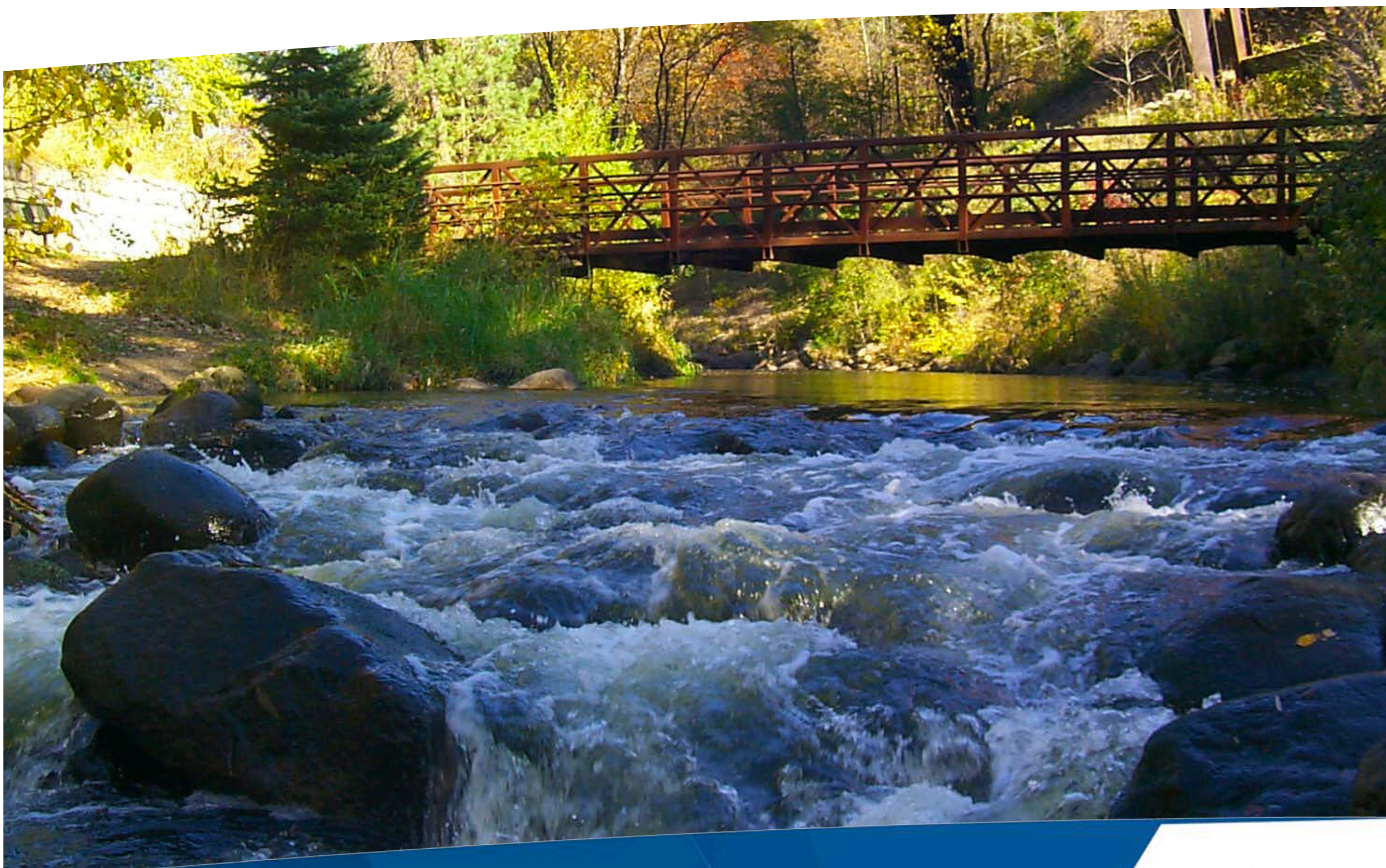
# Comprehensive Water Quality Assessment of Select Metropolitan Area Streams

## NINE MILE CREEK



December 2014

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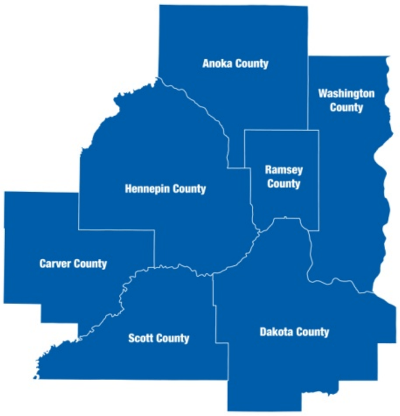


The Metropolitan Council is the regional planning organization for the seven-county Twin Cities area. The Council operates the regional bus and rail system, collects and treats wastewater, coordinates regional water resources, plans and helps fund regional parks, and administers federal funds that provide housing opportunities for low- and moderate-income individuals and families. The 17-member Council board is appointed by and serves at the pleasure of the governor.

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## About the Study

The Twin Cities metropolitan area has a wealth of streams that traverse its landscape and ultimately flow into one of its three major rivers – the Mississippi, the Minnesota, and the St. Croix. These streams provide rich habitat for aquatic life and wildlife and enhance the recreational and aesthetic value of the metro area.

The Metropolitan Council is committed to the conscientious stewardship of the region's streams and works with its partners to maintain and improve their health and function. The foundation for these efforts is the collection and analysis of high-quality data about their condition over time.

The *Comprehensive Water Quality Assessment of Select Metropolitan Area Streams* is a major study conducted by the Metropolitan Council that examines the water quality of 21 streams or stream segments that discharge into the metropolitan area's major rivers. The study provides a base of technical information that can support sound decisions about water resources in the metro area − decisions by the Council, state agencies, watershed districts, conservation districts, and county and city governments.

All background information, methodologies, and data sources are summarized in *Introduction and Methodologies*, and a glossary and a list of acronyms are included in *Glossary and Acronyms*. Both of these, as well as individual sections for each of the 21 streams, are available for separate download from the report website. The staff of Metropolitan Council Environmental Services (MCES) and local partners conducted the stream monitoring work, while MCES staff performed the data analyses, compiled the results and prepared the report.

## About This Section

This section of the report, *Nine Mile Creek*, is one in a series produced as part of the *Comprehensive Water Quality Assessment of Select Metropolitan Area Streams.* Located in Hennepin County, Nine Mile Creek is one of the nine Minnesota River tributaries examined. This section discusses a wide range of factors that have affected the condition and water quality of the Nine Mile Creek.

## Cover Photo

The photo on the cover of this section depicts Nine Mile Creek downstream of the MCES monitoring site. It was taken by Metropolitan Council staff.

## Recommended Citations

Please use the following to cite this section of the report:

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## Introduction

Nine Mile Creek is located in the southern metropolitan area and is a tributary to the Minnesota River. It drains approximately 50 square miles of mixed land cover including open space, bluff land, and urban areas (portions of the cities of Edina, Eden Prairie, Minnetonka, Hopkins, Richfield, and Bloomington) in Hennepin County.

This report:

- documents those characteristics of Nine Mile Creek and its watershed most likely to influence stream flow and water quality.
- presents the results from assessments of flow, water quality, and biological data.
- presents statistical assessments of trends in stream chemistry concentrations.
- draws conclusions about possible effects of landscape features, climatological changes, and human activities on flow and water quality.
- compares Nine Mile Creek flow and water quality with other streams within the metropolitan area monitored by Metropolitan Council Environmental Services (MCES).
- makes watershed-specific recommendations for future monitoring and assessment activities, partnerships, and other potential actions to remediate any water quality or flow concerns.

MCES plans to update this report approximately every 10 years, in addition to issuing annual data summary reports.

## Partnerships

MCES has fully financed water quality monitoring of the station on Nine Mile Creek since 1989. MCES staff maintains the rating curve and operates the monitoring station.

## Monitoring Station Description

The monitoring station is located on Nine Mile Creek in Bloomington, Minnesota, about 1.8 miles upstream from the creek's confluence with the Minnesota River.

The monitoring station includes continuous flow monitoring, event-based composite sample collection, and on-site conductivity and temperature probes. The Nine Mile Creek station also includes an in-stream turbidity sensor (Forest Technology Systems DTS-12). There is no rain gauge at this station; however precipitation data are available from the Minnesota Climatology Working Group, MSP Airport Station Number 215435. Daily precipitation totals from this station were used to create the hydrograph in the ***Hydrology*** section of this report. For the analysis of precipitation-weighted loads, MCES used the Minnesota Climatological Working Group's monthly 10-kilometer gridded precipitation data to represent the variability of rainfall within the watershed (Minnesota Climatology Working Group, 2013). These data are generated from Minnesota's HIDEN (High Spatial Density Precipitation Network) dataset. The gridded data was aerially-weighted based on the watershed boundaries.

## Stream and Watershed Description

Nine Mile Creek drains portions of the Cities of Hopkins, Minnetonka, Eden Prairie, Edina, Richfield, and Bloomington, which are encompassed by Metropolitan Council Districts 3 and 5. The watershed also includes Bryant Lake and Hyland-Bush-Anderson Lakes Regional Parks. The creek flows through the Minnesota Valley National Wildlife Refuge before entering the Minnesota River.

Nine Mile Creek consists of the North Branch (also referred to as the main stem), with headwaters in the City of Hopkins and a total length of approximately 15 miles, and the South Branch, with headwaters in the City of Minnetonka and length of 8.5 miles. The two branches join south of I-494, immediately upstream of Normandale Lake. The Nine Mile Creek Watershed District (NMCWD) notes that the creek's name came not from its length, but from the distance early settlers had to travel from Fort Snelling to the creek crossing along Old Shakopee Road.

The NMCWD, established under MN Statute 103D, provides water resources management within the district boundaries (which approximately follow the physical watershed boundaries) through completion of stormwater best management practices and stream channel restoration projects, cost share grants, rules/permitting system, public education, and additional monitoring.

The Nine Mile Creek watershed is a total of 31,555 acres, with 28,784 acres (91.2%) of the watershed upstream of the monitoring station. The watershed is completely developed, with 20,308 acres/64.4% (18,637 acres/64.7% within the monitored area) developed urban land and

**Table NM-1: Nine Mile Creek Land Cover Classes[1]**

| Land Cover Class | Monitored | | Unmonitored | | Total | |
|---|---|---|---|---|---|---|
| | Acres | Percent | Acres | Percent | Acres | Percent |
| 5-10% Impervious | 241 | 0.8% | 6 | 0.2% | 247 | 0.8% |
| 11-25% Impervious | 651 | 2.3% | 0 | 0.0% | 651 | 2.1% |
| 26-50% Impervious | 6,198 | 21.5% | 813 | 29.4% | 7,011 | 22.2% |
| 51-75% Impervious | 3,857 | 13.4% | 527 | 19.0% | 4,384 | 13.9% |
| 76-100% Impervious | 7,691 | 26.7% | 325 | 11.7% | 8,015 | 25.4% |
| Agricultural Land | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| Forest (all types) | 2,870 | 10.0% | 223 | 8.0% | 3,093 | 9.8% |
| Open Water | 877 | 3.0% | 15 | 0.5% | 892 | 2.8% |
| Barren Land | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| Shrubland | 8 | <0.1% | 0 | 0.0% | 8 | <0.1% |
| Grasses/Herbaceous | 3,220 | 11.2% | 413 | 14.9% | 3,632 | 11.5% |
| Wetlands (all types) | 3,172 | 11.0% | 449 | 16.2% | 3,622 | 11.5% |
| **Total** | **28,784** | **100.0%** | **2,771** | **100.0%** | **31,555** | **100.0%** |

[1] Land cover spatial data file provided by MnDNR. The data is a composite of the 2008 MLCCS (Minnesota Land Cover Classification System), which covered primarily the 7-county metro area; and the 2001 NLCD (National Land Cover Data), which covered the outstate areas not included in the 2008 MLCCS.

no agricultural land. The remaining land cover is primarily a mixture of forest, grasses/herbaceous, and wetlands (Figure NM-1; Table NM-1).

The watershed is fairly evenly urbanized except for the open space of the Hyland Lake Park Reserve in the southwestern portion of the watershed. Several major roads are also present in the watershed, including portions of Interstates 494 and 35W, US 212, US 169, TH 62 and TH 100.

The watershed is fairly hilly in the west and southwestern end moraine portions (Figure NM-2). Near the watershed outlet the topography becomes more gradual before entering the Minnesota River Valley through a fairly steep ravine. The maximum watershed elevation is 1121.4 MSL and the minimum elevation is 716.0 MSL within the monitored area. Within the monitored area 7.2% of the slopes are considered steep, and an additional 3.8% are considered very steep. Steep slopes are those between 12-18%, and very steep slopes are those 18% or greater (MnDNR, 2011).

The watershed includes a number of lakes and wetlands. Shady Oak, Glen, Anderson, and Bush Lakes are relatively large but offline of the creek channel. The South Branch flows through Bryant Lake, Smetana Lake, and a number of small wetlands. The North Branch (the Nine Mile mainstem) flows through a number of small wetlands. After the convergence of the two branches, the creek flows through Normandale Lake and Marsh Lake, before discharging to the Minnesota River.

There are few point sources within the Nine Mile Creek watershed (Figure NM-3). The watershed contains five cooling water, potable water, and dewatering facilities holding NPDES discharge permits. The watershed also contains thirteen sites holding industrial stormwater permits. All permit holders are within the monitored part of the watershed. There are no industrial or domestic wastewater facilities in the watershed. There are no permitted feedlots in the watershed.

The NMCWD and its partners have completed a number of significant water quality and flood improvement projects and studies within the watershed, including:

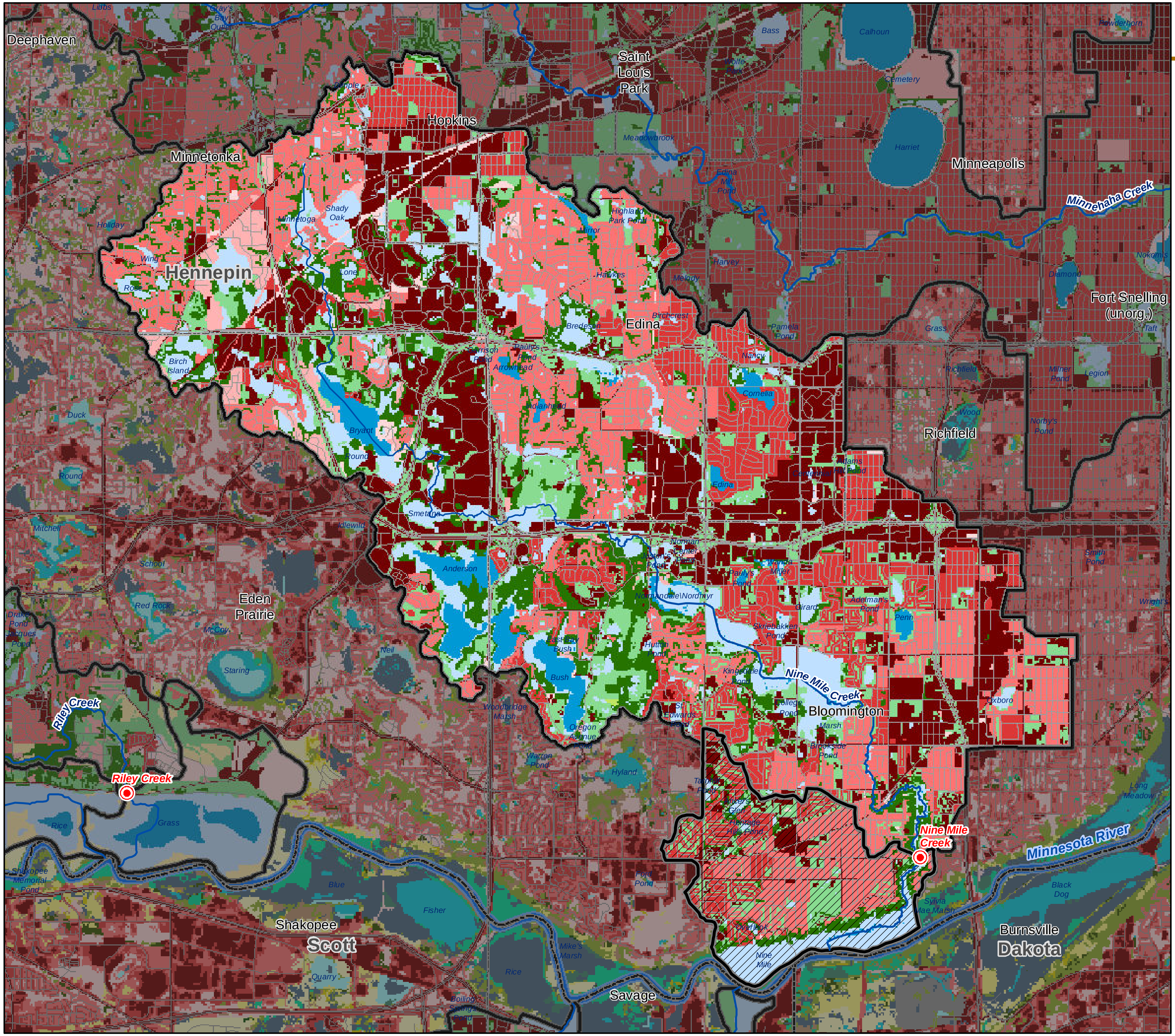
- Nine Mile Creek Lower Valley/Harrison Park. This project restored the creek channel and stabilized erosion. The restoration effort was precipitated by a flood event in 1987, with additional stabilization done in 2008/2009 (NMCWD, n.d.-a).
- Normandale Lake and Marsh Lake Dam Flood Control. The Marsh Lake Dam was constructed in 1970 and Normandale Lake was created in 1979. Both impoundments provide flood control and water quality benefits (NMCWD, n.d.-b).
- Bryant Lake Alum Treatment. Bryant Lake was treated with alum to reduce internal phosphorus load in 2008 (NMCWD, n.d.-c).
- Operation of additional monitoring stations upstream of the MCES station. These stations, on the North and South Branches, provide continuous flow, baseflow grab, and event-based composite samples, similar to the MCES sampling program.

