Zumbro Watershed

Comprehensive Management Plan

Sediment Reduction Component

Zumbro Watershed Partnership

August 9, 2012

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I. Background and Introduction

a. Planning Context:

The coincidence of two events provides the occasion for writing the Zumbro Comprehensive Watershed Management Plan (hereafter Watershed Plan). One event is the completion of a Total Maximum Daily Load (TMDL) study on turbidity impairments in the Zumbro Watershed in 2012; the other is the passage of five years since the first watershed plan was published in September, 2007. The latter document, the initial Zumbro River Watershed Management Plan, called for revisions to the text at five-year intervals. The first such interval arrived in 2012.

Two additional factors will influence the scope and content of the Watershed Plan. One is a grant obtained by the Zumbro Watershed Partnership from the Legislative and Citizens Commission on Minnesota Resources (LCCMR) to apply Geographic Information Systems and LiDAR (light detection and ranging) to identify the 50 highest sediment-contributing sites in the Zumbro Watershed. The results of this study, expected in early 2013, will be included in the Zumbro Watershed Plan as priority sites for sediment control.

Second, the Minnesota Pollution Control Agency (MPCA) has provided funds to support the writing of a plan that meets the needs of the turbidity TMDL while also encompassing additional needs for water quality restoration and protection and making linkages with the water-related plans of local government units. In the case of the Zumbro Watershed, the additional water quality issues include impairments from excess nutrients and pathogens, restoration of degraded aquatic ecosystems and protection of high-quality aquatic ecosystems. The local plans include comprehensive local water plans developed by the counties and soil and water conservation districts within the watershed, and the Storm Water Management Plan and related documents developed by the City of Rochester.

The ultimate goal is to develop a comprehensive watershed management plan: comprehensive with regard to the water quality issues addressed, and with regard to the creation of linkages between the watershed management plan and the local water plans that drive the activities of local governments. This goal is in line with a state-wide trend toward the watershed approach, whereby previously separate water quality programs and activities will be integrated within the boundaries of each of the state's 81 major watersheds, of which the Zumbro Watershed is one. The watershed plan, in this context, provides common goals and strategies, with complementary activities, for local government units within the watershed. Early and frequent public engagement is also emphasized in the watershed approach to ensure that public values are reflected in the plan.

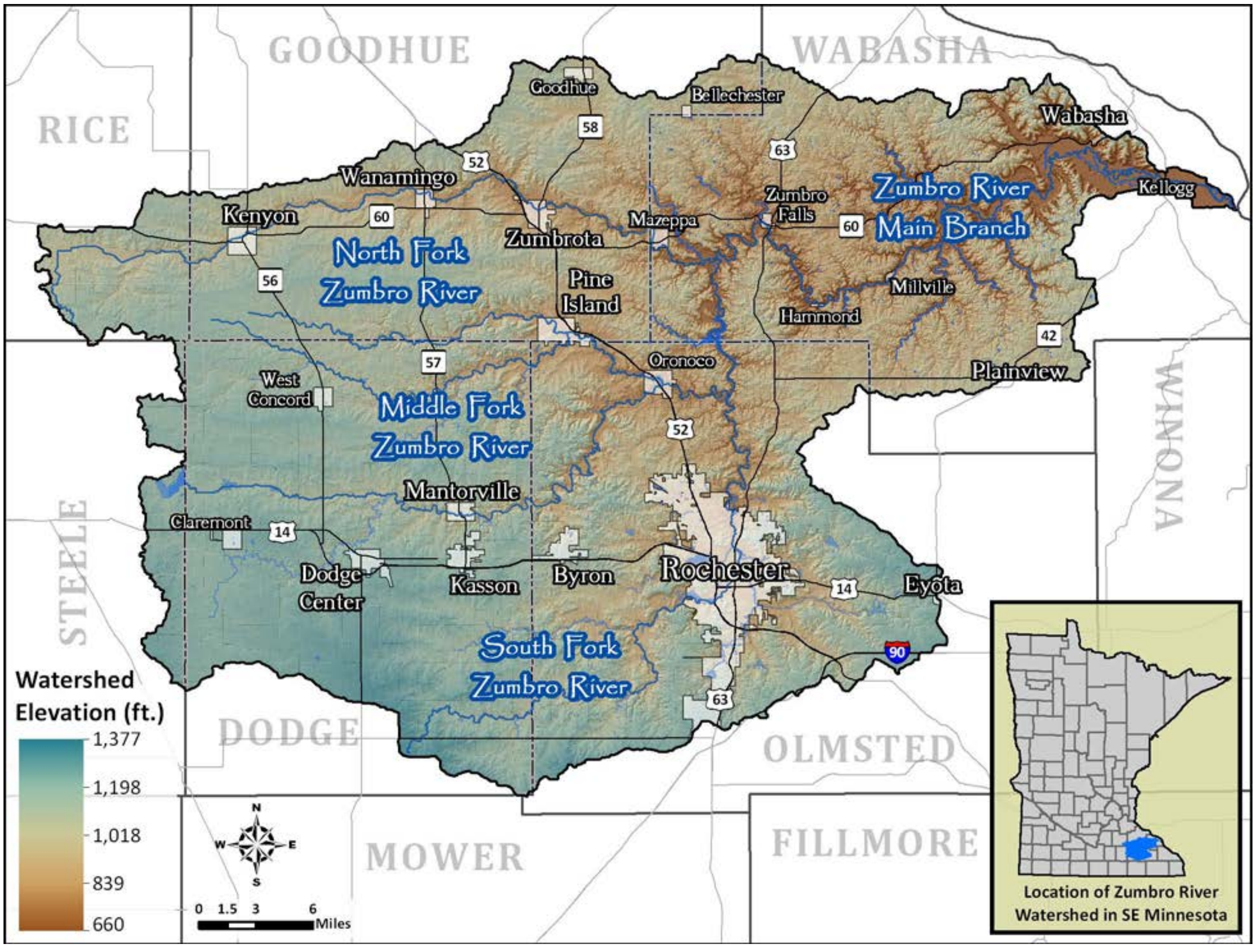
Initially, in this document, the Watershed Plan will confine itself to dealing with implementation of the turbidity TMDL. Since turbidity is a water quality standard that protects aquatic life, the primary goal of this initial plan will be aquatic life use support. For clarity, the initial portion of the Watershed Management Plan will be called the Sediment-Reduction Plan (henceforth Plan). The organization of the Plan according to the three main indicators of aquatic life use support is designed to allow its eventual expansion into a more comprehensive plan -- the Watershed Plan -- in 2013 and thereafter. Thus, while addressing the implementation needs associated with turbidity impairments in the Zumbro River, the planning architecture is intentionally broader that that needed to meet this need alone.

This plan summarizes sediment reduction strategies and action items founded and supported by watershed partners and stakeholders. It is not a regulatory document and it does not bind any entity to execute any of the actions contained in the text. Rather, it will be used to steer and support voluntary project ideas and related grant or other funding applications .

b. The Zumbro River Watershed:

Straddling the divide between flat and rolling cropland to the west, and rugged hill and bluff country to the east, the Zumbro River watershed is a study in contrasts. Along its western fringe, where each of the three major forks of the Zumbro originates, many first-order streams have been straightened into drainage ditches, and most of the land has been drained for crop production by surface and sub-surface

Figure 1. Zumbro River Watershed

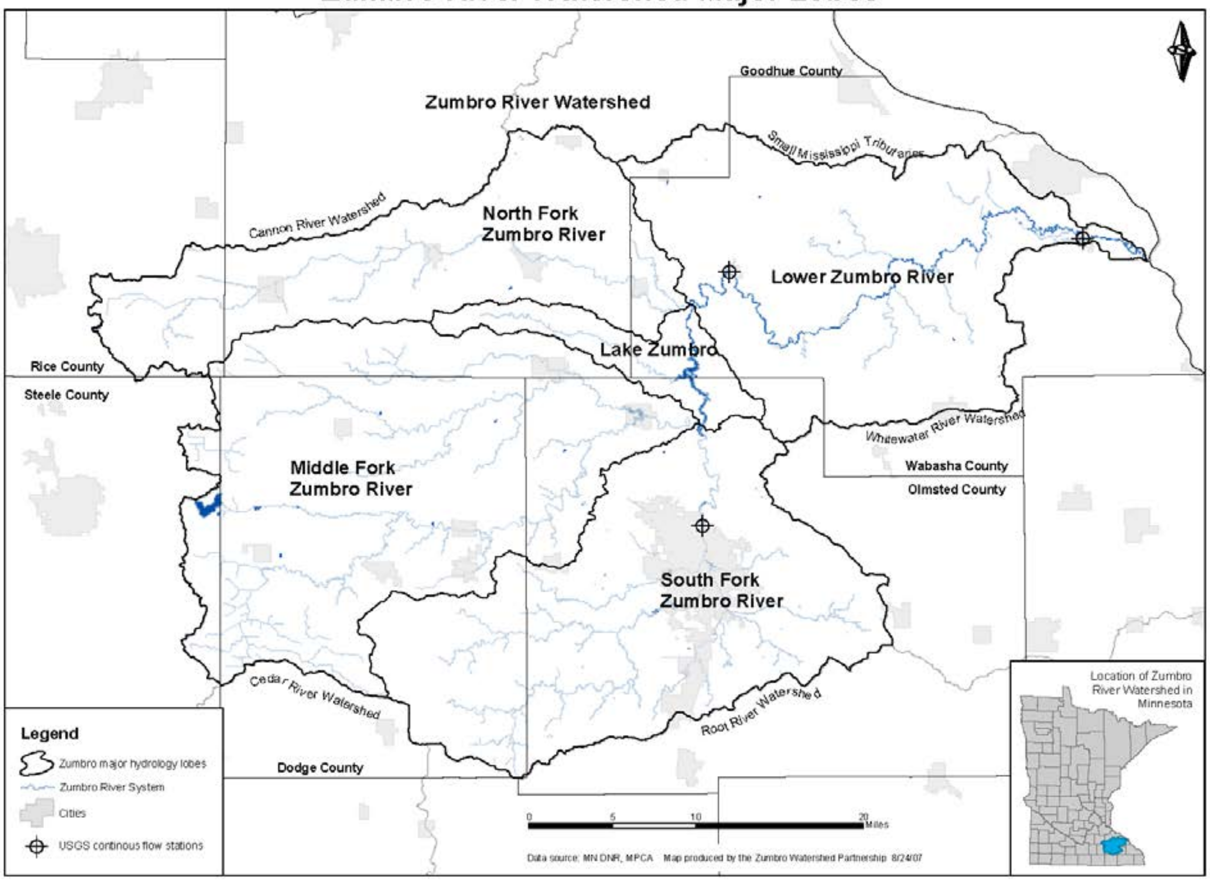


drainage networks. The rich, flat soils of the former prairie and wetland landscape support the production of corn, soybeans and hogs. Water that used to evaporate, get utilized by plants, or seeped slowly toward streams now moves quickly through the soil profile and is sent downstream via a vast network of subsurface tile lines and surface drainage ditches, potentially putting increased pressure on stream bank and bluff erosion.

As the water flows eastward from the headwaters, stream gradient increases, allowing the water to flow quickly and partially scour the bed of sand and silt deposits. Relatively healthy fish populations begin showing up. The Zumbro tributaries pass through small towns with hard pavement that scurries water to storm drains and on to the river. They also pass through rolling farm country with significant, but less intensive, drainage than is found further west. Shallow groundwater seeps and springs sustain stream flow through dry periods. Gentle river valleys and flood plains that once served as dairy pasture now are almost devoid of livestock, and frequently support dense new growth of grass and trees instead. Elsewhere, the floodplain is farmed close to the river's edge.

Figure 2. Zumbro Watershed Major Lobes

Zumbro River Watershed Major Lobes



As South Fork tributaries flow toward Rochester, some of the water encounters a ring of seven flood control reservoirs near the city. The growing City of Rochester covers hundreds of acres of soil with concrete and pavement every year. As a result, developers are required to offset the discharge rate and water quality impacts through storm water impoundments and other best management practices.

North of Rochester, at the now-drained Lake Shady, the South Fork is met by the Middle Fork, which draws water from the west through three tributaries that coalesce just upstream of its confluence with the South Fork. Upon discharging into Lake Zumbro, the river loses much of its current – and sediment load. The reservoir, constructed in 1919, is filling in with sediment from the Zumbro River, to the dismay of lakeshore residents and recreation enthusiasts. Still, excellent fishing and boat recreation opportunities remain to be enjoyed on much of the lake.

Shortly after overflowing the dam, the now-larger Zumbro River soon picks up additional flow from its North Fork, which draws from a long and narrow watershed of rolling hills. Dairy farms still dot the landscape from Kenyon and Wanamingo eastward to Zumbrota, home to a large dairy processing center. At Zumbro Falls, the main stem of the Zumbro enters its home stretch – a zigzag journey through the spectacular scenery of the lower Zumbro valley. Fed by cold-water trout streams, the lower Zumbro cuts a sharp valley through a landscape that is hundreds of thousands years old. Called karst topography, this region is characterized by fertile loess (wind-blown) soils deposited in a thin layer over fractured limestone, dolomite and sandstone layers that are the legacy of a distant age when oceans covered the region.

The gradient of the main stem becomes flatter near the town of Hammond as it flows toward its outlet to the Mississippi, which it encounters near Kellogg after passing through a straightened and diked final reach of river that allows the river to coexist with agriculture on the fertile flood plain. Aerial photographs often show the discharge of the Zumbro to be mud-brown, in comparison to the usually clear Mississippi River, which drops most of its sediment load upstream in Lake Pepin.

c) Recent trends in water quality, aquatic biology and flow

As this Plan is being written, two state agencies have discovered potentially encouraging trends for water quality and fish populations in the Zumbro River. The MPCA has interpreted water quality monitoring data collected on the South Fork of the Zumbro River about three miles north of Rochester, for the period 1973 to 2008. They measured a 64 percent decrease in the concentration of total suspended solids, a magnitude of change somewhat greater than that which was measured in neighboring rivers of southeast Minnesota. Although no analysis has been conducted to correlate this reduction with land use changes over this period, the large reduction suggests that enough positive changes may have occurred to reduce inputs of sediment from the land surface, the stream channel or both. Construction of seven flood control reservoirs near Rochester might also be a contributing factor.

In addition, fish samples conducted by the MDNR in 2010 in the Middle Fork of the Zumbro show mainly positive changes in species abundance and composition in the South Branch and North Branch, with negative changes predominating in the Middle Fork main stem, when compared to sampling data in 1982 (Weiss, 2011). For example, the number of fish species observed increased from 33 to 38 in the South Fork, from 25 to 31 in the North Fork, and declined from 37 to 32 in the main stem Middle Branch. Habitat and fish scores declined in the upper reaches of the Middle Fork. Healthy small mouth bass populations were observed in the South Branch, but not elsewhere. Additional conventional and biological monitoring planned for 2012 by the DNR and MPCA will help to determine if biological improvements are partly the result of reduced suspended sediment concentrations, at monitoring sites throughout the Zumbro Watershed.

There seems to be a popular perception that rainfall patterns have grown more intense, precipitating more flooding of the Zumbro River. Detailed studies of precipitation and flow relationships in the Zumbro River appear to be lacking. Thus, data from studies of nearby watersheds and statewide data must be consulted as our closest guide to local trends. The following information is drawn from a recent study of 18 watersheds in Minnesota and Wisconsin (Lenhart and Nieber, 2011).

Lenhart and Nieber measured changes in the flow characteristics of agricultural and forested watersheds in northern and southern Minnesota, respectively, between two time periods: 1940 to 1979, and 1980 to 2009. They found that increased precipitation was correlated with increased flow in agricultural watersheds, but not forested watersheds. The Zumbro River watershed was not included in the study. However, average annual flows increased by 75 percent in two agricultural watersheds on opposite sides of the Zumbro watershed – the Root River and Blue Earth River watersheds. The volume of flow per unit of precipitation increased by around 50 percent in agricultural watersheds between the two time periods. Streams in the forested watersheds showed no change in the ratio owing to much higher infiltration and evapotranspiration provided by trees, and the presence of many lakes and wetlands in comparison to agricultural watersheds.

Lenhart and Nieber determined that changes in land use and land cover had a greater impact on stream flow than increased precipitation. In particular, they pointed to tile drainage and conversion of pasture and perennial crops to corn and soybean. By routing precipitation through the soil profile and reducing surface runoff, tile drainage appears to increase high, sub-peak flows more than peak flows.

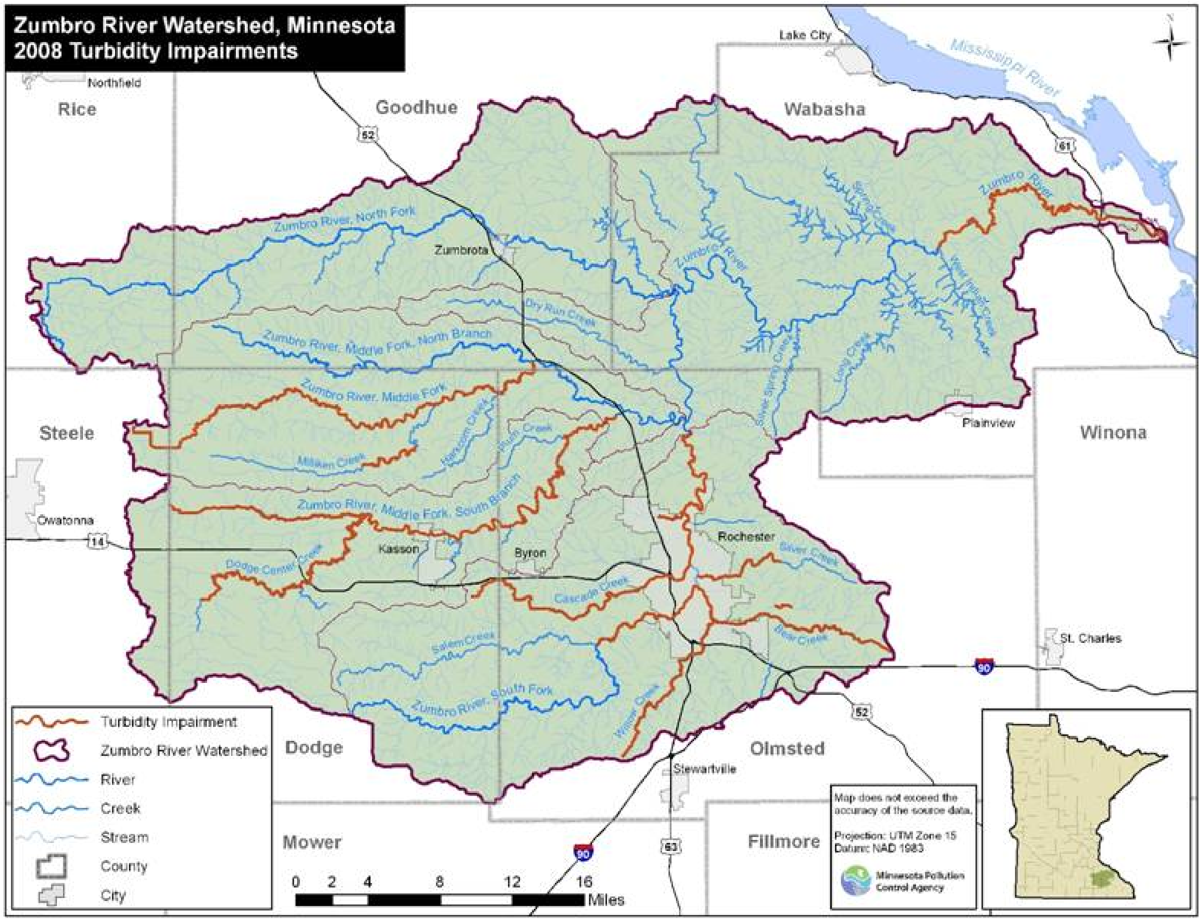
The researchers also compared corn and soybean with prairie grass in a simulation study, and found dramatic differences for the two types of land cover. They found that switching from prairie grass to corn resulted in a 140 percent increase in runoff, and that changing from prairie grass to corn/soybean cover yielded a 100% increase in runoff. Increased infiltration and evapotranspiration by prairie grass owing to much deeper roots, a much higher leaf area index and a well -developed organic layer on the soil surface were the primary causes of reduced runoff between the two periods (Lenhart and Nieber). These estimates indicate how major shifts in land use following World War II may have contributed to higher rates of runoff per unit of precipitation. These changes include a shift from perennial cover (hay, prairie and pasture) to annual row-crops (corn and soybean) accompanied by substantial drainage of agricultural land (BALMM, 2001), and an increase in impervious surfaces associated with the growth of towns and cities. The research reports just cited indicate the kinds of relationships between land use and stream flow that may be operative in the Zumbro Watershed. However, each watershed is unique, and hydrologic research specific to the Zumbro Watershed is an important need that is addressed in Section 5 below.

c. History and Purpose of the TMDL Study:

The water quality standard for turbidity is an indirect measure of the quality of aquatic life in river and stream systems – fish, aquatic insects, mussels, rooted vegetation, etc. Thus, although the TMDL study focusses on turbidity, its ultimate purpose is the support of aquatic life. Therefore, measures of aquatic life health are used as primary goals of the Plan in Section II; the turbidity standard serves as a temporary surrogate for aquatic life metrics until such time as aquatic life is directly measured through biological monitoring protocols, a process that begins in the Zumbro River Watershed in 2012-2013.

A TMDL turbidity study of the Zumbro River and its tributaries was conducted by Barr Engineering, completed by the Minnesota Pollution Control Agency (MPCA) in October 2011, and approved by the U.S. Environmental Protection Agency (EPA) in May 2012. Once EPA approves a TMDL plan, the Minnesota Pollution Control Agency (MPCA) requires that an implementation plan be prepared within one year. As reviewed above, this Plan is the implementation plan for the Zumbro Watershed Turbidity TMDL study.

Figure 3. Reaches Impaired by Turbidity in the Zumbro Watershed



The TMDL study focused on the problem of turbidity, or sediment-clouded water, in 18 individual stream reaches that the MPCA classified as impaired (Figure 3). Stream reaches are designated as impaired when water quality monitoring indicates a failure to meet the state water quality standard for turbidity, which is 25 nephelometric turbidity units for warm water streams, (see Section II.3 below). The TMDL study established conversion ratios in order to express the pollutant in terms of sediment loads rather than turbidity units. Barr Engineering used the duration curve methodology (Cleland, 2011) to approximate a set of the sediment load allocations and loading capacities for each of the watersheds draining to monitoring points on each of the 18 impaired reaches. These loading capacities define the "total maximum daily load" of sediment that can be assimilated without exceeding the water quality standard for turbidity.

From these loading capacities, allocations were defined for nonpoint sources of sediment. Those are termed Load Allocations (LA). Those defined for permitted point sources are termed (Waste Load Allocations (WLA). Municipal and industrial wastewater treatment facility loads are readily calculated as the product of effluent flow and sediment concentration as reported for permit compliance.

