River at St. Croix Falls, WI	USGS	Continuous Annual
25	Bull Bridge at C.T.H. F near Amery, WI	USGS	Crest Stage Gage
23	Apple River near Somerset, WI	USGS	Continuous Annual
5	Kinnickinnic River Tributary at River Falls, WI	USGS	Crest Stage Gage
4	Kinnickinnic River near River Falls, WI	USGS	Continuous Annual
22	Carnelian Creek at May Avenue	WCD	Continuous March through November
21	Carnelian Creek at Ozark Trail	WCD	Continuous March through November
20	Big Carnelian Lake outlet	WCD	Continuous March through November
17	Browns Creek at McKusick Rd	WCD	Continuous March through November
38	Tributary to Sunrise River at Bone Lake North inlet	WCD	Continuous March through November
36	Tributary to Sunrise River at Bone Lake outlet	WCD	Continuous March through November
40	Sunrise River at Forest Lake inlet	WCD	Continuous March through November
39	Sunrise River at Forest Lake outlet	WCD	Continuous March through November
34	Sunrise River at Big Comfort Lake inlet	WCD	Continuous March through November
35	Tributary to Sunrise River at Little Comfort Lake inlet	WCD	Continuous March through November
33	Sunrise River at Big Comfort Lake outlet	WCD	Continuous March through November
37	Tributary to Sunrise River at Bone Lake south inlet	WCD	Continuous March through November
12	Tributary to Long Lake at 62nd St	WCD	Continuous March through November
13	Tributary to Long Lake at Market Drive	WCD	Continuous March through November
10	Willow River at Willow River State Park	USGS	Continuous- Annual
31	Sunrise River at Sunrise, MN	MPCA	Continuous-March through November

Table 4. Nutrient constituents sampled, sample location and sample frequency. Site numbers are shown on figure 6. [WDNR, Wisconsin Department of Natural Resources; MCES, Metropolitan Council Environmental Services; WCD Washington Conservation District; MPCA, Minnesota Pollution Control Agency; NPS, National Park Service][Wb, biweekly; M, monthly; M* monthly March to November and February; Mb, bimonthly; S, Storm event; Mb,S* bimonthly March to November; 8*, eight times per year]

Site number	Station Location	Agency	Phosphorous, total	Phosphorous, ortho, dissolved	Phosphorous, dissolved	Nitrogen, dissolved	Nitrogen, Nitrite + Nitrate dissolved	Nitrogen, ammonia, dissolved	Nitrogen, total kjeldahl
14	St. Croix River at Stillwater	MCES	Wb	Wb	Wb		Wb	W*	M
1	St. Croix River at Prescott	MCES	Wb	Wb	Wb		Wb	W*	M
19	Little Carnelian Lake outlet	MCES*	M,S	M,S	M,S		M,S	M,S	M,S
18	Silver Creek	MCES*	M,S	M,S	M,S		M,S	M,S	M,S
16	Browns Creek at Hwy 96	MCES*	M,S	M,S	M,S		M,S	M,S	M,S
7	Valley Creek	MCES*	M,S	M,S	M,S		M,S	M,S	M,S
49	St. Croix River nr Danbury	MPCA	M**				M*	M*	
45	Kettle River at mile 11	MPCA	M**				M*	M*	
10	Snake River at mile 10	MPCA	M**				M*	M*	
32	Sunrise River at MN-95	MPCA	M**				M*	M*	
15	St. Croix River at Stillwater	MPCA	M**				M*	M*	
8	St. Croix River at Hudson	MPCA	M**				M*	M*	
50	St. Croix River at Hwy 35&Pansy Landing (nr Danbury, WI)	WDNR	M				M	M	M
26	St. Croix River at Interstate S.P. (nr SCFalls, WI)	WDNR	M				M	M	M
53	Namekagon River nr Trego	NPS	M*			M*	M*	M*	
48	St. Croix River at Norway Pt.	NPS	M*			M*	M*	M*	
28	St. Croix River nr Trade R.	NPS	M*			M*	M*	M*	
11	St. Croix River at Bayport	NPS	M*			M*	M*	M*	
6	St. Croix River at Pool 2	NPS	M*			M*	M*	M*	
2	St. Croix River at Pool 4	NPS	M*			M*	M*	M*	
43	Snake River at mouth	NPS	M*			M*	M*	M*	
30	Sunrise River at mouth	NPS	M*			M*	M*	M*	
24	Apple River at mouth	NPS	M*			M*	M*	M*	
9	Willow River at mouth	NPS	M*			M*	M*	M*	
3	Kinnickinnic River at mouth	NPS	M*			M*	M*	M*	
22	Carnelian Creek at May Avenue	WCD	Mb,S*						Mb,S*