# Figure NM-1

METROPOLITAN COUNCIL

*MLCCS-NLCD Hybrid Land Cover*

## Nine Mile Creek




- MCES Stream Monitoring Sites
- USGS Flow Stations
- Mainstems (Monitored and Unmonitored)
- Major Mainstem Tributaries
- Monitored Watershed Boundaries
- Unmonitored Portion of Watersheds
- Street Centerlines (NCompass, 2012)
- County Boundary
- City and Township Boundaries

### MLCCS-NLCD Hybrid Land Cover

- 5-10% Impervious
- 11-25% Impervious
- 26-50% Impervious
- 51-75% Impervious
- 76-100% Impervious
- Agricultural Land
- Barren Land (rock, mud)
- Forest (all types)
- Grasses/Herbaceous
- Open Water
- Shrubland
- Unknown, or No Data
- Wetlands (open water, forest, shrub and emergent)

*Data Source: MnDNR*

**MLSSC/NLCD Hybrid Land Cover**
**Nine Mile Creek**

| Land Cover Class | Monitored Acres | Monitored Percent | Unmonitored Acres | Unmonitored Percent | Total Acres | Total Percent |
|---|---|---|---|---|---|---|
| 5-10% Impervious | 241 | 0.8% | 6 | 0.2% | 247 | 0.8% |
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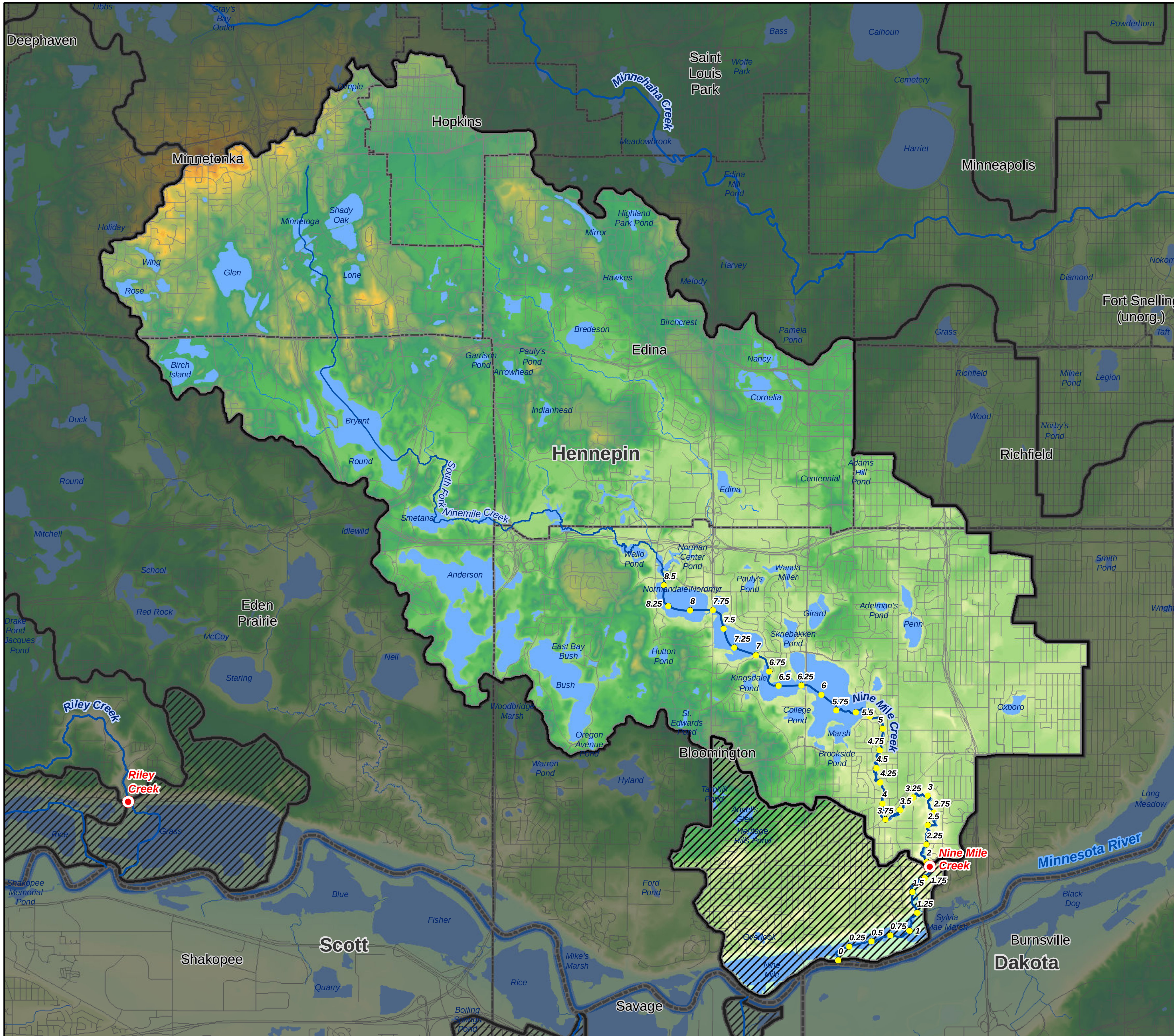
0 1 2 3
Miles

# Figure NM-2

*Watershed Topography*

**Nine Mile Creek**



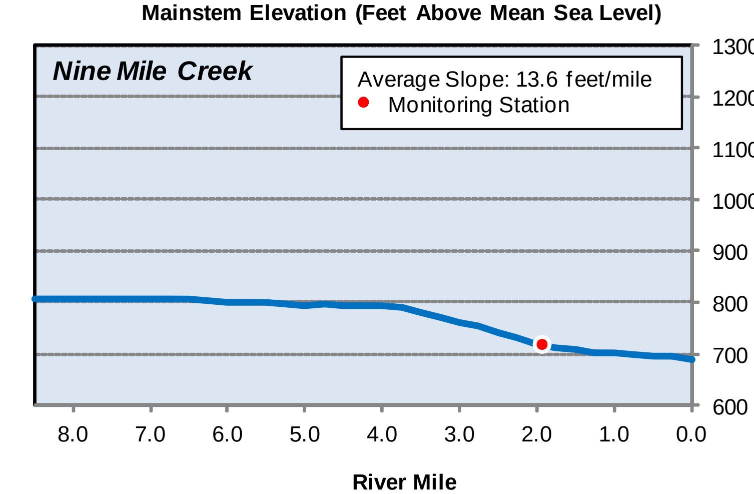

- MCES Stream Monitoring Sites
- USGS Flow Stations
- Stream Mile Markers
- Mainstems (Monitored and Unmonitored)
- Monitored Watershed Boundaries
- Unmonitored Watershed Areas
- Public Waters Inventory
- Other Rivers and Streams
- City and Township Boundaries
- County Boundary
- NCompass Street Centerlines, 2012

**Elevation**
**Feet Above Mean Sea Level**

High : 1594
1400
1200
1000
800
Low : 643

*Source: USGS National Elevation Dataset, 1/3 arc-second, 10-meter resolution*

**Mainstem Elevation (Feet Above Mean Sea Level)**




0 1 2 3
Miles

## Water Quality Impairments

The entire reach of Nine Mile Creek has been listed as impaired (MPCA 2014 Impaired Waters List) for aquatic life based on chloride concentration and the fisheries bioassessments (Table NM-2, Figure NM-3). The creek was previously listed as impaired for turbidity but was delisted in 2010, likely due to decreasing sediment concentrations resulting from numerous stream improvement projects completed by the Nine Mile Creek Watershed District.

**Table NM-2: Impaired Reaches of Nine Mile Creek as Identified on the MPCA 2014 Impaired Waters List**

| Reach Name | Reach Description | Reach ID | Water Quality Imairment[1] | Approved Plan[2] | Needs Plan[2] |
|---|---|---|---|---|---|
| Nine Mile Creek | Headwaters to Minnesota R | 07020012-518 | AQL | T (stream was delisted in 2010)<br>Cl | F-IBI |

[1] AQL = Aquatic Life

[2] T = Turbidity; Cl = Chloride; F-IBI = Fisheries Bioassessments

Four lakes in the Nine Mile Creek watershed (Cornelia, Edina, Rose, and Wing) are impaired for aquatic recreation based on nutrient concentrations, two lakes (Bush and Smetana) are impaired for aquatic consumption based on mercury and are covered by the statewide mercury TMDL, and Bryant Lake is impaired for both.

**Table NM-3: Impaired Lakes in the Nine Mile Creek Watershed as Identified on the MPCA 2014 Impaired Waters List**

| Lake Name | Lake ID | Water Quality Impairment[1] | Approved Plan[2] | Needs Plan |
|---|---|---|---|---|
| Bryant | 27-0067-00 | AQC, AQR | HgF | Nutrients |
| Bush | 27-0047-00 | AQC | HgF | |
| Cornelia (North) | 27-0028-01 | AQR | | Nutrients |
| Edina | 27-0029-00 | AQR | | Nutrients |
| Rose | 27-0092-00 | AQR | | Nutrients |
| Smetana | 27-0073-00 | AQC | HgF | |
| Wing | 27-0091-00 | AQR | | Nutrients |

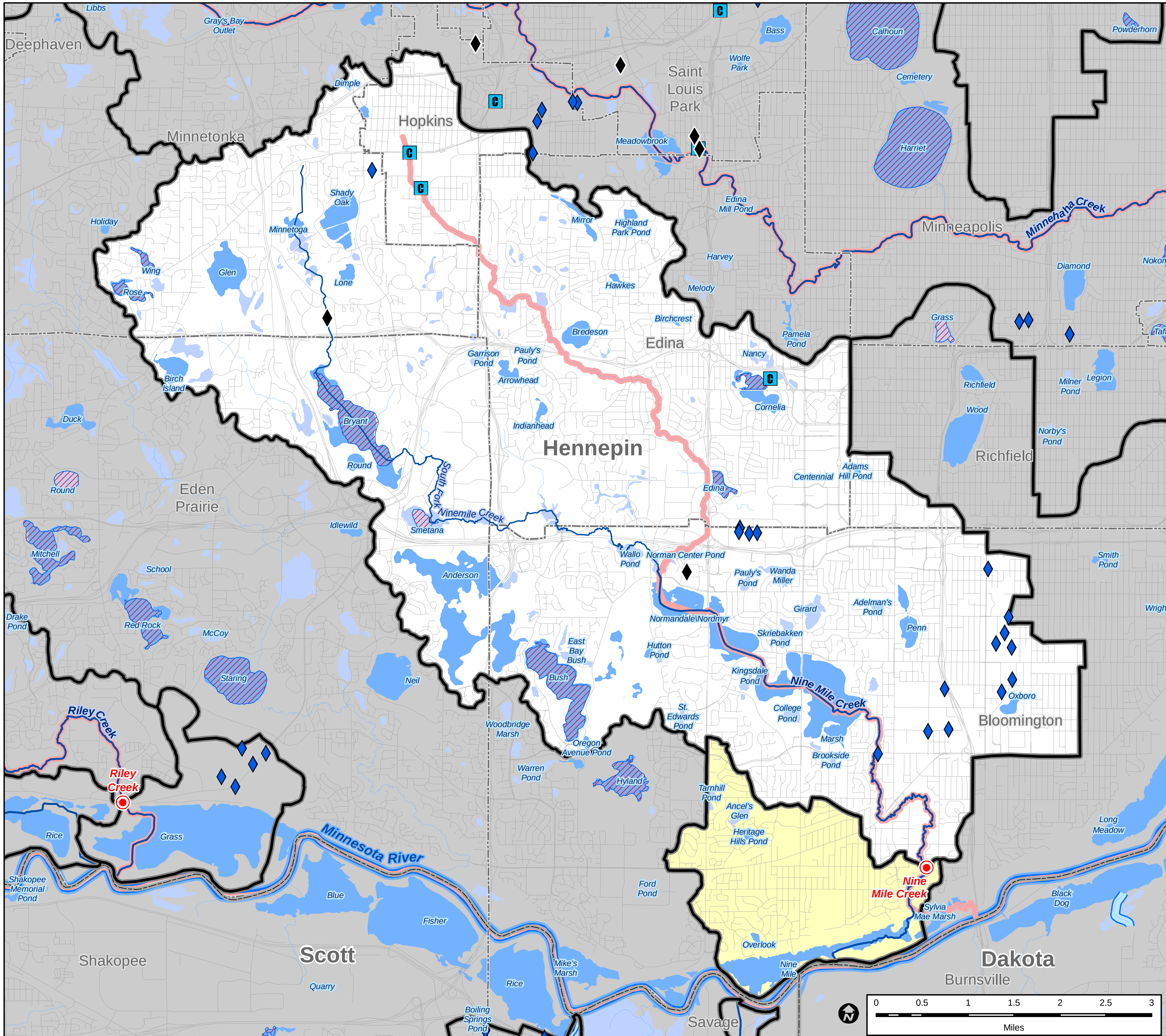
[1] AQC = Aquatic Consumption; AQR = Aquatic Recreation;

[2] HgF = Mercury in Fish Tissue;

# Figure NM-3

***Public and Impaired Waters and Potential Pollution Sources***

**Nine Mile Creek**




- MCES Stream Monitoring Sites
- USGS Flow Stations
- Mainstems (Monitored and Unmonitored)
- Monitored Watershed Boundaries
- Unmonitored Portion of Watersheds

**Industrial Discharges ****

- Industrial Stormwater
- Industrial & Individual Wastewater
- Cooling, Potable Treatment & Dewatering

**Domestic Wastewater Discharges ****

- Class A
- Class B
- Class C
- Class D
- Class Unknown

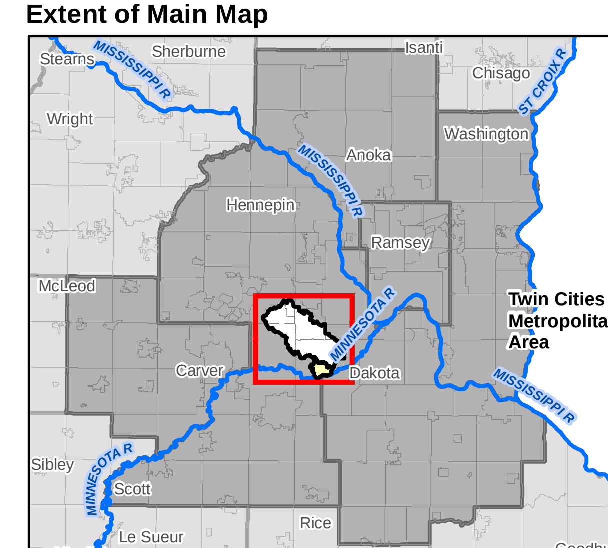
**Feedlots with 100 or more animal units ****

- 100 - 249
- 250 - 499
- 500 - 999
- 1000 or more

- Impaired Lakes (2014 Draft MPCA 303(d) List) **
- Impaired Streams (2014 Draft MPCA 303(d) List) **
- Other Rivers and Streams *
- Lakes and Other Open Water (PWI) *
- Wetlands (PWI) *
- Designated Trout Streams *
- NCompass Street Centerlines, 2013
- County Boundary
- City and Township Boundaries

*Data Sources: * MN DNR, ** MPCA, *** MN DOT*

**Extent of Main Map**



## Hydrology

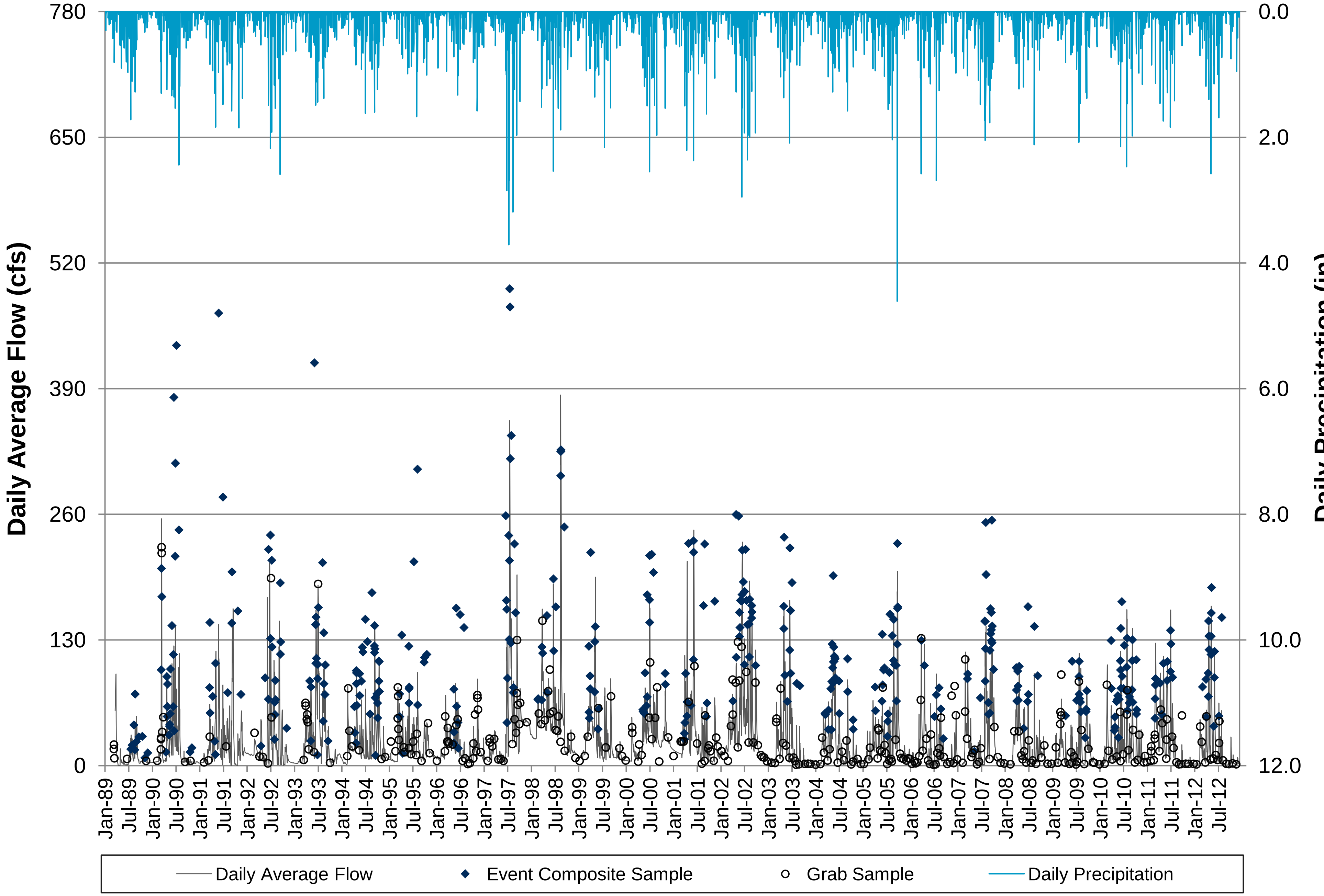
MCES has monitored flow on Nine Mile Creek in Bloomington, Minnesota, since 1989. Flow measurements were collected at 15-minute intervals and converted to daily averages. The hydrograph of Nine Mile Creek, which displays daily average flow, daily precipitation, and the flow associated with grab and composite samples, indicates the variations in flow rates from season to season and from year to year, and the effect of precipitation events on flow (Figure NM-4).