Wastewater treatment facilities are therefore each assigned an individual WLA. There is very little information regarding the flows and sediment concentrations leaving the greater rural landscape of the Zumbro watershed or the large urban area of Rochester. Therefore, nine permitted Municipal Separate Storm Sewer Systems (MS4s) in the Zumbro Watershed received an aggregate or categorical WLA based on the area they occupy as a proportion of the overall watershed areas for each impaired reach. The load allocation was computed in the same manner: according to the areal splits in each watershed between MS4 and non-MS4 areas, which also covers construction storm water discharge. Compliance with the storm water permit (municipal, industrial or construction), as modified to take into account the effect of each individual source on the aggregate stormwater TSS load, will constitute compliance with this TMDL. A margin of safety also is included to account for the scientific uncertainty of achieving the standard if these allocations are achieved. Accordingly, the load allocations and wasteload allocations for the MS4s are not precisely measured or modeled numbers; they do not speak to the intricacies of the constituents of the sediment loads estimated at the gauge points. Rather, they are approximations according to gross allotments of land area and their application going forward should not exceed this resolution.

The TMDL study compares stream sampling data to the water quality standard across a range of flows at each of the 18 impaired sites. Graph coordinates match each monitoring sample to a specific flow range (measured in cubic feet per second) and a specific load of total suspended solids (TSS), which is used as a surrogate for turbidity in the TMDL calculations. TSS load may be calculated as stream flow multiplied by TSS concentration in the stream. Starting on page 26, Table 4, the TMDL document shows total daily loading capacity along with waste load allocations, load allocation and margin of safety (a means of accounting for error), in tons of TSS per day.

d. Summary of Findings:

Each of the impaired reaches can be studied to determine the pattern and degree of exceedence of the water quality standard. In most reaches, the standard is exceeded frequently and by the greatest amount during higher flows. Many of the impaired reaches meet the standard during lower flow periods, including winter months and drier periods of the growing season. The load duration curves depict in summary fashion the timing, magnitude and approximate duration of water quality standard exceedances at monitoring locations on each of the impaired reaches. For example, Bear Creek exceeds the standard only during the highest flows, but Silver Creek shows exceedances across all flow regimes. In this way the analysis can direct management to particular streams and/or flow conditions.

The TMDL study does not include detailed information on sources and pathways of sediment affecting the turbidity-impaired reaches of the Zumbro Watershed. General sources such as farm field and urban erosion, ravines and stream banks are mentioned. The LCCMR study mentioned above is being used to establish protocalls and data sources that can be used to identify the 50 largest sources of sediment in the watershed. Additional research projects described in Section IV will add further detail to sediment source identification.

The implementation discussion (pages 69-71 of the TMDL) specifies a “performance-based management approach” for permitted MS4s, while stating that construction and industrial stormwater permittees will be considered to be in compliance with the aggregate WLA for stormwater as long as they remain in compliance with their stormwater permit, as modified to account for their impact on the aggregate WLA. The TMDL document is less specific regarding how to implement the load allocation for nonpoint sources, by far the greatest contributor to the turbidity impairments in the Zumbro River. Best Management Practices (BMPs) known to be effective in the region are listed, along with a summary of soil erosion concerns and BMP recommendations for areas called agro-ecoregions. This information is summarized from University of Minnesota Dept. of Soil, Water and Climate recommendations and displayed in matrix form in Appendix F of the TMDL.

II. Goals, Indicators and Metrics

Broadly stated, the goal of the Plan is good water quality in the Zumbro River. The EPA identifies three interdependent aspects of water quality for rivers: biological health, physical structure of the river, and chemical properties of the flowing water, including all dissolved or suspended substances that may be considered pollutants. Good water quality requires that minimum criteria be met in each of these three aspects. These three criteria may be defined as indicators of water quality.

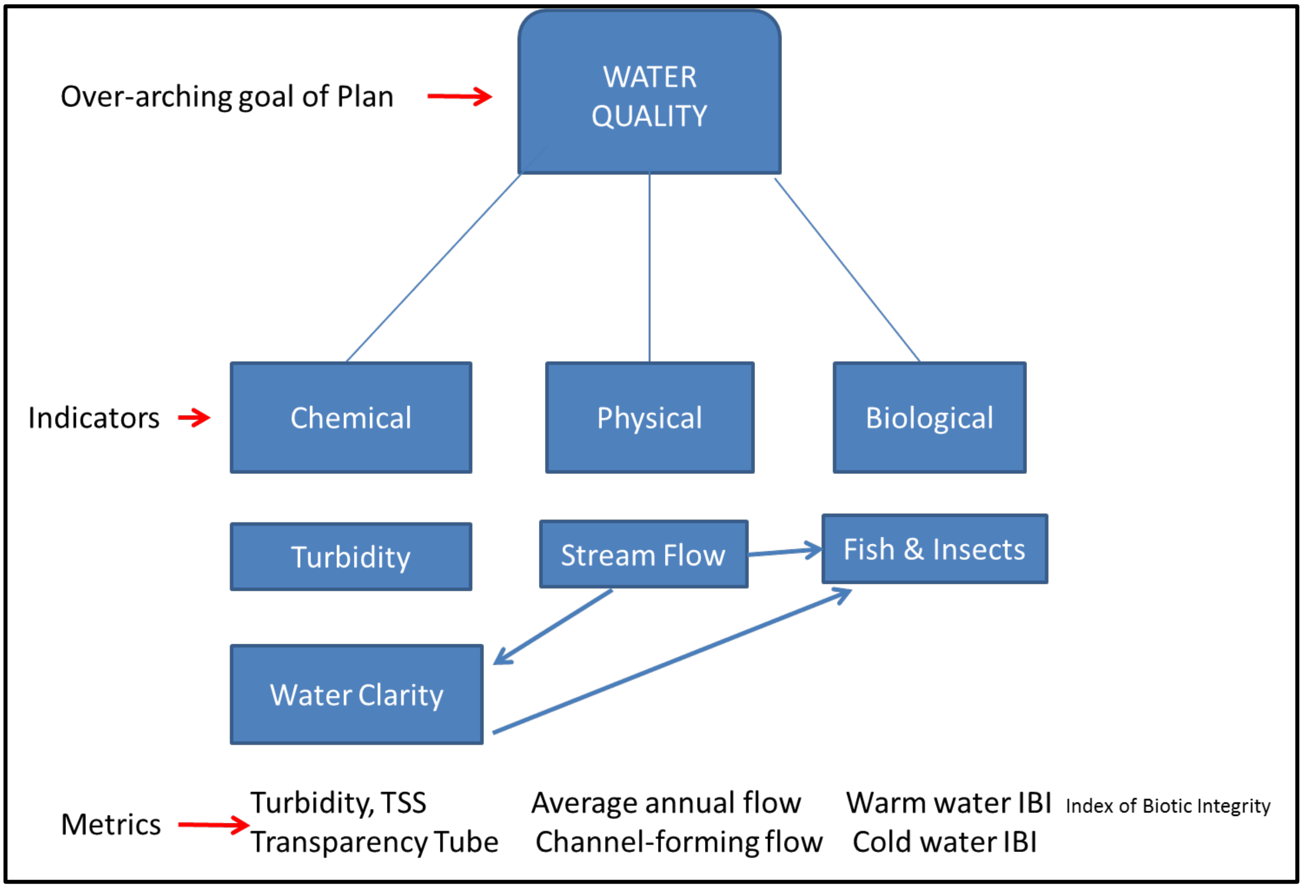
The recent completion of turbidity TMDL for the Zumbro watershed calls for a particular focus on the problem of turbidity, or cloudy water, often measured by TSS in the river. In terms of the above definition, turbidity may be described as a chemical property of the water. In plain language, it measures the clarity of water: the lower the turbidity reading, the clearer the water.

In order to address water quality comprehensively, the Plan will address all three indicators:

- Water chemistry will be partially represented by the indicator “clear water.”
- Stream structure will be represented by one of its most important determinants, “stream flow”;
- Aquatic life will be measured directly with reference to fish and aquatic insects.

Interactions between the three indicators are important to clarify. Both water clarity and stream flow directly affect aquatic life, the primary indicator. The relationship is one-way: aquatic life (as measured by fish and aquatic insect indices) does not influence the other two indicators. Turbidity has direct impacts on aquatic life. It is abrasive to fish gills, reduces the foraging success of sight-feeding fish, destroys spawning areas by sedimentation of cobble beds, inhibits the growth of rooted vegetation through light limitation, and can increase water temperature. Above-normal stream flows can erode the stream channel, destroying habitat and increasing loads of sediment to the stream from bank and bluff erosion. High flows also can prevent the growth of certain species of rooted vegetation.

Figure 4. Goal, Indicators and Metrics for the Plan



The overarching goal of water quality, therefore, will be measured with reference to three indicators: healthy aquatic life, moderate river flows, and water with adequate clarity to support aquatic life. Specific metrics for each indicator are described below that will provide a means of measuring current water quality status against desired water quality goals, and over time allow the identification of temporal trends. Among the three indicators, the health of aquatic life is the most significant, as it directly measures the beneficial use of the Zumbro River that needs to be protected. Flow and turbidity may each be considered as potential stressors of aquatic life, with desired levels defined as that which is necessary to support healthy aquatic life. Criteria for the latter two indicators thus may change as more is learned about their impacts on the primary indicator, aquatic life.

1) **Healthy Aquatic Life**. The primary indicator of water quality in this Plan is the support of healthy aquatic life. The MPCA plans to sample the Zumbro River in 2012 and 2013 as part of its statewide biological monitoring program. The health of aquatic life will be measured with respect to fish and macroinvertebrate insect populations with two types of indices: the Index of Biotic Integrity (IBI) for fish,

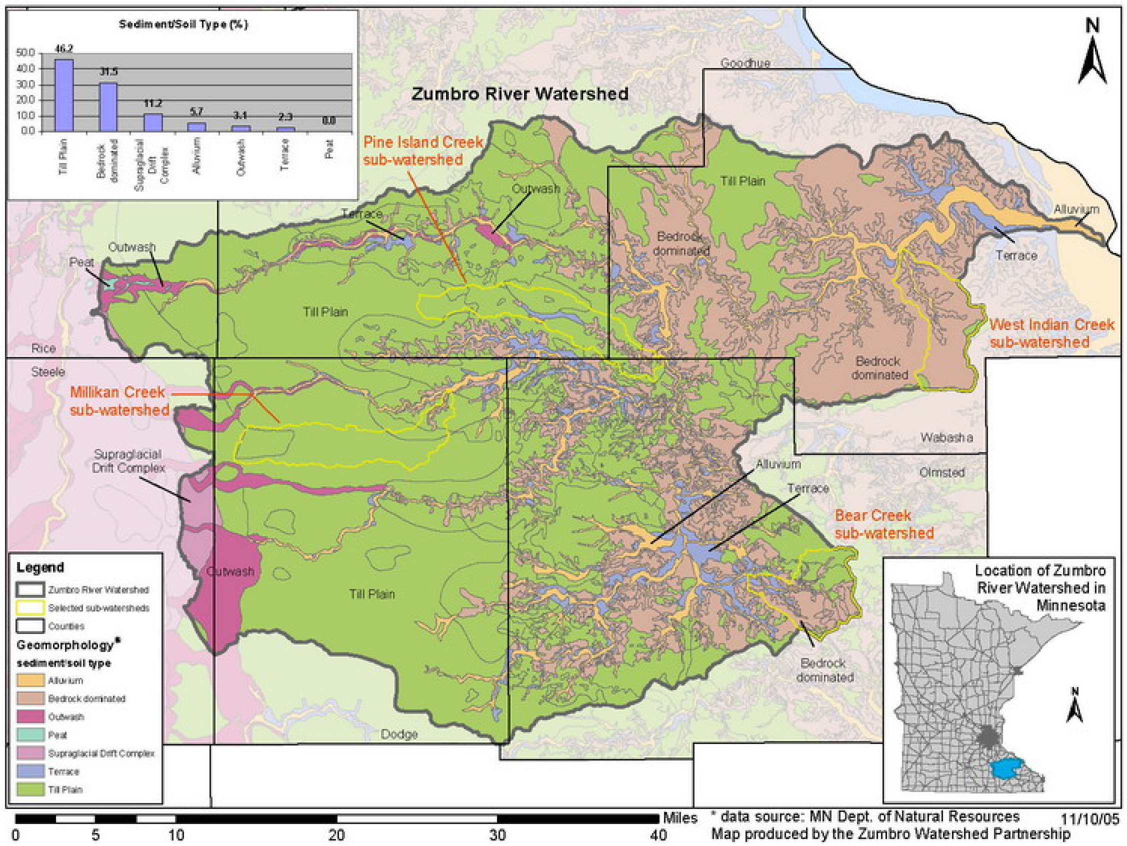
and the IBI for macroinvertebrate insects. IBIs will be measured for fish and macroinvertebrates for both warm and cold water streams in the Zumbro. The "score" for each site will be evaluated using an index ranging from 1 to 100, with higher scores indicating better quality. The Minnesota Department of Natural Resources (DNR) will coordinate its biological monitoring in the Zumbro with the MPCA. By 2014, interpreted biological data should be available for use by the ZWP, at which time metrics for aquatic life may be selected for existing and desired conditions in specific parts of the watershed.

2) Moderate river flows. Recent studies indicate that increased precipitation combined with recent changes in land cover, land use and artificial drainage are responsible for increased stream flows in the Midwest, Minnesota, and southeast Minnesota. (Dadaser-Celik et al.2009; Lenhart and Nieber 2011). For example, at Waseca, average annual precipitation increased by 15 percent between the periods 1950-1979 and 1980-2009. Minnesota-wide, precipitation has increased by 10 to 15 percent in recent decades (Seeley, 2012). Changes in land cover and land use also range across southeast Minnesota, with a steady shift from perennial crops and pasture to corn and soybean (BALMM, 2001).

Effects of these factors on stream flow are widespread, generally positive, and most pronounced in the karst region (Lenhart and Nieber; Figure 5). The steep hills and shallow, fractured bedrock of karst topography are conducive to rapid movement of rainfall and snowmelt from the landscape to streams. Streams in the karst region of southeast Minnesota are more responsive to summer rains than streams in tile-drained agricultural watersheds (Lenhart and Nieber, 2011). In the western part of the watershed, tile and open ditch drainage speed the movement of precipitation from land to streams, but appear to increase below-flood-level flows to a greater extent than flood flows. This is because tile drainage routes potential surface runoff through the soil profile before discharging excess water through the subsurface drainage network. This process increases the time of concentration – that is, the time required for precipitation to reach a surface water discharge point. Urban drainage systems, by contrast, route runoff directly into storm sewers which traditionally have been

Figure 5. Geomorphology and Sediment Characteristics of the Zumbro Watershed

Geomorphology/Sediment of the Zumbro River Watershed



designed for rapid transport directly to receiving water such as a stream. Although urban land was not analyzed in the studies cited here, it is generally accepted that increased impervious surface area tends to increase peak stream flows. In the Lenhart and Nieber study, increased peak flows were found only in karst topography. Bedrock-dominated areas in Figure 5 above represent karst topography.

Casual observation of extreme flooding in late summer and early fall suggests that drastic changes may be occurring. The floods of Sept. 14-15, 2004, Aug. 20, 2007, and Sept. 22-23, 2010 have a return frequency of approximately one in one-thousand (Seeley, 2012). They illustrate a relative shift from the preponderance of spring flooding in the past, to an increased frequency and magnitude of summer and fall flooding.

Increased frequency of flooding is only one aspect of recent changes in watershed hydrology. In Minnesota, from 1980 to 2002, Novotny and Stefan measured significant increases in average annual flow, summer or winter low flows, summer peak flows, and the duration of floods. The most recent decade showed the greatest variability, with periods of sharply increasing and decreasing flows. These trends align with predictions of likely impacts of climate change on stream flow (Novotny and Stefan, 2006).Similarly, Lenhart and Nieber (2011) detected an increase in stream flow up to the small flood stage, defined as a two-year return interval flow. They also measured a 40 to 50 percent increase in the ratio of stream flow to precipitation in agricultural watersheds, consistent with the findings of Schottler (2012) from small watersheds in the Lake Pepin drainage.

Higher stream flows exacerbate the problem of turbidity and sedimentation through increased channel erosion. Mean annual flows are strongly correlated with spring and summer peak flows (Novotny and Stefan) and would thus seem to be a suitable surrogate metric for peak and sub-peak flows. Stream flow goals for specific points in the Zumbro River network are needed both for water quality and flood abatement purposes.

The increasing trend in sub-peak flows in southern Minnesota streams has both beneficial and problematic implications for water quality. On the one hand, maintenance of higher base flows reduces the potential for stresses associated with low flows, such as low dissolved oxygen and hyper-eutrophication. On the other hand, increases in average and higher sub-peak flows could exacerbate stream channel erosion and degrade aquatic habitat, as is occurring in the Minnesota River and its tributaries (MPCA, 2012). Bank-full flow is commonly referred to as the "channel-forming" flow. A frequency target of no higher than 12-24 months return interval for bank-full flows would likely help to reduce stream channel erosion and return streams closer to a state of equilibrium in which channel erosion is balanced by deposition. (Copeland et al., 2000).

In summary, annual average flow, together with a bank-full flow frequency of no more than once per year, would appear to be appropriate and complementary metrics to use in determining flow-reduction targets for the Zumbro River and its tributaries. These metrics could be supplemented by base-flow targets.

3) Water Clarity. Clear water is the hallmark of water quality, essential for healthy aquatic life, pleasant water-contact recreation, and visual aesthetics. There are four metrics available for measuring water clarity in the Zumbro:

a) Turbidity standard. The state water quality standard for warm-water streams is 25 nephelometric turbidity units (NTU). The NTU meter measures the scattering of light caused by suspended particles in the water column. One problem with the 25 NTU standard is that different meters currently used in certified laboratories can yield very different results for the same water quality sample. The MPCA is addressing this problem by using TSS as a surrogate measure of turbidity. TSS is not subject to the same meter-related problems as turbidity, and is measured as a concentration, and therefore can be used to calculate sediment loads. Since the relationship between TSS and turbidity units tends to be site-specific, monitoring data were used to calculate conversion ratios for several of the impaired streams in the TMDL study.

b) Total suspended solids. Use of TSS as a surrogate in TMDL studies is considered a short-term solution to the turbidity meter problem. In the longer term, the MPCA is proposing to replace the turbidity standard with one based on TSS. The latter standard, proposed for adoption in 2012 or 2013, is defined as the 90th percentile of sampling data over the most current 10-year period of water quality monitoring. That is, the new TSS standard will not consider monitoring values in excess of the 90th percentile of total samples to be exceedences of the standard. Such high values are normally associated with high-flow conditions during which streams normally carry elevated amounts of suspended solids.

c) <u>Transparency or Secchi Tube</u>. The MPCA Citizens Stream Monitoring Program (CSMP) makes use of a measuring device formerly called a transparency tube, now called a Secchi tube, which provides volunteers an immediate on-site measure of transparency. Approximately 50 citizen volunteers currently take Secchi tube measurements through the CSMP. The traditional tube measures transparency up to 60 centimeters. A longer tube being introduced in 2012 will allow for measurement of transparency up to 100 centimeters. Those using the Secchi tube learn the transparency characteristics of specific segments of tributaries and the main channel. For example, small upstream tributaries are frequently very transparent. A significant rain or snowmelt event will make the water very cloudy for two to three days, after which clarity returns quickly to the stream. By contrast, the main stem Zumbro tends to be less than fully transparent in the growing season, and remains at lower levels of transparency for a longer time following rain or snowmelt events.

d) <u>Sedimentation of Lake Zumbro and other water bodies</u>. The rate at which various sizes and types of reservoirs fill in with sediment is a means of measuring sediment loads from upstream sources. Dating techniques applied to reservoir sediment cores can provide a history of sediment loads, and sediment fingerprinting techniques can be used to broadly identify sediment sources as originating from the land surface or near the stream channel. A prime example in the Zumbro watershed is Lake Zumbro. A hydroelectric dam that was constructed in 1919 about 1.6 miles north of the Olmsted-Wabasha county border formed Lake Zumbro, a reservoir with a surface area of about 600 acres. The lake is widely used for recreation in this lake-poor region of the state. About one-half of the Zumbro Watershed drains to Lake Zumbro. Ninety three years of sedimentation from its watershed has made parts of Lake Zumbro inaccessible by shore or impassable by boat, and has reduced fish habitat. The Lake Zumbro Improvement Association (LZIA) conducted a sediment analysis of the lake using maps from 1919, 1957, 1978 and 2005. They determined that a total of 13 million cubic yards of sediment has been accumulated in the lake. The data show that sedimentation rates have decreased in recent decades. Reduced sedimentation rates have also been confirmed by bathymetric survey data completed for the City of Rochester' flood-control reservoirs. Setting a goal for continued reduction of sedimentation in Lake Zumbro and possibly other reservoirs is an objective of this plan.

The MPCA is proposing to replace the current turbidity water quality standard with a standard that uses total suspended solids (TSS) criteria. In addition to the change from turbidity to TSS, the proposed criteria vary regionally, and the standard includes explicit language regarding its application (the TSS criteria may be exceeded no more than 10% of the time over the months April-September). The proposed change, if adopted, could go into effect near the end of 2012. Current listed stream reaches will remain on the impaired waters list. There will not be a broad reassessment of all turbidity listings if the TSS standard is adopted. The MPCA is currently transitioning to a system in which all major watersheds in the state will be assessed on a ten-year cycle. This new assessment process relies heavily on biological data (fish and invertebrates) for making aquatic life use support decisions. Thus, in general, assessment against the TSS standard will follow this cycle and will be one of multiple components considered in a weight of evidence process. It is possible that some turbidity listings may remain for several years before re-assessment occurs. In the Zumbro River watershed, this assessment will begin in 2014.

III: Strategies Used to Achieve Goals

The previous section described several inter-related indicators of water quality toward which this plan is directed: support of aquatic life in the Zumbro River; reducing stream flow volume in median to high flow conditions; and increasing water clarity by reducing turbidity. This section describes ways of making progress on these indicators through broadly defined watershed management strategies. The subsequent section of the Plan provides more detailed actions through which the strategies may be implemented.

A major function of this Plan is to provide what is termed "reasonable assurance" that the TMDL will be implemented through the reduction of sediment loads by point and nonpoint sources, and complementary implementation measures that may be identified. As part of its TMDL review, EPA evaluates whether a TMDL provides reasonable assurance that nonpoint source controls will achieve expected load reductions. Section VI of the TMDL addressed the question of reasonable assurance. The reader is referred to page 77-78 of the TMDL report for details. In summary, the TMDL cites:

1) A list of BMPs that are proven to be effective in reducing nonpoint source soil erosion, and local agencies (SWCDs and NRCS) with the expertise needed to implement them on private property;
2) The existence of National Pollutant Discharge Elimination System (NPDES) permits for wastewater facilities and Municipal Separate Storm Sewer Systems (MS4s);
3) A series of projects and tools for prioritizing and focusing management, including the LCCMR project "Prioritizing Critical Restoration Sites in the Zumbro Watershed" mentioned earlier; a State of Minnesota funded shoreland mapping inventory of land use in riparian areas of southeast Minnesota (http://www.crwp.net/shoreland-mapping); widespread availability of LIDAR data for BMP targeting and design; an SWCD inventory of sediment retention basins in the Zumbro watershed; and Intensive Watershed Monitoring by the MPCA to assess aquatic life conditions at 90 sites in 2012-13, with plans to return at 10-year intervals to assess progress.
4) The Clean Water Fund contract with ZWP to develop an implementation plan for the Zumbro Watershed;

5) Voter approval of the Clean Water, Land & Legacy Amendment in November 2008, which provides a continuing source of state funding for water quality improvement and protection projects;
6) Monitoring components to allow benchmarking and tracking of TSS concentrations and loads as well as a systematic watershed-wide assessment of biological indicators at 10-year intervals.