Table 4 continued. Nutrient constituents sampled, sample location and sample frequency. Site numbers are shown on figure 6. [WDNR, Wisconsin Department of Natural Resources; MCES, Metropolitan Council Environmental Services; WCD Washington Conservation District; MPCA, Minnesota Pollution Control Agency; NPS, National Park Service][Wb, biweekly; M, monthly; M* monthly March to November and February; Mb, bimonthly; S, Storm event; Mb,S* bimonthly March to November; 8*, eight times per year]

Site number	Station Location	Agency	Phosphorous, total	Phosphorous, ortho, dissolved	Phosphorous, dissolved	Nitrogen, dissolved	Nitrogen, Nitrite + Nitrate dissolved	Nitrogen, ammonia, dissolved	Nitrogen, total kjeldahl
21	Carnelian Creek at Ozark Trail	WCD	Mb,S*						Mb,S*
20	Big Carnelian Lake outlet	WCD	Mb,S*						Mb,S*
17	Browns Creek at McKusick Rd	WCD	Mb,S*						Mb,S*
38	Tributary to Sunrise River at Bone Lake N. inlet	WCD	Mb,S*				Mb,S*		Mb,S*
36	Tributary to Sunrise River at Bone Lake outlet	WCD	Mb,S*				Mb,S*		Mb,S*
40	Sunrise River at Forest Lake inlet	WCD	Mb,S*				Mb,S*		Mb,S*
39	Sunrise River at Forest Lake outlet	WCD	Mb,S*				Mb,S*		Mb,S*
34	Sunrise River at Big Comfort Lake inlet	WCD	Mb,S*				Mb,S*		Mb,S*
35	Tributary to Sunrise River at Little Comfort Lake inlet	WCD	Mb,S*				Mb,S*		Mb,S*
33	Sunrise River at Big Comfort Lake outlet	WCD	Mb,S*				Mb,S*		Mb,S*
37	Tributary to Sunrise River at Bone Lake S. inlet	WCD	Mb,S*				Mb,S*		Mb,S*
12	Tributary to Long Lake at 62nd St	WCD	Mb,S*				Mb,S*		Mb,S*
13	Tributary to Long Lake at Market Dr.	WCD	Mb,S*				Mb,S*		Mb,S*

Table 5. Sediment constituents sampled, sample location and sample frequency. Site numbers are shown on figure 7. [WDNR, Wisconsin Department of Natural Resources; MCES, Metropolitan Council Environmental Services; WCD Washington Conservation District; MPCA, Minnesota Pollution Control Agency][Wb, biweekly; W, weekly; M, monthly; M* monthly March to November and February; M**, monthly March to November and February when discharge is known; Mb, bimonthly; S, Storm event; Mb,S* bimonthly March to November; 8*, eight times per year]

Site Number	Station Location	Agency	Total Suspended Solids	Volatile Suspended Solids	Particulates, total	Particulates, Kjehdahl
14	St. Croix River at Stillwater	MCES	Wb	Wb	Wb	M
1	St. Croix River at Prescott	MCES	Wb	Wb	Wb	M
19	Little Carnelian Lake outlet	MCES*	M,S	M,S		
18	Silver Creek	MCES*	M,S	M,S		
16	Browns Creek at Hwy 96	MCES*	M,S	M,S		
7	Valley Creek	MCES*	M,S	M,S		
49	St. Croix River near Danbury	MPCA	M**			
45	Kettle River at mile 11	MPCA	M**			
44	Snake River at mile 10	MPCA	M**			
32	Sunrise River at MN-95	MPCA	M**			
15	St. Croix River at Stillwater	MPCA	M**			
8	St. Croix River at Hudson	MPCA	M**			
50	St. Croix River at Hwy 35&Pansy Landing (near Danbury, WI)	WDNR	M			
26	St. Croix River at Interstate S.P. (near SCFalls, WI)	WDNR	M			
53	Namekagon River near Trego	NPS	M*			
48	St. Croix River at Norway Pt.	NPS	M*			
28	St. Croix River near Trade R.	NPS	M*			
11	St. Croix River at Bayport	NPS	M*			
6	St. Croix River at Pool 2	NPS	M*			
2	St. Croix River at Pool 4	NPS	M*			
43	Snake River at mouth	NPS	M*			
30	Sunrise River at mouth	NPS	M*			
24	Apple River at mouth	NPS	M*			
9	Willow River at mouth	NPS	M*			
3	Kinnickinnic River at mouth	NPS	M*			
22	Carnelian Creek at May Avenue	WCD	Mb,S*	Mb,S*		
21	Carnelian Creek at Ozark Trail	WCD	Mb,S*	Mb,S*		
20	Big Carnelian Lake outlet	WCD	Mb,S*	Mb,S*		
17	Browns Creek at McKusick Rd	WCD	Mb,S*	Mb,S*		