The MCES sampling program specifies collection of baseflow grab samples between events and event-composite samples. The hydrograph indicates samples were collected during most events and that base flow was also adequately sampled.

Analysis of the duration of daily average flows indicates that the upper $10^{th}$ percentile flows for the period 1990-2012 ranged between approximately 57.5-383.4 cubic feet per second (cfs), while the lowest $10^{th}$ percentile flows ranged from 0.1-2.0 cfs. (See Figure NM-11 in the ***Flow and Load Duration Curves*** section of this report.)

Additional annual flow/volume metrics are shown on Figures NM-5 to NM-8, along with the annual pollutant load parameters. The first graph on each sheet illustrates an annual flow metric consisting of 1) average annual flow (a measure of annual flow volume); 2) areal-weighted flow; and 3) the fraction of annual precipitation ending up as flow.

## Figure NM-4: Nine Mile Creek Daily Average Flow, Sample Flow, and Precipitation, 1989-2012*




*Precipitation record was acquired from NWS COOP station 215435-Minneapolis/St. Paul AP

## Vulnerability of Stream to Groundwater Withdrawals

Regional analysis (Metropolitan Council, 2010) of hydrogeologic conditions in the seven-county metropolitan area suggests that some surface water features are in direct connection with the underlying regional groundwater flow system and may be impacted by groundwater pumping. While regional in nature, this analysis serves as a screening tool to increase awareness about the risk that groundwater pumping may have for surface water protection and to direct local resources toward monitoring and managing the surface waters most likely to be impacted by groundwater pumping. Additional information, including assumptions and analytical methodologies, can be found in the 2010 report.

To assess the vulnerability of Nine Mile Creek to groundwater withdrawals, MCES staff examined spatial datasets of vulnerable stream segments and basins created as part of the 2010 regional groundwater analysis. Most of the Nine Mile Creek stream segments were identified as potentially vulnerable to groundwater withdrawals. Many of the basins within the watershed were also identified as potentially vulnerable to groundwater withdrawals, including Glen Lake, Shady Oak Lake, Birch Island Lake, Bryant Lake, Round Lake, Smetana Lake, Lake Cornelia, Girard Lake, Penn Lake, Oxboro Lake, Arrowhead Lake, Indianhead Lake, Bredesen Park Wetland, and Marsh Lake, plus a number of smaller, unnamed wetlands.

MCES is continuing to evaluate the effects of groundwater withdrawal on surface waters, including updating analyses with the best available data and linking results to predictive groundwater modeling and the comprehensive planning process involving local communities.

## Pollutant Loads

The U.S. Army Corps of Engineers program Flux32 (Walker, 1999) was used to convert daily average flow, coupled with grab and event-composite sample concentrations, into annual and monthly loads and flow-weighted mean concentrations. Loads were estimated for total suspended solids (TSS), total phosphorus (TP), total dissolved phosphorus (TDP), nitrate ($NO_3$), ammonia ($NH_3$), and chloride (Cl) for each year of monitored data in Nine Mile Creek (1990-2012). Note that chloride monitoring began in 1999; therefore Cl results are presented for the period 1999-2012.

Figures NM-5 through NM-8 illustrate annual loads expressed as mass, as flow-weighted mean (FWM) concentration, as mass-per-unit area (lb/ac), and as mass-per-unit area-per inch of precipitation (lb/ac/in), as well as two hydrological metrics (annual average flow rate and fraction of annual precipitation as flow). A later section in this report (***Comparison with Other Metro Area Streams***) offers graphical comparison of the Nine Mile Creek loads and FWM concentrations with those of the other MCES-monitored metropolitan area tributaries.

The flow metrics indicate year-to-year variability in annual flow rate that is likely driven by variation in annual precipitation amount as well as by variation in frequency of intense storm events. The fraction of annual precipitation delivered as flow is relatively stable between years; year-to-year variation is likely influenced by low soil moisture during dry periods, by increased capacity in upland storage areas during drought periods, and other factors. The highest average annual flow, and thus the highest volume of flow, occurred in 1998 (approximately 45.7 cfs average annual flow); the lowest average annual flow and lowest volume of flow occurred in 2009 (approximately 13.6 cfs average annual flow). The mean average annual flow for 1990-2012 was 24.0 cfs.

The annual mass loads for all parameters exhibited significant year-to-year variation, indicating the influence of precipitation and flow on the transport of pollutants within the watershed and stream. Notable is the apparent decrease in TSS load after 1993. This decrease is likely due to the completion of the Lower Valley Project in 1991, which repaired and stabilized stream banks along the channel in the lower part of the watershed, but upstream of the monitoring station. Further repairs were made in this area in 2009.

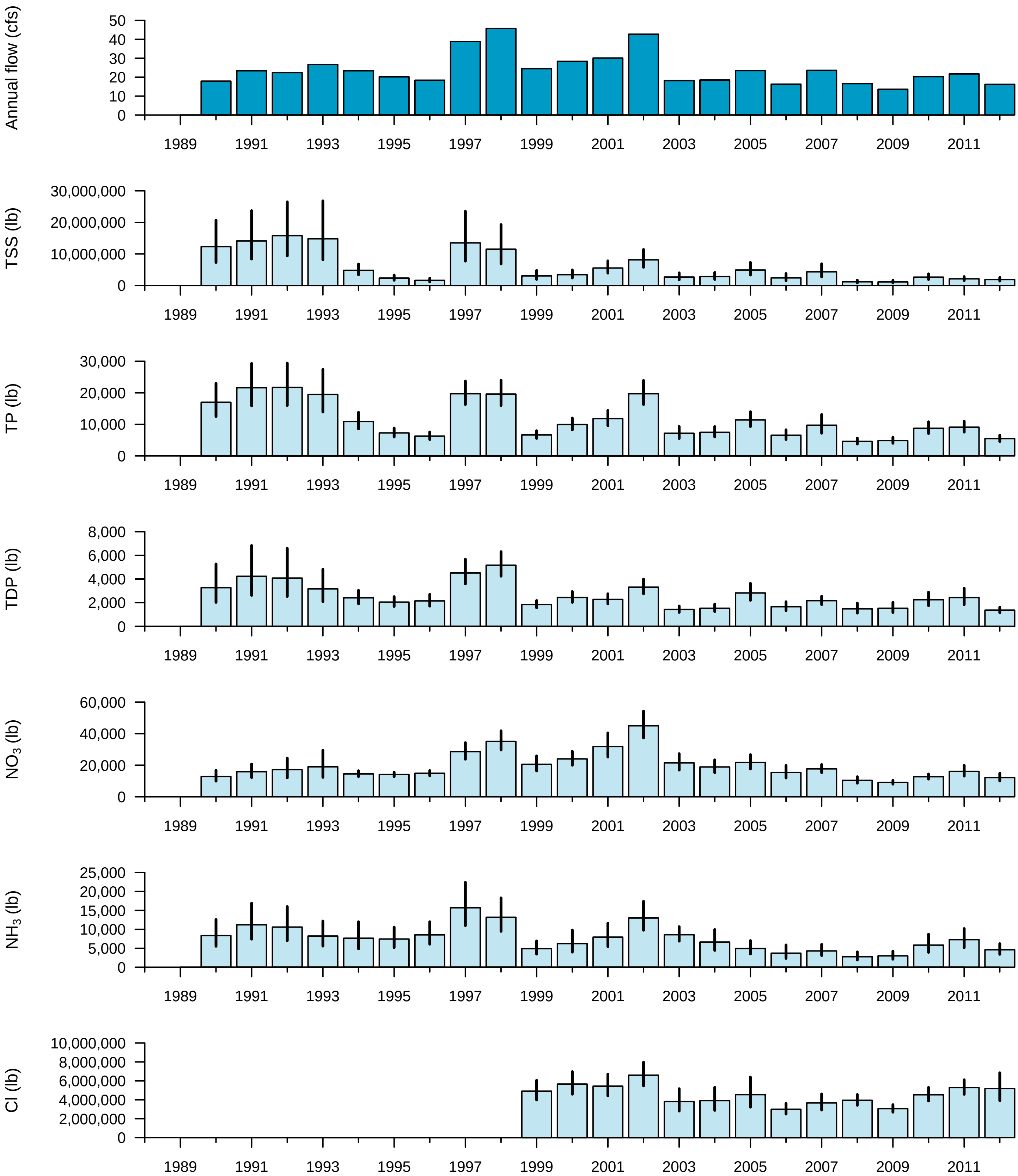
The annual FWM concentrations for all parameters also fluctuated year-to-year, although to a lesser extent than loads; and were also likely influenced by annual precipitation and flow. The TSS concentrations followed the same trend exhibited by the annual loads, with a decrease after 1993.

Figures NM-7 and NM-8 present the areal and precipitation-weighted loads, respectively. These graphics are presented to assist local partners and watershed managers, and will not be discussed here.

The Flux32 loads and FWM concentrations were also compiled by month to allow analysis of time based patterns in the loads in Nine Mile Creek (Figures NM-9 and NM-10). The results for each month are expressed in two ways: the monthly results for the most recent year of data (2012 for Nine Mile Creek) and the monthly average for 2003-2012 (with a bar indicating the maximum and minimum value for that month).

The highest mass loads for most parameters in Nine Mile Creek occurred in spring (March–May) of each year, likely due to the effects of snow melt and spring rains. Secondary load pulses often occurred in August, September, or October and were likely due to thunderstorms and the relatively high percentage of impervious area in the watershed. Construction projects may also have played a role in these months. The FWM concentrations generally showed less month-to-month variability than the loads. Cl loads were highest in March, and concentrations were highest from January through March, likely reflecting the impact of road de-icers applied during winter months.

# Figure NM−5: Nine Mile Creek*
# Annual Mass Load

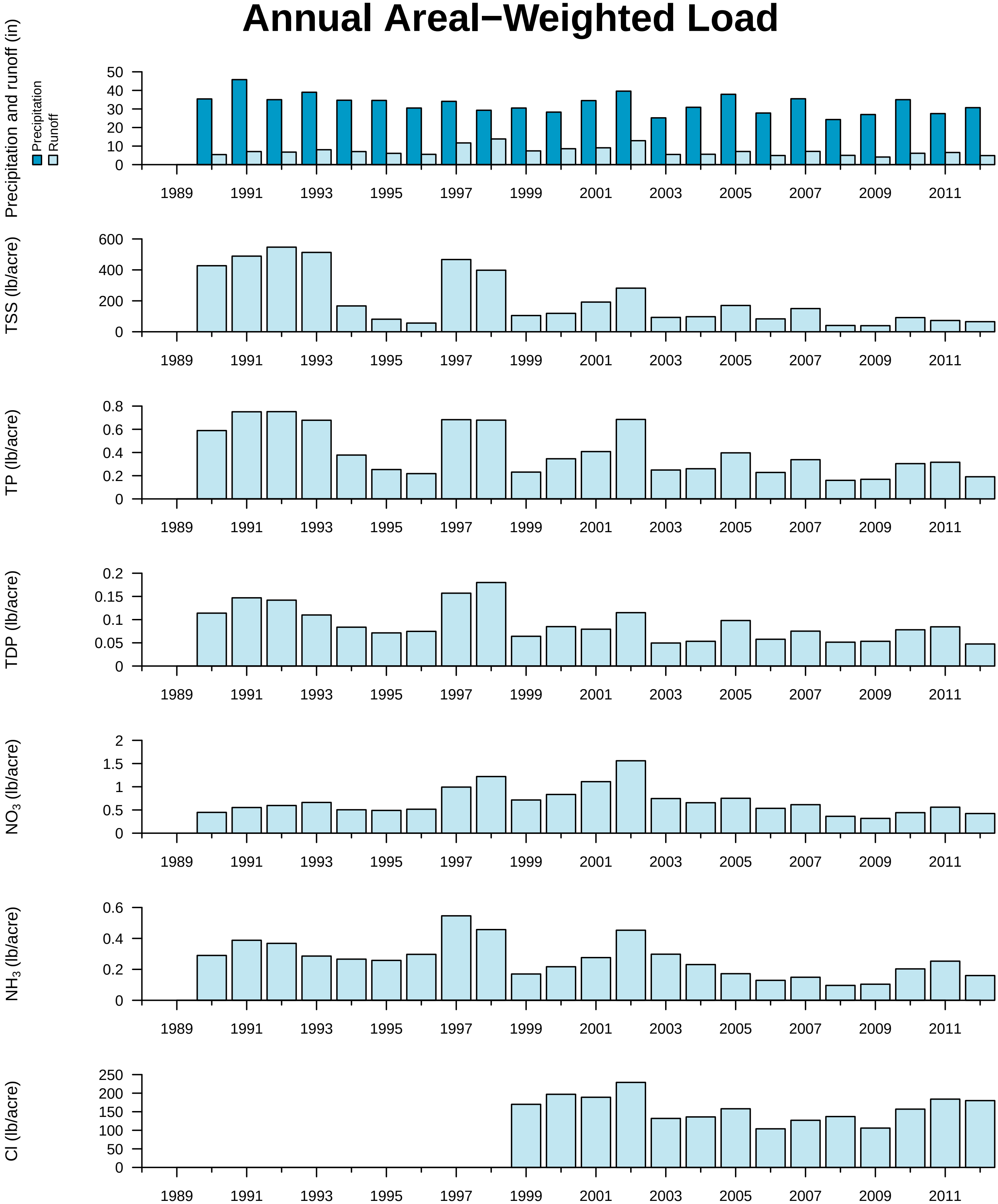



*First full year of sampling for TSS, TP, TDP, NO3, and NH3 began in 1990, Cl began in 1999.
Bars represent 95% confidence intervals as calculated in Flux32.

# Figure NM−6: Nine Mile Creek*
# Annual Flow−Weighted Mean Concentration

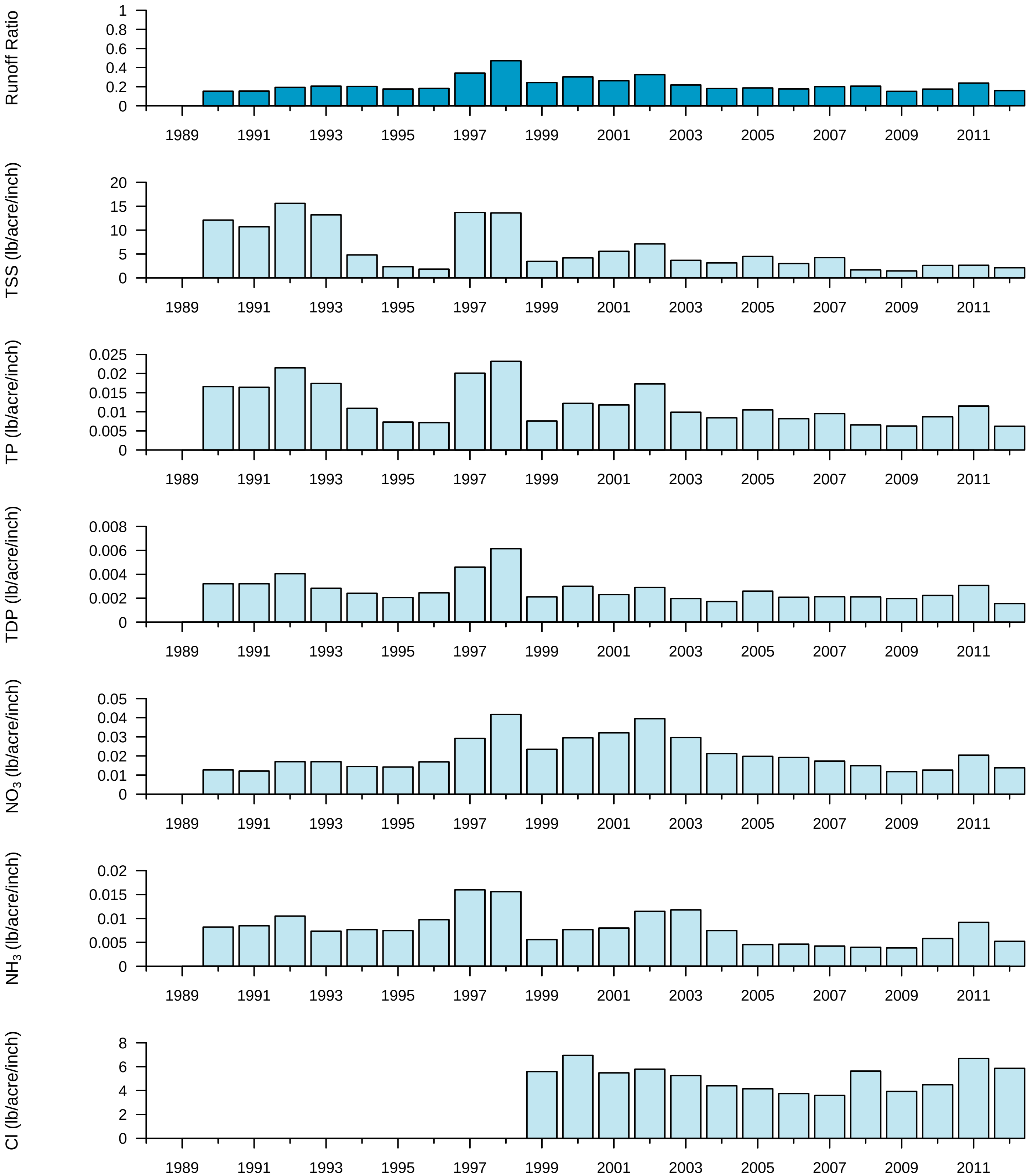

*First full year of sampling for TSS, TP, TDP, NO3, and NH3 began in 1990, Cl began in 1999.