The 910,337-acre Zumbro River Watershed varies significantly from east to west and south to north with respect to topography, soils, land use, stream characteristics and the potential for restoration of different segments of the stream network. In developing strategies to achieve the goals set forth in Section II, these differences need to be taken into account. This section of the report is therefore divided into sub-sections which will enable strategies to be differentiated for the varied conditions of the Zumbro River and its watershed: the whole watershed, the headwaters region, and watershed lobes including the South Fork, Middle Fork, North Fork and lower main stem of the Zumbro River.

A. Watershed-Wide Strategies:

Certain strategies apply broadly to most areas of the vast Zumbro Watershed. These strategies lend themselves to broadly based education, technical assistance, and, in some cases, enforcement of existing regulations. It is often more efficient to undertake watershed-wide projects that cross county boundaries than for each county to separately implement a similar strategy on its own. Coordination on grant-writing and all aspects of implementation are possible on the watershed scale.

1) Decrease soil erosion and runoff in rural areas.

With about 70 percent of the Zumbro Watershed in cultivated cropland, strategies to reduce surface erosion and increase infiltration of water into the soil profile are highly important. Land-use practices that apply throughout the watershed include conservation tillage in addition to constructed conservation practices such as grassed waterways, water and sediment control basins and grade stabilization structures. For maximum effectiveness, conservation practices need to be targeted to sites with high erosion and sediment delivery rates, and designed to fit the landscape, crop rotation and management methods of individual landowners. Professional conservationists from SWCDs and NRCS field offices are knowledgeable about local conditions and familiar with many land owners. They should be closely involved in planning and implementation of conservation practices.

<u>Identify and correct major erosion sites.</u> The Zumbro Watershed Partnership has secured a LCCMR grant to identify and rank erosion sites according to soil loss potential across the Zumbro Watershed. ZWP partners, with technical assistance from the Minnesota Department of Agriculture (MDA) and MPCA, will analyze Light Detection and Ranging (LiDAR) and other Geographic Information System (GIS) data to identify critical erosion areas. They will then conduct in-field evaluations to further evaluate the most significant 50 sediment sources and plan BMPs appropriate for those locations. Partner SWCDs and the ZWP will then use this information to prioritize projects and seek funding sources to implement erosion-reduction measures for the sites.

Most soil conservation practices are voluntary, with technical and financial assistance often available to landowners. Several regulatory mechanisms are available, however, including: county ordinances requiring perennial buffer strips along DNR protected waters (Minn. Stat. 103F.201); drainage law requiring filter strips along drainage ditches following a redetermination of benefits proceedings(Minn. Stat. 103E.021); a Soil Loss Limits ordinance available to counties(Minn. Stat. 103F.415); and conservation compliance provisions of the US Farm Bill by the NRCS and Farm Service Agency on farmers' federal conservation plans for highly erodible land (1985 Farm Bill as amended).

Filter strips along streams and drainage ditches: Minnesota law (Minn. Stat. 103F.201; Minn. Rules 6130.3300, subp. 7) requires counties to adopt ordinances to protect a 50-foot shore impact zone with permanent vegetative cover on streams classified as protected waters by the DNR. Generally, these are perennial streams draining a catchment of two square miles or more. The reason for the stream buffer requirement is to protect the health of Minnesota streams. Buffer strips filter out pollutants, greatly reduce runoff from the buffered area, and enhance wildlife habitat along the stream corridor (http://files.dnr.state.mn.us/publications/waters/buffer_strips.pdf). Revisions to the shoreland rule in 2010 clarified and elaborated on provisions for the 50-foot shore impact zone and the 300 foot shoreland district on each bank of protected waters in agricultural regions (http://www.dnr.state.mn.us/waters/watermgmt_section/shoreland/shoreland_rules_update_project.html). Then-governor Pawlenty decided not to authorize the new rules. The current state administration has not announced a decision to pursue rule revision as of August 2012. The revisions reflect input from BALMM members in southeastern Minnesota. They may be adopted by individual counties wishing to go beyond the degree of protection offered by current state rules, or to anticipate potential future rules.

In southeast Minnesota, BALMM started a buffer initiative in 2006 in order to raise awareness about county shoreland ordinances by county commissioners, many of whom were not aware of the ordinance. Following several years of education and publicity on the subject, counties began to enforce the buffer provision of the shoreland ordinance either on their own initiative or in response to citizen complaints. To date, within the Zumbro Watershed, Dodge, Olmsted, Wabasha and Goodhue counties have taken steps to notify landowners of stream buffer requirements. Dodge County has achieved almost full compliance; Olmsted County is actively approaching noncompliant landowners, while the other two counties are taking a more gradual approach.

Opportunities to increase stream shoreland protection include: 1) working toward full compliance with current ordinances; 2) maintaining compliance once near-full compliance is achieved, as in Dodge County; 3) promoting the protection of small headwater stream segments not covered by the shoreland rule; 4) or adopting provisions of the draft revised rules of 2010.

Soil Loss Limits Ordinance: Minnesota law provides a means for counties to adopt ordinances specifying limits on soil loss, or soil erosion (Minn. Stat. 103F.415). Several counties in southeast Minnesota have had such an ordinance in place since the late 1980s: Mower, Fillmore, Winona and Olmsted. Within the Zumbro Watershed, two additional counties, Dodge and Steele, list adoption or consideration of a soil loss limits ordinance in their current county water plans. Recent discussions in the region have focused on an apparent trend to reduced residue levels on farm fields, increased use of the moldboard plow, conversion of Conservation Reserve Program (CRP) land to row crop land, and destruction of conservation practices such as waterways and contour strips. As higher land prices appear to be inducing farmers to practice more intensive tillage in some cases, and to plant row crops on land previously in the Conservation Reserve Program, it may be an appropriate time to consider the merits of county soil loss ordinances as a tool to slow or reverse this trend. The ordinance also provides counties a means of addressing individual cases of extreme erosion.

Conservation Plan Compliance Checks: The USDA is discussing a policy shift with regard to enforcement of the conservation compliance provisions of the federal farm program. If implemented, it will affect all counties, SWCDs and NRCS field offices in the Zumbro Watershed. (The Wabasha County water plan already calls for spot-checking one-fifth of the county for farm plan compliance on an annual basis.) Since the 1985 farm bill, farmers with highly erodible land (HEL) have been required to operate such land according to a conservation plan. Non-compliance with the conservation plan could trigger loss of USDA benefits. To date, there has been a nation-wide trend of non-enforcement of conservation compliance (Schnepf, 2012; Soil and Water Conservation Society, 1992). Reasons may include lack of staff, the reluctance of local field staff to enforce against landowners with whom they need to deal to solve the erosion problem in question, and a reluctance to impose a total removal of federal price support for non-compliance with a conservation plan. To address these issues, the USDA is discussing several policy modifications. First, compliance checks would be conducted by staff from outside the landowner's county – either by staff from a neighboring county or the area office. Second, graduated penalties would be used instead of all-or-nothing decisions for cases of non-compliance – made possible by a change to the 2008 farm bill (Schnepf, 2012). Staff, and local FSA offices, would be able to better match the penalty to the degree of non-compliance. Third, the goal of HEL plans is the achievement of significant soil loss reductions over untreated conditions. If these changes are introduced in 2012, as currently expected, SWCDs and NRCS offices may be turning more of their attention and resources to compliance-related activities and the follow-up conservation planning and implementation this will generate. Local units of government within the ZWP may wish to jointly discuss how additional resources may be applied to the increased work load this policy is likely to generate.

Conservation tillage, or residue management, involves managing the intensity(frequency and aggressiveness) of soil-disturbing activities related to residue management, seedbed preparation, nutrient application, planting and pest control while planting and growing crops. A traditional target for residue management for erosion control is at least 30 percent of the field surface covered with residue after planting. The practice has widespread applicability, effectively controls soil erosion, and tends to make complementary conservation practices more effective by reducing the potential for soil erosion across the field. Suitable equipment is available for everything between no-till and full-width tillage. Both university research and farmer experience is available to those interested in adopting any of the many variations of conservation tillage.

In the Zumbro watershed, differences in topography and soils from east to west influence the performance of different tillage systems. In the eastern karst region, conservation tillage practices up to and including no-till can be applied with little or no yield penalty in a corn-soybean rotation, considerable savings in operating costs, and long-term benefits to soil quality (University of Minnesota, 2002; Archer and Reicosky, 2009). Further to the west, in the loess-cap soils region, natural soil drainage is sometimes poor, making no-till less feasible for planting corn. However, strip-tillage, a variety of no-till that prepares narrow tilled rows in the fall for planting the following spring, overcomes most of the problems of strict no-till, and often produces yields comparable with full-width tillage systems in a corn-soybean rotation. Yield penalties for no-till are greater with continuous corn in both regions. Most no-till is used in soybeans following corn.

Recent informal reports from Soil and Water Conservation Districts indicate that gains in conservation tillage are being eroded as farmers utilize more aggressive tillage practice. This trend appears to be driven by several factors: high crop prices induce farmers to use more aggressive tillage in order gain a slight yield advantage; earlier maturing harvests and more open, milder winters provide more opportunities for tillage operations. Discussions on ways of responding to this trend are ongoing.

2) Increase soil infiltration and water-holding capacity

Practices that increase soil organic matter and provide surface cover will tend to increase the volume of water infiltration into the soil, and the volume of water retained as available soil water. On farm fields, use of very reduced tillage and cover crops are potential ways of accomplishing these results. In residential areas, use of compost, rain gardens and other perennial plantings can work.

<u>Cover crops:</u> Planting a cover crop following harvest of canning crops or corn silage is an effective, low-cost way of controlling erosion, holding surface residue in place, improving soil quality, and, with deep-rooted cover crops, breaking through the plow pan. By almost doubling the time a field is penetrated by growing roots, cover crops encourage the growth of beneficial fungus such as mycorrhizae. These micro-organisms feed on nematodes and, under low-soil-disturbance, significantly increase the amount of soil organic matter compared to aggressively cultivated fields, which tend to have bacteria-dominated soils. Winter rye and oats are common cover crops for this region. Adoption of the practice is low, but may increase as universities try to find crop varieties and management practices that can make cover crops more successful. A major obstacle to broader adoption in southern Minnesota relates to climate. Particularly with corn and soybeans, it is difficult to get the cover crop seeded early enough to become established before the growing season ends. A second factor limiting the use of cover crops is moisture competition in years with a dry spring.

The periods following canning crop harvest or silage chopping tend to be more feasible than following corn or soybean harvest, although aerial seeding in late August has seen some success with corn and soybean fields. A potential new use for cover crops is to reduce erosion and maintain soil quality on corn fields where stover is removed after harvest for biogas production (http://www.iowafarmertoday.com/news/regional/rye-planted-to-boost-water-holding-capacity/article_b033ca3c-6315-11e1-a234-001871e3ce6c.html).

Cover crops that survive the winter can be grazed in the spring prior to planting, taking grazing pressure off pasture. If burned down with glyphosate in the spring, the cover crop provides protective residue and excellent conditions for no-till, strip-till or other low-disturbance systems during the April-June period when fields are the most vulnerable to surface runoff and erosion. Cover crops have become more common recently in the region between Rochester and Plainview.

No-till and strip-till used alone or in combination with cover crops can over time improve the aggregate structure of soil, particularly at the surface, to increase infiltration, while increasing the organic matter content of soil to increase soil water storage capacity, commonly referred to as available soil water (Olness and Archer, 2004; Hudson, 1994).

Residential lawn care: Lawn care practices that increase infiltration and soil water storage capacity include use of compost as a soil amendment, plantings of perennials in rain gardens and as decoration, replace bare spots with growing plants, and use of rain barrels to trap rooftop runoff.

Programs to encourage landowners to increase soil organic matter could have a significant effect on soil moisture storage and local hydrology. In addition to increasing the amount of rainfall infiltration into the soil, an increase of soil organic matter of, say, two percentage points can increase available soil moisture by an estimated two-thirds inch (Hudson, 1994). Because the water is stored in the micro-pores of organic matter, it does not decrease soil aeration or contribute to soil saturation. On the contrary, increased available soil moisture is defined as the difference between field capacity and wilting point. If anything, increased available soil moisture would be expected to increase field capacity – the point beyond which water added to a field will drain through the soil matrix or run off the surface.

3) Increase water storage on the land.

One strategy for reducing flow peaks and the duration of high flows is to store more precipitation on the land. This will increase the portion of precipitation that is used for evapotranspiration or groundwater recharge, and help to desynchronize runoff from various parts of the watershed to the stream, thereby reducing peak and sub-peak flows. Conversion of farm or urban land to wetlands or deep-rooted native prairie is a well-known, but increasingly costly, method. Slowing the rate of flow from land to water is also important. It is also possible to engineer the stream and its corridor to create more opportunities for temporary storage on the floodplain. Beavers do this naturally; humans use engineered in-stream structures that retain part of the stream flows during high-flow events without harming the stream ecology. There are many ways in which water can be stored on the land in order to reduce the magnitude of flows in streams. The following five listed here have been used in southern Minnesota:

a) Restore drained wetlands and adjacent upland;
b) Capture, retain and slowly release drainage tile discharge water.
c) Modify drainage ditch design for water storage
d) Construct additional grade stabilization ponds with "ample" storm water storage space (i.e., perhaps beyond that needed for sediment storage life span and storm stage interval.
e) Construct reservoirs designed to reduce downstream flows and floods.

f) Reconnect the main channel with the floodplain where this connection has been severed by dikes, increased elevation of the floodplain through years of sediment deposition, or other causes.

Each of these methods will be elaborated in the following section on Implementation Activities.

4) Stabilize eroding stream banks and bluffs.

Strategies 1-3, and some that follow, will all contribute toward the stabilization of stream flows, especially the increase in higher flows that has been observed in recent decades. In addition to these watershed practices that increase infiltration and storage of water on the landscape, there is a need for on-site treatment of seriously eroding stream banks and bluffs where this is not cost-prohibitive. For example, eroding stream banks and bluffs are typically vertical. As the toe is undermined by flows with high energy, caving of soil from the bluff into the stream over time is the typical result. At times, excavation of stream banks to create a stable angle, perhaps with complementary in-stream modifications, can help to reduce erosion. Goodhue County has obtained a general permit from DNR which allows their staff to assist landowners with stream bank projects without the need for a special permit. In certain cases, the planting of deep-rooted native vegetation can help to armor stream banks and stabilize the top of bluffs. Restrictions on building and agricultural activities near bluffs also can help to reduce or slow down the rate of bluff collapse. Ultimately, however, the effect of stream flow on toe erosion must be reduced to establish more stable stream banks and bluffs in the long term (Wilcock, 2009).

5) Maintain appropriate stream corridor vegetation

Viewed from an ecological perspective, a stream is more than the narrow ribbon of water that one sees usually flowing between its two banks. This most apparent portion of the stream interacts with the land within its corridor, especially its floodplain. Insects upon which fish feed may spend part of their life cycle in the stream, and part on land. The combination of land and water creates a biological corridor with potential for a rich and diverse ecosystem. Vegetated stream corridors add variety to the landscape and provide habitat for a wide variety of mammals, amphibians, reptiles, birds and insects. They are a rich biological treasure on the highly altered landscape of the Zumbro Watershed. Filter strips along streams can be very effective sediment traps from sheet and rill erosion. When used in combination with conservation tillage and other practices which prevent gullies or ravines from forming, buffers along streams can be particularly effective in reducing sediment loads.

As explained in (1) above, county ordinances require that a 50-foot vegetated buffer be maintained along DNR-designated “protected waters”, which includes most perennial streams. The very upper portion of streams, where the catchment area is less than two square miles, is excluded from the ordinance. Most counties in the Zumbro Watershed have begun enforcing their agricultural shoreland ordinances to some extent within the past five years. As a result, many fields that once were farmed close to the stream edge now are separated from the stream by a 50-foot buffer. Native vegetation is preferred, with its deep roots to help protect the stream bank. Trees can be effective; however, shade-tolerant species such as box elder can prevent the growth of ground cover, and often have a net netative effect on stream bank stability. By mapping riparian corridors and determining where buffers are present and where they are absent, opportunities for development of river corridors can become evident.

6) Improve woodland and forest stands.

In the eastern portion of the Zumbro Watershed, much of the steepest, most erosion-prone land is covered with trees or used as pasture. Poor management of either tree stands or pasture can lead to increased runoff and erosion. Forest land that is managed according to a Forest Stewardship plan, such as under the DNR's Forest Land Improvement Program, will improve soil quality, increase water infiltration, while reducing runoff and erosion.

7) Improve pasture land.

Pasture land that is managed according to a paddock grazing system, called Management Intensive Grazing, will grow more grass than a conventional pasture while improving soil quality, increasing infiltration, and reducing runoff and soil erosion. Regional efforts to promote rotational grazing go back to 2002, when a BALMM initiative in four karst counties obtained an EPA grant to develop 30 new rotational grazing plans in each county over a four year period. Since then, some SWCD and NRCS staff have received training in assisting producers to develop rotational grazing plans. Fillmore County houses a grant-supported grazing specialist for the Root River watershed. The Area 7 NRCS office in Rochester also has a regional grazing specialist. The key to success in rotational grazing is timely movement of livestock from one fenced-in paddock to another. This keeps grass in the vegetative mode of growth rather than going to seed, while preventing over-grazing. Well managed grazing systems can compete with row crops for profitability; indeed, some of the new grazing plans developed under the 319 grant converted row-crop land to grass. A potential benefit some producers take advantage of is a growing specialty market for lean, grass-fed meat and dairy products, often free of antibiotics. Organic markets pay a premium for meat and milk meeting the right specifications.

The water quality benefits of rotational grazing are likely highest in the steep topography of the eastern part of the Zumbro watershed, where soil erosion potential is the highest. However, farmers throughout the watershed are using the practice, illustrating its broad potential for increasing the acreage of perennial vegetation on the landscape.

7) **Control runoff from towns where a stormwater permit is not required**

Only one city in the Zumbro Watershed, Rochester, is currently regulated by an MS4 storm water permit by the MPCA. The remaining 21 towns are not subject to storm water rules. City staff often lack training in basic storm water management. Unregulated towns with runoff problems should be encouraged to:

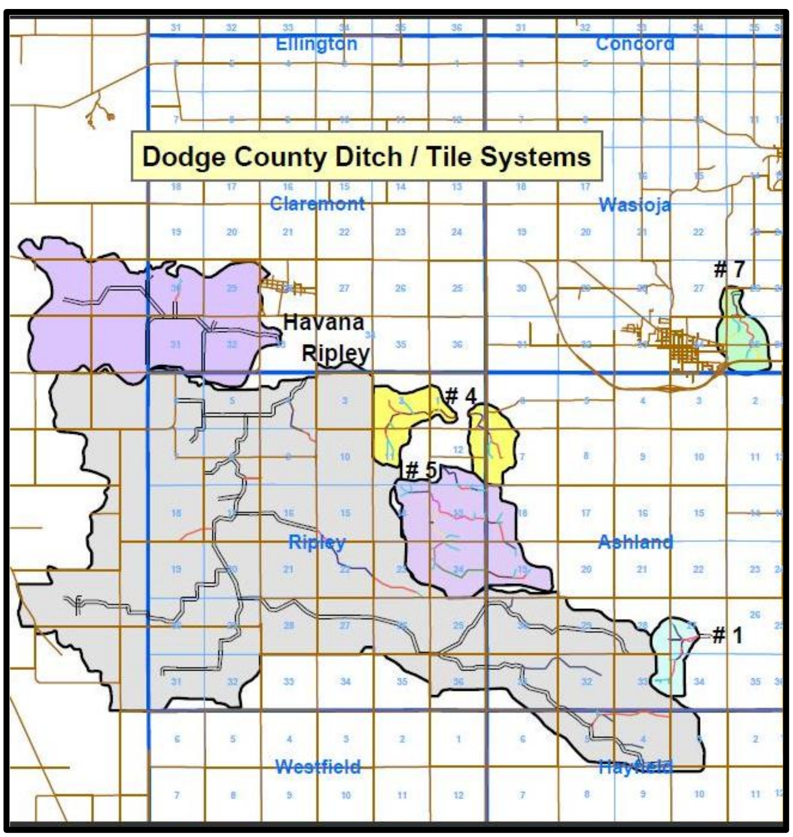
a) Approve grading plans and inspect active construction sites for compliance with erosion control requirements.
b) Respond to complaints of non-storm water discharges to their storm sewer system.

c) Adopt ordinances to increase the amount of tree canopy cover on boulevards and other locations, along with the development of forest master plans.
d) Operate and maintain their storm sewer system to maximize water quality treatment;
e) Establish urban riparian buffers;
f) Obtain technical assistance and training for local storm water management needs. Provide residents and elected officials with education.
g) Promote the installation of rain gardens and rain barrels by residents and businesses.

B. Strategies for headwater streams and their watersheds:

The headwaters of the Zumbro River are comprised of a network of small creeks that form in the nearly flat upper reaches of each major watershed lobe and in the uppermost reaches of barely formed brooks and creeks found throughout the Zumbro River Watershed.