Table 5 continued. Sediment constituents sampled, sample location and sample frequency. Site numbers are shown on figure 7.
[WDNR, Wisconsin Department of Natural Resources; MCES, Metropolitan Council Environmental Services; WCD Washington Conservation District; MPCA, Minnesota Pollution Control Agency][Wb, biweekly; W, weekly; M, monthly; M* monthly March to November and February; M**, monthly March to November and February when discharge is known; Mb, bimonthly; S, Storm event; Mb,S* bimonthly March to November; 8*, eight times per year]

Site Number	Station Location	Agency	Total Suspended Solids	Volatile Suspended Solids	Particulates, total	Particulates, Kjehdahl
38	Tributary to Sunrise River at Bone Lake north inlet	WCD	Mb,S*	Mb,S*		
36	Tributary to Sunrise River at Bone Lake outlet	WCD	Mb,S*	Mb,S*		
40	Sunrise River at Forest Lake inlet	WCD	Mb,S*	Mb,S*		
39	Sunrise River at Forest Lake outlet	WCD	Mb,S*	Mb,S*		
34	Sunrise River at Big Comfort Lake inlet	WCD	Mb,S*	Mb,S*		
35	Tributary to Sunrise River at Little Comfort Lake inlet	WCD	Mb,S*	Mb,S*		
33	Sunrise River at Big Comfort Lake outlet	WCD	Mb,S*	Mb,S*		
37	Tributary to Sunrise River at Bone Lake south inlet	WCD	Mb,S*	Mb,S*		
12	Tributary to Long Lake at 62nd St	WCD	Mb,S*	Mb,S*		
13	Tributary to Long Lake at Market Dr.	WCD	Mb,S*	Mb,S*		
31	Sunrise River at Sunrise, MN	MPCA	M**			

Table 6. Biological constituents sampled, sample location and sample frequency. Site numbers are shown on figure 8. [MCES, Metropolitan Council Environmental Services; WDNR, Wisconsin Department of Natural Resources; MPCA, Minnesota Pollution Control Agency; NPS, National Park Service][A, annual; Wb, biweekly; W, weekly; M, monthly; M* monthly March to November and February; M**, monthly March to November and February when discharge is known; Mb, bimonthly; S, Storm event; 8*, eight times per year]

Site Number	Station Location	Agency	Chlorophyll a, total	Chlorophyl-A, pheophyton, corrected	Phyto plankton	Periphyton	Zoo plankton	Macro invertebrates
14	St. Croix River at Stillwater	MCES	Wb	Wb	A	A	A	A
1	St. Croix River at Prescott	MCES	Wb	Wb	A	A	A	A
19	Little Carnelian Lake outlet	MCES*	M,S	M,S				
18	Silver Creek	MCES*	M,S	M,S				A
16	Browns Creek at Hwy 96	MCES*	M,S	M,S				A
7	Valley Creek	MCES*	M,S	M,S				A
49	St. Croix River near Danbury	MPCA	M**			M**		
45	Kettle River at mile 11	MPCA	M**			M**		
44	Snake River at mile 10	MPCA	M**			M**		
32	Sunrise River at MN-95	MPCA	M**			M**		
15	St. Croix River at Stillwater	MPCA	M**			M**		
8	St. Croix River at Hudson	MPCA	M**			M**		
50	St. Croix River at Hwy 35&Pansy Landing (near Danbury, WI)	WDNR	M					
26	St. Croix River at Interstate S.P. (near SCFalls, WI)	WDNR	M					
53	Namekagon River near Trego	NPS	M*					
48	St. Croix River at Norway Pt.	NPS	M*					
28	St. Croix River near Trade River	NPS	M*					
11	St. Croix River at Bayport	NPS	M*					

Table 6. continued. Biological constituents sampled, sample location and sample frequency. Site numbers are shown on figure 8.
[MCES, Metropolitan Council Environmental Services; WDNR, Wisconsin Department of Natural Resources; MPCA, Minnesota Pollution Control Agency; NPS, National Park Service][A, annual; Wb, biweekly; W, weekly; M, monthly; M* monthly March to November and February; M**, monthly March to November and February when discharge is known; Mb, bimonthly; S, Storm event; 8*, eight times per year]

Site Number	Station Location	Agency	Chlorophyll a, total	Chlorophyl-A, pheophyton, corrected	Phyto plankton	Periphyton	Zoo plankton	Macro invertebrates
6	St. Croix River at Pool 2	NPS	M*					
2	St. Croix River at Pool 4	NPS	M*					
43	Snake River at mouth	NPS	M*					
30	Sunrise River at mouth	NPS	M*					
24	Apple River at mouth	NPS	M*					
9	Willow River at mouth	NPS	M*					
3	Kinnickinnic River at mouth	NPS	M*					
31	Sunrise River at Sunrise, MN	MPCA	M**		M**			