# Figure NM−7: Nine Mile Creek*
# Annual Areal−Weighted Load




*First full year of sampling for TSS, TP, TDP, NO3, and NH3 began in 1990, Cl began in 1999.

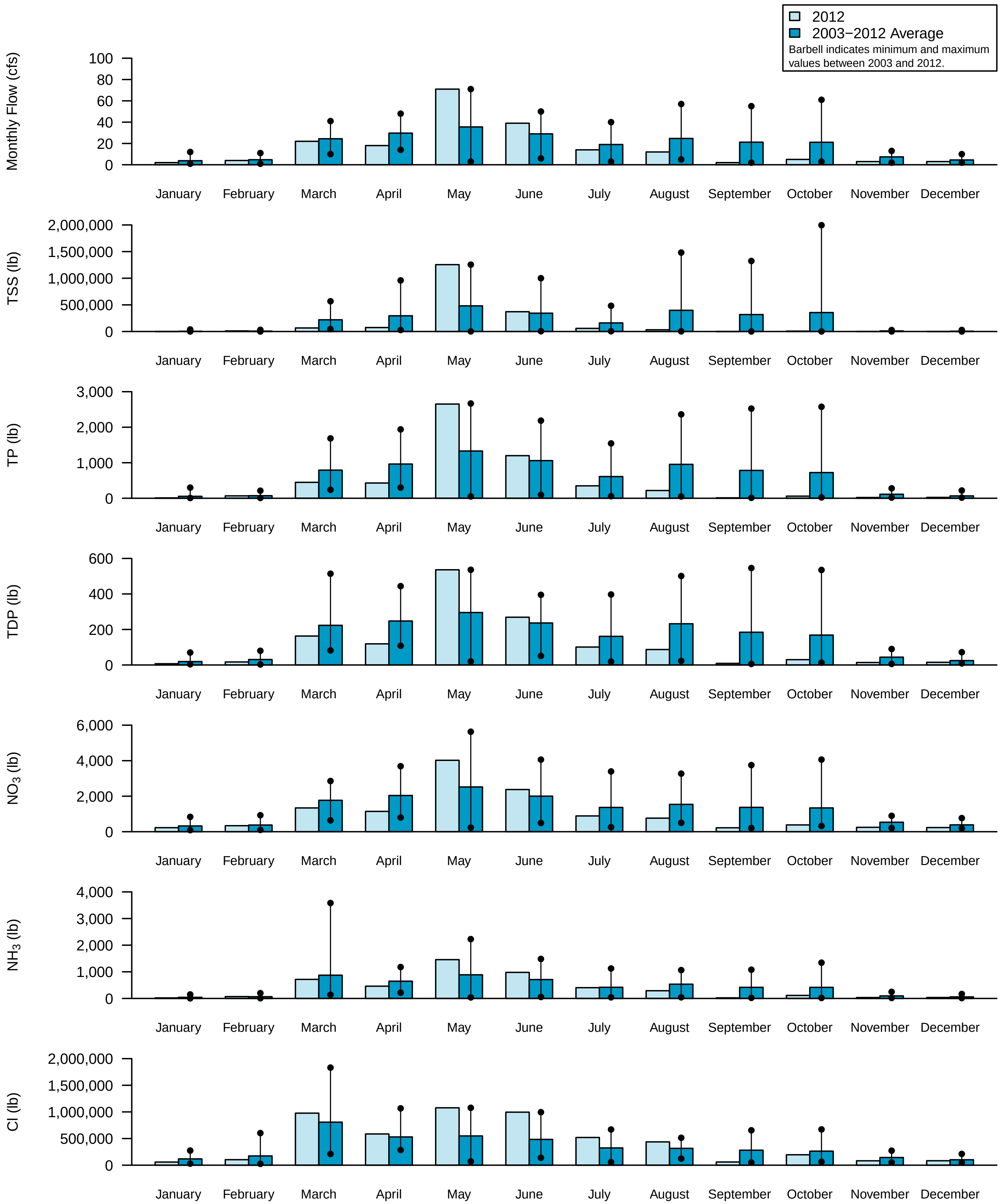
# Figure NM−8: Nine Mile Creek*
# Annual Precipitation−Weighted Areal Load




*First full year of sampling for TSS, TP, TDP, NO3, and NH3 began in 1990, Cl began in 1999.

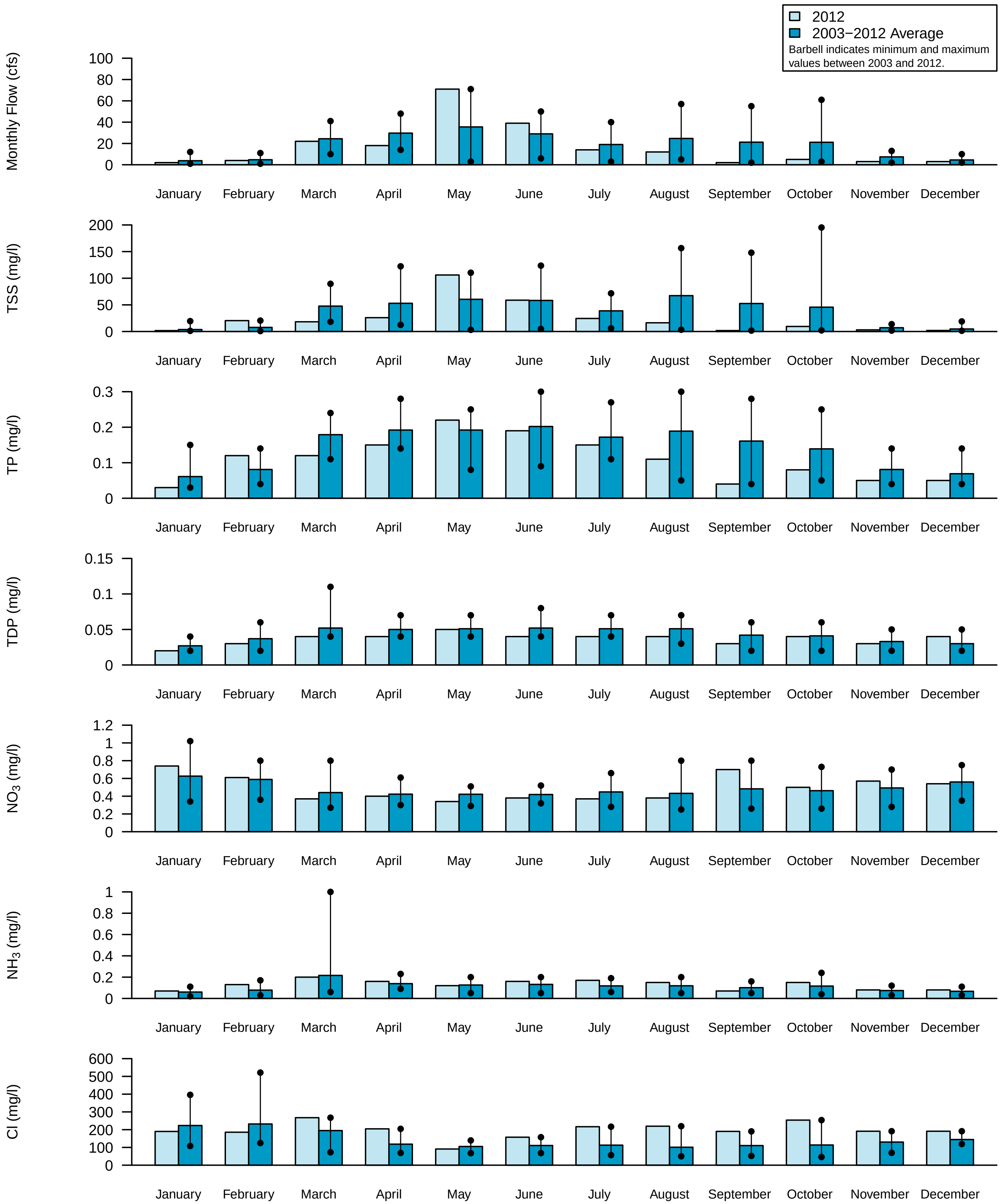
# Figure NM−9: Nine Mile Creek Mass Load by Month

## Most Recent Year (2012) of Data Compared to 2003−2012 Average



# Figure NM−10: Nine Mile Creek Flow−Weighted Mean Concentation by Month

## Most Recent Year (2012) of Data Compared to 2003−2012 Average



## Flow and Load Duration Curves

Load duration curves are frequently used to assess water quality concentrations occurring at different flow regimes within a stream or river (high flow, moist conditions, mid-range, dry conditions, and low flow). The curves can also be used to provide a visual display of the frequency, magnitude, and flow regime of water quality standard exceedances if standard concentrations are added to the plots (USEPA, 2007).

MCES developed flow and load duration curves for each stream location using U.S. Environmental Protection Agency (USEPA) recommendations, including:

- Develop flow duration curves using average daily flow values for the entire period of record plotted against percent of time that flow is exceeded during the period of record.
- Divide the flow data into five zones: high flows (0-10% exceedance frequency); moist conditions (10-40%); mid-range flows (40-60%); dry conditions (60-90%); and low flows (90-100%). Midpoints of each zone represent the $5^{th}$, $25^{th}$, $50^{th}$, $75^{th}$, and $95^{th}$ percentiles, respectively.
- Multiply concentration and flow for each sampling event for period of record, to result in approximate daily mass loads included on the curve as points.
- Multiply water quality standard concentration and monitored flow to form a line indicating allowable load. Sample load points falling below the line meet the standard; those falling above the line exceed the standard.

The final load duration curves provide a visual tool to assess if standard exceedances are occurring, and if so, at which flow regimes.

MCES selected four parameters to assess using load duration curves: TSS, TP, $NO_3$, and Cl. Each of the parameters was plotted using Nine Mile Creek monitoring station daily average flows and sample data, along with the most appropriate MPCA draft numerical standard as listed in Table NM-4. No draft standard has been set for $NO_3$, so MCES used the drinking water standard of 10 mg/l.

Most of the draft standards proposed by MPCA have accompanying criteria that are difficult to show on the load duration curves. For example, for a water body to violate the draft TP river standard, the water body must exceed the causative variable (TP concentration), as well as one or more response variables: sestonic (suspended) chlorophyll, biochemical oxygen demand ($BOD_{5)}$, dissolved oxygen (DO) flux, and/or pH (MPCA, 2013a). Thus for this report, the load duration curves are used as a general guide to identify flow regimes at which water quality violations may occur. The MPCA is responsible for identifying and listing those waters not meeting water quality standards; the results of this report in no way supersede MPCA's authority or process.

The 1990–2012 flow duration curve and load duration curves for TSS, TP, $NO_3$, and Cl for the Nine Mile Creek monitoring station (mile 1.8) are shown in Figure NM-11.

TSS concentrations have remained below the draft standard at low flow; the draft standard was exceeded several times at dry conditions and mid-range flows; during moist conditions about half of the samples exceeded the standard, and at high flow conditions most of the samples exceeded the draft standard. This response is consistent with other streams in the Minnesota River watershed, where high flows lead to streambank, bluff, and ravine erosion.

For TP, there were a few exceedances of the draft nutrient criteria at low flow, dry conditions, and mid-range flows; more than half of the samples exceeded the criteria during moist conditions, and most of the samples exceeded it at high flows.

Almost all $NO_3$ concentrations at all flow regimes met the drinking water standard of 10 mg/l. The final river nutrient standard for nitrate will likely be much less than this, and may be exceeded at the higher flow regimes.

Cl concentrations in Nine Mile Creek exceeded the draft Cl standard a few times at all flow regimes. As stated previously, there are several freeways and highways, as well as many local roads, in the Nine Mile Creek watershed. The high Cl loads may be due to salt applied for winter road, sidewalk, and parking lot deicing in the watershed.

**Table NM-4: Nine Mile Creek Beneficial Use and River Nutrient Region (RNR) Classifications and Pollutant Draft Standards**

| Monitoring Station | Use Classification[1] for Domestic Consumption (Class 1) and Aquatic Life and Recreation (Class 2) | River Nutrient Region (RNR)[2] of Monitoring Station | Chloride Draft Stnd[3] (mg/l) | TSS Draft Stnd[4] (mg/l) | TP Draft Criteria[5] (ug/l) | Nitrate DW Stnd[6] (mg/l) |
|---|---|---|---|---|---|---|
| Nine Mile Creek below 106th St. (NM1.8) | 2B | Central | 230 | 30 | 100 | 10 |

[1] Minn. Rules 7050.0470 and 7050.0430

[2] MPCA, 2010.

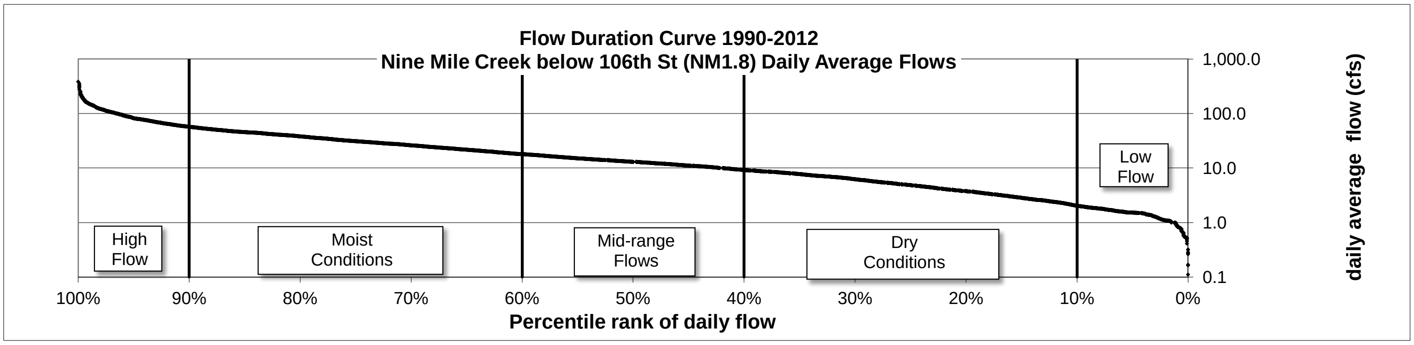
[3] Mark Tomasek, MPCA, personal communication, March 2013. MCES used 230 mg/l as the draft chloride standard pending results of EPA toxicity tests.

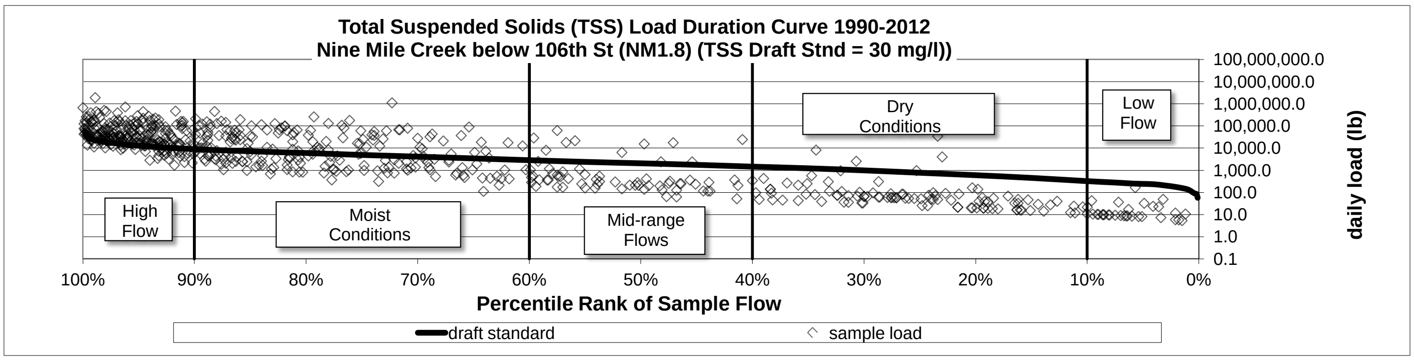
[4] MPCA, 2011. Draft standard states TSS standard concentration for Class 2A and 2B water must not be exceeded more than 10% of the time over a multiyear data window, with an assessment period of April through September.

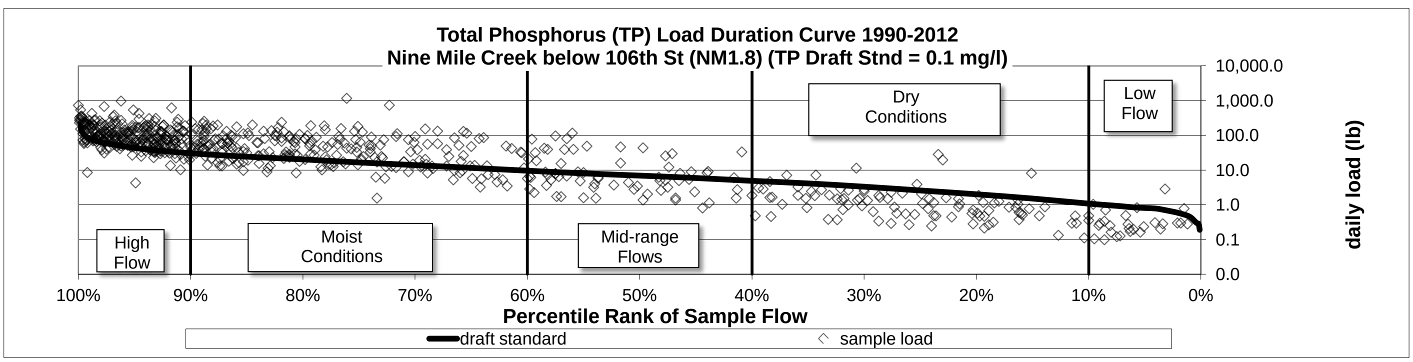
[5] MPCA, 2013a. To violate standard, concentration of causative variable (TP) must be exceeded, as well as one or more response variables: sestonic chlorophyll, $BOD_5$, DO flux, and/or pH.