Figure 6. The Ripley Ditch Watershed



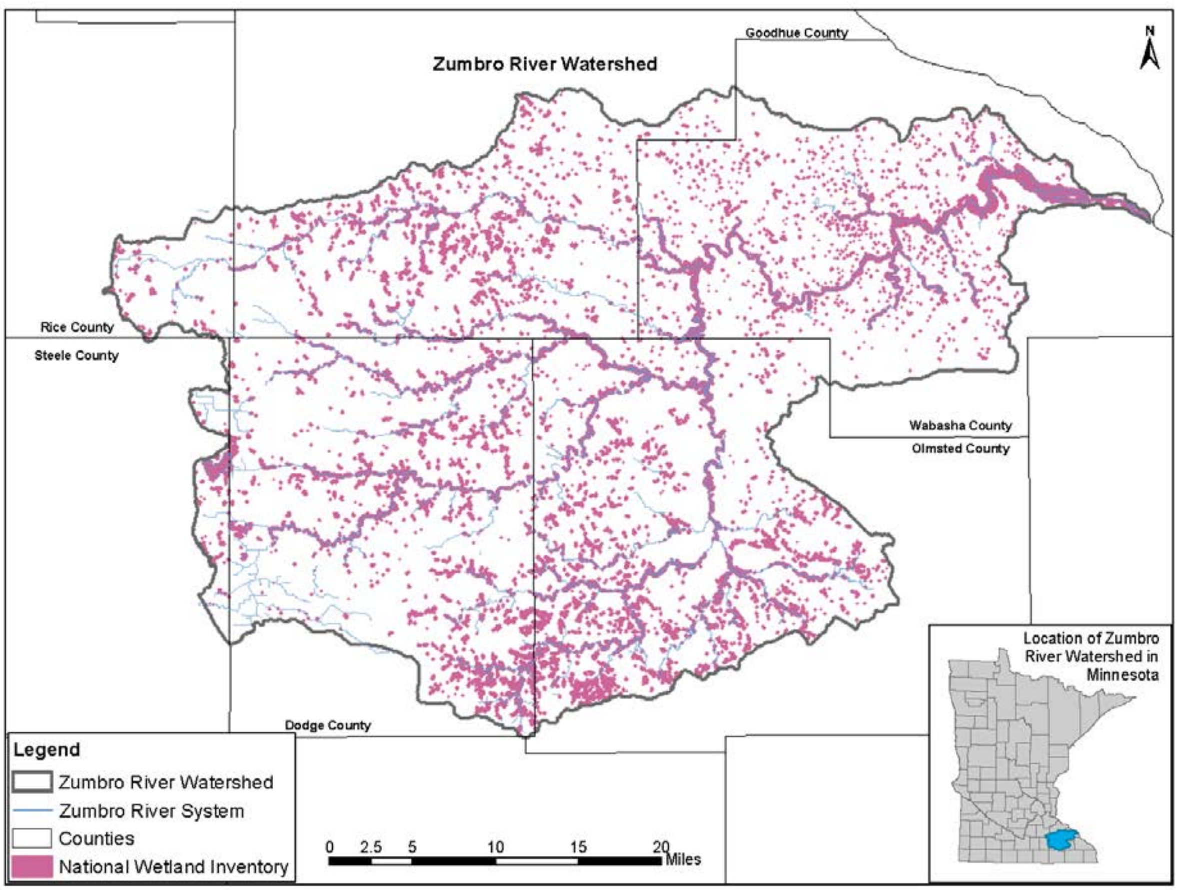
The level western portion of the watershed forms a contiguous headwaters region. Prairie and wet prairies comprised the major pre-settlement vegetation in this area, with wet prairie located at the very upper reaches of the watershed, near and slightly beyond the western border of Dodge and Goodhue counties. This area is now devoted largely to the production of corn and soybeans. West of Highway 56, the Ripley Ditch and other drainage ditches, fed by a dense network of sub-surface drainage tile, has rendered the flat, rich soil along the Dodge/Steele county border suitable for commercial crop production. On the other side of the highway, small creeks provide an outlet for drainage tile. Small headwater creeks, having less water than the downstream tributaries, are especially vulnerable to periods of low flow, to the point of drying up. They also tend to be more sensitive to inputs of pollutants due to the lack of dilution. In addition, the low stream gradient near the source of the creeks, and in the drainage ditches, is conducive to the settling out of silt particles, sometimes in large amounts. Besides incurring clean-out costs on the drainage system, silt harbors potentially pathogenic organisms and attached pollutants which are re-mobilized with the next flushing event. Fine sediments also degrade habitat for most fish and macro-invertebrate species. The following strategies address these concerns.

a) **Maintain vegetative filter strips along streams and drainage ditches:** The riparian corridors of streams are especially vulnerable to disturbance by tillage and grazing in the upper, level parts of the Zumbro Watershed. It is here that it is most likely that landowners who are unaware of county stream buffer ordinances are likely to farm closer to the stream high-water mark than the 50-foot separation distance required. (Personal communication, Melissa DeVetter, Dodge County Planning and Zoning). Education, compliance inspections and technical assistance have succeeded in bringing most landowners into compliance in Dodge County; other counties are at earlier stages of the process. These efforts need to be maintained.

b) **Observe setbacks for manure and pesticide application**: State rules specify set-back distances from "critical areas" for application of manure (Minn. Rule 7020; specific citations found at http://www.pca.state.mn.us/index.php/component/option,com_docman/task,doc_view/gid,3578) and pesticides (Minn. Rules 18B). In the case of manure, the set-back distance is 300 feet from a stream or ditch. This setback requirement can also be met with a 50-foot vegetated buffer, with manure applied up to the buffer edge. The setback distance for atrazine is 66 feet. Minnesota Department of Agriculture recommends a similar setback distance for all herbicides. Each of these setback requirements can be met along most streams simply through compliance with the stream buffer ordinance if herbicide applications are kept 16 feet away from the buffer to prevent damage from spray drift. The exception to this rule is upstream of what the state DNR refers to as "protected waters," where the state's shoreland rule does not apply. A stream becomes a protected water of the state at the point at which its drainage area reaches two square miles. Buffering of water ways upstream of protected waters is recommended to provide a runoff filter, to increase water infiltration, and to serve as an indicator of where manure and pesticides should not be applied. http://www.pca.state.mn.us/index.php/component/option,com_docman/task,doc_view/gid,3530

d) **Restore wetlands:** First-order stream watersheds in pre-settlement times were dotted with wetlands, most of which have been drained to allow productive agriculture, the building of roads and the settlement of land in towns and rural areas. The drainage of wetlands, coupled with conversion of prairie land to crop production over the past century or more, has drastically altered the hydrology of the upper Zumbro Watershed, with impacts on stream flow and stream channel stability throughout the system downstream. Restoration of wetlands is a means of stabilizing local hydrology. The Steele County water plan was amended in 2009 to designate high-priority areas for wetland restoration, a requirement for participation in Wetland Conservation Act restoration programs. One of the priority areas identified is the Ripley Ditch Watershed (Figure 6) – an area along the Steele/Dodge county border that was un-farmable until the Ripley Ditch system was constructed. The Ripley Ditch discharges ultimately into the Middle Fork Zumbro. Thus, wetland restoration in the Steele County portion of the Ripley Ditch Watershed can be used as part of a flow-abatement strategy for the entire Middle Fork. The Steele SWCD/NRCS has recently acquired a Reinvest in Minnesota / Wetland Reserve Program wetland restoration easement in northeast Steele County. This 885 acre easement is located in the headwaters of the Zumbro River sub watershed 41077. The easement conservation plan includes 740 acres of wetland restoration and 145 acres of adjoining uplands restored to native vegetation. The wetland restoration work will begin in the summer of 2012 and be completed in the spring of 2013. This sizable restoration will store and filter runoff water, reduce downstream flooding, and provide wildlife habitat.

Figure 7. National Wetland Inventory of the Zumbro River Watershed



e) **The non-contiguous portion of the headwaters region** is comprised of small, first-order watersheds on the uppermost portion of the landscape throughout the Zumbro Watershed. It is here, especially on steep topography, that conservation structures such as grade stabilizers, water and sediment control basins, terraces, contour strips and grass buffers will often be needed either to supplement or replace the practices listed above that are appropriate for more level land. These practices are designed for highly erodible land, and are most effectively implemented as part of an integrated conservation plan whose aim is to curtail runoff or prevent runoff from leaving the fields following a defined magnitude precipitation event. Since watershed size in this region can be as small as 50 acres, relatively small, low-cost structures and practices can be used to curtail or prevent runoff without retiring extensive acreages from crop production. Thus, it is here where a "slow-the-flow" strategy may be most economically implemented, provided landowners are motivated to cooperate with local SWCD and NRCS offices. SWCDs are conducting an inventory of grade stabilization structures in 2012. The results will help to target resources to grade-stabilization structures in critical source areas that are in need of clean-out and repair.

C. Strategies for major tributaries and main Stem Zumbro

The suggested approach to each of the major sub watersheds of the Zumbro – the North Fork, Middle Fork, and South Fork – builds on the strategies described above for the Zumbro Watershed as a whole, and for the small watersheds draining to first-order streams along the western edge of the Zumbro Watershed. The strategy for these three large sub-watersheds, along with the lower main stem and its drainage basin, relies heavily on engaging residents in designing integrated solutions to the specific situations found in one or more priority sub-watersheds. The strategy includes the following four steps:

a) **Choose priority sub-watersheds**: There are at least two important reasons for choosing small sub-watersheds as part of this implementation plan: First, on this scale it is more likely that residents and land-users can be engaged in an ongoing process of developing, executing, and evaluating a watershed restoration or protection plan. Second, on this scale it is more likely that the execution of such a plan can be pursued with sufficient intensity and breadth to have a measurable impact on land use, hydrology and water quality. Four sub-watersheds were selected for priority emphasis in the early years of the ZWP: Milliken Creek in Dodge County, Pine Island Creek in Goodhue County, West Indian Creek in Wabasha County, and Bear Creek in Olmsted County. It may be that these watersheds will serve current purposes well enough. However, it would be prudent to revisit the selection of watersheds with current purposes in mind. In addition to the two reasons cited above, the following factors are pertinent to the selection of priority sub-watershed:

    i. The nature and extent of impairment, in cases requiring restoration, or the value and vulnerability of the aquatic ecosystem, in cases requiring protection.
    ii. Potential for restoration or protection of water quality and related aquatic ecosystem components, such as fish populations;

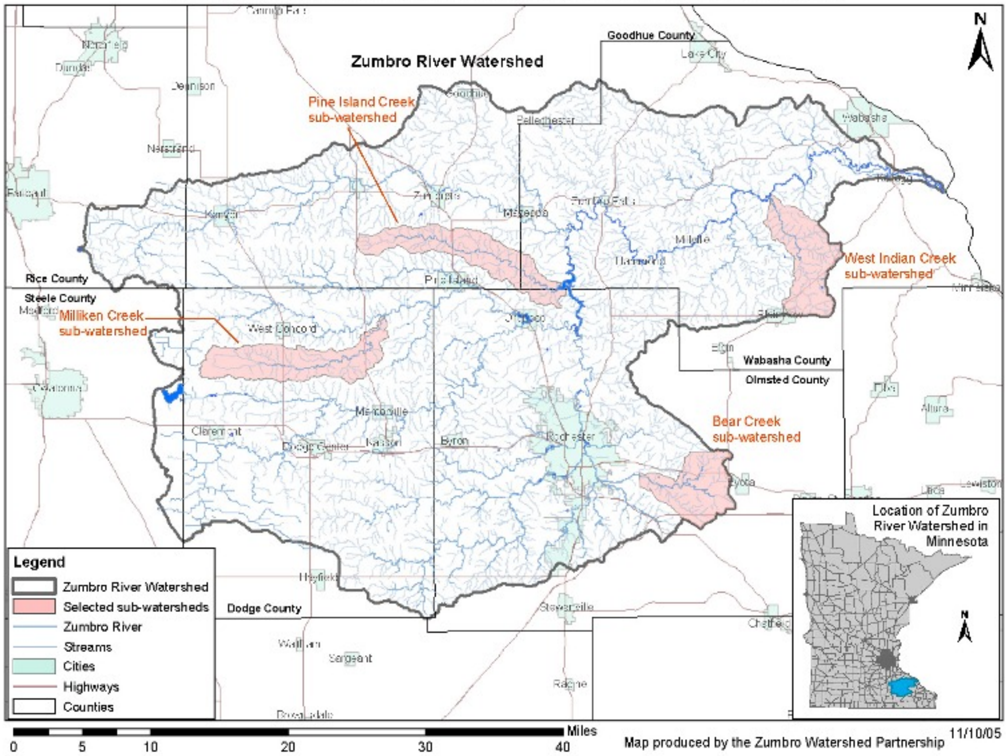
iii. Its value as a “sentinel” watershed, where the success or failure of implementation efforts can be applied as lessons to similar small watersheds within the tributary or main stem watershed;
iv. A record of monitoring data to define a base level of water quality for different flow regimes, and commitments to continue monitoring into the future;
v. Community capacity for civic engagement;
vi. Progressive land uses being applied to serve as local examples for emulation.

b) Establish a citizen engagement process in at least one priority sub-watershed in each lobe of the Zumbro Watershed. Targeted civic engagement activity will be focused at the small watershed level. It will follow a deliberate process designed to involve residents in developing a sub-watershed management plan. The process begins with the establishment of a group of volunteer residents to form a watershed council. The first task of the council will be an assessment of the watershed community from the perspective of natural resources (focus on water quality), aquatic and terrestrial ecosystems, human settlement, social networks and communications, leading to the identification of individual interests and community interests. Following this assessment, community residents will be invited to participate in strategic planning on ways of achieving community interests while taking into account individual needs and interests. The strategy will be informed by technical information, with a focus on how to engage citizens in specific resource protection and restoration activities. The intended outcome is ongoing citizen involvement in the protection and restoration of the priority tributary and its watershed. Lessons learned may then be applied to additional sub-watersheds.

c) Write and implement the work plan developed with the citizen’s council: The outcome of the citizen engagement process will be used as the basis for developing a work plan. ZWP will assist in the writing of the work plan, and will cooperate with local SWCDs and other local units of government, as appropriate, to implement the work plan. This may include writing grants or establishing contracts with state and federal government agencies or non-profit organizations.

Figure 8. Priority Sub-Watersheds from 2007 Zumbro Watershed Management Plan

Zumbro River Watershed and Sub-watersheds in SE Minnesota



c) **Measure results.** One advantage of concentrating implementation work in a small area is being able to document change – in peoples' knowledge and attitudes, in land use and adoption of BMPs, and ultimately in water quality as measured by clarity, flow or biology. A system for measuring results should be part of the project design from the outset.

D. Strategies for Regulated Point Sources.

Point sources, for the purpose of this TMDL, are those facilities or entities that discharge or potentially discharge solids to surface water and require a NPDES (National Pollutant Discharge Elimination System) permit from the MPCA. Point sources are required to demonstrate progress toward achieving the Waste Load Allocations prescribed in the TMDL.

In this watershed the point source categories are:

- Wastewater treatment facilities. NPDES permitted discharges for cooling water and industrial wastewater are included in the 'wastewater treatment facilities' category. Each of the wastewater treatment facilities in the watershed has a calendar month average effluent TSS limit ranging from 20 to 45 mg/L TSS. By design of their respective permits, these facilities (listed in Appendix A of the TMDL) help to attain and maintain the turbidity water quality standard in their receiving waters as long as they operate within permit limits. Therefore, operating according to permitted effluent limits is deemed to represent compliance with the TMDL. Monthly discharge monitoring reports to the MPCA and compliance checks by the MPCA help to ensure compliance with permitted effluent limits. Examination of discharge monitoring reports from 2001- 2011 indicates that 18 wastewater facilities in the Zumbro Watershed exceeded the effluent limit for TSS a total of 135 times. The ratio of value reported to effluent limit ranged from 1.1 to 23.33. In 101 cases, the degree of exceedence was less than two times the standard. Many exceedences occurred during floods, according to the MPCA. A report on the exceedences will be provided by the MPCA.

- Construction activities. Regarding construction, the MPCA issues permits for any construction activities disturbing one acre or more of soil; or less than one acre of soil if that activity is part of a "larger common plan of development or sale" that is greater than one acre; or less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources. Although stormwater runoff at construction sites that do not have adequate runoff controls can be significant on a per acre basis (MPCA Stormwater web page, 2006), the number of projects per year in this predominantly rural watershed is relatively small. Therefore, this source appears to be a very minor turbidity source. Regardless, MS4s must have a regulatory program for erosion and sediment control on construction sites that typically involves conducting inspections at active construction sites and, where applicable, enforcing local grading and erosion and sediment control ordinances.

- Municipal (for Rochester urbanized area) stormwater sources. The MS4 program currently regulates storm water activities in a significant portion of the South Zumbro Watershed, including Olmsted County, the City of Rochester, Cascade Township, Haverhill Township, Marion Township, and Rochester Township. In addition to these local government units, MnDOT District 6, the Federal Medical Center and the Rochester Community and Technical College are also MS4 permittees that own and operate storm sewer systems within the Rochester Urbanizing Area. Regarding MS4-permitted stormwater runoff, approximately 34,000 acres (53 square miles) from the City of

Rochester and surrounding urbanized areas drains to the South Fork of the Zumbro River and its tributaries.

The MS4 permit requirements for addressing impaired waters and TMDLs have been changed in the revised general MS4 permit, which will be put on public notice in spring 2012. In both the current and revised permit, the MS4s must decide how to modify their Storm Water Pollution Prevention Program (SWPPP), if needed, to address the waste load allocations stated in EPA-approved TMDL reports. The selected practices may be any combination of structural or non-structural BMPs that make progress toward meeting the approved load reduction goals. The MPCA has added EPA-recommended changes to the revised general permit that will now require MS4s to incorporate their WLA into their permit applications and SWPPPs as a discharge limit. Permittees will also be asked to identify measurable targets, interim milestones and a final date for achievement of the WLA in their SWPPP and to track progress toward meeting their goals in each annual report.
For the Zumbro Turbidity TMDL addressed in this implementation plan, each of the eight MS4s will need to account for the following items:

1. MS4 Permit Reissuance: Estimate the individual MS4 share of the aggregate WLA; describe stormwater reduction BMPs already in place; determine an end date by which the individual WLA will be completely achieved; list and estimate the type and quantity of additional BMPs that will be needed to fully achieve the individual WLA.
2. Implementation Staging: Establish interim milestones of 3-5 years, and list which BMPs or policies (such as new ordinances) will need to be implemented to achieve the TSS load target established for each milestone. For example, policies for developing urban areas may be advantageous to establish and implement in early stages, with retrofitting of build-up areas left for later milestones to allow coordination with city redevelopment planning.

This Plan is not a regulatory document. It does not attempt to define detailed BMPs or schedules for individual MS4s. In addition to the above guidance for MS4 permit reissuance, strategic guidance is available for MS4s located wholly or partially in karst topography, and where the risk is high that infiltration basins will contribute to groundwater pollution. Guidelines to prevent groundwater contamination should be carefully observed. A memo prepared by Barr Engineering as part of the Minimal Impact Design Standards addresses how to design or use alternatives to infiltration basins in less than ideal situations: http://www.pca.state.mn.us/index.php/view-document.html?gid=15663

The TMDL document is not enforceable on its own. The WLAs developed in the TMDL inform the permitting process, and through the NPDES permit program, enforceable discharge limits are included in permits. Those discharge limits become enforceable once coverage under the permit is granted. The MPCA will be developing guidance on how to translate WLAs into discharge limits in MS4 permits. These limits will be included at the time of application for coverage under the MS4 general permit and reviewed by MPCA staff.

MS4 permittees will establish goals for achieving the discharge limits associated with TMDL WLAs at the time of permit application. It is not expected that the MS4 will be able to fully achieve the discharge limit for this TMDL within the current permit cycle; therefore, a compliance schedule will accompany the permit application that includes interim milestones, timelines, and an end date for meeting the discharge limit. Annual reporting to the MPCA as part of the MS4 permit will include an estimated cumulative reduction in pollutant loading from each MS4.

- Regarding industrial stormwater sources, there are thirteen water discharge permit holders in the watershed according to the MPCA's DELTA database. These are mainly gravel pits, and do not appear to represent a TSS loading concern in this watershed if facilities are discharging at permitted TSS limits and design flows. (For the purpose of the TMDL this source is lumped with construction stormwater in a categorical WLA.)

IV: Actions to Implement Strategies

The following action items are designed to implement the strategies described in Section III. They are organized by the three watershed management areas: watershed-wide; headwaters region; sub-watershed lobes; and regulated point sources. Actions that received four or more votes in either of two priority-setting meetings with stakeholders (March 29, 2012) and the Project Advisory Team (May 3, 2012) are underlined; those receiving 2-3 votes are listed in italics.

A. Watershed-Wide Actions

WW Strategy 1: Decrease soil erosion and runoff in rural areas

<u>WW Action 1: Identify and correct major erosion sites</u>

a) From the LCCMR erosion site prioritization project, identify and rank the 50 highest sediment sources among the ravines, stream banks and other sources listed. Group priority sites within watershed lobes: South Fork, Middle Fork, North Fork, and Lower Main Stem.
b) Contact landowners and seek their cooperation in a project to design and implement solutions with cost-share assistance from state or federal funding sources.
c) ZWP in cooperation with LGUs completes grant application for up to four project clusters (one for each lobe).

WW Action 2: Increase the adoption of conservation tillage

a) Conduct watershed-wide transect survey of crop residue cover after planting in 2013 with cooperation of SWCDs and NRCS. Plan to repeat at least every five years.

b) Working through SWCDs and NRCS, determine which reduced tillage systems are working for farmers in each part of the watershed. Include ridge-till, strip-till and no-till operations.
c) Interview practitioners and review University Extension tillage guidelines for southeast Minnesota to determine critical success factors for each system. Use this information to generate an information/education program for local farmers including simple fact sheets, articles in local newspapers, and field tours.

WW Action 3: Soil Loss Limits Ordinances

a) Establish a small group of county and SWCD staff and BWSR to review the use of Soil Loss Limits ordinances in the area (Minn. Stat. 103F.021).
b) Contingent on outcome of (a), plan a watershed workshop exploring local experience with the ordinance, and potential new applications that could be tried. Invite county and SWCD commissioners, supervisors and staff.
c) On workshop evaluation form ask participants their view of developing a soil loss limits ordinance for their county if they don't have one, or changing how it is used if they have one.
d) Publicize results and hold follow-up meeting with county/SWCD staff to determine if there is a need for further action.

WW Action 4: Conservation Compliance Checks

a) Establish a small group of NRCS, FSA, agricultural producers and SWCD if changes that have been discussed for conservation compliance go forward in 2012.
b) Determine the need and value of an information/education program to inform farmers of the changes.
c) If results of (b) are positive, develop and execute an information/education program based on any new emphasis or processes introduced for conservation compliance checks in the region.