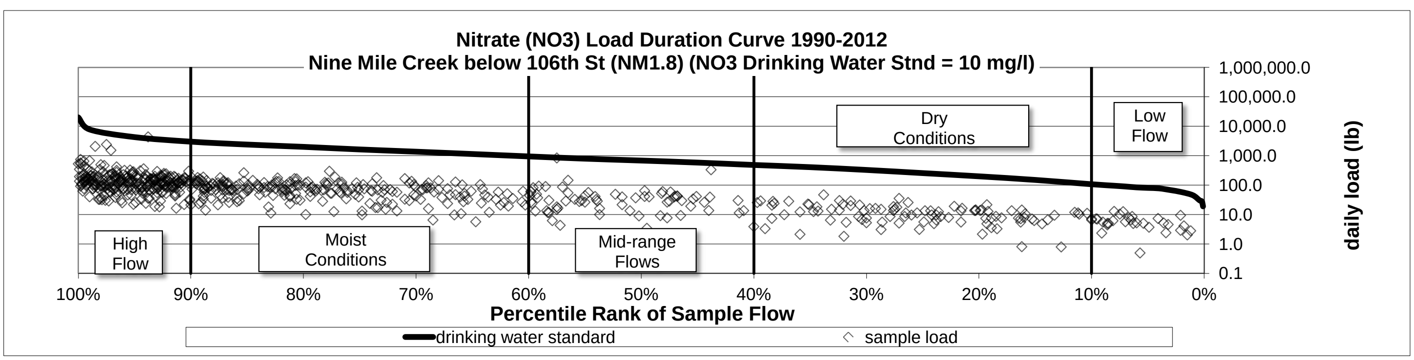
[6] MCES used the nitrate drinking water standard of 10 mg/l pending results of EPA toxicity tests and establishment of a draft nitrate standard for rivers and streams.

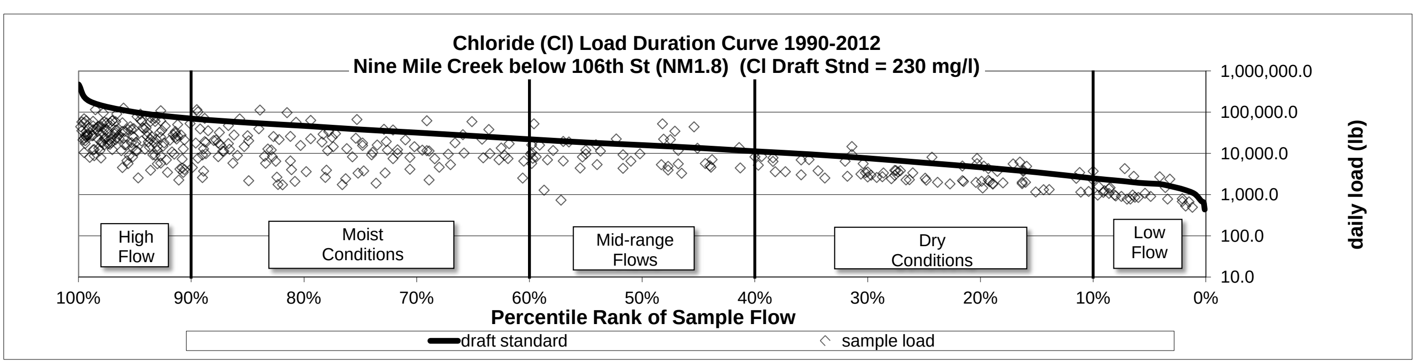
# Figure NM-11: Nine Mile Creek Flow and Load Duration Curves, 1990-2012



## Aquatic Life Assessment Based on Macroinvertebrates

Macroinvertebrates, including aquatic insects, worms, snails, crustaceans, and bivalves, are important indicators of water quality. Different types of macroinvertebrates have differing sensitivities to changes in pollution levels, habitat, flows, energy, and biotic interactions. As these environmental attributes change over time, they shape the composition of the macroinvertebrate community. Metrics have been developed that relate these community shifts with human-caused stresses.

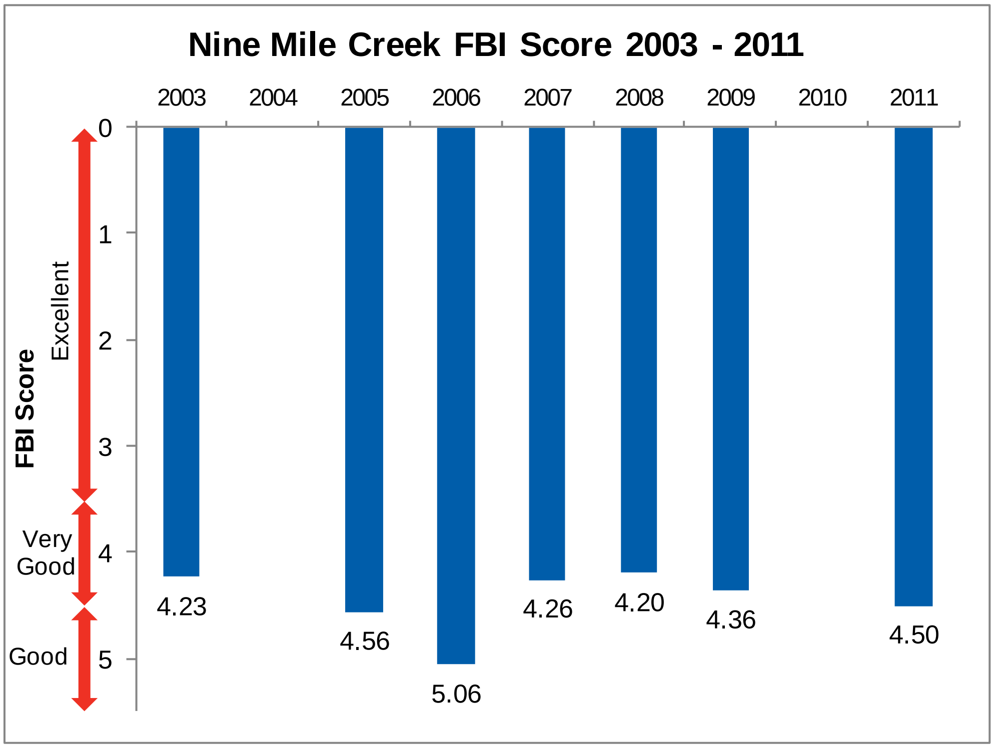
Each metric is independently important and clarifies one aspect of the ecosystem health: species richness, community diversity, water quality, and other factors. The results may have conflicting conclusions when comparing the single metric results. However, integrating the individual metrics into a multi-metric analysis provides a holistic assessment of the stream system.

MCES has been sampling for macroinvertebrates in Nine Mile Creek since 2003. The entire dataset was analyzed with three metrics: Family Biotic Index (FBI), Percent Intolerant Taxa, and Percent POET Taxa. A subset of data, 2004-2009 and 2011, was analyzed using the multi-metric, Minnesota-specific, MPCA 2014 Macroinvertebrate Index of Biological Integrity (M-IBI).

### *Family Biotic Index (FBI)*

FBI is a commonly used water quality assessment. Each family is assigned a tolerance value that describes its ability to tolerate organic pollution. The values range from 0 to 10; zero is intolerant to pollution, ten is quite tolerant of pollution. The tolerance values are used to calculate a weighted average tolerance value for the sample, allowing for comparisons from year to year. The Nine Mile Creek FBI scores show very good water quality (for years 2003, 2007-2011) to good water quality (2005, 2006), indicating the possible presence of organic (oxygen demanding) pollution (Figure NM-12).

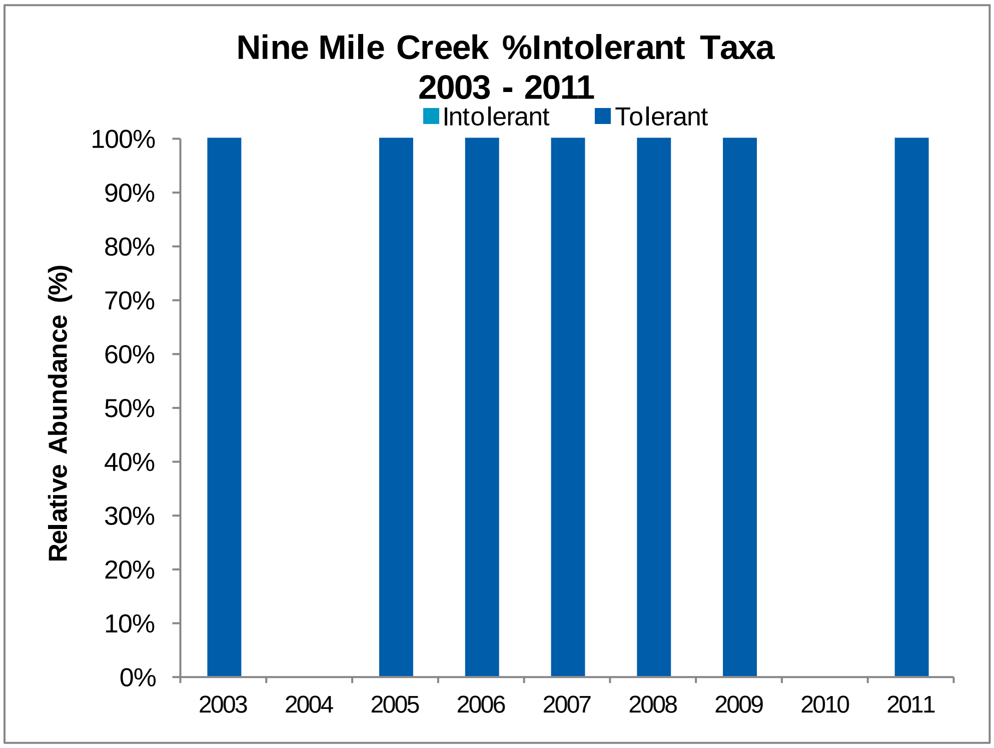
**Figure NM-12: Nine Mile Creek Annual Family Biotic Index (FBI) Scores, 2003-2011**




## *Percent Intolerant Taxa*

The Percent Intolerant Taxa is another assessment to evaluate the degree of pollution at the monitoring reach. This metric identifies the percent of taxa with a tolerance value of two or less (Figure NM-13). The presence of moderate numbers of intolerant taxa is an indicator of good aquatic health (Chirhart, 2003). There were no intolerant taxa present in any Nine Mile Creek sample collected during the period of record. These results are inconsistent with the FBI scores, and suggest that pollutants may be consistently present in the stream system.

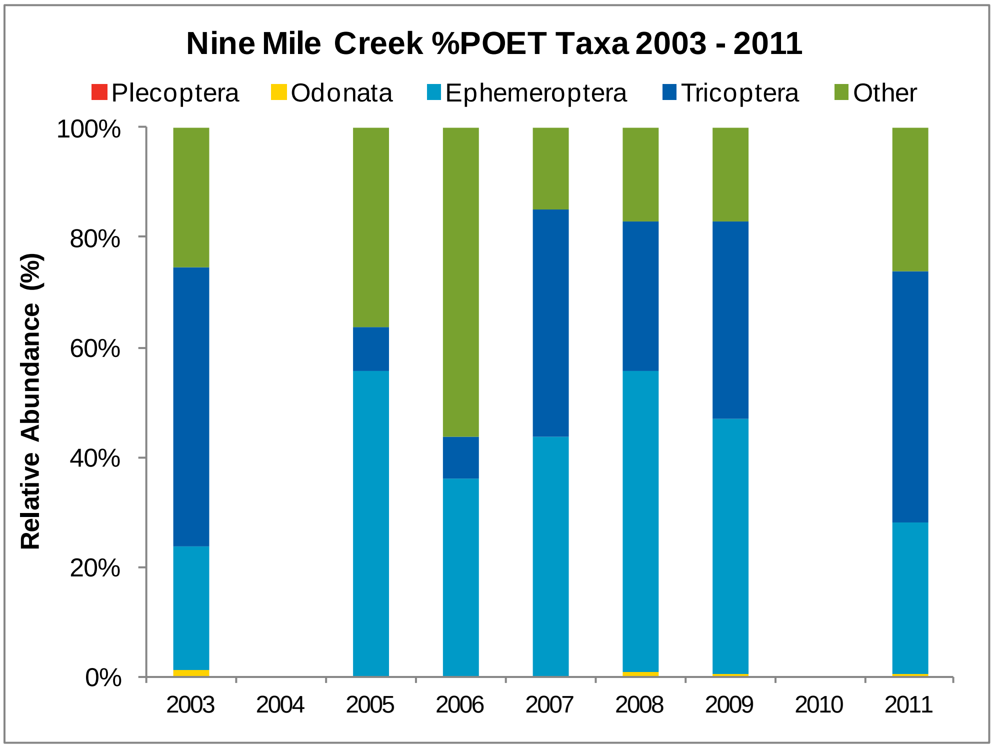
**Figure NM-13: Nine Mile Creek Percent Abundance of Pollution Intolerant Taxa, 2003-2011**




## *Percent POET Taxa*

The taxonomic richness metric, Percent POET Taxa (Figure NM-14), is the percent of individuals in the sample which belong to the orders **P**lecoptera (stoneflies), **O**donata (dragonflies and damselflies), **E**phemeroptera (mayflies), and **T**richoptera (caddisflies). Individuals in these orders vary in sensitivity to organic pollution and sedimentation. High percent POET values indicate high community diversity due to good water quality. The percent POET taxa value was highest in 2007 at 85%, and lowest in 2006 at 44%. No Plecoptera were found in Nine Mile Creek in any of the years sampled.

**Figure NM-14: Nine Mile Creek Percent Abundance of POET Taxa, 2003-2011**




## *Macroinvertebrate Index of Biotic Integrity (M-IBI)*

The M-IBI score integrates community richness and composition, pollution tolerance, life histories, trophic interactions, and physical and other parameters that all are components of the biological integrity of the stream. These composite scores are usually shown in context with a threshold value and confidence levels to aid in the assessment of the water quality. If the value for a given year is above the threshold of impairment and the upper confidence level, it can confidently be said the site is not impaired. Conversely, if the value is below the threshold of impairment and below the lower confidence level, it can be said the site is likely to be impaired.

All six years of monitoring Nine Mile Creek resulted in M-IBI scores below the impairment threshold (Figure NM-15). In 2007, the M-IBI score was below the lower confidence level. This suggests the stream reach during that year may not have been able to sustain the needs of aquatic life.

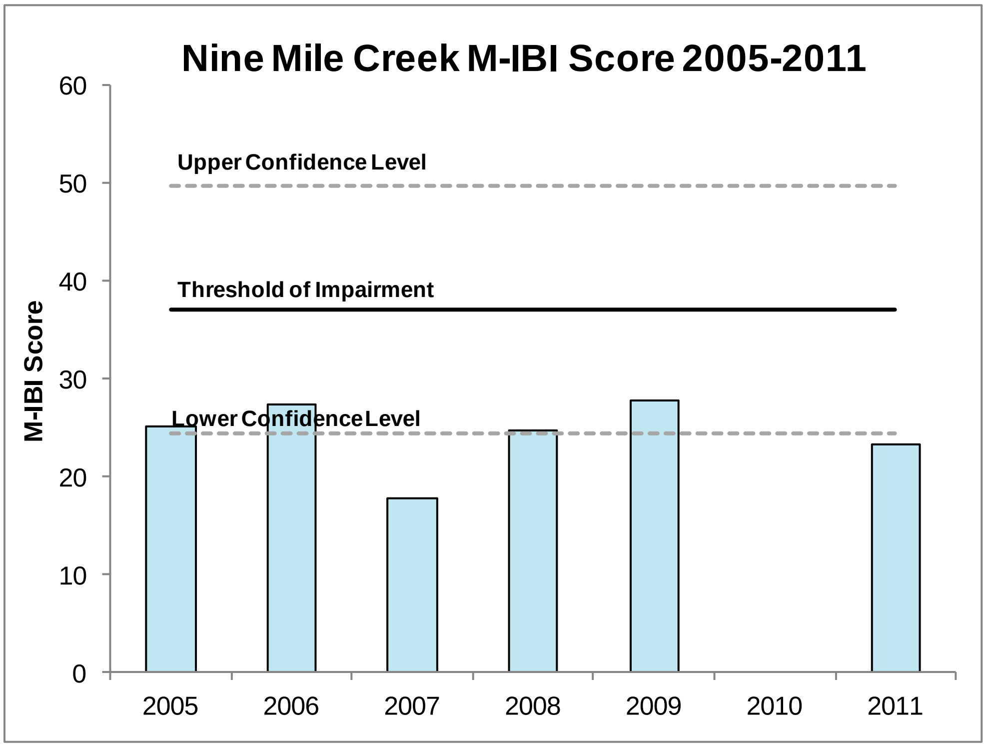
The M-IBI scores in 2005-2006, 2008-2009, and 2011 were between the threshold of impairment and the lower confidence level. When the scores fall between the confidence levels, it is difficult to confidently assess the water quality by biological assessment alone. It is necessary to incorporate other monitoring information, such as hydrology, water chemistry and land use change (MPCA, 2014b).

Understanding the physical and chemical influences on M-IBI scores leads to a more complete assessment of water quality. When plausible physical or chemical explanations exist for M-IBI scores between the confidence levels, these scores may be assigned more or less weight in the final evaluation.

Nine Mile Creek has a highly impervious watershed. The stream hydrology is flashy; storm runoff quickly flows into the stream, the storm hydrograph peaks rapidly and flow recedes quickly after the storm. This flow regime flushes macroinvertebrates and alters community composition. Additionally, the storm runoff carries a higher pollutant load which can reduce the number of pollution intolerant individuals (Carlisle *et al.*, 2013).

The most recent M-IBI scores, 2008, 2009, and 2011, are near or at the lower confidence level. Most likely, stressors are negatively affecting the macroinvertebrate community. MCES is planning additional future analysis to fully investigate our biological monitoring data.

**Figure NM-15: Nine Mile Creek Annual Macroinvertebrate Index of Biological Integrity (M-IBI) Scores, 2005-2011**




## Trend Analysis

Trend analysis was completed for the historical record of TSS, TP, and $NO_3$ using the U.S. Geological Survey (USGS) program QWTREND (Vecchia, 2003). QWTREND removes the variability of annual flow from the statistical analysis, thus any trend identified should be independent of flow.

Due to relatively short flow record for the monitored streams, MCES did not attempt to assess increases or decreases in flow. However other researchers have performed regional assessments of variations in flow rate; their results can be used to form general assumptions about changes in flows in the metropolitan area streams.

Novotny and Stefan (2007) assessed flows from 36 USGS monitoring stations across Minnesota over a period of from 10 to 90 years, finding that peak flow due to snowmelt was the only streamflow statistic that has not changed at a significant rate. Peak flows due to rainfall events in summer were found to be increasing, along with the number of days exhibiting higher flows. Both summer and winter baseflows were found to be increasing, as well. Novotny and Stefan hypothesized that increases in annual precipitation, larger number of intense precipitation events, and more days with precipitation are driving the increased flows.

Alterations in land use and land management have also likely contributed to increasing flow rates. For example, Schottler et al. (2013) found that agricultural watersheds with large land use changes have exhibited increases in seasonal and annual water yields, with most of the increase in flow rate due to changes in artificial drainage and loss of natural storage. MCES staff plan to repeat the following trend analyses in five years. At that time, we anticipate sufficient data will have been collected for us to assess changes in flow rate, as well as to update the pollutant trends discussed below.

MCES staff assessed trends for the period of 1990-2012 on Nine Mile Creek for TSS, TP, and $NO_3$. The results are presented below, and shown in Figure NM-16.

## *Total Suspended Solids (TSS)*

Two downward trends were identified for TSS flow-adjusted concentration in Nine Mile Creek during the assessment period of 1990 to 2012 (Figure NM-16, top panel). The analysis was performed using QWTREND without precedent 5-year flow setting. The trends identified were statistically significant (p=0).

- Trend 1: 1990 to1996, TSS flow-adjusted concentration decreased from 54.2 mg/l to 11.8 mg/l (-78%) at a rate of -6.1 mg/l/yr.
- Trend 2: 2000 to 2012, TSS flow-adjusted concentration decreased gradually from 11.8 mg/l to 5.4 mg/l (-55%) at a rate of -0.40 mg/l/yr.

The five-year trend in TSS flow-adjusted concentration in Nine Mile Creek (2008-2012) was calculated to compare with other MCES-monitored streams, shown in the report section ***Comparison with Other Metro Area Streams***. TSS flow-adjusted concentration decreased from 6.4 mg/l to 5.4 mg/l (-16%) at a rate of -0.21 mg/l/yr. Based on the QWTREND results, the water quality in Nine Mile Creek in terms of TSS has improved during 2008-2012.

## *Total Phosphorus*

Two trends were identified for TP flow-adjusted concentration in Nine Mile Creek from 1990 to 2012 (Figure NM-16, middle panel). The assessment was performed using QWTREND without precedent 5-year flow setting. The trends identified were statistically significant ($p=2.64x10^{-6}$).

- Trend 1: 1990 to 1996, TP flow-adjusted concentration decreased from 0.17 mg/l to 0.09 mg/l (-48%) at a rate of -0.011 mg/l/yr.
- Trend 2: 2000 to 2012, TP flow-adjusted concentration decreased from 0.09 mg/l to 0.07 mg/l (-19%) at a rate of -0.0010 mg/l/yr.

The five-year trend in TP flow-adjusted concentration in Nine Mile Creek (2008-2012) was calculated to compare with other MCES-monitored streams, shown in the report section ***Comparison with Other Metro Area Streams***. TP flow-adjusted concentration decreased from 0.073 mg/l to 0.07 mg/l (-4%) at a rate of -0.0006 mg/l/yr. Based on the QWTREND results, the water quality in Nine Mile Creek in terms of TP has improved during 2008-2012.

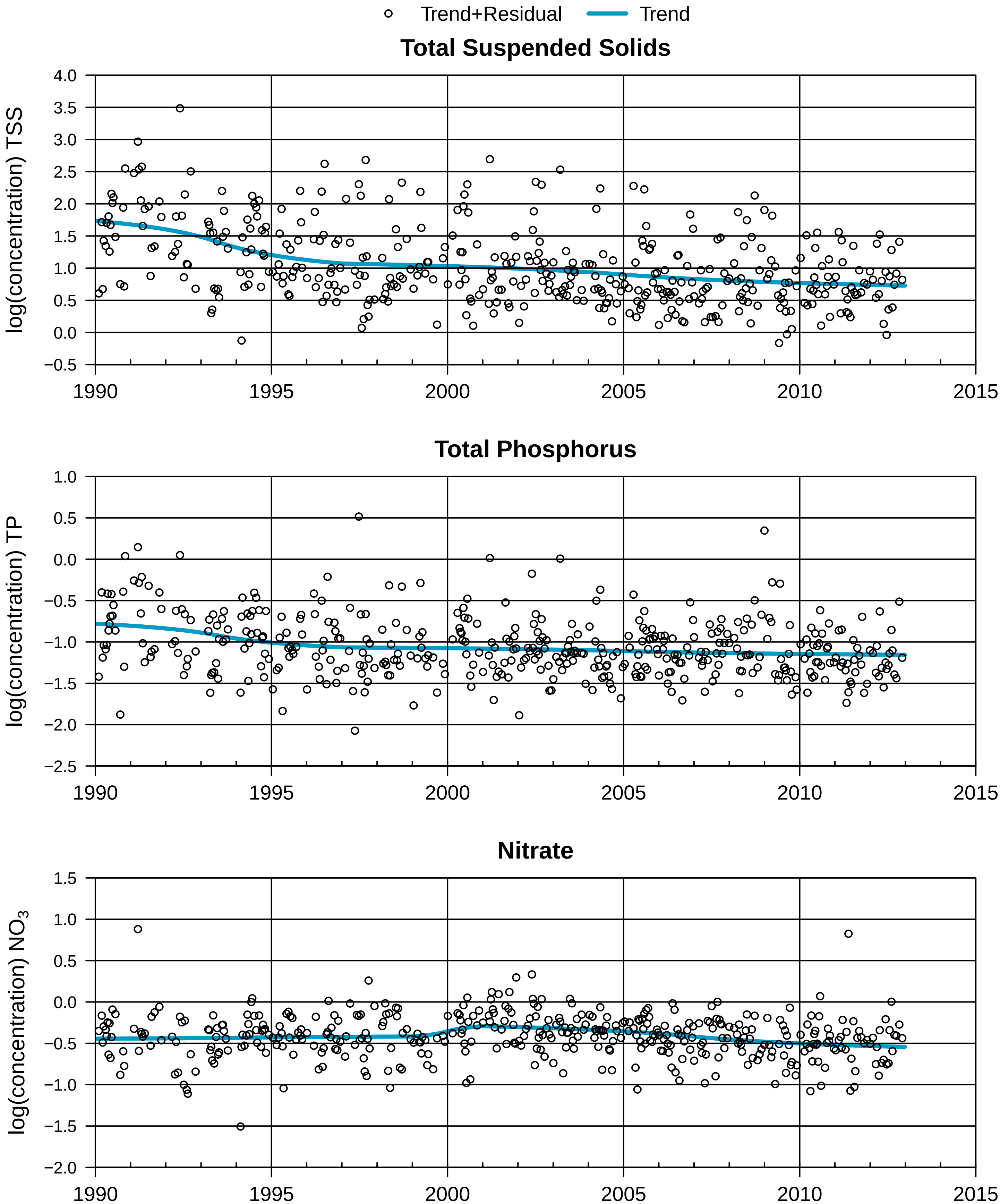
## *Nitrate*

Three trends were identified for $NO_3$ flow-adjusted concentration in Nine Mile Creek from 1990 to 2012 (Figure NM-16, lower panel). The assessment was performed using QWTREND without precedent 5-year flow setting. The trends identified were statistically significant ($p=3.6x10^{-5}$).

- Trend 1: 1990 to 1998, NO3 flow-adjusted concentration increased slightly from 0.36 mg/l to 0.38 mg/l (6%) at a rate of 0.0025 mg/l/yr.
- Trend 2: 1999 to 2000, NO3 flow-adjusted concentration increased from 0.38 mg/l to 0.51 mg/l (33%) at a rate of 0.064 mg/l/yr.
- Trend 3: 2001 to 2012, NO3 flow-adjusted concentration decreased from 0.51 mg/l to 0.29 mg/l (-44%) at a rate of -0.019 mg/l/yr.

The five-year trend in $NO_3$ flow-adjusted concentration in Nine Mile Creek (2008-2012) was calculated to compare with other MCES-monitored streams, shown in the report section ***Comparison with Other Metro Area Streams***. $NO_3$ flow-adjusted concentration decreased from 0.35 mg/l to 0.29 mg/l (-19%) at a rate of -0.0.13 mg/l/yr. Based on the QWTREND results, the water quality in Nine Mile Creek in terms of NO3 improved during 2008-2012.

# Figure NH−16: Nine Mile Trends for TSS, TP and $NO_3$



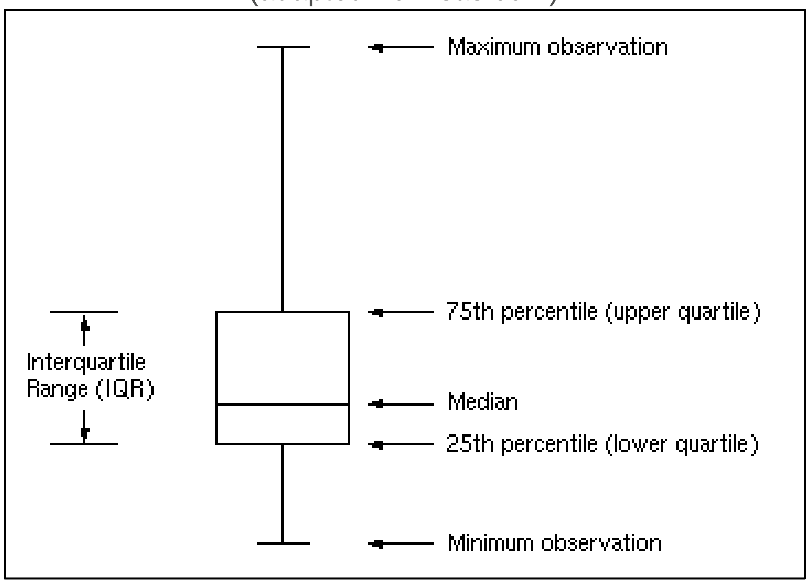
## Comparison with Other Metro Area Streams

### *Chemistry*

Box-and-whisker plots are used to summarize the comparison of the historical flow, TSS, TP, $NO_3$, and Cl data for Nine Mile Creek with those of the other metropolitan area streams monitored by MCES and with the major receiving water (in this case the Minnesota River). The comparisons are shown in Figures NM-18 to NM-21.

Figure NM-17 shows the formatted legend of the box-and-whisker plots used in this report. Note that 50% of data points fall within the box (also known as the interquartile range), with the centroid delineated by the median line. The outer extents of the whiskers designate the maximum and minimum values.

**Figure NM-17: General Schematic of a Box-and-Whisker Plot**
(adapted from *sas.com*)




Comparisons for each chemical parameter for the period 2003-2012 are shown using box-and-whisker plots of four metrics (annual flow-weighted mean (FWM) concentration, annual runoff ratio (volume/precipitation, which are identical on each of the four parameter pages), total annual load, and annual areal yield), grouped on one page, with streams grouped by major receiving river and listed in order of upstream-to-downstream. In addition, the plot of FWM concentration includes the 2003-2012 FWM concentration for the three receiving rivers (Mississippi, St. Croix, and Minnesota), shown as a dashed line.

*Total Suspended Solids*. The median annual FWM concentration for TSS in Nine Mile Creek is greater than that of Willow and Eagle Creeks, but it is lower than that of other monitored Minnesota River tributaries like Sand, Bluff, Riley, Bevens, Carver, and Credit River. The FWM concentration in Nine Mile Creek is also lower than that in the Minnesota River measured at Jordan Minnesota; (70 mg/l vs. 142 mg/l, respectively) and thus serves to decrease the TSS concentration in the river (Table NM-5; Figure NM-18). It is apparent that those tributaries entering the Minnesota River nearest Jordan have significantly higher FWM TSS concentrations and annual yields (expressed in lb/acre) than the other tributaries to the Minnesota or any of the Mississippi or St. Croix River tributaries monitored by MCES. This reflects the relatively unstable landform within the Minnesota River watershed, where the tributaries' channels and associated gullies and ravines are still down-cutting towards geographic equilibrium (Jennings, 2010). Nine Mile Creek is fully developed compared to the more agricultural land cover in some of the other Minnesota River tributaries. In addition Nine Mile has some upstream detention which may tend to moderate TSS concentrations.

*Total Phosphorus.* As with TSS, the Nine Mile Creek TP median annual FWM concentration is lower than that of most other monitored Minnesota River tributaries with the exceptions of Eagle Creek and Willow Creek (Figure NM-19). The FWM TP concentration in Nine Mile Creek is slightly lower than that of the Minnesota River (0.21 mg/l vs. 0.24 mg/l, respectively).

The Nine Mile Creek median annual TP load ranks near the middle of the monitored Minnesota River tributaries, lower than that of the agricultural Minnesota River tributaries (Sand, Bevens, Carver, and Credit River), but higher than that of Eagle, Willow, Riley, and Bluff Creek. The Nine Mile Creek median annual yield is lower than that of all the other monitored Minnesota River tributaries, except Willow Creek.

*Nitrate.* The median annual FWM $NO_3$ concentration in Nine Mile Creek of 0.38 mg/l is lower than that of the Minnesota River (6.8 mg/l), and thus serves to dilute the river concentration (Figure NM-20). The FWM $NO_3$ concentration is lower than that of all other monitored Minnesota River tributaries except Eagle and Willow Creeks.

As with TP, the median annual $NO_3$ load ranks near the middle of the monitored Minnesota River tributaries; with the Nine Mile Creek load lower than that of the Bevens, Carver, Credit River and Sand Creeks, but higher than that of Willow, Eagle, Bluff, and Riley Creek. Again as with TP, the Nine Mile Creek median annual yield is lower than that of all the other monitored Minnesota River tributaries, except Willow Creek.

*Chloride.* In contrast to the other monitored parameters, median annual Cl FWM concentration in Nine Mile Creek, at 110 mg/l, is higher than that in the Minnesota River (26 mg/l) and is higher than the concentration observed in all other monitored Minnesota River tributaries, except Willow Creek (116 mg/l) (Figure NM-21).

Nine Mile Creek has the second highest median annual Cl load of the monitored Minnesota River watersheds (after Sand Creek), and the third highest median areal yield. This is likely due to runoff from roads, sidewalks, and parking lots where salt has been applied as a deicing chemical.

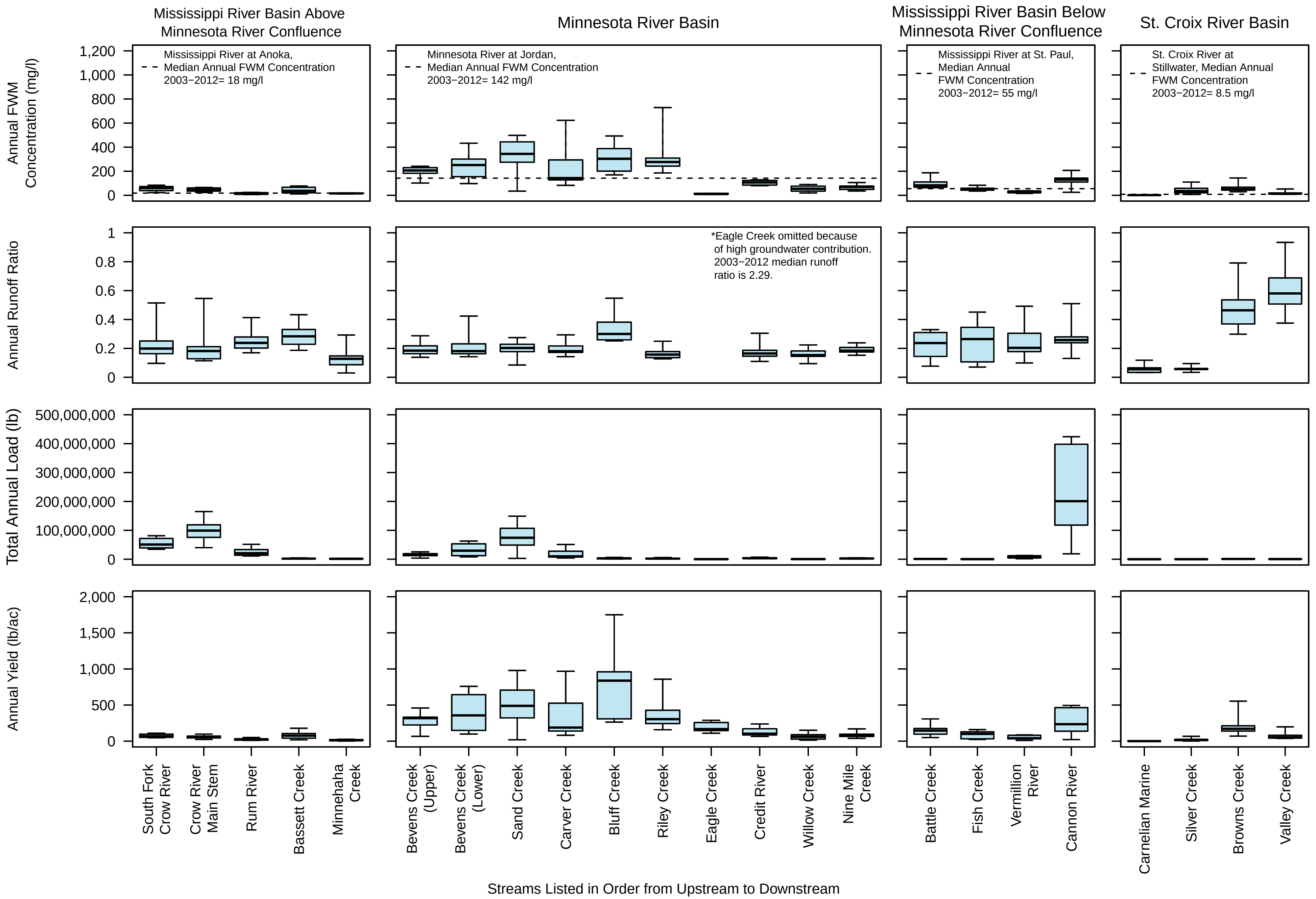
## *Macroinvertebrates*

The historic biomonitoring data, summarized as M-IBI scores, are also shown as box-and-whisker plots. However, the streams were divided by stream type as the MPCA impairment thresholds are type-specific and this attribute does not correlate with major river basins.