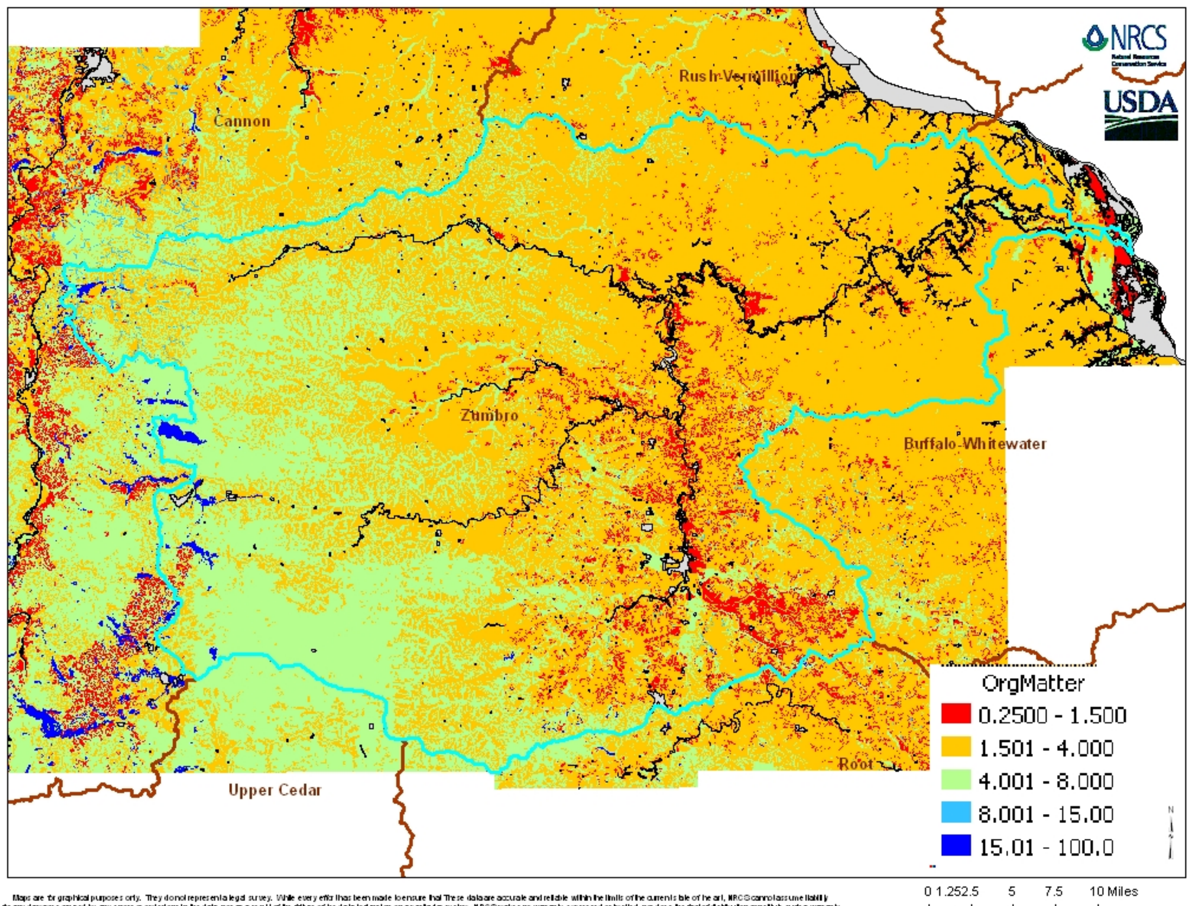
WW Strategy 2: Increase soil infiltration and water-holding capacity

WW Action 5: Increase the adoption of cover crops

a) Confer with cover crop practitioners, Mark Zumwinckle of the Minnesota Department of Agriculture and SWCDs to identify farming niches with a high probability of success – for example, winter rye grass following silage chopping in dairy operations. Determine critical success factors for each niche (.e.g., corn/soybeans, c/s plus peas and sweet corn, dairy with corn silage, etc.).

b) Use information gained in (a) to develop an information/education program with fact sheets, articles for local newspapers, and field days for area farmers. Stay alert for cover crop conferences in the region, and publicize them to watershed farmers through SWCDs.
c) Attempt to measure initial degree of cover crop adoption in high priority niches, and the maximum potential for adoption. Establish 2-year milestones against which to measure future adoption.

Figure 9. Soil Organic Matter Variation Across Zumbro Watershed



WW Action 6: Track Increased Soil Organic Matter and Water-Holding Capacity

a) Solicit partners to measure soil organic matter, water infiltration rates and available water-holding capacity on fields under poor, good and excellent land-use practices. In agriculture, this could mean under moldboard plowing, much-reduced tillage, and much-reduced tillage with cover crop. In urban areas, it could mean poorly maintained lawn, well-maintained lawn, and native prairie. In urban areas, consideration also should be given to modifying development ordinances to add requirements for reversing soil compaction prior to establishing vegetation.

b) Work with NRCS soils specialist in the Rochester area office to calculate the difference in available soil water between contrasting land uses. Determine the type and extent of land-use change needed to achieve water storage equivalent of a large wetland or flood control reservoir.
c) Use this information to establish goals for adoption of very reduced tillage and cover cropping in WW2 and WW3 above.

WW Strategy 3: Maintain Appropriate Vegetation in Riparian Corridors

WW Action 7: Support compliance with county shoreland ordinances

a) Consult shoreland mapping inventory developed with State of Minnesota funding for southeast Minnesota at http://crwp.net/shoreland, or contact counties directly, to determine the extent of compliance with county agricultural shoreland ordinances.
b) Hold a watershed conference to:
    i. Share experience gained by local government units in attempting to increase compliance with shoreland ordinances;
    ii. Explore alternative uses of agricultural shoreland such as haying or wildlife corridor enhancement.
    iii. Explain requirements for setback distances from water bodies for manure application (300 feet) and pesticide spraying (66 feet for atrazine) and how the minimum 50-foot buffer can replace the 300-foot manure application setback and thereby increase the field area available for manure application.
    iv. Develop a strategy for taking the next steps in increasing compliance with shoreland ordinances.
c) Based on outcome of (b), apply for grant to obtain technical assistance needed to assist counties and SWCDs in promoting vegetated buffers along DNR protected waters.
d) Track progress annually against goal of full compliance.

WW Strategy 4: Increase water storage on the land

WW Action 8: Restore drained wetlands and surrounding uplands

a) Develop an inventory of cropped, drained and restorable wetland sites in the Zumbro watershed. Identify hydric soils that are being cropped. Use this database to identify potential wetland restoration sites.
b) Evaluate restoration efforts and priorities at the watershed scale. Identify and target wetlands which, if restored, would provide a high degree of benefit to hydrology, water quality and biodiversity.

c) Based on the above information, and landowner interest, assess the annual need for wetland protection and restoration in the Zumbro Watershed. Evaluate the funding needed to support this degree of protection and restoration. Determine the adequacy of existing funding sources relative to this need.
d) Apply for funding to meet the demonstrated annual need for wetland restoration.

WW Action9: Demonstrate conservation drainage methods

a) In western uplands of Dodge, Steele, Rice and Goodhue counties, work through local SWCDs and the MDA to identify a set of conservation drainage methods -- including alternative drainage ditch designs, water table management through tile outlet controls, and methods of tile drainage that avoid loss of nearby wetlands – suitable for the area.
b) Solicit landowner cooperators to host demonstration projects on their land.
c) Include education and outreach components in projects, and linkage among projects in different counties.
d) Apply for Clean Water Fund grant from BWSR or MDA.

WW Action 10: Construct new and repair old grade stabilization structures

a) Counties and SWCDs are developing inventories of grade stabilization structures in the Zumbro watershed. Inventories should note the age, condition and expected life of structures.
b) Establish Task Force (see Task 4S below) to resolve issues associated with ongoing maintenance of damaged or filled-in structures.
c) Identify areas of highest erosion potential in Zumbro River sub-watersheds. Design a sub-watershed plan to control erosion and provide increased storage of water through a combination of new and repaired grade stabilization structures. As feasible, build in excess water storage capacity beyond normal design parameters for erosion control.
d) Develop sub-watershed proposals to address severe soil erosion and increase water storage capacity to reduce flow of receiving stream at high flows

WW Action11: Evaluate reducing culvert size to store water and reduce flows

a) Work with DNR and SWCD staff to identify areas where culvert size reduction would not impair stream biology. Culverts in perennial streams should be avoided, based on early discussions.
b) Identify upland areas where culvert size reduction appears to be feasible and effective in storing water. Consult with DNR, county highway departments, etc.
c) Consult with staff of Area 2 Minnesota River Basin Projects in southwest Minnesota, on their considerable experience with culvert size reduction to abate flows.
d) Based on this information, develop guidance for culvert size restriction. As feasible, implement at times of road construction to minimize costs. Include the use of V-notch weirs upstream of the culvert as an option for certain situations.

WW Action 12: Evaluate use of reservoirs to reduce flows and control floods

a) Support and participate in studies to evaluate alternative methods of reducing stream flows and flood frequency.
b) Encourage the evaluation of both structural and non-structural alternatives on the basis of cost, effectiveness, and ecological impacts.

WW Strategy 5: Stabilize eroding stream banks & bluffs

WW Action 13: Develop policy and guidance for re-sloping stream banks on private property

a) Host a workshop of farmers, Trout Unlimited, DNR, SWCDs and experts in fluvial geomorphology to discuss whether guidance might be developed which landowners and others could use to stabilize stream banks on their property without the need for licenses, etc.
b) If agreement is reached on feasible guidelines, publicize results to residents with riparian land and inquire about their interest in a stream bank sloping project.
c) Work with landowners to secure funding and expertise to implement stream bank stabilization projects.

WW Action 14: Stabilize bluff tops

WW Action 14: Develop guidance for bluff top stabilization

a) Work with BALMM and the Southeast Minnesota Water Resources Board to host a conference on bluff top protection in southeast Minnesota. Feature bluffland protection ordinances, vegetation and other methods of preventing erosion from bluff tops.
b) Write a report on useful ideas presented or discussed at the meeting and circulate for comment until reasonable agreement is reached. Publicize report to members for use in their own bluffland protection activities.

c) Address ravines eroding from cropland down steep valleys through a combination of water retention and buffer strips along the field at the top of the ravine, piping water from the top to bottom of the ravine, and stabilizing exposed ravine sides with vegetation.

WW Strategy 6: Improve woodland and pastureland management

WW Action15: Forest and Pastureland improvement

a) Determine existing vs. potential adoption of sustainable small woodlot management and management intensive grazing in the blufflands area of the Zumbro Watershed.
b) Identify successful practitioners of small woodlot management and management intensive grazing. Seek their agreement to allow an information kiosk and placards to be placed on the edge of a forest plot or field, for use in self-guided tours by interested individuals and groups.
c) Secure funding for technical assistance to complement staff of SWCD and NRCS offices. Confer with local staff to determine what type of expertise is most needed.

WW Strategy 7: Control runoff from urban areas

WW Action 16: Runoff controls for non-regulated urban areas

a) Promote the use of effective urban storm water BMPs in small communities
b) Provide technical assistance for urban storm water management, such as
    i. Approving grading plans and inspect active construction sites to insure compliance with erosion and sediment control requirements during construction and post-construction storm water management requirements
    ii. Responding to complaints of non-storm water dischargers to their storm sewer system
    iii. Operating and maintaining their storm sewer system to maximize water quality treatment
    iv. Adopting ordinances to increase the amount of tree canopy cover on boulevards and other locations, along with the development of forest master plans
    v. Establishing urban riparian buffers
    vi. Educating staff, citizens and elected officials about storm water management needs and practices.

WW Action 17: Regulated Municipal Separate Storm Sewer System (MS4) Programs

a) Nine entities in the Rochester area must comply with the requirements of the state's MS4 permit. At a minimum, these permit holders must:
   i. Provide education and outreach opportunities;
   ii. Enable public participation and involvement;
   iii. Detect and eliminate illicit discharges (non-stormwater discharges into a storm drain system);
   iv. Implement a regulatory program to control erosion and sediment on construction sites;
   v. Insure that storm water management BMPs are in place once new construction is completed;
   vi. Follow good housekeeping and pollution prevention practices for their municipal operations.
   vii. Follow the approach outlined in Part 3.D of this Plan for incorporating the aggregate WLA for MS4s into individual permits and SWPPPs.

b) Public input received during the development of this Plan resulted in the following recommendations for specific additional practices beyond the minimum permit requirements. Some of the MS4s already address the recommendations. For those that have not been considered, each MS4 should evaluate the applicability of each recommendation for their jurisdiction in the context of their SWPPP and the permit's Maximum Extent Practicable standard.
   i. Make storm water plans more user-friendly for citizens;
   ii. Provide incentives to construct pervious surfaces;
   iii. Change parking lot regulations to reduce the number of parking spaces by eliminating requirements that they be sized for peak-use periods, and
   iv. Provide incentives for rain garden construction and maintenance.

WW Action 18: MPCA Report on Wastewater Treatment Facility Exceedances.

a) Ask the MPCA Rochester office to explain the scope and magnitude of exceedences of wastewater treatment facility effluent permits from TSS.
b) Explore with MPCA means of improving compliance with effluent limits, if necessary.

B: Headwaters Region Actions

HR Action 1: Maintain filter strips along streams and drainage ditches

a) See WW7 above: apply action to headwaters region.
b) Explore status of drainage ditch buffers in western watershed (Dodge, Goodhue, Steele and Rice Counties). ZWP to contact SWCD staff in the four counties.
c) Depending on outcome of (b), conduct a four- county workshop on the process of redetermination of ditch benefits (Minn. Stat. 103E.021) through which the requirement for 16.5 foot grass buffers comes about. Invite land managers from Freeborn and Martin Counties, which have systematically proceeded with redetermination procedures in concert with ditch improvements which benefit water quality and drainage efficiency.
d) Follow up with counties to determine the status of discussions regarding redetermination of benefits.

HR Action 2: Prevent channelized flow on row crop land

a) Follow WW Action 2 above, on conservation tillage.
b) In farm conservation planning, aim to eliminate channel flow from edge of field for design storm by use of conservation tillage, grassed waterways, grade stabilization structures, and other conservation practices. Reducing the frequency of channel flows will improve the effectiveness and maintain the integrity of stream and ditch filter strips.
c) SWCD inventory of grade stabilization structures, underway in 2012, can help to identify conservation structures in need of repair or clean-out. Apply for grant to clean out and repair structures in different lobes of watershed.

HR Action 3: Restore Wetlands

a) Coordinate across counties identifying high priority areas for wetland restoration in county water plans. This will help to ensure that wetland projects that cross county lines will qualify for participation in the Wetland Conservation Act restoration programs.
b) Work with willing landowners and seek funding from USDA, U.S Fish and Wildlife Service and the State of Minnesota for wetland restoration.

C: Major Tributaries &Watersheds

The following set of actions is intended for implementation in the following watersheds: South Fork, Middle Fork, North Fork and Lake Zumbro Dam to Mississippi River.

MT Action 1: Choose priority sub-watershed

a) After the Critical Source Area Study is complete, bring together local unit of government staff, state and federal agency staff, and locally elected officials to discuss options for choosing a priority sub-watershed
    i. Option 1: Keep existing priority watershed listed in the 2007 Zumbro River Watershed Management Plan (Figure 8).
    ii. Option 2: Select criteria for choosing priority sub-watersheds, and apply those criteria to several candidate sub-watersheds, such as those listed above in Section III.C.a. An additional resource available from the EPA is a Recovery Potential Screening Tool for watersheds. Information on the tool is posted at: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/recovery/index.cfm

MT Action 2: Establish Citizen Engagement Process in Priority sub-watershed

a) Identify types of people to form new sub-watershed councils, and invite people who match the descriptions of these types.
b) Assign support staff to work with the sub-watershed councils, including a group facilitator/coordinator, and technical staff who can be called upon as needed.
c) Familiarize sub-watershed council members with water quality and quantity issues in the Zumbro, and invite them to engage in identifying local issues to address. Summarize issues in a brief goal statement.

MT Action 3: Work with Sub-Watershed Councils to develop action plans

a) With guidance from Watershed Council goal statement and related parts of this Plan, SWCD/NRCS offices collect and examine aerial photos of Council member/farmers to identify opportunities for conservation practices. Prepare rough conceptual plans, cost ranges, and other pertinent information to share with the landowners.
b) Meet with small clusters of landowners in the Council (6-10 people) to go over aerial photos and conservation opportunities in a group setting. The goal is for each member to agree to consider or pursue a conservation opportunity on his or her land. (Consult Brad Becker of Dakota SWCD for more information on this approach).

MT Action 4: Work with sub-watershed councils to implement action plans

a) Follow up small-group meeting with one-on-one farm visits to complete conservation planning.

    a. Work with individuals and Watershed Council to obtain cost-share grants to implement conservation plans.

b) Follow up with implementation.
c) Meet with Watershed Council following implementation to show overall results of their activities and to explore how to build on initial conservation investments.

V: Research Needs

Additional research in the areas of hydrology, sediment source identification and aquatic life is needed to improve our understanding of watershed dynamics, provide metrics for the three indicators used in the Plan, and allow more precise targeting of efforts to improve water quality. Each of these three topics will be discussed in turn. Their sequence in the narrative does not imply degree of importance or urgency.

A: Hydrology Research Needs

Hydrology is closely linked to the water cycle as it operates within a limited area, often a watershed of small or large size. The water cycle shows how precipitation falls on the land or on surface water, and in large part is routed back to the atmosphere through evaporation and transpiration, leaving the remaining water from the precipitation budget to be routed to lakes and streams (surface water) or groundwater (shallow or deep aquifers). Watershed models that attempt to correlate land uses with water quality depend upon an accurate, quantitative depiction of hydrology in order to produce accurate water quality predictions. This is because hydrology – the movement of water in time over space – is what primarily determines the quality and magnitude of land use-water quality relationships. Its understanding is fundamental to watershed management.

Regional trends in hydrology are discussed elsewhere in the Plan (I-c and II-2). Historically, high-flow events have been concentrated in spring and early summer, when precipitation is highest and evapotranspiration is at its lowest owing to cooler temperatures and scant vegetation on annual row-crop fields. In recent years, especially 2007 and 2010, unusually heavy and intense rainfall has led to severe flooding in August and September. This shift in the pattern of precipitation has been noted elsewhere in agricultural watersheds of southern Minnesota, especially in the Minnesota River Basin (Engstrom & Schottler, 2011).

Research is needed to determine whether the trends in precipitation, hydrology and channel erosion observed elsewhere in southern Minnesota apply to the Zumbro Watershed, and, if so, how the magnitude of change in the Zumbro compares to neighboring watersheds. The following are some of the research needs related to hydrology; others are likely to become apparent as more is learned from hydrology-related investigations.

Task 1H: Quantify the water budget for the Zumbro River Watershed, and hydrologic components thereof. Items needing quantification include precipitation, evapotranspiration, surface runoff from urban and rural land, interflow (whether naturally through soil or through tile drains), shallow groundwater and deep aquifer recharge. The presence of long-term monitoring stations will dictate where water budgets can be conducted.

Task 2H: Test the hypothesis of changing precipitation patterns and flows over time through the analysis of historical precipitation and stream flow monitoring data. The pattern of change that emerges from this initial investigation will set the stage for further investigations, such as determining the main causes for increased flows, whether increased flows are resulting in more stream channel erosion, and whether sediment loads are increasing even though sediment concentrations have fallen over time, as is indicated by trend data for the South Fork monitoring station between Rochester and Lake Zumbro.

Task 3H: Evaluate the role of soil organic matter (SOM) in storing water on the landscape and thereby altering the water cycle in such a way as to moderate surface runoff and stream flows. Evaluate which areas have the greatest potential for increased SOM, how an increase in SOM could be effected through land-use change, and the volume of increased water storage that could be expected to result.

Task 4H: Develop a watershed hydrologic model capable of predicting how the full range of stream flows (the hydrograph of the stream) would likely be affected at critical locations (those subject to high risk of flooding and flood damage) by alternative measures to reduce flows in upstream tributaries. Evaluate a range of structural (wetland restoration, flood retention reservoirs, grade-stabilization structures, etc.) and non-structural (changes in vegetation, farming practices, urban & rural settlement patterns, flood plain occupancy, etc.) measures. The effect of changing the capacity of bridges and culverts and road ditches should also be evaluated using a process similar to that used to develop the South Fork Zumbro Capital Improvement Project Plan. These alternatives would then be compared against each other based on community support, initial capital costs, maintenance costs and effect on stream flow, stream hydrology at critical points, and estimated flood damage. Hydrologic analysis would be combined with economic optimization to develop a recommended strategy for flood hazard abatement. Impacts on sediment loads would be evaluated through scenarios developed in 5S below. The modeling system would be able to evaluate trade-offs among alternative structural and non-structural measures to enable flexibility in execution of any plan that might be developed. In practice, an integrated system of models rather than a single one will likely be needed: a hydraulic model such as XP-SWMM (XP Software Co.) combined with a hydrologic model such as HEC-HMS (U.S. Army Corps of Engineers), a land-use watershed model such as SWAT (Agricultural Research Service, U.S. Department of Agriculture), and an economic model or spreadsheet.

B: Sediment Research Needs

Sediment moves from the land surface to surface water through a series of interconnected events. The better these events are understood in the specific context of a watershed, the higher the quality of interventions that can be brought to bear on reducing sediment loads to streams. The following sequential events affect soil erosion, deposition and resuspension:

Detachment. Rainfall, snowmelt and wind are the primary means by which sediment particles become detached from the soil matrix. The movement of machinery over the land, whether for constructing a commercial or residential development or for tilling the soil, often entails both pulverization of soil aggregates into detached individual particles, and physical movement of the detached particles with earth-moving equipment. In rural areas, cropland with surface residue cover of 30% or greater reduces particle detachment from wind, rainfall and snowmelt. In urban landscapes, areas covered with grass or tree canopy reduces sediment particle detachment.

Mobilization: The next step in sediment transport is the mobilization of detached particles by water or wind. The movement of soil particles over the land surface is called erosion. The degree of soil erosion by water movement depends on factors such as soil type and structure, field slope and the duration, intensity and amount of precipitation. Land use practices which reduce sediment particle detachment also may reduce soil erosion. Conservation tillage is a prime example. Surface residue both breaks the impact of soil-shattering rain drops and creates tiny dams scattered haphazardly across the field surface, thereby preventing soil erosion. Contour farming in which alternative grass/legume strips and untilled crop stubble are configured perpendicular to the slope, utilize crop rows as miniature terraces or grade stabilization structures which, managed properly, prevent the mobilization of detached soil particles.

Transport: Once mobilized, detached soil particles remain in transport until physical impediments or a reduced surface gradient diminish the energy of moving water or wind and their potential to transport soil particles. Water erosion typically begins as a sheet moving over the land surface until sufficient water has gathered to coalesce into tiny rills. When several rills run together, channel erosion begins: first with temporary (or ephemeral) gullies that are small enough to disappear after tillage; then with gully erosion; and then on to deeper and wider gullies which often extend past the edge of fields into hillside ravines. Ravine erosion is common in the eastern karst topography where fields atop plateaus discharge water from gullies into ravines, which carry large volumes of runoff down steep slopes that line the valleys of many tributaries.

Deposition: Eroded soil particles may be deposited anywhere along the transport route. Deposition occurs when the velocity of runoff water slows to the point that its kinetic energy is no longer sufficient to carry particles of a given size. As runoff slows, larger sand particles settle out first, followed by silt and clay particles of progressively smaller size and mass. The art and science of erosion control deals with the design of impediments to water runoff all along the transport route. Many soil and water conservation professionals prefer to impede runoff as close to its origin as possible. Installation of BMPs in small upland catchments prevents the formation of large gullies and ravines that can be much more costly to deal with.

Collapse of near-channel sediment aggregates. Recent and ongoing research on sediment sources and pathways in south central Minnesota has identified sediment sources near the stream channel as being of increasing significance over the past 70 years or so. Research has shown that in the Minnesota River basin, approximately two thirds of the sediment load discharged to the Mississippi River originates from near- channel sources: ravines, river bluffs or stream banks (Schottler, 2012; Wilcox, 2009). Near-channel sources appear to be increasing primarily in response to increased river flows. The mechanism is roughly as follows. River flows have increased mainly in response to changes to the landscape in the form of reduced perennial cover, increased row crops and near-complete coverage with artificial drainage networks of surface ditches connected to subsurface drainage tile lines. These man-made changes to the land, undertaken in order to improve agricultural productivity, have inadvertently altered the water budget such that less precipitation evaporates from wetlands, which have been drained, making more water available for either groundwater infiltration or surface runoff. Considerably less water infiltrates the soil into shallow-groundwater, while a greater proportion of precipitation is shunted rapidly to streams through the drainage network. As a result, stream channels that formed over thousands of years to accommodate runoff conditions associated with pre-settlement, wetland-rich prairie conditions, now are being overwhelmed with higher volumes of water delivered much quicker from field to stream. Greater erosive energy is applied by the stream current to stream banks and bluffs. The resulting channel instability and bluff collapse has been observed in southeast Minnesota streams. However, no studies have yet been conducted to determine the proportion of river sediment loads that originate from fields vs. near-channel sources, and how this proportion has changed over time, in the Zumbro watershed. Considerable data on channel shape and stability have been gathered for the turbidity TMDL, which can be used to evaluate near-channel sediment sources in the eastern karst and the western Corn Belt plain ecosystems of the Zumbro watershed.