The M-IBI scores for Nine Mile Creek were below the MPCA impairment threshold (Figure NM-22). This includes the median which suggests that this stream reach habitat and water quality typically were not optimal to sustain the needs for aquatic life. These results are similar to those of other Mississippi River basin urban watersheds, like Minnehaha or Battle Creek. The only urban watershed in the metropolitan area that does not score below the threshold is Eagle Creek, a spring-fed system. The surface water-fed, urban watersheds, like Minnehaha Creek, clearly have negative stressors affecting the macroinvertebrate communities.

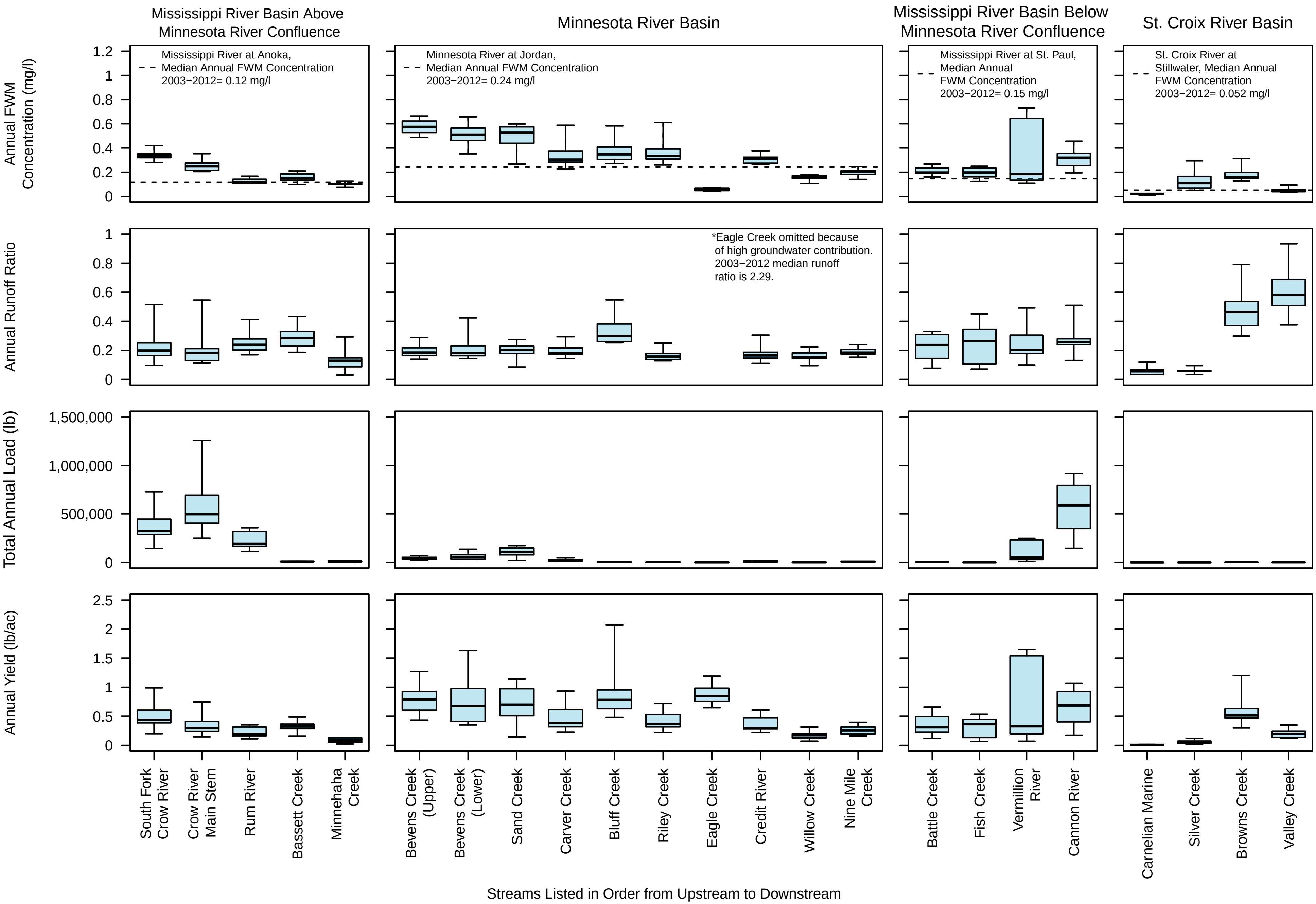
# Figure NM−18: Total Suspended Solids for MCES−Monitored Streams, 2003−2012

## Organized by Major River Basin



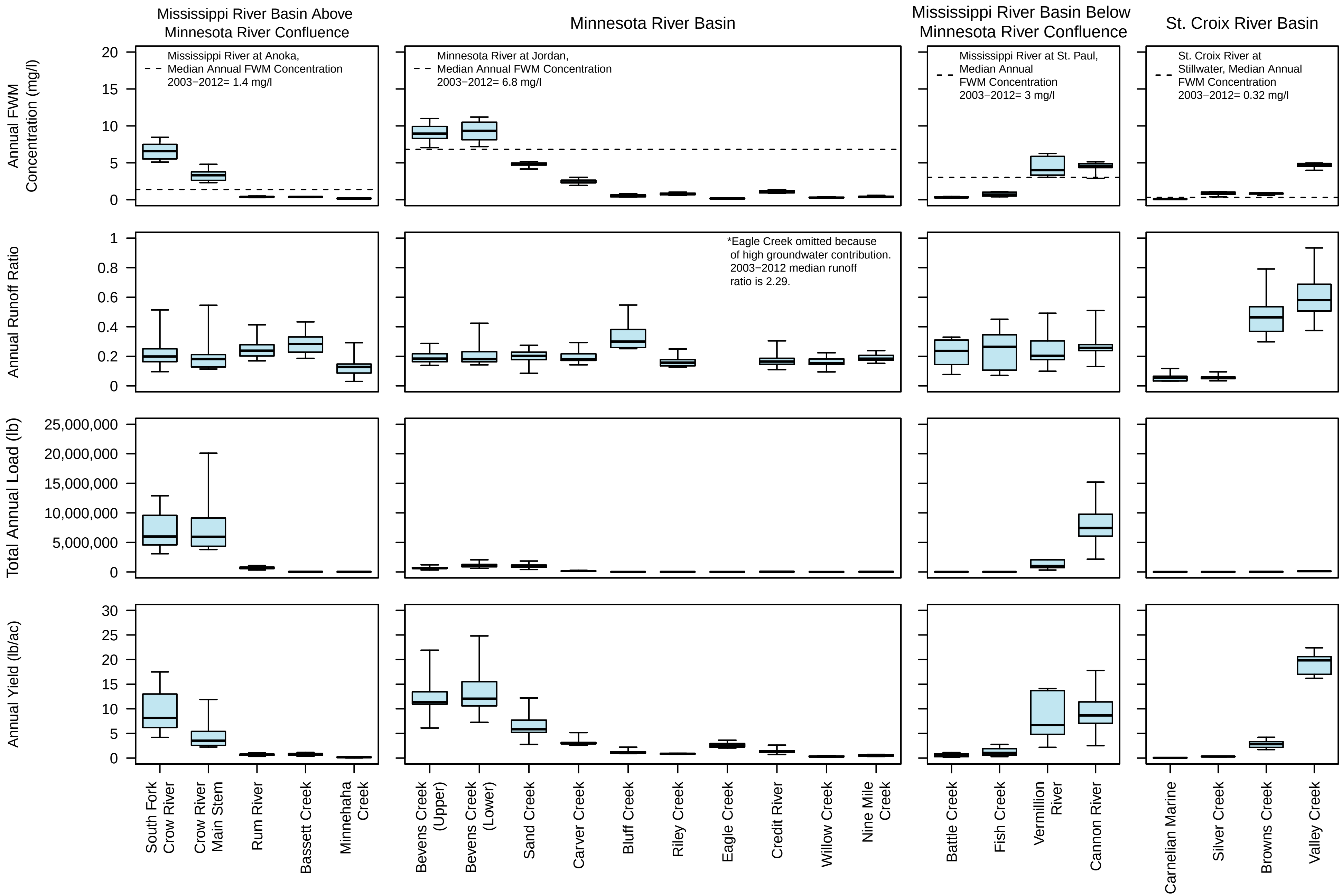
# Figure NM−19: Total Phosphorus for MCES−Monitored Streams, 2003−2012

## Organized by Major River Basin



# Figure NM−20: Nitrate for MCES−Monitored Streams, 2003−2012

## Organized by Major River Basin



# Figure NM−21: Chloride for MCES−Monitored Streams, 2003−2012

## Organized by Major River Basin

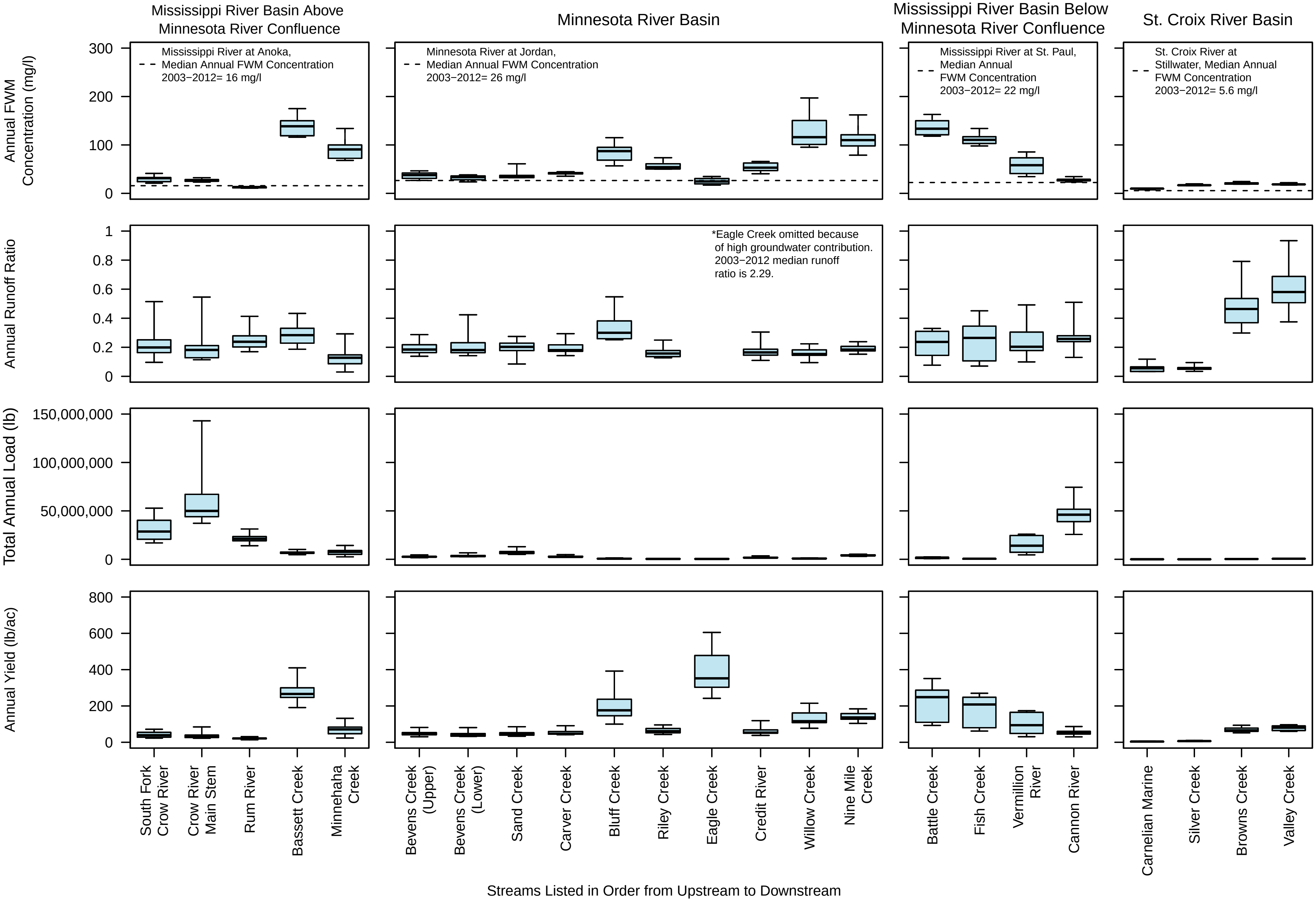


**Table NM-5: Annual Median Concentrations, Loads, and Yields for MCES-Monitored Streams, 2003-2012**

| Station | Stream Name | Major Watershed | Median Runoff Ratio[1] | TSS Median Annual FWM Conc[2] (mg/l) | TSS Median Annual Load[3] (lb/yr) | TSS Median Annual Yield[4] (lb/ac/yr) | TP Median Annual FWM Conc[2] (mg/l)l | TP Median Annual Load[3] (lb/yr) | TP Median Annual Yield[4] (lb/ac/yr) | $NO_3$ Median Annual FWM Conc[2] (mg/l) | $NO_3$ Median Annual Load[3] (lb/yr) | $NO_3$ Median Annual Yield[4] (lb/ac/yr) | Cl Median Annual FWM Conc[2] (mg/l) | Cl Median Annual Load[3] (lb/yr) | Cl Median Annual Yield[4] (lb/ac/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BE5.0 | Bevens Creek (Upper) | Minnesota | 0.18 | 207 | 17,600,000 | 319 | 0.575 | 43,650 | 0.791 | 8.95 | 628,000 | 11.4 | 38 | 2,600,000 | 47.2 |
| BE2.0 | Bevens Creek (Lower) | Minnesota | 0.18 | 252 | 29,550,000 | 357 | 0.511 | 55,950 | 0.677 | 9.34 | 996,500 | 12.1 | 34 | 3,395,000 | 41.1 |
| SA8.2 | Sand Creek | Minnesota | 0.20 | 344 | 74,200,000 | 489 | 0.526 | 106,000 | 0.700 | 4.85 | 886,000 | 5.8 | 36 | 6,980,000 | 46.0 |
| CA1.7 | Carver Creek | Minnesota | 0.18 | 143 | 9,870,000 | 188 | 0.304 | 20,200 | 0.385 | 2.35 | 157,000 | 3.0 | 41 | 2,500,000 | 47.5 |
| BL3.5 | Bluff Creek | Minnesota | 0.30 | 304 | 3,025,000 | 838 | 0.348 | 2,820 | 0.782 | 0.61 | 4,405 | 1.2 | 87 | 635,500 | 176.0 |
| RI1.3 | Riley Creek | Minnesota | 0.16 | 277 | 2,025,000 | 305 | 0.335 | 2,440 | 0.367 | 0.79 | 5,840 | 0.9 | 54 | 407,000 | 61.3 |
| EA0.8 | Eagle Creek | Minnesota | 2.29 | 11 | 181,000 | 167 | 0.055 | 918 | 0.848 | 0.17 | 2,760 | 2.6 | 25 | 381,000 | 352.0 |
| CR0.9 | Credit River | Minnesota | 0.16 | 107 | 3,090,000 | 103 | 0.312 | 8,800 | 0.293 | 1.15 | 37,400 | 1.3 | 53 | 1,590,000 | 53.1 |
| WI1.0 | Willow Creek | Minnesota | 0.15 | 54 | 391,000 | 61 | 0.161 | 1,130 | 0.175 | 0.28 | 1,980 | 0.3 | 116 | 750,000 | 116.0 |
| NM1.8 | Nine Mile Creek | Minnesota | 0.18 | 70 | 2,520,000 | 88 | 0.205 | 7,335 | 0.255 | 0.38 | 15,750 | 0.5 | 110 | 3,930,000 | 136.5 |
| CWS20.3 | Crow River (South) | Mississippi | 0.20 | 60 | 50,800,000 | 69 | 0.339 | 322,500 | 0.438 | 6.58 | 5,995,000 | 8.2 | 31 | 28,650,000 | 39.0 |
| CW23.1 | Crow River (Main) | Mississippi | 0.18 | 46 | 98,950,000 | 59 | 0.248 | 496,000 | 0.294 | 3.33 | 5,960,000 | 3.5 | 27 | 49,950,000 | 29.6 |
| RUM0.7 | Rum River | Mississippi | 0.24 | 12 | 20,700,000 | 21 | 0.119 | 193,000 | 0.191 | 0.38 | 654,000 | 0.6 | 13 | 21,150,000 | 21.0 |
| BS1.9 | Bassett Creek | Mississippi | 0.28 | 37 | 1,905,000 | 77 | 0.150 | 8,090 | 0.325 | 0.38 | 19,350 | 0.8 | 139 | 6,620,000 | 266.0 |
| MH1.7 | Minnehaha Creek | Mississippi | 0.13 | 16 | 1,415,000 | 13 | 0.102 | 9,095 | 0.084 | 0.17 | 16,400 | 0.2 | 91 | 7,700,000 | 71.0 |
| BA2.2 | Battle Creek | Mississippi | 0.24 | 83 | 1,043,000 | 146 | 0.197 | 2,220 | 0.311 | 0.32 | 3,945 | 0.6 | 134 | 1,775,000 | 248.5 |
| FC0.2 | Fish Creek | Mississippi | 0.26 | 55 | 296,500 | 101 | 0.198 | 1,066 | 0.364 | 0.71 | 3,035 | 1.0 | 111 | 610,000 | 208.0 |
| VR2.0 | Vermillion River | Mississippi | 0.20 | 29 | 6,025,000 | 40 | 0.185 | 49,000 | 0.328 | 4.02 | 1,001,500 | 6.7 | 58 | 14,050,000 | 94.1 |
| CN11.9 | Cannon River | Mississippi | 0.26 | 130 | 201,000,000 | 235 | 0.320 | 589,000 | 0.687 | 4.59 | 7,435,000 | 8.7 | 28 | 46,050,000 | 53.8 |
| CM3.0 | Carnelian-Marine Outlet | St. Croix | 0.06 | 2 | 7,570 | 0.4 | 0.022 | 156 | 0.009 | 0.10 | 701 | 0.04 | 10 | 69,500 | 3.9 |
| SI0.1 | Silver Creek | St. Croix | 0.06 | 35 | 80,700 | 15 | 0.108 | 235 | 0.042 | 0.83 | 1,765 | 0.3 | 17 | 37,100 | 6.7 |
| BR0.3 | Browns Creek | St. Croix | 0.46 | 51 | 785,500 | 172 | 0.160 | 2,355 | 0.514 | 0.86 | 12,900 | 2.8 | 20 | 300,000 | 65.6 |
| VA1.0 | Valley Creek | St. Croix | 0.58 | 14 | 392,500 | 54 | 0.047 | 1,415 | 0.193 | 4.74 | 145,500 | 19.9 | 19 | 589,500 | 80.4 |