Re-suspension: Detached particles that are mobilized by field runoff often are deposited along the runoff route either in the field, behind a stabilization structure, in the river floodplain, in slack-water areas of the river itself, or on stream banks. Soil particles in depositional areas of the land surface, drainage conveyances and streams become resuspended when the energy of flowing water is sufficient to detach, mobilize and transport them. The process of deposition and re-suspension occurs repeatedly. The largest particles, sand, tend to shuffle along the ditch or stream bottom as bed load. Shifting sand depositions may have little impact on water clarity, but significant impact on the breeding habitat needed by fish and the aquatic insects they feed on. Fish requiring cobble for successful reproduction are likely to move to more favorable locations if sand or silt continually embeds the spaces between pebbles on the stream bed. Silt and clay particles are more readily resuspended and transported downstream than sand particles. These particles contribute to turbidity impairment and, in slack water portions of streams, may cause cobble areas to become embedded.

The following research tasks are recommended based on the foregoing description of sediment transport, as applies to the Zumbro River and its watershed:

Task 1S: Using the modeling system developed under Task 4H, above, develop estimates of sediment loads for each of the four watershed lobes (South Fork, Middle Fork, North Fork, Lower Main Stem) based on historical stream monitoring data. Conduct trend analysis to determine whether flows and sediment concentrations and sediment loads are increasing, decreasing, or staying about the same. Summarize results in a report.

Task 2S: Conduct analysis of two to three Lake Zumbro sediment cores to determine the rate of sediment accumulation in Lake Zumbro from 1911 (date of construction) to present. In addition, conduct "sediment fingerprinting" analysis by measuring radionuclide concentrations in the sediment core samples to estimate the proportion of the sediment load to Lake Zumbro originating from surface vs. non-surface (near channel) sources. Typically, the radioactive compounds utilized in such research are cadmium, beryllium, lead and other compounds which have been deposited on the earth surface from the atmosphere either as a result of natural processes or hydrogen bomb testing in the mid-twentieth century. These compounds have a long half-life; hence their concentration in a sediment core sample indicates the preponderance of sediment originating from the land surface, generally defined as the upper 10 inches of the soil profile. Sediment originating from deeper in the soil profile often have no trace – or a very small trace – of isotopes from atmospheric fallout. For more information on this research method, and results obtained for south-central Minnesota, see: http://www.smm.org/static/science/pdf/scwrs-2010fingerprinting.pdf

The results of this research will help to determine on a broad-scale basis whether the traditional focus on field erosion as a source of sediment needs to be complemented with a sharper focus on near-channel sediment sources: ravines, stream banks and stream bluffs.

Task 3S: Use Geographic Information System information supplemented with LiDAR (Light Detection and Ranging) where appropriate to identify approximately 50 of the highest-contributing sediment sources to the Zumbro River and its tributaries. (See WW Action 1) This task will allow local units of government to begin addressing some of the most significant sediment sources that are contributing to turbidity impairment, before longer-term research aimed at improved understanding of hydrology and sediment movement at a watershed-wide scale has been completed. Funding has been secured from the Legislative and Citizens Commission on Minnesota Resources (LCCMR) for this project. Follow-on research to design abatement practices for the 50 high priority sediment sources also will be needed.

Task 4S: SWCDs in the watershed are developing an inventory of grade-stabilization structures (WW Action 10). Grade stabilization structures are widely used by the NRCS and SWCDs to reduce the length of a long slope subject to high erosion rates. The structures are designed, somewhat like terraces, to arrest the flow of runoff with an earthen detainment structure -- a small dam. Behind the dam is enough storage space to allow receiving water to settle out whatever sediment might be suspended in the surface runoff. Thus, these structures are essentially designed to fill up with sediment over time. Structures that have been in place for more than 20 years are often in need of sediment cleanout and associated maintenance. However, the cost-share agreements that helped landowners to pay for the initial structures state that the landowner is responsible for maintenance, which can be expensive. A plan is needed to make landowners aware of their obligation to maintain grade stabilization structures, while providing technical and economic support as needed to get the job done. It is recommended that a task force be established to find a resolution to this problem.

Task 5S: Estimate the relationship between stream flow and sediment load in three to six minor watersheds representing the main topographic features of the Zumbro Watershed. This information will help to determine the degree of flow reductions needed to achieve sediment load targets, besides placing flow at the center of implementation strategy development which is important for sediment reduction and flood hazard reduction objectives.

Task 6S: Estimate the effect of alternative land uses on water storage, of changes in water storage on stream flow, and of changes in stream flow on TSS loads. Examples of land uses that may be so evaluated are:

a) Current land use baseline: 2006 GIS land cover or later.
b) Extrapolate current trends (increased urbanization, less dairy, increased row crops, less hay and pasture, reduced CRP)
c) Moderate BMP implementation – conservation tillage, vegetated riparian buffers, maintain current wetlands and CRP, low-impact urban development, etc.
d) Soil quality improvement: increase soil organic matter content by, say, one percentage point in critical areas of the watershed through rural and urban prairie and wetland restoration and increased use of no-till farming with cover crops.
e) Other land-use scenarios that may be suggested by landowners, city and county water planners.

Results of these analyses would be incorporated into the SWAT model (see Task 4H) to create alternative scenarios. The scenarios would be evaluated against the dual objectives of sediment-load reductions for the turbidity TMDL, and river flow targets established for flood damage reduction.

C: Aquatic Life Research Needs

The quality of the Zumbro River and its tributaries with respect to fish and other aquatic organisms is subject to ongoing investigation in 2012-2013. The results of this analysis, based on monitoring samples taken by the MPCA, will not be ready until 2014 at the earliest. The following assessment of research needs is likely to change, based on findings of ongoing research.

This being said, it is possible to list a number of research needs based on existing knowledge of fish and aquatic insect populations in various parts of the stream network, and based on watershed management activities described earlier. We can expect activities undertaken in the three different regions of the Zumbro watershed to have different kinds and degrees of impacts on aquatic life. For example, activities undertaken to reduce stream flows in the headwaters region of the Zumbro watershed will improve downstream habitat conditions for sport fish such as small mouth bass and trout. However, we do not expect a notable improvement in fish species composition or individual fish populations in the headwaters region itself, owing to structural limitations such as low stream gradient, consequent siltation of the stream bed, and high water temperatures.

In the third watershed region, the floodplain of the major tributary channels and the main stem downstream of Zumbro Falls, likewise, we might expect improvements from flow-abatement strategies taken in the uplands in the form of more moderate flows and less frequent flooding. These improvements would enhance the quality of recreational opportunities on the larger tributary channels and main stem, such as canoeing, swimming, wildlife watching, and riverside camping. However, we would not expect dramatic improvements in fish species composition, or in the population or range of individual fish species, owing again to structural constraints such as low stream gradient and higher stream temperatures.

In is in the second, middle, range where efforts can be focused specifically to enhance the fishery – the range, population, or species mix of desirable fish species in the Zumbro. In this middle range of the river, stream gradients are steeper and currents flow fast enough to prevent sand and silt from settling on cobble breeding beds. The streams cut down into deeper aquifers for base flow, creating colder water in summer months. Since colder water holds more oxygen, conditions are more congenial to a greater range of fish species in warm and cool-water streams. Small tributaries that cut through cold-water aquifers such as the Prairie du Chien or Jordan often are cold enough to support trout populations: brown trout in the marginal cold-water streams and self-reproducing populations of brook trout (a native species to the region) in prime habitat stretches.

Our present research needs are focused on better characterizing current conditions and then assessing the potential for improvement of stream reaches in the second, or middle, category.

Task 1F: Index of Biotic Integrity (IBI). Goals for streams in each of the fork tributaries, and the lower main stem, should be established based on IBI scores for fish and macroinvertebrates in cold and warm-water streams. The MPCA will undertake monitoring in 2012 and 2013, coordinating with the DNR where possible, to establish baseline IBI scores. An expert team will be assembled to propose technically feasible future IBI scores for use as goals, to be reviewed by the PAC before being inserted into the comprehensive watershed management plan.

Task 2F: Select Priority Stream Reaches. After IBI monitoring is completed and interpreted, it will be combined with other factors such as public interest, accessibility and feasibility to select priority stream reaches for restoration. However, considering that the IBI research will take several years to complete, provisional priorities will be based on best professional judgment, public interest and feasibility. Three such sites proposed by the aquatic habitat sub-committee are:

• South Fork Zumbro from 37th Street bridge to 75th Street bridge. A project could include removal of an unused bridge that creates frequent logjams, and installing a boat landing at the red bridge and at 37th Street to improve public access.

• West Indian Creek at Whippoorwill Campground, where a habitat and bank improvement project is planned to begin in spring of 2012. Water temperature, IBI scores and soil loss will be monitored before and after by project partners (Trout Unlimited, DNR,). This site can be used to learn what kind and degree of improvements can be expected from stream restoration practices on trout reaches.

• Cold Spring Brook, upstream of Zumbro Falls. Similar to the West Indian Creek project, this project will involve monitoring of temperature, biota and soil loss before and after stream channel improvements in a trout stream reach. It, too, is proposed as a source of information on improvements that can be expected from stream restoration practices for trout reaches.

Task 3F: Determine flow-reduction goals. Since fish and macroinvertebrate habitat are strongly affected by abnormal stream flows, it is important to determine the extent of flow reductions needed to achieve more stable stream channel conditions. To this end, it is recommended that a research project be designed and implemented to determine goals for stream flow at critical sites in the Zumbro River network. Possible approaches include hydraulic and hydrologic modeling, or examining flow data to determine the current frequency of bank-full flows so that this can be compared to a "normal" return frequency of 18 months, which would serve as a flow goal. Bank-full flows are key, as they are the flows that most strongly determine stream channel evolution. A normal frequency of bank-full flows could be expected to eventually lead to a normal rate of stream channel evolution.

Task 4F: Identify cold-water reaches with a history of healthy insect hatches (midges, mayflies, etc.), but which now lack significant hatches to attract trout in large numbers. Conduct field research to determine which ones have been impaired by sediment deposition. Consider possibilities for restoration of robust insect hatches.

Task 5F: Involve school students in research projects as feasible. (More detail)

Task 6F: Determine the influence of tile drainage outfall on water temperature of receiving streams. DNR has anecdotal evidence of a cooling effect on streams creating microhabitat favorable to certain cool water species.

Task 7F: **Explore DNR work on spring-shed mapping** (Jeff Green) in the Zumbro for its possible applicability to identification of areas for priority protection or restoration.

VII: Water Quality and Quantity Monitoring

The goals of monitoring are to (1) provide information on water quality conditions relative to applicable standards; (2) measure progress toward TMDL-related goals including water quality standards and pollutant loads, and (3) inform and guide implementation activities. Particularly important facets of monitoring when considering aquatic life use support are long-term collection of flow, turbidity, TSS and transparency data and periodic assessments of aquatic biota and associated habitat. Monitoring in the Zumbro River watershed provides a strong base of multi-purpose information, including that which supports these critical components.

Following are the major components of current and planned water quality and quantity monitoring.

1) **Long-term stream gauges:** The U.S. Geological Survey has operated gauges at Kellogg (05374900), Zumbro Falls (05374000) and Rochester (05372995). They continue to maintain the Rochester site, while the Minnesota Department of Natural Resources (DNR) now operates the

gauge at Kellogg. The station at Zumbro Falls is a stage-only site. Together, these records extend back to the early 1900s, although none of the three is continuous. The monitoring records associated with these sites may be accessed at the following web locations:

a) http://waterdata.usgs.gov/mn/nwis/uv?site_no=05379000 (Kellogg)
b) http://waterdata.usgs.gov/mn/nwis/uv?site_no=05374000 (Zumbro Falls)
c) http://waterdata.usgs.gov/mn/nwis/uv?site_no=05372995 (Rochester)

2) **Flood warning gauges:** The DNR maintains flood warning gauges upstream of Rochester: Bear Creek (41051001), Cascade Creek (41064001), Silver Creek (4105001), and South Fork Zumbro River (41061001). There is also one site upstream of Wanamingo (41010001) and a new site on the South Branch of the Middle Fork Zumbro River upstream of Pine Island (41015001). The latter site was established in 2006. All of these records can be reviewed at the Cooperative Stream Gauging interface maintained by the MPCA and DNR: http://www.dnr.state.mn.us/waters/csg/index.html.

3) **Long-term comprehensive monitoring stations:** The MPCA monitors sites at West Indian Creek (S004-452), Milliken Creek (S004-486), and the South Fork Zumbro River (S003-802). Regular monitoring includes grab sampling and continuous recording of turbidity and temperature. The MPCA maintains the West Indian Creek and the Milliken Creek gauges. The site on the South Fork of the Zumbro River (S003-802) is just downstream of a USGS site (05372995) and very near the MPCA Milestone site (S000-268), which will no longer be monitored. At West Indian Creek, the DNR performs annual surveys of fish and aquatic macroinvertebrates in addition to scheduled surveys of stream geomorphology and habitat measures.

4) **Citizen Stream Monitoring Program:** As of April, 2011, 51 active volunteers in the Zumbro River watershed monitor stream transparency on a regular basis at fixed sites.

5) **MPCA load-monitoring network:** The Zumbro River at Kellogg (05374900) is sampled by the MPCA on a regular basis, to allow for the computation of pollutant loads, including for TSS. This sampling is long term and will allow for trend analysis of overall sediment load and yield from the watershed.

6) **Aquatic Biota Monitoring**:
   a) DNR mussel survey: Several watershed mussel surveys have been completed. The most recent survey was completed in 2010, and included 77 sites.
   b) DNR fish surveys: Several reaches in the Zumbro River watershed are assessed by DNR Fisheries. Reports for the Middle Fork and South Branch Middle Fork were completed in 2009. These assessments are long-term, being repeated at roughly __-year intervals.
   c) Intensive Watershed Monitoring (IWM): MPCA staff will execute an intensive monitoring effort in the Zumbro River Watershed in 2012 and at 10-year intervals thereafter. This

design will provide comprehensive assessments of various designated uses, including aquatic life (sampling of fish and aquatic macroinvertebrates) at approximately 90 sites distributed throughout the watershed. A primary goal of the IWM design is to allow for benchmarking with other watersheds, and tracking progress toward improved water quality.

7) **USGS sediment site at Kellogg**: The MPCA and USGS have cooperated to provide monitoring of various sediment parameters (TSS, turbidity, and suspended sediment concentration; and in the future, bed load) at the Zumbro River at Kellogg (05374900). This monitoring effort is designed to improve our understanding of sediment dynamics and movement in the river system.

8) **Best Management Practice Implementation:** The installation and maintenance of BMPs is tracked for the state by SWCDs using the ELink reporting system. The NRCS uses the federal Performance Results System. Both SWCDs and NRCS in some counties track tillage trends using a crop residue transect survey method developed by the Conservation Technology Information Center at Purdue University.

9) **Future Monitoring:** The most distinct omission from the above list of monitoring activities is field scale or very small watershed monitoring to evaluate the effectiveness of alternative land-use practices.

Taken together, these monitoring components will allow for tracking of water quality trends, computation of TSS loads at various watershed scales, and regular assessment of aquatic biota. There are sufficient data to execute trend analysis at some sites (preliminary trend analysis completed by the MPCA has documented statistically significant decreasing trends in TSS concentration at the Milestone site (S000-368)). River flow patterns and trends can be analyzed using date from the USGS and DNR flow gauges. Overall watershed TSS yield will be closely tracked in the future. Volunteers will continue to monitor transparency at numerous sites in the watershed, allowing for potential trend analysis in coming years. Local government units record BMP implementation – information that can be paired with water quality trend analysis. In 2012, a more comprehensive assessment of aquatic life use support in the watershed will begin; this will provide further guidance in planning and project design. In 2022 intensive watershed monitoring will be repeated, allowing comparisons to be made at sites throughout the watershed. If successful, biotic monitoring will provide a direct indication of the status of aquatic life, rather than indirect measures using turbidity, transparency of TSS.

For purposes of TMDL implementation monitoring, TSS load monitoring at the small watershed scale (Milliken Creek and West Indian Creek); watershed lobe scale (South Fork site north of Rochester) and the whole Zumbro watershed (Kellogg site) are particularly pertinent. Since Milliken Creek and West Indian Creek currently are priority watersheds, the effects of intensive implementation efforts can be monitored over time at a scale small enough to detect cause-effect relationships. The South Fork and Kellogg sites will indicate whether TSS loads are increasing or decreasing at larger scales. This is important to determine, as it is possible that decreasing concentrations at the South Fork site have been accompanied by increased flows, keeping TSS loads high. Ultimately, biological monitoring should prove to be the best indicator of water quality, as it directly measures the health of aquatic life.

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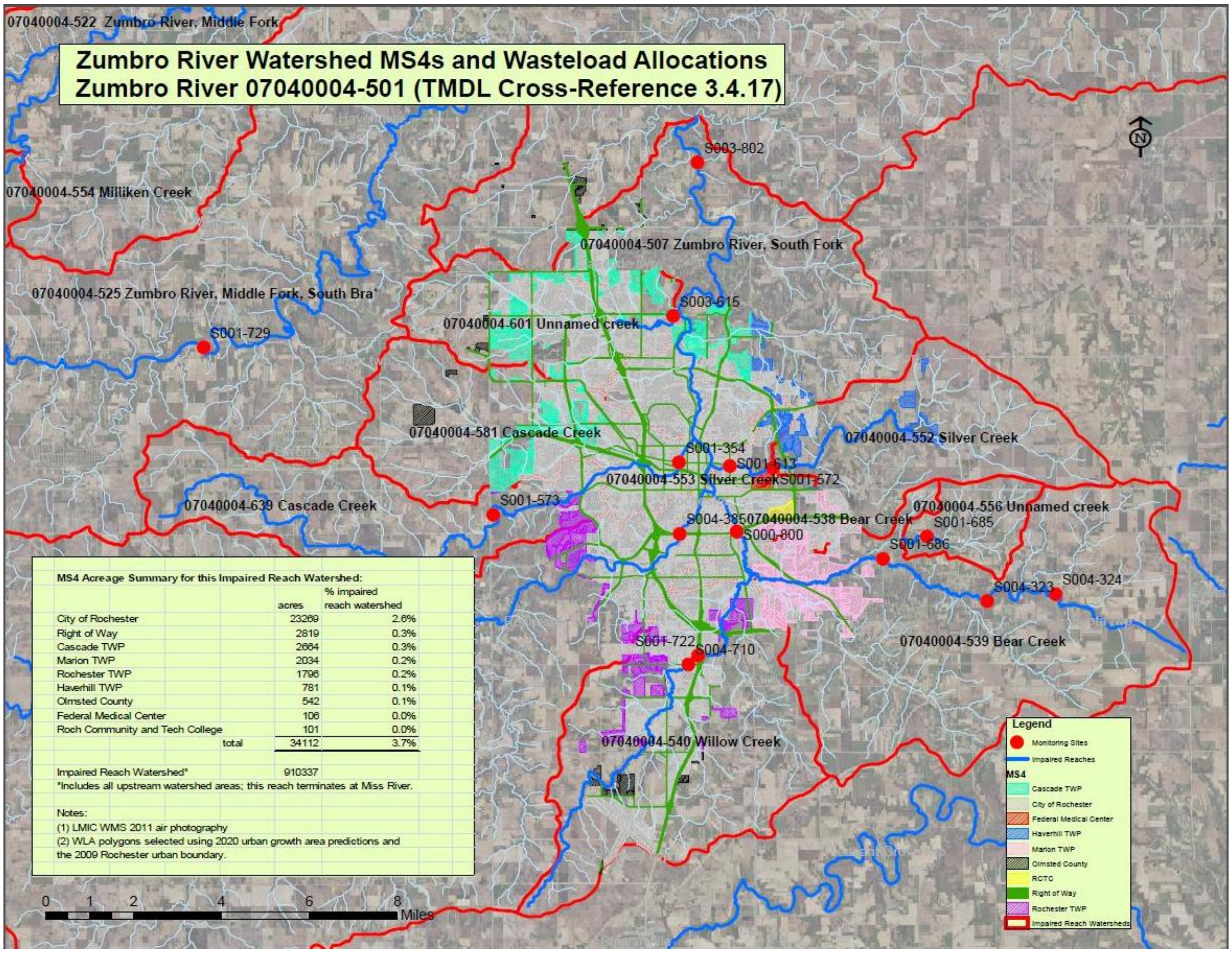
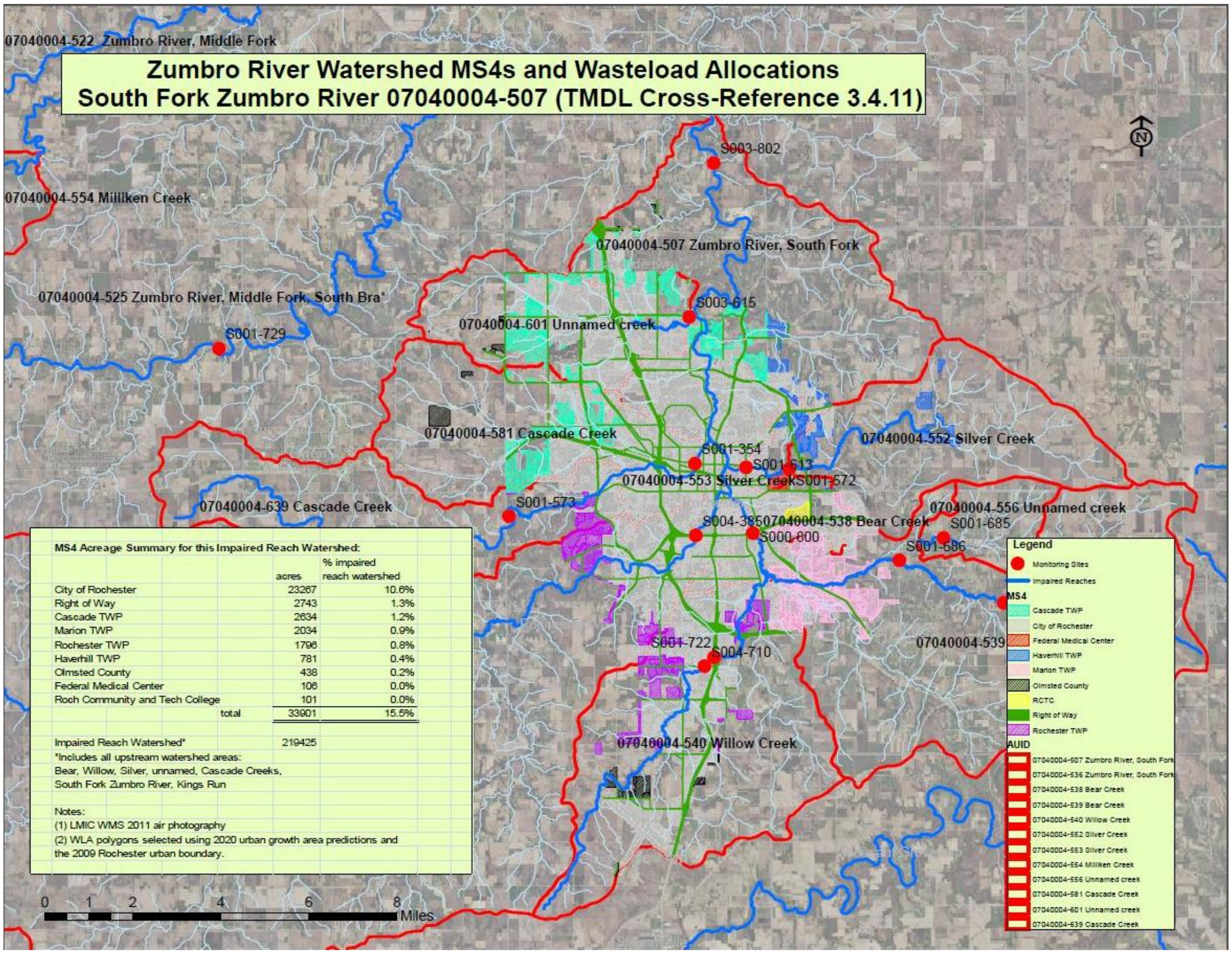
APPENDIX



Zumbro River Watershed MS4s and Wasteload Allocations
Zumbro River 07040004-501 (TMDL Cross-Reference 3.4.17)
07040004-522 Zumbro River, Middle Fork
07040004-554 Milliken Creek
07040004-525 Zumbro River, Middle Fork, South Bra
S001-729
S003-802
07040004-507 Zumbro River, South Fork
S003-615
07040004-601 Unnamed creek
07040004-581 Cascade Creek
07040004-552 Silver Creek
S001-354
S001-613
07040004-553 Silver Creek
S001-572
07040004-639 Cascade Creek
S001-573
S004-385
07040004-538 Bear Creek
S000-800
07040004-556 Unnamed creek
S001-685
S001-686
S004-323
S004-324
07040004-539 Bear Creek
S001-722
S004-710
07040004-540 Willow Creek
MS4 Acreage Summary for this Impaired Reach Watershed:
acres
% impaired reach watershed
City of Rochester 23269 2.6%
Right of Way 2819 0.3%
Cascade TWP 2664 0.3%
Marion TWP 2034 0.2%
Rochester TWP 1796 0.2%
Haverhill TWP 781 0.1%
Olmsted County 542 0.1%
Federal Medical Center 106 0.0%
Roch Community and Tech College 101 0.0%
total 34112 3.7%
Impaired Reach Watershed* 910337
*Includes all upstream watershed areas; this reach terminates at Miss River.
Notes:
(1) LMIC WMS 2011 air photography
(2) WLA polygons selected using 2020 urban growth area predictions and the 2009 Rochester urban boundary.
0 1 2 4 6 8 Miles
Legend
Monitoring Sites
Impaired Reaches
MS4
Cascade TWP
City of Rochester
Federal Medical Center
Haverhill TWP
Marion TWP
Olmsted County
RCTC
Right of Way
Rochester TWP
Impaired Reach Watersheds

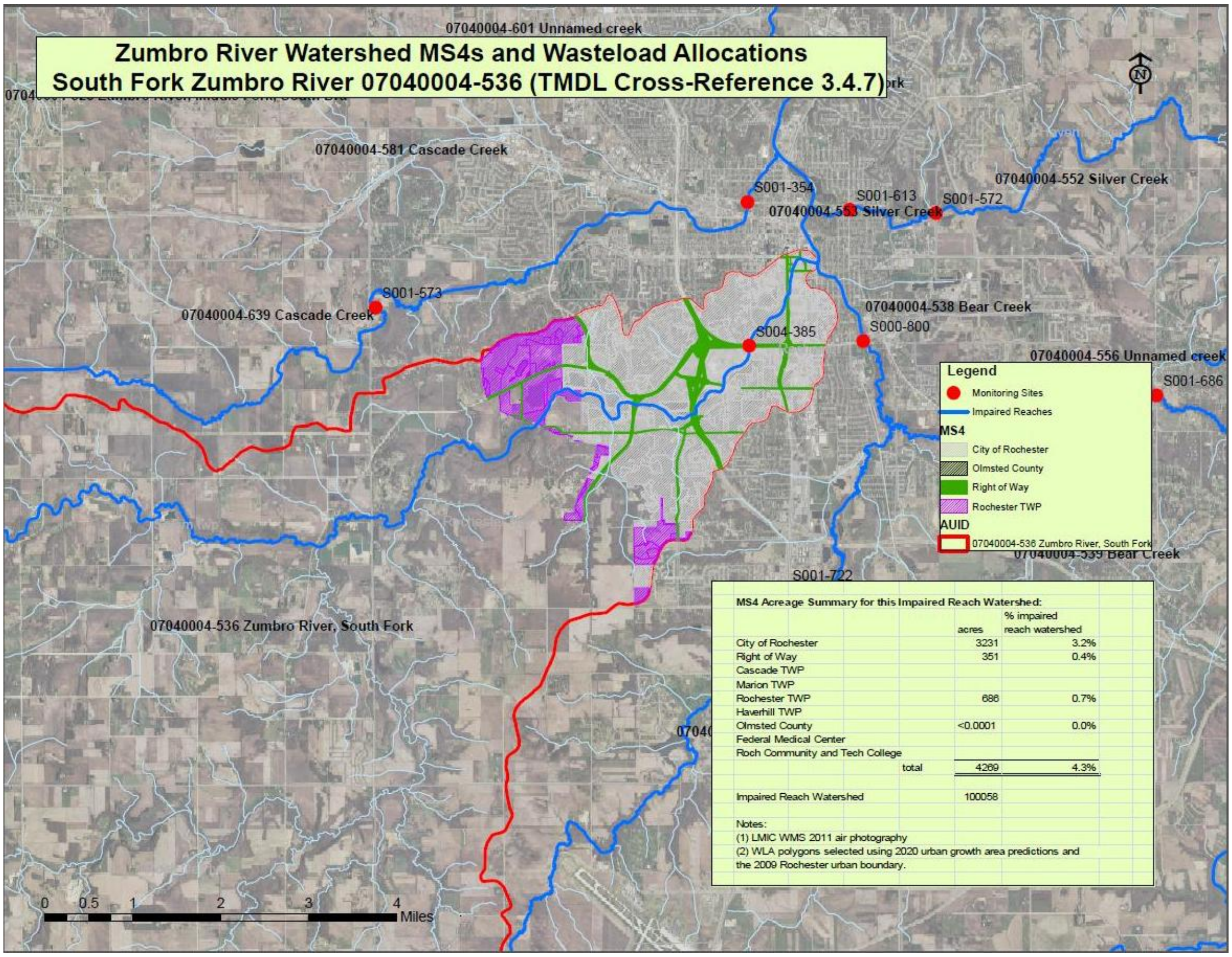


MS4 Acreage Summary for this Impaired Reach Watershed:

	acres	% impaired reach watershed
City of Rochester	23267	10.6%
Right of Way	2743	1.3%
Cascade TWP	2634	1.2%
Marion TWP	2034	0.9%
Rochester TWP	1796	0.8%
Haverhill TWP	781	0.4%
Olmsted County	438	0.2%
Federal Medical Center	106	0.0%
Roch Community and Tech College	101	0.0%
total	33901	15.5%
Impaired Reach Watershed*	219425	

*Includes all upstream watershed areas:
Bear, Willow, Silver, unnamed, Cascade Creeks,
South Fork Zumbro River, Kings Run

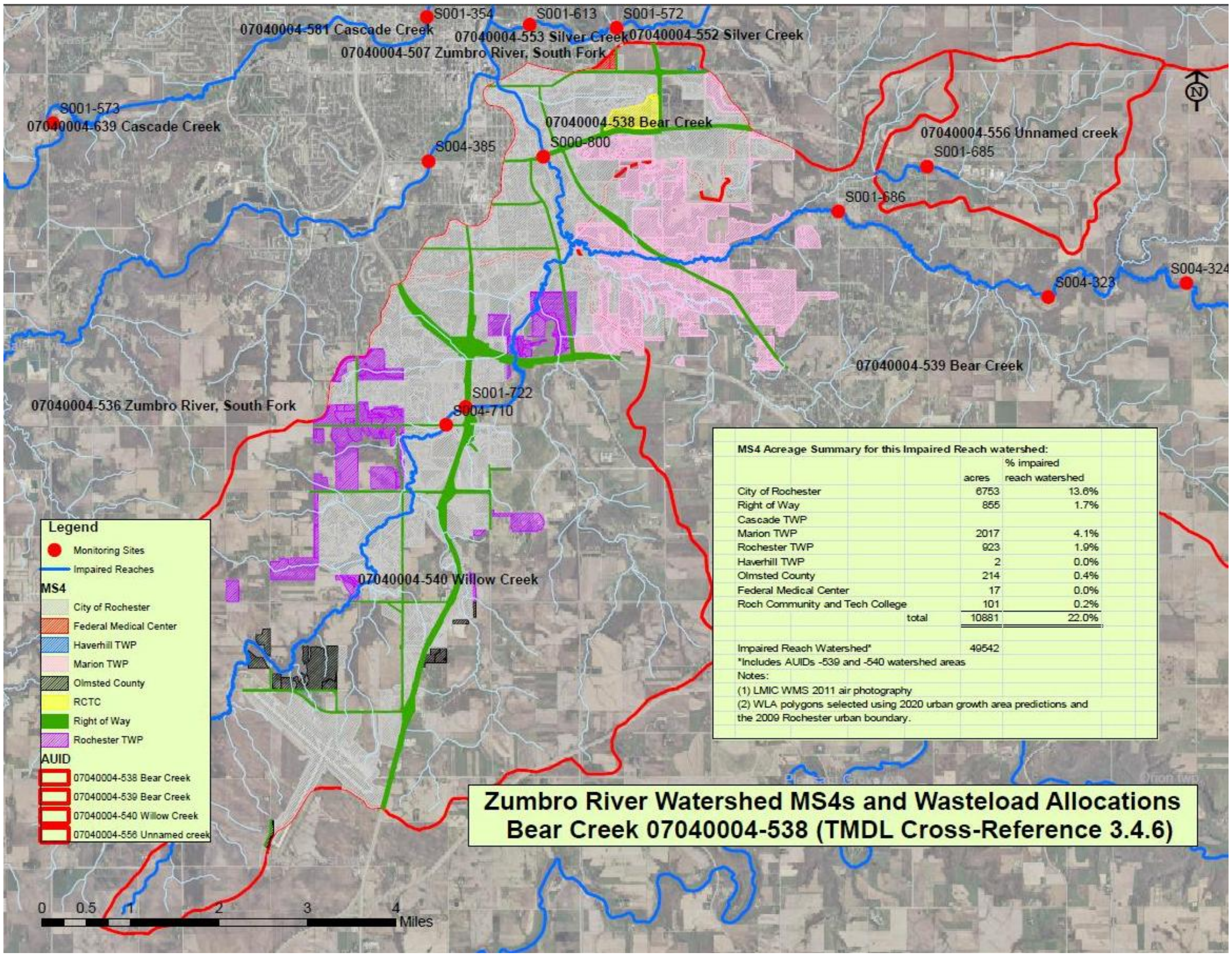
Notes:
(1) LMIC WMS 2011 air photography
(2) WLA polygons selected using 2020 urban growth area predictions and the 2009 Rochester urban boundary.

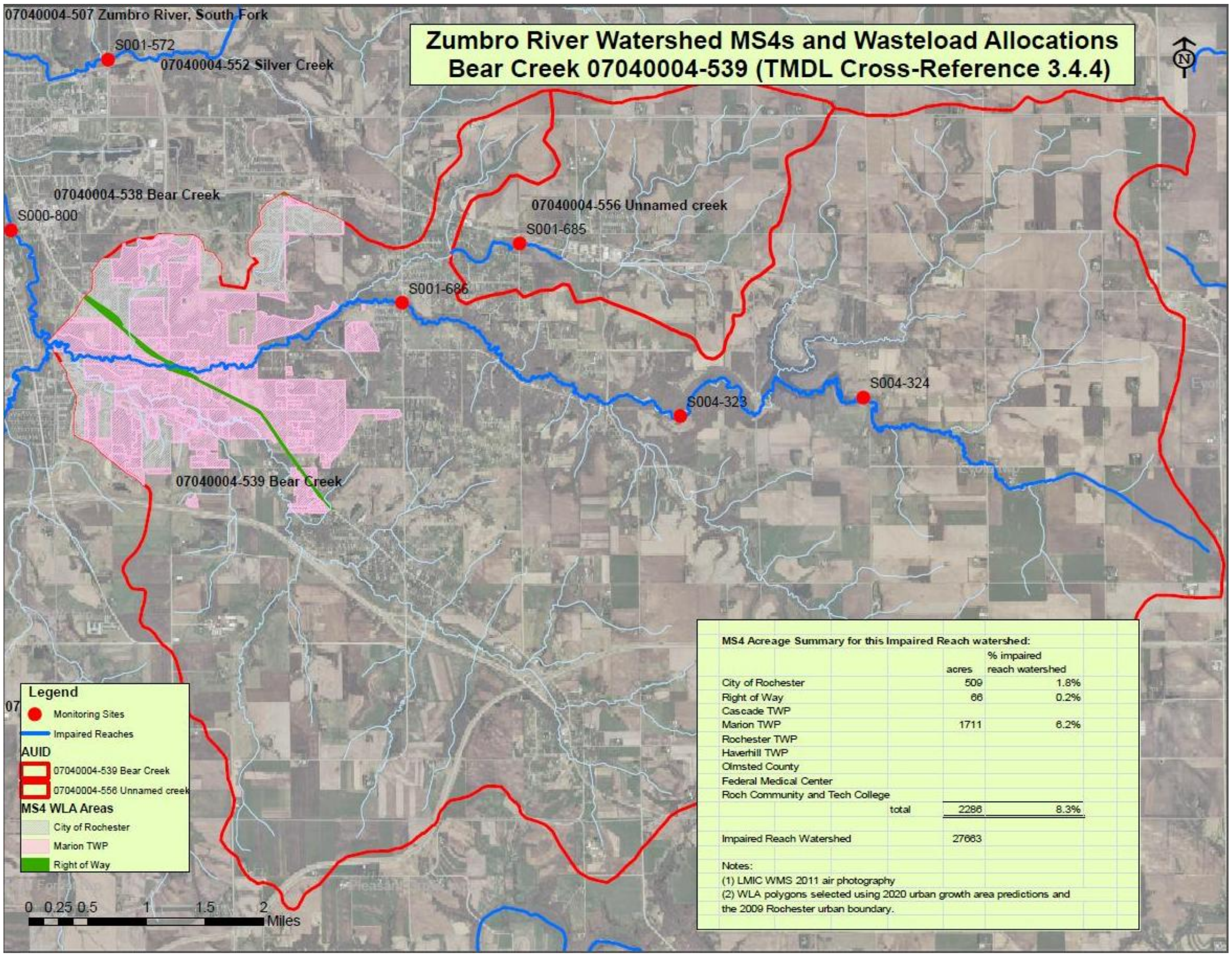


MS4 Acreage Summary for this Impaired Reach Watershed:

	acres	% impaired reach watershed
City of Rochester	3231	3.2%
Right of Way	351	0.4%
Cascade TWP		
Marion TWP		
Rochester TWP	686	0.7%
Haverhill TWP		
Olmsted County	<0.0001	0.0%
Federal Medical Center		
Roch Community and Tech College		
total	4269	4.3%
Impaired Reach Watershed	100058	

Notes:
(1) LMIC WMS 2011 air photography
(2) WLA polygons selected using 2020 urban growth area predictions and the 2009 Rochester urban boundary.

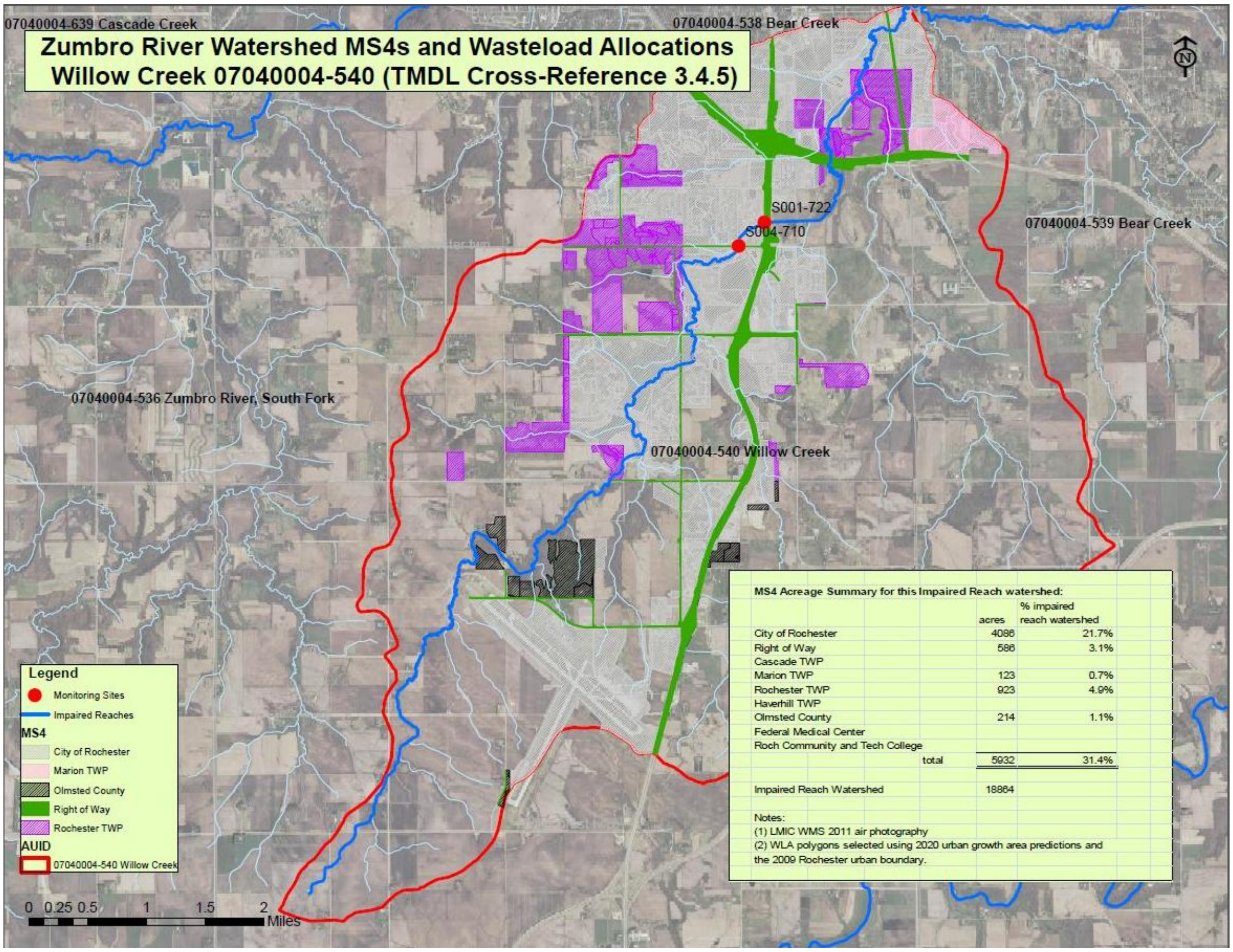

Zumbro River Watershed MS4s and Wasteload Allocations
Bear Creek 07040004-538 (TMDL Cross-Reference 3.4.6)
S001-354
S001-613
S001-572
07040004-581 Cascade Creek
07040004-553 Silver Creek
07040004-552 Silver Creek
07040004-507 Zumbro River, South Fork
S001-573
07040004-639 Cascade Creek
07040004-538 Bear Creek
S004-385
S000-800
07040004-556 Unnamed creek
S001-685
S001-686
S004-323
S004-324
07040004-539 Bear Creek
07040004-536 Zumbro River, South Fork
S001-722
S004-710
07040004-540 Willow Creek
MS4 Acreage Summary for this Impaired Reach watershed:
acres
% impaired reach watershed
City of Rochester 6753 13.6%
Right of Way 855 1.7%
Cascade TWP
Marion TWP 2017 4.1%
Rochester TWP 923 1.9%
Haverhill TWP 2 0.0%
Olmsted County 214 0.4%
Federal Medical Center 17 0.0%
Roch Community and Tech College 101 0.2%
total 10881 22.0%
Impaired Reach Watershed* 49542
*Includes AUIDs -539 and -540 watershed areas
Notes:
(1) LMIC WMS 2011 air photography
(2) WLA polygons selected using 2020 urban growth area predictions and the 2009 Rochester urban boundary.
Legend
Monitoring Sites
Impaired Reaches
MS4
City of Rochester
Federal Medical Center
Haverhill TWP
Marion TWP
Olmsted County
RCTC
Right of Way
Rochester TWP
AUID
07040004-538 Bear Creek
07040004-539 Bear Creek
07040004-540 Willow Creek
07040004-556 Unnamed creek
0 0.5 1 2 3 4
Miles