[1] Runoff ratio = annual flow volume at monitoring station / annual area-weighted precipitation. Area-weighted precipitation for each watershed provided by Minnesota Climatological Working Group (2013)

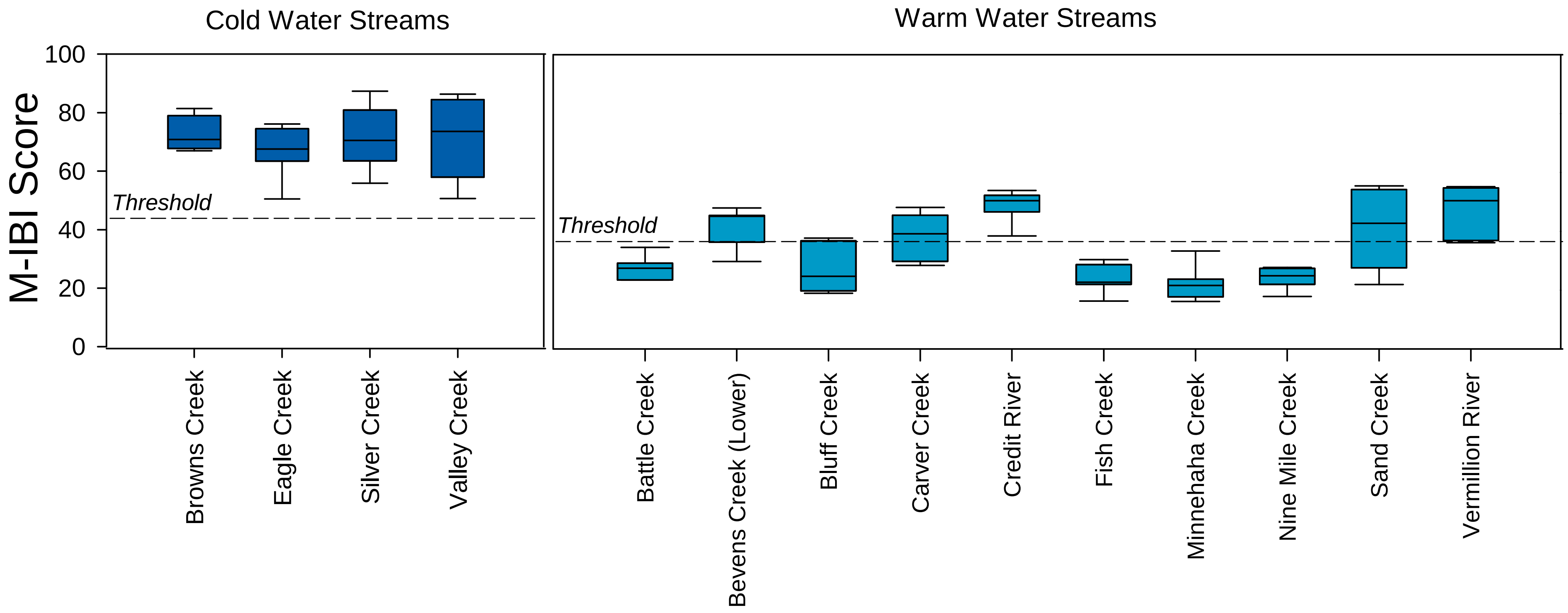
[2] FWM conc = annual flow-weighted mean concentration estimated using Flux32 (Walker, 1999).

[3] Load = annual pollutant load mass estimated using Flux32 (Walker, 1999).

[4] Yield = watershed pollutant yield calculated from annual pollutant load mass estimated using Flux32 (Walker, 1999) divided by area of watershed upstream of MCES monitoring station

## Figure NM-22: M-IBI Results for MCES-Monitored Streams, 2004-2011

Organized by Stream Type




Higher M-IBI scores are indicative of a better water quality.
Each stream type has system-specific impairment thresholds set by the MPCA (2014b).
If a portion of the box plot is below the threshold, the stream may not have supported the needs of aquatic life during the study period.

## *Metropolitan Area Trends Analysis*

Statistical trend analysis for each MCES stream monitoring station was performed using QWTREND (Vecchia, 2003). Trend estimates were calculated for 2008-2012 (the last five years of available data) to allow comparison of changes in water quality between streams. A similar approach was used in the 2013 MPCA nitrogen study (MPCA, 2013b) to compare QWTREND assessments in statewide streams and rivers.

Estimated changes for TSS, TP, and $NO_3$ in MCES-monitored streams are presented below in two ways. First, tabulated results with directional arrows indicating improving (blue upward arrow) and declining (red downward arrow) water quality paired with percent change in flow-adjusted concentration estimated for 2008-2012 (Figure NM-23). Second, changes are shown by three seven-county metropolitan area maps (one each for TSS, TP, and $NO_3$ trends), with stream watersheds colored to represent improving and declining water quality (Figure NM-24).

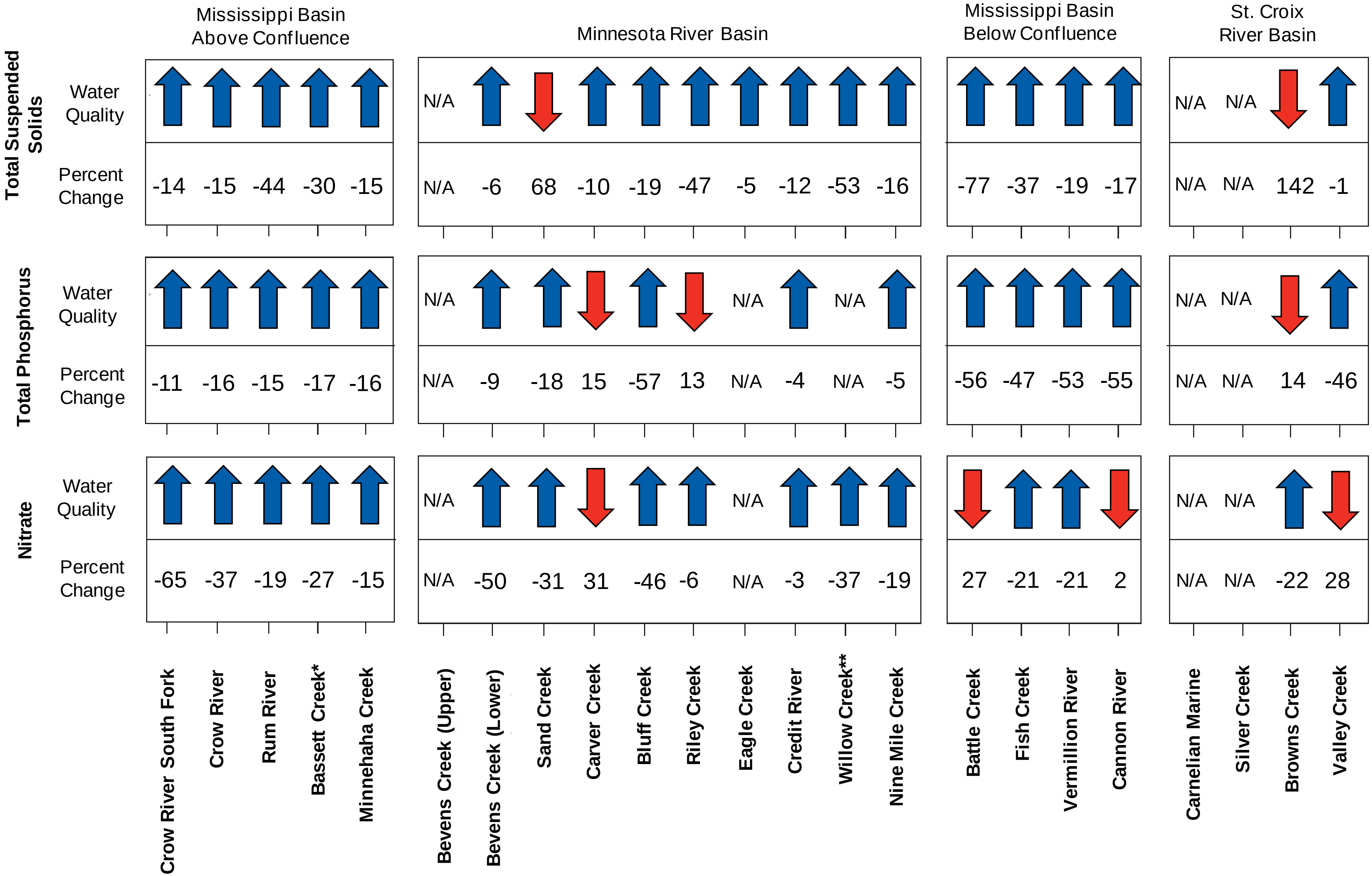
In general, of the 20 monitoring stations assessed, most exhibited improving water quality (and thus decreasing concentration) for TSS, TP, and $NO_3$. There does not appear to be a spatial pattern for those few stations with declining water quality. There is no station with declining water quality for all three parameters, although both TP and $NO_3$ concentrations increased in Carver Creek (a Minnesota River tributary) and TSS and TP increased in Browns Creek (a St. Croix River tributary).

Estimated trends in Nine Mile Creek show decreasing concentrations of TSS, TP, and $NO_3$ (improving water quality) during the 2008-2012 period. During this period, $NO_3$ has shown the largest decrease, 19 per cent, followed by TSS (16 per cent decrease) and TP, (5 per cent decrease).

The Minnesota River and its tributaries typically have had higher TSS concentrations than the Mississippi or St. Croix Rivers and their associated tributaries. The trend analysis results indicate decreasing TSS flow-adjusted concentrations in all Minnesota River tributaries with the exception of Sand Creek. In addition to decreasing TSS concentrations, Nine Mile Creek also had decreasing TP and $NO_3$ concentrations over the last five years.

## Figure NM-23: Regional Estimated Trends in Flow-Adjusted Stream Concentrations of TSS, TP, and $NO_3$, 2008-2012

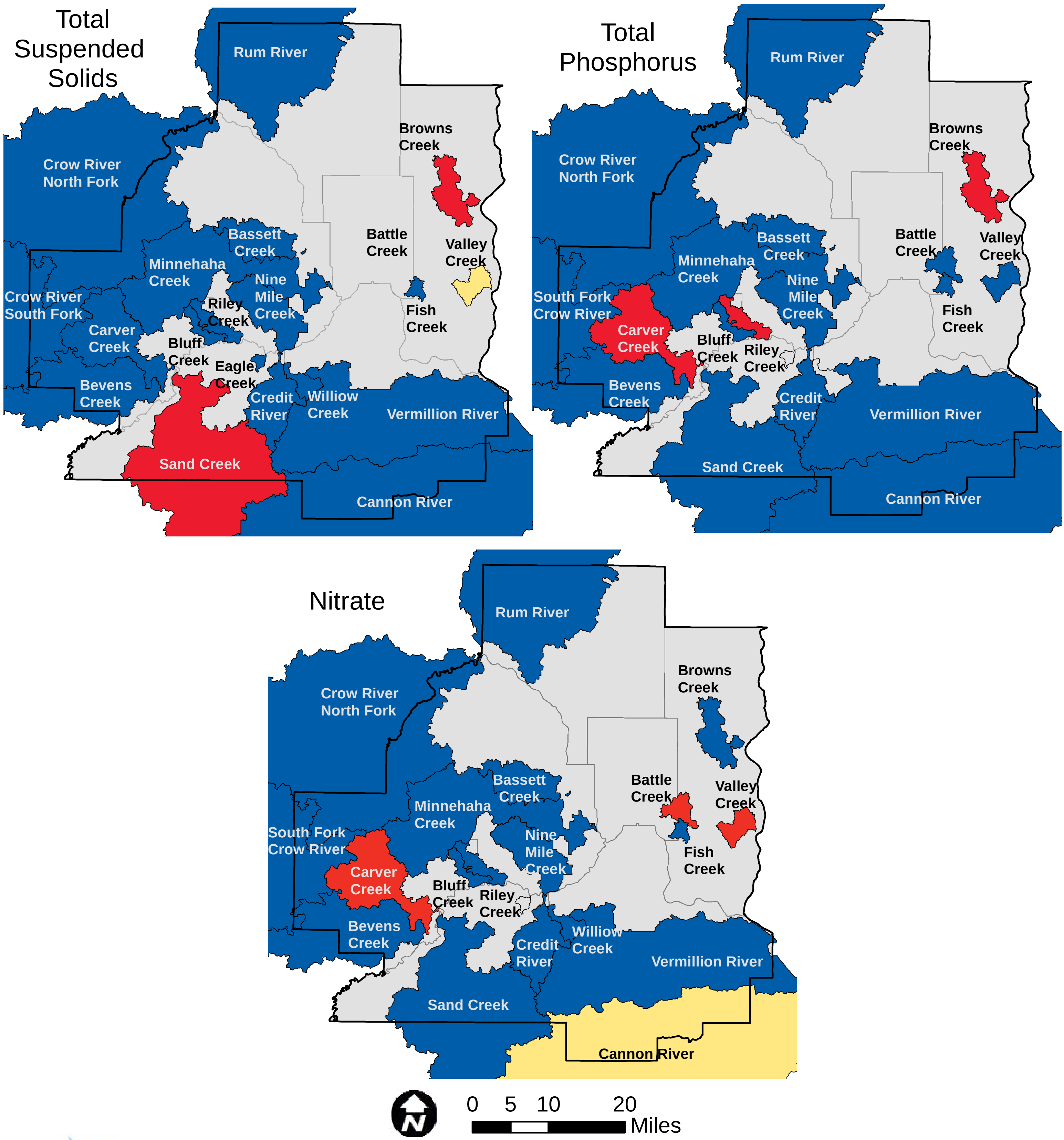
**(Grouped by Major River Basin; As estimated by QWTrend)**




Blue arrows indicate improved water quality; Red arrows indicate declining water quality.
"N/A" indicates analysis was not performed as data were not appropriate for analysis by QWTrend.
* Bassett Creek TSS Trends were assessed over 2009-2013. **Monitoring at Willow Creek was suspended in 2009.

## Figure NM-24: Regional Maps of Estimated Trends in Flow-Adjusted Stream Concentrations of TSS, TP, and NO3, 2008-2012

**(As estimated by QWTrend)**




Less than -3% Change (Indicates Increasing Water Quality)

-3% to 3% Change

Greater than 3% Change (Indicates Decreasing Water Quality)

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## Conclusions

Nine Mile Creek is a tributary to the Minnesota River in Hennepin County. Its watershed includes portions of the cities of Edina, Eden Prairie, Minnetonka, Hopkins, Richfield, and Bloomington (Metropolitan Council Districts 3 and 5). The watershed is approximately 50 square miles in area and is completely developed with about 64 percent impervious cover. Land cover includes residential, commercial, roadways, parks, lakes, and wetlands.

Nine Mile Creek flows from north-to-south through several large channelized wetlands before its confluence with the Minnesota River. The creek flows through the Minnesota Valley National Wildlife Refuge before entering the Minnesota River. Bryant Lake and Hyland-Bush-Anderson Lakes Regional Parks are located in the creek watershed. There are few point sources in the watershed, and no permitted waste water treatment plants within the watershed.

Macroinvertebrate monitoring suggests that conditions in the creek are not optimal for support of aquatic life. Trend analysis shows that total suspended solids, total phosphorus, and nitrate flow-adjusted concentrations in Nine Mile Creek have all decreased over the last five years, resulting in improved water quality for those pollutants.

## Recommendations

This section presents recommendations for monitoring and assessment of Nine Mile Creek, as well as recommendations for partnerships to implement stream improvements. MCES recognizes that cities, counties, and local water management organizations, like NMCWD, are ideally suited to target and implement volume reduction, pollutant removal, and stream restoration projects within the watershed. It is beyond the scope of this document to suggest locations for implementation projects. Instead, MCES encourages the local water management organizations to use the results of this report to leverage funding and partnerships to target, prioritize, and implement improvement projects. MCES will repeat its analysis of water quality trends in 5 years, to assess potential changes in water quality.

The following recommendations have been drafted from the results of this report and are intended to assist MCES and its partners in directing future assessment work:

- MCES should continue monitoring of Nine Mile Creek and should partner with NMCWD to investigate possible sources of pollutants in the creek.
- As staff time and budget allows, MCES should support NMCWD to assess loads, water quality, and trends at the two upstream stations on the North and South Branches of Nine Mile Creek.
- MCES should partner with the U.S. Fish and Wildlife Service to assess impacts of Nine Mile Creek on the Minnesota River National Wildlife Refuge.
- MCES and partners (especially NMCWD) should create a timeline of past projects and management activities that may have improved or altered stream flow and/or water quality. This information would allow more accurate assessment and interpretation of trends.
- As resources allow, MCES should provide NMCWD and other local water managers with information about the heightened potential for surface waters to be impacted by

groundwater changes in the Nine Mile Creek watershed. This information should be included in watershed and local surface water management plan updates.

- MCES should continue to evaluate the effects of groundwater withdrawal on surface waters, including updating analyses with the best available data and linking results to predictive groundwater modeling and the comprehensive planning process.
- MCES should continue macroinvertebrate monitoring in Nine Mile Creek and further investigate the lack of intolerant species. MCES should continue to analyze and evaluate the biomonitoring program. Potential additions should include a Stream Habitat Assessment similar to the habitat surveys performed by the MPCA or the addition of fish population and algal community data.
- The trend analysis should be repeated in 5 years, expanding the list of assessed parameters to include NH3, bacteria, and chlorophyll. Sufficient data should exist at that time to also assess trends in Cl and flow.
- MCES should partner with NMCWD to investigate and mitigate high Cl concentrations in the creek.

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