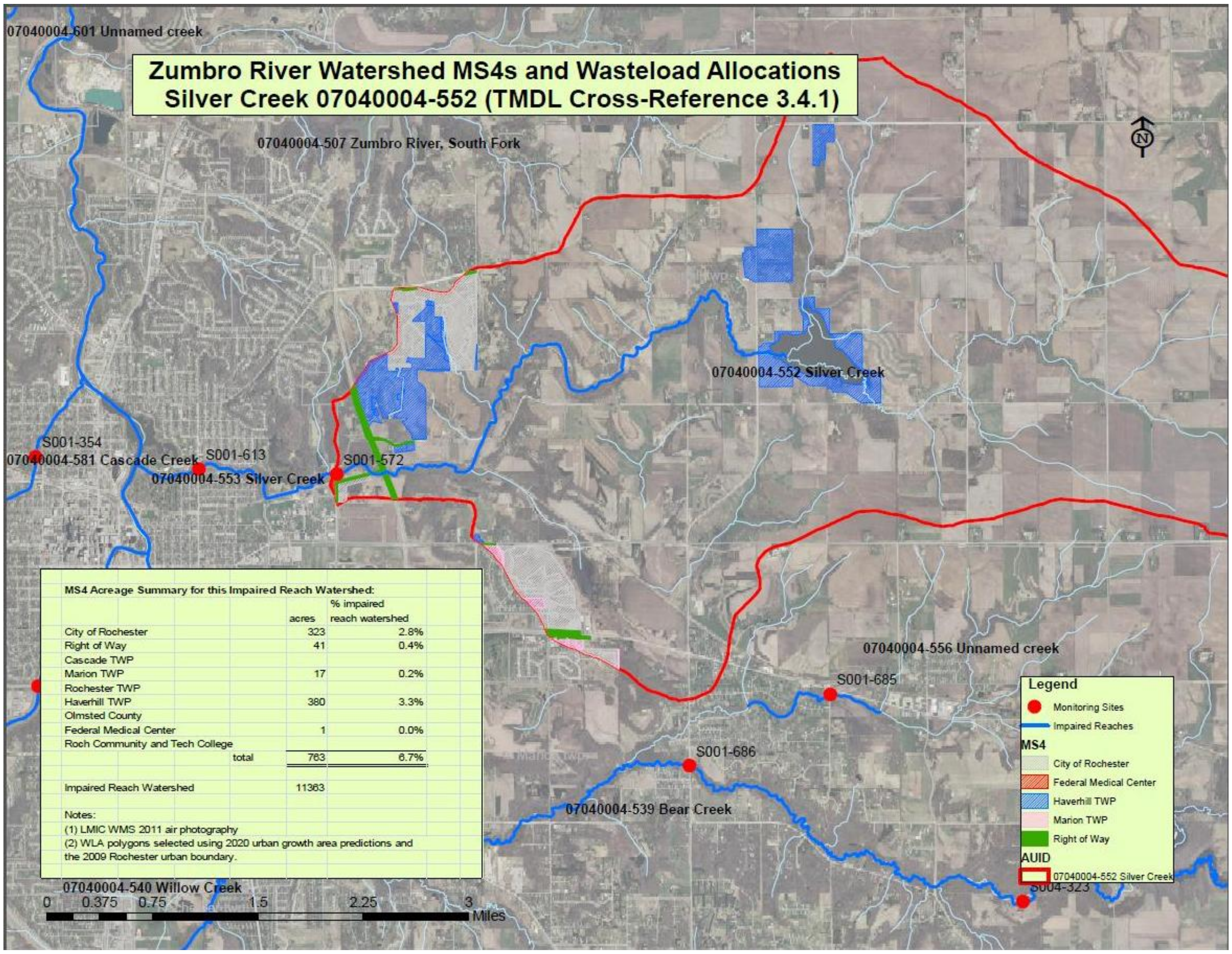
MS4 Acreage Summary for this Impaired Reach watershed:

		acres	% impaired reach watershed
City of Rochester		509	1.8%
Right of Way		66	0.2%
Cascade TWP			
Marion TWP		1711	6.2%
Rochester TWP			
Haverhill TWP			
Olmsted County			
Federal Medical Center			
Roch Community and Tech College			
	total	2286	8.3%
Impaired Reach Watershed		27663	

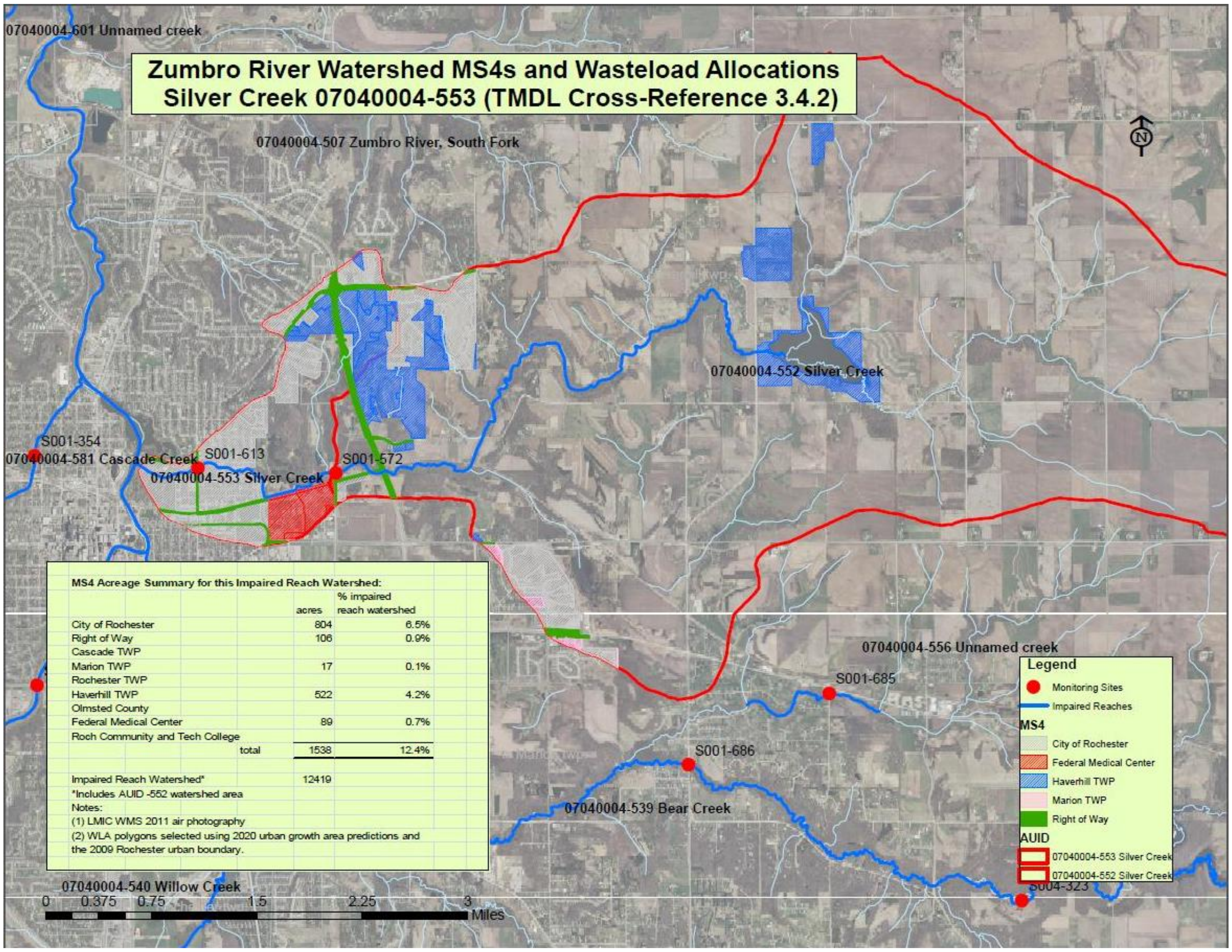
Notes:
(1) LMIC WMS 2011 air photography
(2) WLA polygons selected using 2020 urban growth area predictions and the 2009 Rochester urban boundary.



	acres	% impaired reach watershed
City of Rochester	4086	21.7%
Right of Way	586	3.1%
Cascade TWP		
Marion TWP	123	0.7%
Rochester TWP	923	4.9%
Haverhill TWP		
Olmsted County	214	1.1%
Federal Medical Center		
Roch Community and Tech College		
total	5932	31.4%
Impaired Reach Watershed	18864	



Zumbro River Watershed MS4s and Wasteload Allocations
Silver Creek 07040004-552 (TMDL Cross-Reference 3.4.1)
07040004-601 Unnamed creek
07040004-507 Zumbro River, South Fork
07040004-552 Silver Creek
S001-354
07040004-581 Cascade Creek
S001-613
07040004-553 Silver Creek
S001-572
07040004-556 Unnamed creek
S001-685
S001-686
07040004-539 Bear Creek
07040004-540 Willow Creek
S004-323
MS4 Acreage Summary for this Impaired Reach Watershed:
acres
% impaired reach watershed
City of Rochester 323 2.8%
Right of Way 41 0.4%
Cascade TWP
Marion TWP 17 0.2%
Rochester TWP
Haverhill TWP 380 3.3%
Olmsted County
Federal Medical Center 1 0.0%
Roch Community and Tech College
total 763 6.7%
Impaired Reach Watershed 11363
Notes:
(1) LMIC WMS 2011 air photography
(2) WLA polygons selected using 2020 urban growth area predictions and the 2009 Rochester urban boundary.
0 0.375 0.75 1.5 2.25 3 Miles
Legend
Monitoring Sites
Impaired Reaches
MS4
City of Rochester
Federal Medical Center
Haverhill TWP
Marion TWP
Right of Way
AUID
07040004-552 Silver Creek



MS4 Acreage Summary for this Impaired Reach Watershed:

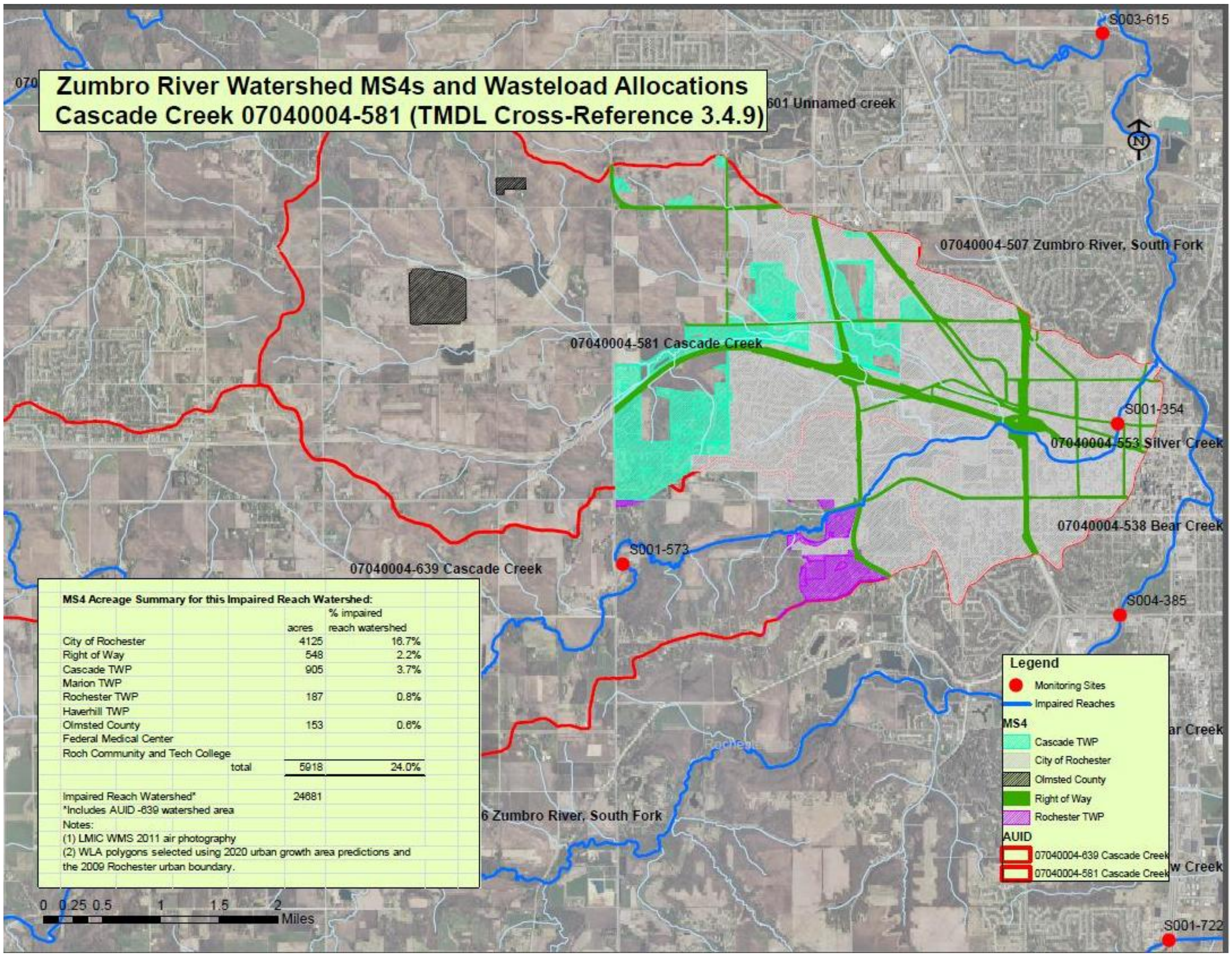
	acres	% impaired reach watershed
City of Rochester	804	6.5%
Right of Way	106	0.9%
Cascade TWP		
Marion TWP	17	0.1%
Rochester TWP		
Haverhill TWP	522	4.2%
Olmsted County		
Federal Medical Center	89	0.7%
Roch Community and Tech College		
total	1538	12.4%
Impaired Reach Watershed*	12419	

*Includes AUID -552 watershed area

Notes:

(1) LMIC WMS 2011 air photography

(2) WLA polygons selected using 2020 urban growth area predictions and the 2009 Rochester urban boundary.

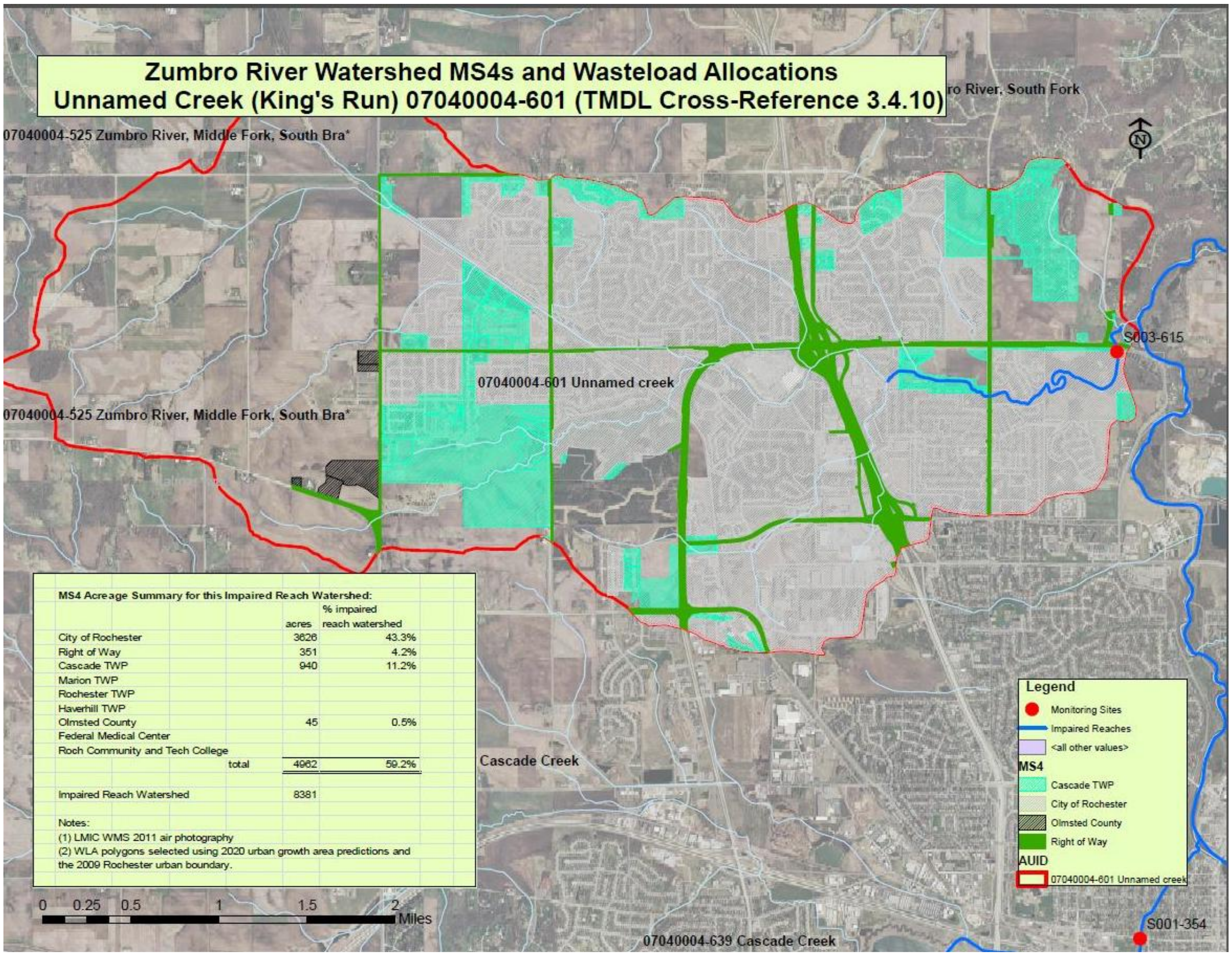


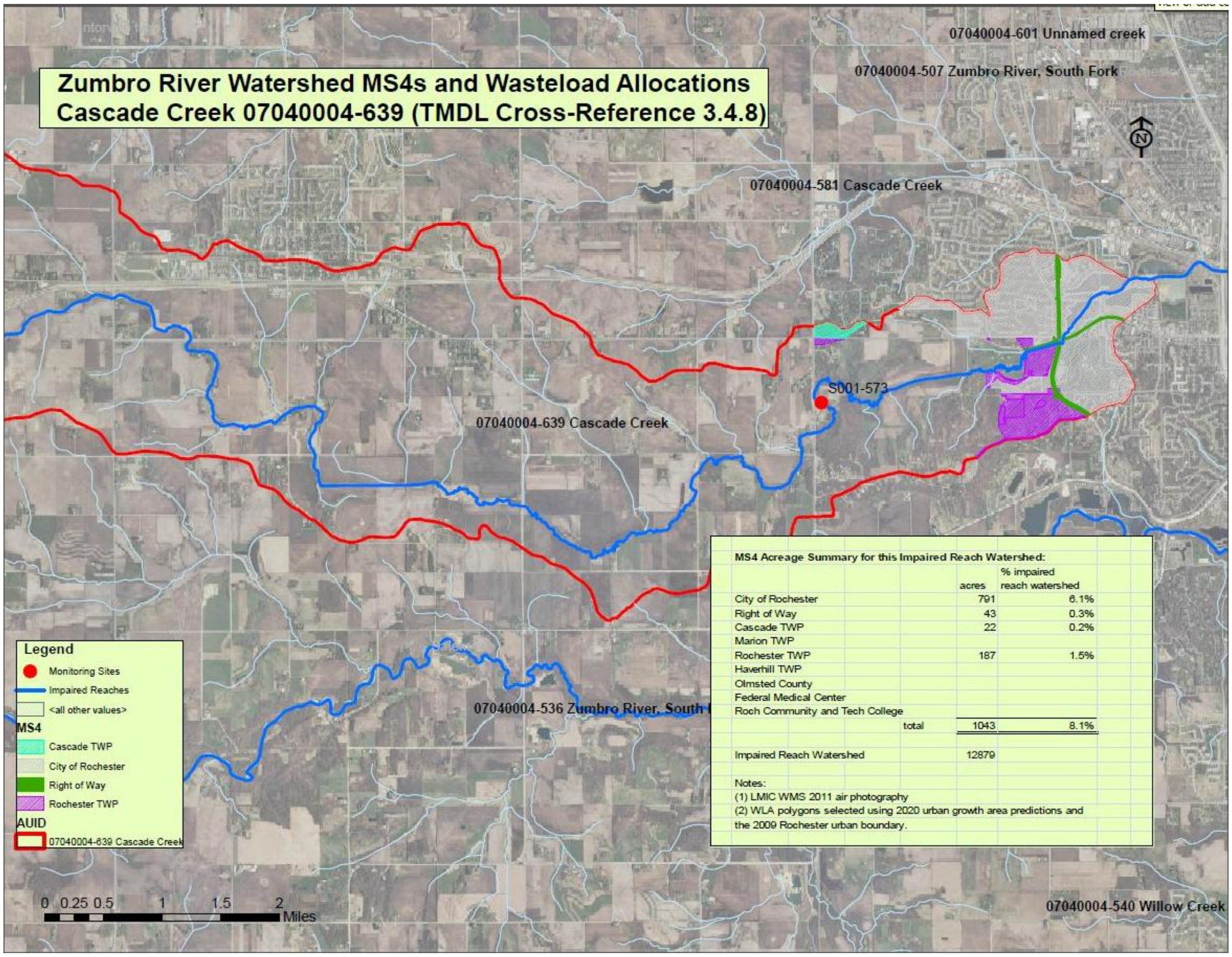
MS4 Acreage Summary for this Impaired Reach Watershed:

	acres	% impaired reach watershed
City of Rochester	4125	16.7%
Right of Way	548	2.2%
Cascade TWP	905	3.7%
Marion TWP		
Rochester TWP	187	0.8%
Haverhill TWP		
Olmsted County	153	0.6%
Federal Medical Center		
Roch Community and Tech College		
total	5918	24.0%
Impaired Reach Watershed*	24681	

*Includes AUID -639 watershed area

Notes:
(1) LMIC WMS 2011 air photography
(2) WLA polygons selected using 2020 urban growth area predictions and the 2009 Rochester urban boundary.


Zumbro River Watershed MS4s and Wasteload Allocations
Unnamed Creek (King's Run) 07040004-601 (TMDL Cross-Reference 3.4.10)
ro River, South Fork
N
07040004-525 Zumbro River, Middle Fork, South Bra*
07040004-601 Unnamed creek
07040004-525 Zumbro River, Middle Fork, South Bra*
S003-615
Cascade Creek
07040004-639 Cascade Creek
S001-354
MS4 Acreage Summary for this Impaired Reach Watershed:
acres
% impaired reach watershed
City of Rochester 3626 43.3%
Right of Way 351 4.2%
Cascade TWP 940 11.2%
Marion TWP
Rochester TWP
Haverhill TWP
Olmsted County 45 0.5%
Federal Medical Center
Roch Community and Tech College
total 4962 59.2%
Impaired Reach Watershed 8381
Notes:
(1) LMIC WMS 2011 air photography
(2) WLA polygons selected using 2020 urban growth area predictions and the 2009 Rochester urban boundary.
0 0.25 0.5 1 1.5 2 Miles
Legend
Monitoring Sites
Impaired Reaches
<all other values>
MS4
Cascade TWP
City of Rochester
Olmsted County
Right of Way
AUID
07040004-601 Unnamed creek



MS4 Acreage Summary for this Impaired Reach Watershed:

	acres	% impaired reach watershed
City of Rochester	791	6.1%
Right of Way	43	0.3%
Cascade TWP	22	0.2%
Marion TWP		
Rochester TWP	187	1.5%
Haverhill TWP		
Olmsted County		
Federal Medical Center		
Roch Community and Tech College		
total	1043	8.1%
Impaired Reach Watershed	12879	

Notes:
(1) LMIC WMS 2011 air photography
(2) WLA polygons selected using 2020 urban growth area predictions and the 2009 Rochester urban boundary.

Zumbro River Watershed MS4s and Wasteload Allocations
N
New Haven twp.
Oronoco twp.
Farmington twp.
Milton twp.
Elgin twp.
Cascade twp.
07040004-525 Zumbro River, Middle Fork, South Bra*
07040004-507 Zumbro River, South Fork
07040004-601 Unnamed creek
Mantorville twp.
Kalmar twp.
Haverhill twp.
Viola twp.
07040004-581 Cascade Creek
07040004-552 Silver Creek
Byron
07040004-553 Silver Creek
07040004-639 Cascade Creek
Rochester
07040004-538 Bear Creek
07040004-556 Unnamed creek
Canisteo twp.
Salem twp.
Rochester twp.
Marion twp.
Eyota twp.
07040004-539 Bear Creek
07040004-536 Zumbro River, South Fork
07040004-540 Willow Creek
Rock Dell twp.
High Forest twp.
Pleasant Grove twp.
0 0.5 1 2 3 4
Miles
Legend
Impaired Reaches
Impaired Reach Watersheds
MS4 WLA Areas
Cascade TWP
City of Rochester
Federal Medical Center
Haverhill TWP
Marion TWP
Olmsted County
RCTC
Right of Way
Rochester TWP